Analyzing the Effectiveness of Monetary Policy Transmission Mechanism in Ethiopia: A VAR Model Approach

Abstract

This study examines the effectiveness of monetary policy transmission mechanism in Ethiopia and dynamic relationships between key macroeconomic variables - real GDP growth (RGDP), consumer price index (CPI), broad money supply (M2), and real interest rates (RIR) in Ethiopia from 1995 to 2024. Using vector autoregressive (VAR) modeling and time series analysis. The empirical analysis reveals several important findings. First, GDP growth demonstrates strong persistence, with current growth significantly influenced by its own lagged values. Second, monetary variables (CPI and M2) show statistically insignificant short-run effects on GDP growth, suggesting limited immediate impact from monetary policy interventions. Third, the Johansen co-integration test indicates no strong long-run equilibrium relationship among the variables at conventional significance levels. Findings suggest important policy implications that structural reforms in infrastructure, education, and institutions may be more effective than monetary adjustments for sustaining long-run growth; central banks should adopt cautious, forward-looking monetary policies; and policymakers need to develop coordinated fiscal-monetary strategies that account for the limited short-run responsiveness of growth to monetary variables.

Keywords: macroeconomic policy, GDP growth, monetary policy, vector autoregressive.

1 INTRODUCTION

The Monetary Transmission Mechanism (MTM) is crucial for achieving a central bank's goals of price stability and economic growth. It works by transmitting monetary policy actions from the central bank to the real economy through various channels, including the interest rate, exchange rate, credit, asset prices, and expectations(Mishchenko et al., 2021). Monetary policy also describes the relationship between interest rate in an economy and broad money supply. Both of these factors are controlled by different tools to control the outcome of economic growth, inflation rate, bank credit rate and exchange rate with other currency(Khan, 2012). it is implemented to achieve macroeconomic objectives of sustained economic growth, full employment, stable price and equilibrium balance of payment(Sulaiman & Migiro, 2014). Developing countries often face challenges related to their macroeconomic performance, which refers to the overall behavior and trends in the economy at a national level (Sena et al., 2021).

Monetary policy is a key tool used by a country's central bank to manage money supply, interest rates, and credit to achieve macroeconomic goals such as controlling inflation, ensuring maintained equilibrium in international trade, fostering long-term economic development, preserving the strength of the national currency, and ensuring a resilient financial system. It plays a vital role in stabilizing the economy and addressing negative economic trends (Akanbi & Ajagbe, 2012). It is a key factor of macroeconomic management in opened economy to invigorate financial solidness and to advance financial improvement through its effect on financial factors and to accomplish craved destinations(Van Dan & Binh, 2019).

The National Bank of Ethiopia has increasingly adopted indirect monetary tools such as interest rate adjustments, open market operations, and Treasury bill sales to manage the economy. It is now working to improve the effectiveness of these tools and is exploring the introduction of new instruments to enhance its monetary policy framework(NBE, 2010). The health of an economy in transmitting the effects of monetary policy action on growth has been identified to depend mostly on the development of the financial sector and the totality of the financial makeup of a country, with the financial system acting as the medium through which monetary policy impacts the real economy (Sena et al., 2021)

1.2 Statement of the problem

The purpose of monetary policy on the economic development and changing the whole economic activity depend on how monetary policy is running and the independency of the national bank to choose the appropriate monetary instruments to formulate the monetary policy of macroeconomic objectives(Alavinasab, 2016). The precise data on the adequacy of the arrangement on the large scale economy is the most issue of the approach creator to effectively usage of any economic policy in common to attain the dependable yield development, the specialist and arrangement creator continuously targets on the middle factors incorporate the brief term intrigued rate, cash supply, exchange rate and residential credit that are considered as the foremost capable instrument of financial approach(Srithilat & Sun, 2017). According (Bekele, 2024) the results revealed how that real GDP was positively and significantly affected by the real effective exchange rate, money supply, gross capital formation (investment), credit for private sector, trade of openness Over the long term, both the real lending interest rate and the consumer price index (a measure of inflation) exhibit a significant negative impact.

In Ethiopia, the National Bank of Ethiopia's efforts to use monetary policy tools to achieve macroeconomic stability, there is limited empirical research on the effectiveness of these tools within the Ethiopian context. Specifically, the channels through which monetary policy impacts inflation, output, and other economic variables are not well-defined. This lack of clarity hinders the ability of policymakers to design and implement effective monetary policies that can stabilize the economy and foster sustainable growth. Therefore, the study is to empirically analyze the effectiveness of the monetary policy transmission mechanism in Ethiopia by employing a Vector Autoregressive (VAR) model and examining the dynamic relationships between key monetary and macroeconomic variables, this research seeks to provide a comprehensive understanding of how monetary policy impacts the Ethiopian economy. Specifically, the study focused to analyze the factors affecting monetary policy transmission mechanism in Ethiopia, to evaluate short run relationship monetary policy and its determinants, and to forecast monetary policy (GDP) in Ethiopia based on its determinants.

Hypothesis

In this study the empirical relationship between inflation rate and its determinants in Ethiopia was investigated. The testable hypotheses are that:

- Null Hypothesis(H_0): there is no significant relationship between monetary policy and its determinants in the short-run.
- Alternative Hypothesis(H_1): there is significant relationship between monetary policy and its determinants in the short-run.

2. Methodology

2.1 The data type and variables of the study

This study was utilized secondary data that collected from National Bank of Ethiopia (NBE), Central Statistical of Agency (CSA) and World Bank. The data points were spanned from 1995 to 2024. The study was considered macroeconomic variables which were expected to influence the monetary policy transmission mechanism in Ethiopia. These were gross domestic growth (GDP), money supply (M_2), real interest rate (RIR), and Consumer price index (CPI).

2.2 Model Specification

The multivariate time series analysis was employed to analysis effectiveness of monetary policy transmission mechanism in Ethiopia. Vector autoregressive (VAR) model was introduced by (Sims, 1980), serves as powerful tool for macroeconomists to characterize the joint dynamic behavior of a collection of variables without imposing the strong restrictions typically required to identify structural parameters. It has become widely used methods in time series modeling. Although estimating the equations of a VAR model does not require strong identification assumptions, several important applications of the estimates, such as calculating impulse-response functions (IRFs), conducting variance decompositions do require identifying restrictions. These restriction often takes the form of an assumptions about dynamic relationship between a pair of variables.

3.2.1 Stationary Vector Autoregressive Model

Let $Y_t = (y_{1t}, y_{2t}, \ldots, y_{nt})'$ denote a $(n \times 1)$ vector of time series variables. The basic p-lag vector autoregressive (VAR (p)) model has the form (Hamilton & Susmel, 1994):

$$\mathbf{Y_t = C + \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + \cdots + \Pi_p Y_{t-p} + \varepsilon_t,\ t = 1, 2, \ldots, T} \text{---------------------} (\mathbf{1})$$

where $\mathbf{C}$ denotes an $n \times 1$ vector of constants and $\mathbf{\Pi_j}$ is an $n\, x\, n$ matrix of autoregressive coefficients for $j = 1, 2, \ldots, p$. The $n\, x\, 1$ vector $\boldsymbol{\varepsilon_t}$ is a vector generalization of white noise:

$$\mathbf{E(\varepsilon_t) = 0}$$

$$\mathbf{E(\varepsilon_t, \varepsilon_s)} = \begin{cases} \mathbf{\Sigma, if\ s = t} \\ \mathbf{0, if\ s \neq t} \end{cases}$$

where $\mathbf{\Sigma}$ is an $(n\ x\ n)$ symmetric positive definite matrix with sample variance of $\mathbf{Y_{jt}}$ along the diagonal and sample covariance between $\mathbf{Y_{jt}}$ and $\mathbf{Y_{it}}$ along off-diagonal where j is not equal to i.

To build the mathematical formulation for monetary policy in the term GDP based on its determinants, which are real gross domestic growth (RGDP), money supply (M_2), exchange rate (ER), interest rate (IR), Consumer price index (CPI), the functional form of monetary policy has the following form:

$\mathbf{lnY_t = F(lnCPI, lnM_2, lnRIR,)}$; The reduced form of the VAR model can be written as follows:

$\mathbf{y_t = C_i + \sum_{j=1}^{4} \Pi_n y_t + v_t}$ **…………………………..…………………… (2)**

$\mathbf{y_t}$ is monetary policy in term of **Real GDP** $\mathbf{C_i}$ n x 1 vector of constants (intercepts), $\mathbf{\Pi_n}$ represents a $4\ x\ 4$ matrix of autoregressive coefficients for j = $1, 2, \ldots, 4$ and the $n\ x\ 1$ vector $\mathbf{v_t}$ is a vector of white noise:

To write the **mathematical form of the VAR (1) model** using **one lag**, we assume that all variables in the system (i.e., $\mathbf{lnY_t\ lnCPI, lnM_2, lnRIR}$) are endogenous. So, we set up a **VAR (1)** system as follows:

Let $y_t = lnY_t(e.g., output)$

$cpi = lnCPI$

$m_2 = lnM_2$

$rir = lnRIR$

Then the VAR (1) model is

$y_t = \alpha_1 + \mathbf{\Pi_1 \Delta LnRGDP_{t-1} + \Pi_2 \Delta LnCPI_{t-1} + \Pi_3 \Delta LnM2_{t-1} + \Pi_4 \Delta LnRIR_{t-1} + v_t}$ **…..…. (3)**

Where:

α_1 is intercept term for target variable ($\mathbf{\Delta LnRGDP_t}$) $\mathbf{\Pi_i}$ are autoregressive coefficients (i = 1,2,3,4), Δ is first differenced of lagged variables, Ln is natural logarithm.

3. Results and Discussions

The empirical analysis was done based on annual datasets on real gross domestic product (RGDP), on consumer price index (CPI), broad money supply (M2), real interest rate (RIR) for the period from 1995 to 2024 that were obtained from the National Bank of Ethiopia (NBE) database, the Central Statistical Agency (CSA) and https://data.gov/. The total of 30 observations were used for analysis. In this chapter, the results of the VAR model specification, applied to forecast GDP and assess the real sector impact of the monetary transmission mechanism, are presented. The results are interpreted and discussed accordingly. Finally, inflation was forecasted, and the overall data analysis was performed using EViews 9 and R.

3.1 Descriptive Analysis

In this empirical analysis, four aggregate series were used: real gross domestic product (RGDP), consumer price index (CPI), broad money supply (M2), and real interest rate (RIR). The time plots of these series are presented in Figure 4.1. Descriptive statistics—including the mean, standard deviation, coefficient of variation, minimum, and maximum values—were employed to summarize the data, as shown in Table 4.1.

According to the results, the average real gross domestic product (RGDP) over the past 30 years was 47.66, with a standard deviation of 44.77. Similarly, the average consumer price index (CPI) was 13.87, with a standard deviation of 10.92. These findings reveal that the coefficient of variation (CV) for the broad money supply (M2) exceeds one, indicating a high degree of variability in the data.

Table 3.1: Descriptive Statistics of Series: 1992 to 2021 (original data)

Series	Obs	Mean	Std.Dev	Min	Max	Skewness	Kurtoses	CV (%)
RGDP	30	47.66	44.77	7.84	163.55	0.94	2.78	0.9395
CPI	30	13.87	10.92	0.66	44.36	1.08	3.55	0.7873
M2	30	483646.5	678316.9	14763.08	2407485	1.56	4.34	1.4025
RIR	30	109.08	54.09	2.11	218.82	4.34	3.06	0.4959

3.2 Test of Stationarity

3.2.1 Unit Root Properties of Individual Series

The time series under consideration should be checked for stationarity before one can attempt to fit a suitable model. That is, variables have to be tested for the presence of unit root(s) thereby the order of integration of each series is determined. From **figure 4.1** suggests that the series of the endogenous variables display a non-stationary behavior, they still contain elements of trend.

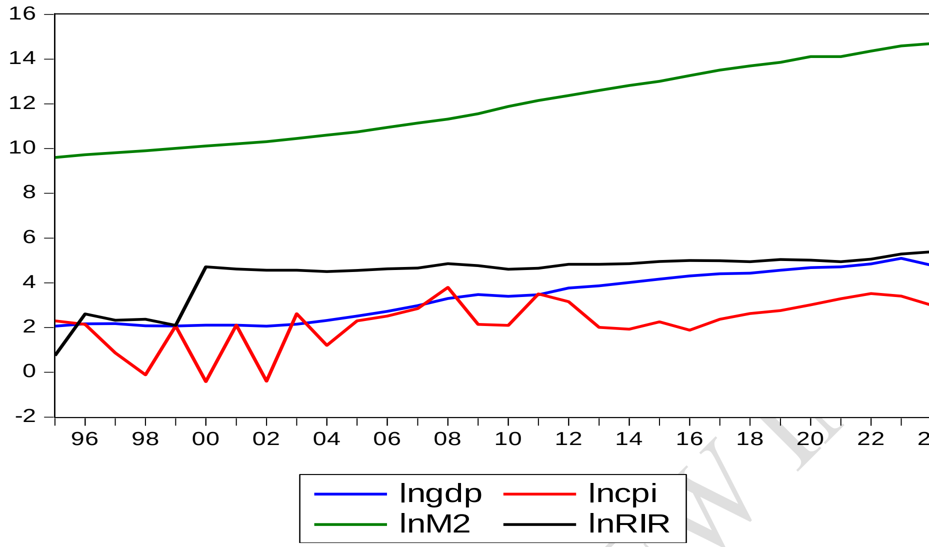

Figure 3.1: Time series plot of lnGDP, lnCPI, lnM2 and lnRIR at level

3.2.2 Augmented Dickey-Fuller (ADF) test and a Phillips and Perron (PP) test

The stationarity of the time series was examined using both the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test. The null and alternative hypotheses for the unit root tests are specified as follows:

- **H_0**: The series is non-stationary (contains a unit root)
- **H_1**: The series is stationary (does not contain a unit root)

The results of the ADF and PP tests at levels, with both intercept only and intercept with trend specifications, are presented in Table 3.1. The critical values used in the evaluation are based on MacKinnon (1996).

From the results in Table 3.1, it can be observed that for most of the series, the test statistics in levels are less negative than the 5% critical values, and their corresponding p-values are greater than 0.05. This implies that the null hypothesis of a unit root cannot be rejected at the 5% significance level, suggesting that the series in levels are non-stationary.

However, there are exceptions such as the LNCPI series, which shows significant test statistics in both ADF and PP tests under both specifications (intercept only and intercept with trend), with p-values well below 0.05. This indicates that LNCPI is stationary in levels.

Given that the majority of the series are found to be non-stationary in levels (as shown in Table 3.1), the same unit root tests were applied to the first differences of the series (illustrated in Figure 4.2). The order of integration, denoted as I(d), refers to the number of times a series needs to be differenced to achieve stationarity. The results from the differenced series indicate that all the variables become stationary after first differencing, implying that they are integrated of order one, I(1).

Table 3.2: Unit root test results (At level)

Series	**Level with Intercept**				**Level with Intercept and trend**			
	Test Statistic		Prob.*		Test Statistic		Prob.*	
	ADF	PP	ADF	PP	ADF	PP	ADF	PP
LNGDP	-0.085	-0.172	0.942	0.932	-1.982	-2.053	0.586	0.549
LNCPI	-3.726	-3.914	0.0089	0.0057	-5.708	-5.686	0.0003	0.0004
LNM2	-1.105	1.2278	0.6957	0.998	-3.963	-2.393	0.0255	0.3753
LNRIR	1.086	-5.328	0.9959	0.0002	-2.407	-7.1398	0.3655	0.0000
Critical value (5%)	-2.97				-3.59			

3.2.3 Unit root test after first differenced

The results presented in Table 4.3 indicate that the null hypothesis of a unit root is rejected for all five series in their first differences, at the 5% level of significance. This conclusion is based on both the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests, which include an intercept and trend. Specifically, the p-values obtained from the tests are less than 0.05, confirming statistical significance.

The graphical representation of the first-differenced series (Diff_lngdp, Diff_lncpi, Diff_lnM2, and Diff_lnRIR) further supports this finding. The series fluctuate around a constant mean and show no visible trend, which is consistent with stationarity in the first differences.

Therefore, the time series for real GDP (lngdp), consumer price index (lncpi), broad money supply (lnM2), and real interest rate (lnRIR) are all non-stationary in their levels but become stationary after first differencing. This implies that the variables are integrated of order one, denoted as I(1).

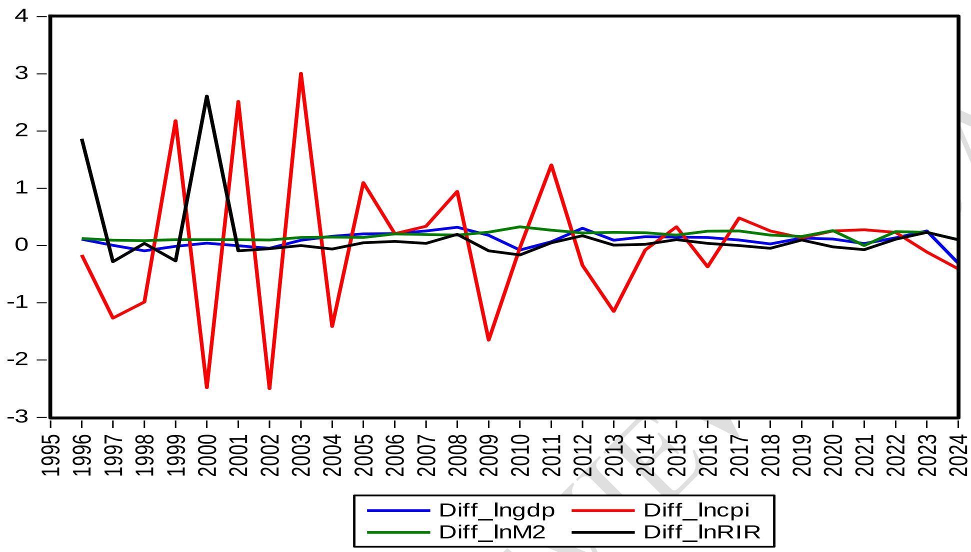

Figure 3.2: Time series plot of lnGDP, lnCPI, lnM2 and lnRIR (after first deference)

The unit root test results in Table 3.2 show that all four series of lnGDP, lnCPI, lnM2, and lnRIR become stationary after first differencing. This suggests that the variables are **integrated of order one, I(1)**. While some minor differences exist between the ADF and PP test results, especially for lnM2 and lnRIR, the overall evidence supports stationarity in the first differences.

Table 3.3: Unit root test results (After first differencing)

Series	Level with Intercept				Level with Intercept and trend			
	Test Statistic		Prob.*		Test Statistic		Prob.*	
	ADF	PP	ADF	PP	ADF	PP	ADF	PP
D(lnGDP)	-3.1298	-2.991	-3.050	0.0423	-2.610	-2.821	0.279	0.2019
D(lnCPI)	-12.366	-13.62	0.0000	0.0000	-12.218	-13.476	0.0000	0.0000
D(lnM2)	-1.566	-3.726	0.4851	0.0092	-1.099	-4.159	0.9099	0.0145
D(lnRIR)	-4.358	-7.915	0.0020	0.0000	-2.429	-9.886	0.3555	0.0000
Critical values (5%)	-2.97				-3.64			

MacKinnon (1996) one-sided p-values

Based on the VAR lag order selection results in Table 4.4, the VAR model that includes one lag (lag order 1) is optimal for the data. It outperforms the zero-lag model across several diagnostic criteria, notably showing improved log-likelihood, reduced prediction error (FPE), and lower information criteria values (AIC, SC, and HQ), along with a statistically significant improvement as evidenced by the LR test.

Table 3.4: VAR lag order selection results (EViews 9 software)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-106.9274	NA	0.024693	7.650162	7.838755	7.709227
1	21.32685	212.2828*	1.09e-05*	**-0.091507***	0.851456*	0.203817*

* indicates lag order selected by the criterion

LR: Likelihood ratio; FPE: Final prediction error; AIC: Akaike information criterion; SC: Schwarz information criterion HQ: Hannan-Quinn information criterion

3.3 Johansen Co-integration analysis

Based on the Johansen co-integration test results presented in Table 3.3, there is no strong evidence of co-integration among the variables at the conventional 5% significance level. For the null hypothesis of no co-integrating vector (r = 0), the Trace statistic (45.56190) is slightly below the 5% critical value (47.85613), with a p-value of 0.0808, indicating that the null hypothesis cannot be rejected at the 5% level. Similarly, the Maximum Eigenvalue statistic (27.23948) is just below its corresponding critical value (27.58434), with a p-value of 0.0553, again suggesting failure to reject the null hypothesis at the 5% significance level.

However, the p-values associated with the first rank are relatively close to the 5% threshold, indicating a possible weak co-integration relationship if a 10% significance level is considered.

For the hypotheses of at most one or two co-integrating relationships, both the Trace and Maximum Eigenvalue tests show much smaller test statistics relative to their critical values, and the corresponding p-values are substantially higher than 0.05, confirming the absence of additional co-integrating relationships.

Overall, based on these results, there is no strong evidence of co-integration among the variables at the 5% significance level, although a weak co-integration relationship may be present at the 10% level.

Table 3.5: Johansen Co-integration test results (By assumption: Linear deterministic trend)

Number of Co-integrating Vector	Eigenvalue	Trace Test			Maximum Eigenvalue Test		
		Statistic	**0.05 Critical Value**	Prob.	Statistic	**0.05 Critical Value**	Prob.
None*	0.635369	45.56190	47.85613	0.0808	27.23948	27.58434	0.0553
At most 1*	0.394889	18.32242	29.79707	0.5424	13.56329	21.13162	0.4019
At most 2	0.111863	4.759126	15.49471	0.8339	3.202998	14.26460	0.9323

Normalized co-integrating coefficients (standard error in parentheses)

LNGDP	LNCPI	LNM2	LNRIR
1.000000	0.039112	-0.715453	0.340745
	(0.06462)	(0.03101)	(0.04936)

Max-eigenvalue test indicates 1 co-integrating eqn(s) at the 0.05 level

denotes rejection of the hypothesis at the 0.05 level

MacKinnon-Haug-Michelis (1999) p-values

Source: Model output

After the Johansen co-integration test results revealed the absence of a co-integration relationship among the variables under study, the researcher proceeded with the Vector Autoregressive (VAR) model.

3.4 Estimating Vector Autoregressive (VAR) Model

When there is co-integration relationship between multivariate macroeconomic variables the appropriate model for estimating and forecasting is standard (unrestricted) VAR(1) model and under this study VAR Model with one lag was used:

$$\Delta LnRGDP_t = 0.728\Delta LnRGDP_{t-1} + 0.052\Delta LnCPI_{t-1} + 0.298\Delta LnM2_{t-1} + 0.013\Delta LnRIR_{t-1} - 0.944 \quad \text{.... Eq(i)}$$

LnRGDP equation model (Dependent Variable: GDP Growth):

The coefficient of real gross domestic product ($\mathbf{LnRGDP_{t-1}}$) is positive and significant, indicating persistence in gross domestic product growth over time, where coefficient of consumer price index ($\mathbf{LnCPI_{t-1}}$) shows weak positive effect, suggesting mild inflationary pressure on GDP. The coefficient of broad money supply ($\mathbf{LnM2_{t-1}}$) positive but statistically insignificant, implying money supply has limited short-term impact GDP. Additionally, the coefficient of real interest rate ($\mathbf{LnRIr_{t-1}}$) is insignificant, suggesting real interest rates do not strongly influence GDP in this model.

Based on VAR model results, R^2 and adjusted R^2 values for the short-run model are 98.8% and 98.3% respectively. This indicates that approximately 98.3% of the variation in real gross domestic product ($\mathbf{LnRGDP_{t-1}}$) is explained by explanatory variable in the short-run model.

3.5 Model Diagnostic Test

To ensure that the estimated model provides a valid and reliable representation of the underlying data-generating process, a series of model diagnostic tests must be conducted. These tests help identify any potential issues such as model misspecification, non-normality, autocorrelation, heteroscedasticity, or multicollinearity that could affect the validity of the model's inferences.

3.5.1 Test of residual autocorrelation

Table 4.6 presents the results of the Portmanteau Q-statistic and the Lagrange Multiplier (LM) test for detecting serial correlation in the residuals of the Vector Autoregressive (VAR) model. These tests assess whether the residuals exhibit significant autocorrelation up to a specified lag—in this case, lag 1. The LM test at lag 1 yields a p-value of 0.0641, indicating no strong evidence of residual autocorrelation at the 5% significance level. However, the result is marginal, lying close to the cutoff point, which may warrant further investigation.

It is crucial to note, as indicated in the table, that the test is valid only for lags greater than the VAR lag order. Since lag 1 is not greater than the selected VAR lag order, the validity of this result is questionable.

Table 4.6: Test of residual autocorrelation

Lags	Q-Stat		Adj-Q-Stat		LM-Stat	
	Value	Prob	Value	Prob	Value	Prob
1	6.516210	NA*	6.757551	NA*	25.33640	0.0641

*The test is valid only for lags larger than the VAR lag order.

Following the residual diagnostic tests, the stability of the VAR model was assessed using the inverse roots of the AR characteristic polynomial**.** As shown in **Figure 3.3**, all the inverse roots lie inside the unit circle. This indicates that the eigenvalue stability condition for the Vector Autoregressive (VAR) model is satisfied, confirming the stability of the fitted VAR model.

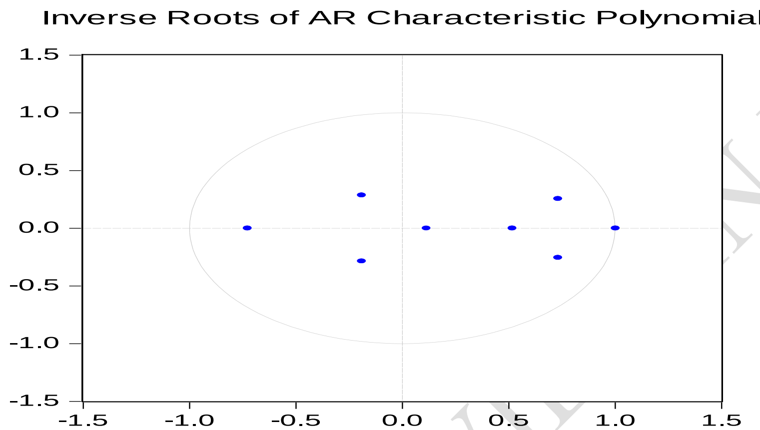

Figure 3.3: Eigenvalue stability condition

3.5.2 Test of Normality

To assess whether the residuals of the model follow a normal distribution, the multivariate Jarque-Bera test was employed. This test examines whether the skewness and kurtosis of the residuals significantly deviate from those expected under a normal distribution.

The results presented in **Table 4.7** indicates that for Component 2, the p-values for the Jarque-Bera test (0.7357), skewness (0.4336), and kurtosis (0.9776) are all greater than the 5% significance level, suggesting that the residuals of this component are normally distributed. However, for Components 1, 3, and 4, the p-values for the Jarque-Bera tests are less than 5%, indicating rejection of the null hypothesis of normality. Particularly, skewness and kurtosis measures for these components also have p-values below 5%, pointing to significant deviations from normality.

Therefore, the normality test results show that only Component 2 meets the normality assumption, as indicated by high p-values for the Jarque-Bera, skewness, and kurtosis tests. In contrast, Components 1, 3, and 4 significantly deviate from normality, with low p-values across the tests. Additionally, the joint test strongly rejects the assumption of multivariate normality across all components. It is also important to note that conclusions about serial correlation cannot be drawn from these tests, as they assess normality, not autocorrelation.

Table 3.7: Normality Tests

Components	**Jarque-Bera**	**Prob**	**Skewness**	**Prob**	**Kurtosis**	**Prob**
1	29.02515	0.0000	-1.676168	0.0003	6.693311	0.0001
2	0.613852	0.7357	0.362452	0.4336	2.974048	0.9776
3	9.204318	0.0100	-1.083291	0.0193	4.787550	0.0535
4	31.38543	0.0100	1.471833	0.0015	7.270436	0.0000
Joint	70.22875	0.0000	29.31004	0.0000	40.91871	0.0000

The **figure 3.4** shown below is actual and forecasted values plot for growth domestic product (GDP). The GDP forecast shows a continued upward trend over the next 5 years, following consistent historical growth. While the central forecast suggests moderate growth, the widening shaded area reflects increasing uncertainty over time. The model provides a realistic projection with confidence intervals, highlighting that near-term forecasts are more reliable than long-term ones.

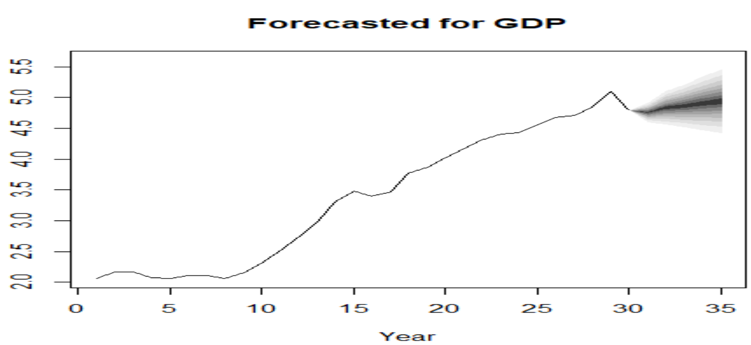

Figure 3.4: forecasted and actual values plot of GDP

4. Conclusion and Recommendation

4.1 Conclusion

This study analyzed the dynamic relationships among real gross domestic product (RGDP), consumer price index (CPI), broad money supply (M2), and real interest rate (RIR) using annual time series data from 1995 to 2024. The key findings are summarized as follows:

Descriptive results revealed that significant high degree fluctuation in money supply. These descriptive insights underscore the underlying volatility and dynamics of the selected macroeconomic indicators throughout the study period. Stationarity Tests (ADF & PP) confirmed that all variables were non-stationary at levels but became stationary after first differencing (I(1)), supporting the use of differenced data for analysis. Johansen Co-integration Test suggested no strong long-run equilibrium relationship at the 5% significance level, though weak co-integration was observed at the 10% level. Vector Autoregressive (VAR) Model Estimation showed that the past GDP growth ($\Delta \mathbf{LnRGDP_{t-1}}$) had a significant positive impact on current real gross domestic product (RGDP), CPI, M2, and RIR had statistically insignificant short-term effects, indicating limited immediate influence on GDP. The model exhibited high explanatory power (adjusted R^2 = 98.3%), capturing most short-run variations. Diagnostic Tests confirmed model stability (all inverse roots within the unit circle) and no severe autocorrelation (LM test p-value = 0.0641). However, residual non-normality in some components suggests potential model refinements. GDP Forecasts projected a continued upward trend, though with increasing uncertainty over longer horizons.

4.2 Recommendations

Based on the findings of the empirical study, the following policy recommendations are proposed:

- Ethiopian policymakers should prioritize long-term structural reforms such as infrastructure, education, innovation, and institution, improvement to enhance productivity, competitiveness, and build a resilient, inclusive economy that can withstand external shocks.
- The empirical findings indicate that the consumer price index (CPI) and broad money supply (M2) have statistically insignificant short-term effects on GDP growth in Ethiopia. This suggests that aggressive monetary policy measures—such as sharp interest rate adjustments or large-scale liquidity injections—may have limited immediate influence on economic growth and could increase macroeconomic volatility.
- The National Bank of Ethiopia should balance inflation control with sustainable economic growth, especially during uncertain times, while ensuring strong coordination with fiscal authorities for effective macroeconomic management.

- To enhance monetary policy transmission in Ethiopia, financial markets should be deepened, access to financial services expanded, and financial institutions strengthened, with a focus on promoting financial inclusion in rural and underserved areas.
- Regular monitoring of macroeconomic indicators and investment in quality, timely data are essential for informed policymaking. Using forward-looking models and scenario analysis will enhance the effectiveness and flexibility of Ethiopia's monetary policy in responding to changing economic conditions.

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