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# The impact of interest rates shocks on Namibia`s Treasury bonds pricing

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Degree:

**MASTER OF MANAGEMENT IN FINANCE AND INVESTMENT**

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# THE IMPACT OF INTEREST RATES SHOCKS ON NAMIBIA`S TREASURY BONDS PRICING

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# LIST OF ACRONYMS

| | |
|---|---|
| ADB | African Development Bank |
| AIC | Akaike Information Criterion |
| BON | Bank of Namibia |
| CPI | Consumer Price Index |
| DCF | Discounted Cash Flows |
| EMH | Efficient Market Hypothesis |
| GMM | Generalised Methods of Moments |
| ILB | Inflation-Linked Bonds |
| IRF | Impulse Response Functions |
| IPPR | Institutes of Public Policy Research |
| NA | Namibia |
| NAD | Namibian Dollar |
| NDP | National Development Plan |
| NXS | Namibia Stock Exchange |
| OTC | Over the Counter |
| RMB | Rand Merchant Bank |
| US | United State of America |
| SA | South Africa |
| SACU | Southern African Customs Union |
| SARB | South African Reserve Bank |
| VAR | Vector Autoregressive |

# ABSTRACT

This study investigates the impact of interest rate shocks—caused by rising inflation, currency depreciation, and global commodity price fluctuations—on Namibian Treasury bonds. Using a Vector Autoregressive (VAR) model and Impulse Response Functions (IRFs), the research analyses how bond prices and yields respond to sudden interest rate shocks. The findings reveal that fixed-rate bonds, such as GC24, tend to react sharply and negatively to interest rate increases, especially during the first month. Conversely, inflation-linked bonds initially show a positive response to rate hikes, which is contrary to typical expectations; this suggests that during the study period, increases in the repo rate were perceived by investors as signals of rising inflation, leading to increased demand for inflation-protected securities. The study also finds that interest rate shocks significantly raise bond yields and borrowing costs, posing challenges to long-term debt sustainability for Namibia. Variance decomposition results indicate that short-term bond yield fluctuations are mainly driven by past yield shocks, while long-term movements are increasingly influenced by macroeconomic fundamentals and policy variables. Overall, the research highlights the importance of strengthening Namibia's bond market resilience and emphasizes the need for informed monetary and fiscal policy coordination. These insights are crucial for policymakers aiming to manage debt sustainability, stabilize markets, and develop bond instruments better equipped to absorb economic shocks.



**Keywords**: Interest rate, Bond prices, Fixed rate bonds, Inflation linked bonds,VAR,IRF

# CHAPTER 1: INTRODUCTION

## 1.1. Introduction

Namibia is well known for its abundant natural resources, such as the commodities that are being exported internationally. Exported commodities contribute 65% of the country's Gross Domestic Product (GDP) (Mabuku, 2023). However, it was hugely affected by the 2007/2008 Global Financial Crisis (Institute of Public Policy Research, 2023). The Bank of Namibia (BoN) 2022 report has also highlighted the shocks in the system because of the Russia-Ukraine conflict.

A financial crisis is defined as a sharp and usually uncontrollable rise in banking or systemic risk that adversely affects the overall health of the economy. Most studies (Jiuding, 2022; Yihan, 2023) agree that the United States (US) was the source of the global financial crisis after the housing bubble burst and increased subprime mortgage foreclosures. The crisis began in the financial market and spread to the goods market (real sector). The demand for Namibia's commodities, such as diamond, copper, zinc and uranium, dropped due to the decline in commodity prices. Declining commodity prices resulted in lower export revenues, increased fiscal strain, and a lack of foreign currency (Mupunga and Ngundu, 2020; Oluwole, 2009).

As worldwide demand for commodities declined, the Namibian dollar (NAD) most certainly fell. A weaker currency causes imported inflation, which raises the cost of imported products. Inflation caused by a weaker currency and greater import costs may have led the BoN to raise interest rates to keep inflation under control (Sheefeni and Ocran, 2014). This was not a gradual adjustment, but rather a reaction to severe economic stress and volatility in the global markets (BoN, 2019). While higher interest rates can help to control inflation, they can also limit economic growth. Namibia's interest rate shocks were caused by a combination of external forces (such as global commodity price decline and financial market volatility) and internal pressures (such as inflation from a weakening currency and increasing import costs). These shocks were responses to sudden economic hardship, not routine policy adjustments. This has an adverse impact on national income and overall economic growth.

A study by Lu and Qu (2023) lamented that to compensate for the lower revenue, the government needed to borrow more, and this increased the issuance of treasury bonds and other debt instruments. Increased borrowing results in higher interest rates and inability to service existing debt, which results in investors demanding a higher premium. While it is noted that the global interest rates fell, which might have at first raised bond prices, in the long run, lower bond prices might have dropped due to concerns about Namibia's economic stability and higher risk premium (Mupunga and Ngundu, 2020). Most emerging market economies, including Namibia, that had benefited from the commodities boom prior to the crisis ended up performing poorly; thereafter, economic growth dropped. The Namibian economy is vulnerable to external shocks resulting from fluctuations in foreign exchange rates and commodity prices due to its dependence on mineral exports to a few trading nations, the US and Europe. Most of these issues were clearly apparent when one considered how trade shocks affected inflation, output and trade balance.

Given Namibia`s ongoing efforts to develop its financial markets, understanding the dynamics between interest rate shocks and bond prices is crucial. The bond market is vital to the country`s overall financial landscape because it acts as a barometer for the state of the economy

(Sheefeni, 2014). Most central banks use the bond market, which is a crucial component of the financial system, as a working tool for monetary policy formulation and execution. In addition, central banks employ open market operations to communicate with the financial markets to drive market rates to constantly fluctuate around the target rate (Zekaing, 2023).

Short-term rates at which central banks lend money to commercial banks are known as the repo rate (market interest rate); hence, interest rates are driven by the repo rates (BoN, 2023). Commercial banks promptly modify their interest rates (lending rates) in response to changes in the repo rate. Interest rates are an aspect that compares savings and investments. Businesses and consumers theoretically adjust their spending, savings and investment decisions in response to changes in commercial bank lending rates (Rose, 2003).

The BoN annual report of 2018 highlights that government bond issues continue to hold a significant market share in the domestic bond market. To restrict the amount of money in circulation or when the government is running a budget deficit, the government issues bonds through open market operations. The government, through the central bank, conducts open market operations and the Namibia Stock Exchange (NXS) issues bonds on the secondary market through over-the-counter transactions (OTC). The most issued securities by the BoN are the Treasury bills, Fixed-rate bonds (FRB) and Inflation-linked bonds (ILB). These are explained below:

- Treasury bills can be described as short-term securities with a maturity of less than a year.
- Fixed-rate bonds are long-term securities that pay a fixed coupon payment semi-annually on the nominal value of the bond, and on maturity, the nominal value is paid to the investor.
- Inflation-linked bonds pay fixed coupon payments that are adjusted for inflation, and the final maturity is based on the official consumer price index.

This study focuses on the effects of interest rate shocks on treasury bonds (FRB and ILB) pricing, as opposed to a normal change in the interest rate. The pricing of Treasury bonds was significantly impacted by interest rate shocks in Namibia, which were caused by both internal and external factors, such as inflation from a declining currency and rising import costs, as well as external factors including drops in global commodity prices and financial market volatility (IPPR 2023). These shocks usually resulted in higher yields on FRB as investors demanded higher returns to offset the increased risk and inflationary pressures. The local currency of Namibia weakened because of Namibia's reduced export earnings due to a decline in global commodities prices (Sheefeni and Ocran, 2012). Increased inflation and unpredictability in the financial markets were caused by this depreciation. Due to new issues or other investment options that provided higher returns or inflation protection, the fixed interest payments on these bonds lost their appeal (BoN, 2020). As a result, investors demanded higher yields, which caused the values of already-existing FRB to decline.

The impacts of ILB, on the other hand, which were intended to provide inflation protection, were more complex. Even though these bonds are inflation-adjusted, greater-than-expected inflation rates may have resulted from the depreciation of the currency and higher import expenses (Torres et al., 2021; Abuelfadl and Yamani, 2021). This adjustment process raised nominal yields and, consequently, the pricing of new inflation-linked issues while maintaining the real value of returns for investors. In times of high inflation, investors would value these bonds higher, which might raise their price and make them more attractive than FRB. The

overall stability and pricing dynamics of inflation-linked bonds could be impacted if inflation expectations significantly exceeded historical norms or if the inflation adjustment mechanism declined (Torres et al., 2021).

The National Planning Commission report of 2021 highlights how the financial sector and overall economic environment of Namibia are significantly shaped by the Treasury FRB and ILB issued by the government. Because FRB offer investors a steady and predictable stream of income, they are a popular choice for conservative investors looking for security, making them important. By providing set interest payments, these bonds impact the pricing of credit and loans throughout the economy by acting as a benchmark for other interest rates in the financial market (Rath, 2022). In addition, the Namibian government manages its public debt and finances vital public services and infrastructure projects with the regular issuing of fixed-rate bonds (BoN, 2018) because fixed-rate bonds are predictable, the market is more liquid and stable, which helps the debt market run smoothly and makes government investment and financing easier.

The ILB, on the other hand, are essential for investors looking to hedge against inflation, especially in situations where there is currency depreciation and economic uncertainty. These bonds maintain the buying power of investors' gains by providing inflation-adjusted returns (BoN, 2018). With growing commodity prices and currency volatility, in particular, this attribute makes them a vital instrument for controlling inflation risk and preserving investor confidence. Adelagan and Radzawick's 2009 study emphasises that these bonds draw in a wide range of investors because of their inflation protection, including those who are concerned about their long-term purchasing power. In addition, the issue of ILB helps Namibia's financial market grow by offering a way to diversify investment options and protect against inflation. When taken as a whole, these bonds serve investor risk management as well as the government's financing needs by strengthening the financial market's depth and durability.

The yield curve for the treasury bonds illustrates the relationship between bond yields and term to maturity (term structure of the interest rate). The treasury bond yield curve is used as a benchmark for financial goods, and it is crucial to the financial system (Zekaing, 2023).

## 1.2 Research Problem

A combination of internal and external variables has resulted in interest rate shocks that have created severe volatility in the Namibian financial sector (Rath, 2022). The pricing and valuation of Namibian Treasury bonds have been significantly impacted by both internal and external factors, such as rising inflation brought on by a weakening currency and rising import costs as well as by sharp drops in the price of commodities globally and increased volatility in the financial markets (Koroleva and Kopeykin, 2022). This study specifically aims to investigate how these interest rate shocks affect Namibian Treasury bond prices. Treasury bonds with fixed interest rates, which provide a steady yield through predetermined interest payments, are more sensitive to changes in inflation expectations and market interest rate movements (Westerhout, 2021). On the other hand, the price of inflation-linked bonds, which are intended to shield investors from inflationary pressures, varies according to how precisely and promptly inflation adjustments are made (Westerhout, 2021).

Understanding how these cumulative shocks impact yield spreads, market stability, and investor behaviour with respect to fixed-rate and inflation-linked Treasury bonds is the main

issue this research attempts to solve (Rath, 2022). This involves looking at how the dynamics of fixed-rate bond pricing and yields are affected by the combination of falling global commodity prices and unstable financial markets, as well as how inflation adjustments affect the pricing of inflation-linked bonds in the context of shifting local inflation rates (Institute of Public Policy Research, 2023. The study intends to make policy recommendations for strengthening Namibia's bond market's resilience in the face of upcoming economic uncertainties, as well as provide insights into the various ways in which these shocks affect bond pricing and assess how well-suited current financial instruments are to mitigate them.

### 1.2. Research Objectives

The impact of interest rate shocks on Namibia Treasury Fixed Rate Bond and Inflation-Linked Bond pricing is examined in this study. Interest rate shocks affect bond valuations in different ways depending on whether they are caused by internal pressures like domestic inflation and currency depreciation or external ones like changes in the price of commodities globally and volatility in the financial markets (Carlos et al., 2005). While Inflation-Linked Bonds, which compensate for inflation, may respond differently depending on the level of inflationary pressures, Fixed Rate Bonds, which provide continuous coupon payments, often see a reduction in price when interest rates rise (Cieslak and Pang, 2021). The specific objectives that will guide the study to fulfil the research aim are listed below:

- Determine the speed and magnitude of price adjustments in reactions to interest rates shocks.
- Examine how interest rate shocks affect the cost of borrowing for the government and the sustainability of debt.

### 1.4. Research Questions

- How quickly and to what extent do Namibia Treasury Fixed Rate Bonds and Inflation-Linked Bonds adjust in price in response to interest rate shocks?
- How do interest rate shocks affect the Namibian government's borrowing costs and the sustainability of its debt?

### 1.5. Contribution of the study

The contribution of this study lies in its detailed analysis of how interest rate shocks, driven by both external and internal factors, affect the pricing of Namibian Treasury bonds. By examining the impact of global commodity price declines, financial market volatility, domestic inflation, and currency depreciation on bond valuations, the study provides a nuanced understanding of how these variables interact to influence bond prices. By experimentally demonstrating the susceptibility of Namibian Treasury FRB and ILB to such shocks, this study fills a gap in the literature and offers crucial new insights into the dynamics of developing market bonds.

Furthermore, by assessing how these shocks impact government borrowing costs and debt sustainability, and by examining market liquidity and investor behaviour during times of elevated interest rate volatility, the study adds to the body of practical knowledge. Policymakers, investors, and financial analysts can be better equipped to manage and react to interest rate shocks in the Namibian context by using this thorough approach, which offers actionable information.

## 1.6. Significance of the study

The investigation of how interest rate shocks affect the pricing of Namibian Treasury bonds is essential to comprehending the ways in which changes in macroeconomic variables affect the valuation of Treasury bonds in developing economies. Insights from this research may assist in evaluating the sensitivity of bond prices to interest rate changes, which in turn informs investment strategies and risk management procedures, given Namibia's reliance on Treasury bonds for financing government projects and managing fiscal policy. By looking at this relationship, the study could help to improve the understanding of Namibia's bond market dynamics, which benefits investors, policymakers, and financial institutions by helping them make better decisions and increase the stability of the financial system.

## 1.7. Overview of the research

The paper is organised into five chapters. Chapter one covers the introduction, problem statements, research objectives, research questions, contributions, and significance of the study. The second chapter will assess the theoretical background on interest rate, most issued bonds in the Namibian bond market, and empirical evidence. Chapter three concentrates on the methodology applied. Chapter four will present the results, their analyses, interpretation and discussion. Chapter five summarizes the outcome and provides conclusions and recommendations. The last section contains the reference list.

# CHAPTER 2: LITERATURE REVIEW

This chapter seeks to review theoretical concepts and the literature on the subject under study. The focus is on the interest rates and the Namibian bond market.

## 2.1 Theoretical background

### 2.1.1. Bonds issued by the government (Treasury)

#### i) Fixed rate bonds (FRB)

The fundamental pricing of FRB is based on the Discounted Cash Flow (DCF) model. Jiayi (2022) defines the "DCF method for bond pricing as:

> A technique used to determine the fair value of a bond by calculating the present value of its expected future cash flows. The cash flows typically include periodic coupon payments and the face value (or principal) of the bond, which is paid at maturity. The core idea is to discount the future cash flows back to their present value using an appropriate discount rate, which reflects the current market interest rates and the risk associated with the bond.

Mangiero et al. (2019) state that maturity is no longer a feasible tool to quantify volatility and risk; the two main interconnected approaches to measure bond risk are now duration and convexity.

Andrew (2000) defines convexity as the degree to which a bond's price will rise or fall in response to a change in interest rates. A study by James et al (2021) highlighted the importance of duration in bond pricing; duration is essential because it measures how sensitive a bond is to changes in interest rates, offering a linear estimate of how bond prices will respond to fluctuations in interest rates. Duration addresses the following key aspects:

- **Interest rate sensitivity:** Duration is an essential tool for evaluating interest rate risk. It illustrates the estimated amount of change in bond prices in response to a 1% change in interest rates. This indicates how sensitive the bond is to changes in interest rates. A longer duration is a sign of increased interest rate sensitivity (Xiao and Yiye, 2022).
- **Portfolio risk management**: Duration approach ensure that the portfolio value is constant, and investors can attain immunity, by matching assets and liabilities which helps shield the value of the portfolio from changes in the interest rates. (Xiao and Yiye (2022).

#### ii) Inflation-linked bonds (ILB)

"The world`s first known ILB were issued by the Commonwealth of Massachusetts in 1790 during the revolutionary war; these are bonds that have their principal daily adjusted for inflation or deflation based on the consumer price index" (Shiller, 2023). The BoN, on behalf of the government through the open market operation, issued the first ILB in 2015(BoN Circular, 2018). ILB provides investors with inflation protection. To maintain the investors' purchasing power, these bonds' principal and coupon payments rise in tandem with an increase in the consumer price index (CPI).

In Pierre's (1998) study on inflation-linked bonds, theoretical frameworks provide a relationship between nominal interest rates, real interest rates and expected inflation. It asserts

that nominal rates represent the compensation for anticipated inflation as well as the real rate of return. The study further emphasizes how investors seek compensation for the uncertainty of future inflation, influencing interest rates and economic decisions, by including the inflation risk premium in his study (Torres et al., 2021). Pierre's (1998) theory is closely related to the idea of inflation-linked bonds, which are intended to provide protection against inflation risk by modifying their payouts in accordance with variations in the rate of inflation. The significance of comprehending inflation risk in bond pricing is highlighted by Pierre`s findings, which show how theoretical frameworks, such as the Fisher equation, are essential for assessing the worth and efficacy of inflation-linked securities in mitigating inflation-related financial risks.

### 2.1.2 Interest rates

John Maynard Keynes was one of the economists who conducted early research on interest rates and introduced the theory of interest rates (Appelt, 2016). In his theory, he defines "interest rates as a market interest rate, [for example,] the rate governing the terms on which funds are being supplied" (Appelt, 2016). His theory postulates that the state uses interest rates as a tool for monetary policy to join the market. This is done to ensure effective use of resources and avoid conserving too much money, which could cause unemployment.

According to John et al. (1985), interest rate fluctuations have been the subject of in-depth study and examination in the discipline of economics since they are essential to the operation of financial markets and the overall economy. These authors emphasise the three-term structure of interest rate theory and how it affects bond pricing. (Kessel (1965) defines the term structure of interest rate as the relationship between interest rates or bond yields and different terms to maturity. The three theories are expectation theory, liquidity preference theory. and market segment theory.

- **Expectation theory** of interest rates provides more insight into interest rates. The theory provides an explanation of the relation between short- and long-term rates. Interest rate risk and inflation are the two factors that set long-term bonds apart from short-term bonds. The supply and demand of money, which depends on the reasons for people holding cash balances, affect interest rates (Kessel, 1965). A graphical depiction of this theory is a downward sloping curve, which simply means short-term yields are greater when compared to longer-term. According to this theory, market participants' expectations about future interest rate changes determine interest rates (Mbowe et al., 2020; Ojwang, 2016). It is associated with economic stagnation, high inflation, which causes bond prices to be depressed and tight monetary policy. Given that scenario, investors are advised to avoid the risk of making investments or opt for hedgeable investment securities. Since assumptions regarding the behaviour of the term structure are essential to economic models and theory, researchers and those in charge of monetary and economic policy must have a thorough understanding of it.

- **Liquidity preference theory** was introduced by Keynes (1936). According to the liquidity preference theory, people store money for purposes other than simple exchange. This theory attempted to explain how various significant factors interact and influence interest rates. When people think that interest rates will rise, they hang on to the money to invest. The theory is graphically illustrated by an upward sloping curve, which means

that long-term bonds have greater interest rates than short-term bonds. As a result, most institutional investors, including pension and insurance funds, are forced to adopt a buy-and-hold strategy, since the market is in-liquid (BoN, 2004).

- **Market segmentation** theory states that "the markets for bonds with varying maturities are entirely segregated. Without considering the anticipated returns on the bonds with other maturities, the supply and demand for each bond with a different maturity determine the interest rate for that bond is regarded as a seldom practice" (Ojwang, 2016).

### 2.1.3 Interest rate risk

Lukmanova and Rabitsch (2021) investigated the effects of the shocks on monetary transmission mechanisms and economic variables. The study provides a detailed grasp of the various ways that shocks to monetary policy affect the financial markets and the economy. According to their findings, interest rate shocks cause FRB pricing to alter immediately and significantly because rising interest rates make these bonds less appealing and lower their market value. On the other hand, inflation-linked bonds are more susceptible to shocks to the inflation target because they are made to modify payouts in response to inflation expectations. These shocks change investor expectations for inflation in the future, and the actual yield and pricing of bonds are impacted. As a result, while inflation-linked bonds are impacted by changes in inflation expectations, fixed-rate bonds respond mainly to changes in nominal interest rates.

The study emphasizes how Asian bond markets, in contrast to those in Western nations, might respond to interest rate shocks in different ways (Kim et al., 2021). Events like the global financial crisis, creates uncertainty that's impacts investor demand for bonds and bonds demand. The study further concluded that financial uncertainty causes volatility in Asian bond market that trigger the interest rates, which in fact affect the FRB pricing.

### 2.1.4Relationship between interest rates, inflation and bond pricing

#### *Relationship between interest rates and Treasury bond pricing*

Extensive literature shows that bond prices and interest rates have an inverse relationship; as central banks adjust their policies in response to economic conditions, equilibrium interest rates fluctuate, causing commensurate changes in bond prices. Specifically, as interest rates rise, the present value of bonds' fixed future cash flows falls, resulting in lower bond prices. In contrast, lower interest rates increase the appeal of existing bonds, causing their prices to rise. This study stresses the importance of monetary policy in driving bond market dynamics, demonstrating how changes in interest rates can have a considerable impact on bond valuations (Favero C. et.al., 2023).

In other words, the impact of interest rate hikes on bond prices or yields may appear different, whether viewed over short intervals (such as a day) versus longer durations (such as a week or month). This shows that market dynamics and investor behaviour can shift over time, resulting in varying bond pricing or market reactions. The nuanced study demonstrates how the timing

and character of market reactions to interest rate fluctuations might affect various investing strategies (Cai, 2023)

Short-term investors should be mindful that the bond market does not usually react quickly to interest rate rises. As a result, they may change how frequently they buy and sell bonds to capitalize on these delayed reactions. Long-term investors, on the other hand, may consider the total or cumulative impact of interest rate increases across different periods. They can make better informed judgments regarding their investment portfolios by monitoring how the market reacts over the course of a day, week, or month.

***Relationship between inflation and interest rates***

A study by Borowski et al. (2024) indicates that central bank interest rates and inflation in Poland are significantly correlated. The results show that the Central Bank of Poland's higher interest rates have helped to lower inflation over time. This inverse link is consistent with the economic theory, which states that higher interest rates often reduce inflation by discouraging investment and consumer expenditure. The study also highlights that this relationship is complicated by outside influences. For instance, government social assistance programs have driven up prices, partially counteracting the impacts of increased interest rates, even as the central bank tightens monetary policy to limit inflation. This demonstrates a misalignment between monetary and fiscal policy, which makes reaching steady inflation goals more difficult. It offers empirical proof that when fiscal measures undermine the goals of monetary policy, monetary policy alone is insufficient.

The findings by Bórawski et al. demonstrate how interest rates affect borrowing costs, investment, and consumption, which in turn affect inflation. Understanding this relationship is essential to comprehending how interest rate shocks may impact the inflation expectations embedded into Namibia's inflation-linked bonds. If inflation expectations decline, higher interest rates intended to contain inflation may make fixed-rate bonds more appealing while decreasing the allure of inflation-linked bonds. Bond yields and prices in Namibia may be equally impacted by differences in central bank interest rate changes and government fiscal policy.

***Relationship between Inflation and bond pricing***

There is an inverse relationship between inflation and bond pricing. An increase in inflation decreases the bond price. Camba-Mendez (2019) examined the relationship between inflation risk and bond yields across various countries, where he concluded that there is a positive relationship between inflation and bond pricing. Camba-Mendez used a comprehensive empirical framework to examine how changes in inflation expectations affect sovereign bond pricing, revealing that higher expected inflation typically leads to higher yields as investors seek compensation for the declining purchasing power of future cash flows. The findings highlight the importance of inflation risk in sovereign bond valuation, implying that policymakers and investors should actively watch inflation trends to make educated bond market decisions.

### 2.1.5 How inflation expectations affect interest rates and bond markets in Namibia

Interest rate in Namibia (NA) is driven by the monetary policy that is set by the BoN. The BoN monetary policy is not independent due to the fixed exchange rate regime between Namibia and South Africa (SA) (BoN, 2020). The BoN repo rate must be at par or in line with the South African Reserve Bank (SARB). This means if the SARB increases their repo rate, the BoN must follow suit, adjusting its repo rate, which will result in the modification of interest rates. These have two negative bearings on the Namibian economy at large. One the one hand, if the BoN has to respond to the increase in the official rate, this has a negative bearing on Namibian economy, given that the country has been battling with a high rate of inflation, low economic growth, and a high rate of unemployment. The BoN's 2023 monetary policy framework clarified this by keeping the repo rate constant to promote economic expansion and preserve price stability. On the other hand, if the BoN did not respond to an increase in repo rate, that means the NA interest rates would be lower than that of SA. Consequently, investors will deviate from investing locally to SA where there will be better returns on investment, thereby suppressing the NA financial markets (BoN, 2020).

### 2.1.6 Namibian bond market

There was essentially no bond market in Namibia, and the financial sector was controlled by institutions like commercial banks, pension funds, and insurance companies. These institutions mobilized deposits and contractual savings that were primarily directed towards uses within the South African economy rather than being used productively in the Namibian real sector. Namibia's first National Development Plan (NDP1) (1995) states that after independence, it was difficult for the Namibian government to revive and maintain economic growth, create jobs, reduce poverty and tackle the unequal distribution of wealth. The historical development means that Namibia must build its financial market to a level that is important to this process of economic growth and development.

The country has been struggling to establish a well-structured bond market due to small market size and liquidity; because of that, accurately determining bond prices and yields was a cumbersome process (ABSA Financial Market Index, 2020). However, due to close monetary ties between Namibia and South Africa, Namibia's bonds are benchmarked against those of South Africa. South African bonds are more liquid, which makes the price and yields more precise. The African Development Bank (ADB) (2010) stated that in sub-Saharan Africa, South Africa is well-known for its well-structured bond market and liquidity.

To have an independent and well-functioning bond market requires all markets participants, for example, policy makers, regulatory bodies, issuers, and issues, to pull together and carry out analysis on how to properly do intrinsic bond valuation to correctly price the bonds rather than using South African benchmarked bonds (BoN, 2004). An efficient market will prompt investigation into how efficiently the Namibian bond market incorporates changes in interest rates into the prices of treasury bonds (FRB and ILB). To ensure the efficiency of the market, one must be on the lookout for the following:

- **Efficient market:** Titan (2015) defines an efficient market as "a market with a great number of rational, profit-maximisers actively competing, with each trying to predict future market values of individual securities". Additionally, "current important

information is almost freely available to all participants. The author further added that market efficiency can be fully understood by using the Efficient Market Hypothesis (EMH). The EMH is a financial theory that suggests that financial instruments should reflect all available information at any given time.
Tobias and Wegener (2022) alluded that news is the most common way for knowledge to spread; it is believed that news stories have an impact on the value of financial instruments. Therefore, knowing the ramifications of such knowledge is essential for educating market participants if the Efficient Market Hypothesis truly holds. Proper market efficiency evaluation is needed.

- **Speed of price adjustment:** Speed of price adjustment emphasizes how quickly bond prices react to new information on interest rates. Complex dynamics are revealed by studies on how interest rate information affects the price adjustment of treasury bonds. In their study, Antonius and Julius (2020) stated that Central bank rates trigger interest rates and inflation, which have a negative impact on bond prices. Their study investigated whether changes in the U.S. interest rates, as a major global economic indicator, lead to swift adjustments in Indonesian bond prices. This includes assessing the transmission mechanism of the U.S. monetary policy on local bond markets and how quickly such international factors are reflected in bond pricing. They concluded that a market is more efficient when prices adapt more quickly to incorporate new information. Michael et al. (2020) argued that information about economic policy is not as influential in driving variation in the government bond market as political competition is.

- **Market participants:** Investors can assess the efficacy of the bond market by gaining insight into how quickly bond prices respond to changes in interest rates. It can inform policymakers on the operation of the financial markets and have an impact on investment plans and choices. Large investors can have a substantial impact on risk-taking and portfolio composition through strategic engagement, which could alter the role of inflation-linked bonds.

Bond price and interest rates are inversely related. In 2023, most fixed income markets saw a decline in global bond prices as yields increased, as most countries were still trying to recover from the world pandemic from 2019 to 2022 (Cheah et al., 2023). This raises the fiscal deficit for most governments, including NA. Given the size of liquidity, this resulted in institutional investors adopting a buy-and-hold strategy. Bonds in the Namibian market are issued in either the primary market or the secondary market. The BoN, on behalf of the state, issued bonds on the primary market through an open market operation and the NXS was granted permission by the regulatory authorities to list bonds on the NXS and create a secondary market (National Assembly, 2021). The bonds can provide a reliable source of long-term income where the investor`s financial and personal circumstances moderate risk. Daily current and prior fixed-rate bonds are listed at the NXS for secondary trading. Given that their pricing is determined by a flat yield curve that is derived from a weighted average cost of funding, these bonds can act as a hedge against rising inflation.

Nonetheless, it should be noted that “bond market stability is measured by the yield curve” (Muzindutsi and Obalade, 2024). The analysis of negotiable securities, which are all

marketable securities, regardless of eligibility for bank investment, was used to create the 1945 treasury yield curve. However, a recent study by Yu (2024) highlights that "inflation expectation, economic growth, and monetary policy may be seen as tools that determine the yield curve". Durran and Winn (1947) emphasize that "most treasury bonds are not callable; unlike corporate bonds, their yield fluctuates slightly because of small changes in the interest rate-derived coupon rate".

## 2.2 Related literature

### 2.2.1 Radier et al. (2016)

The study titled "Determinants of bond yield spread changes in South Africa" by Radier et al. (2016) investigated the emerging markets perspective on the determinants of bond yield spread changes. The study further emphasises how bond yields were affected by the country's financial crisis of 2007-2008. The main aim of their research was to ascertain the effects of the country`s established inflation target framework on short-term rates, which are subject to fluctuations because of changes in the repo rate, which in turn affects the yield curve's slope and long-term interest rates. The goal was to identify the variables that influence the spread of bond yields, and the study found that the three most important ones are the changes in stock volatility, interest rate levels, and the slope of the yield curve are the main determinants of the bond yield spread in the South African market.

Their study differentiates what drives the bond yields in developed markets and emerging markets. Though South Africa is a developing country, it holds a large financial market in Africa, with a fully developed bond market in terms of liquidity, instruments to be issued, and market participants that make it equivalent to the developed markets.

### 2.2.2 Muzindutsi & Obalade(2024) and Umoru et al., 2022

Muzindutsi & Obalade(2024) examine how external shocks and regime shifts impact bond markets in South Africa, their focus was mainly on external influences and macroeconomic policy changes. Their study mainly used panel data estimate approaches to examine how country risk shocks affect the performance of the South African bond market under regime transitions, most likely using fixed or random effects models. With an emphasis on long-term relationships and variability across regimes and time, they have additionally included dynamic panel estimators such as Generalised Methods of Moments(GMM)to address endogeneity and lag effects. Umoru et al., 2022 study demonstrate that the type of exchange rate regime influences how external shocks, such as fluctuations in commodity prices, impact import costs and foreign reserves in African nations. Countries with flexible exchange rates tend to better absorb these shocks, reducing market volatility, whereas fixed regimes often leave economies more exposed to instability. Similar to Muzindutsi & Obalade(2024), the study used panel data regression techniques, including fixed effects or random effects models, to examine the long-term interactions between foreign reserves, import prices, and exchange rate regimes across several African nations. In contrast, this study employs Vector Autoregression (VAR) to examine how bond prices, both fixed-rate and inflation-linked, react instantly and dynamically to interest rate shocks. Over a 12-month horizon, VAR models are excellent at capturing impulsive reactions and short-term transmission mechanisms, offering insights into the magnitude and pace of price changes.

Estimation of Panel Data (Muzindutsi & Obalade 2024) (Umoru et al., 2022): While accounting for unobserved heterogeneity, it is appropriate for investigating long-term, regime-dependent connections across several nations or regimes. It works well for comprehending structural changes and long-lasting impacts, but it is not as good at grasping quick dynamic reactions.
VAR (Current Study): Perfect for examining dynamic, short-term responses to shocks in Namibia's bond market. It enables thorough impulse response analysis, demonstrating the persistence of shocks and the speed at which bond prices adjust—two crucial components of comprehending market stability in a small, open economy.

Muzindutsi & Obalade 2024, did not concentrate on the short-term, immediate effects of interest rate shocks within a single country context, particularly Namibia, even though they offered insightful information about how external shocks affect South African bond markets over the long run. This gap is filled by the current study, which looks at how quickly and how much bond prices react to interest rate shocks.
Providing policy-relevant findings specific to Namibia by concentrating on domestic bond markets; Providing a dynamic, short-term analysis that enhances the long-term, regime-based approach of previous studies.

This combined viewpoint contributes to more thorough debt and monetary policy frameworks by improving comprehension of both short-term market responsiveness and long-term structural implications

### 2.2.3 Namibia National budget 2021/2022

As alluded early that inflation, economic growth, and political pressure are crucial tools that drive long-term bond yields, fiscal deficit may also be seen as a factor that drives bond yields in emerging economies (Ministry of Finance, 2014). In the Namibian context, according to the National Budget Statement 2021/2022, although the repo rate was kept as low as possible at 3.75% to stimulate the country's growth, the finance minister explained the high-interest rate expenses of +/- N$ 7.7 billion that the state incurred, which deprived the economic growth of the country. However, the state makes provision for all debts, for example, Eurobonds due, by creating a sinking fund account where the transferred funds on a quarterly basis cover all debts due at maturity (International Monetary Fund, 2022).

## 2.3 Conclusion

Interest rate shock is a monetary policy action that generates a temporary deviation from the equilibrium real interest rate. A temporary real interest rate shock generates a temporary fall in money and output, but prices rise initially before eventually declining.

Long-term bond yields indicate that investors are still confident in the market because long-term bonds have higher interest rates than short-term bonds. There has been a significant inflow of capital into the long-term bond market from investors (individuals and institutions) who are more negative about the short-term market economic forecasts. This results in the market demand for long-term bonds to increase, and interest rates on these bonds decline, but eventually the market will be in the opposite position, which is bad for economic growth.

# CHAPTER 3: METHODOLOGY

## 3.1 Introduction

The type and source of data used in the study is described in depth in this section. In accordance with time series analysis, the variables are defined and the models to be used are estimated.

Numerous studies have employed the term "structure of interest rates", which is derived from the Dynamic Nelson Siegel (DNS) model. Salachas et al. (2024) examined the relationship between changes in the term structure of interest rates, specifically the yield curve, and economic performance during the COVID-19 epidemic, using industrial production as a proxy for economic activity. While Delluchi and Giribone (2023) used bond yields as a proxy for the term structure of interest rates, specifically the yields of government bonds with varying maturities. The author used a Gaussian Process Regression machine learning to model the yield curve.

Accordingly, the current study used the Liquidity preference theory of the term structure of interest rates to model interest rate shocks; to understand the effects it has on bond valuation.

## 3.2 Data Collection

### 3.2.1 Data Sources

The study collected data from the BoN and Namibia Statistics Agency (NSA), Fixed Rates Bond (FRB) named GC24 10-year bond, and Inflation Linked Bond (ILB) named GI22; 7-year bonds are from the BoN. The NSA provides data on inflation rates and Gross Domestic Product (GDP) growth rates. All the data gathered was from 2014 to 2024. Credit ratings data were gathered from the Global economy.

### 3.2.2 Data Types

To ascertain the relationship and interpret the results of the chosen independent variable on the Treasury bonds, the study employed a quantitative research methodology that used secondary data. The purpose of employing quantitative time-series data is to ascertain how interest rate shocks as an independent variable affect Treasury bond prices, which inform bond yields. A study by Abdullai et al. (2023) highlighted how rigid statistical analysis was made possible by the quantitative approach by spotting important trends and linkages that would not have been seen using only qualitative methods. The application of quantitative research not only improves the validity of their conclusions but also makes it easier to create evidence-based suggestions for legislators and investors.

## 3.3 Construction of Variables and Measurement

To ascertain the speed and magnitude of price adjustments in response to interest rate shocks, the study selected Vector Auto-Regressive (VAR) as the suitable econometric technique. The time series data to be gathered were subjected to econometric analysis by the researchers using E-views software.

**Table 3.1**

Variables used in the study

| Research objectives | Independent variables | Dependents variables | Controllable variables |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Determine the speed and magnitude of price adjustments in reaction to interest rate shocks.** | Interest rates (market rates) | Fixed rate bonds price (GC24)<br><br>Inflation-linked bond price (GI22) | Market volatility: economic indicator, for example, GDP growth and Inflation rates<br><br>Bond Characteristic: Credit quality, maturity |
| **Examine how interest rate shocks affect the cost of borrowing for the Namibian government and the sustainability of debt.** | Interest rates (market rates) | Cost of borrowing measured by Government bond yield | Debt-to-GDP ratio (D/GDP ratio) |

### 3.3.1. Justification of variables

Interest rates are the primary factor influencing the yield and market value of bonds as well as the cost of borrowing for the government. A study by Meyer et al. (2020) used interest rate as a significant variable since they are a major factor in determining government bond yields, which in turn affects bond prices and market dynamics.

Bond prices give an accurate indication of how the market reacts to rate shocks, broken down by each bond type. Koroleva and Kopeykim's 2022 study emphasises how yield calculations are indirectly influenced by price information. Although their study primarily examined bond yields, the reciprocal relationship between bond prices and yields suggests that yield analysis inherently involves price considerations. Correspondingly, the current study used bond prices since they exhibit sensitivity to interest rate variations as they represent the present value of future cash flows discounted at current interest rates. Thus, the analysis of bond prices reveals the speed and extent to which market participants modify their expectations and valuations in reaction to interest rates.

Market volatility (such as GDP growth and inflation rates) was used as a controllable variable because it reflects how the overall state of the economy influences bond market dynamics and sensitivity to changes in interest rates (Mahirun et al., 2024). The inclusion of bond attributes, such as credit quality and maturity, stems from the fact that they directly affect a bond's duration and risk, influencing how swiftly and dramatically its price responds to interest rate shocks.

Yields on government bonds are a crucial metric for evaluating fiscal sustainability since they directly gauge borrowing costs and the interest the government must pay to finance its debt. Investors evaluate a country's government debt as a percentage of GDP to gauge its ability to make future debt payments, which influences yields on government bonds and borrowing costs (Mahirun et al., 2024).

## 3.4 Conceptual framework

### Relationship between the variables

Interest Rate Shocks → Bond Prices:

Liquidity Preference Theory asserts that:

- Short-term bonds are more sensitive to short-term interest rate shocks due to the need for liquidity.

- Long-term bond prices (Fixed-rate and Inflation-linked bonds) are influenced by long-term expectations of inflation and the term structure of interest rates, which reflect the required inflation and term premiums.

As bonds have features like maturity and credit quality, these factors tend to offset the above influences.

Interest Rate Shocks → Government Borrowing Cost and Debt Sustainability:

- An increase in short-term rates could result in an increase in the yield on government bonds and so in borrowing costs.

- Cost increases are aggravated further by high Debt/GDP ratios that create soaring perceptions of default risk and poor confidence in the market.

### 3.5 Analytical framework

The analytical framework describes how the data was analysed.

#### 3.5.1 Regression Model Specification

To determine how the yield curve responds to interest rate shocks. The study used Keynes' (1936) model, the liquidity preference theory of the term structure of interest rates.

To ascertain how interest rate shocks impact the values of inflation-linked and fixed-rate bonds, the model should take into consideration bond features, market volatility, interest rates, and their interplay. A multiple linear regression model can be used to illustrate the relationship between the independent and dependent variables for both types of bonds. The general structure of this model is as follows:

$$P_{Fixed}^{t} = a_0 + a_1 IR_t + a_2 V_t + a_3 M_t + a_4 CQ_t + \epsilon_t \quad \text{.....(1)}$$

$$P_{Inflation}^{t} = \beta_0 + \beta_1 IR_t + \beta_2 V_t + \beta_3 M_t + \beta_4 CQ_t + \nu_t \quad \text{.....(2)}$$

Where :

$P_{Fixed}^{t}$ and $P_{Inflation}^{t}$ are the Fixed rate and Inflation-linked bond prices at time t

$IR_t$ is the interest rate at time t

$V_t$ is the market volatility at time t

$M_t$ is bond maturity at time t

$CQ_t$ is the credit quality of the bond at time t

$a_0, a_1, a_3, a_4$ and $\beta_1, \beta_2, \beta_3, \beta_4$ are the coefficients to be estimated

$\epsilon_t$ and $\nu_t$ are the error terms

Impulse Response Functions (IRFs) from a Vector Autoregressive (VAR) model can be used to estimate the speed and size of price adjustments to interest rate shocks. This method assists in evaluating how bond values react over time following a shock to interest rates. The dynamic relationship between the interest rate shock and the bond price can be examined using the Impulse Response Analysis in a VAR model, which illustrates how quickly and how much bond prices adjust to the shock.

To examine the relationship between interest rate shocks, bond yield, and debt sustainability, the yield on government bonds serves as a major indicator of the cost of borrowing. The following regression model can be used to explain how interest rate shocks affect the cost of borrowing (the yield on government bonds).

$$Y_{Gov}^{t} = Y_0 + Y_1 IR_t + Y_2 \left(\frac{Debt}{GDP}\right) + Y_3 V_t + \eta_t \quad \text{.....(3)}$$

Where:

$Y_{Gov}^{t}$ is the government bond yield at time t

$IR_t$ is the interest rate at time t

$\frac{Debt}{GdP}$ is the Debt-GDP ratio at time t

$V_t$ is market volatility at time t

$Y_0, Y_1, Y_2, Y_3$ are the coefficients to be estimated

$\eta_t$ the error term at time t

The model assists in evaluating how the cost of borrowing for the government reacts to fluctuations in interest rates.

### 3.5.2 Model Estimation Techniques

As previously mentioned, the Vector Autoregressive (VAR) model is appropriate for examining the dynamic interaction between a number of time series variables, such as interest rates, bond prices, and market volatility. Impulse Response Functions (IRFs) and interactions can be modelled using the VAR model to observe how bond prices respond to interest rate shocks over time.

To ascertain the correlation between the dependent variable (government bond yield) and the independent variable (interest rate), a VAR model was conducted, including the IRF and variance decomposition

### 3.6 Data Analysis

This study used time series econometric analysis to assess the impacts of interest rate shocks on the price of the Namibian treasury bonds (fixed-rate and inflation-linked bonds) as well as the cost of borrowing. The first step will be to establish the presence of unit roots in the time-

series dataset using the Augmented Dickey-Fuller (ADF) test. Should the series be non-stationary, the first differencing technique should be used to achieve stationarity. This is done to avoid spurious regression (Roza et al., 2022).

The study analysed the A Vector Autoregression (VAR) model to describe the interaction between bond prices over time and interest rate shocks, with Impulse Response Functions (IRFs) included to estimate the rate and size of price movements. The results are framed around the discussion regarding the monetary policy and the debt sustainability of Namibia, which may help policymakers evaluate the outcomes and formulate appropriate measures concerning the financial stability and management of the economy.

# CHAPTER 4: RESULTS AND DISCUSSION

## 4.1 Introduction

This chapter delineates the findings of the study emphasizing the effects of interest rate shocks on the values of Namibia treasury bonds (both fixed and inflation-linked bonds) and the effects of Fixed rate bond yield implications for the cost of debt. The findings are presented in the following manner: Section 4.2 presents the analysis of descriptive statistics, and then Section 4.3 presents the unit root tests.

## 4.2 Descriptive statistics of fixed-rated bond GC24

Table 4.1 below presents the summary statistics of the results obtained from the analysis of five variables: A ten years Fixed rate bonds (GC24), GDP growth rate, inflation rate, ratings and the Repo rate (market interest rates), and monthly data spanning the decade from January 2014 till December 2024 with 131 observations.

**Table 4.1.**
Descriptive Statistics for Fixed-rate bond GC24 (2014-2024)

Date: 03/24/25 Time: 18:46
Sample: 2014M01 2024M12

| | BOND_GC24 | GDP_GROW | INFLATION_ | RATINGS | REPO_RATE |
|---|---|---|---|---|---|
| Mean | 105.1085 | 14.81706 | 0.382600 | 4.977099 | 6.127863 |
| Median | 106.0116 | 22.63000 | 0.265880 | 5.300000 | 6.750000 |
| Maximum | 116.8302 | 91.80321 | 3.227924 | 6.800000 | 7.750000 |
| Minimum | 10.14230 | -76.25930 | -0.342535 | 1.000000 | 3.750000 |
| Std. Dev. | 9.157520 | 40.68630 | 0.452300 | 0.790284 | 1.277154 |
| Skewness | -8.562361 | -0.437156 | 2.907968 | -1.095365 | -0.846650 |
| Kurtosis | 89.73286 | 2.580570 | 16.36441 | 6.286630 | 2.432881 |
| Jarque-Bera | 42661.48 | 5.132713 | 1159.528 | 85.15673 | 17.40604 |
| Probability | 0.000000 | 0.076815 | 0.000000 | 0.000000 | 0.000166 |
| Sum | 13769.22 | 1941.035 | 50.12056 | 652.0000 | 802.7500 |
| Sum Sq. Dev. | 10901.82 | 215198.8 | 26.59475 | 81.19130 | 212.0458 |
| Observations | 131 | 131 | 131 | 131 | 131 |

A study done by Ganchev A. (2022) utilised descriptive statistics to summarize and analyse the behaviour of the Indonesian government bond market during the pandemic. In relation to that, the study highlights that descriptive statistics must be conducted prior to ecometric analysis. This is done to understand data characteristics, detect outliers or missing variables in the data, verify data distribution and normality, and finally assess volatility in time series data.

The descriptive statistics from the dataset provide insight into the significant characteristics regarding the behaviour of the variables over the observed time. The average bond price (GC24) is 105.11, closely corresponding to the median of 106.01, indicating a moderate central tendency. The range is considerable, spanning from a low of 10.14 to a maximum of 116.83, potentially indicating extreme outliers or data recording anomalies. The GDP growth exhibits

a comparable extensive range, fluctuating between a minimum of -76.25 and a maximum of 91.80, signifying substantial economic volatility, presumably resulting from macroeconomic shocks. In their analysis of the asymmetric relationship between exports and growth in Namibia, Mosikari and Eita (2020) underscore the susceptibility of developing economies to external and internal shocks, frequently leading to substantial variations in GDP growth over time.

Statistical metrics of distribution indicate significant deviation from normality in most of the variables within the sample. The bond price (GC24) demonstrates significant non-normality, characterized by a skewness of -8.56 and a kurtosis of 89.73, indicating a markedly left-skewed distribution with extraordinarily heavy tails, implying a prevalence of extremely low values. These characters correspond with Joslin (2014), who contends that the pricing and hedging of volatility risk in fixed income securities are substantially affected by higher-order moments of return distributions, including skewness and kurtosis, which indicate market participants' sensitivity to tail risks and asymmetric return patterns.

Likewise, the inflation rate and credit ratings exhibit high positive kurtosis values of 16.36 and 6.29, respectively, indicating highly peaked distributions with heavy tails. This observation aligns with the findings of Alber and Massoud (2024), who emphasize that sovereign credit ratings are frequently affected by macroeconomic variables exhibiting non-normal distributions, especially in emerging and transitional economies, where inflation volatility and structural risk factors lead to fat-tailed data behavior.

The Jarque-Bera test statistics for bond price, inflation, credit ratings, and the repo rate yield p-values of 0.0000, decisively rejecting the null hypothesis of normality. Only GDP growth nears normalcy, with a p-value of 0.0768. The results indicate substantial skewness and excess kurtosis in the data, highlighting the necessity of resolving non-normality via data transformation or employing robust, non-linear econometric models in further study.

### 4.3 Unit root tests

In using the unit root tests, the first step is to establish the presence of unit roots in the time-series dataset using the Augmented Dickey-Fuller (ADF) test. Should the series be non-stationary at the level, the first and second differencing techniques are used to achieve stationarity. This is done to avoid spurious regression (Roza et al., 2022).

**Rule of thumb:**

*$H_0$: Null Hypothesis = Data is not stationary → if the p-value >0.05*
*$H_1$: Alternative Hypothesis = Data is stationary→if the p-value <0.05*

**Table 4.2**
Augmented Dicker-Fuller (ADF) for BondGC24

| Augmented Dicker-Fuller (ADF) |
|---|
| **Individual Intercept** |

| Variables | At level | | 1st Difference | | 2nd Difference | | Order of integration |
|---|---|---|---|---|---|---|---|
| | T-statistics | P-values | T-statistics | P-values | T-statistics | P-values | |
| Bond Price | -10.0175 | 0.0000 | | | | | I (0) |
| Inflation rate | -12.2076 | 0.0000 | | | | | I(0) |
| GDP Growth rate | -1.0227 | 0.7436 | -3.1965 | 0.0226 | | | I(1) |
| Repo rate | -2.1042 | 0.2435 | -3.2369 | 0.0201 | | | I(1) |
| Credit ratings | -3.7714 | 0.0135 | | | | | I(01) |

The results of the Augmented Dickey-Fuller (ADF) presented in Table 4.2 above show that the variables used in the study exhibit stationarity. Variables: bondGC24, inflation rate, and credit ratings are stable at level I(0), signifying that differencing is unnecessary to get stationarity, while GDP growth rate and interest rate exhibit p-values beyond 0.05, indicating the existence of unit roots and non-stationarity. Their respective test statistics are not adequately negative to reject the null hypothesis of non-stationarity. Nonetheless, following the initial differencing, these variables have significant p-values (< 0.05) and increasingly negative ADF test statistics, indicating their stationarity at I(1).

### 4.4. VAR interpretation

**1.Coefficients**: dynamics interactions among variables

As presented in Figure 4.2 below, each row illustrates the influence of lagged values of the dependent variable and other variables within the system.

**Table 4.3.**
Vector autoregression estimates

Vector Autoregression Estimates
Date: 03/25/25 Time: 19:22
Sample (adjusted): 2014M02 2024M12
Included observations: 131 after adjustments
Standard errors in ( ) & t-statistics in [ ]

| | BOND_GC24 | GDP_GROW | INFLATION_ | RATINGS | REPO_RATE |
|---|---|---|---|---|---|
| BOND_GC24_PRICES(- | 0.066936 | 0.013875 | -0.002041 | -0.002270 | 0.000123 |
| | (0.08894) | (0.04841) | (0.00451) | (0.00576) | (0.00177) |
| | [ 0.75259] | [ 0.28661] | [-0.45283] | [-0.39434] | [ 0.06935] |
| GDP_GROWTH__RATE( | -0.017958 | 0.971092 | 0.001196 | 0.000623 | 0.001967 |
| | (0.01984) | (0.01080) | (0.00101) | (0.00128) | (0.00039) |
| | [-0.90496] | [ 89.9045] | [ 1.18929] | [ 0.48477] | [ 4.98062] |
| INFLATION_RATE(-1) | -0.337518 | -0.390759 | -0.079400 | -0.063745 | 0.050325 |
| | (1.75279) | (0.95406) | (0.08883) | (0.11344) | (0.03489) |
| | [-0.19256] | [-0.40957] | [-0.89380] | [-0.56192] | [ 1.44254] |
| RATINGS(-1) | -0.739502 | 1.191109 | -0.003079 | 0.674952 | -0.014309 |
| | (1.01057) | (0.55006) | (0.05122) | (0.06540) | (0.02011) |
| | [-0.73177] | [ 2.16541] | [-0.06011] | [ 10.3197] | [-0.71142] |
| REPO_RATE_MKT_INT | -1.602765 | -1.626137 | -0.008109 | -0.031524 | 0.994997 |
| | (0.63676) | (0.34660) | (0.03227) | (0.04121) | (0.01267) |
| | [-2.51706] | [-4.69174] | [-0.25126] | [-0.76493] | [ 78.5099] |
| C | 111.9629 | 2.715714 | 0.666219 | 2.076943 | 0.052278 |
| | (12.3686) | (6.73233) | (0.62686) | (0.80050) | (0.24617) |
| | [ 9.05222] | [ 0.40338] | [ 1.06279] | [ 2.59457] | [ 0.21236] |
| R-squared | 0.069622 | 0.985634 | 0.018562 | 0.472263 | 0.981223 |
| Adj. R-squared | 0.032407 | 0.985059 | -0.020696 | 0.451153 | 0.980472 |
| Sum sq. resids | 10155.48 | 3008.801 | 26.08561 | 42.53828 | 4.022909 |
| S.E. equation | 9.013536 | 4.906160 | 0.456820 | 0.583358 | 0.179397 |
| F-statistic | 1.870811 | 1715.178 | 0.472824 | 22.37206 | 1306.402 |
| Log likelihood | -470.8434 | -391.1645 | -80.17617 | -112.2070 | 42.26814 |
| Akaike AIC | 7.280051 | 6.063580 | 1.315667 | 1.804687 | -0.553712 |
| Schwarz SC | 7.411740 | 6.195268 | 1.447355 | 1.936376 | -0.422024 |
| Mean dependent | 105.0939 | 14.33528 | 0.374161 | 4.989313 | 6.145038 |
| S.D. dependent | 9.163237 | 40.13764 | 0.452165 | 0.787425 | 1.283757 |

| | |
|---|---|
| Determinant resid covariance (dof adj.) | 3.899145 |
| Determinant resid covariance | 3.084345 |
| Log likelihood | -1003.180 |
| Akaike information criterion | 15.77374 |
| Schwarz criterion | 16.43218 |
| Number of coefficients | 30 |

Based on Table 4.3 above, the following is an overview of essential insights:

**1.a**) Dependent variable: Bond Price (BOND_GC24_PRICES)
BondGC24(-1): Minor positive coefficient (0.0669), not statistically significant → restricted persistence.

| | | |
|---|---|---|
| GDP growth rate | (-1): | Marginally negative, little significance → historical GDP growth exerts minor influence. |
| Inflation rate | (-1) | Significantly negative (-0.3375), not statistically significant -> indicates potential price fall following previous inflation. |
| Ratings | (-1) | Negative (-0.7395), not significant => deteriorating credit quality may marginally decrease bond prices. |
| Repo rate | (-1) | Highly negative and statistically significant (-1.6028, t = -2.52) => rises in historical interest rates substantially diminish bond prices. |

b) Dependent variable: GDP growth rate
Significant own-lag effect (0.9711, t = 89.90) indicates highly persistent growth dynamics.
Negative impact of Repo rate (-1) (-1.6261, t = -4.69) suggests that interest rate increases hinder GDP growth.
Ratings (-1) exhibit a positive and significant effect (1.1911, t = 2.17), indicating that improved credit quality enhances growth.

c) Dependent variable: Inflation rate
The modest own lag of -0.0794 is not significant, indicating that inflation does not exhibit substantial persistence. Other lags, including interest rates, are similarly not substantial.

d) Dependent variable: Ratings
Substantial positive own lag (0.6749, t = 10.32) indicates that ratings exhibit significant persistence.

e) Repo rate (-1) is negative yet insignificant, suggesting that interest rate increases may somewhat diminish ratings over time.) Dependent variable: Repo rate Robust and substantial own lag (0.9949, t = 78.51) indicates highly persistent policy behaviour. Negligible major influence from additional variables.

The VAR results for the Namibian sovereign bond correspond with the findings of Kumar et al. (2024) on India, emphasizing interest rate fluctuations, particularly the repo rate, as a primary determinant of bond prices. Both studies indicate that a more stringent monetary policy results in diminished bond valuations, although variables such as inflation and credit ratings exert minimal short-term influence. The results highlight the pivotal influence of monetary policy and macroeconomic momentum on sovereign bond market dynamics.

### 4.5. Standard error and t-statistics

To evaluate the significance of a coefficient, the t-statistic needs to be examined.

**Rules of thumb:**
$|t| > 1.96 \rightarrow$ *statistically significant at 5%*
$|t|$ *between 1.6 and 1.96* $\rightarrow$ *marginally significant*
$|t| < 1.6 \rightarrow$ *insignificant*

- Repo rate (-1) is significant in the bond price and GDP growth formula
- Ratings (-1) → substantial in GDP growth and Ratings equations.
- The GDP growth rate at lagged period (-1) is incorporated within its own equation (with significant emphasis).

Most other variables are not statistically significant, suggesting their past values do not have strong predictive power in the short term. In a study in South Africa, Meyer et al. (2020) found that interest rates, notably the repo rate, affect bond prices and GDP growth, which the VAR results support. Other macroeconomic variables have little short-term forecasting potential except credit ratings and GDP growth. The results show that monetary policy dominates emerging economy bond market behavior.

### 4.6. R-squared and Adjusted R-squared

R-squared indicates the proportion of variance in the dependent variable that is explained by the independent factors (lagged values of all variables). Adjusted R-squared modifies the R-squared value by accounting for the number of predictors, imposing a penalty if excessive variables are included with minimal explanatory significance. R-square and Adjusted R-square (see Table 4.4 below) indicate the extent to which the variation in the dependent variable is explained by the lagged values of all variables.

**Table 4.4**
R-squared and Adjusted R-square

| **Variables** | $R^2$ | **Adj $R^2$** | **Interpretation** |
|---|---|---|---|
| *BondGC24* | *0.070* | *0.032* | *Merely 7% of price volatility is accounted for by historical values, indicating a weak correlation.* |
| *Repo Rate* | *0.981* | *0.980* | *Significant explanatory power => The repo rate exhibits substantial autoregressiveness.* |
| *Inflation rate* | *0.019* | *-0.021* | *Exceptional explanatory ability indicates that growth is markedly enduring and well explained by historical data.* |
| *Ratings* | *0.472* | *0.451* | *Moderate fit, past values partially explain interest rate fluctuations,* |
| *GDP growth rate* | *0.986* | *0.985* | *Exceptional explanatory ability indicates that growth is markedly enduring and well explained by historical data.* |

The VAR model effectively captures dynamics for repo rate and GDP growth, although it exhibits significant deficiencies in predicting bond prices and inflation. Bond prices exhibit minimal responsiveness to their historical values or the macroeconomic variables included in this formulation, potentially suggesting delayed market response. It provides a moderate explanation of fluctuations in credit ratings.

$R^2$ and Adjusted $R^2$ evaluate the predictive efficacy of each equation; nevertheless, they do not confirm the general stability of the system or the causal links. The subsequent essential step is to verify the stability of the VAR system, confirming that all characteristic roots are within the unit circle. The stability test was conducted (see Table 4.5).

**Table 4.5.**
VAR stability condition check

Roots of Characteristic Polynomial
Endogenous variables:
BOND_GC24_PRICES
GDP_GROWTH__RATE
INFLATION_RATE RATINGS
REPO_RATE_MKT_INTEREST_RAT
ES_
Exogenous variables: C
Lag specification: 1 1
Date: 03/25/25 Time: 19:24

| Root | Modulus |
|---|---|
| 0.984511 - 0.057663i | 0.986199 |
| 0.984511 + 0.057663i | 0.986199 |
| 0.673944 | 0.673944 |
| -0.083602 | 0.083602 |
| 0.069211 | 0.069211 |

No root lies outside the unit circle.
VAR satisfies the stability condition.

A stable VAR guarantees that the impact of shocks, such as interest rate increases, diminishes with time on the system variables. Should the system exhibit instability, shocks may exacerbate or result in explosive trajectories, rendering the model inappropriate for forecasting or policy modelling (Rong and Solo, 2024). As per the results in Table 4.5 above, all roots of the characteristic polynomial reside within the unit circle (that is, all moduli are less than 1). This implies that the VAR is stable.

### 4.7. Impulse response function (IRF)

To reflect how the shock affects the fixed rate bonds over time, the study performed an IRF depicted by the graph Fig 4.1, below

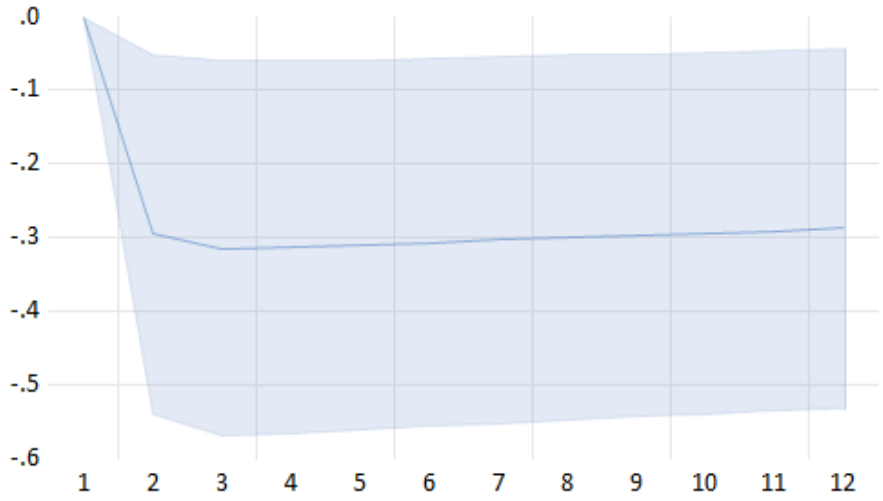



*Figure 4.1.* Response of Bond_GC24_PRICES to REPO_RATE_MKT_INTEREST_RATES_ Cholesky One S.D. (d.f. adjusted) Innovation 95% CI using analytic asymptomatic S.E.s (For research question 1 on Fixed rate bond GC24)

X-axis:1-12months (months after interest rate shocks)
Y-axis: In negative decimals (change in GC24 Bond price)
Shock type: Cholesky One Standard Deviation shock to the repo rate.
Confidence band: 95% confidence interval represented in blue shading & solid line-estimated price response

A one-standard deviation shock to the repo rate causes Namibia's fixed-rate GC24 bond prices to drop significantly—by around three units—in the first month, according to the IRF displayed in Figure 4.1. This drop, which amounts to about a 10-15% drop from normal bond values, is statistically and economically significant and emphasizes how sensitive bond valuations are to changes in interest rates. With an impact that lasts for the full 12-month period, the immediate response shows a substantial correlation between monetary policy shocks and bond prices.
Bond prices typically level out after the initial steep drop, suggesting that the shock was quickly adjusted for. The persistence of the lower level indicates that monetary tightening affects bond values over an extended period. This finding is in line with study done by Meyer et al. (2020), who found that comparable policy shocks in South Africa caused rapid and persistent increases in bond rates.

**Economic Significance:** A drop of roughly three units in bond prices indicates a significant and noteworthy effect that may influence investor behavior and government debt management plans. The need of prompt policy responses is highlighted by the quick adjustment made in the first month.

**Lag Structure Selection in VAR**
To balance model accuracy and simplicity, the Akaike Information Criterion (AIC) was used to find the ideal lag length. One month's lag was used since it yielded the lowest AIC value and successfully captured the important short-term changes without overfitting.

### 4.8. Answer to research question 1 on Fixed rate bond GC24

According to the IRF, Namibia's GC24 fixed-rate bonds react quickly to interest rate shocks, exhibiting a significant and long-lasting drop of roughly three units in the first month. The influence of monetary policy shocks on bond prices is semi-permanent, as evidenced by the fact that this effect lasts for the full 12-month period.

### 4.9. Inflation-linked BondGI22

**Table 4.6**

Descriptive statistics for BondGI22 (For research question 1 on Inflation linked bond GI22)

Date: 03/26/25 Time: 13:39
Sample: 2015M01 2022M10

| | BOND_GI22 | GDP_GROW | INFLATION_ | RATINGS | REPO_RATE |
|---|---|---|---|---|---|
| Mean | 103.5427 | -0.080626 | 0.383743 | 4.931915 | 5.832447 |
| Median | 99.95769 | 6.539088 | 0.261686 | 5.100000 | 6.500000 |
| Maximum | 122.0100 | 64.18693 | 3.227924 | 6.800000 | 7.000000 |
| Minimum | 90.51210 | -76.25930 | -0.342535 | 1.000000 | 3.750000 |
| Std. Dev. | 8.561076 | 36.56550 | 0.489417 | 0.797740 | 1.292757 |
| Skewness | 0.894794 | -0.431199 | 3.114173 | -1.227797 | -0.778907 |
| Kurtosis | 2.722613 | 2.300700 | 16.40793 | 7.770478 | 1.800506 |
| Jarque-Bera | 12.84499 | 4.828281 | 856.0456 | 112.7507 | 15.14015 |
| Probability | 0.001625 | 0.089444 | 0.000000 | 0.000000 | 0.000516 |
| Sum | 9733.014 | -7.578826 | 36.07184 | 463.6000 | 548.2500 |
| Sum Sq. Dev. | 6816.158 | 124344.3 | 22.27621 | 59.18426 | 155.4235 |
| Observations | 94 | 94 | 94 | 94 | 94 |

The descriptive statistics detailed essential attributes of the variables employed to assess the influence of interest rate shocks on Namibia's inflation-linked bond prices (GI22). As presented in Table 4.6 above, the mean bond price during the sample period (2015M01–2022M10) is 103.54, accompanied by a standard deviation of 8.56, indicating moderate variability. The bond price distribution exhibits moderate right skewness (0.89) and near-normal kurtosis (2.72). The Jarque-Bera (JB)statistic (12.84) with a p-value of 0.0016 confirms a deviation from normality in bond prices, likely attributable to sporadic large price fluctuations. Conversely, GDP growth demonstrates extreme volatility, with values spanning from -76.26 to 64.19 and a substantial standard deviation of 36.57. Despite a slightly negative mean (-0.08), the median of 6.54 indicates asymmetric variations. While the distribution reveals slight left skewness (-0.43) and low kurtosis (2.30), the JB test p-value of 0.0894 is marginal, suggesting near-normal behaviour but warranting caution.

Inflation has significant volatility and a non-normal distribution, characterized by a pronounced positive skewness (3.11) and exceptionally high kurtosis (16.41), indicating substantial inflationary spikes during the time. The JB statistic of 856.05 and a p-value of 0.0000 substantiate this non-normality. Credit ratings, expressed as numerical numbers, exhibit minimal variance (mean = 4.93; std. dev. = 0.80), however, are markedly left-skewed (-1.23) and leptokurtic (7.77), signifying rare but pronounced downgrades or upgrades. The repo rate (repo rate), utilized for evaluating monetary policy, has an average of 5.83 and a standard

deviation of 1.29, indicating mild policy modifications. The distribution has a small left skewness (-0.77) and is platykurtic (1.80), indicating a scarcity of extreme values. The JB statistic (15.14) and p-value (0.0005) demonstrate a statistically significant divergence from normalcy.

Recent studies conducted between 2020 and 2024 corroborate the descriptive statistics of Namibia's inflation-linked bond market (GI22) and associated macroeconomic factors. The Namibia Consumer Price Index Bulletin (2024) and the BoN's Inflation Outlook (2024) indicate considerable inflation volatility, with rates varying from 5.9% in 2023 to an anticipated 5.0% in 2024, consistent with the noted positive skewness and elevated kurtosis in inflation data. The African Development Bank's 2024 Country Focus Report similarly underscores swings in GDP growth, decreasing from 5.3% in 2022 to 4.2% in 2023, which aligns with the extensive GDP growth range and substantial standard deviation identified in the analysis. These sources collectively confirm the existence of non-normal distributions, economic volatility, and macroeconomic instability shown in statistical results of the study.

### 4.9.1. Units' roots

To ensure the validity of econometric modelling and interpretation of time series data used in the study ADF test, was performed.

**Rule of thumb:**

*$H_0$: Null Hypothesis = Data is not stationary→ if the p-value >0.05*
*$H_1$: Alternative Hypothesis = Data is stationary→if the p-value <0.05*

**Table 4.7**

Augmented Dicker-Fuller (ADF) for BondGI22

| **Augmented Dicker Fuller (ADF)** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Individual Intercept** | | | | | | | |
| **Variables** | **At level** | | **1st Difference** | | **2nd Difference** | | **Order of integration** |
| | **T-statistics** | **P-values** | **T-statistics** | **P-values** | **T-statistics** | **P-values** | |
| Bond Price | -1.6563 | 0.4500 | -7.8912 | 0.0000 | | | I(1) |
| Inflation rate | -10.3285 | 0.0000 | | | | | I(0) |
| GDP Growth rate | -1.6198 | 0.4684 | 2.7051 | 0.0711 | | | I(1) |
| Repo rate | 1.7551 | 0.0400 | | | | | I(0) |
| Credit ratings | 5.0721 | 0.0000 | | | | | I(0) |

The results of the Augmented Dickey-Fuller (ADF) presented in Table 4.7 above show that the variables used in the study exhibit stationarity. Variables: inflation rate, repo rate and credit ratings stable at level I(0), signifying that differencing is unnecessary to get stationarity. while

GDP growth rate, bondGI22, and interest rate exhibit p-values beyond 0.05, indicating the existence of unit roots and non-stationarity. Their respective test statistics are not adequately negative to reject the null hypothesis of non-stationarity. Nonetheless, following the initial differencing, these variables have significant p-values (< 0.05) and increasingly negative ADF test statistics, indicating their stationarity at I(1).

**Table 4.8.**
Vector Autoregression estimates (For research question 1 on Inflation-linked bond GI22)

Vector Autoregression Estimates
Date: 03/26/25 Time: 20:17
Sample (adjusted): 2015M02 2022M10
Included observations: 93 after adjustments
Standard errors in ( ) & t-statistics in [ ]

| | BOND_GI22 | GDP_GROW | INFLATION_ | RATINGS | REPO_RATE |
|---|---|---|---|---|---|
| BOND_GI22_PRICES(-1) | 0.917906 | -0.407083 | -0.015122 | -0.004624 | 0.000596 |
| | (0.05391) | (0.05937) | (0.00898) | (0.01197) | (0.00340) |
| | [ 17.0272] | [-6.85615] | [-1.68322] | [-0.38622] | [ 0.17525] |
| GDP_GROWTH__RATE( | -0.006294 | 0.898529 | -0.000500 | 0.000230 | 0.003183 |
| | (0.01351) | (0.01489) | (0.00225) | (0.00300) | (0.00085) |
| | [-0.46569] | [ 60.3644] | [-0.22184] | [ 0.07665] | [ 3.73313] |
| INFLATION_RATE(-1) | -0.233780 | -0.600180 | -0.121579 | -0.034845 | 0.038212 |
| | (0.63631) | (0.70084) | (0.10604) | (0.14131) | (0.04014) |
| | [-0.36740] | [-0.85638] | [-1.14653] | [-0.24658] | [ 0.95186] |
| RATINGS(-1) | 0.687881 | 1.074710 | 0.044090 | 0.490092 | -0.027895 |
| | (0.43847) | (0.48293) | (0.07307) | (0.09738) | (0.02766) |
| | [ 1.56883] | [ 2.22538] | [ 0.60339] | [ 5.03299] | [-1.00839] |
| REPO_RATE_MKT_INT | 0.282978 | -3.192411 | -0.009791 | -0.138067 | 1.014238 |
| | (0.29545) | (0.32541) | (0.04924) | (0.06561) | (0.01864) |
| | [ 0.95780] | [-9.81054] | [-0.19886] | [-2.10425] | [ 54.4129] |
| C | 3.548161 | 55.91332 | 1.832375 | 3.825581 | -0.016955 |
| | (6.34432) | (6.98769) | (1.05728) | (1.40896) | (0.40026) |
| | [ 0.55927] | [ 8.00168] | [ 1.73311] | [ 2.71518] | [-0.04236] |
| R-squared | 0.889973 | 0.992607 | 0.060003 | 0.366574 | 0.980819 |
| Adj. R-squared | 0.883649 | 0.992182 | 0.005980 | 0.330170 | 0.979717 |
| Sum sq. resids | 748.8324 | 908.4108 | 20.79659 | 36.93284 | 2.980619 |
| S.E. equation | 2.933815 | 3.231332 | 0.488918 | 0.651548 | 0.185095 |
| F-statistic | 140.7425 | 2336.216 | 1.110696 | 10.06965 | 889.7525 |
| Log likelihood | -228.9564 | -237.9393 | -62.31309 | -89.01861 | 28.02050 |
| Akaike AIC | 5.052825 | 5.246007 | 1.469099 | 2.043411 | -0.473559 |
| Schwarz SC | 5.216219 | 5.409400 | 1.632492 | 2.206804 | -0.310166 |
| Mean dependent | 103.5770 | -0.490394 | 0.379572 | 4.941935 | 5.830645 |
| S.D. dependent | 8.600983 | 36.54605 | 0.490387 | 0.796094 | 1.299645 |

| | |
|---|---|
| Determinant resid covariance (dof adj.) | 0.198239 |
| Determinant resid covariance | 0.142027 |
| Log likelihood | -569.0505 |
| Akaike information criterion | 12.88281 |
| Schwarz criterion | 13.69977 |
| Number of coefficients | 30 |

The Vector Autoregression (VAR) output (see Table 4.8. above) detailed the dynamic interrelationships among the five variables: bondGI22 prices, GDP growth rate, inflation rate, ratings, and repo rate (mkt interest rate). The coefficients indicate the response of each variable to its own historical values and those of other variables. The coefficient of bondGI22 prices (-1) is 0.918, signifying a robust persistence in bond prices, where previous values substantially affect current values. Significantly, GDP growth rate (-1) exerts a negative influence on bond prices (-0.407), indicating that increased growth in the preceding month correlates with diminished current GDP growth. repo rates exhibit significant persistence (coefficient = 1.014) and are only weakly affected by other variables.

The standard errors and t-statistics facilitate the evaluation of statistical significance. A general guideline is that t-statistics exceeding |1.96| are statistically significant at the 5% level. For

bond prices, its own lag is highly significant (t = 17.03), while the GDP growth rate (-1) is equally significant with t = -6.86. The other variables in the bond price equation lack statistical significance, as their t-values are below 2. In the GDP equation, the GDP growth rate (-1) (t = 60.36) and the repo rate (-1) (t = 3.73) are both highly significant. In terms of ratings, its own lag is significant (t = 5.03), and the repo rate (-1) is also statistically significant (t = -2.10), indicating that previous changes in the repo rate affect present credit ratings. In the inflation rate equation, none of the lagged variables exhibit significant t-statistics, indicating limited prediction

The R-squared and adjusted R-squared values reflect the explanatory capacity of each equation. The bondGI22 prices have a $R^2$ of 0.89, meaning that 89% of the volatility is accounted for by the model, signifying a robust model fit. The GDP growth rate exhibits an exceptionally high $R^2$ of 0.99, signifying nearly complete explanatory capability, possibly attributable to the predominance of its own lag and the repo rate. Conversely, the inflation rate equation exhibits a minimal $R^2 = 0.06$, indicating that the model accounts for merely 6% of its variation, reinforcing the previous observation that inflation is only weakly influenced by historical values in this framework. The ratings exhibit a modest explanatory power with a $R^2$ of 0.37, however, the repo rate demonstrates a robust $R^2$ of 0.98, indicating a significant influence from its historical value. The VAR model proficiently captures the dynamics of bond prices, GDP growth, and interest rates, although it inadequately explains inflation behavior.

The VAR analysis is substantiated by recent empirical investigations from 2020 to 2024, which corroborate the observed interactions among bond prices, GDP growth, interest rates, and credit ratings in Namibia. The African Development Bank (2024) affirms economic volatility via variable GDP growth, consistent with the model's conclusion that delayed GDP growth adversely impacts bond prices. Fitch Ratings (2024) indicates a continued repo rate policy, reinforcing the robust persistence noted in your interest rate coefficient. The World Bank (2024) underscores Namibia's high debt-to-GDP ratio and fiscal challenges, aligning with your model's perspective on the impact of macroeconomic stress on bond prices and credit ratings. These investigations collectively affirm the robustness and significance of the study of VAR model in elucidating the principal determinants of bond market dynamics within the Namibian environment.

The subsequent essential step is to verify the stability of the VAR system, confirming that all characteristic roots are within the unit circle. The stability test was conducted and presented in Table 4.9 below.

**Table 4.9.**
VAR stability condition check (For research question 1 on Inflation linked bond GI22)

Roots of Characteristic Polynomial
Endogenous variables: BOND_GI22_PRICES GDP_GROWTH__RATE INFLATION_RATE RATINGS REPO_RATE_MKT_INTEREST_RATES_
Exogenous variables: C
Lag specification: 1 1
Date: 03/26/25 Time: 20:41

| Root | Modulus |
|---|---|
| 0.976381 - 0.085773i | 0.980141 |
| 0.976381 + 0.085773i | 0.980141 |
| 0.885278 | 0.885278 |
| 0.483496 | 0.483496 |
| -0.122349 | 0.122349 |

No root lies outside the unit circle.
VAR satisfies the stability condition.

The stability assessment of the VAR (Vector Autoregression) model is essential for guaranteeing that the time series forecasts are reliable and significant. An unstable VAR model may produce misleading or explosive findings in impulse response functions and variance decompositions. Stability guarantees that disturbances to the system progressively lose their impact over time, mirroring actual economic conduct. (Rong and Solo (2024).

As per the results in Table 4.9 above, all roots of the characteristic polynomial reside within the unit circle (i.e., all moduli are less than 1). This implies that the VAR is stable.

### 4.9.2. Impulse Response Functions (IRF)

To assess, how inflation-linked bond will respond to the rate shock, the study performed IRF,depicted by the graph below.

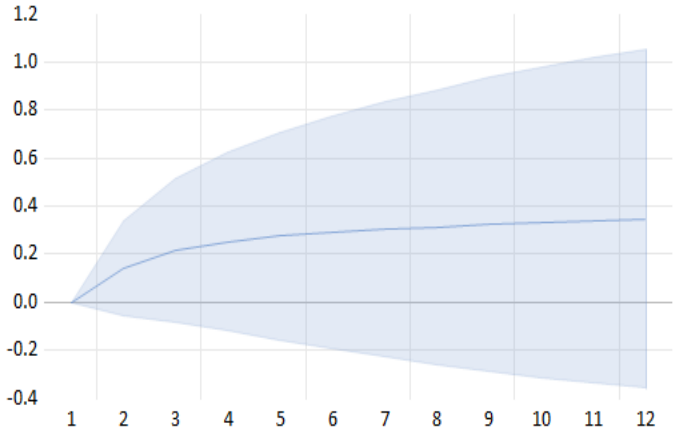


***Figure 4.2***. Response of Bond_GI22_PRICES to
REPO_RATE_MKT_INTEREST_RATES_ Cholesky One S.D. (d.f. adjusted) Innovation
95% CI using analytic asymptomatic S.E.s (For research question 1 on Fixed rate bond GC24)

X-axis:1-12months (months after interest rate shocks)
Y-axis: In negative decimals (change in GI22 Bond price)
Shock type: Cholesky One Standard Deviation shock to the repo rate.
Confidence band: 95% confidence interval represented in blue shading & solid line-estimated price response

**Response to magnitude**
The bond price initially responds favorably to the interest rate shock. The response initiates at approximately 0.1 and progressively ascends to just over 0.8 by the 12th period (month). This indicates that a positive interest rate shock results in a rise in the price of inflation-linked bonds over time.

**Speed of adjustments (rate of adjustments)**
The response initiates promptly (in period 1) and escalates progressively. The curve stabilizes after approximately 8–10 months, signifying that most of the adjustment occurs during the initial year. By period 12, the response seems to settle, with no substantial further fluctuation thereafter.

**Statistical significance**
The 95% confidence intervals consistently remain narrow for the whole duration. This signifies that the response is statistically significant from zero over most of the term, especially following the initial months.

The IRF indicates that Namibia's inflation-linked bond prices (GI22) react favourably to repo rate shocks, which contradicts conventional theory that suggests rate increases diminish bond prices. This indicates that, over the analysed period, markets perceived repo rate hikes as an indication of escalating inflation, hence enhancing the demand for inflation-linked bonds. This corresponds with the findings of the Federal Reserve Bank of San Francisco (2024), indicating that in emerging countries, interest rate increases associated with inflation apprehensions might result in elevated prices for inflation-linked bonds due to heightened investor demand.

### 4.10. Answer to research question 1 on Inflation-linked bond GI22

The graph distinctly illustrates that the alteration in bond prices commences instantaneously and attains near complete effect within 8 to 12 months. The cumulative impact of the shock on bond prices attains around 0.8 to 1.0 units by the twelfth month. Adjustment commences instantly. The price response aggregates over multiple months. The overall effect is favourable and enduring, achieving stability within one year.

To address the effects of interest rate shocks on bond yields, which affect borrowing costs and debt sustainability, the study employs a VAR model, IRF and variance decomposition (see Table 4.10 below).

**Table 4.10**.
Vector autoregression estimates (For research question 2 on short-term rates(market interest rates) and long-term rates(GC24 Yields)

Vector Autoregression Estimates
Date: 03/31/25 Time: 02:53
Sample (adjusted): 2014M02 2024M12
Included observations: 131 after adjustments
Standard errors in ( ) & t-statistics in [ ]

| | GC24_YIELDS | REPO_RATE | D_GDP_RAT |
|---|---|---|---|
| GC24_YIELDS(-1) | 0.828957 | -0.009583 | 0.015802 |
| | (0.04867) | (0.02513) | (0.11509) |
| | [ 17.0337] | [-0.38131] | [ 0.13730] |
| REPO_RATE_MKT_INT | 0.057737 | 0.990544 | -0.080379 |
| | (0.02961) | (0.01529) | (0.07002) |
| | [ 1.94998] | [ 64.7840] | [-1.14792] |
| D_GDP_RATIO(-1) | -0.007472 | -0.000753 | 0.986249 |
| | (0.00349) | (0.00180) | (0.00825) |
| | [-2.14299] | [-0.41843] | [ 119.601] |
| C | 1.532581 | 0.193092 | 1.298105 |
| | (0.54187) | (0.27982) | (1.28145) |
| | [ 2.82833] | [ 0.69006] | [ 1.01300] |
| R-squared | 0.876614 | 0.976895 | 0.995781 |
| Adj. R-squared | 0.873699 | 0.976349 | 0.995681 |
| Sum sq. resids | 18.56299 | 4.950093 | 103.8154 |
| S.E. equation | 0.382316 | 0.197426 | 0.904126 |
| F-statistic | 300.7635 | 1789.890 | 9990.838 |
| Log likelihood | -57.89215 | 28.68335 | -170.6467 |
| Akaike AIC | 0.944918 | -0.376845 | 2.666363 |
| Schwarz SC | 1.032711 | -0.289053 | 2.754155 |
| Mean dependent | 8.952800 | 6.145038 | 50.21969 |
| S.D. dependent | 1.075770 | 1.283757 | 13.75742 |

| | |
|---|---|
| Determinant resid covariance (dof adj.) | 0.004388 |
| Determinant resid covariance | 0.003998 |
| Log likelihood | -195.9549 |
| Akaike information criterion | 3.174884 |
| Schwarz criterion | 3.438261 |
| Number of coefficients | 12 |

## 4.11 The interpretation of VAR on short term &long-term rates Coefficients

The VAR results demonstrate the response of each variable to its own historical values and those of other variables. The yield on GC24 bonds exhibits great persistence, evidenced by a substantial coefficient of 0.83 on its own lag, signifying that previous bond yields significantly affect current yields. The repo rate demonstrates significant persistence (coefficient = 0.99), indicating that alterations in monetary policy often occur gradually. The debt-to-GDP ratio

exhibits significant persistence (coefficient = 0.99), reflecting enduring economic trends. Cross-variable implications are often minimal; for instance, GC24 yields are somewhat affected by the repo rate (0.0577) and adversely by the debt-to-GDP ratio (-0.0075).

**Standard Errors and t-statistics**

Statistical significance is evaluated by t-statistics, with values exceeding |1.96| deemed significant at the 5% level. The own lags of GC24 yields, repo rates, and the debt-to-GDP ratio exhibit substantial significance, with t-values of 17.03, 64.78, and 119.60, respectively, thereby affirming robust autoregressive behavior. The repo rate exerts a marginally significant influence on GC24 rates (t = 1.95), whereas the debt-to-GDP ratio has a considerable negative effect on bond yields (t = -2.14). Other cross-variable interactions exhibit t-values significantly below 2, indicating little short-term predictive capability among variables beyond their individual histories.

**R-squared and Adjusted R-squared**

The model exhibits robust explanatory capability across all equations. The R-squared values are highest for the debt-to-GDP ratio (0.996), followed by the repo rate (0.977) and bond yields (0.877), signifying that the model accounts for a substantial fraction of the variability in each variable, particularly for macroeconomic indicators such as debt ratios and interest rates. Adjusted R-squared values closely align with R-squared figures, indicating negligible overfitting. These findings confirm the efficacy of the VAR model in accurately representing the principal dynamics of bond yields, policy rates, and fiscal indicators within the Namibian environment.

Recent empirical evidence corroborates the above VAR findings about the enduring patterns of bond yields, repo rates, and the debt-to-GDP ratio in Namibia. The BoN's Annual Report (2023) outlines a measured adjustment of the repo rate, increasing from a pandemic-induced low of 3.75% in August 2020 to a peak of 7.75% by June 2023, illustrating the gradual nature of monetary policy, consistent with the high coefficient persistence observed in the VAR model.

The World Bank's Namibia Overview (2024) indicates that the country's debt-to-GDP ratio remains elevated at around 70%, influenced by persistent budgetary pressures, sluggish growth, and rising debt payment costs, mirroring the ongoing patterns identified in the VAR results. The IPPR's Namibia Quarterly Economic Review (Q3 2024) corroborates that alterations in the repo rate were predominantly influenced by macroeconomic factors, particularly inflation, with less immediate impact on other variables. These studies collectively affirm the VAR model's assertion that bond yields, policy rates, and debt levels in Namibia have significant persistence and only limited short-run interdependence, reflecting the structural attributes of the nation's macroeconomic landscape.

The subsequent essential step is to verify the stability of the VAR system, confirming that all characteristic roots are within the unit circle. The stability test was conducted and presented below (also see Table 4.11 below).

**Table 4.11**.
VAR stability condition check (For research question 2 on short-term and long-term rates)

Roots of Characteristic Polynomial
Endogenous variables: GC24_YIELDS
REPO_RATE_MKT_INTEREST_RAT
ES_ D_GDP_RATIO
Exogenous variables: C
Lag specification: 1 1
Date: 03/31/25 Time: 02:43

| Root | Modulus |
|---|---|
| 0.991225 | 0.991225 |
| 0.981542 | 0.981542 |
| 0.832982 | 0.832982 |

No root lies outside the unit circle.
VAR satisfies the stability condition.

As per the result in Table 4.11, all roots of the characteristic polynomial reside within the unit circle (that is, all moduli are less than 1). This implies that the VAR is stable.

### 4.12 Impulse Response Functions (IRF)

The depiction of the graph (Figure 4.3) below illustrates how the yields respond to rate shocks

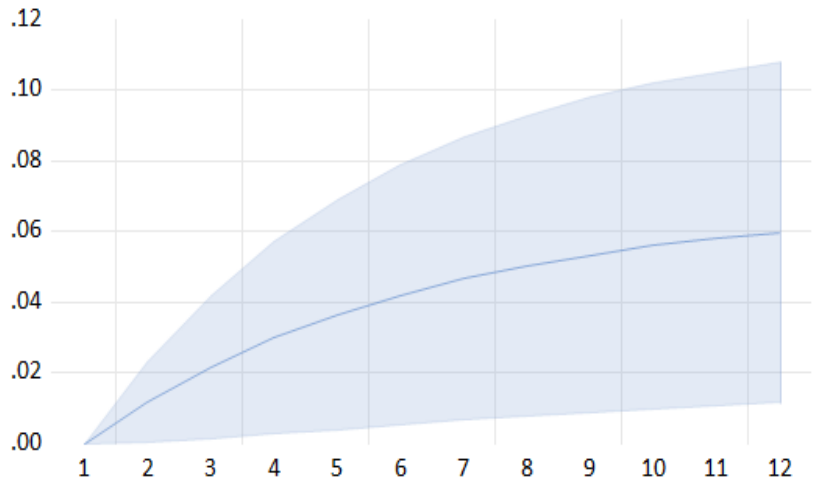



***Figure 4.3*** Response of GC24 YIELDS to REPO_RATE_MKT_INTEREST_RATES_ Cholesky One S.D. (d.f. adjusted) Innovation 95% CI using analytic asymptomatic S.E.s (For research question 2 on Effects of rate shocks on yields)

***Response to Magnitude***
The initial response of GC24 yield to an interest rate shock is modest, beginning just above zero, signifying a small immediate effect on bond yields.

***Speed of Adjustments***
Short run (1-4 months): bond yields exhibit a consistent upward trajectory. By the fourth month, the response is approximately 0.04 (4 percentage), signifying that bond yields begin to shift upwards relatively swiftly after an interest rate shock.
Medium-long run (5-12 months), the reaction consistently increases, diminishing rate, ultimately stabilizing at approximately 0.06 (6 percentage) after a year (12 months). The rate of rise diminishes, indicating a reduced effect with time, yet yields remain high

***Confidence interval***
The confidence intervals (shaded area) expand over time, indicating heightened uncertainty over the long-term response. The persistence of the confidence interval's lower bound above zero after the early months indicates a statistically significant positive effect of interest rate shocks on bond yields

The IRF results strongly correspond with the findings of Meyer et al. (2020) in South Africa, confirming that interest rate shocks generally result in increased bond yields, heightened borrowing costs, and difficulties in maintaining debt sustainability. This comparison highlights that Namibia encounters comparable risks to South Africa regarding fiscal stability, especially considering the regional connections, economic frameworks, and monetary policy impacts of both economies.

**Variance Decomposition**
As presented in Table 4.11 below, the variance decomposition indicates that GC24 bond yields are predominantly self-determined, with 99.99% of the variance accounted for by their own shocks at period 1. As time progresses, external forces have a greater influence: by period 12, endogenous shocks constitute 93.86%, while the repo rate and debt-to-GDP ratio account for 4.72% and 1.42%, respectively. This underscores the escalating influence of monetary policy and, to a lesser degree, fiscal indicators on bond yields, indicating a heightened responsiveness to macroeconomic fundamentals over time. The decomposition indicates that although yields are primarily endogenous, macroeconomic fundamentals and monetary policy signals gain significance in explaining yield dynamics over extended periods.

**Table 4.12.**
Variance decomposition of GC24_YIELD using Cholesky(d.f. adjusted) factors (for research question 2)

| Period | S.E. | GC24_YIEL | REPO_RAT | D_GDP_RA |
|---|---|---|---|---|
| 1 | 0.382316 | 100.0000 | 0.000000 | 0.000000 |
| | | (0.00000) | (0.00000) | (0.00000) |
| 2 | 0.495527 | 99.92508 | 0.056585 | 0.018337 |
| | | (0.07751) | (0.07109) | (0.01917) |
| 3 | 0.559615 | 99.74510 | 0.192851 | 0.062054 |
| | | (0.26099) | (0.23996) | (0.06386) |
| 4 | 0.599442 | 99.45505 | 0.412979 | 0.131966 |
| | | (0.54923) | (0.50662) | (0.13298) |
| 5 | 0.625362 | 99.05457 | 0.717681 | 0.227748 |
| | | (0.93265) | (0.86363) | (0.22362) |
| 6 | 0.642817 | 98.54770 | 1.104300 | 0.348002 |
| | | (1.39543) | (1.29754) | (0.33188) |
| 7 | 0.654983 | 97.94231 | 1.567244 | 0.490444 |
| | | (1.91817) | (1.79106) | (0.45360) |
| 8 | 0.663813 | 97.24920 | 2.098660 | 0.652138 |
| | | (2.48043) | (2.32542) | (0.58493) |
| 9 | 0.670546 | 96.48101 | 2.689217 | 0.829773 |
| | | (3.06297) | (2.88252) | (0.72255) |
| 10 | 0.675976 | 95.65121 | 3.328876 | 1.019909 |
| | | (3.64915) | (3.44651) | (0.86374) |
| 11 | 0.680613 | 94.77324 | 4.007563 | 1.219196 |
| | | (4.22576) | (4.00459) | (1.00633) |
| 12 | 0.684784 | 93.85980 | 4.715682 | 1.424522 |
| | | (4.78305) | (4.54726) | (1.14864) |

Cholesky One S.D. (d.f. adjusted) Innovations
Cholesky ordering: GC24_YIELDS REPO_RATE_MKT_INTERE ST_RATES_ D_GDP_RATIO
Standard errors: Monte Carlo (100 repetitions) standard deviations in parentheses

### 4.13. Answer to research question 2:

The initial response of GC24 yield to an interest rate shock is modest, beginning just above zero, signifying a small immediate effect on bond yields. The IRF results strongly correspond with the findings of Meyer et al. (2020) in South Africa, confirming that interest rate shocks generally result in increased bond yields, heightened borrowing costs, and difficulties in maintaining debt sustainability

# CHAPTER 5: CONCLUSIONS

## 5.1 Introduction

The chapter delineates insights derived from the examination of interest rate shocks on Namibia Treasury bonds, notably assessing the sensitivity of fixed-rate and inflation-linked bond prices

## 5.2 Summary of the study

### 5.2.1. Fixed-rate bond GC24

The descriptive statistics of Fixed rate bond GC24 shows a huge difference in the range, that are extreme outliers or data recording anomalies. GDP growth is highly volatile with a minimum of -76.25 and maximum of 91.80. The Jarque-Bera test statistics for bond price, inflation, credit ratings, and the repo rate yield p-values of 0.0000, decisively rejecting the null hypothesis of normality. Only GDP growth nears normalcy, with a p-value of 0.0768.

The results indicate substantial skewness and excess kurtosis in the data, highlighting the necessity of resolving non-normality via data transformation or employing robust, non-linear econometric models in further study.

Unit roots test was conducted, and two variables, GDP growth rate and Inflation were stationary at first difference. The VAR model effectively captures dynamics for repo rate and GPD growth, although exhibits significant deficiencies in predicting bond prices and inflation. Bond prices exhibit minimal responsiveness to their historical values, or the macroeconomic variables included in this formulation, potentially suggesting a delayed market response.

It provides a moderate explanation of fluctuations in credit ratings.
The IRF findings indicate that GC24 bond prices react markedly and significantly to interest rate shocks, especially in the initial stages. The IRF fully addresses the research objective that: When there is a rate shock, the price of GC24 bonds goes down sharply, this happens immediately within one month.

### 5.2.2. Inflation-linked bond GI22

The descriptive statistics of Inflation-linked bond GI22 Inflation has significant volatility and a non-normal distribution, characterized by a pronounced positive skewness (3.11) and exceptionally high kurtosis (16.41), indicating substantial inflationary spikes during the time. The result was supported by the Namibia Consumer Price Index Bulletin (2024) and the BoN's Inflation Outlook (2024) indicate considerable inflation volatility, with rates varying from 5.9% in 2023 to an anticipated 5.0% in 2024, consistent with the noted positive skewness and elevated kurtosis.

The VAR results show that GDP growth rate (-1) exerts a negative influence on bond prices (-0.407), indicating that increased growth in the preceding month correlates with diminished current GDP growth. The result was supported by the African Development Bank (2024) affirms economic volatility via variable GDP growth, consistent with the model's conclusion that delayed GDP growth adversely impacts bond prices.

The bond price initially responds favorably to the interest rate shock. This indicates that, a positive interest rate shock results in a rise in the price of inflation-linked bonds over time. The favorably responds contradicts conventional theory that suggests rate increase diminish bond

prices. This indicates that over the analysed period, markets perceived repo rate hikes as an indication of escalating inflation, hence enhancing the demand for inflation-linked bonds.

### 5.2.3. The effects of rate shocks on yields and debt sustainability

The IRF results strongly correspond with the findings of Meyer et al. (2020) in South Africa, confirming that interest rate shocks generally result in increased bond yields, heightened borrowing costs, and difficulties in maintaining debt sustainability

The variance decomposition study reveals that bond yield movements (GC24) are predominantly influenced by their previous shocks, suggesting that short-term yield variations are primarily affected by bond-specific factors. As the forecasting horizon lengthens (toward period 12), yields increasingly react to external macroeconomic factors, notably monetary policy (shown by the repo rate) and fiscal stability metrics (expressed by the debt-to-GDP ratio). This indicates that, over extended periods, bond yields increasingly respond to economic fundamentals and policy measures.

# CHAPTER 6: RECOMMENDATION

## 6.1 Introduction

The results highlight how interest rate changes impact bond prices, borrowing costs, and financial stability. The following strategic recommendations aim to improve debt management and mitigate future risks.

## 6.2. Recommendation to Bank of Namibia:

***Monetary Policy Communication***

Hold frequent press conferences and release quarterly outlooks with distinct interest rate pathways. Changes to the policy rate must be announced at least two weeks in advance. Establish defined targets and tolerance levels for inflation and standardize communication.

***Market Development/Expansion***

To increase liquidity, create primary dealer networks and electronic trading platforms. Put in place real-time bond market monitoring. Provide financial institutions with technical assistance in risk management and stress testing.

## 6.3. Recommendation to Ministry of Finance:

***Issuance of Debt and Strategy***

Balance fixed-rate and inflation-linked bonds (aim for 70:30), issue longer-term ILBs (15–30 years), and create floating-rate notes to diversify your issuance. Align bond auctions with the pre-announced issuance calendars and the Bank's monetary cycle. Increase loan maturities to reduce the risk of refinancing.

***Fiscal Management and Market Growth***

Set medium-term fiscal goals, accumulate emergency funds, and keep the debt-to-GDP ratio below 60%. Encourage financial knowledge on ILBs, provide tax breaks for long-term investors, and set minimum benchmark sizes of N$2 billion. Organize frequent investor roadshows, release debt reports every month and set up a special investor relations department. For policy alignment, establish a joint coordination committee between the Ministry of Finance and the Bank of Namibia.

## 6.4. Constraints on Monetary Policy Independence due to currency peg:

To ensure exchange rate stability, the Bank of Namibia (BoN) must match its repo rate with that of the South African Reserve Bank (SARB), which restricts the BoN's capacity to establish independent interest rates. This restriction affects Namibia's ability to utilize monetary policy instruments to combat inflation or promote economic expansion.

**Recommendations for the Bank of Namibia:**

Increase Inflation Forecasting: Develop better models to predict inflation and direct policy decisions. Enhance Interaction: Explain in detail the rationale behind interest rate decisions made to control market expectations. To manage liquidity without altering interest rates, employ macroprudential instruments such as reserve requirements and credit regulations. Regional Policy Coordination: Work together with Southern African Customs Unions (SACU) and SARB partners to improve monetary policy alignment.

**Recommendations for Ministry of Finance:**

Encourage fiscal-monetary cooperation: By using counter-cyclical spending, fiscal policy can control inflation and stabilize the economy. Expand the domestic debt markets: Increase the

depth and liquidity of bond markets to lessen need on foreign capital. Strategically Issue Bonds Linked to Inflation: Bonds that shield investors from inflation can be issued to control inflation expectations. Diversify Your Investor Base: Increase the number of long-term investors by offering incentives and enhancing the market infrastructure.

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| DATE | GC24 PRI | GC24 YIEL | GI22 PRIC | REPO RAT | INFLATIOI | GDP GRO' | RATINGS | D/GDP RA' |
|---|---|---|---|---|---|---|---|---|
| Jan-14 | 102.5146 | 10.495 | | 5.50 | 0.94 | 91.80 | 4.00 | 25.43 |
| Feb-14 | 102.4123 | 10.295 | | 5.50 | 0.68 | 91.29 | 4.00 | 25.32 |
| Mar-14 | 102.4123 | 10.325 | | 5.50 | 0.62 | 89.47 | 4.00 | 25.24 |
| Apr-14 | 102.4123 | 10.215 | | 5.50 | 0.96 | 86.51 | 4.00 | 25.12 |
| May-14 | 103.5412 | 10.055 | | 5.50 | 0.30 | 82.59 | 4.00 | 24.94 |
| Jun-14 | 103.5412 | 10.155 | | 5.75 | 0.30 | 77.89 | 4.00 | 24.72 |
| Jul-14 | 103.5412 | 10.06 | | 5.75 | 0.17 | 72.59 | 4.00 | 24.49 |
| Aug-14 | 106.4529 | 9.905 | | 6.00 | 0.25 | 66.86 | 4.00 | 24.28 |
| Sep-14 | 106.4529 | 10.01 | | 6.00 | 0.16 | 60.88 | 4.00 | 24.18 |
| Oct-14 | 106.4529 | 10 | | 6.00 | 0.12 | 54.83 | 4.00 | 24.26 |
| Nov-14 | 106.4529 | 9.445 | | 6.00 | 0.22 | 48.89 | 4.00 | 24.58 |
| Dec-14 | 106.4529 | 10.075 | | 6.00 | -0.17 | 43.23 | 4.00 | 25.09 |
| Jan-15 | 113.76984 | 8.4975 | 100.3531 | 6.00 | 0.77 | 38.03 | 4.00 | 25.73 |
| Feb-15 | 116.83021 | 7.97167 | 100.3531 | 6.25 | -0.18 | 33.42 | 4.00 | 26.42 |
| Mar-15 | 113.0565 | 8.485 | 100.3531 | 6.25 | 0.44 | 29.37 | 4.00 | 27.01 |
| Apr-15 | 112.25721 | 8.5867 | 99.12945 | 6.25 | 0.50 | 25.78 | 4.00 | 27.36 |
| May-15 | 109.14002 | 9.03333 | 99.298 | 6.25 | 0.37 | 22.57 | 4.00 | 27.45 |
| Jun-15 | 106.45179 | 9.439 | 99.296 | 6.50 | 0.34 | 19.64 | 4.00 | 27.86 |
| Jul-15 | 107.78432 | 9.22492 | 99.8451 | 6.50 | 0.40 | 16.91 | 4.00 | 29.34 |
| Aug-15 | 107.61437 | 9.2448 | 100.3531 | 6.50 | 0.32 | 14.29 | 4.00 | 32.30 |
| Sep-15 | 105.21131 | 9.62992 | 100.3531 | 6.50 | 0.13 | 11.70 | 4.00 | 35.82 |
| Oct-15 | 106.46161 | 9.4194 | 99.64509 | 6.50 | 0.16 | 9.04 | 4.00 | 38.69 |
| Nov-15 | 106.0116 | 9.48554 | 99.38867 | 6.50 | 0.17 | 6.23 | 4.00 | 39.99 |
| Dec-15 | 104.676 | 9.697 | 99.38867 | 6.50 | 0.20 | 3.18 | 4.50 | 40.17 |
| Jan-16 | 98.96195 | 10.678 | 99.57761 | 6.50 | 2.37 | -0.20 | 4.50 | 39.98 |
| Feb-16 | 100.06032 | 10.482 | 98.6168 | 6.75 | 0.59 | -3.95 | 4.50 | 40.03 |
| Mar-16 | 100.83348 | 10.3453 | 99.12943 | 6.75 | 0.77 | -7.98 | 4.00 | 40.28 |
| Apr-16 | 104.88978 | 10.3453 | 99.45387 | 7.00 | 0.61 | -12.13 | 4.00 | 40.55 |
| May-16 | 104.89 | 10.31 | 99.33904 | 7.00 | 0.50 | -16.27 | 4.00 | 40.68 |
| Jun-16 | 105.1201 | 10.11 | 99.91538 | 7.00 | 0.32 | -20.25 | 4.00 | 40.70 |
| Jul-16 | 106.6451 | 9.77 | 98.27786 | 7.00 | 0.64 | -23.92 | 4.00 | 40.68 |
| Aug-16 | 106.6891 | 9.68 | 99.297 | 7.00 | 0.16 | -27.14 | 4.00 | 40.70 |
| Sep-16 | 96.08195 | 9.70165 | 100.14719 | 7.00 | 0.20 | -29.78 | 4.00 | 40.75 |
| Oct-16 | 107.412 | 10.02 | 98.77242 | 7.00 | 0.50 | -31.67 | 4.00 | 40.82 |
| Nov-16 | 107.418 | 10.18 | 98.84518 | 7.00 | 0.25 | -32.69 | 4.00 | 40.93 |
| Dec-16 | 107.415 | 10.22 | 98.33323 | 7.00 | 0.16 | -32.68 | 4.50 | 41.11 |
| Jan-17 | 108.1715 | 10.04 | 98.03112 | 7.00 | 3.23 | -31.51 | 4.50 | 41.42 |
| Feb-17 | 108.0451 | 10.05 | 97.26059 | 7.00 | 0.18 | -29.08 | 4.50 | 41.91 |
| Mar-17 | 109.2716 | 9.9 | 96.38449 | 7.00 | 0.12 | -25.54 | 4.50 | 42.44 |
| Apr-17 | 108.2184 | 10.1 | 95.26842 | 7.00 | 0.26 | -21.11 | 4.00 | 42.88 |
| May-17 | 109.6145 | 9.95 | 94.55603 | 7.00 | 0.12 | -16.00 | 4.00 | 43.11 |
| Jun-17 | 109.6988 | 9.81 | 94.57512 | 7.00 | 0.14 | -10.40 | 4.00 | 43.15 |
| Jul-17 | 108.5542 | 9.99 | 95.45087 | 7.00 | 0.04 | -4.53 | 4.00 | 43.06 |
| Aug-17 | 108.5569 | 9.88 | 96.31862 | 6.75 | 0.09 | 1.40 | 5.90 | 42.88 |
| Sep-17 | 108.6672 | 9.76 | 96.60303 | 6.75 | 0.39 | 7.18 | 5.90 | 42.65 |
| Oct-17 | 103.05684 | 9.88436 | 96.88849 | 6.75 | 0.11 | 12.61 | 5.90 | 42.41 |
| Nov-17 | 108.412 | 10.61 | 97.00944 | 6.75 | 0.26 | 17.48 | 5.10 | 42.20 |

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|---|---|---|---|---|---|---|---|---|
| Dec-17 | 108.612 | 10.27 | 96.067 | 6.75 | 0.16 | 21.58 | 5.10 | 42.12 |
| Jan-18 | 109.6988 | 9.81 | 96.06718 | 6.75 | 1.65 | 24.70 | 5.10 | 42.28 |
| Feb-18 | 109.6988 | 9.56 | 96.0421 | 6.75 | 0.15 | 26.68 | 5.10 | 42.72 |
| Mar-18 | 109.6988 | 9.37 | 94.6312 | 6.75 | 0.11 | 27.54 | 5.10 | 43.29 |
| Apr-18 | 109.6988 | 9.4 | 94.5123 | 6.75 | 0.32 | 27.32 | 5.10 | 43.77 |
| May-18 | 109.6988 | 9.84 | 93.1645 | 6.75 | 0.38 | 26.09 | 5.10 | 44.04 |
| Jun-18 | 10.1423 | 10.18 | 92.5146 | 6.75 | 0.25 | 23.91 | 5.10 | 44.29 |
| Jul-18 | 102.3885 | 9.96869 | 90.5121 | 6.75 | 0.53 | 20.84 | 5.10 | 44.80 |
| Aug-18 | 103.6591 | 9.98 | 90.5121 | 6.75 | 0.03 | 16.93 | 5.90 | 45.76 |
| Sep-18 | 107.4125 | 10.15 | 92.5148 | 6.75 | 0.75 | 12.25 | 5.90 | 46.90 |
| Oct-18 | 107.5121 | 10.48 | 93.6128 | 6.75 | 0.43 | 6.85 | 5.90 | 47.85 |
| Nov-18 | 100.69275 | 10.33904 | 114.29 | 6.75 | 0.68 | 0.79 | 5.10 | 48.35 |
| Dec-18 | 103.66825 | 9.66049 | 119.46 | 6.75 | -0.23 | -5.87 | 5.10 | 48.48 |
| Jan-19 | 104.6 | 9.44 | 119.57 | 6.75 | 1.17 | -13.07 | 5.10 | 48.39 |
| Feb-19 | 104.81 | 9.38 | 115.6 | 6.75 | -0.09 | -20.72 | 5.10 | 48.26 |
| Mar-19 | 104.95 | 9.34 | 113.86 | 6.75 | 0.19 | -28.65 | 5.10 | 48.25 |
| Apr-19 | 105.46 | 9.16 | 114.39 | 6.75 | 0.35 | -36.62 | 5.10 | 48.55 |
| May-19 | 105.8 | 9.11 | 118.9 | 6.75 | -0.06 | -44.42 | 5.10 | 49.24 |
| Jun-19 | 106.61 | 8.91 | 119.57 | 6.75 | 0.12 | -51.85 | 5.10 | 50.05 |
| Jul-19 | 107.38 | 8.71 | 120.11 | 6.75 | 0.24 | -58.67 | 5.10 | 50.64 |
| Aug-19 | 106.35 | 8.93 | 120.36 | 6.50 | 0.10 | -64.68 | 5.10 | 50.81 |
| Sep-19 | 106.89 | 8.79 | 120.45 | 6.50 | 0.32 | -69.66 | 5.10 | 50.90 |
| Oct-19 | 106.59 | 8.83 | 120.73 | 6.50 | 0.19 | -73.40 | 5.30 | 51.40 |
| Nov-19 | 105.85 | 9 | 120.98 | 6.50 | 0.14 | -75.67 | 5.30 | 52.64 |
| Dec-19 | 106.12 | 8.91 | 121.26 | 6.50 | -0.11 | -76.26 | 5.50 | 54.26 |
| Jan-20 | 106.67 | 8.74 | 121.67 | 6.50 | 0.64 | -74.96 | 5.50 | 55.72 |
| Feb-20 | 107.69 | 8.46 | 121.92 | 6.25 | 0.31 | -71.63 | 5.50 | 56.66 |
| Mar-20 | 102.73 | 9.78 | 122.01 | 5.25 | 0.10 | -66.49 | 5.50 | 57.31 |
| Apr-20 | 100.73 | 10.3 | 107.38 | 4.25 | -0.34 | -59.83 | 1.00 | 58.06 |
| May-20 | 100.73 | 10.3 | 107.38 | 4.25 | 0.35 | -51.96 | 5.50 | 59.15 |
| Jun-20 | 100.73 | 10.3 | 107.38 | 4.00 | 0.20 | -43.16 | 5.30 | 60.32 |
| Jul-20 | 109.86465 | 7.71313 | 107.38 | 4.00 | 0.18 | -33.75 | 5.30 | 61.17 |
| Aug-20 | 109.86465 | 7.71313 | 107.38 | 3.75 | 0.42 | -24.01 | 5.30 | 61.43 |
| Sep-20 | 109.86465 | 7.71313 | 107.38 | 3.75 | 0.32 | -14.24 | 5.30 | 61.35 |
| Oct-20 | 109.86465 | 7.71313 | 107.38 | 3.75 | 0.05 | -4.75 | 5.30 | 61.32 |
| Nov-20 | 109.86465 | 7.71313 | 107.38 | 3.75 | 0.10 | 4.17 | 5.30 | 61.65 |
| Dec-20 | 111.8825 | 6.92633 | 107.38 | 3.75 | 0.01 | 12.22 | 5.50 | 62.34 |
| Jan-21 | 111.8825 | 6.92633 | 107.38 | 3.75 | 0.9 | 19.11 | 5.50 | 63.32 |
| Feb-21 | 111.8825 | 6.92633 | 107.38 | 3.75 | 0.4 | 24.62 | 5.50 | 64.52 |
| Mar-21 | 111.8825 | 6.92633 | 107.38 | 3.75 | 0.5 | 28.84 | 5.50 | 65.91 |
| Apr-21 | 111.8825 | 6.92633 | 107.38 | 3.75 | 0.4 | 31.95 | 5.50 | 67.47 |
| May-21 | 111.8825 | 6.92633 | 107.38 | 3.75 | 0.3 | 34.13 | 5.50 | 69.07 |
| Jun-21 | 111.8825 | 7.03063 | 107.38 | 3.75 | 0.5 | 35.56 | 5.50 | 70.33 |
| Jul-21 | 111.8825 | 6.93 | 107.38 | 3.75 | 0.2 | 36.43 | 5.3 | 70.73 |
| Aug-21 | 111.8825 | 6.92633 | 107.38 | 3.75 | -0.2 | 36.90 | 5.3 | 70.01 |
| Sep-21 | 109.83005 | 6.93 | 107.38 | 3.75 | 0.3 | 37.15 | 5.3 | 68.77 |
| Oct-21 | 108.30127 | 7.34984 | 99.5483 | 3.75 | 0.2 | 37.38 | 5.3 | 67.83 |
| Nov-21 | 107.28506 | 7.6698 | 99.5869 | 3.75 | 0.6 | 37.74 | 5.3 | 67.72 |

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|---|---|---|---|---|---|---|---|---|
| Dec-21 | 107.6233 | 7.41189 | 99.5666 | 3.75 | 0.4 | 38.42 | 5.3 | 67.80 |
| Jan-22 | 107.90879 | 7.26041 | 99.6239 | 3.75 | 1.1 | 39.61 | 5.3 | 67.16 |
| Feb-22 | 106.8452 | 7.6 | 99.6465 | 4.00 | 0.2 | 41.42 | 5.3 | 65.24 |
| Mar-22 | 105.6196 | 8.0146 | 99.6989 | 4.00 | 0.5 | 43.78 | 5.3 | 62.91 |
| Apr-22 | 105.8119 | 7.894 | 99.7319 | 4.25 | 1.4 | 46.54 | 6.8 | 61.42 |
| May-22 | 105.4315 | 7.9984 | 100.0217 | 4.25 | 0.1 | 49.58 | 6.8 | 61.60 |
| Jun-22 | 105.00016 | 8.1236 | 100.3675 | 4.75 | 1.0 | 52.76 | 5.6 | 62.81 |
| Jul-22 | 103.6788 | 8.6528 | 100.78035 | 4.75 | 1.0 | 55.95 | 5.6 | 64.00 |
| Aug-22 | 104.0371 | 8.4306 | 100.4953 | 5.50 | 0.3 | 59.00 | 5.6 | 64.40 |
| Sep-22 | 103.6054 | 8.5513 | 100.0175 | 5.50 | 0.1 | 61.79 | 5.6 | 64.45 |
| Oct-22 | 103.7132 | 8.4336 | 100 | 6.25 | 0.2 | 64.19 | 5.6 | 64.83 |
| Nov-22 | 104.0476 | 8.1886 | | 6.25 | 0.5 | 66.05 | 5.6 | 65.96 |
| Dec-22 | 103.8894 | 8.1952 | | 6.75 | 0.3 | 67.24 | 5.6 | 67.09 |
| Jan-23 | 104.5371 | 7.9892 | | 6.75 | 1.1 | 67.63 | 5.6 | 67.20 |
| Feb-23 | 103.9064 | 7.7945 | | 7.00 | 0.4 | 67.12 | 5.6 | 65.63 |
| Mar-23 | 104.0216 | 7.7522 | | 7.00 | 0.6 | 65.74 | 5.6 | 63.33 |
| Apr-23 | 103.5407 | 7.9685 | | 7.25 | 0.4 | 63.59 | 5.6 | 61.63 |
| May-23 | 102.5356 | 8.6175 | | 7.25 | 0.2 | 60.74 | 5.6 | 61.46 |
| Jun-23 | 102.6832 | 8.5777 | | 7.75 | 0.1 | 57.26 | 5.6 | 62.24 |
| Jul-23 | 102.6077 | 8.2389 | | 7.75 | 0.3 | 53.23 | 5.6 | 62.99 |
| Aug-23 | 102.9094 | 8.1 | | 7.75 | 0.4 | 48.74 | 5.6 | 63.04 |
| Sep-23 | 102.2799 | 8.2671 | | 7.75 | 0.8 | 43.85 | 5.6 | 62.81 |
| Oct-23 | 101.3184 | 8.7399 | | 7.75 | 0.8 | 38.65 | 5.6 | 63.01 |
| Nov-23 | 101.0642 | 8.7209 | | 7.75 | 0.3 | 33.22 | 5.6 | 64.05 |
| Dec-23 | 101.0527 | 9.1055 | | 7.75 | -0.1 | 27.63 | 5.6 | 65.13 |
| Jan-24 | 101.2569 | 8.678 | | 7.75 | 1.3 | 21.96 | 5.6 | 65.13 |
| Feb-24 | 101.0764 | 8.7476 | | 7.75 | 0.0 | 22.63 | 5.6 | 63.35 |
| Mar-24 | 100.9768 | 8.7227 | | 7.75 | 0.0 | 28.63 | 5.6 | 60.71 |
| Apr-24 | 100.8157 | 8.8191 | | 7.75 | 0.7 | 24.63 | 6 | 58.54 |
| May-24 | 100.6834 | 8.7136 | | 7.75 | 0.3 | 24.63 | 5.6 | 57.85 |
| Jun-24 | 100.5948 | 8.498 | | 7.75 | -0.2 | 28.69 | 5.6 | 58.36 |
| Jul-24 | 100.4915 | 8.2581 | | 7.75 | 0.2 | 28.69 | 5.6 | 59.47 |
| Aug-24 | 100.3756 | 8.0625 | | 7.50 | 0.3 | 48.32 | 5.6 | 59.47 |
| Sep-24 | 100.1579 | 7.6404 | | 7.50 | -0.20 | 21.96 | 5.6 | 59.47 |
| Oct-24 | 100.0582 | 7.4887 | | 7.25 | 0.40 | 33.22 | 5.6 | 59.47 |
| Nov-24 | 100.0582 | 7.4692 | | 7.25 | 0.26 | 33.22 | 5.6 | 59.47 |
| Dec-24 | 100.0582 | 7.6621 | | 7.00 | 0.25 | 33.22 | 5.6 | 59.47 |