Multivariate Time Series Analysis of Inflation rate

Change, Exchange Rate Change and Nifty 50 Index Change using VAR

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MADRAS SCHOOL OF ECONOMICS

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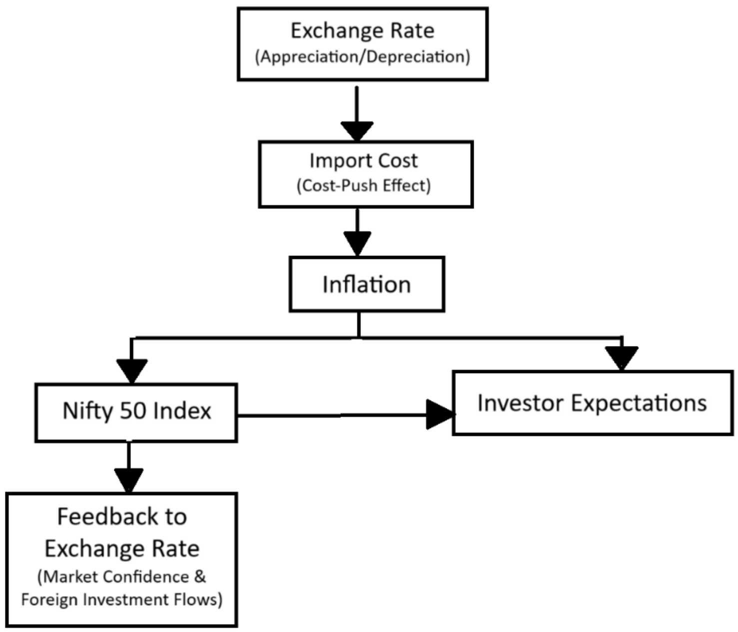
1. Introduction

An analysis of how dynamic relations between inflation and the Nifty 50 stock market performance determine exchange rates in India will yield insight into the nature of how such crucial macroeconomic variables unfold and are intertwined within the fabric of a developing economy. Depreciation in the exchange rate is one of the primary causes of inflation in India, and the essential mechanism is cost-push in relation to import prices, especially those related to essential commodities like oil. Increased import costs feed through into general price levels and add to inflation. The Nifty 50 index also provides insight into investor sentiment and gauges the macro-level aggregation of economic expectations. By changing stock market performance, indirect effects on inflation would be experienced due to investor confidence impacting the aggregate demand and, hence inflation level. However, for appropriate modelling of the relationships between these variables, it becomes quite essential that one uses strong econometric techniques which will capture both direct and indirect relationships. All variables-inflation, exchange rate, and Nifty 50 returns-are stationary or integrated at order zero, I (0), in this study. Considering this, a VAR model is suitable for the analysis of such relationships as it is built to model the dynamic interactions between stationary time series without concern for cointegration and which is actually more relevant to I(1) data. The VAR model considers each variable endogenous; that is, inflation, exchange rates, and stock market returns all have the ability to influence one another in the system. This kind of approach, easily aligned with the real-world interdependencies of these variables since movements in exchange rates, stock market returns, and inflation can themselves both be causes and effects depending on the context, makes VAR that much more suitable to capture the complexity of economic dynamics in India. It conducts the Granger causality test being one of the most important features of the VAR model in this study. With the Granger causality analysis, it is possible to check whether the past values of one variable could help predict other variables. For instance, we may examine if past fluctuations in the exchange rate assist in predicting the inflation trend or whether inflation influences subsequent periods' returns for the Nifty 50. The Granger causality test does not establish causation in the strictest sense but indicates the presence of a predictive influence between the variables. Information from such a test will be very useful in identifying which economic factors are responsible for inflationary trends in India and how sensitive the economy is to movements in exchange rates and stock market performance. Such clues can guide the policymakers toward identifying the leading indicators for inflation and help investors anticipate shifts in the market. With the IRF provided by the VAR model, the analysis further deepens in observing how each variable interacts with shocks over time. An IRF may depict how inflation responds to a shock in the exchange rate or a surprise in the Nifty 50 index movement and track these responses over multiple time periods. Thus, for instance, in the case of a significant depreciation in the real exchange rate, the IRF may capture the amplitude and duration of inflation's response to this shock. One can also capture how a shock in stock market returns drives both inflation and the rates of exchange. These response paths provide both qualitative and quantitative insight into the way each variable responds once the unexpected changes have affected it, giving a timeline over the immediate and lagged effects of an economic shock. This kind of insight for variables regarding times of reaction and intensities helps policymakers and investors realize the potential effects occasioned by the sudden changes in the economic environment. Variance Decomposition provides transparent decomposition of how much of the variance for the forecast error of each variable will be assigned to shocks in all other variables. In this study variance decomposition provides an understanding of how much of fluctuations in inflation is caused by change in exchange rates and Nifty 50 returns. This analysis identifies the most important factors driving inflation, computing the proportion of the inflation forecast error variance explained by shocks in stock market performance and currency fluctuations. This might be useful information for policymakers trying to figure out which levers to prioritize in fighting inflation and economic instability. This makes it relatively useful for investor use, especially in emerging markets like India, where different elements of economic volatility affect asset prices. The VAR model, constructed in the context of stationary I(0) data, looks to be a robust framework that can be used to assess the dynamic relationships between Indian inflation, the exchange rate, and the Nifty 50 stock index. The inclusion of Granger causality, impulse response functions, and variance decomposition in the approach emphasizes direct as well as indirect linkages among these variables. Insights gained through such analysis are important not just to investors who seek their way through this increasingly intricate macroeconomic landscape of India but also to policymakers who wish to better manage inflation. The VAR model not only lets us see how inflation responds to shocks in the exchange rate and stock market but also helps quantify the importance of each factor, thus giving a more balanced view of macroeconomic dynamics in India. These techniques thus allow us to gain better insights into the intricate economic interlinkages; we can apply these insights to improve economic planning and investment strategies for India's economy, which is constantly evolving.

2.Literature Review

Influence over inflation in India has been based on changes in Nifty index and exchange rates. Nifty 50 is more frequently used while assessing the mood of an investor and how it relates to the overall economy; thus, the effects are indirectly felt in terms of welfare effects and consumer behaviour changes in inflation. Earlier studies show that despite short-run impacts on inflation of various stock market movements, differences are shown to exist across countries and over time (Jones & Kaul, 1996). Again, dynamics of inflation depend on the dynamics of an exchange rate also in a country like India where depreciation of currency results in higher import prices. Change in the rate of exchange in India has mainly been found to affect the inflation cost of imported goods; the prices of energy, it suggests are the most essential items (Bhattacharya, 2016). This author Patnaik, 2010 holds the opinion that, basically, inflation in India is subjected to both demand- and supply-side factors; therefore, stabilization policies concerning both kinds of inflations must be controlled. Bicchal.et.al further uses an SVAR model by analysing the complex interaction of monetary policy, inflation and exchange rates relating with India-2006. This model points out that RBI uses call money rate to control inflation, and so it strikes balance between control over inflation and stability to the exchange rates especially about a cause due to change in global economics. Such interrelatedness calls for a VAR model; this is an appropriate tool for monthly data and hence captures dynamic short-run interrelationships between inflation, Nifty changes, and exchange rates. The VAR approach has enough force in investigating interactions among economic and financial variables and thus enriches our knowledge about Indian inflation trends.

Transmission Channels of Exchange Rate, Nifty 50 and Inflation



The following flowchart depicts the complicated interaction of the exchange rate, inflation and the Nifty 50 Index. The leading role at the top of the chain is played by the appreciation or depreciation of the exchange rate that determines cost on imports. When the currency depreciates, this increases the import costs with resultant cost-push inflation out from increased prices of imported goods as well as raw material. This direct link between movement in exchange rates and the inflation experienced is of primary importance to India, as its import has been oil lately. Going further, additional import charges increase inflation, impacting the Nifty 50 Index as well as the expectation of investors. With every rise in inflation, some purchasing powers decline and uncertainty is introduced regarding the future economic environment. Such uncertainty typically reflects in the Nifty 50 Index, the benchmark stock index of India, as it reflects the ideology of investors about the economy at large. The higher the inflation rate, the more reduced corporate profitability and the lower investor confidence, and therefore, the worse the performance of the stock market. In this sense, inflation simultaneously shapes investor expectations that in turn influence their economic outlook and decisions on investment. A feedback loop thus ties Nifty 50 Index with investor sentiment back toward the exchange rate. Given that the stock market can sustain itself, it will be well positioned to support higher market confidence and foreign investments; foreign investments may even strengthen currency. Weak markets will lead to capital outflow and add further steep devaluation of the currency. This network system makes visible how both factors interact in order to effect inflation in India-whether stock market-derived inflation or results due to exchange rates.

3. Data and Methodology

3.1 Data

This study uses monthly data on three key economic indicators in India: inflation change, Nifty index change, and exchange rate change. The variables are defined as follows:

- **Inflation Change (IChange)**: Monthly percentage change in the inflation rate, which reflects the rate at which the general price level for goods and services increases over time. This measure is essential for understanding purchasing power and economic stability.
- **Nifty 50 index Change (NChange)**: Monthly percentage change in the Nifty index, a prominent stock market index in India that reflects the overall performance of the equity market. The Nifty index is sensitive to macroeconomic factors and investor sentiment, making it an important indicator of economic activity.
- **Exchange Rate Change (EChange)**: Monthly percentage change in the exchange rate (INR/USD), representing the value of the Indian Rupee relative to the US Dollar. Exchange rate fluctuations impact trade balances, inflation, and foreign investment, making this variable significant for economic analysis.

The dataset spans January 2015 to January 2025 and consists of 109 observations monthly observations for each variable.

3.2 Preprocessing and Stationarity Testing

Before proceeding with the analysis, we checked the stationarity of each variable to ensure that the data meets the requirements of the Vector Autoregressive (VAR) model. A stationarity test was conducted using the Augmented Dickey-Fuller (ADF) test, where the null hypothesis is that the series contains a unit root (non-stationary). The results confirmed that all variables are stationary at level, i.e., they are integrated of order zero, I(0)I(0)I(0). This stationarity allows us to proceed directly with the VAR model without differencing the data.

3.3 Lag Selection

The lag order of the VAR model was determined based on lag selection criteria, Akaike Information Criterion (AIC).The lowest value of AIC was chosen. After examining the criteria, a lag order of 4 was chosen, balancing model complexity with explanatory power. This lag length is appropriate for capturing the short- and medium-term dynamic relationships among the variables.

3.4 Equation for Ichange Based on Estimated Coefficients

The equation below represents the relationship between **Ichange** and its predictors, **EChange** and **NChange**, at various lags. Based on the estimated coefficients, we can substitute each term with its respective coefficient as follows:

$$\begin{aligned}&\text{Ichange} = 0.23527 \times \text{EChange}_{t-11} - 0.52957 \times \text{NChange}_{t-11} + 0.20672 \times \text{Ichange}_{t-11} - 0.31707 \times \text{EChange}_{t-12}\\&-0.69800 \times \text{NChange}_{t-12} - 0.28648 \times \text{Ichange}_{t-12} + 1.08792 \times \text{EChange}_{t-13} - 0.09758 \times \text{NChange}_{t-13}\\&-0.03073 \times \text{Ichange}_{t-13} + 1.27971 \times \text{EChange}_{t-14} + 0.38331 \times \text{NChange}_{t-14} + 0.02693 \times \text{Ichange}_{t-14}\\&+1.13483\end{aligned}$$

Each Term: Each lagged term is multiplied by its respective coefficient. This coefficient represents the effect or influence of that lagged predictor on the current value of Ichange.

EChange Terms: These terms represent changes in exchange rates at different lags, where, for instance, each coefficient quantifies the impact of the exchange rate change at that specific lag on the current value of Ichange.

NChange Terms: These terms capture changes in the Nifty50 index at various lags,The coefficients for each NChange term indicate the effect of those lagged Nifty50 changes on Ichange.

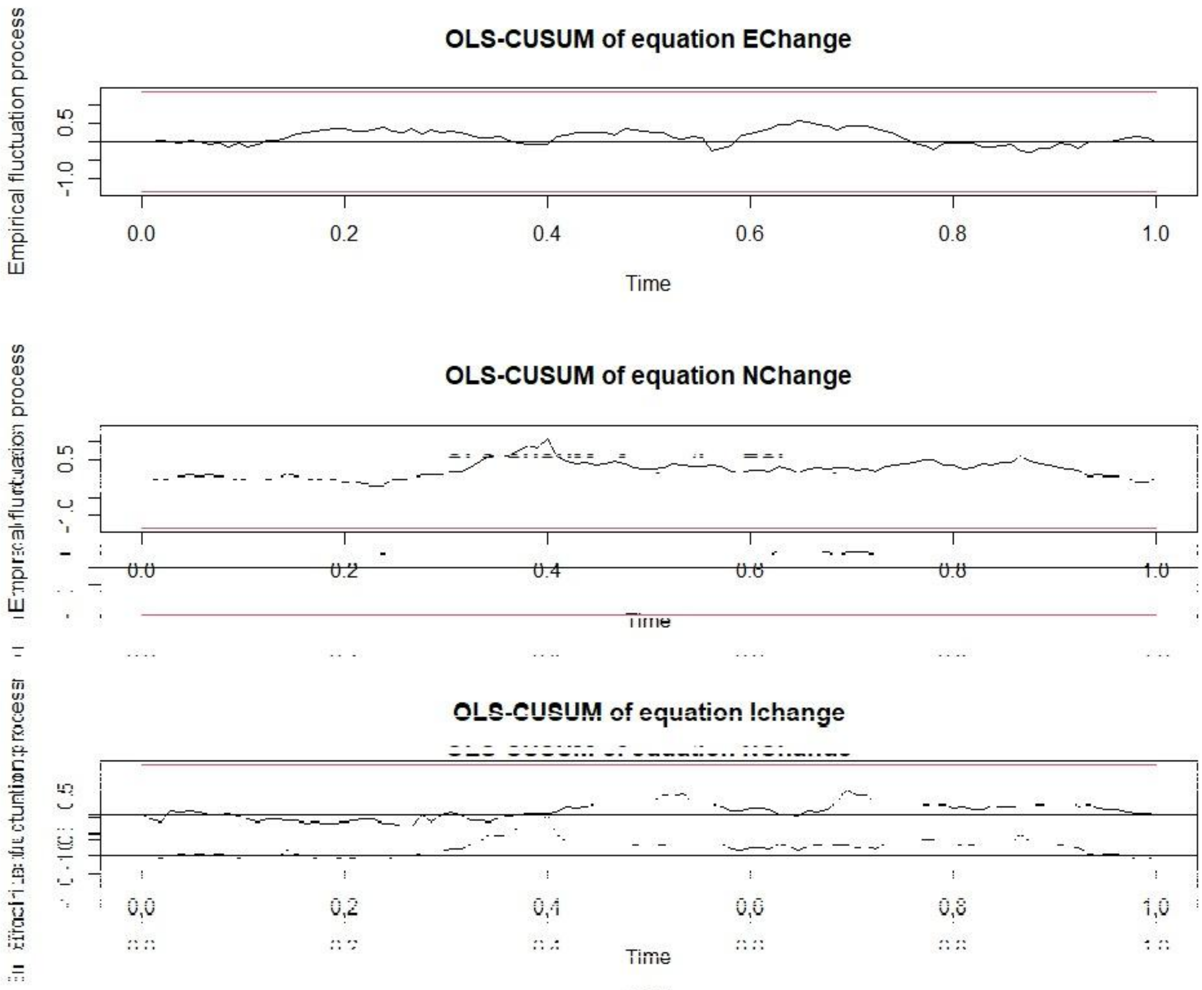
Ichange Terms: These lagged terms represent past values of Ichange itself, with each coefficient showing the influence of prior Ichange values on the current value.

Constant Term: The final constant term (+1.13483) serves as the intercept, indicating the baseline value of Ichange when all predictors are zero.

4. Diagonistic Checks

4.1 CUSUM Test

The **CUSUM (Cumulative Sum) test** is used to assess the stability of parameters in a time series model over time. In this analysis, the CUSUM test is applied to three different equations: **EChange**, **NChange**, and **IChange**. The CUSUM test helps to detect whether the parameters remain stable across the sample period or if there are structural breaks or instabilities.



The results of the CUSUM test across all three equations (EChange, NChange, and IChange) show that the parameters remain stable over time, with the cumulative sums staying within the confidence intervals. This implies that the model is structurally stable and that the relationships captured by each equation hold consistently over the sample period. This stability is essential for reliable forecasting and analysis, as parameter stability indicates that the model's assumptions are not violated.

4.2 Granger Causality

Granger causality is a statistical hypothesis test used to determine whether one time series can predict another. Specifically, it tests if past values of one variable provide significant information in forecasting another variable, beyond what the past values of the latter variable already provide. However, Granger causality does not imply true causation; it only suggests that one series leads or is informative for another in a predictive sense.

We examine Granger causality among three variables: Inflation change, Exchange rate change, and Nifty change, within our VAR model

1. Granger Causality Test for Inflation Change: The null hypothesis is that Inflation change does not Granger-cause Exchange rate change and Nifty Change. The F-Test statistic is 1.1941 with a p-value of 0.3024, indicating that Inflation change does not Granger-cause Exchange rate change and Nifty Change at the 5% significance level.

2. Granger Causality Test for Exchange rate Change: Here, the null hypothesis is that Exchange rate change does not Granger-cause Nifty change and Inflation change. The F-Test statistic is 1.2617 with a p-value of 0.2636, suggesting Exchange rate Change does not Granger-cause Nifty Change and Inflation change. However, the instantaneous causality test shows a significant result with a Chi-squared statistic of 22.95 and a p-value of 1.038e-05, indicating a significant instantaneous relationship between Exchange rate change and Nifty Change/Inflation change.

3. Granger Causality Test for Nifty Change: The null hypothesis here is that Nifty change does not Granger-cause causality test again indicates a significant instantaneous relationship, with a Chi-squared statistic of 23.002 and a p-value of 1.012e-05, pointing to an instantaneous effect between Nifty change and Exchange rate change/Inflation change.

In summary, none of the variables Granger-cause one another significantly, but there exists an instantaneous causality between Exchange rate Change and Nifty Change, as well as Exchange rate Change and Inflation change. This may indicate a simultaneous influence or shared dynamics among the variables rather than a predictive lead-lag relationship. and Inflation change.

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If there is no Granger causality but some instantaneous causality between Exchange rate change, Inflation change, and Nifty change, it suggests that these variables may respond to each other simultaneously within the same time period rather than in a predictive, lead-lag manner.

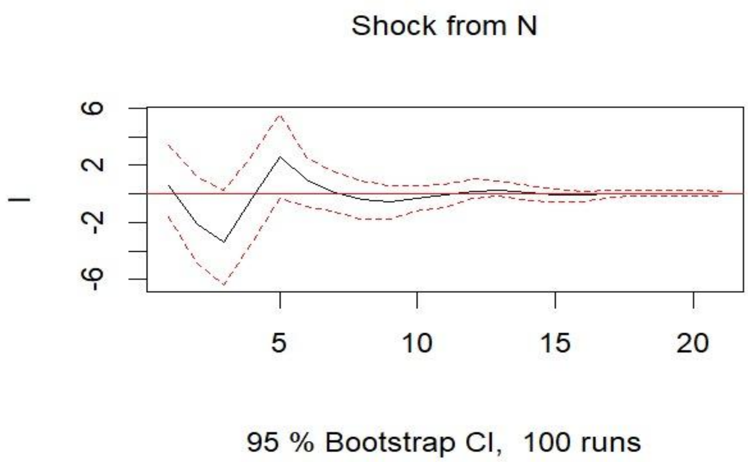
In the short run, instantaneous causality implies that shocks or changes in one variable (e.g., exchange rates) might immediately reflect in the other variables (e.g., inflation and Nifty) within the same period, perhaps due to external factors affecting all three variables concurrently. This can occur when macroeconomic events or market news impact all variables at once, causing them to co-move. For instance, an economic shock might simultaneously influence inflation, exchange rates, and stock markets, causing these variables to exhibit a contemporaneous relationship without one distinctly leading or lagging the others.

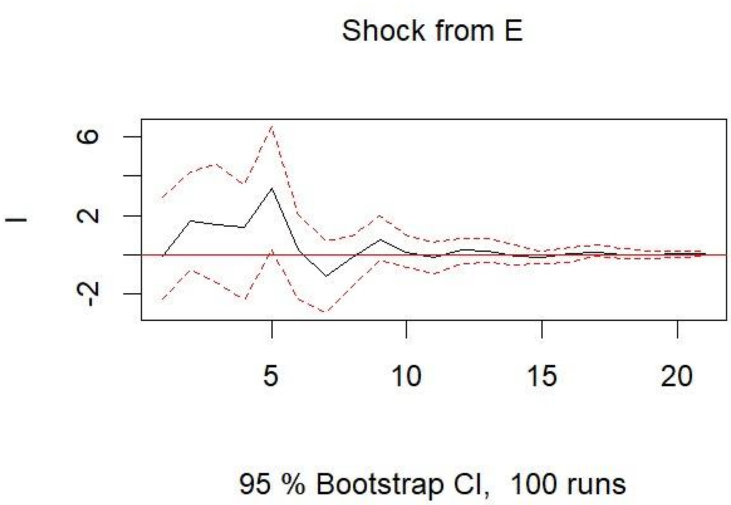
Thus, while there is no directional causality (Granger causality), the presence of instantaneous causality indicates that these economic factors may share interconnected dynamics in the short term, driven by immediate responses to external stimuli rather than a sequential predictive relationship.

4.3 Impulse Response Function

In time series Vector Autoregression (VAR) analysis, the Impulse Response Function (IRF) is a key tool used to understand the dynamic interactions among variables. The IRF measures how a one-time shock to one variable impact other variables in the system over time. In a VAR model, each variable is affected by its past values and the past values of other variables, so an initial shock in one variable can ripple through the system, influencing the future values of other variables.

The IRF allows us to visualize and quantify these effects by showing the response of each variable to a shock in another. This analysis is particularly useful in economic and financial contexts, as it provides insights into how external events, like changes in inflation or exchange rates, might affect other economic indicators over various time horizons.

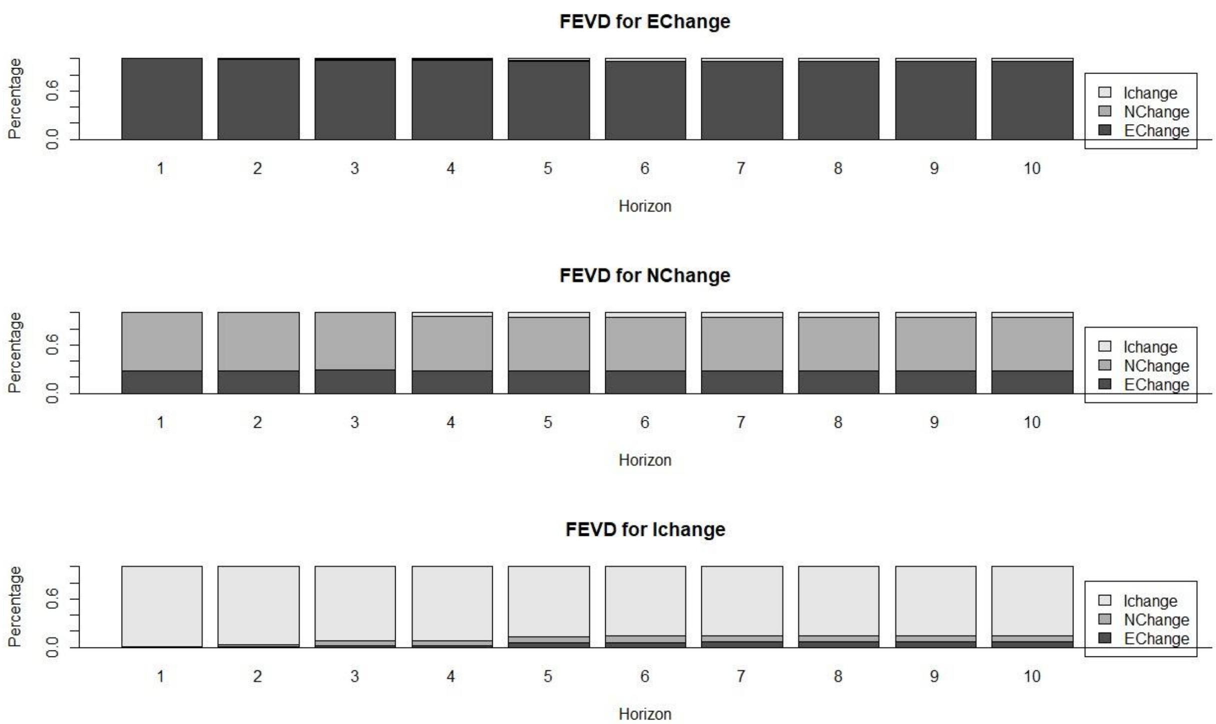




4.4 Variance Decomposition

Variance Decomposition (also known as Forecast Error Variance Decomposition or FEVD) is a technique in time series analysis that breaks down the forecast error variance of each variable in a Vector Autoregressive (VAR) model into components attributed to each variable in the system. Essentially, it shows how much of the forecast error variance of a variable is explained by its own shocks versus shocks to other variables over different time horizons. This helps in understanding the relative importance of each variable in influencing the forecasted behavior of other variables.

In the context of VAR analysis, variance decomposition is useful for examining the interconnectedness of variables, as it reveals the influence that each variable has on the future values of others.



The three bar plots show the FEVD results for each variable—Exchange Rate Change (EChange), Nifty Change (NChange), and Inflation Change (IChange)—over a 10-month horizon.

1. FEVD for EChange: In the first plot, the forecast error variance of exchange rate change (EChange) is primarily explained by its own shocks (dark gray bars) throughout all time horizons, indicating that EChange is largely self-driven with minimal influence from other variables.

2. FEVD for NChange: In the second plot, the forecast error variance of Nifty change (NChange) shows a more mixed attribution, where the forecast variance is influenced by both its own shocks and those of other variables (including EChange and IChange, represented in different shades). This suggests that NChange is affected not only by its own past values but also by movements in exchange rate and inflation over time.

3. FEVD for IChange: In the third plot, inflation change (IChange) shows that its forecast error variance is predominantly influenced by its own shocks, with a small but gradually increasing influence from other variables over time. This pattern suggests that inflation changes are relatively independent, though other variables begin to contribute slightly to its variance as the horizon extends.

Thus, the variance decomposition results reveal that each variable has varying degrees of independence and interdependence with others in the VAR system. Exchange rate changes are almost entirely self-driven, while Nifty change shows some dependence on both exchange rate and inflation changes. Inflation change is mostly independent, but there is slight interdependence observable at longer horizons. This analysis highlights the dynamics and influence of economic variables on each other, providing insights into how shocks propagate through the system.

5. Conclusion

Based on the findings and analyses conducted in this report, we have developed a comprehensive understanding of the dynamic interactions between inflation changes (Ichange), Nifty index changes (NChange), and exchange rate changes (EChange) in the Indian financial context using a Vector Autoregression (VAR) model. The Granger causality tests allowed us to examine the directional influences among these variables, identifying significant causal relationships that contribute to our understanding of the interplay between market indicators and macroeconomic variables.

The impulse response function (IRF) analysis provided insights into how shocks in one variable influence others over time. We observed the persistence and magnitude of these effects, illustrating the interconnectedness of inflation, the stock market, and exchange rates in India. Variance decomposition analysis further highlighted the extent to which each variable's forecast error can be attributed to shocks in the other variables, underscoring the influential role of each factor in driving variations over different forecast horizons.

In terms of model diagnostics, the application of the CUSUM test enabled us to assess model stability. The CUSUM test indicated that the model was stable over the sample period,.

In summary, this analysis has revealed significant interdependencies among inflation, Nifty index changes, and exchange rates, providing valuable insights for policymakers, investors, and analysts who seek to understand these variables' roles in India's economic landscape. While the model captures essential dynamics, improvements in residual normality and potential extensions to capture non-linearities or structural breaks could enhance the robustness of future analyses. Overall, this report demonstrates the applicability of VAR analysis in studying macro-financial linkages and contributes to a more informed decision-making process in economic and financial policy.

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