International Journal of Research in Finance and Management

P-ISSN: 2617-5754
E-ISSN: 2617-5762
IJRFM 2023; 6(1): 94-100
Received: 10-10-2022
Accepted: 13-11-2022

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Uncovering the roots of Nepalese inflation: An empirical investigation

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DOI: https://doi.org/10.33545/26175754.2023.v6.i1b.200

Abstract
Nepal's reliance on imports and its vulnerable position to external economic shocks, understanding the factors that drive inflation is especially important in order to ensure stability and competitiveness in the country's economy. This research aims to explore the factors that influence inflation in Nepal over the period from 2000 to 2021. To do so, we analyzed the relationship between the current account, government expenditure, money supply, and inflation using empirical methods and statistical techniques such as the OLS method and ADF test for stationarity, as well as static forecasting and a VAR model. We hypothesized that a deficit in the current account, high levels of government expenditure, and an increase in the money supply may contribute to higher domestic inflation. Our analysis revealed that there was high multicollinearity and non-stationary time series data, but the regression model had satisfactory predictive power. Additionally, we found that an exogenous shock to inflation had an immediate effect on government expenditure, current account, and money supply, and there was a unidirectional causality between inflation and money supply. These findings can help policymakers make informed economic decisions to minimize negative impacts on Nepal's economy.

Keywords: Inflation, current account, economic shocks, VAR model, static forecasting

Introduction
Inflation is a trend of rising prices in an economy over time. It can be seen as a continuous increase in the general price level of goods and services, or as a decline in the value of money and other fixed-priced assets. According to Kimani and Mutuka (2013) [8], inflation is a prolonged increase in the overall price level. Economic development relies on sustained growth in production and employment, which can be disrupted by unstable prices. To measure the rate of inflation, economists often use the consumer price index and GDP deflator. High levels of inflation can be detrimental to economic development as they can cause instability and turmoil in the economy.

The balance of payments (BOP) is a record of a nation's international financial transactions over a specific period of time. It includes all exchanges of money between domestic and foreign individuals, businesses, and government entities. In general, the BOP comprises of capital account, current account, and financial account, and includes trade of goods, services and capital, along with the transfer of funds through payments like remittances and foreign aid. The BOP and a nation's net international investment position (NIIP) together make up its international accounts. Imbalances and changes in the items included in the BOP can impact a country's internal economic balance.

The current account is a part of the balance of payments (BOP) and incorporates transactions in goods, services, investment income, and current transfers. The trade balance, which is the difference between a country's exports and imports, is a key element of the current account and can have significant impacts on commodity, labor, monetary, and financial markets. A trade deficit, where imports exceed exports, can contribute to higher domestic inflation as imported goods can drive up domestic prices (Alawin & Oqaily, 2017) [1]. However, the current account is not solely influenced by the trade balance. Other components such as balance of services and current transfers can also impact the domestic economy. For example, current transfers such as workers' remittances and foreign aid can help stimulate economic growth by providing much-needed liquidity for production, consumption and development.

Nepal is small in size and underdeveloped nation with a liberal economic policy. It is reliant on imports to support its economic development, but its exports, which primarily consist of soybean oil, cardamom, and some seasonal agricultural products, have limited competitiveness on the global market. Furthermore, Nepal's decision to peg its exchange rate to the Indian currency makes it difficult to use the exchange rate as a buffer against external shocks to the local economy. Overall, Nepal's reliance on imports and its exposure to external shocks make it vulnerable in terms of economic stability.

Our paper aims to identify the key factors influencing inflation in Nepal over the period 2000 to 2021 by analyzing the association between the current account, government expenditure, money supply, and inflation, in order to provide policymakers with the necessary information to implement effective economic policies that can prevent negative impacts on the local economy.

Literature Review

The current account is a measure of a nation's international trade and financial transactions, including the import and export of goods and services, payments made to foreign investors, and foreign aid payments. If a nation is a net exporter of goods and services, it will have a positive (surplus) current account. On the other hand, if it is a net importer, it will have a negative (deficit) current account. A current account deficit can either decrease or increase inflationary pressure depending on its impact on import and export prices, as well as domestic demand for imported goods and services (Alawin & Oqaily, 2017) [1]. Likewise, Chude and Chude (2015) [4] have found that foreign aid and market access can contribute on economic growth, but they also deteriorate the regulation of currency supply and domestic inflation.

There are various factors that can affect the current account, including trade and current transfers such as foreign aid and workers' remittances, and these can impact inflation and current account in following ways (Alawin & Oqaily, 2017) [1]: Imports can have a dual impact on inflation in the domestic economy. Firstly, they can contribute to "imported inflation," which occurs when an economy has structural imbalances, such as food or energy shortages, that necessitate importing goods. Imported goods can also drive up domestic prices. On the other hand, imports can also decrease inflation by helping to satisfy domestic demand, which can reduce excess demand and lower prices.

If exports decrease, either due to decreased demand for national products or weak competitiveness in global markets, the cash flow of the export sector will also decrease. This will lead to lower income for the government through taxes on exports and workers in this sector, undermining its ability to fund its expenditures. In the short term, the government may turn to borrowing or increasing the supply of money to finance its budget deficit, which can put upward pressure on inflation (Zaki, 1980) [10].

Thirdly, a reduction in current transfers such as foreign aid or workers' remittances will reduce the financial resources for financing projects and development programs available to the economy that consequently lower inflationary pressure as well as consumer and investment demand.

Thus, Alawin and Oqaily (2017) [1] pointed that in the long run, widening of the current account gap can have a negative impact on domestic inflation. A current account deficit may reduce inflation by absorbing excess domestic demand, and the economy's ability to produce alternatives to imported goods in the long run, but it may cause a positive impact on inflation in the short run because of the difficulty to produce substitute goods quickly to balance the effect of imports on prices.

Methodology

In this paper, we delve into identifying the key factors influencing inflation in Nepal over the period 2000 to 2021 by analyzing the relationship between the current account, government expenditure, money supply, and inflation obtained from the Nepal Rastra Bank. To ensure the validity of our findings, we utilize a range of statistical methods including the Ordinary Least Squares (OLS) method, normality test, correlation analysis, multicollinearity test, heteroscedasticity test, Chow test, and specification bias diagnostic tests (Brooks, 2002) [2]. Additionally, we perform a time series stationarity test using the Augmented Dickey-Fuller (ADF) method to verify that our data is suitable for the OLS analysis (Engle and Granger, 1987). In addition to static forecasting, we also employ the Vector Autoregression (VAR) model to further investigate the association between the current account, government expenditure, money supply, and inflation in Nepal. In this paper, the data is organized in Microsoft Excel and imported into Eviews to be analyzed and produce results.

Econometric Model Specification

This paper incorporates the following logarithmic equation (log-linear model) as prescribed by (Alawin and Oqaily, 2017) [1] to assess the relationship between current account, government expenditure, money supply, and inflation in Nepalese economy for the period (2000- 2021):

$$LnCPI = \alpha 0 + \alpha 1 LnRCAt + \alpha 2\ LnRERt + \alpha 3 LnRGt + \alpha 4 LnRMt + Ut$$

In this equation, the natural logarithm of the Consumer Price Index (LnCPI) is being analyzed in relation to natural logarithms of the real current account (LnRCA), real exchange rate (LnRER), real government expenditure (LnRG), and real broad money supply (LnRM). The error term (U) and the model's parameters (αi) are also included, as well as the current time period (t). The goal is to understand the relationship between these variables.

The following describes the hypothesized association among the variables

1. α1 measures effect that a current account deficit has on local inflation. The deficit may be caused by increase in imports that can contribute to imported inflation, or by a decrease in exports, which can lead to lower economic growth and reduced prices. The overall impact on inflation is determined by how these various factors interact with each other.
2. α2 measures impact of real exchange rate of the Nepalese currency on local inflation. An increase in the real exchange rate, which signifies the depreciation of the domestic currency, is anticipated to have a positive

sign which means that more domestic currency is needed to purchase foreign currency, which can lead to higher prices for imported goods and put upward pressure on local inflation.

3. α3 measures impact of government expenditure on local inflation. High levels of government spending can boost aggregate demand and lead to higher domestic prices, and is anticipated to have a positive sign.
4. α4 measures effect that money supply has on local inflation. It is anticipated to have a positive sign because an increase in money supply can lead to increased aggregate demand and put upward pressure on local prices if the aggregate supply remains fixed.

In this study, all variables are transformed into natural logarithms for analysis purposes. However, a constant value was added to the current account variable, which had negative values, before taking its natural logarithm. The exchange rate variable was not included in the analysis due to a lack of sufficient data for the sample period. Furthermore, since the Nepalese currency is pegged to the Indian currency, the impact of the exchange rate is assumed to be insignificant.

Based on a review of the literature and the conceptual framework applied in this paper, the following hypotheses were developed to address the research question.

H_1: There is significant relationship between Current account and Inflation.

H_2: There is significant relationship between Government Expenditure and Inflation.

H_3: There is significant relationship between Money Supply and Inflation.

Analysis and Results

Regression Analysis

The data was analyzed using the Ordinary Least Squares method, and the outcome of the regression analysis is shown in table 1. The model fit, as measured by the adjusted R-squared value, is 99.7%, indicating that the regressors have a high ability to explain the dependent variable. However, a high R-squared value (above 0.8) and few significant t-ratios may indicate multicollinearity. In this case, only two variables were found to be significant at the 5% level of significance. Therefore, a multicollinearity test is warranted.

Table 1: Ordinary least square

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Current Account	0.036483	0.008973	4.065930	0.0008
Govtexpn	0.086694	0.072018	1.203772	0.2452
Money Supply	0 *366996*	0.067073	5.471574	0.0000
C	-2.312727	0.179652	-12.87336	0.0000
R.-squared	0997043	Mean dependent var		4.259524
Adjusted A-squared	0996522	S.D. dependent var		0.453778
S.E. of regression	0.026763	A kai ke info criterion		-4.233936
Sum squared resid	0.012177	Schwarz criterion		-4.034979
Log likelihood	48.45632	Haman-Quinn criter		-4.190757
F-statistic	1910.885	Durbin-Watson stat		1.65 7149
Prob.(F-statistic)	0.000000			

Normality Test: The Jarque Bera normality test indicates that the residuals are normally distributed. The test did not reject the null hypothesis, which assumes that the residuals are normally distributed, since the P-value of the test statistic was 0.88, which is higher than the 5% level of significance. This can be observed in figure 1, which shows the normal distribution of the residuals.

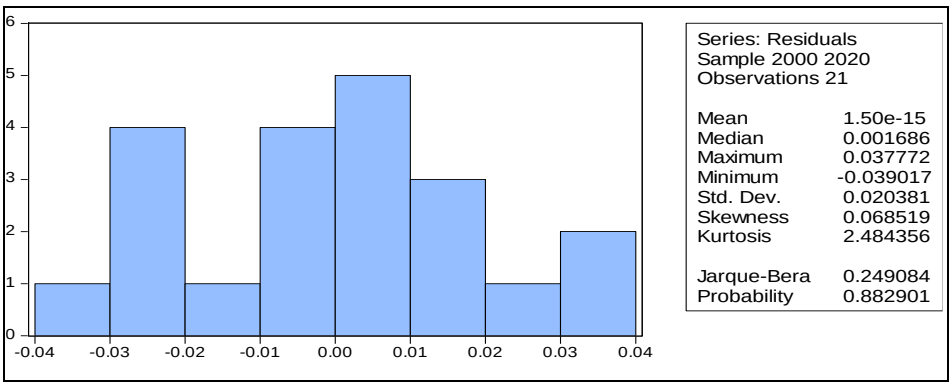

Fig 1: Normally test

Heteroskedasticity Test

The Breusch-Pagan test for heteroskedasticity did not reject the null hypothesis at the 5% level of significance, revealing that there is no issue of heteroscedasticity in the model. This result is presented in table 2.

Table 2: Heterokedaticity Test: Breusch-pagan-godgrey

F-statistic	0.639733	Prob. F (4, 16)	0.6418
Obs*R-squared	2.895508	Prob. Chi-Square (4)	0.5755
Scaled explained SS	1.247482	Prob. Chi-Square (4)	0.8702

Autocorrelation Test

The Breusch-Godfrey Serial Correlation LM test did not reject the null hypothesis at the 5% level of significance, revealing that there is no issue of autocorrelation in the model. This result is presented in table 3.

Table 3: Breusch-godgrey serial correlation LM test

F-statistic	1.988638	Prob. F (2, 14)	0.1737
Obs*R-squared	4.646020	Prob. Chi-Square (2)	0.0980

Ramsey Reset Test: The Ramsey Reset test revealed that it failed to reject the null hypothesis at a 5% significance level, suggesting that the model is correctly specified and does not have a model specification error. This result is presented in table 4.

Table 4: Ramey reset test

	Value	Df	Probability
t-statistic	0.452475	15	0.6574
F-statistic	0.204734	(1, 15)	0.5936
Likelihood ratio	0.24689	1	0.5936

Chow Test

The 2015 earthquake in Nepal had a significant impact on the economy, and the Chow test was used to determine whether there were any structural changes as a result. However, the Chow Breakpoint test at the year 2015 did not find sufficient evidence to reject the null hypothesis at a 5% significance level, with a p-value of 0.0395, indicating that there were no structural changes in the models and a dummy variable was not necessary. Similarly, Nepal was also affected by COVID-19 in 2019, but due to a smaller sample size, it was not possible to detect any structural changes. This result is presented in table 5.

Table 5: Chow breakpoint test 2015

F-statistic	3.448188	Prob. F(4, 13)	0.0395
Likelihood ratio	15.18682	Prob. Chi-$ Square (4)	0.0043
Wald statistic	13.79275	Prob. Chi-$ Square (4)	0.0080

Correlation analysis

The result of correlation analysis found that inflation had a statistically significant positive association with government expenditure and broad money supply at a 5% significance level, but a negative and statistically insignificant relationship with the current account. This result is presented in table 6.

Table 6: Correlation matrix

	Inflation	Current account	Govt. Expn.	Money supply
Current account	-0.471517	1		
Govt. Expn	0.995018 (0.0000)	-0.510301 (0.0181)	1	
Money supply	0.996831 (0.0000)	-0.520840 (0.0155)	0.996249 (0.0000)	1

Multicollinearity Test

High multicollinearity among the variables in a model can be indicated by a high variance inflation factor (VIF), which is generally considered to be above 10 when the model's R2 value is above 0.90. In this case, government expenditure and broad money supply had a high level of multicollinearity, while the current account did not. To address this issue, the study applied a log transformation to the data and also considered using a difference transformation. The difference transformation can also make a non-stationary time series stationary, which is discussed further in the analysis of the VAR model.

Table 7: Multicollinearity Test

Variable	Coefficient variance	Uncentered VIF	Centered VIF
Current account	8.05E-05	373.3414	1.391044
Govt. Expn	0.005187	24040.53	135.3589
Money supply	0.004499	24888.31	137.3774

Static Forecasting: In order to make reliable predictions about the future, we're using a regression model and a dataset spanning from 2000 to 2020. While we're using the data from 2000 to 2018 to fine-tune our model, we'll be using the data from 2019 to 2020 to put our model to the test and see how well it can forecast. To make sure our model is ready for forecasting, we checked for any potential biases that could affect its accuracy, including serial correlation, heteroscedasticity, and abnormal residuals. Jarque-Bera test revealed that the residuals were normally distributed, the Breusch-Godfrey Serial Correlation LM test showed no evidence of autocorrelation, and the Breusch-Pagan test failed to reject the null hypothesis of homoscedasticity. Our analysis has given us the green light to proceed with forecasting, as our model has been determined to be free from serial correlation, heteroscedasticity, and any issues with normal residual distribution. The regression model's ability to accurately forecast inflation is indicated by its small root mean square error (RMSE) of 0.084. The RMSE measures the difference between predicted and actual values, with a small value indicating a high level of accuracy. In this case, the model's small RMSE suggests it is performing well in its inflation prediction capabilities.

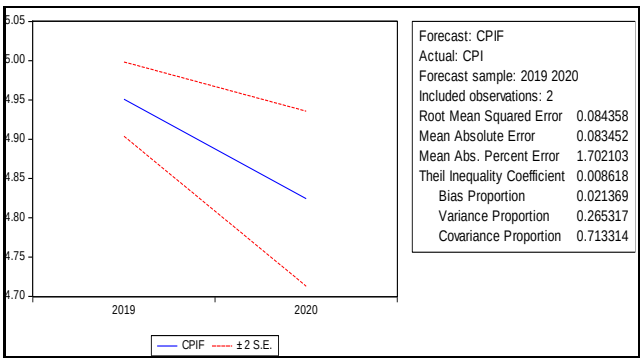

Fig 2: Forecasts: Root mean squared error

Furthermore, the accuracy of our forecasting model is examined through the alignment of actual and forecasted inflation values over time. A close alignment between these values suggests that the model is performing well and accurately predicting inflation. Based on the graph, it seems that the actual and forecasted values are closely aligned, with a small forecasting error. This indicates that the model has a satisfactory ability to predict inflation.

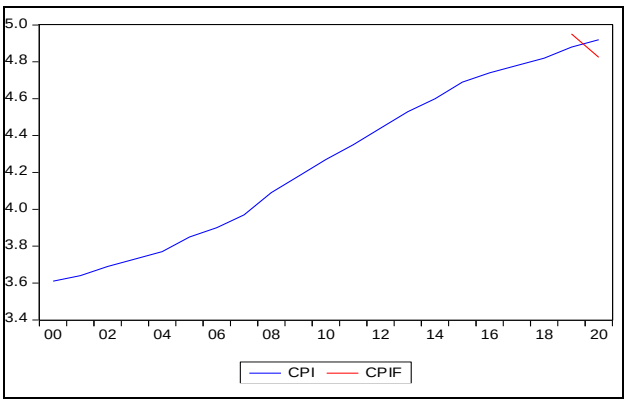

Fig 3: Forecasts graph

VAR model

Vector autoregressive (VAR) models are used to analyze the linear relationships between multiple time series. They are an extension of univariate autoregressive models, which only consider one variable, and represent each variable in the model as a combination of past values and the past values of other variables in the model, as well as an error term. VAR models are useful for data analysis and forecasting, as they allow for consistent and credible evaluation of the relationships between variables and the impacts of policy changes. In this study, we've set up a VAR model to investigate the factors that influence inflation by analyzing relationship between the current account, government expenditure, money supply, and inflation.

To analyze time series data using a VAR model, the following steps are followed:

1. The stationary nature of each individual variable is tested.
2. The lag-length selection criterion is used to determine the number of previous values that are considered in the VAR model for predicting the current value.
3. A VAR model with the optimal number of lags, as determined by the lag-length selection criteria, is constructed.
4. The Lagrange Multiplier test is used to evaluate the correlation among the residual errors (residual autocorrelation) in the VAR model.
5. The stability of the VAR system, or the ability of the model to accurately forecast future values, is evaluated using an autoregressive (AR) roots graph.
6. A test for determining causality between variables, called the Granger causality test, is carried out.

Testing of Stationary

Before constructing a VAR model, it's important to check that the time series data is stationary, as non-stationary data could lead to incorrect statistical properties in the model. To test for stationarity, we can use the augmented Dickey-Fuller test (ADF). This statistical test checks whether the statistical properties of a time series remain constant over time or if it is stationary. Ensuring that the time series data is stationary is crucial for building an accurate VAR model and correctly capturing the patterns in the data.

According to Table 8, the ADF test found that inflation, current account, government expenditure, and broad money supply all had unit roots at the level. However, when the test was repeated using the first difference of the data, the results were insignificant for government expenditure and broad money supply, with p-values less than 5%. Additionally, both inflation and current account were insignificant when using the second difference. These results suggest that the data is stationary in both the first and second differences.

Table 8: ADF unit root rest

	Intercept level	First difference	Second difference
Inflation	0.034 (0.95)	-2.468 (0.13)	-5.98
Current account	-0.27 (0.91)	0.84 (0.99)	-12.11 (0.00)
Govt. Expn	0.078 (0.95)	-3.18 (0.04)	
Money supply	1.40 (0.99)	-3.45 (0.02)	

Selecting Lag Length

When building a vector autoregressive (VAR) model, we need to decide how many previous observations (lags) to include as predictors. One common approach is to begin with large number of lags and apply restrictions to identify a more parsimonious model with fewer lags. However, it's important to strike a balance and not include too few lags, which could lead to auto correlated errors, or too many lags, which could cause over fitting and increase mean-square-forecast errors (Lütkepohl, 2005). Choosing the right number of lags is crucial for making accurate inferences using a VAR model.

According to Table 9, the optimal lag length for this annual data set is one, as it results in the minimal AIC value and passes the test for residual autocorrelation.

Table 9: VAR lag order selection criteria

Lag	Log L	LR	FPE	AIC	SC	HQ
0	58.70986	NA*	2.69e-08*	-6.078873	-5881013*	-6.051591*
1	75.08576	23.65407	2.74e-08	-6.120640*	-5.131338	-5.984228

*Indicates lag order selected by the criterion
LR: sequential mondified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Residual Autocorrelation

To ensure that our VAR model is reliable, we used the Lagrange Multiplier (LM) test to check for residual serial correlation, or correlation between the residual errors in the model. Ideally, VAR model should have residuals that are uncorrelated and do not show autocorrelation. If there is autocorrelation in the residuals, it could indicate the model is lacking important information, such as having too few lags included.The null hypothesis of the LM test is that there is no serial correlation in the residuals of a statistical model up to a certain lag order, meaning that the effect of past values on the future value of the variable is not considered until the designated lag value in the VAR model. Both Table 10 and the VAR Lag Order Selection Criteria test suggest that there is no serial correlation at lag order 1, so we used this lag order for our analysis.

Table 10: VAR Residual serial correlation

Lags	LM-Stat	Prob
1	24.2172	0.0839
2	39.57757	0.0009
3	8.448496	0.9344
4	12.07783	0.7386
5	21.69122	0.1534
6	18.37198	0.3026
7	22.21619	0.1363
8	14.12256	0.5896
9	20.51363	0.1980
10	15.15850	0.5131
11	31.36413	0.0121
12	31.42388	0.0119

Probs from chi-square with 16 df.

To evaluate the stability and forecasting ability of our VAR system, we examined the roots of the characteristic polynomial using variables such as inflation, current

account, government expenditure, and broad money supply, along with a specified number of lags. By visually assessing the roots of the characteristic polynomial, we can determine the stability of the VAR model. If all roots of the characteristic polynomial lie within the unit circle, it means the stability condition is met and the model can accurately forecast future values. From the Figure 5, it is revealed that VAR model satisfies model stability.

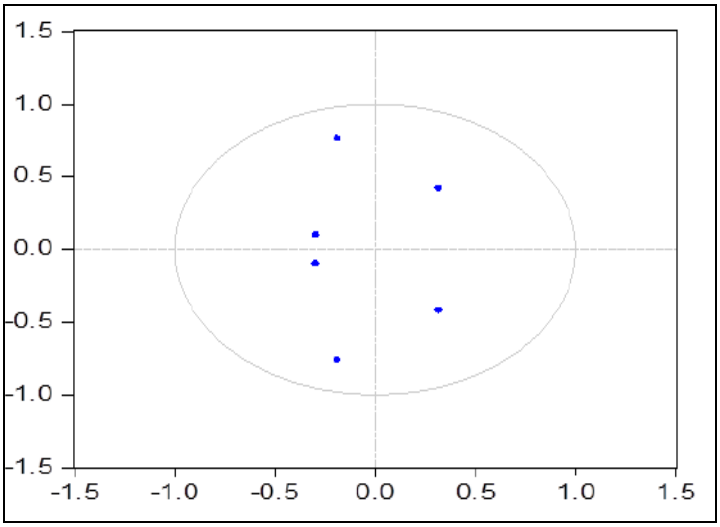

Fig 4: Inverse roots of AR characteristic polynomial

To gain a deeper understanding of the relationships between the variables, we conducted impulse response analysis and Granger causality tests. Impulse response analysis looks at how a system responds to a sudden change in one of its variables, while Granger causality tests determine whether one time series can be used to predict another. These analyses allowed us to better understand the dynamics of the variables and their relationships with each other.

Impulse response Function: Figure 6 shows that a sudden change in inflation (Exogenous shock) has an immediate impact on government expenditure, current account, and broad money supply, indicating that inflation can influence the other variables in the system.

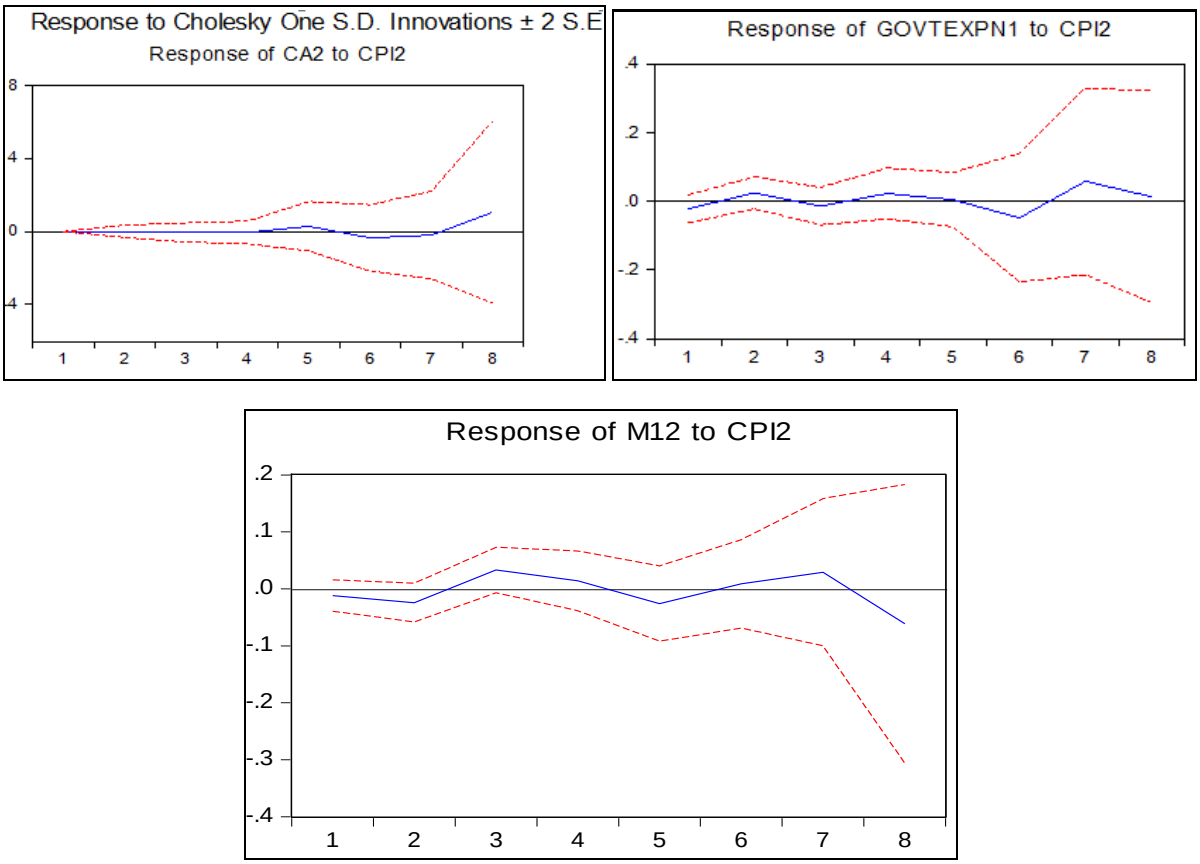

Fig 5: Impulse response function

Granger Causality Test

To understand the causal relationship between inflation and the other variables, we conducted a Granger causality test to identify the presence or absence of unidirectional and bidirectional forms of causality.

Table 11 demonstrates the lack of unidirectional or bidirectional causality between inflation and current account, as well as between inflation and government expenditure. The results also suggest that money supply is not influenced by inflation, but that fluctuations in inflation can be observed in money supply after a month. These findings are supported by p-values that are higher than the 5% level of significance, indicating that there is no causality running from either inflation or current account to the other, or from inflation or government expenditure to the other. However, a unidirectional causality running from inflation to money supply was found at the 10% level of significance.

Table 11: Granger causality between inflation, current account, government expenditure and money supply

Null hypothesis	F-Statistic	Prob.
Inflation does not granger cause current account	0.21890	0.8065
Current account does not granger cause current account	0.11173	0.8952
Government expenditure does not granger cause inflation	0.29771	0.7478
Inflation does not granger cause government expenditure	0.87428	0.4421
Money supply does not granger cause inflation	0.25245	0.7809
Inflation does not granger cause money supply	3.46871	0.0647

Conclusion

This paper analyzed the factors that impact inflation in Nepal using a regression model, which was estimated using ordinary least squares (OLS) methods. To assess the model, various statistical tests such as regression analysis, normality, heteroscedasticity, autocorrelation, model specification, and multicollinearity tests were conducted. Results showed that the model could be estimated using OLS, but high levels of multicollinearity were found. The study also tested the stationarity of the time series data to ensure the accuracy of results. Furthermore, this paper also incorporated static forecasting methods and a VAR model to predict the behavior of variables, such as government spending and the current account, in response to changes in inflation. The results showed that the VAR model was effective at making predictions, and the impulse response analysis indicated that shocks to inflation had an immediate effect on other variables. The Granger causality test found no causal relationship between inflation and current account or between inflation and government expenditure, but there was a unidirectional causality between inflation and money supply. These findings can help policymakers in Nepal make informed economic decisions that minimize negative impacts on the country's economy.

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