The Dynamic Interaction of Inflation, Monetary Policy Rate and Economic Growth: Evidence from Zambia

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ABSTRACT

Sustained economic growth relies heavily on the stability of key macroeconomic indicators. This study examines the dynamic interactions among economic growth, inflation, and the monetary policy rate in Zambia over the period 2012–2022 using a Vector Autoregressive (VAR) framework. Optimal lag length was determined based on the Akaike Information Criterion (AIC), Schwarz Criterion (SC), and Hannan–Quinn Information Criterion (HQ). Diagnostic tests confirm that the model is robust, with no evidence of serial correlation, heteroskedasticity, or structural breaks. Empirical results indicate a generally negative relationship between economic growth and inflation, while neither variable exerts a statistically significant effect on the monetary policy rate. The analysis also reveals that causal dynamics among the variables are unstable in the short run. Forecast simulations suggest that all three variables may rise in the near term but are likely to moderate or decline over the medium to long term. The findings underscore the need for coordinated monetary and fiscal policies, strengthened transmission channels, and targeted structural investments to support sustainable economic growth while maintaining price stability in Zambia.

Key words: inflation, monetary policy rate, economic growth, VAR model

INTRODUCTION

In the dynamic landscape of modern economics, the relationship between monetary policy, inflation, and economic growth has long been a subject of profound interest and extensive debate among policymakers, economists, and researchers. The monetary policy rate, often set by central banks, plays a pivotal role in shaping the overall economic climate by influencing the cost and availability of credit. Simultaneously, inflation, as a persistent and multifaceted economic phenomenon, has significant implications for both macroeconomic stability and individual financial well-being. Understanding the intricate interplay between these variables is crucial, as it provides valuable insights for crafting effective policy measures and guiding economic growth strategies.

This study seeks to shed light on the intricate relationship between the monetary policy rate, inflation, and economic growth, examining their effects and interactions through empirical analysis and economic theory. The relevance of this investigation is further underscored by the fact that the policy decisions of central banks, such as setting interest rates, have profound consequences not only for financial markets but also for real economic outcomes (Mishkin, 2010). Consequently, comprehending the intricacies of this relationship is of utmost importance for both academics and policymakers.

The impact of monetary policy on economic growth is not limited to its influence on inflation but extends to various other channels. By adjusting interest rates and influencing the money supply, central banks can affect investment, consumption, and overall economic activity (Taylor, 1993). Similarly, inflation, when persistent and high, can erode purchasing power, disrupt resource allocation, and discourage long-term investment. This paper aims to unravel the multifaceted nature of these relationships and the role played by monetary policy in managing inflation to foster economic growth.

To navigate this complex terrain, the study encompassed both historical and contemporary contexts, considering the experience of Zambia through its central banks. By critically examining the relationship between monetary policy rates, inflation, and economic growth, this research intends to offer valuable insights that can guide future policy decisions and foster a more nuanced understanding of these vital economic dynamics.

The legacy of monetary policy and Economic growth in Zambia

The history of Zambia's monetary policy and its influence on economic growth is complex and multifaceted. Over the years, the country has experienced alternating periods of expansion and contraction, often closely linked to shifts in monetary policy. This section provides a brief historical overview of key policy developments and their economic implications, supported by relevant citations and references.

Early Years of Independence-1964 to 1973

Upon gaining independence in 1964, Zambia pursued an expansionary monetary policy to stimulate economic growth. This period saw substantial investment in infrastructure, driven by increased copper production, which was the backbone of the Zambian economy (Mulenga and Chileshe, 2016). The policy contributed to steady economic growth during the 1960s.

Economic Challenges and Policy Shifts-1970 to 1980

The 1970s brought a global commodity price crash, severely affecting Zambia's copper-dependent economy (Mvunga, 2010). In response, Zambia implemented austerity measures and sought financial assistance from international institutions. These policies led to a period of economic decline and rising inflation, demonstrating the vulnerability of Zambia's economy to external shocks (Mkandawire and Soludo, 1999).

Economic Liberalization and Structural Adjustment – 1990 to 2000

In the 1990s, Zambia embarked on an ambitious structural adjustment program, which included monetary policy reforms aimed at stabilizing the economy and attracting foreign investment (Zambia, Ministry of Finance and National Planning, 2002). This era witnessed positive economic growth, fueled by diversification efforts and a more stable monetary policy.

Economic Volatility and Challenges – 2000 to present.

Zambia's economic landscape remained volatile in the 2000s, with fluctuations in global commodity prices impacting the country's economic performance. Monetary policy continued to play a crucial role in responding to these challenges, with interest rate adjustments and inflation-targeting strategies (Daka and Shendam, 2015). However, fiscal imbalances and external debts have posed persistent challenges (Chansa, 2019).

In the past decade starting from 2011, Zambia has seen a persistent increase in average price level. In the years leading up to 2021, annual inflation rates often exceeded double digits, primarily driven by factors such as food price increases and currency depreciation. The country's inflation woes were linked to broader macroeconomic challenges, including fiscal deficits, external debt burdens, and foreign exchange shortages. These factors contributed to inflationary pressures (Zambia Statistics Agency, 2023).

The depreciation of the Zambian kwacha against major currencies, such as the US dollar, played a role in driving up import costs and, consequently, inflation. A weaker currency made imported goods more expensive. Food inflation was a significant driver of overall inflation in Zambia. Factors like weather-related disruptions to agriculture and supply chain issues could contribute to food price volatility (IMF).

The Bank of Zambia, which is the country's central bank, implemented various monetary policy measures to manage inflation, including adjusting interest rates and using reserve requirements. However, the effectiveness of these policies in curbing inflation depended on other macroeconomic factors. High and volatile inflation rates can have detrimental effects on an economy, including eroding purchasing power, increasing uncertainty, and making it challenging for businesses to plan and invest.

Based on the above observations, it is essential to understand the dynamics between inflation and economic growth in Zambia to inform effective policy implementation and evaluation. The remainder of the paper is structured as follows: Section 2 describes the data and methodology used to examine the interactions among the three variables. Section 3 presents the empirical results along with their interpretation. Section 4 summarizes the main findings and conclusions, while Section 5 provides policy recommendations based on the study's insights.

Objectives of the study

The general objective of the study was to assess the relationship between inflation, monetary policy rate, and economic growth.

Specific Objectives of the study

i. To analyze the impact of changes in the monetary policy rate on economic growth.

ii. To examine the relationship between inflation and economic growth.

iii. To assess the contribution of a shock to the behavior of different variables.

Significance of the study

This research holds significant implications for policymakers, by providing insights to make informed decisions regarding monetary policy and inflation targeting. For economists, it contributes to the ongoing debate on the efficacy of monetary policy measures. For investors and financial institutions, the study provides insights into market conditions influenced by these factors. Businesses need to avoid closure by aiding in strategic planning and risk management. The study will add to the growing body of knowledge on macroeconomic dynamics.

DATA AND METHODOLOGY

Data and Sample

The study used secondary and quarterly data from the Ministry of Finance and the Zambia Statistics Agency in Zambia. The target variables are inflation, monetary policy rate, and gross domestic product growth rate from 2012 to 2022. Therefore, the sample has 43 observations. Two statistical packages namely, R software and Excel were used in data cleaning and manipulation. All the variables were made stationary by first-difference or were integrated of order 1 (see Tables 1 and 2 on unit root tests)

Model

The study employed Vector autoregressive modeling (VAR) to analyze the interlink between inflation, monetary policy rate, and economic growth. The VAR modeling is important because economic variables are not isolated (Sims, 1980). The Model is simply a standard or basic vector autoregression:

$$\boldsymbol{Y_t} = \boldsymbol{\beta_0} + \boldsymbol{A_1 Y_{t-1}} + \cdots + \boldsymbol{A_p Y_{t-p}} + \boldsymbol{\epsilon_t}$$

Where $\boldsymbol{Y_t}$ is a 3×1 vector, $\boldsymbol{\beta_0}$ is 3×1 coefficients of intercepts (or simply constants),

$\boldsymbol{A_i}$ is 3×3 vector and $\boldsymbol{\epsilon_t}$ is an assumed white noise or error term with mean 0 and variance-covariance matrix $(\sum_u)$, thus,

$$\boldsymbol{\epsilon_t} \sim N(0, \sum_u)$$

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There are several advantages associated with the utilization of the Vector Autoregression (VAR) model. Firstly, the VAR model accommodates time series data with inherent autocorrelation, making it well-suited to address such temporal and autocorrelation challenges. Secondly, the VAR model captures dynamic and potentially causal relationships among economic variables, a capacity that classical regression models lack. As a result, VAR proves valuable in policy analysis and macroeconomic planning. Finally, many prominent scholars rely on the VAR model to investigate topics like monetary policy and economic growth. This widespread use makes VAR a convenient choice for comparative analysis (Kumar & Paramanik, 2020).

However, it should be noted that the model excluded the structural vector autoregression model because the variables don't affect each other contemporaneously. Inflation, GDP growth, and monetary policy rates often do not change contemporaneously. Research by Mishkin (1995) suggests that central banks typically respond to changes in inflation with a lag, as they must assess whether inflation trends are temporary or persistent. Similarly, monetary policy adjustments, as determined by central banks, may take time to affect GDP growth, with lags in transmission mechanisms. For example, Taylor (1993) notes that it can take 12 to 18 months for monetary policy changes to have their full impact on economic output. While these variables are interconnected, their movements are influenced by various factors and exhibit different time lags, making it challenging to pinpoint exact contemporaneous changes (Blanchard & Gali, 2007). Furthermore, the relationship between these variables may evolve over time, depending on the prevailing economic conditions and policy strategies.

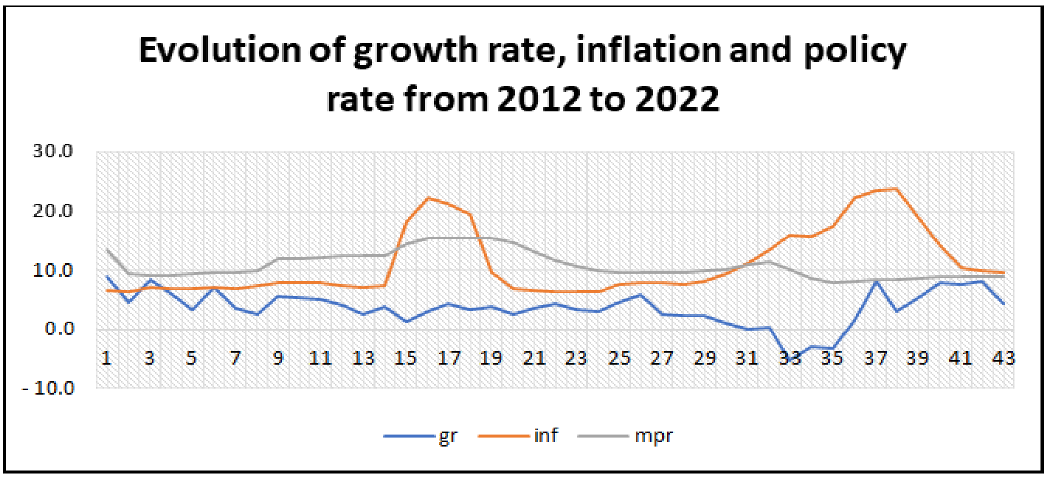
Limitation of the study

The study employed a Vector Autoregressive (VAR) model because macroeconomic variables typically influence one another with time lags (Gujarati, 2004). VAR models are particularly useful when theoretical restrictions are weak, as they allow the data to determine the dynamic interactions among variables (Sims, 1980). However, without structural restrictions, a reduced-form VAR cannot identify contemporaneous relationships, which limits its ability to distinguish immediate causal effects (Lütkepohl, 2005). As a result, the model may omit important contemporaneous dynamics, potentially biasing short-run interpretations. Moreover, VAR models generally require relatively large sample sizes to ensure stable parameter estimation and reliable impulse response functions (Brooks, 2014). It is also important to note that standard VAR frameworks are mainly suited for short-run dynamic analysis, as they do not impose long-run theoretical constraints unless extended to VECM or structural forms.

RESULTS

The study focused on three key macroeconomic variables—economic growth rate, inflation, and the monetary policy rate (interest rate)—over the period 2012 to 2022. The data were obtained from the World Bank and the Bank of Zambia. Figure 1 illustrates the evolution of these quarterly variables over time, highlighting their trends and fluctuations throughout the sample period.

Figure 1: Evolution of economic growth, inflation, and monetary policy rate.



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Stationarity tests of economic growth, inflation, and monetary policy rate variables

In economic and financial applications, the stationarity of variables is of paramount importance for policy recommendations. For instance, central banks rely on VAR models to make informed decisions regarding monetary policy (Dinh, 2020). Non-stationary data can lead to misguided policy recommendations. Vector autoregression (VAR) models assume that the time series data are stationary. Stationarity means that the statistical properties of the time series, such as mean, variance, and autocorrelation, do not change over time. If the data is not stationary, the underlying assumptions of VAR are violated, and the model results may not be valid. Non-stationary data can lead to spurious correlations and misleading results. By ensuring that the data is stationary, you increase the likelihood that the relationships captured by the VAR model reflect genuine economic or causal connections (Gujarati, 2004). Therefore, the variables used in the study were subjected to stationarity tests using an augmented Dickey-Fuller (ADF) test (see Table 1 below).

Table 1: Augmented Dickey-Fuller unit root test

Variable	Test statistic	Critical value at 5%
GDP growth rate	-2.2054	-3.50
Inflation	-3.3963	-3.50
Monetary policy rate	-2.6077	-3.50

Table 1 shows that all the variables are non-stationary as the test statistics are insignificant as they are less than the critical values in absolute terms. Hence, the null hypothesis of the unit root cannot be rejected. For us to do an unbiased estimation of the coefficients, all the variables were transformed by differencing them and they were all stationary [*integrated of order 1 i.e. I (1)*] (see Table 2 below).

Table 2: Stationary first-order differenced variables

Variable	Test statistic	Critical value at 5%
GDP growth rate	-5.9417	-3.50
Inflation	-3.7886	-3.50
Monetary policy rate	-3.653	-3.50

Diagnostic Tests

Lag selection

The study employed four standard approaches to determine the optimal lag length: the Akaike Information Criterion (AIC), Schwarz Criterion (SC), Hannan–Quinn Information Criterion (HQ), and Final Prediction Error (FPE). All four criteria consistently indicated an optimal lag length of 10. However, only four lags are displayed in the output due to presentation limitations (see Table 3 below).

Table 3: Lag selection criteria

Information criteria used	AIC(n)	HQ(n)	SC(n)	FPE(n)
Number of lags	10	10	10	10

Serial Correlation

To assess the validity of the estimated model, the study conducted a serial correlation test among other diagnostics. The residuals were found to be serially uncorrelated, as shown in Appendix F, with p-values exceeding the 5% significance level. The null hypothesis of the test states that no serial correlation exists in the residuals, which is not rejected, indicating that the model does not suffer from serial correlation.

Heteroskedasticity

The study also examined whether the residuals exhibited heteroskedasticity using a multivariate ARCH model (see Appendix G). Since the p-value exceeds the 5% significance level, the null hypothesis of homoskedasticity is not rejected. This indicates that the variance of the residuals is constant over time and does not depend on temporal fluctuations.

Normality of Residuals

The Jarque–Bera test was employed to test the normality of residuals (see Appendix H). The results indicate that the residuals are normally distributed, as the p-values exceed the 5% significance level. Consequently, the null hypothesis of normality is not rejected, confirming that the errors follow a normal distribution.

Structural Breaks

Finally, the study tested for structural breaks using the CUSUM test to assess the stability of the estimated coefficients. Detecting structural breaks is important because abrupt changes in the data-generating process can compromise model validity and lead to misleading results. As shown in Appendix I, the CUSUM plot remains within the 5% significance bands throughout the sample period. This indicates that no structural breaks are present, confirming that the model estimates are stable, reliable, and free from spurious relationships.

Model Estimation

Since our diagnostic tests have proved the validity and reliability of our data, we can now perform our VAR estimates. The results show that economic growth is not significantly influenced by any of the lagged values of inflation or the monetary policy rate (see Column 1 of Table 4), as all estimated coefficients are statistically insignificant. Nonetheless, most coefficients are negative, suggesting that persistent inflationary pressures or higher policy rates may exert a mild restraining effect on output over time. While the insignificance limits strong causal claims, the direction of the coefficients offers policy-relevant signals about how macroeconomic conditions might evolve.

Turning to the interaction between inflation and output growth, the first lag of inflation exerts a positive influence on growth, whereas the second lag has a negative effect. This pattern implies that moderate inflation may initially stimulate economic activity—possibly by reducing real interest rates—but that inflationary pressures become harmful once they persist or escalate beyond a certain threshold. This interpretation is consistent with long-standing macroeconomic theory, including the short-run Phillips Curve (Samuelson & Solow, 1960), which highlights the temporary trade-off between inflation and output. As these lagged effects unfold over time, they provide insight into how inflation shocks propagate, reinforcing the need for early and well-timed policy interventions.

Examining Column 2 of Table 4, inflation dynamics reveal meaningful feedback effects. The first lag of all variables increases inflation, whereas the second and third lags of output growth significantly reduce it. These results suggest that economic expansion may help stabilize prices in the medium term, possibly through productivity improvements or supply-side responses. For policymakers, this indicates that promoting sustained growth can contribute to inflation moderation, thereby reducing the burden on monetary authorities to rely solely on interest rate adjustments.

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With respect to the monetary policy rate (Column 3), the rate is strongly and positively influenced by its own first lag, reflecting the typical inertia or gradual adjustment behavior observed in most central banks. Although the effects of output growth and inflation on the policy rate are negative and statistically insignificant, they nevertheless point to a policy stance where the central bank may ease monetary conditions when economic activity weakens or when price pressures begin to subside. This aligns with the conventional monetary transmission mechanism described by Christiano, Eichenbaum and Evans (1999), where timely policy responses help stabilize fluctuations in output and inflation.

The negative relationship observed between inflation and the monetary policy rate also highlights the central bank's stabilization role. Increases in inflation typically prompt contractionary monetary policy, which in turn helps dampen inflationary pressures. This dynamic is consistent with Goodfriend and King (1995), who argue that central banks maintain credibility and price stability by responding decisively to inflationary shocks. The VAR results therefore provide useful policy insights, even in the absence of strict contemporaneous causal identification: they show how policy instruments and macroeconomic variables interact over time and how delayed responses can shape the effectiveness of monetary actions.

Overall, these dynamic relationships underscore the importance of timely policy adjustments. Policymakers should monitor the evolution of inflation and output over multiple periods, as the impact of shocks materializes gradually and may require pre-emptive rather than reactive interventions.

Table 4: VAR estimation

Dependent variable:			
y(gr) 1		(inf) 2	(mr) 3
dgr.l1	-0.194 (0.193)	0.030 (0.222)	0.016 (0.062)
dinf.l1	0.185 (0.189)	0.242 (0.218)	0.009 (0.061)
dmr.l1	-0.183 (0.701)	0.461 (0.808)	0.626** (0.227)
dgr.l2	-0.234 (0.180)	-0.449** (0.208)	-0.039 (0.058)
dinf.l2	-0.179 (0.195)	-0.123 (0.224)	-0.044 (0.063)
dmr.l2	-0.113 (0.756)	-0.195 (0.871)	-0.150 (0.245)
dgr.l3	0.153 (0.192)	-0.474** (0.221)	0.046 (0.062)
dinf.l3	0.157 (0.198)	0.076 (0.228)	0.085 (0.064)

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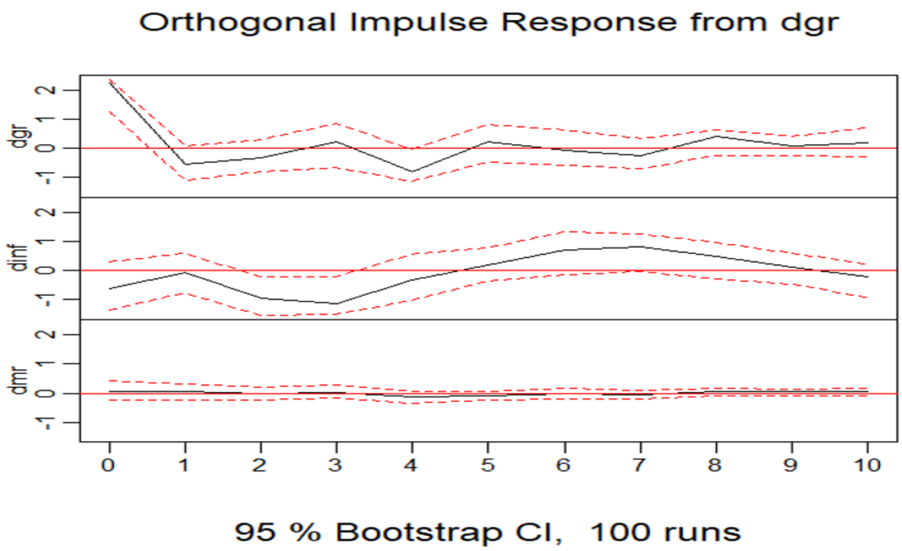
dmr.l3	-1.236 (0.727)	-0.504 (0.837)	-0.033 (0.235)
dgr.l4	-0.208 (0.196)	-0.347 (0.226)	-0.087 (0.064)
dinf.l4	0.262 (0.176)	-0.368* (0.203)	-0.027 (0.057)
dmr.l4	-0.007 (0.501)	0.041 (0.577)	0.018 (0.162)
const	-0.133 (0.374)	0.167 (0.431)	-0.021 (0.121)
Observations	38	38	38
R2	0.440	0.522	0.393
Adjusted R2	0.172	0.293	0.102
Residual Std. Error (df = 25)	2.255	2.598	0.730
F Statistic (df = 12; 25)	1.640	2.277**	1.349
Note:	*p<0.1; **p<0.05; ***p<0.01		

Impulse Response function and variance Decomposition

Impulse response functions indicate how an innovation (or disturbance or shock) to one variable propagates through the system and affects other variables. The Figure 2 below shows how variables in the system respond to a unit shock to GDP growth. The first panel shows a positive impact to economic growth itself and the effect will quickly die out in the next period. However, a shock to GDP growth has no impact on inflation and monetary policy rate (see the lower two panels of Figure 2).

Figure 2: impulse response functions from economic growth rate.



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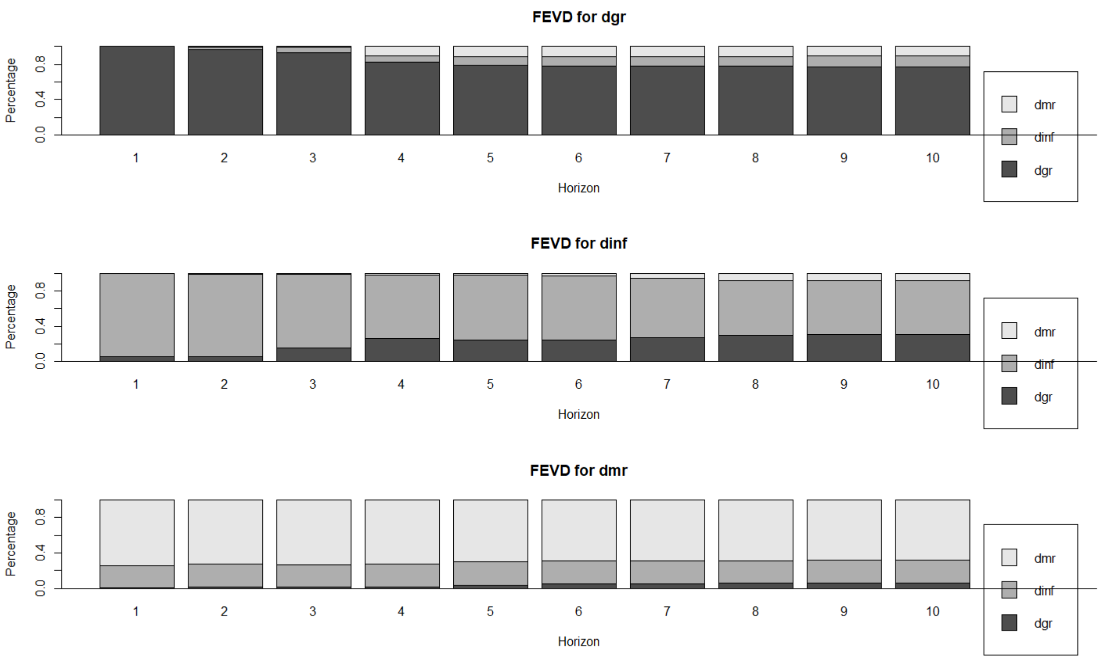
See Appendix A showing the response of inflation, and policy rate to their own shocks and shocks from other variables.

However, *the impulse response functions cannot tell us how important each shock is*. How much of the variation, for example, in economic growth is due to shocks in inflation? It will be useful to know how inflation shocks affect economic growth across different leads or lags. Hence, this need is satisfied by the forecast error variance decomposition (FEVD). This tells us what percentage of the variation in one variable from the forecasted value is due to shocks of itself and shocks of other variables.

Figure 3: showing forecast error variance decomposition.



The top panel in Figure 3 shows that most of the variation in economic growth across time is due to the shocks of itself and some negligible effects to shocks of inflation and policy rate over time. The middle panel shows the variation of inflation. The impulses of economic growth and inflation account for most of the variation in inflation. Hence, any shocks to the two variables will result in meaningful variation in inflation. The last panel shows the forecast error decomposition for the monetary policy rate. Most of the variation in it is due to changes in the variable itself and variations in inflation. The growth rate has a negligible impact on the monetary policy rate. The results from these panels are verified by the direction of association in the estimated coefficients in Table 4. Further, the findings are consistent with Mulenga and Chileshe (2016) study which showed that the monetary policy rate is mostly unaffected by changes in gross domestic product growth.

Forecasting

One of the most important aspects of vector autoregression estimation is to give forecasts of variables. VAR models are particularly useful when you have a set of related time series data and want to capture the dynamic interactions between these variables. Forecasting a variable in time series analysis is essential for a variety of practical and theoretical reasons. It allows businesses, researchers, and policymakers to make informed decisions and plan (Hyndman, & Athanasopoulos, 2018). Regarding economic policy, time series forecasting is employed by governments and central banks to inform their economic decisions. For instance, the prediction of inflation, GDP growth, and policy rates assists policymakers in determining interest rates, fiscal policies, and stimulus measures. Figure 4, displayed below, demonstrates the anticipated evolution of growth rates, inflation, and policy rates over the next eight years.

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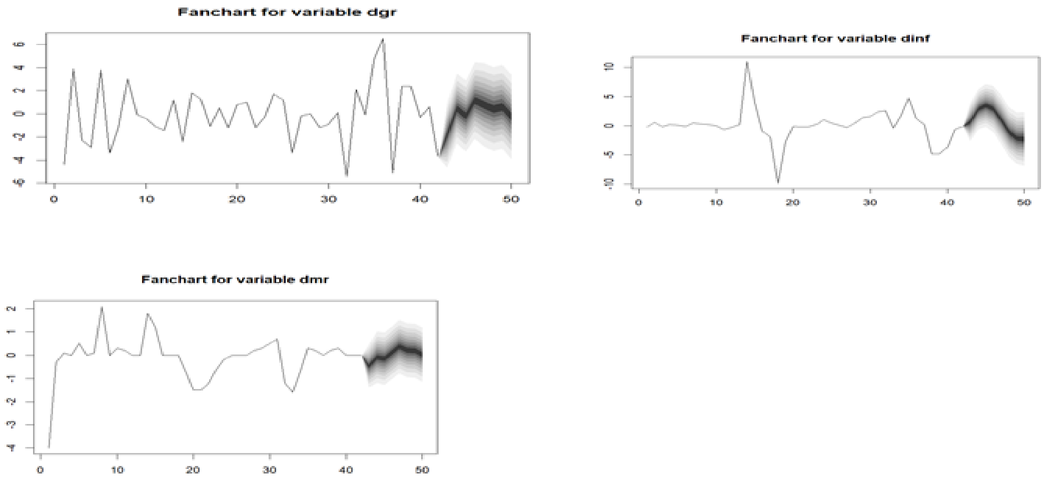
Figure 4: Fan charts for the forecasted values of economic growth, inflation, and monetary policy rate.



The forecast shows that the variables are all likely to increase in the short run but will eventually slow down or reduce towards the sixth and eighth years ahead.

CONCLUSION

The relationship between GDP growth, inflation, and the monetary policy rate is central to effective macroeconomic management. Although the study finds that interactions among these variables are generally negative and statistically weak in the short run, the direction and timing of these effects provide valuable insights for Zambia's economic policy framework. The results indicate that periods of robust economic expansion are often accompanied by emerging inflationary pressures, while persistent inflation or higher policy rates may moderately constrain output growth. However, the lack of strong statistical significance suggests that the transmission mechanisms of monetary policy remain relatively weak or unstable.

These findings carry important implications for Zambia's monetary and fiscal authorities. When output expands rapidly, rising demand can exert upward pressure on prices, as reflected in the estimates. In such circumstances, the Bank of Zambia should calibrate policy rate increases carefully to prevent excessive inflation without unnecessarily dampening growth. Conversely, during periods of economic slowdown or recession, a more accommodative monetary stance—such as gradually lowering the policy rate—can stimulate borrowing, investment, and consumption. The limited significance of monetary policy variables in affecting growth suggests that interest rate adjustments alone may be insufficient to steer the economy, highlighting the need for strengthened policy transmission channels.

Furthermore, given the observed unstable causality between inflation, growth, and the policy rate, Zambia would benefit from enhanced coordination between fiscal and monetary authorities. Fiscal policy—through targeted public investment, efficient spending, and credible deficit management—can complement monetary interventions by improving productivity and stabilizing inflation expectations. Strengthening fiscal discipline reduces reliance on interest rate adjustments as the sole stabilization tool, thereby enhancing overall macroeconomic resilience.

POLICY RECOMMENDATIONS

While the results indicate weak short-run causal dynamics, they suggest clear policy priorities for sustaining economic stability and growth in Zambia:

i. Strengthen Monetary Transmission Channels:

Improve the effectiveness of policy rate adjustments by enhancing credit market efficiency and ensuring that changes in central bank rates translate into lending rates and broader economic activity.

ii. Enhance Fiscal–Monetary Coordination:

Align fiscal policy with monetary actions to reinforce macroeconomic stability, avoid pro-cyclical fiscal expansions during inflationary periods, and support growth-oriented interventions.

iii. Support Long-Term Productivity and Structural Development:

Invest in key sectors such as agriculture, mining, and manufacturing to reduce supply-side constraints, moderate inflationary pressures, and promote sustainable economic growth.

Implementing these measures would enhance Zambia's ability to manage inflation effectively while fostering long-term economic growth, ensuring that monetary and fiscal policies are mutually reinforcing and responsive to evolving economic conditions.

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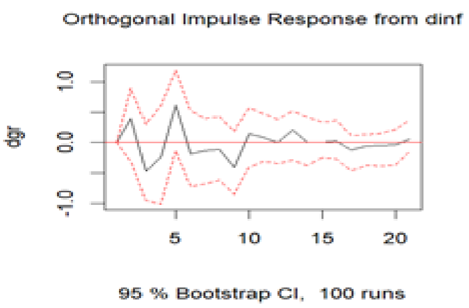
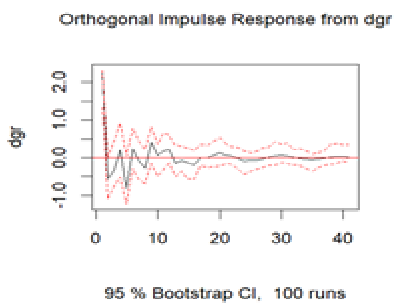
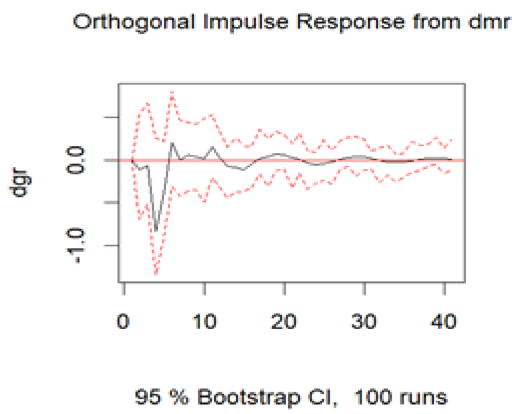
APPENDIX A: IMPULSE RESPONSE FUNCTION

a. Response of GDP growth from shocks







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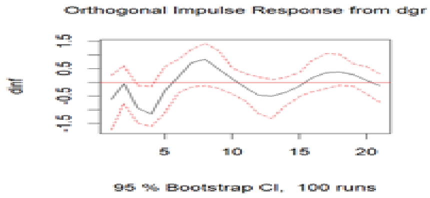
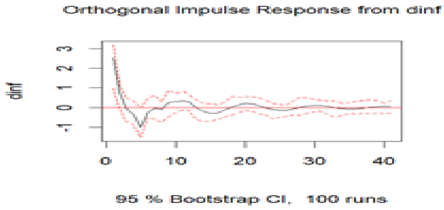
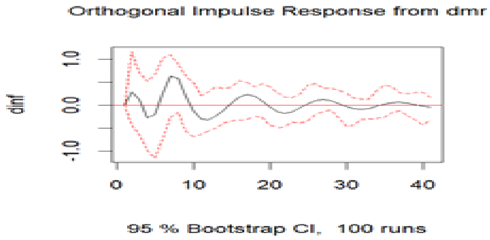
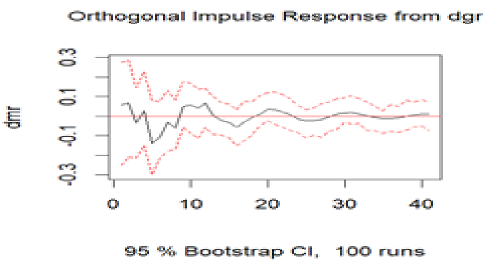
b. Response of inflation from shocks

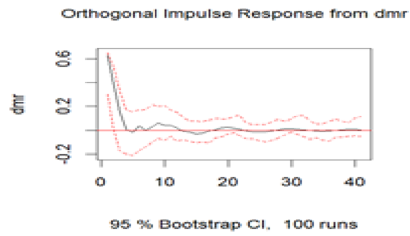


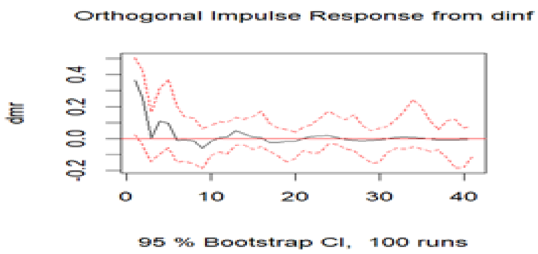




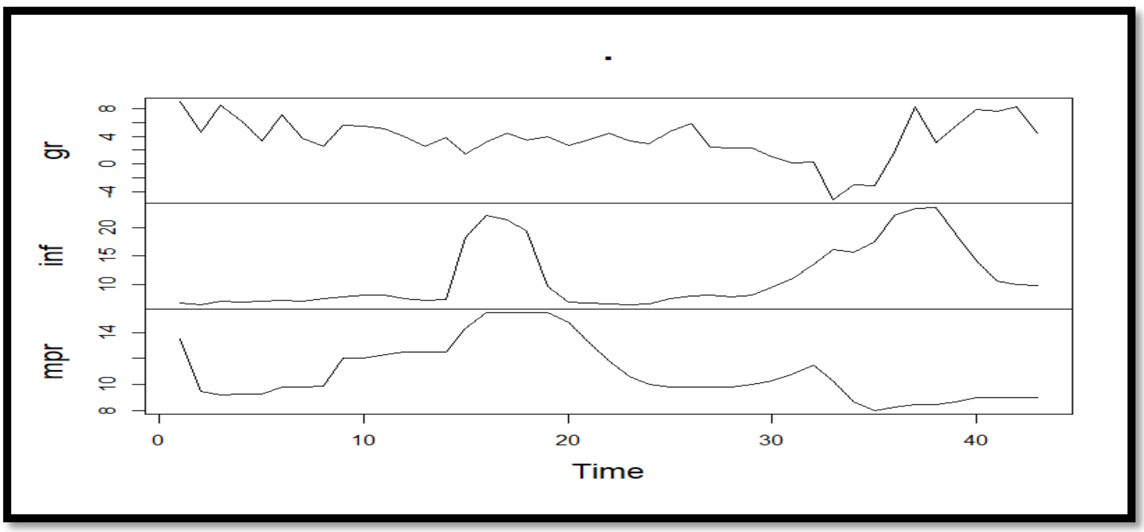
c. Response of monetary policy rate to shocks







Appendix B: The Evolution of economic growth, inflation, and monetary policy rate (R output).



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Appendix C: Granger Causality between from GDP growth to inflation and monetary policy rate

```
$Granger

        Granger causality H0: dgr do not Granger-cause dinf dmr

data:  VAR object bv_est
F-Test = 1.8679, df1 = 8, df2 = 75, p-value = 0.07775


$Instant

        H0: No instantaneous causality between: dgr and dinf dmr

data:  VAR object bv_est
Chi-squared = 3.5923, df = 2, p-value = 0.1659
```

Appendix D: Granger Causality from inflation to GDP growth and monetary policy rate

```
$Granger

        Granger causality H0: dinf do not Granger-cause dgr dmr

data:  VAR object bv_est
F-Test = 0.92366, df1 = 8, df2 = 75, p-value = 0.5021


$Instant

        H0: No instantaneous causality between: dinf and dgr dmr

data:  VAR object bv_est
Chi-squared = 8.6671, df = 2, p-value = 0.01312
```

Appendix E: Granger Causality from monetary policy rate to GDP growth and inflation

```
$Granger

        Granger causality H0: dmr do not Granger-cause dgr dinf

data:  VAR object bv_est
F-Test = 1.0786, df1 = 8, df2 = 75, p-value = 0.3873


$Instant

        H0: No instantaneous causality between: dmr and dgr dinf

data:  VAR object bv_est
Chi-squared = 7.771, df = 2, p-value = 0.02054
```

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Appendix F: Portmanteau Test of serial correlation

```
        Portmanteau Test (asymptotic)

data:  Residuals of VAR object bv_est
Chi-squared = 60.775, df = 72, p-value = 0.8245
```

Appendix G: Testing for heteroskedasticity

```
        ARCH (multivariate)

data:  Residuals of VAR object bv_est
Chi-squared = 156, df = 432, p-value = 1
```

Appendix H: Testing for normality of the residuals.

```
        JB-Test (multivariate)

data:  Residuals of VAR object bv_est
Chi-squared = 139.95, df = 6, p-value < 2.2e-16


$Skewness

        Skewness only (multivariate)

data:  Residuals of VAR object bv_est
Chi-squared = 21.422, df = 3, p-value = 8.602e-05


$Kurtosis

        Kurtosis only (multivariate)

data:  Residuals of VAR object bv_est
Chi-squared = 118.53, df = 3, p-value < 2.2e-16
```

Appendix I: CUSUM test for Structural Breaks.