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Analyzing the Structural Relationship between Money Supply, Inflation, and Economic Growth in Sierra Leone: A VAR Model Approach

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Abstract

This study examines the structural relationship between money supply, inflation, and economic growth in Sierra Leone using the Vector Autoregressive (VAR) model from 1981 to 2022. The study employed the unit root tests, granger causality tests, impulse response analysis, and variance decomposition analysis to investigate the causal relationship between the key macroeconomic indicators used in the study. Through applying the ADF and PP tests, it is ascertained that the variables used in the model are stationary at the first difference. Findings from the Granger causality tests revealed that there exists unidirectional causality from money supply to GDP Per Capita and no causality between inflation and GDP per capita. On the other hand, there exists a bidirectional causality between money supply and inflation. The Impulse response functions suggest that GDP Per Capita responds to shock in the Money Supply, and the response seems to be significantly negative, indicating an adverse long-term effect. Variance decomposition analysis further underscores the pivotal role of money supply in influencing GDP per capita, while inflation's impact remains relatively weak. The study's findings emphasize the critical importance of money supply management in promoting economic growth and maintaining financial stability.

Keywords

Vector Autoregressive (VAR) Model, Money Supply, Inflation, Economic Growth, Sierra Leone, Granger Causality, Impulse Response Function, Variance Decomposition

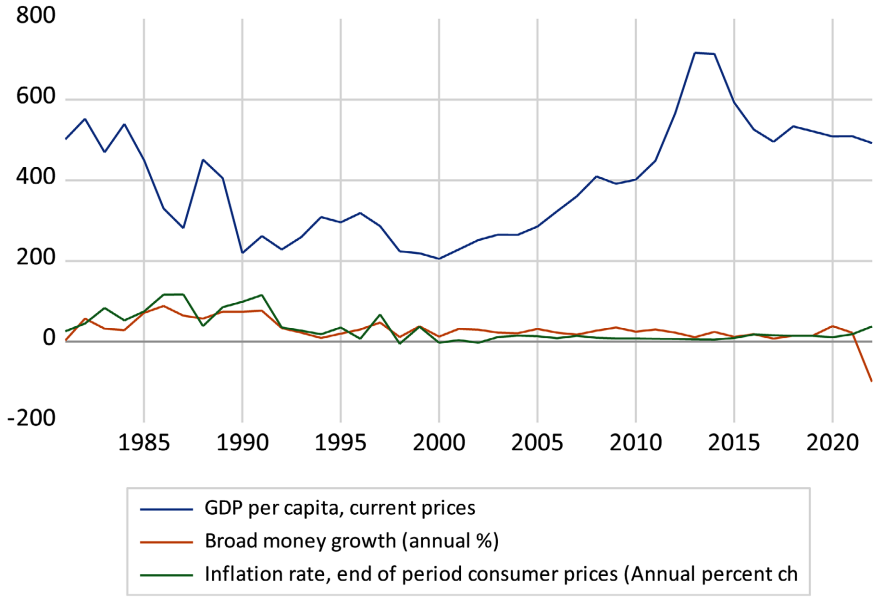
1. Introduction

The relationship between money supply, inflation rate, and economic growth is a topic of interest to the global community. Money supply, which is an essential determinant that can influence macroeconomic conditions, stimulates growth and affects the condition of economic activity (Lee & Yu, 2020). Swaray (2023) emphasizes that price stability coupled with inflation targeting is key among the core objectives for any central bank across developed and developing countries to foster sustainable long-run economic growth. Additionally, Daboh and Duramany-Lakkoh (2023) indicate how an effective and stable financial system constitutes a core facet of economic stability, stressing that central banks have a crucial role to play in the attainment of financial system stability. This underscores the need to have a resilient financial system that will enable the improvement of the economy and regulation of systemic risks. However, the relationship between the money supply, inflation, and economic growth remains a topic of ongoing debate among economists.

Our study investigates the contrasting views of Keynesian and Monetarist economists. Keynesian economists maintained that small but positive inflation can definitely stimulate expenditure and investment and thus shift the ratio in favor of the economy. They assumed that in case of an increase in income, demand for money upswings, the price for the commodity also rises and total economic activity is achieved (Keynes, 1936). In contrast, monetarist economists stress the critical importance of regulating the growth of the money supply to maintain price stability and prevent inflation. They contend that inflation occurs when the growth rate of the money supply surpasses the rate of economic growth, leading to resource allocation distortions, decreased purchasing power, and hindrances to long-term economic development (Friedman, 1971).

The influence of money supply on economic growth is essential in both developed and developing countries. The central bank's primary control over the money supply significantly impacts inflation. According to Mishkin (2007), an excessive expansion of the money supply may trigger inflationary pressures by raising aggregate demand compared to aggregate supply. On the other hand, developing countries, in particular, had to address the problem of expanding monetary circulation as a source of development while offsetting the use of inflationary stimulation.

It is also important to note that in recent years Sierra Leone has faced some severe economic challenges, such as high inflation rates and an increase in the official exchange rate. This was an average of more than a 16% point for Sierra Leone as indicated by the World Bank for each period between the years 2010 and 2020, which led to a more dramatic reduction of citizens' purchasing power. In addition, the country's economic growth has for a long time been volatile where the growth rates in GDP have often fluctuated showing weaknesses and vulnerabilities in the structural framework of the country's economy (IMF, 2021) (**Figure 1**).



Source: International Monetary Fund (World Economic Outlook).

Figure 1. Trend Analysis of Money Supply, Inflation, and Economic Growth in Sierra Leone.

The graph illustrates Sierra Leone's economic indicators from 1981 to 2022, covering GDP per capita, broad money growth, and inflation rates. The GDP per capita shows a general upward trend, indicating economic growth and improved average incomes. However, this growth is punctuated by fluctuations due to factors like political instability, global economic conditions, and internal policies. Periods of significant GDP increases reflect economic reforms, foreign investment, and recovery from the civil war conflicts, while downturns correspond to economic crises and other adverse global events.

Broad money growth and inflation rates highlight the challenges Sierra Leone faces in managing its monetary policy and maintaining price stability. High broad money growth periods suggest expansionary policies to stimulate the economy, often followed by high inflation rates, indicating difficulty in controlling price levels. Conversely, periods of low or negative money growth reflect efforts to curb inflation or economic stagnation. The inflation rate's volatility underscores the impact of excessive money supply growth, supply chain disruptions, and external shocks on consumer purchasing power. This economic instability highlights the need for stable policies to manage shocks, control inflation, and achieve sustainable growth. According to (Jackson, Jabbie, Tamuke, & Ngombu, 2020), they posit that the main factor that makes Sierra Leone prone to inflation is her reliance on imported commodities, especially food items, whose impact on the Consumer Price Index (CPI) composite basket is significant.

The primary objective of this study is to examine the Structural Relationship between Money Supply, Inflation, and economic growth in Sierra Leone using a VAR Model Analysis from 1981-2022. Therefore, this study's focus on the

Structural relationship between money supply, inflation, and economic growth will be of immense benefit to policymakers, economists, and various stakeholders. The rest of this paper is structured as follows; section two of this paper entails the underlying literature review which is categorized as a theoretical and empirical review. Section three, of this paper consists of the methodology used throughout this study, it clearly defined and explained both the theoretical and empirical methodology. Finally, section four of this study consists of the findings, conclusion, and policy recommendations.

2. Literature Review

2.1. Theoretical Literature Reviews

2.1.1. Monetary Neutrality and Classical Economics

Classical economics has always been given a clearer perspective by prominent scholars like Adam Smith, and David Ricardo (Smith, 1776; Ricardo, 1817). Monetary neutrality, one of the principles of the classical economy, was originally discussed in the Quantity Theory of Money. This theory was supported by classical economists such as Irving Fisher and later supported by monetarists such as Milton Friedman (Fisher, 1911; Friedman, 1989). The philosophy of monetary neutrality is based on the idea that an expansion of the money supply over time would be associated with proportional changes in prices while real economic factors remain unchanged. This concept is depicted by the exchange equation MV = PQ where M stands for money supply, V for velocity of money, P for price level, and Q for real production. Classical economics asserts that employment is full in the long run and, therefore, an increase in M impacts only price level since prices adjust to an increase in M (Ricardo, 1817). This view suggests that when and in whatever way the money supply changes, it only masks real transactions in terms of their price and does not in any way alter the capacities of the economy to produce.

Monetary neutrality is however a fact that has the following implications; Central banks ought to keep a stable quantity of money since changes in the quantity of money would only lead to short-run movements in the price level and not affect the trend of growth in the economy. This theory has been used in determining the central bank's policies especially when monetarist theories were in vogue (Friedman, 1989). However, the actual implementation of the conception of classical monetary theory has stirred much controversy, especially concerning short-range changes and economic processes. Opponents postulate that fluctuations in the money supply are capable of bringing about a transformation in the economy in the short run (Keynes, 1936). For instance, during recessionary periods, a higher money supply can boost spending and investment, consequently improving aggregate demand, economic activity, and employment in the short run. Moreover, the key assumption about full employment in the long run of monetary neutrality has been criticized by the existence of unemployment and underemployment in many economies. In such cases, the money supply can indeed affect

employment and output levels especially if it leads to changes like aggregate demand and investment. V, known as the velocity of circulation warns that it is not constant; it changes within periods due to changes in conditions or institutional factors, as stated by Friedman (1989). This point implies that variations in the money supply may not trigger equivalent or similar variations in the general price level as postulated by the classical monetary theory. Muth (1961) also notes that expectations and psychological considerations introduced into the economic decision process might distort the influence of variations in the money supply on real variables. For example, when consumers and businesses, expect an increase in price level because of an increase in monetary supply, they adapt by changing their expenditures and investments which may affect real economic factors.

2.1.2. Keynesian Economics and Demand Management

Unlike the ideals of classical economics, Keynesian economics asserts that changes in money supply possess moderate short-term effects on the economy. John Maynard Keynes posited that fluctuations in aggregate demand were responsible for oscillations in economic activity. Hence, money supply and interest rates are some of the ways through which monetary policy can be used to influence aggregate demand to achieve economic stability. The Keynesian approach especially stresses expansive fiscal policy during recessions that includes the use of monetary policy which involves increasing the money stock to reduce interest rates and thus encourage investment and consumption. To achieve this, expansionary monetary policy reduces the interest rate to make debt cheaper in the hope of boosting investment in capital projects and consumption expenditure to give a boost to aggregation demand. On the other hand, during inflationary pressure, expansion monetary policy is replaced by contraction monetary policy to avoid inflation. The monetarist policy aims at decreasing expenditure and investment through higher interest rates and limited credit, reducing the total demand and offsetting inflation (Keynes, 1936).

It should be noted that the effectiveness of Keynesian demand management programs is dependent on one or the other factors such as the elasticity of investment and consumption to changes in interest rates and other macroeconomic conditions. For instance, if fluctuations in interest rates significantly influence investment or consumption then monetary policy may well be a potent tool for stabilization (Friedman, 1995). But if more structural hindrances to investment and consumption exist, for instance, bureaucratic restraints or unpredictable outlook of the future macroeconomic environment, then the effectiveness of monetary policy may shrink (Friedman, 1995). Moreover, the channels through which changes in the monetary aggregate influence real economic variables, namely the intermediate transmission mechanism, could have changed given the structure of the financial system and the behavior of agents (Tobin, 1969). For instance, if a nation has a highly leveraged financial sector, then changes in interest rates will significantly affect borrowing and spending, thus magnifying the roles that monetary policy plays in shifting the aggregate demand curve (Tobin, 1969).

Barro (1974) further posited that the activism of other macroeconomic distortions such as fiscal imbalance and balance of payments inequalities could hamper the implementation of monetary policy. As Lucas Jr. (1972) highlighted, the measures taken by the monetary policy to control the aggregate demand and stabilize the economy may be limited by supply-side factors that include physical capacity constraints or severe deficiencies in inputs.

2.1.3. Endogenous Money and Credit Theory

There has been a criticism of the classical and neoclassical theories of money leading to the development of new theories such as endogenous money theory and credit theories of money. These variants challenge the post-Keynesian conventional wisdom of a vertical supply of money controlled by the central bank and add to the understanding of how money creation, credit, and economic activity are interrelated. Economists including Basil Moore and Hyman Minsky have come up with a different theory on the monetary system known as the endogenous money theory (Moore, 1988; Minsky, 1986). Based on this idea, money is not created exogenously by the central bank but is endogenously through the creation of loans and deposits within the banking system. In other words, when banks give credit to borrowers, they create money, and money is primarily created in the form of deposits. Endogenous money theory regards changes in the money supply as endogenous variables and thus not the cause of fluctuations in economic activity. When banks make loans and take more deposits, the money supply increases expenditure and hence promotes economic activity. On the other hand, when the banks contract or reduce their extent of lending, the circulation of money reduces, and hence expenditure and ultimately the rate of economic growth is affected. Hyman Minsky builds on Kern's credit theory by stating that financial instability is a natural part of economic processes (Minsky, 1986). Minsky argues that financial markets are inherently unstable due to the activities of economic agents engaged in speculation and Ponzi financing. In this regard, the literature suggests that during phases of economic calm, confidence in the financial system increases and with it, propensity for risk and leverage. However, as the levels of debt increase and speculative bubbles appear, the financial system becomes more unstable and it turns into a catastrophe.

Hence, credit theories of money are prolonged to endogenous money theory where credit relations and financial intermediations are affected by the change in the economy (Mitchell-Innes, 1913; Graziani, 1989). All these concepts indicate that variations in credit conditions and regulations can moderately influence investment, expenditure, and thereby, total demand. Moore (1988) categorizes credit theories of money under the financial intermediary theories of money since they posit that monetary circulation characterizes the functions of the banks besides the exchange of financial credits. These institutions are very important in the process of transferring funds from savers to borrowers, determining capital investment for maximum productivity, and controlling total economic activity.

2.2. Empirical Literature Review

Jawo et al. (2023) examined the interplay between The Gambia's inflation, exchange rate, money supply, and economic growth using the ARDL model from 1985 to 2021. Their findings indicated that all variables had positive and negative effects on inflation in the long and short term, respectively, at a significant level of 1%, indicating a high degree of confidence in the results, except for the real effective exchange rate and money supply, which were significant at the 5% level in the long run, indicating a slightly lower but still significant level of confidence. The recursive cumulative sum analysis indicated stability in the relationship, while the square recursive cumulative sum suggested instability due to exogenous shocks in output and increased public debts.

Sultana et al. (2019) examined the relationship between money supply and inflation in Bangladesh using monthly data from May 2010 to December 2017. Employing cointegration and Vector Error Correction Modeling (VECM) techniques, they found that money supply does not impact inflation in the short run, while the reverse is invalid. However, a bi-directional causal relationship between money supply and inflation was observed in the long run. They conclude that in the short run, inflation in Bangladesh is not primarily driven by financial factors but can stimulate money supply growth. In contrast, in the long run, inflation is significantly influenced by changes in the money supply.

Jazia and Khabbouch (2024) investigated the impact of monetary policy on inflation control in Saudi Arabia, a country with a unique economic structure, from 1980 to 2016. Employing quantitative methodology, they utilized ordinary least squares (OLS) to assess the effects. The study found that money supply is positively related to and significantly impacts inflation and unemployment, while gross domestic product (GDP) is negatively related and shows no association with money supply. However, in correlation analysis, all independent variables exhibit moderate correlations with the dependent variable, with correlation values of 0.560457, 0.605725, and 0.501308 for GDP, inflation, and unemployment, respectively.

Shen and Dong (2019) studied the structural relationship between Chinese money supply and inflation using a Vector Autoregressive (VAR) model. The study utilized the consumer price index (CPI) as a critical measure of inflation. The sample data included monthly observations from January 2008 to March 2019 for money in circulation (M0), narrow money (M1), broad money (M2), and CPI. By constructing a VAR model and applying econometric techniques such as the impulse response function and variance decomposition, the study examined the interactions among M0, M1, M2, and CPI. The results characterized the relationships and varying impacts of these different money supply measures on inflation, as represented by the CPI.

Hasan (2021) investigated the dynamic relationships among economic growth, money supply, inflation, and exchange rates using OLS and VAR methods from 2010Q1 to 2019Q4. The VAR estimates indicated that in the short term (Lag_1),

the Consumer Price Index (CPI) and exchange rates (ER) have a significantly positive impact on changes in economic growth (DLNGDP). However, this impact turns significantly negative in the longer term (Lag_2). Additionally, the influence of lagged DLNGDP (DLNGDP_1 and DLNGDP_2) is negative, indicating that economic growth is heavily influenced by its past values. The Impulse Response Function showed that shocks have a permanent effect, moving increasingly away from the equilibrium point. Variance Decomposition results demonstrated that DLNGDP, DLNCPI, and DLNER are endogenous variables. The model's forecasting accuracy is high, with errors approaching zero. These findings suggest that policymakers should consider the long-term effects of changes in money supply and inflation on economic growth, and researchers should further explore the mechanisms behind these relationships.

Tarawalie and Kamara (2022) made a significant contribution to the field by examining the relationship between inflation and economic growth in Sierra Leone using a non-linear model and time-series data from 1980 to 2020. Their analysis unveiled a threshold inflation level of 10.3 percent, a unique finding that adds to our understanding of the economic dynamics in Sierra Leone. The study also identified investment, openness, and periods of war as significant factors influencing economic growth, further enriching the existing literature. The research underscores the importance of maintaining inflation within a moderate range for sustained economic growth in Sierra Leone, and it highlights the roles of investment, openness, and political stability in driving economic development.

Ilyas et al. (2022) investigated the shock effects of inflation, money supply, and exchange rates on the West African Monetary Zone (WAMZ) economies from 1987 to 2019. Employing various tests, including the Kapetanios-Shin-Snell nonlinear cointegration test and Kilian-Vigfusson asymmetric tests, they analyzed asymmetric effects using the Hatemi technique. Their findings revealed asymmetric shock effects in all WAMZ countries except Guinea and inflation in Liberia. Gambia and Nigeria were impacted solely by money supply, while Ghana, Guinea, and Liberia were unaffected by any variable. In contrast, both money supply and exchange rates influenced Serra Leone's economy. Overall, familiar sources of shocks from monetary and exchange rate policies were observed across the WAMZ countries, except for the Gambia, which was solely affected by monetary policy shocks.

Bangura et al. (2022) conducted a comprehensive analysis of Sierra Leone's financial markets' impact on money demand behavior from 1981 to 2010. Their findings have direct policy implications, as they provide a guide for informing monetary policy strategies in Sierra Leone's financial markets. Using the ARDL approach, they found significant long-run and short-run effects of real GDP, inflation, real exchange rate, and foreign interest rates on real money balances. Granger causality tests revealed uni-directional causality from real balances to inflation and real effective exchange rate. These findings offer policymakers a clear

understanding of the dynamics of money demand and its relationship with macroeconomic variables, which can help them design effective monetary policies to promote economic stability and growth.

Danlami et al. (2018) examined the impact of interest rates on inflation in Sierra Leone using ARDL models from 1970 to 2016, which is a testament to the complexity of economic research. Their findings indicate that interest rates positively and significantly influence short- and long-term inflation, challenge conventional views, and support fiscal policy arguments. However, the study's conclusions are also a reminder of the limitations of data and methods, highlighting the need for further research and a nuanced understanding of the relationship between interest rates and inflation in Sierra Leone.

Daboh and Jackson (2023) investigated the relationship between deposit and lending interest rates and money demand in Sierra Leone from 1980 to 2020, aiming to shed light on interest rate volatility's impact on economic growth. Employing the Autoregressive Distributed Lag (ARDL) approach, they analyzed long- and short-term relationships. Findings indicate that deposit interest rates have a positive yet insignificant long-term impact on money demand while lending rates have a negative and insignificant long-term effect. However, in the long run, these effects become insignificant. To enhance economic stability, we suggest implementing a uniform interest rate for commercial banks and vigilant monitoring of competitive lending rates as policy measures.

3. Methods and Materials

This paper employed the annual time series data covering 1981-2022. The macroeconomic variables include broad money growth, inflation, and economic growth. The secondary data used in this study were collected from the International Monetary Fund (World Economic Outlook).

The study makes use of various econometrics techniques with the ultimate goal of analyzing the structural relationship that exists between money supply, inflation, and economic growth. Firstly, the stationarity properties of the time series data were checked using the Unit Root test, specifically the Augmented Dickey-Fuller (ADF) and the Phillips-Perron Unit Root Test. Also, the Granger Causality Test was employed to determine the causal relationship between the variables. Finally, in determining the reaction of one variable behavior to shock to another over time in the economy, the Impulse Response Analysis was used to explore such behavior and the level of deviation from the steady state.

Model Specification

To investigate the long-run relationship between the variables, the study utilized the following functional model:

$$GDPPC = f\left(M2, Inflation\right) \tag{1}$$

The econometric form of the equation is thus stated as:

$$GDPPC_t = \alpha_{1?} + \beta_1 M2_t + \beta_2 INFLATION_t + \varepsilon_t \tag{2}$$

where in Broad Money Growth (annual %), denoted as *M*2, GDP Per Capita, denoted as *GDPPC*, and the Inflation Rate (end of period consumer prices, annual % change). Also, the model's coefficient β_1 and β_2 and the error term ε_t are included.

3.1. Time Series Test for Stationarity

It is essential to check the stationarity properties of time series data, as it will help avoid spurious and inaccurate results, which might lead to misleading conclusions. In this study, we employed the Augmented Dickey-Fuller (ADF) and the Phillips-Perron Unit Root Test to check the stationarity of the data. The ADF is thus stated as:

$$\Delta y_t = \alpha + \beta_t + \gamma y_{t-1} + \sum_{i=1}^{p} \delta_i \Delta y_{t-1} + \varepsilon_t \tag{3}$$

where Δy_t is the first difference of the variable y at time t, α is the constant term and β_t is the trend component. Also, γy_{t-1} is the lagged level of the variable, $\delta_i \Delta y_{t-1}$ represents the lagged differences and ε_t is the error term. The null hypothesis (H_0) of the ADF test is that the series has a unit root, indicating non-stationarity. The alternative hypothesis (H_1) is that the series is stationary.

3.2. Time Series Causality Test

We employed the Granger Causality Test, a method designed to determine if one time series is useful in forecasting another, to ascertain whether one variable can predict another. This test is useful in ascertaining the causal relationship between the macroeconomic indicators used in this study. The Granger causality test involves estimating the following Vector Autoregression (VAR) models:

$$GDPPC_t = \alpha_1 + \sum_{i=1}^{p} \beta_{1i} GDPPC_{t-i} + \sum_{i=1}^{p} \gamma_{1i} M2_{t-i} + \sum_{i=1}^{p} \delta_{1i} Inflation_{t-1} + \varepsilon_{1t} \tag{4}$$

$$M2_t = \alpha_2 + \sum_{i=1}^{p} \beta_{2i} M2_{t-i} + \sum_{i=1}^{p} \gamma_{2i} GDPPC_{t-i} + \sum_{i=1}^{p} \delta_{2i} Inflation_{t-1} + \varepsilon_{2t} \tag{5}$$

$$Inflation_t = \alpha_3 + \sum_{i=1}^{p} \beta_{3i} Inflation_{t-i} + \sum_{i=1}^{p} \gamma_{3i} GDPPC_{t-i} + \sum_{i=1}^{p} \delta_{3i} M2_{t-1} + \varepsilon_{3t} \tag{6}$$

where;

$GDPPC_t$, $M2_t$, and $INFLATION_t$ are the values of GDP Per Capita, Broad Money Growth, and Inflation Rate at time t.

α_1, α_2 and α_3 are the constants.

β_{1i}, β_{2i}, and β_{3i} are the coefficients of the lagged dependent variables.

γ_{1i}, γ_{2i}, and γ_{3i} are the coefficients of the other variables' lagged values.

δ_{1i}, δ_{2i}, and δ_{3i} are the coefficients of the remaining variables' lagged values.

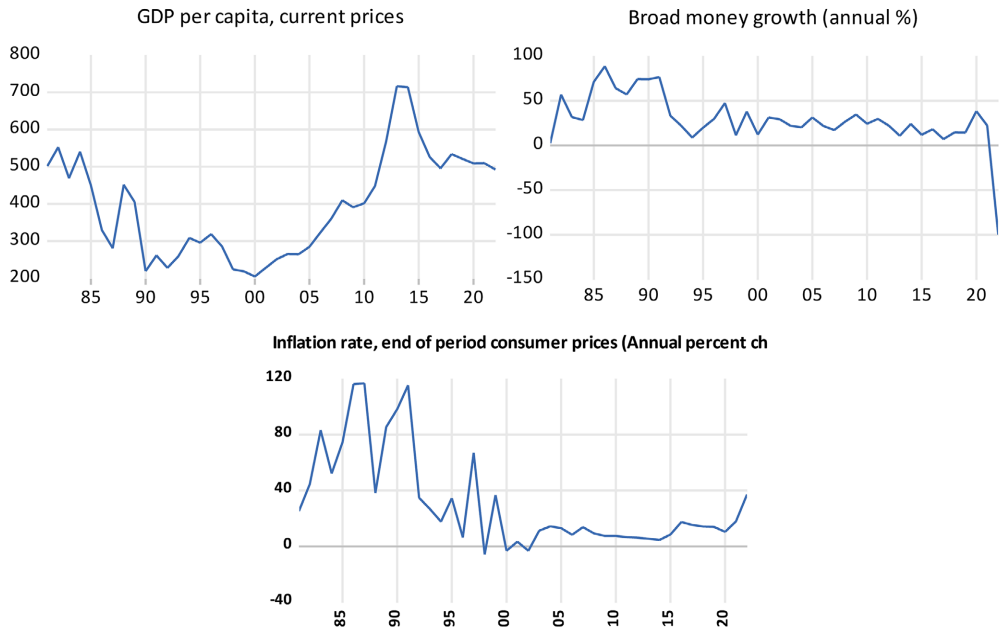
ε_{1t}, ε_{2t}, and ε_{3t} are the error terms.

p is the number of lags determined by criteria such as the Akaike Information Criterion (AIC).

4. Empirical Results

4.1. Data Visualization

The result from Figure 2, provides a visual inspection of the time series variables employed in the study such as GDP per Capita (USD) in current prices, Broad Money Growth (annual %) and Inflation Rate, end of period consumer prices. The graphical inspection revealed that the GDP per Capita is trending upward, while Inflation and Broad Money Growth tend to significantly fluctuate without returning to their reverting long-term mean. Thus, the study further conducted the unit root test to check the stationarity properties of the time series variables.



Source: Author's Computation, 2024.

Figure 2. Time series trend analysis.

4.2. Unit Root Test

The times series properties of the variables were examined using both the Augmented Dickey-Fuller (ADF) and Phillips-Perron Unit Root Test to check for the presence of unit roots. The results are shown in Table 1 and Table 2 below.

Table 1. Augmented dickey-fuller (ADF) unit root test.

Augmented Dickey-Fuller (ADF) Unit Root Test						
Variables	Level		First Difference		Level of Significance	Order of Integration
	Test Statistics	Prob Value	Test Statistics	Prob Value		
GDPPC	−1.940654	0.3110	−5.558557	0.0000	5%	I (1)
M2	−1.791455	0.3794	−5.341967	0.0001	5%	I (1)
INFLATION	−1.134936	0.6919	−10.0031	0.0000	5%	I (1)

Source: Author's Computation, 2024.

Table 2. Phillips-Perron unit root test.

Phillips-Perron Unit Root Test						
Variables	Level		First Difference		Level of Significance	Order of Integration
	Test Statistics	Prob Value	Test Statistics	Prob Value		
GDPPC	−1.601713	0.4727	−5.516733	0.0000	5%	I (1)
M2	−1.791455	0.3794	−4.722384	0.0004	5%	I (1)
INFLATION	−2.765946	0.0721	−19.8183	0.0001	5%	I (1)

Source: Author's Computation, 2024.

The results from Table 1 and Table 2 report the Augmented Dickey-Fuller (ADF) Unit Root Test and the Phillips-Perron Unit Root Test. Results from the study revealed that the null hypothesis of the unit root tests cannot be rejected for GDP per Capita (USD) in current prices, Broad Money Growth (annual %) and Inflation Rate, end of period consumer prices, indicating that these variables are non-stationary at their level. However, we reject the null hypothesis of the unit root test after first differencing for GDP per Capita, Broad Money Growth, and Inflation Rate, indicating that these variables are stationary at first differencing or integrated at I (1).

4.3. Unit Root Test on the Residual

We conducted a unit root test on the residuals using the Augmented Dickey-Fuller (ADF) to determine whether the variables are cointegrated or share a long-run equilibrium relationship. The results are presented in Table 3 below.

Table 3. Unit root test on the residual.

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		−1.77209	0.3887
Test critical values:	1% level	−3.60099	
	5% level	−2.935	
	10% level	−2.60584	

Source: Author's Computation, 2024.

The Augmented Dickey-Fuller (ADF) test results for the residuals from Table 3 show a test statistic of −1.772089 and a p-value of 0.3887, indicating that we cannot reject the null hypothesis of a unit root. Since the residuals are non-stationary, this suggests that the original time series are not cointegrated, meaning they do not share a common long-term equilibrium relationship.

4.4. Lag Length Selection

The study makes use of the SC information criterion, Final Prediction Error, AIC information criterion, likelihood ratio (LR), LR test statistics, and the Hannan-Quinn Criteria (HQC) to choose the maximum lag length. Table 4 shows the estimated lag length criteria results.

Table 4. Lag length selection.

Lag Length Selection						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	−618.204	NA	1.37E+10	31.85663	31.98459	31.90254
1	−569.876	86.74311	1.83E+09	29.83979	30.35165*	30.02344
2	−555.446	23.67952*	1.40e+09*	29.56134*	30.45711	29.88274*
3	−546.903	12.70581	1.47E+09	29.58475	30.86441	30.04388

Source: Author's Computation, 2024

The result from Table 4 revealed that the Schwarz Besiayan Criteria (SBC) recommends one (1) lag length. In contrast, the Akaike Information Criteria (AIC), Final Prediction Error (FPE), likelihood ratio (LR), and as well as the Hannan-Quinn Criteria (HQC) suggest two (2) lag lengths. However, this study's most appropriate optimal lag length is two (2) based on the (LR, FPE, AIC, and HQ).

4.5. Diagnostic Test

To check the validity of the model used in the study, we conducted a series of diagnostic tests, such as stability test, heteroskedasticity, and serial correlation test, with the ultimate goal of confirming the model's suitability for the study.

4.6. Stability Test

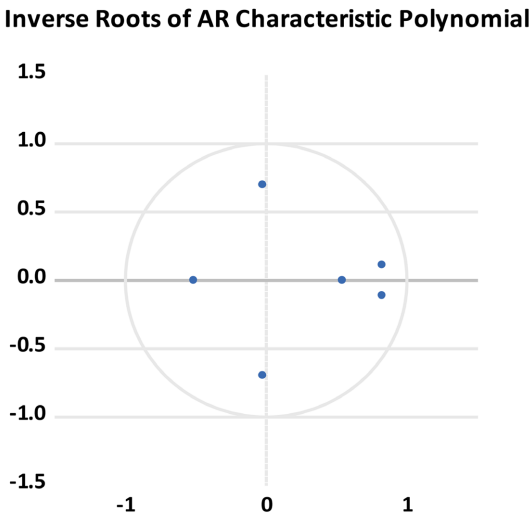
To confirm the stability of the VAR model, it is appropriate to estimate the inverse roots of the AR characteristic polynomial. The result of the VAR AR root table and the graph is shown in Table 5 and Figure 3 below.

The result from Table 5 and Figure 3 shows the model's stability. Evidence from the graph revealed that all the Inverse Roots of AR Characteristic polynomials lie within the unit circle, indicating that the model is highly stable and appropriate. The stability of this model highlights the significant relationship that exists between GDP per Capita, Broad Money Growth, and Inflation Rate in Sierra Leone.

Table 5. Inverse Roots of AR characteristic polynomial.

Root	Modulus
0.824742 − 0.112237i	0.832344
0.824742 + 0.112237i	0.832344
−0.024148 − 0.698161i	0.698579
−0.024148 + 0.698161i	0.698579
0.541079	0.541079
−0.513416	0.513416

Source: Author's Computation, 2024.



Source: Author's Computation, 2024.

Figure 3. Inverse roots of AR characteristic polynomial.

4.7. Serial Correlation LM Tests

We further conducted the Serial Correlation LM Tests to check for the presence of serial correlation in the model, assuming that it is free from any serial correlation. Violation of this assumption indicates that serial correlation exists in the model's residual. Table 6 below shows the results from the Serial Correlation LM Tests.

Table 6. Serial correlation LM test.

Null hypothesis: No serial correlation at lag h		
Lag	df	*P*-Value
1	9	0.2554
2	9	0.3432
Null hypothesis: No serial correlation at lags 1 to h		
Lag	df	*P*-Value
1	9	0.2554
2	18	0.2903

Source: Author's Computation, 2024.

The result from Table 6 shows the Serial Correlation LM Tests. It reveals that the probability value of each lag and combined lag is greater than 5% (0.05), indicating that we accept the null hypothesis of no serial correlation in the model. The absence of serial correlation in the model revealed that the residuals are white noise and indicate that the model was well specified.

4.8. Residual Heteroskedasticity Tests (Levels and Squares)

To check the volatility in the model residual, we conducted the Heteroskedasticity

Tests with the assumption that the error terms are homoscedastic. Table 7 below presents the results from the Heteroskedasticity Tests.

Table 7. VAR residual heteroskedasticity tests.

Joint test:		
Chi-sq	**df**	**Prob.**
81.03833	72	0.2180

Source: Author's Computation, 2024.

The result from Table 7 revealed that the probability value of the Joint test is greater than 5% (0.05), indicating that we fail to reject the null hypothesis of no heteroscedasticity in the error variances and thus conclude that the disturbance terms are homoscedastic in nature.

4.9. VAR Residual Normality Tests

We also used the VAR Residual Normality Tests, using Cholesky orthogonalization, with the aim to determine whether the residuals from the Vector Autoregression (VAR) model are multivariate normal. Results from the normality test are presented in Table 8 below.

Table 8. VAR residual normality tests.

Component	Jarque-Bera	df	Prob.
1	3.652333	2	0.161
2	214.5319	2	0.0000
3	0.41627	2	0.8121
Joint	218.6005	6	0.0000

Source: Author's Computation, 2024.

The VAR Residual Normality Tests using Cholesky orthogonalization assess if the residuals from a VAR model are multivariate normal, with 40 observations from 1981 to 2022. Component 1 has a Jarque-Bera statistic of 3.652333 (p-value: 0.1610), suggesting normal distribution. Component 2 shows a statistic of 214.5319 (p-value: 0.0000), rejecting normality. Component 3's statistic is 0.416270 (p-value: 0.8121), indicating normal distribution. Jointly, the test yields a statistic of 218.6005 with 6 degrees of freedom and a p-value of 0.0000, rejecting the null hypothesis of multivariate normality. Thus, despite some components being normally distributed, the overall residuals are not.

4.10. Granger Causality Test

We further employed the Granger causality tests to examine the causal relationship between money supply, inflation, and economic growth in Sierra Leone. The results from the Granger causality tests are presented in Table 9.

Table 9. Granger causality test.

Null Hypothesis:	Obs	F-Statistic	Prob.	Remark
M2 does not Granger Cause GDPPC	40	4.85222	0.0138	Reject
GDPPC does not Granger Cause M2		0.05425	0.9473	Accept
INFLATION does not Granger Cause GDPPC	40	0.3503	0.7069	Accept
GDPPC does not Granger Cause INFLATION		2.18822	0.1272	Accept
INFLATION does not Granger Cause M2	40	4.27823	0.0218	Reject
M2 does not Granger Cause INFLATION		5.46557	0.0086	Reject

Source: Author's Computation, 2024.

The result from Table 9 reports the Granger causality tests; the results revealed that money supply (M2) does Granger Cause GDPPC, indicating a unidirectional causality and thus GDPPC does not Granger Cause M2, which implies that changes in the money supply do predict changes in GDP Per Capita, and does not vice versa. Also, no causality exists between inflation and GDP Per Capita, which indicates that changes in inflation do not have any predictive power to explain changes in GDP Per Capita and vice versa. In contrast, bidirectional causality exists between inflation and money supply, implying that inflation has a high predictive power in explaining changes in the money supply and vice versa. The study findings further revealed a predictive relationship between money supply (M2) and GDP Per Capita but not vice versa. On the other hand, there exists a predictive relationship between money and inflation and vice versa, which serves as a vital instrument for the formulation of policy and ensures the financial system's stability as a whole.

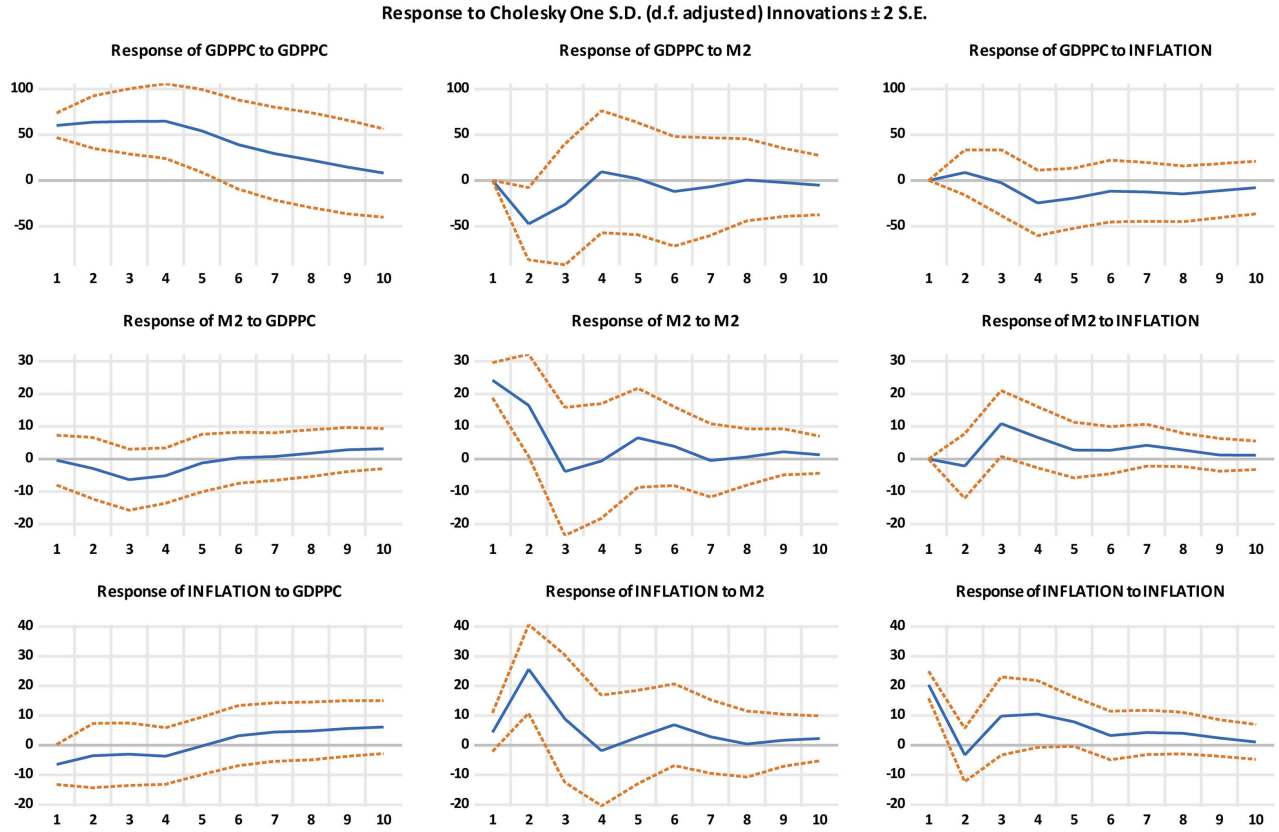
4.11. Impulse Response Function

The impulse response function (IRF) analysis provides insights into how shocks to one variable in a system affect other variables over time. Figure 4 shows the impulse response function results.

The Impulse Response Function (IRF) analysis examines how money supply (M2), gross domestic product per capita (GDPPC), and inflation react to shocks in one another over a period of ten years. The results demonstrate that when affected by its impulse, GDP Per Capita shows an immediate strong positive response peaking in the second period before declining gradually to its steady state. Ultimately, when GDP Per Capita responds to shock in the Money Supply, the response seems to be significantly negative, indicating an adverse long-term effect.

Also, a one-standard-deviation shock on the money supply has a gradual negative effect on GDP Per Capita. From the 2nd period, the response gradually increases until the 5th period when it hits its steady-state value. Beyond the 5th period, GDP Per Capita decreases below its steady-state value and remains negative in the region. Indicating that the money supply has an adverse effect on the GDP Per Capita both in the short and long run. On the other hand, a one standard

deviation shock on the inflation rate has a gradual positive effect on the GDP Per Capita. From the 3rd period, this positive response sharply declines below its steady-state value and remains negative in the region till its 10th period. Indicating that in the short run, inflation has a positive effect on GDP Per Capita, while having a detrimental impact on the long run.



Source: Author's Computation, 2024.

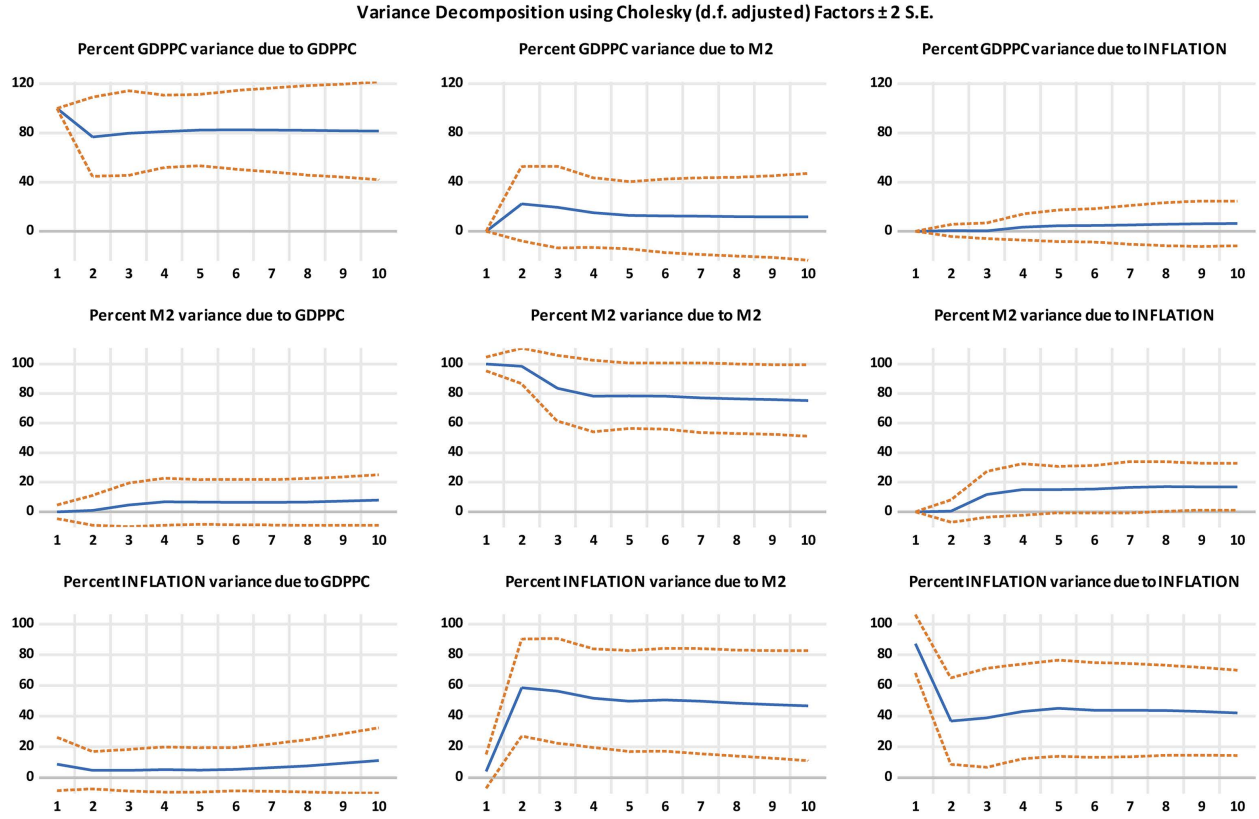
Figure 4. Impulse response function.

Additional insights into the dynamic interrelationships among the variables can be obtained from the responses of money supply and inflation to shocks. In addition, a one standard deviation shock on the GDP Per Capita initially has no noticeable impact on the money supply. From the 1st and 5th periods, this response has been negative and gradually declines until the 6th period when it hits its steady-state value. Beyond the 6th period, the money supply rises above its steady-state value and remains positive in that region. Also, a one standard deviation shock on inflation initially increases the money supply. This positive response sharply declines in the 3rd period when it rises above its steady-state value and then remains positive in that region. Furthermore, a one standard deviation shock on the GDP Per Capita has a gradual negative effect on inflation, the response gradually declines until the 6th period when it hits its steady-state value. Beyond the 6th period, inflation rises above its steady-state value and remains in the

positive region. Implying that shocks in the GDP Per Capita will have adverse effects in the short run and then become positive in the long run. On the other hand, a one standard deviation shock on the money supply has a gradual positive effect on inflation. This positive effect sharply declines until the 4th period when it hits its steady-state value from where it remains negative in the region, from the 5th period to about the 8th period, inflation rises above its steady-state value and remains positive in the region. Indicating that in the short run shock on the money supply has a negative effect on inflation and thus, becomes positive in the long run.

4.12. Variance Decomposition

To determine the distinct impacts of various shocks on GDP per capita (GDPPC), inflation, and money supply (M2) variances over a ten-period horizon, we can use variance decomposition analysis. Figure 5 below shows the variance decomposition results.



Source: Author's Computation, 2024.

Figure 5. Variance decomposition.

The variance decomposition analysis helps us to understand the relative importance of different shocks that explain GDP per capita (GDPPC), money supply (M2), and inflation variances in a ten-period horizon. Regarding GDP per capita,

it is evident that a large part of its variance is explained by its shocks, especially at the beginning period which shows a strong autoregressive element. From this point on, however, the influence of Money supply on GDP Per Capita variance becomes more pronounced, indicating the important role of the money supply in affecting GDP Per Capita. GDP Per Capita variances are relatively unaffected by inflationary shocks across the period suggesting fairly weak causal links between the two variables.

In contrast, the Self-reinforcing nature of the Money supply is mainly driven by its shocks and in this case, the variance is high. However, shocks to GDP Per Capita also contribute to the variance of Money supply, although slightly implying that the volume of economic output has a positive but small effect on money supply. On the other hand, inflation has most of its variances explained by its shocks showing strong autoregressive behavior. GDP Per Capita and Money supply shocks contribute relatively weakly to the variation of inflation underscoring the fact that though it might be influenced by both GDP Per Capita and Money supply, inflation's main explanatory factors are simply its past values. This reveals how complicated these variables interact with each other where M2 plays a critical role in influencing GDP per capita and having a reciprocal relationship with inflation.

5. Conclusion and Policy Implications

The study concludes that in Sierra Leone, there exists a unidirectional causality from money supply to GDP Per Capita, implying that proportionate changes in the money supply can help predict changes in GDP Per Capita, but not vice versa. Moreover, the study found no causation between inflation and GDP per capita, indicating that when inflation changes it doesn't lead to changes in GDP per capita. However, inflation can help predict money supply whereas money supply also predicts inflation implying bidirectional causality between them. This assertion is supported by the variance decomposition analysis which shows that while most of the variations in the GDP per Capita are a result of its shocks initially, over time money supply dominates more. Inflation variance is driven primarily by itself pointing out its reinforcing nature. These findings highlight how important it is to manage money supply and inflation to ensure economic stability and growth in Sierra Leone.

The study proposes that the Central Bank of Sierra Leone should give top priority to managing the money supply to curb inflation, thereby achieving price stability and sustainable economic growth, given the robust bidirectional causality between these variables. The adoption of an inflation-targeting framework could serve as a valuable tool to anchor inflation expectations and steer monetary policy more effectively, while at the same time ensuring financial stability and facilitating continuous economic growth. This dual focus on money supply and inflation will help create a stable economic environment conducive to growth and development.

Applicability of Findings to Other Developing Economies

The study on Sierra Leone's relationship between money supply, inflation, and economic growth offers valuable insights for effective money supply management within the country. However, applying these findings to other developing economies requires consideration of their unique socio-economic and political contexts. For instance, Ghana's diversified economy and stable political environment, as well as Nigeria's dependence on oil exports and political instability, illustrate how different sources of economic volatility and political conditions can lead to distinct dynamics in these relationships.

In countries like Kenya and Bangladesh, the variations in financial system development and economic structure highlight the need for context-specific analyses. Kenya's more advanced financial system and higher levels of financial inclusion could lead to different impacts from monetary policy changes due to more effective transmission mechanisms. Conversely, Bangladesh's robust manufacturing sector, especially in textiles, presents a different set of economic drivers compared to Sierra Leone. These examples revealed the importance of understanding each country's unique factors to enhance the broader relevance of the study's findings.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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