Forecasting and Analyzing Indian Headline Inflation: An Empirical Analysis Using ARIMA and VAR Models

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1. INTRODUCTION:

Macroeconomic indicators such as Gross Domestic Product (GDP), the unemployment rate, the inflation rate, the balance of payments, and external sector performance serve as crucial barometers for evaluating an economy's overall health and performance (Ouanes & Thakur, 1997). Among these, inflation is particularly impactful, due to its profound effect on the daily lives of individuals and households. It directly shapes the standard of living by influencing consumption patterns, earning capacities, and financial decisions (Burkacky et al., 2024).

In India, inflation is widely recognized as a fundamental driver of economic disparities (Pattnaik & Samantaraya, 2006), especially in rural areas where livelihoods often hinge on the affordability of essential goods. The fluctuation of prices not only dictates daily expenditure but also influences long-term financial planning and savings behavior (Singh et al., 2022). Understanding current inflation trends and accurately forecasting future rates are therefore crucial for informed economic decisions, impacting everything from household budgets to national policy (Ranyard et al., 2008). Aligned with these considerations, the Indian government, in consultation with the Reserve Bank of India (RBI), sets the headline inflation target every five years using the Consumer Price Index Combined (CPI-C). As recommended by the Dr. Urjit Patel Committee, the current inflation target is set at 4 percent for the period from April 1, 2021, to March 31, 2026 (Muduli & Shekhar, 2023). This target framework includes an upper tolerance limit of 6 percent and a lower tolerance limit of 2 percent, providing a clear guideline for monetary policy aimed at ensuring price stability and guiding economic decision-making in India.

Building on this context, this study aims to comprehensively understand the structure and components of the Indian Consumer Price Index Combined (CPI-C) and its characteristics over the past decade, from 2013 to 2024. We seek to forecast the expected CPI-C interval for the coming year. Furthermore, central to achieving price stability are the monetary policy rates set by the RBI, which influence inflation dynamics and growth trajectories. The RBI is recognized as one of the foremost central banks globally, with its monetary policy successfully achieving these objectives, especially post-COVID-19. Understanding how the major rates set by the RBI, such as the Cash Reserve Ratio (CRR), Policy Repo Rate, and Bank Rate, influence the inflation rate and interact with the INR/USD spot rate, and how all these variables interact is crucial. These rates are

significant determinants of investment in the economy and play a vital role in fostering economic growth. We aim to understand how well these rates can anchor inflation in the short run without exerting excessive pressure on prices. To achieve these objectives, we deploy both univariate and multivariate models using ARIMA and VAR methodologies.

The rest of the paper is organized as follows: Section II reviews the relevant literature; Section III lays out the empirical strategy; Section IV presents the results and forecast evaluation; and Section V concludes the dissertation.

2. LITERATURE REVIEW

The study of inflation and its impact on economic dynamics is a well-established field within macroeconomics. Several key theories and empirical findings have shaped the understanding of inflation's determinants, its forecasting methodologies, and the role of monetary policy in managing inflationary pressures.

2.1 Theoretical Background

Classical Theories of Inflation: Inflation, defined as the persistent increase in the general price level of goods and services, affects economic agents' purchasing power and financial decisions (Oner, 2010). Classical economic theories, such as the Quantity Theory of Money, emphasize the relationship between money supply and price levels. According to Friedman (1956, 1968), excessive growth in the money supply leads to inflation. This theory assumes that the velocity of money and output are constant, thus implying a direct relationship between changes in the money supply and price levels.

Keynesian Perspectives: In contrast to classical theories, Keynesian economics focuses on demand-pull inflation, which occurs when increased demand for goods and services outstrips supply, causing prices to rise (Keynes, 1936). Keynesians also highlight the role of fiscal policy in managing demand and, consequently, inflation. Additionally, cost-push inflation arises from rising production costs, including wages and raw materials, which are passed on to consumers through higher prices (Sihotang & Nopeline, 2020; Jain et al., 2022). The traditional Phillips Curve, introduced by Phillips (1958) and expanded by Samuelson and Solow (1960), illustrates an inverse relationship between inflation and unemployment. This suggests a short-run trade-off between the two, which remains a cornerstone in the analysis of inflationary pressures.

New Keynesian Models: New Keynesian models incorporate price stickiness and inflation expectations, providing a more comprehensive framework for understanding short-term inflation dynamics (Mankiw & Reis, 2002). The New Keynesian Phillips Curve (NKPC) builds on the traditional Phillips Curve by including forward-looking expectations and the concept of price rigidity. This means that current inflation depends not only on the level of economic activity but

also on expected future inflation and the degree of price stickiness across different sectors (Abbas et al., 2016).

External Shocks and Inflation: External shocks, such as oil price increases or supply disruptions, can also lead to inflation by causing immediate spikes in relative prices or accelerating overall price levels over time (Pierce et al., 1974). These shocks can originate from geopolitical events, natural disasters, or global economic fluctuations, highlighting the vulnerability of domestic inflation to external influences.

2.2 Empirical Studies on Inflation in India

India's inflation dynamics have been extensively studied, particularly in the context of its economic liberalization post-1991. The transition to a market-driven economy introduced new complexities in managing inflation, with several studies highlighting the role of both domestic and international factors. Domestic factors, notably food inflation, have been a focal point. Bhattacharya et al. (2017) examines the drivers of food inflation in India, focusing on the impact of agricultural wage inflation and fuel price increases. They find significant pass-through effects of food inflation to non-food and headline inflation. Goyal (2015) argued that high inflation episodes in India are driven by supply shocks, including rising wages, exogenous shocks, and governance failures, rather than demand fluctuations, with sectoral bottlenecks and food price inflation being significant contributors.

Monetary and fiscal policies also play crucial roles. Mohanty and John (2015) identified crude oil prices, output gaps, fiscal policy measures, and monetary policy actions as standard determinants influencing inflation. Their study emphasized the persistence of inflation and its implications for policy formulation. Additionally, the influence of global commodity prices and exchange rate fluctuations on domestic inflation dynamics has been extensively studied. Ha, Stocker, & Yilmazkuday (2020) and Burstein & Gopinath (2014) highlighted the significant impact of these factors, underscoring their role in shaping inflation outcomes in India.

In modeling and forecasting inflation, Kapur (2012) utilized an augmented Phillips curve framework to analyze inflation trends in India. The study emphasized the influence of demand conditions on non-food manufactured products (NFMP) inflation compared to headline WPI inflation, highlighting the sensitivity of NFMP to global non-fuel commodity prices and exchange rate movements. This framework provided insights into the differential impacts across inflation categories and underscored the role of global economic conditions in shaping domestic inflation dynamics, where inflationary pressures are followed by sharp depreciations.

Comparative studies have also shed light on India's inflation behavior. Ball et al. (2016) compared headline and core inflation trends since 1994, noting the stability of core inflation driven by past inflation and output deviations, contrasted with the volatility of headline inflation influenced by food and energy price fluctuations. The study drew parallels with inflation management in advanced economies and found that India's inflation behavior is still explained by traditional

Phillips curve models. This contrasts with the more anchored inflation expectations in advanced economies post-2000s, enabled by inflation targeting frameworks. The paper speculates on whether India's inflation behavior will evolve under the RBI's new monetary policy framework introduced in 2016.

2.3 Role of Monetary Policy

The Reserve Bank of India's (RBI) new monetary policy framework has evolved to address these challenges, focusing on both price stability and supporting economic growth. The introduction of inflation targeting in 2016 marked a pivotal shift in the RBI's strategy, aiming to anchor inflation expectations and enhance policy credibility (Patnaik & Pandey, 2020).

Monetary policy in India operates through multiple channels, including the interest rate, exchange rate, and monetary channels, influencing both prices and output dynamics (Mohan & Patra, 2009). Salunkhe and Patnaik (2017) find that efforts to control inflation can impact output to a significant extent, sometimes with consequences that may hinder overall economic growth. Banerjee et al. (2020) discusses the limited effectiveness of monetary policy in directly controlling inflation, suggesting complexities in its transmission mechanisms.

Mishra and Mishra (2012) propose a flexible inflation targeting approach tailored to India's incomplete financial markets, aiming to optimize policy effectiveness under specific local conditions. Additionally, Mohan (2008) provides an insightful analysis of the monetary policy transmission mechanism in India, underscoring the role of financial sector development in augmenting policy impact.

Batini and Nelson (2001) reaffirm Friedman's findings on the delayed impact of monetary policy on inflation using data from the US and UK spanning 1953 to 2001. Their research underscores that despite advancements in financial markets and technology, inflation response times to policy changes remain persistent. This suggests ongoing challenges for macroeconomic modeling and policy formulation.

The interaction between fiscal policy and monetary policy is another critical area of research. Viral V Acharya (2020) investigate the fiscal dominance in India and its implications for financial sector policies and regulations. They argue that fiscal discipline is essential for effective inflation control, as large fiscal deficits can undermine monetary policy efforts.

2.4 Forecasting Inflation

Traditional models such as ARIMA have been widely used to forecast inflation due to their simplicity and effectiveness in capturing time series data patterns (Box & Jenkins, 1976). However, these models often struggle with structural breaks and changing economic conditions. To address these limitations, structural models incorporate economic theory, providing a more comprehensive forecasting framework. For instance, VAR models have been extensively used to assess the dynamic relationship between inflation and its determinants. Bicchal (2010)

demonstrates the effectiveness of VAR models in capturing the impact of monetary policy on inflation.

Recent advancements in machine learning offer new possibilities for inflation forecasting. Methods such as neural networks and support vector machines can handle large datasets and uncover complex patterns (Stock & Watson, 2018). Ghosh & Bhargava (2018) applied these techniques to Indian inflation data, finding improvements in forecasting accuracy compared to traditional models.

The extensive body of literature on inflation in India highlights the complex interplay of domestic and international factors, the evolving role of monetary policy, and the advancements in forecasting methodologies. This study aims to contribute to this rich field by providing new insights into the effects of key monetary policy indicators on inflation using recent data. The application of ARIMA and VAR models will offer a nuanced understanding of inflation dynamics in India.

3. RESEARCH METHODOLOGY

Data: This study uses the Consumer Price Index-Combined (CPI-C) for ARIMA modeling and key monetary policy indicators, including inflation rates, cash reserve ratios (CRR), bank rates, policy repo rates, and the INR-USD spot rate for the VAR model. We utilize monthly data spanning from January 2013 to April 2024, divided into two distinct phases, for our analysis. The period from January 2013 to May 2023 is utilized for analysis purposes, while the subsequent period from June 2023 to April 2024 serves as training data. The study employs R and Stata software for econometric modelling and estimation.

Data source: The Monthly Consumer Price Index – Combined data is sourced from the Ministry of Statistics and Programme Implementation (MOSPI, 2024a). The monthly variables for the VAR model - Inflation Rates, Cash Reserve Ratio, Bank Rate, Policy Repo Rate, and the INR-USD Spot Rate, are sourced from the Reserve Bank of India Database (RBI, 2024)

Econometric model: This study employs both univariate and multivariate time series models to forecast headline inflation in India and explore its interaction with key economic rates. The univariate approach utilizes an Autoregressive Integrated Moving Average (ARIMA) model, while the multivariate approach adopts a Vector Autoregressive (VAR) model, chosen for their established success in forecasting applications (Litterman, 1986; Stockton and Glassman, 1987; Jose, et al. 2021).

i) ARIMA Model:

The ARIMA (Auto Regressive Integrated Moving Average) model utilizes the Box-Jenkins methodology, which comprises a series of systematic steps to accurately model and forecast time series data. Here, we provide an in-depth explanation of each step in the ARIMA modeling process for forecasting Indian CPI inflation.

Data Collection and Plotting: The process begins by collecting monthly CPI data from the Ministry of Statistics and Programme Implementation (MOSPI), spanning from January 2013 to May 2023. This dataset ensures a comprehensive analysis over a significant period. The CPI data is then plotted to visualize its underlying characteristics. The time plot reveals a noticeable upward trend in the CPI series, but the presence of seasonality is less clear from the initial plot.

Decomposition of CPI Series: To gain a clearer understanding of the seasonal patterns in the inflation data, the CPI series is decomposed into its multiplicative components: trend, seasonality, and random effects. This decomposition is typically done using techniques like seasonal decomposition of time series (STL) or the classical decomposition method. Decomposing the series helps in isolating the seasonal component, thereby providing insights into how each component contributes to the long-term trends observed in the CPI data.

Stationarity Assessment: Stationarity is a critical prerequisite for applying the ARIMA model, as non-stationary data can lead to spurious results. Stationarity means that the statistical properties of the time series, such as mean, variance, and autocorrelation, are constant over time. The stationarity of the CPI series is first assessed visually using the time plot. Non-stationarity is typically indicated by trends or varying variance over time. This visual inspection is followed by formal testing using the Augmented Dickey-Fuller (ADF) test. The ADF test helps in statistically confirming whether the series is non-stationary. If the p-value of the ADF test is above the chosen significance level (usually 0.05), the null hypothesis of a unit root (non-stationarity) cannot be rejected, indicating the need for differencing (Baumohl & Lyocsa 2009).

Differencing to Achieve Stationarity: If the CPI series is found to be non-stationary, differencing is performed to achieve stationarity. Differencing involves subtracting the previous observation from the current observation. Typically, first-order differencing (subtracting the value at time t-1 from the value at time t) is sufficient to make the series stationary. The differenced series is then re-evaluated using the ADF test to ensure stationarity. In cases where first-order differencing is not sufficient, higher-order differencing may be applied (Gujarati, 2004).

Model Identification: Once stationarity is achieved, the next step is to identify the appropriate ARIMA model parameters: autoregressive order (p), differencing order (d), and moving average order (q). This is done using the Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) plots. The ACF plot helps in identifying the order of the moving average part (q), while the PACF plot helps in identifying the order of the autoregressive part (p). The differencing order (d) is determined during the stationarity assessment step.

Parameter Estimation and Model Fitting: With the ARIMA model specified, the parameters are estimated using techniques such as maximum likelihood estimation (MLE) or least squares estimation. The model is then fitted to the CPI data, and its adequacy is assessed through diagnostic checks.

Diagnostic Checking: Diagnostic checks are performed to ensure the residuals of the fitted model are white noise, meaning they are uncorrelated and have a constant mean and variance. This involves examining the residuals using the Ljung-Box Q Statistic. The Ljung-Box test checks whether any of the autocorrelations of the residuals are significantly different from zero. A p-value above 0.05 indicates that the residuals are uncorrelated, suggesting the model is well-fitted.

Forecasting and Validation: Using the fitted ARIMA model, CPI values are projected over the next two years. The forecasted values are then validated against training data to assess the model's predictive accuracy. This involves comparing the forecasted values with the actual observed values and calculating forecast error metrics such as Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE). Any significant deviations in the forecasted values are investigated to understand the underlying causes and refine the model if necessary.

ii) VAR Model:

The Vector Autoregression (VAR) methodology is employed to analyze the interdependencies among multiple time series variables over time. In this study, the VAR model is used to examine the relationships between Indian CPI inflation rate and key economic variables such as the Cash Reserve Ratio (CRR), Bank Rate, Policy Repo Rate, and the INR/USD spot exchange rate.

Stationarity Assessment: The process begins with assessing the stationarity of all variables included in the VAR model. The stationarity of each variable is first assessed visually using time plots, followed by formal testing using the Augmented Dickey-Fuller (ADF) test. If any of the variables are found to be non-stationary, differencing is performed to achieve stationarity. Typically, first-order differencing is sufficient to make the series stationary.

Model Specification: Once all variables are confirmed to be stationary, the next step is to specify the VAR model. This involves determining the appropriate lag length for the model, which is crucial for capturing the dynamic relationships among the variables. The optimal lag length is selected using criteria such as the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and the Hannan-Quinn Criterion (HQC). These criteria help balance model complexity and goodness of fit.

Parameter Estimation and Model Fitting: With the lag length specified, the VAR model is estimated using Ordinary Least Squares (OLS) for each equation in the system. Each variable in the VAR system is regressed on its own lagged values as well as the lagged values of all other variables in the system. This estimation process provides insights into the dynamic interdependencies among the variables. The model assesses how changes in policy rates and

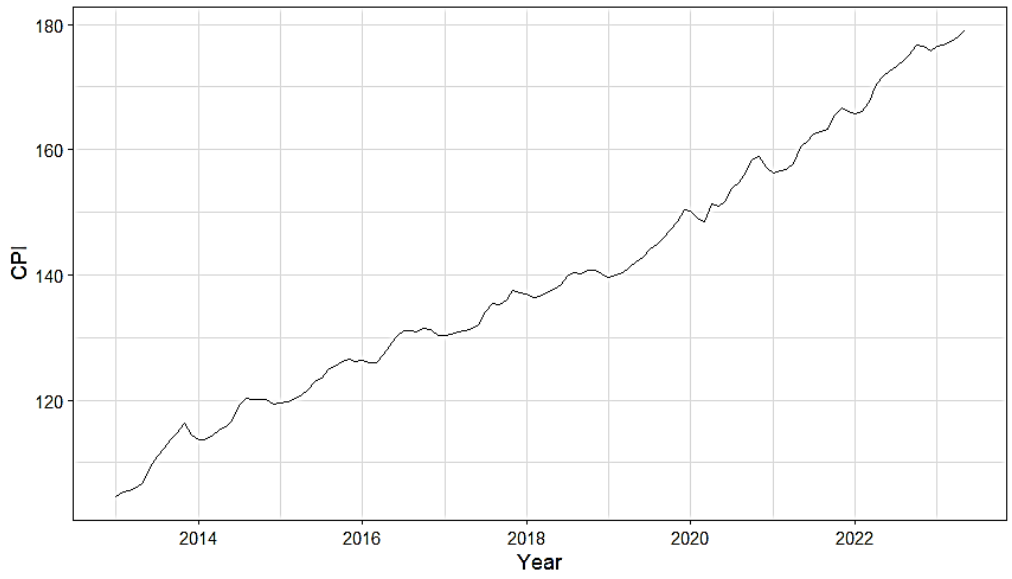
exchange rates influence inflation and vice versa, accounting for lagged effects to capture both short-term and delayed responses in monetary policy transmission.

Further research: While this study primarily focuses on estimating the VAR model and understanding the interdependencies among the variables, further analysis using Impulse Response Functions (IRFs) and Forecast Error Variance Decomposition (FEVD) can be done. IRFs trace the effects of a one-time shock to one of the variables on the current and future values of all variables in the system, providing insights into the transmission mechanisms over time. FEVD decomposes the variance of the forecast error of each variable into contributions from each shock to the VAR system, highlighting the relative importance of each variable in explaining the system's variations. These advanced analyses can offer deeper insights into the effectiveness of monetary policy and the dynamics of inflation (Faster Capital, 2024).

4. RESULTS

4.1. Visualisation of Trend

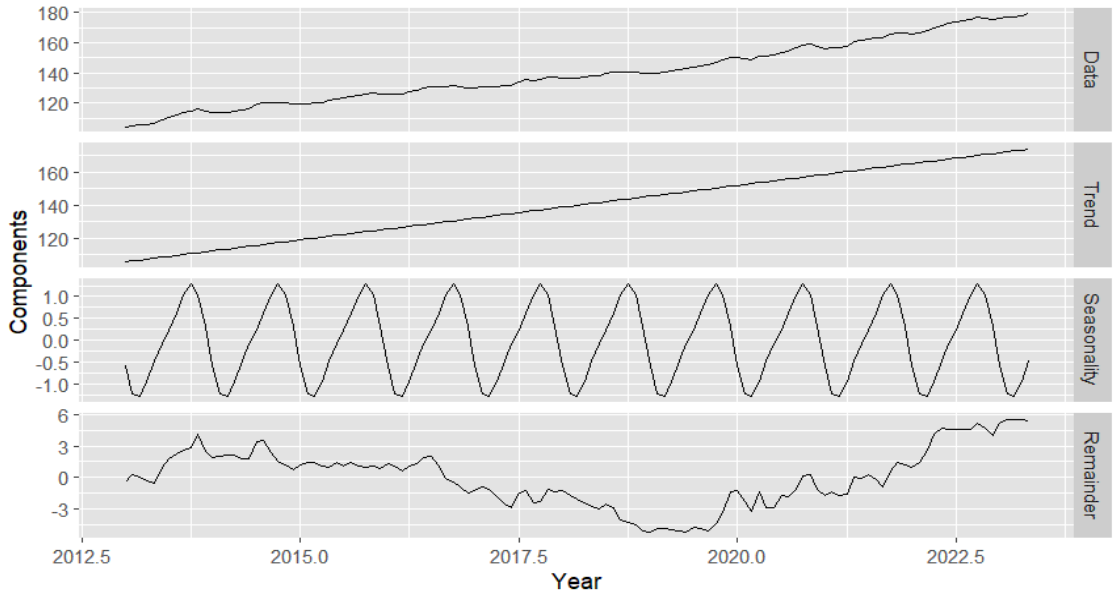
Figure 1: CPI - C from 2013 to 2023



The graph clearly shows that the CPI time series is not stationary, as it exhibits an upward trend over the period under study. This indicates that the mean of the CPI is changing over time, and the variance is not constant, reflecting a consistent increase in inflation. For accurate forecasting, we need to transform the data to make it stationary.

4.2. Decomposition of CPI

Figure 2: Multiplicative Components of CPI-C



In the context of CPI analysis, the Indian Consumer Price Index (CPI - C) exhibits notable seasonal fluctuations primarily influenced by agricultural production cycles, weather conditions, and cultural events such as festivals and holidays with fixed annual schedule (Joshi & Tripathi, 2003). These factors contribute to periodic increases in CPI, particularly evident in food and beverage prices, which experience seasonal peaks between July and November. For instance, vegetable prices peak during the monsoon period, while fruit prices rise in the summer months due to variations in supply and persistent demand (Sardar et al., 2020). To accurately forecast future CPI values, it is crucial to apply seasonal adjustments to remove these predictable fluctuations and isolate underlying trends. Additionally, preliminary analysis of Figure 2 indicates that the random error component is not a white noise process, as it does not exhibit a zero mean and constant variance, indicating the presence of autocorrelation. This finding is validated by the Ljung-Box Test (p-value <2.2e-16).

4.3. Stationarity of Time Series

(i) The Augmented Dickey-Fuller (ADF) Test has the following hypothesis:

- H_0 : Unit root exists (non-stationary)
- H_1 : No unit root Exists (stationary)

Dickey-Fuller test for unit root		Number of obs =	124
	Interpolated Dickey-Fuller		
Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
Z(t) 0.538	-3.502	-2.888	-2.578

MacKinnon approximate p-value for Z(t) = 0.9860

At a 95% confidence level, we fail to reject the null hypothesis ($p = 0.9860 > 0.05$), indicating that the CPI for the period under study is not stationary. Therefore, differencing is required to render the series stationary.

(ii) Augmented Dickey-Fuller Test for the First - Differenced Data:

Dickey-Fuller test for unit root		Number of obs =	123
	Interpolated Dickey-Fuller		
Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
Z(t) -7.436	-3.502	-2.888	-2.578

MacKinnon approximate p-value for Z(t) = 0.0000

Upon evaluating the p-value ($p < 0.05$), it is confirmed that the data achieves stationarity after undergoing first differencing. The Augmented Dickey-Fuller test, well-regarded for its effectiveness in assessing stationarity, validates the model's adherence to this criterion (Mushtaq, 2011; Cheung & Lai, 1995). With the CPI inflation data now stationary, it is appropriate to proceed with developing an ARIMA model.

4.4. Fitting of ARIMA

The ARIMA (2,1,0) (0,1,1) [12] model is best suited for Indian CPI inflation data, which reveals important economic insights into inflation dynamics. The autoregressive terms (AR1 = 0.2396 and AR2 = -0.2118) suggest that the current inflation rate is positively influenced by the inflation rate from one month ago but negatively influenced by the rate from two months ago. This implies that if inflation was high last month, it is likely to remain high this month as well, showing that inflation does not immediately drop or rise sharply month-to-month but tends to follow a similar direction sequentially. Moreover, if inflation was high two months ago, it is likely to decrease now, and vice versa. This pattern indicates that inflation in India exhibits a short-term persistence but also a corrective behavior over a slightly longer horizon, due to monetary policy responses or market adjustments.

The seasonal moving average term (SMA1 = -0.8689) highlights strong seasonal effects in inflation data. This means that certain times of the year consistently see higher or lower inflation

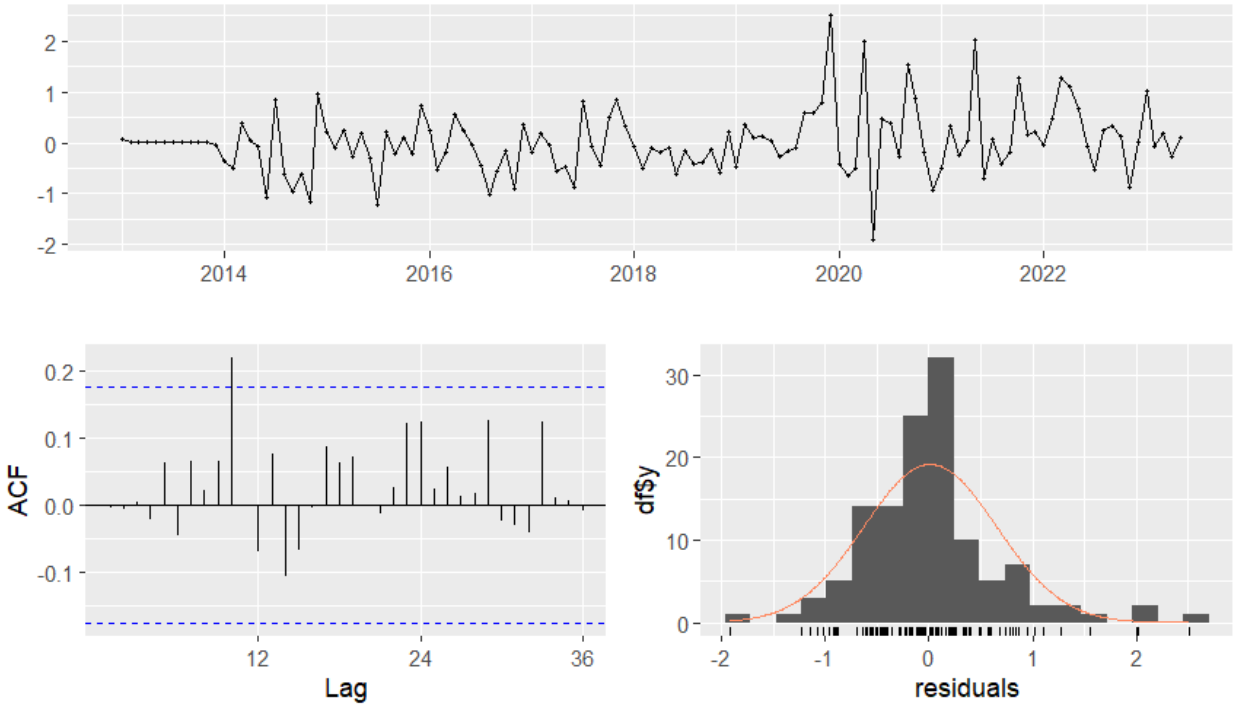
rates due to predictable seasonal factors. We also see that, when inflation deviates from its usual pattern, it tends to revert quickly to its typical trend. For instance, if inflation spikes or drops due to seasonal factors (like the harvest season or a major festival), it will soon stabilize back to its typical trend. These seasonal effects could stem from agricultural cycles affecting food prices, a major component of CPI inflation, increased demand during festivals driving up prices temporarily, or policy changes at specific times impacting inflation (Joshi & Tripathi, 2003). Lastly, the model's fit is robust, indicated by the low sigma^2 value of 0.4653, suggesting that the residual variance is small.

```
Series: cpi_ts
ARIMA(2,1,0)(0,1,1)[12]

Coefficients:
         ar1      ar2     sma1
      0.2396  -0.2118  -0.8689
s.e.  0.0929   0.0920   0.1503

sigma^2 = 0.4653:  log likelihood = -122.58
AIC=253.16   AICc=253.54   BIC=264.04

Training set error measures:
                     ME      RMSE       MAE          MPE      MAPE      MASE          ACF1
Training set 0.01160281 0.6370085 0.4454821 -0.00409647 0.3142749 0.063576 -0.004882835
```

4.5. White Noise Test

The analysis of residuals indicates that they are independently and identically distributed, resembling a normal distribution with a mean of zero and constant variance, suggesting that the CPI time series exhibits characteristics of white noise. The autocorrelation function (ACF) plot shows no significant spikes except at lag 10, indicating that each value in the series is largely uncorrelated with others, except potentially at this specific lag. The Ljung-Box test confirms that the monthly CPI data successfully passes the white noise test, yielding a probability value ($p = 0.5458$) greater than the 5% significance level ($p > 0.05$), confirming that the residuals of the model (ε_i terms) demonstrate white noise properties. Therefore, the model is suitable for forecasting future CPI values.

Figure 3: Residuals from ARIMA (2,1,0)(0,1,1)[12]



4.6. Forecasting Headline Inflation in India

After applying the ARIMA (2,1,0) (0,1,1) [12] model to forecast CPI – C inflation in India from June 2023 to May 2025, we assessed its performance by comparing the predicted values with training data from June 2023 to April 2024. Our analysis confirms that the model generally produced forecasts within the 95% and 99% confidence intervals during this period, indicating its overall reliability. However, notable deviations occurred in June and July 2023, coinciding with significant spikes in CPI inflation.

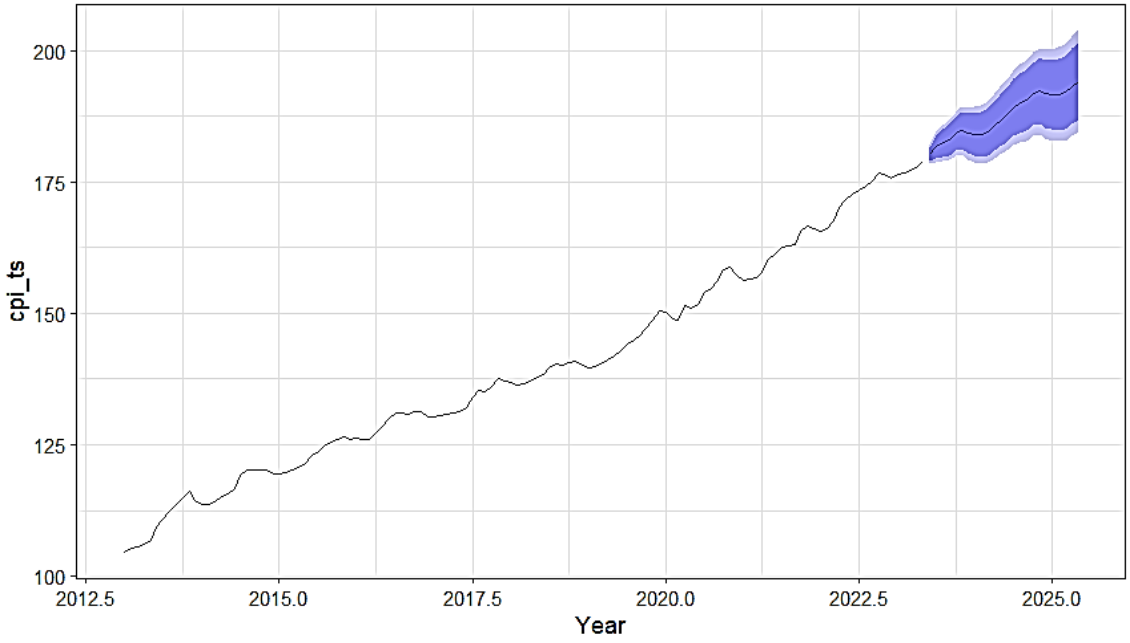
In July 2023, inflation surged to 7.44% from 4.87% in June, followed by a peak of 6.83% in August before easing to 5.02% in September 2023 (MOSPI, 2024a). These fluctuations were primarily driven by significant price increases in the food and beverages category, which accounts for 45.86% of the entire CPI-C (MOSPI, 2024b). Particularly, tomatoes experienced a year-on-year price rise of 202% in July and 180% in August. Similarly, ginger prices surged by 177% and 158% during the same period. These sharp increases in fruits, vegetables, and pulse products under the food and beverages segment contributed substantially to the overall inflationary pressures observed. This anomaly was caused by adverse weather conditions in July 2023, including excessive rains and flooding especially in Himachal Pradesh and Haryana. These events inundated fields and damaged tomatoes and other crops, which are majorly supplied to the Delhi market from these regions (Sangwan, 2024).

The forecasted observations align with the ARIMA model findings, indicating that current inflation rates in India are positively influenced by the previous month's inflation but negatively impacted

by rates from two months prior. For instance, the CPI index rose to 186.3 in July 2023 and remained relatively high at 186.2 in August, reflecting momentum from the preceding month before declining to 184.1 by September 2023. Effective intervention strategies led by the Department of Consumer Affairs played a pivotal role in mitigating the impact of soaring tomato prices on consumers. These strategies focused on targeted procurement and distribution across specific regions and consumption centers, successfully stabilizing prices and ensuring continued availability of tomatoes—a crucial commodity in the Indian market (PIB, 2023). Thus, corrective behavior was observed in the inflation numbers due to government intervention in the market.

Overall, the forecasts show a steady increase in the annual values of CPI – C in India. The study predicts that inflation will continue to rise from July 2023 onward, supported by confidence intervals in the forecast that consistently project an increase in monthly CPI-C throughout the forecasted period from 2023 to 2025.

Figure 4: Forecasts from ARIMA (2,1,0)(0,1,1)[12]



4.7. VAR Model:

Before applying the Vector Autoregression (VAR) model, we conducted stationarity tests on all variables involved in the analysis. The results indicated that only the inflation rate was stationary at level. Consequently, we had to apply first differencing to the other variables—namely the Cash Reserve Ratio (CRR), Bank Rate, Policy Repo Rate, and INR/USD Spot Exchange Rate—to achieve stationarity. Once these variables were transformed into their stationary forms, we proceeded with the VAR analysis.

Vector autoregression

Sample: 4 - 113			Number of obs	=	110
Log likelihood =	125.2146		AIC	=	-1.27663
FPE =	1.93e-07		HQIC	=	-.7289653
Det(Sigma_ml) =	7.06e-08		SBIC	=	.0736102

Equation	Parms	RMSE	R-sq	chi2	P>chi2
Inflation_Rates	11	.674945	0.8246	517.308	0.0000
D_CRR	11	.113801	0.1614	21.17866	0.0199
D_BankRate	11	.14363	0.2491	36.48312	0.0001
D_PolicyRepoRate	11	.127451	0.2893	44.77878	0.0000
D_INRUSSpotRat~g	11	.897855	0.0662	7.801098	0.6483

The R-squared value indicates that the inflation rate model demonstrates the highest degree of explanatory power, with a substantial portion of its variation explained by the included variables. This implies that changes in policy rates and the exchange rate are strongly associated with changes in inflation. Conversely, the differenced INR/USD Spot Exchange Rate exhibits a low explanatory power, suggesting that its changes are less influenced by the variables in the model and are likely driven by other external factors, which is typically the case.

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Inflation_Rates						
Inflation_Rates						
L1.	1.158494	.0928007	12.48	0.000	.9766081	1.34038
L2.	-.3081425	.0935944	-3.29	0.001	-.4915841	-.1247008
CRR						
LD.	1.558223	.6057726	2.57	0.010	.3709307	2.745516
L2D.	-.5381101	.5869917	-0.92	0.359	-1.688593	.6123724
BankRate						
LD.	.1745341	1.360277	0.13	0.898	-2.491559	2.840627
L2D.	-.6345173	.7091214	-0.89	0.371	-2.02437	.7553351
PolicyRepoRate						
LD.	-.267955	1.503459	-0.18	0.859	-3.214681	2.678771
L2D.	.427997	.5953377	0.72	0.472	-.7388434	1.594837
INRUSSpotRatePerForeig						
LD.	.1508771	.0709518	2.13	0.033	.0118141	.28994
L2D.	-.0218221	.0760981	-0.29	0.774	-.1709716	.1273274
_cons	.6956967	.2301259	3.02	0.003	.2446583	1.146735

Inflation Rate Equation

Effect of Inflation Rates: The first lag of inflation exhibits a significant positive impact on current inflation, indicating the presence of inertia in inflation dynamics. This suggests that past

inflationary trends strongly influence current inflation, demonstrating a momentum effect. In contrast, the second lag shows a negative effect, which aligns with the over-correction observed in ARIMA results. This suggests that high inflation periods tend to be followed by decreases, stabilizing overall inflation trends through a mean-reverting process.

Effect of CRR: The initial lag of the differenced Cash Reserve Ratio (CRR) unexpectedly shows a positive influence on inflation, implying that increases in CRR, typically a tool for contracting monetary policy, correlate with higher inflation. This counterintuitive outcome may stem from delayed effects in monetary policy transmission or initial liquidity constraints. However, the lack of significance in the second lag indicates that this impact is not sustained over longer periods.

Effect of Bank Rate and Policy Repo Rate: Lagged values of both the differenced Bank Rate and Policy Repo Rate do not significantly affect inflation, indicating that indicating that short-term changes in these key policy instruments, used by the central bank to signal monetary policy direction, do not have a direct and immediate effect on inflation rates. This suggests that their influence on inflation may be indirect or become evident over a longer horizon, highlighting the potential role of other factors or the importance of long-term influences on inflation.

Effect of INR/USD Spot Rate: The first lag of the differenced spot Rate has a significant positive coefficient, indicating that a depreciation of the Indian Rupee (an increase in the exchange rate) is associated with a rise in inflation. This findings also aligns with results by Kapur (2012). This effect is consistent with the concept of imported inflation, where a weaker domestic currency increases the cost of imports, thereby elevating overall price levels. The second lag, however, is not significant, suggesting that the immediate impact of exchange rate changes on inflation diminishes over time.

D_CRR						
Inflation_Rates						
L1.	.0308027	.015647	1.97	0.049	.0001352	.0614702
L2.	-.030428	.0157808	-1.93	0.054	-.0613578	.0005018
CRR						
LD.	.0662291	.1021384	0.65	0.517	-.1339584	.2664166
L2D.	.1153935	.0989717	1.17	0.244	-.0785875	.3093746
BankRate						
LD.	.0419115	.2293541	0.18	0.855	-.4076142	.4914372
L2D.	-.0227272	.1195638	-0.19	0.849	-.257068	.2116136
PolicyRepoRate						
LD.	.1301148	.2534959	0.51	0.608	-.366728	.6269577
L2D.	-.054385	.1003789	-0.54	0.588	-.2511241	.1423541
INRUSSpotRatePerForeig						
LD.	-.0372986	.0119631	-3.12	0.002	-.0607457	-.0138514
L2D.	.0080798	.0128308	0.63	0.529	-.0170681	.0332277
_cons	.0099737	.0388012	0.26	0.797	-.0660751	.0860226

CRR Rate Equation

Effect of Inflation Rates: The first lag of inflation has a small yet significant positive effect on the Cash Reserve Ratio (CRR), suggesting that higher inflation may prompt the central bank to increase CRR as a measure to tighten liquidity to counteract inflationary pressures. Conversely, the negative impact observed in the second lag indicates a delayed adjustment pattern, where past inflation trends influence future CRR decisions, albeit marginally.

Effect of CRR: Lagged values of CRR do not show statistically significant coefficients, indicating that historical changes in the CRR do not influence current adjustments. This is evident as the CRR adjustments by the central bank are primarily responsive to present economic conditions, particularly prevailing inflationary pressures, rather than past CRR adjustments.

Effect of Bank Rate and Policy Repo Rate: Both variables are not statistically significant, suggesting that changes in these policy rates (Bank Rate and Policy Repo Rate) do not directly affect CRR.

Effect of INR/USD Spot Rate: The first lag shows a statistically significant negative coefficient, indicating that a depreciation of the Indian Rupee initially decreases CRR to help stimulate the economy. However, the second lag is not statistically significant, suggesting that the initial effect does not persist over the longer term. CRR exhibits an adaptive response to exchange rate fluctuations in the short run.

D_BankRate						
Inflation_Rates						
L1.	.0130836	.0197483	0.66	0.508	-.0256223	.0517895
L2.	.0073727	.0199172	0.37	0.711	-.0316643	.0464097
CRR						
LD.	.040831	.1289104	0.32	0.751	-.2118287	.2934907
L2D.	.0609141	.1249137	0.49	0.626	-.1839123	.3057405
BankRate						
LD.	-.0878385	.2894712	-0.30	0.762	-.6551917	.4795147
L2D.	.3317219	.1509033	2.20	0.028	.0359568	.627487
PolicyRepoRate						
LD.	.2285094	.319941	0.71	0.475	-.3985635	.8555822
L2D.	-.0087416	.1266898	-0.07	0.945	-.257049	.2395658
INRUSSpotRatePerForeig						
LD.	.0098249	.0150988	0.65	0.515	-.0197681	.039418
L2D.	-.0107688	.0161939	-0.66	0.506	-.0425083	.0209707
_cons	-.1174778	.0489715	-2.40	0.016	-.2134602	-.0214954

D_PolicyRepoRate						
Inflation_Rates						
L1.	.01045	.0175238	0.60	0.551	-.0238959	.0447959
L2.	.0086461	.0176736	0.49	0.625	-.0259936	.0432858
CRR						
LD.	.0183739	.1143894	0.16	0.872	-.2058251	.242573
L2D.	.0749285	.1108429	0.68	0.499	-.1423197	.2921766
BankRate						
LD.	-.1758586	.256864	-0.68	0.494	-.6793028	.3275856
L2D.	.3335718	.133905	2.49	0.013	.0711229	.5960207
PolicyRepoRate						
LD.	.3555024	.2839015	1.25	0.210	-.2009344	.9119392
L2D.	-.0285423	.1124189	-0.25	0.800	-.2488794	.1917947
INRUSSpotRatePerForeig						
LD.	-.0030905	.013398	-0.23	0.818	-.02935	.0231691
L2D.	-.0081034	.0143698	-0.56	0.573	-.0362677	.0200608
_cons	-.1019969	.0434552	-2.35	0.019	-.1871674	-.0168263

Bank Rate and Policy Repo Rate Equations

The VAR analysis demonstrates that only the second lagged Bank Rate shows a significant positive effect, suggesting that past adjustments in the Bank Rate influence current changes in both the Bank Rate and the Policy Repo Rate. Mixed and largely insignificant effects from other variables suggest that these policy rates may be more reactive to broader economic conditions than proactive in directly influencing them. This implies that rates should be viewed more as reactions to economic trends rather than as tools actively driving growth or stability. Additionally, both rates display a persistent negative baseline effect, indicating a tendency to decrease over time independently of other factors.

D_INRUSSpotRatePerForeig						
Inflation_Rates						
L1.	-.0652893	.1234494	-0.53	0.597	-.3072456	.1766671
L2.	.1343783	.1245053	1.08	0.280	-.1096475	.3784041
CRR						
LD.	.5175462	.8058374	0.64	0.521	-1.061866	2.096958
L2D.	-.0310578	.7808538	-0.04	0.968	-1.561503	1.499388
BankRate						
LD.	-2.41713	1.809527	-1.34	0.182	-5.963737	1.129477
L2D.	1.080584	.9433186	1.15	0.252	-.7682861	2.929455
PolicyRepoRate						
LD.	2.535999	1.999998	1.27	0.205	-1.383924	6.455923
L2D.	-.6696378	.7919562	-0.85	0.398	-2.221843	.8825679
INRUSSpotRatePerForeig						
LD.	.0725982	.0943846	0.77	0.442	-.1123922	.2575886
L2D.	.0279303	.1012306	0.28	0.783	-.170478	.2263385
_cons	-.1774918	.3061281	-0.58	0.562	-.7774919	.4225083

INR / USD Spot Rate Equation

None of the variables show considerable influence on the INR/USD Spot Rate. This suggests that global market sentiment, international trade dynamics, geopolitical factors, and foreign investment flows play decisive roles in determining fluctuations in the INR/USD exchange rate, overshadowing the impact of domestic monetary policy actions in the Indian context.

5. CONCLUSION:

Headline inflation in India has exhibited significant volatility over recent decades, reflecting the country's journey through various economic phases. Following the liberalization, privatization, and globalization (LPG) reforms, inflation surged into double digits amid economic recovery from the balance of payments (BOP) crisis and the onset of the Asian financial crisis. Despite periods of stability from 2000 to 2008, the global financial crisis in 2008 disrupted this calm, leading to a sharp inflationary spike. By 2013, India found itself among the 'Fragile Five' economies, grappling with high fiscal and current account deficits alongside sustained double-digit inflation (Department of Consumer Affairs, 2024). The Reserve Bank of India (RBI) played a pivotal role in containing inflation within its target range; yet persistent upward trends in the Consumer Price Index for Combined (CPI-C) indicate enduring inflationary pressures driven by domestic demand and global economic shifts as India progresses towards becoming a developed economy.

Analytical models like the ARIMA (2,1,0) (0,1,1) [12] have been identified as the optimal specification for forecasting Indian CPI-C inflation, capturing short-term persistence and corrective behaviors despite occasional volatility observed in mid-2023. Similarly, VAR analysis reveals interactions between inflation and key monetary policy rates, emphasizing the gradual rather than immediate impact of policy changes on inflation dynamics. The limited short-term impact of policy rates highlights the challenges faced by the RBI in effectively managing inflation expectations. Clear communication and robust statistical measures are essential for enhancing public understanding and forecasting of inflation expectations, which remain crucial for precise policy formulation.

More importantly, the study found that the depreciation of the INR/USD spot rate correlated positively with inflation, mainly due to higher import costs. However, the immediate impact of exchange rate changes on inflation diminished over time, showing temporary effects on inflation dynamics. This emphasizes the challenge of managing inflation in a globalized economy, where external factors can strongly affect domestic prices. India's vulnerability to imported inflation stresses the importance of maintaining economic stability and a strong currency amid global uncertainties. As the rupee gains international recognition, achieving internal economic balance becomes increasingly imperative. These findings underscore the necessity for adaptive policy frameworks capable of responding effectively to evolving economic conditions and external shocks.

Looking ahead, India's economic landscape post-2014 has been characterized by robust GDP growth, resilient stock market performance, and increased manufacturing investments under new government leadership. India's journey from an emerging economy to one of the strongest global performers in the post-COVID-19 recovery period has been remarkable. However, despite these achievements, several challenges persist. The influx of investments necessitates structural readiness to absorb them without causing excessive imbalances or inflationary pressures. The nation has faced pressures, particularly due to soaring oil prices and global geopolitical events like the Russia-Ukraine conflict, which triggered imported inflation pressures. While these pressures have moderated over time, India remains susceptible to sudden economic shifts, including weather-related disruptions in food supply, overheating from rapid investments, shifting political sentiments, and regulatory changes.

The recent volatility observed during this year's Lok Sabha elections, one of the world's largest democratic exercises, had a significant impact on stock markets. The elections demonstrated the economy's sensitivity to short-term political changes, with markets initially collapsing followed by a substantial rise, impacting investor sentiment and market equilibrium. Political stability is needed in India for maintaining economic calm and fostering investor confidence, essential for sustaining growth momentum.

In conclusion, managing inflation remains pivotal to India's economic policies, intertwined with GDP performance, unemployment rates, fiscal stances, and global economic dynamics. Addressing these interconnected challenges comprehensively will be essential for sustaining India's economic growth trajectory and ensuring long-term stability in a rapidly evolving global landscape. Strengthening policy frameworks, enhancing public understanding of inflation dynamics, and navigating external and internal shocks will be crucial steps towards achieving these goals and securing India's position as a resilient global economy.

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