Dermatology Research: SkinInsights

PRIME OPEN ACCESS

Volume 1, Issue 1

Research Article

Date of Submission: 03 March, 2025
Date of Acceptance: 28 March, 2025
Date of Publication: 08 April, 2025

Food Inflation in India

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Citation: Singh, A. (2025). Food Inflation in India. *Dermatol Res SkinInsights, 1*(1), 01-12.

Abstract
This study delves into the dynamics of food inflation in India, analysing data from 1982-83 to 2019-20 to understand the effects of real rural wages, minimum support prices (MSP), and trade liberalisation. Utilising the Johansen Cointegration Test, Vector Error Correction Model (VECM), and Chow Test for structural breaks, we uncover the long-term and short-run relationships influencing food prices. Our findings highlight the significant role of policy adjustments and income factors, alongside identifying structural shifts in the inflationary trend. This research offers valuable insights for crafting policies to achieve food price stability while ensuring economic welfare, thus enriching the dialogue on managing food inflation in India.

Keywords: Food Inflation, Real Rural Wages, Minimum Support Prices (MSP), Trade Liberalisation, Johansen Cointegration Test, Vector Error Correction Model (VECM), Structural Breaks, Economic Policy and Agricultural Productivity in India

Introduction: Background and Rationale
India's economic landscape has been characterised by significant transformations over the past few decades, propelling the nation towards rapid industrialisation and urbanisation. Concurrently, the agricultural sector, which remains the backbone of the Indian economy, supporting a majority of the rural population, has encountered numerous challenges. Among these, food inflation stands out as a persistent issue that not only affects the economic fabric of the country but also has far-reaching implications on social equity and nutritional security.

Food inflation, the rate at which food prices increase over time, is a multifaceted phenomenon in India, influenced by a complex interplay of supply-side constraints, demand-side pressures, policy interventions, and global market dynamics. It directly impacts the cost of living, eroding the purchasing power of consumers, particularly the poor, who allocate a larger share of their income to food. This necessitates a deeper investigation into the drivers of food inflation, making the study not only timely but essential for crafting informed policy responses. The rationale for focusing on food inflation in India stems from its significant role in the overall inflationary environment and its implications for monetary policy and food security. The persistent nature of food inflation poses challenges to achieving the dual objectives of controlling inflation and ensuring nutritional security. It highlights the need to unravel the underlying causes, including the impact of minimum support prices (MSPs), changes in consumption patterns towards higher-value and protein-rich foods, the role of agricultural productivity, and the effects of global price transmission on domestic food prices.

Furthermore, the evolving dietary preferences of a growing middle class, alongside the constraints in agricultural production and supply chain efficiencies, underscore the urgency to address food inflation. The government's policy measures, including trade policies and fiscal interventions, have been pivotal in shaping the food inflation trajectory. However, their effectiveness in mitigating inflationary pressures without compromising on the growth and development of the agricultural sector remains a subject of analysis. This study, therefore, aims at inflationary pressures without compromising location in India by identifying its key drivers, assessing the impact of policy interventions, and exploring

the interrelationships between various economic indicators and food prices. By doing so, it seeks to contribute to the formulation of holistic policy measures that can address the root causes of food inflation, thereby promoting economic stability, ensuring food security, and enhancing the welfare of the Indian population.

Focus and Objectives

The focus of this paper on "Food Inflation in India" is to dissect the underlying factors contributing to the persistent and fluctuating nature of food inflation within the Indian context. By leveraging a multidimensional framework that encompasses economic, policy, environmental, and societal indicators, the study aims to unearth the complex interplay between various determinants of food inflation. This detailed examination is guided by the objective to not only understand the mechanisms driving food inflation but also to provide actionable insights and policy recommendations to mitigate its impacts effectively.

Objectives

- To identify key drivers of food inflation, we need to understand how factors such as rural wages, MSP, and changes in dietary preferences contribute to food inflation.
- To Examine Policy Impacts on Food Prices: Analyse the role of government policies, including MSP adjustments and trade liberalisation, in shaping food inflation trends.
- To Assess the Impact of Climate Change and Global Price Shocks: Evaluate how externalities like climate variability and global commodity price transmission affect domestic food inflation.
- To Explore Supply Chain Dynamics: Investigate the influence of supply chain efficiencies and disruptions on food price volatility.
- To Offer Policy Recommendations: Based on the analysis, propose targeted policy interventions to stabilise food prices without compromising agricultural productivity and growth.

Literature Review and Our Contributions

The study of food inflation in India has been enriched by a diverse range of academic contributions, each examining different facets of this complex phenomenon. The existing literature elucidates the distinct roles of demand and supply factors alongside delineating between short-term and long-term influences.

Demand Factors

Short-term:

• Rising Real Rural Wages: Identify increasing rural wages as a key driver of heightened food demand, particularly for protein-rich foods, in the short term [1]. This surge in purchasing power among rural populations exerts immediate pressure on food prices.

Long-term:

• Changing Consumption Patterns: Highlight a long-term shift towards higher-value and protein-rich foods, fueled by rising incomes and changing lifestyle choices. This structural change in dietary preferences steadily influences food inflation over time.

Supply Factors

Short-term:

• Agricultural Wage Inflation: Discuss how inflation in agricultural wages can lead to short-term spikes in food prices by increasing production costs, a phenomenon less influenced by immediate changes in fuel and international prices [2].

Long-term:

• Minimum Support Prices (MSP) and Input Costs: Although MSP adjustments and input costs are significant, suggest their long-run impact on food inflation is moderate, pointing to deeper structural issues within agricultural policy and productivity [1].

• Supply-Side Constraints: Also explore long-term supply-side constraints, including agricultural productivity and land usechanges, which have profound effects on the supply-demand equilibrium and, hence, food inflation [2].

Structural Breaks and Global Price Transmission

Emphasise recognising structural breaks in the food inflation trend [1]. These breaks, indicative of significant policy shifts or economic events, underscore the dynamic nature of food inflation, intertwining short-term impacts with long-term structural changes. Furthermore, the integration of global price transmissions highlights the external influences that permeate domestic food markets, affecting both immediate and sustained price levels [3-11]. The literature collectively underscores a multi-dimensional understanding of food inflation, incorporating economic, policy, and global perspectives. However, a gap exists in synthesizing these insights into a comprehensive framework that also accounts for the impact of structural breaks in the food inflation trend. Structural breaks caused by significant policy shifts, economic reforms, or global economic shocks can alter the trajectory of food inflation, necessitating a differentiated analysis for periods pre and post-breaks.

Our Paper's Contribution

The current project advances the literature by systematically incorporating the analysis of structural breaks into the study

of food inflation in India. By identifying specific periods marked by potential structural breaks and analysing the distinct characteristics of food inflation within these periods, this study offers a nuanced understanding of how major events and policy interventions have reshaped the inflationary landscape. Moreover, while existing literature has extensively explored the roles of rural wages, MSP, and global price transmission in influencing food inflation, this project aims to integrate these insights with analysis of supply chain efficiencies, climate variability, and monetary policy impacts. This comprehensive approach allows for a more holistic understanding of the drivers of food inflation, addressing the multifaceted nature of this issue. Additionally, by leveraging recent data and employing advanced econometric techniques, this project aims to provide up-to-date empirical evidence on the dynamics of food inflation in India. This effort not only bridges the gap between past and present analyses but also offers actionable policy recommendations tailored to the current economic context [12-18]. In essence, this project seeks to extend the existing body of literature by offering a more granular and temporally sensitive analysis of food inflation in India, contributing valuable insights for policymakers and researchers alike. Through this endeavour, we aim to illuminate the pathways through which economic, policy, environmental, and external factors converge to influence food inflation, thereby paving the way for more effective inflation management strategies.

Key Indicators (Follow-up on Literature Review)

To thoroughly analyse food inflation in India, it is imperative to consider a wide array of indicators that directly or indirectly impact the phenomenon. Drawing from the hypotheses formulated based on the insights from the literature review, several critical indicators necessary for understanding the dynamics of food inflation can be drawn. Each indicator is pivotal for testing the outlined hypotheses and provides a comprehensive view of India's multifaceted nature of food inflation.

Real Rural Wages

Real rural wages represent the purchasing power of rural labour after adjusting for inflation. An increase in rural wages boosts the demand for food, particularly protein-rich and higher-value foods, as rural households have more disposable income. This demand-side pressure can lead to an upward price adjustment, contributing to food inflation. Real rural wage growth is a critical indicator for assessing how income changes among rural populations influence food price levels. The Consumer Price Index for Agricultural Laborers (CPI-AL) measures the average change over time in the prices paid by agricultural labourers for a basket of goods and services consumed. Changes in income levels can influence the consumption patterns of agricultural labourers. Higher income may lead to increased consumption of specific goods and services, while lower income may result in reduced consumption. These changes in consumption patterns are reflected in the weights assigned to different items in the CPI-AL calculation.

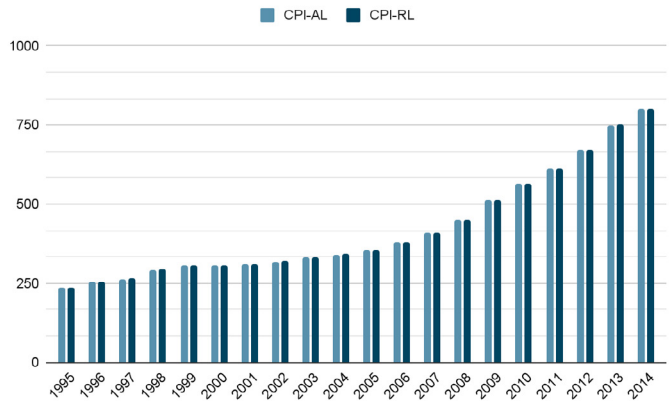


Figure 1: Comparative Statement of Variation in CPI for Agricultural and Rural Labourers on Base 1986-87=100

Minimum Support Price (MSP)

The MSP is a government-set price at which it purchases crops from farmers to ensure farmers make a minimum profit from their harvest. Changes in MSP can directly influence market prices of food grains by setting a price floor. If MSPs are increased, it can lead to higher food prices as farmers and traders adjust their selling prices upwards. Analysing MSP changeshelps in understanding the policy-induced pressures on food inflation.

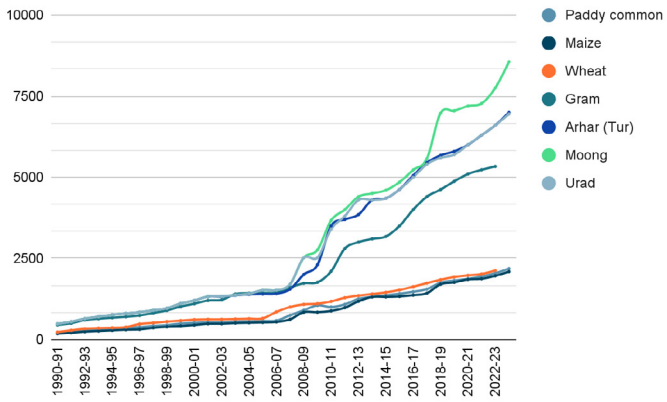


Figure 2: Minimum Support Price (MSP) (₹ Per Quintal)

Expenditure on Protein-Based Food

The shift in dietary preferences towards protein-based foods such as meat, dairy, and eggs, attributed to rising incomes and changing lifestyle choices, affects food inflation. The demand for these foods tends to grow faster than the supply, leading to higher prices. Tracking expenditure on protein-based foods aids in examining the impact of changing consumption patterns on food inflation.

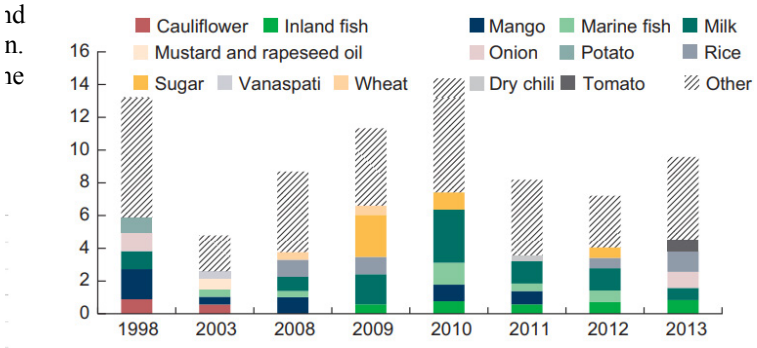


Figure 3: Contribution of Leading Commodities to Food Inflation

Agricultural Productivity

Agricultural productivity, particularly pulses and vegetables, is crucial for meeting the increasing food demand without causing price surges. Low productivity and yield gaps can lead to supply shortages, contributing to food inflation. Indicators of agricultural productivity, including yield per hectare and output volumes, are necessary to assess the supply-side capabilities and their effects on food prices. Implementing schemes such as the National Food Security Mission (NFSM) and trade liberalisation has aimed to increase agricultural productivity in India, particularly in crops like pulses and vegetables, to meet the growing food demand and mitigate price surges.

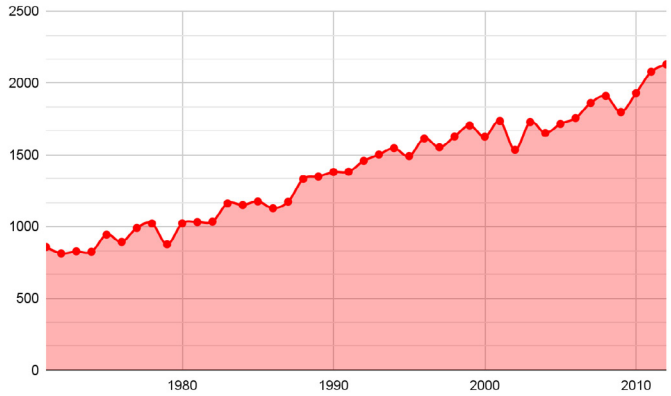


Figure 4: Agricultural Productivity: Yield Per Hectare (Kg/Hectare)

Trade Liberalisation and Global Price Transmission

The extent of trade liberalisation and the transmission of global commodity prices into the domestic market are critical for understanding food inflation. Global price shocks, especially in oil and essential food commodities, can influence domestic food prices through increased costs of transportation, fertilisation, and production inputs. Indicators of trade openness and global commodity price indices are analysed to capture the external influences on domestic food inflation.

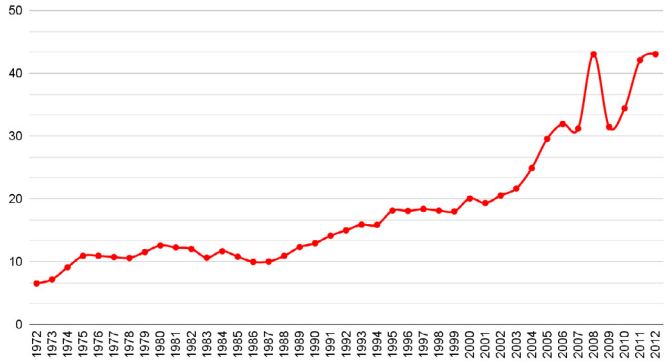


Figure 5: Merchandise Trade (% of GDP)

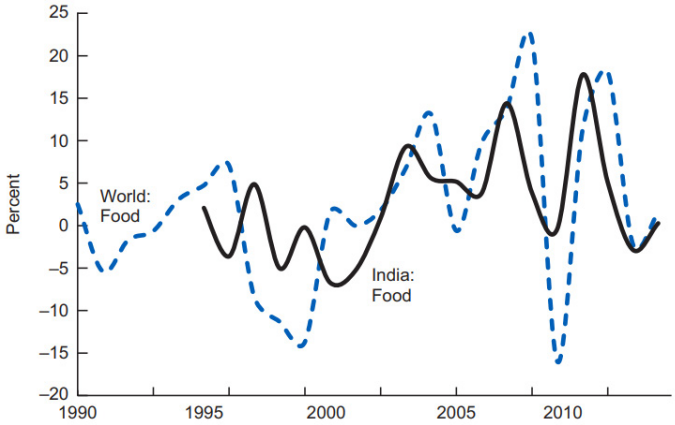


Figure 6: Domestic and International Food Prices, 1990–2013

Monetary Policy Indicators (Interest Rates, Liquidity Conditions)

Monetary policy tools, such as interest rates and liquidity provisions, influence inflationary expectations and investment in agriculture. Tight monetary policy can affect agricultural investment negatively, reducing production and exacerbating food inflation. Key indicators include the repo rate, reverse repo rate, and liquidity measures in the financial system.

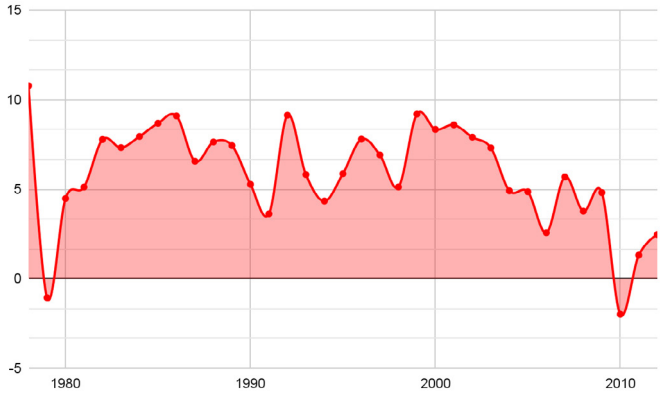


Figure 7: Real Interest Rates in India

Climate Variability and Weather Anomalies

Climate change and weather anomalies, such as droughts, floods, and irregular monsoons, directly impact agricultural output and food supply. Rainfall variability and temperature anomalies serve as indicators for assessing the impact of climate conditions on crop production and, subsequently, on food inflation.

Supply Chain Efficiencies

Efficiencies in the supply chain, from production to market, affect food prices through transportation, storage, and wastage costs. Logistics performance indices and estimates of post-harvest losses are essential for evaluating how supply chain disruptions and inefficiencies contribute to food inflation. These indicators collectively provide a holistic framework for analysing food inflation in India. They encompass the broad spectrum of economic, policy, environmental, and supply chain factors influencing food prices. Data used for the hypothesis testing will revolve around these indicators.

Hypothesis

In examining the complexities of food inflation in India, our research navigates through a diverse array of hypotheses that encapsulate both the demand and supply influences alongside an exploration of structural and policy-driven factors affecting both short-term and long-term inflation dynamics. Central to our analysis is the assertion that increasing real rural wages significantly amplifies food inflation, primarily through demand-driven pressures that may be sustained over extended periods due to persistent income growth. On the supply front, we hypothesise that challenges in agricultural productivity and growth inadequately meet the burgeoning demand for food, laying a foundation for prolonged inflationary pressures. This scenario is further examined through the lens of Minimum Support Prices (MSP) adjustments, posited to have an immediate impact on food inflation with potential ripple effects into the future, underscoring the critical role of agricultural policy in food price stability.

Additionally, our study delves into the effects of public expenditure and monetary policy measures, theorising that increases in government spending and expansions in the money supply significantly influence food inflation. The interplay between these fiscal and monetary dynamics and food prices highlights the intricate balance between economic stimulus and inflationary control. Trade liberalisation and the implementation of the National Food Security Mission (NFSM) are also central to our hypothesis framework, where we explore their respective impacts on food inflation. Trade liberalisation, by opening domestic markets to global price fluctuations, and NFSM, by aiming to enhance food production and security, are hypothesised to have nuanced effects on food prices, necessitating a thorough investigation. Moreover, the hypothesis that structural breaks—marked by significant policy changes, economic events, or shifts in global market dynamics—alter the trajectory of food inflation provides a crucial perspective on the temporal variability in food price determinants. The examination of exchange rate (ER) fluctuations further complements this analysis, positing that currency valuation changes can influence import costs and, subsequently, food prices. Collectively, these hypotheses strive to unravel the multifaceted drivers of food inflation in India, blending insights from demand and supply considerations with the impacts of macroeconomic policies, structural shifts, and global economic interactions. This comprehensive approach aims to shed light on the underlying mechanisms of food inflation, offering a solid foundation for policy recommendations to achieve long-term price stability and food security.

Data and Methodology

To rigorously analyse food inflation in India and test the proposed hypotheses, this study employs a multifaceted approach, leveraging quantitative data and advanced econometric techniques. The empirical investigation is structured around a comprehensive dataset that includes variables reflective of the key indicators identified in the hypotheses. The study was conducted based on secondary data from 1971-72 to 2012-13 of various variables. The empirical investigation is structured around a diverse dataset comprising the following variables:

1. **Agricultural Productivity:** Yield per hectare (Kg/hectare): Represents the output per unit of agricultural land, explicitly focusing on crop yield.
2. **Real Interest Rate in India:** Accounts for inflation, providing a measure of the actual cost of borrowing or the return on investment adjusted for changes in purchasing power.
3. **Official Exchange Rate (Indian Rupee per US$, annual average):** Reflects the value of the Indian Rupee relative to the US Dollar, impacting the prices of imported goods, including food items.
4. **Trade Openness:** Merchandise trade (% of GDP): Measures the degree of openness of the Indian economy to international trade, influencing domestic price dynamics.
5. **Value added by Agriculture, forestry, and fishing (% of GDP):** Represents the contribution of the agriculture, forestry, and fishing sectors to the country's gross domestic product, indicating the economic significance of these sectors.
6. **Wholesale Price Index for Food Articles (FWPI):** Tracks changes in the average price level of food articles at the wholesale level.
7. **Consumer Price Index for Food for Industrial Workers (CPI IW F):** Reflects changes in the average price level of food items specifically for industrial workers.
8. **Wholesale Price Index for All Commodities (WPIAC):** Represents changes in the average price level of all commodities at the wholesale level, providing a benchmark for comparing food price inflation with overall inflation.
9. **Annual Growth Rates:**

- Growth Rate of Wholesale Price Index for Food Articles (**GR_WPI**)
- Growth Rate of Production of Food Grains (**GR_Pr_Fg**)
- Growth Rate of Per Capita Net National Product (NNP) at Constant Prices (**GR_Per_capita_NNP**)
- Growth Rate of Public Expenditure of the Central and State Governments (**GR_GE**)
- Growth Rate of Indian Foreign Exchange Rate with respect to US$ (**GR_ER**)

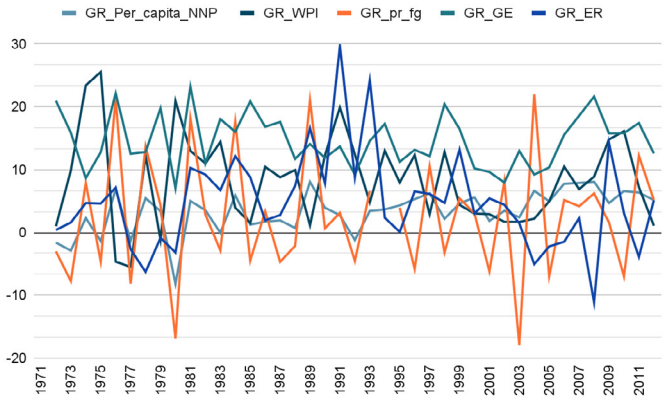


Figure 8: Growth Rates

Methodology

The methodological framework of this study is designed to test each hypothesis with appropriate econometric models, ensuring the robustness and validity of the findings. The data were transformed in natural log form to remove unit roots in the time series data. The data processing was carried out to convert raw data into a suitable form for interpretation. The analysis was done using Stata software. The objective here is to determine the time series properties of the data, mainly whether the data is stationary or exhibits trends over time.

The Augmented Dickey-Fuller (ADF) Test

The ADF test was employed to estimate the order of integration among the variables. The procedure involved testing all variables for unit roots by comparing the null hypothesis of "presence of a unit root" (indicating non-stationarity) against the alternative hypothesis of "series is stationary." If the data is non-stationary based on the Augmented Dickey-Fuller (ADF) test results, the next step in the flow is to differentiate the series and re-test for stationarity. Differencing involves computing the difference between consecutive observations in the time series data. This transformation helps stabilise the mean and variance of the series, making it stationary.

Structural Break Test (Chow Test)

The Chow Test aims to identify significant shifts or changes in the relationships between variables within a time series dataset. These shifts, often called structural breaks, can signify essential policy changes, economic events, or underlying trend shifts. The Chow Test compares the stability of coefficients in regression models across different data segments. By examining whether coefficients significantly differ between segments, the test helps pinpoint potential breakpoints in the data where structural changes may have occurred. The time series data is segmented around suspected structural change points identified through exploratory data analysis. Separate regression models are estimated for each segment, capturing the relationships between variables within each period. Computed based on regression results, the Chow Statistic measures the difference in coefficients between segments and assesses the significance of structural breaks. Significant breaks detected by the Chow Test suggest that relationships between variables have changed significantly at those points. These breakpoints may reflect critical policy shifts, economic events, or underlying trend changes.

Johansen Cointegration Test

The statistical implication of the existence of a long-run association between the variables is cointegration. The Johansen Cointegration Test is employed in this study to examine long-term relationships between food inflation and independent variables across different time segments, particularly before and after identified structural breaks in the data. The Johansen Cointegration Test is conducted separately for each time segment defined by structural breaks in the data. This involves estimating cointegrating vectors and testing the hypothesis of cointegration against the null hypothesis of no cointegration. The results of the Johansen Cointegration Test provide insights into the long-term relationships between variables within each segment.

Vector Error Correction Model (VECM)

Upon identifying cointegration within segments, the analysis transitions to conducting separate Vector Error Correction Model (VECM) analyses for each segment. VECM is a valuable tool for investigating the dynamic relationships among variables, encompassing both short-term adjustments and long-term equilibrium effects inferred from the cointegrating vectors. Using VECM, the study aims to delve deeper into the interdependencies among variables over time. This modelling approach facilitates capturing immediate responses to shocks and establishing long-term equilibrium relationships indicated by cointegration. By employing VECM, the study endeavours to comprehensively understand the dynamics underlying food inflation and its determinants, encompassing short-term fluctuations and enduring relationships across various time segments.

Hypothesis Testing Across Regimes

• Demand-Side Hypotheses: For hypotheses related to the demand side, such as real rural wages and protein-based food expenditure, the study utilises Vector Error Correction Model (VECM) analysis to examine their impact on food inflation. By employing VECM, the study assesses the dynamic interactions between demand-side variables and food inflation, capturingboth short-term adjustments and long-term equilibrium effects.

• Supply-Side and Policy-Related Hypotheses: For hypotheses pertaining to the supply side and policy-related factors, such as Minimum Support Prices (MSP) and agricultural productivity, the study employs VECM to ascertain their effects on food inflation dynamics. Through VECM analysis, the study investigates how changes in supply-side variables and policy measures influence food inflation over time, accounting for both short-term fluctuations and long-term equilibrium relationships.

• External Shocks and Structural Breaks: Incorporating external shocks and structural breaks into the analysis, the study utilises dummy variables to account for these factors. By incorporating dummy variables for structural breaks, the study aims to assess their impact on food inflation dynamics and distinguish their effects from other explanatory variables. This approach enables the identification and analysis of changes in the relationships between variables over different periods, contributing to a comprehensive understanding of the factors driving food inflation.

Robustness Checks

To ensure the robustness of our findings, we conduct sensitivity analysis by varying the lag lengths in Vector Autoregression (VAR) or Vector Error Correction Model (VECM) models. By exploring different lag structures, we assess the stability and consistency of our results across different specifications. This analysis helps us identify the most suitable lag length that optimally captures the dynamic relationships between variables.

Econometric Analysis and Results

Augmented Dicky-Fuller Test

Dicky Fuller Test for the second difference of Food Wholesale Price Index (FWPI), Per Capita Income (PC_NNI), and Broad Money Supply (M3) showed that FWPI and PC_NNI were stationary after the second difference, but M3 was not stationary up to second difference.

```
Augmented Dickey-Fuller test for unit root

Variable: WPI_FA_diff2                          Number of obs   =        37
                                                Number of lags  =         2

H0: Random walk without drift, d = 0

                                                Dickey-Fuller
                     Test                   critical value
                  statistic           1%              5%              10%
------------------------------------------------------------------------------
 Z(t)            -4.832          -3.668          -2.966          -2.616
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000.
```

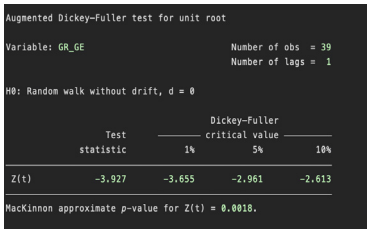
```
. dfuller PC_NNI_diff2, lags(2)

Augmented Dickey-Fuller test for unit root

Variable: PC_NNI_diff2                          Number of obs   =        37
                                                Number of lags  =         2

H0: Random walk without drift, d = 0

                                                Dickey-Fuller
                     Test                   critical value
                  statistic           1%              5%              10%
------------------------------------------------------------------------------
 Z(t)            -7.473          -3.668          -2.966          -2.616
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000.
```

```
Augmented Dickey-Fuller test for unit root

Variable: M3_diff2                              Number of obs   =        37
                                                Number of lags  =         2

H0: Random walk without drift, d = 0

                                                Dickey-Fuller
                     Test                   critical value
                  statistic           1%              5%              10%
------------------------------------------------------------------------------
 Z(t)            -2.415          -3.668          -2.966          -2.616
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.1375.
```

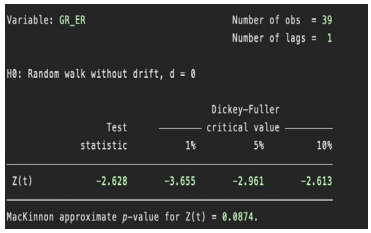
We also conducted stationary tests on the Growth Rates of FWPI, Production of Food, Expenditure of State and Central Government, Exchange Rate of the Indian Rupee wrt USD.

```
Augmented Dickey-Fuller test for unit root

Variable: GR_WPI                                Number of obs   =        39
                                                Number of lags  =         1

H0: Random walk without drift, d = 0

                                                Dickey-Fuller
                     Test                   critical value
                  statistic           1%              5%              10%
------------------------------------------------------------------------------
 Z(t)            -4.881          -3.655          -2.961          -2.613
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000.
```

```
Augmented Dickey-Fuller test for unit root

Variable: GR_pr_fg                              Number of obs   =        36
                                                Number of lags  =         1

H0: Random walk without drift, d = 0

                                                Dickey-Fuller
                     Test                   critical value
                  statistic           1%              5%              10%
------------------------------------------------------------------------------
 Z(t)            -7.026          -3.675          -2.969          -2.617
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000.
```



```
Augmented Dickey-Fuller test for unit root

Variable: GR_GE                          Number of obs   =        39
                                         Number of lags  =         1

H0: Random walk without drift, d = 0

                                         Dickey-Fuller
                    Test                 critical value
                statistic        1%           5%           10%
------------------------------------------------------------------
 Z(t)             -3.927        -3.655       -2.961       -2.613
------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0018.
```



```
Variable: GR_ER                          Number of obs   =        39
                                         Number of lags  =         1

H0: Random walk without drift, d = 0

                                         Dickey-Fuller
                    Test                 critical value
                statistic        1%           5%           10%
------------------------------------------------------------------
 Z(t)             -2.628        -3.655       -2.961       -2.613
------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0874.
```

The Exchange Rate growth is non-stationary at a 5% significance level, while the Growth rates of FWPI, Production of Food, and Expenditure of State and Central Government Expenditur are Stationary. Similar tests were conducted on CPI, Interest Rate, and Exchange Rate; all were stationary up to the first difference. According to the methodology, this gives us a green signal to conduct the Johansen Cointegration Test for the stationary variables.

Johansen Cointegration Test

The Cointegration Test is used to find meaningful long-term relationships between variables.

```
. regress Food_Wholesale_Price_Index PC_NNI

      Source |       SS           df       MS      Number of obs   =        42
-------------+----------------------------------   F(1, 40)        =    327.97
       Model |  2497084.22         1  2497084.22   Prob > F        =    0.0000
    Residual |  304547.475        40  7613.68688   R-squared       =    0.8913
-------------+----------------------------------   Adj R-squared   =    0.8886
       Total |  2801631.69        41  68332.4803   Root MSE        =    87.256

------------------------------------------------------------------------------
Food_Whole~x | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
       PC_NNI |   .8158476   .0450495    18.11   0.000     .7247991    .906896
        _cons |  -18.55769   22.81627    -0.81   0.421    -64.67108    27.5557
------------------------------------------------------------------------------
```

Johansen Cointegration Test between Food Wholesale Price Index (FWPI) and Per Capita Income (PC_NNI) showed there are at least two cointegrating relationships among the variables included in the model, which suggests a stable long-term relationship that holds them together over time. This means that these economic series move together in the long run, although they might exhibit short-term fluctuations.

```
. vecrank id fwpi_d prfg_d, trend(constant)

Johansen tests for cointegration
Trend: Constant                          Number of obs   =        36
Sample: 1973 thru 2008                   Number of lags  =         2
------------------------------------------------------------------------------
                                                                      Critical
Maximum                                              Trace            value
  rank       Params          LL       Eigenvalue    statistic          5%
     0           12   -427.91991                .      41.1888       29.68
     1           17   -413.25191          0.55731     11.8528*       15.41
     2           20   -407.89509          0.25740       1.1391       3.76
     3           21   -407.32551          0.03115
------------------------------------------------------------------------------
* selected rank
```

The Johansen Cointegration Test between the first differences in Food Wholesale Price and Production of Food Grains. The output suggests evidence of one cointegrating relationship at a 5% significance level. This implies that there is a long-term relationship between the variables that persist over time.

```
. vecrank Food_Wholesale_Price_Index M3

Johansen tests for cointegration
Trend: Constant                          Number of obs   =        40
Sample: 1973 thru 2012                   Number of lags  =         2
------------------------------------------------------------------------------
                                                                      Critical
Maximum                                              Trace            value
  rank       Params          LL       Eigenvalue    statistic          5%
     0            6   -640.05977                .     4.5668*       15.41
     1            9    -637.9534          0.09996      0.3541       3.76
     2           10   -637.77635          0.00881
------------------------------------------------------------------------------
* selected rank
```

The money supply doesn't adequately account for the price increase, according to the test results. The Food Wholesale Price Index (WPI) and M3 aren't co-integrated, indicating a lack of substantial long-term relationships among them. A durable cointegration connection is identified, featuring three equations linking food inflation, exchange rate, interest rate, consumer price index, and dummy variables representing trade liberalisation and the National Food Security Mission, indicating a long-term relationship.

```
. vecrank GR_WPI GR_GE

Johansen tests for cointegration
Trend: Constant                          Number of obs  = 36
Sample: 1973 thru 2008                   Number of lags =  2
-------------------------------------------------------------
                                                    Critical
Maximum                                     Trace      value
   rank  Params        LL  Eigenvalue   statistic        5%
      0       6  -230.03366           .   28.4544     15.41
      1       9    -219.192     0.45246    6.7711      3.76
      2      10  -215.80644     0.17146
-------------------------------------------------------------

.
```

```
. vecrank GR_WPI GR_ER

Johansen tests for cointegration
Trend: Constant                          Number of obs  = 36
Sample: 1973 thru 2008                   Number of lags =  2
-------------------------------------------------------------
                                                    Critical
Maximum                                     Trace      value
   rank  Params        LL  Eigenvalue   statistic        5%
      0       6  -251.51853           .   29.1366     15.41
      1       9  -239.91229     0.47523    5.9242      3.76
      2      10  -236.95021     0.15173
-------------------------------------------------------------

.
```

Regression Results

```
. regress Food_Wholesale_Price_Index PC_NNI

      Source |       SS           df       MS      Number of obs   =        42
-------------+----------------------------------   F(1, 40)        =    327.97
       Model |  2497084.22         1  2497084.22   Prob > F        =    0.0000
    Residual |  304547.475        40  7613.68688   R-squared       =    0.8913
-------------+----------------------------------   Adj R-squared   =    0.8886
       Total |  2801631.69        41  68332.4803   Root MSE        =    87.256

------------------------------------------------------------------------------
Food_Whole~x | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
      PC_NNI |   .8158476   .0450495    18.11   0.000     .7247991     .906896
       _cons |  -18.55769   22.81627    -0.81   0.421    -64.67108     27.5557
------------------------------------------------------------------------------
```

The Food Wholesale Price Index (FWPI) was regressed on Per Capita Income (PC_NNI) and showed a positive value of .8158, which is strongly significant even at a 95% confidence level. This shows that Per Capita Income (used as a dummy for Real Wage) is one of the major drivers of Food Inflation.

```
. regress GR_WPI GR_pr_fg GR_GE GR_ER

      Source |       SS           df       MS      Number of obs   =        40
-------------+----------------------------------   F(3, 36)        =      1.39
       Model |  208.798709         3  69.5995695   Prob > F        =    0.2615
    Residual |  1802.38039        36  50.0661219   R-squared       =    0.1038
-------------+----------------------------------   Adj R-squared   =    0.0291
       Total |   2011.1791        39  51.5686948   Root MSE        =    7.0757

------------------------------------------------------------------------------
      GR_WPI | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
    GR_pr_fg |  -.1800855   .1217593    -1.48   0.148    -.4270247    .0668537
       GR_GE |   -.225988   .2724694    -0.83   0.412    -.7785815    .3266055
       GR_ER |   .1535419   .1481498     1.04   0.307    -.1469198    .4540036
       _cons |   11.18204   4.137849     2.70   0.010     2.790098    19.57399
------------------------------------------------------------------------------
```

The table shows a statistically significant relationship between the growth rate of the Food Wholesale Price Index and the growth rate of the Production of Food Grains. It shows that Food Inflation is negatively affected by the Production of Food Grains. If the production increases, this leads to oversupply, and hence, the prices drop down. The model's overall fit, however, is not robust, as indicated by the low R-squared value of 0.1038, implying that the model explains approximately 10.38% of the variance in the growth rate of food WPI.

Chow Test

	RSS	Observations	K
Pooled reg	0.29	38	5
1st set (1983 - 1994)	0.01	12	5
2nd set (1995 - 2010)	0.01	16	5
3rd set (2011 - 2020)	0.01	10	5
F_{cal}	72.10		
F_{tab}	2.69		

The analysis incorporates the Clemente Montanes Reyes Test, identifying two distinct structural shifts in the timeline: one in 1994 and another in 2010, thus demarcating three distinct periods for evaluation: 1983-1994, 1995-2010, and 2011-2020. Research indicates a notable shift in food consumption patterns towards high-value crops during the latter years of the Green Revolution, spanning from 1983 to 1994. The comparative assessment across the three intervals suggests a statistically significant variation in the regression coefficients, leading to the rejection of the hypothesis

positing uniformity across these temporal segments. This outcome points to a transformation in the factors influencing food prices, aligned with changes in agricultural trends and consumption over the examined periods.

Conclusions

Our empirical investigation, drawing from extensive econometric analysis, has sought to test specific hypotheses regarding the determinants of food price inflation in India against the backdrop of a burgeoning economy marked by agricultural sector challenges. The study has incorporated a comprehensive dataset spanning from 1982-83 to 2019-20, utilised the Johansen Cointegration Test and Vector Error Correction Model to examine the interactions between food inflation and influential macroeconomic factors, including the food wholesale price index, the consumer price index for agricultural labour, interest rates, exchange rates, and pivotal policy reforms such as trade liberalisation and the National Food Security Mission. The findings validate the hypothesis that a significant and positive relationship exists between rising per capita income levels and the growth rate of food prices, confirming the demand-side pressures hypothesised to drive food inflation. Furthermore, our results are in consonance with the hypothesized supply-side constraints, as evidenced by the negative association between the growth rate of food grain production and food price inflation. The Johansen Cointegration Test substantiates a long-run equilibrium relationship among the examined variables, while the Vector Error Correction Model points to a 12.6% annual adjustment speed toward this long-term equilibrium.

Additionally, the incorporation of the Clemente-Montanes-Reyes Test has allowed for the identification of structural breaks within the dataset, thereby validating the hypothesis that different periods in the series exhibit significantly varied coefficient relationships. This is particularly evident in the distinct pre- and post-policy reform eras identified by the breaks in the years 1994 and 2010. Our econometric findings thus not only lend robust support to our initial hypotheses but also highlight the complexities inherent in the relationship between macroeconomic growth and food price inflation in India. The study thereby contributes to the understanding of inflation dynamics, emphasising the need for targeted policy interventions that address both immediate and structural determinants of food price levels.

Summary and Policy Implications

The research findings offer comprehensive insights into India's complex dynamics of food inflation. Through rigorous econometric analysis, key drivers of food inflation have been identified, including rural wages, Minimum Support Prices (MSP), and changes in dietary preferences. The Augmented Dickey-Fuller (ADF) test revealed stationary behaviour for variables like the Food Wholesale Price Index (FWPI), and Per Capita Income (PC_NNI) after the second difference. At the same time, Broad Money Supply (M3) exhibited non-stationarity. Policy impacts on food prices were examined, highlighting the significant influence of government policies such as MSP adjustments and trade liberalisation. Johansen Cointegration Test results indicated stable long-term relationships between FWPI and PC_NNI, reflecting the effects of policy interventions on food prices. Climate variability and global commodity price transmission significantly affected domestic food inflation, with Structural Break Tests identifying critical points of change.

The analysis also explored the influence of supply chain dynamics on food price volatility, emphasising the importance of considering supply chain resilience in understanding food inflation trends. Based on the findings, targeted policy recommendations were proposed to stabilise food prices without compromising agricultural productivity and growth. These recommendations include measures to enhance supply chain resilience, strengthen climate resilience in agriculture, and fine-tune policy interventions to mitigate inflationary pressures. Overall, the research underscores the importance of holistic policy approaches that address both demand and supply-side factors and external shocks to effectively manage food inflation and ensure food security for the population.

Based on the identified significant drivers of food inflation, we offer the following policy recommendations:

- **Demand-side policies:** Implement measures to enhance real rural wages and increase the affordability of protein-based foods for rural households. This may involve policies to improve agricultural productivity through technology, infrastructure, and extension services investments. Additionally, promoting rural employment opportunities and providing income support to low-income households can bolster purchasing power and stimulate demand for essential food items.
- **Supply-Side and Agricultural Policies:** Strengthen agricultural infrastructure and invest in research and development to improve productivity and reduce supply bottlenecks. Enhancing support mechanisms such as Minimum Support Prices (MSP) can ensure fair remuneration for farmers, incentivise production and stabilise food prices. Moreover, facilitating access to credit, inputs, and technology for smallholder farmers can enhance their productivity and resilience to external shocks.
- **Trade and External Policies:** Monitor global commodity prices and trade openness to anticipateexternal shocks and mitigate their impacts on domestic food prices. Strengthening trade agreements and partnerships can ensure stable food supply chains and reduce reliance on volatile international markets. Additionally, promoting diversification of agricultural exports and enhancing market access for smallholder farmers can enhance resilience to external price fluctuations.
- **Monetary and Fiscal Policies:** Adopt prudent monetary and fiscal policies to manage inflationary pressures and stabilise the macroeconomic environment. This may involve maintaining price stability through effective monetary policy measures, such as interest rate adjustments while ensuring fiscal sustainability through responsible budgetary management. Coordination with relevant stakeholders is essential to ensure the effective implementation of policies

aimed at controlling inflation without compromising economic growth and food security.

- **Climate Resilience and Disaster Management:** Develop strategies to enhance climate resilience in agriculture and improve disaster management mechanisms to mitigate the adverse effects of climate variability on food production and prices. This may include promoting climate-smart agricultural practices, investing in irrigation infrastructure, and strengthening early warning systems for extreme weather events. Additionally, enhancing insurance coverage for farmers and implementing risk-sharing mechanisms can help mitigate losses due to climate-related shocks.

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