# Understanding Food Inflation

## Dynamics and Policies to Tame it

Shyma Jose | Ranjana Roy | Ashok Gulati

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# Foreword

Over the past few decades, India has emerged as one of the fastest-growing economies in the world. To sustain the high-level of economic growth and improve the well-being of its population, India must maintain macroeconomic stability, with price stability at its core. Taming inflation in India presents unique challenges, due to the composition of its Consumer Price Index (CPI) basket that differs from the advanced economies. India's CPI is heavily influenced by food and fuel prices, which are considered to be the most volatile components of the basket. The strong emphasis on food within the CPI makes India's inflation dynamics distinct from those in advanced economies, where food prices play a much smaller role.

It is this idiosyncratic nature of India's inflation that prompted the Finance Minister Srimati Nirmala Sitharaman to once comment at an ICRIER event that "inflation management cannot be "singularly" left to the monetary authorities." The Reserve Bank of India (RBI) agrees that fluctuations in food and fuel prices are driven by factors beyond its control, complicating its efforts to maintain stable inflation. The challenge is intensified by outdated CPI basket weights that have not been revised for more than a decade. The CPI may no longer accurately reflect the current consumption patterns, potentially distorting the measurement of inflation and formulation of policy responses. Therefore, understanding the dynamics of food prices, including factors influencing demand and supply is crucial for achieving price stability.

This book on 'Understanding Food Inflation Dynamics and Policies to Tame It' aims to identify the determinants of food inflation and provide reliable forecasts, which is essential for formulating timely policies to keep food inflation within the RBI's tolerance band. It undertakes a detailed, commodity-specific analysis to understand the stakeholders in the value chain, construct balance sheets, and explore alternative approaches to identifying the determinants of food inflation. Each chapter analyses and manages inflation for five major commodity groups: livestock (milk, poultry meat, eggs), cereals (rice, wheat), pulses (*tur*, gram, *moong*), vegetables (tomato, potato, onion), and fruits (mango, banana, grapes). The book also provides a methodology to model inflation accurately and provide inputs for the monetary policy framework.

We hope the study will significantly contribute in identification of policy levers to stabilise food inflation. The evidence-based research presented offers valuable insights for a wide range of stakeholders including policymakers, experts, and practitioners promoting informed decision-making and helping them navigate the complexities of inflation management in India.

**Dr. Deepak Mishra**
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# Preface

India's approach to tackling inflation has evolved over time, reflecting its increasing integration with the global economy. Unlike central banks in other major economies, India's inflation management cannot rely solely on monetary policy instruments, since food and beverages account for 45.9 per cent of the CPI basket. Over the past decade, food inflation has been a persistent challenge, impacting India's economic landscape. High food inflation affects overall inflation levels and impacts household welfare, especially for poorer consumers who spend a large portion of their income on food.

Between 2002-03 and 2022-23, India experienced four major episodes of high and volatile food price inflation, exceeding 10 per cent in 2008-09, 2009-10, 2012-13, and 2013-14. The high share of food in the CPI basket, with its susceptibility to supply shocks, presents challenges in managing inflation within a flexible inflation targeting (FIT) regime. Before the COVID-19 pandemic, the FIT regime managed to keep food inflation moderate, with occasional spikes due to volatile vegetable prices. However, after 2020, food inflation remained high, averaging 7.7 per cent from March to October 2022 and 8.7 per cent from July 2023 to April 2024 due to geopolitical tensions and adverse climate events. Sharp increases in food prices force poorer households to shift to cheaper, less nutritious diets, exacerbating undernutrition.

Understanding and managing food inflation has become a central concern for India's economic policy. Several studies have identified key drivers of food inflation, such as rural wages, fiscal deficits, international food prices, and government policies. Emphasis is placed on improving supply responses in agricultural markets and reducing wastage through structural and institutional reforms. Factors like the Minimum Support Price (MSP), real wages, demand for protein-rich items, input costs, supply chain bottlenecks, adverse weather conditions, climate change, and restrictive trade policies have significantly impacted food inflation. Recent geopolitical tensions and export restrictions have exacerbated food inflation, particularly in the prices of cereals and other commodities.

This book, based on a comprehensive study titled *"Understanding Price Dynamics of Major Agricultural Commodities and Identifying Ways to Improve Value Chains,"* initiated by the Reserve Bank of India (RBI) in collaboration with the Indian Council for Research on International Economic Relations (ICRIER), unravels the complex dynamics of food inflation in India. The study focuses on identifying key factors influencing food inflation and providing reliable forecasts to help formulate timely and effective policies to maintain inflation within the RBI's tolerance band. A novel balance sheet approach was employed to investigate agricultural commodity prices and inventories, computing monthly balance sheets from annual data to capture monthly demand and supply conditions. This methodology adds depth and dynamism to the understanding of agricultural markets and value chains, improving price forecasts.

The study examines five main categories of agricultural commodities: livestock (milk, poultry meat, and eggs), cereals (rice and wheat), pulses (*tur*, gram, and *moong*), vegetables (tomato, potato, and onion), and fruits (mango, banana, and grapes). It explores the entire value chain, develops a robust market intelligence network, and establishes a reliable information base through primary surveys to enhance understanding of price dynamics and forecasting. The analysis monitored supply-side factors such as acreage, production, imports, and stock changes, and demand-side factors, including domestic and global demand and export patterns. The stock-to-use ratio was tested for its early warning properties in assessing upcoming pressures on food inflation, helping to anticipate market tightness and potential price surges. This approach helped forecast inflation up to 12 months ahead and provided a rigorous evaluation of the performance of different forecasting models.

Despite commendable achievements in production levels, farmers face challenges in finding markets for their produce during surplus periods, leading to distress sales and wastage. Livestock and cereal farmers receive a higher share of consumer prices, while vegetable and fruit farmers receive only a third of consumer spending, due to inefficient and fragmented value chains and inadequate storage facilities.

The book provides important policy suggestions to control food inflation, combining short-term measures, such as regulating domestic supplies and trade policies, with long-term strategies to address structural inefficiencies in the agricultural sector. A comprehensive approach that addresses both supply-side constraints and demand-side dynamics can help stabilise food supplies, manage inflation, and benefit farmers, consumers, and the broader economy. Indian policymakers face the dual challenge of ensuring that farmers receive fair remuneration without causing price spikes while ensuring that consumers have access to food at affordable prices.

The insights presented in this book provide policymakers, researchers, and market participants with an understanding of the factors driving food inflation in India and the tools required to manage it effectively. The findings underscore the need for pre-emptive policy measures to maintain inflation within the RBI's tolerance band, advocating a proactive approach to inflation targeting. The novel approach of using monthly balance sheets to predict food inflation is expected to prove valuable for future research. As global and domestic scenarios evolve, the balance sheet and forecasting methodologies can adapt to keep pace with the ever-changing landscape.

*Editors*

Shyma Jose, Ranjana Roy, Ashok Gulati

# Acknowledgements

This study is part of a collaborative research project titled *"Understanding Price Dynamics of Major Agricultural Commodities and Identifying Ways to Improve Value Chains,"* conducted jointly by the RBI and ICRIER. We extend our deepest gratitude to the many individuals whose guidance and feedback were crucial to the completion of this study.

We express our sincere thanks to the RBI for its generous financial support that made this study possible. We are especially grateful to Shri Shaktikanta Das, Governor, RBI, and Dr. Michael Debabrata Patra, former Deputy Governor, RBI, for their encouragement and support throughout the project.

We acknowledge the invaluable contributions of Dr. Sitikantha Pattanaik, former Executive Director of DEPR (Department of Economic and Policy Research); Mr. Muneesh Kapur, Executive Director of DEPR; Dr. Rajiv Ranjan, Executive Director, Monetary Policy Department; and various other RBI officials for their insightful guidance and feedback during the study. We also appreciate the anonymous reviewers for their feedback and suggestions on the original research reports.

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Finally, we note that any errors, omissions, or views expressed in this book are those of the authors alone.

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# List of Abbreviations

| | |
|---|---|
| AAY | Antyodaya Anna Yojana |
| APL | Above Poverty Line |
| ADF | Augmented Dickey-Fuller Test |
| AHIDF | Animal Husbandry Development Fund |
| AIC | Akaike Information Criterion |
| AIDC | Agricultural Infrastructure and Development Cess |
| AMIS | Agricultural Market Information System |
| APEDA | Agricultural and Processed Food Products Export Development Authority |
| APMC | Agricultural Produce Marketing Committee |
| ARDL | Autoregressive Distributed Lag |
| ARIMA | Autoregressive Integrated Moving Average |
| ARIMAX | Autoregressive Integrated Moving Average with Exogenous Variables |
| AVU | Availability-to-Usage |
| BAHS | Basic Animal Husbandry Statistics |
| BIC | Bayesian Information Criterion |
| BMC | Bulk Milk Chilling |
| BPL | Below Poverty Line |
| BVAR | Bayesian Vector Autoregression |
| CAGR | Compound Annual Agricultural Growth |
| CES | Consumption Expenditure Survey |
| CFA | Carrying and Forwarding Agent |

| | |
|---|---|
| CFPI | Consumer Food Price Index |
| CIPHET | Central Institute of Post-Harvest Engineering & Technology |
| CMIE-CPHS | Centre for Monitoring Indian Economy–Consumer Pyramids Household Survey |
| CPI | Consumer Price Index |
| CPI-IW | Consumer Price Index for Industrial Workers |
| CSO | Central Statistics Organisation |
| CWC | Central Warehousing Corporation |
| CUSUM | Cumulative Sum of Recursive Residual |
| DAHD | Department of Animal Husbandry and Dairying |
| DEPR | Department of Economic and Policy Research |
| DES | Directorate of Economics and Statistics |
| DGCI&S | Directorate General of Commercial Intelligence and Statistics |
| DGFT | Directorate General of Foreign Trade |
| DIDF | Dairy Infrastructure Development Fund |
| DM | The Diebold-Mariano Test |
| DoA&FW | Department of Agriculture & Farmers' Welfare |
| DoC | Day old Chick |
| DoCA | Department of Consumer Affairs |
| DoRB | De Oiled Rice Bran |
| DSIM | Department of Statistics and Information Management |
| ECA | Essential Commodities Act |
| ECM | Error Correction Model |
| ECTA | Economic Cooperation and Trade Agreement |
| EU | European Union |
| e-NAM | Electronic National Agriculture Market |
| e-NWR | electronic Negotiable Warehouse Receipts |
| F&V | Fruits and Vegetables |
| FAO | Food and Agricultural Organisation |

| | |
|---|---|
| FCR | Feed Conversion Ratio |
| FDI | Foreign Direct Investment |
| FGD | Focused Group Discussion |
| FIT | Flexible Inflation Targeting |
| FMD | Foot and Mouth Disease |
| FPC | Farmer Producer Companies |
| FPO | Farmer Producer Organisation |
| FPS | Fair Price Shop |
| GAP | Good Agriculture Practices |
| GARCH | Generalized Autoregressive Conditional Heteroskedasticity |
| GCA | Gross Cropped Area |
| GCMMF | Gujarat Cooperative Milk Marketing Federation Ltd. |
| GEA | Grape Export Association |
| GGP | Great Grand Parent |
| GoI | Government of India |
| GVO | Gross Value of Output |
| HCES | Household Consumption Expendutire Survey |
| HOPCOMS | Horticultural Producers' Co-operative Marketing and Processing Society Ltd |
| HORECA | Hotels, Restaurants, Catering services |
| HP Filter | Hodrick–Prescott Filter |
| HPAI | Highly Pathogenic Avian Influenza |
| ICAR | Indian Council of Agricultural Research |
| ICRISAT | International Crop Research Institute for Semi-Arid Tropics |
| IGC | International Grain Council |
| IPPP | Innovative Poultry Productivity Project |
| KMS | Kharif Marketing Season |
| LDCs | Least Developed Countries |
| LIT | Low-input Technology |
| LKPD | Lakh Kg Per Day |

| | |
|---|---|
| LLPD | Lakh Litres of Milk Per Day |
| MA | Moving Average |
| MarkFed | Marketing Federation |
| MEIS | Merchandise Exports from India Scheme |
| MEP | Minimum Export Price |
| MGNREGA | Mahatma Gandhi National Rural Employment Guarantee Act |
| MIP | Minimum Import Price |
| MLP | Multi-Layer Perceptron |
| MMT | Million Metric Tonnes |
| MoA&FW | Ministry of Agriculture and Farmers' Welfare |
| MoCAFPD | Ministry of Consumer Affairs, Food and Public Distribution |
| MOFPI | Ministry of Food Processing Industries |
| MoM | Momentum (month on month) |
| MOSPI | Ministry of Statistics and Programme Implementation |
| MoU | Memorandum of Understanding |
| MPCE | Monthly Per Capita Household Consumption |
| MRL | Maximum Residue Limit |
| MSP | Minimum Support Price |
| MSR | Marketed Surplus Ratio |
| MT | Metric Tonnes |
| NAFED | National Agricultural Cooperative Marketing Federation of India Ltd |
| NAM | National Agriculture Market |
| NARDL | Non-linear Autoregressive Distributed Lag |
| NDDB | National Dairy Development Board |
| NECC | National Egg Coordination Committee |
| NFSA | National Food Security Act |
| NFSM | National Food Security Mission |
| NHB | National Horticulture Board |

| | |
|---|---|
| NHRDF | National Horticultural Research and Development Foundation |
| NLM | National Livestock Mission |
| NPDD | National Programme for Dairy Development |
| NSO | National Statistical Office |
| NSSO | National Sample Survey Office |
| OECD | Organisation for Economic Co-operation and Development |
| OGL | Open General License |
| OIV | International Organisation of Vine and Wine |
| PC | Phillips Curve |
| PCY | Per Capita Income |
| PFCE | Private Final Consumption Expenditure |
| PHC | Pre-harvest Contractors |
| PMGKAY | Pradhan Mantri Garib Kalyan Anna Yojana |
| PPP | Public-Private Partnership |
| PSF | Price Stabilization Fund |
| PSS | Price Stabilization Scheme |
| QR | Quantitative Restriction |
| Qtl | Quintal |
| R&D | Research and Development |
| RBI | Reserve Bank of India |
| RMS | Rabi Marketing Season |
| RMSE | Root Mean Square Error |
| RW | Random Walk |
| SAE | Second Advance Estimates |
| SARIMA | Seasonally Adjusted Autoregressive Integrated Moving Average |
| SARIMAX | Seasonally Adjusted Autoregressive Integrated Moving Average with Exogenous Variables |
| SAS | Situation Assessment Survey |
| SFW | Seed, Feed, Wastage |

| | |
|---|---|
| SMP | Skimmed Milk Powder |
| SNF | Solid Not Fat |
| STU | Stock-to-Use |
| SVAR | Structural Vector Autoregression |
| SWC | State Warehousing Corporation |
| SWS | Social Welfare Surcharge |
| TE | Triennium Ending |
| TOP | Tomato Onion Potato |
| TRQ | Tariff Rate Quota |
| UNGA | United Nations General Assembly |
| USDA | US Department of Agriculture's Production, Supply and Distribution |
| VAR | Vector Autoregression |
| VAR-X | Vector Autoregression with Exogenous Variable |
| VCA | Value Chain Analysis |
| VECM | Vector Error Correction Model |
| WEO | World Economic Outlook |
| WFP | World Food Programme |
| WMP | Whole Milk Powder |
| WPI | Wholesale Price Index |
| Y-o-Y | Year on Year |

# 1

ASHOK GULATI, RANJANA ROY and SHYMA JOSE

# Understanding Food Inflation in India

*An Introduction*

## 1.1 Introduction

Effectively managing and curbing inflation is a pivotal challenge for central banks overseeing the macroeconomic landscape of an economy. Governments use a mix of fiscal and monetary instruments to navigate structural supply constraints, sectoral rigidities, and the need for significant public sector investment while balancing the dual goals of controlling inflation and promoting growth. The structuralist school views growth and development as inevitable in the absence of inflation. In contrast, the monetarist view holds that money supply is the primary factor determining inflationary pressure in the economy. If there is excess liquidity in the system, it results in a sustained rise in prices, with 'too much money chasing too few goods.'

High inflation compels central banks to adopt stringent monetary and fiscal measures, leading to the risk of dampened economic growth, as seen during the pandemic. Strict policies, such as COVID-induced lockdowns and mobility restrictions, had adverse effects on global economies. To address rising unemployment and economic slowdowns, governments worldwide implemented expansionary fiscal measures, including guarantees, grants, tax reliefs, deferrals, equity participation, and public loans. In addition to these measures, major central banks employed Keynesian strategies, like reducing policy rates, such as repo rates, to increase the money supply and stimulate economic activity. These combined expansionary monetary and fiscal policies resulted in a sustained increase in global inflation.

In response, leading central banks shifted their focus to combat inflation by tightening monetary policies and adjusting policy rates to pre-pandemic levels, which pushed major economies into recession.

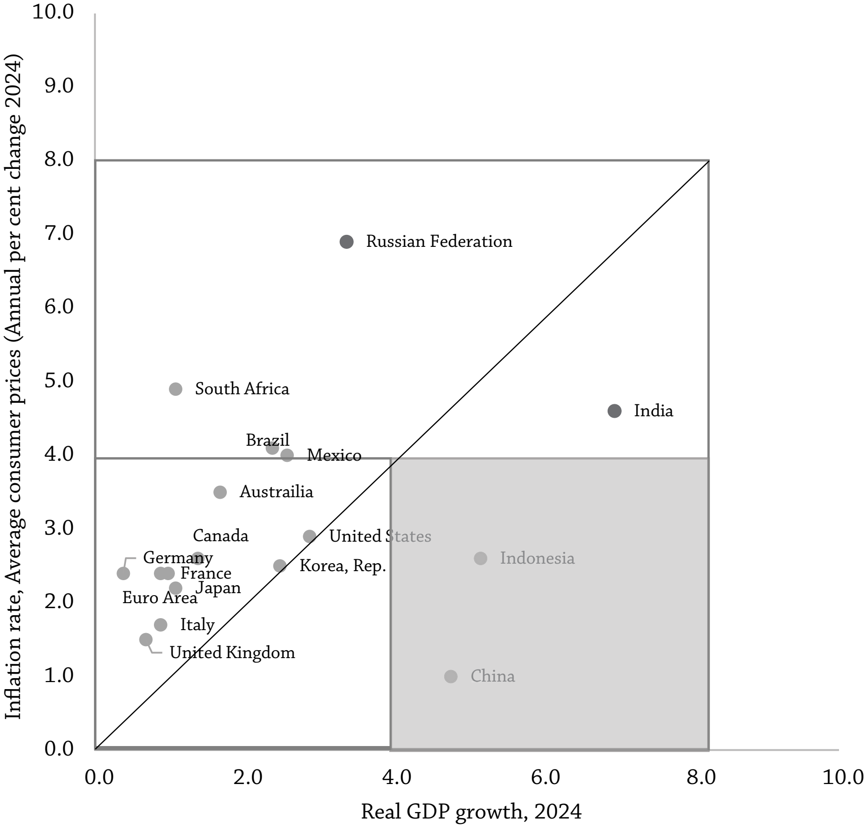
The trade-off between inflation and economic growth has been a perennial debate among policymakers. The central question remains: how can sustained economic growth be achieved while effectively managing inflation?

Figure 1.1 illustrates the scatter plot of inflation and real GDP growth rates across the G-20 countries. The different panels in the graph show the various combinations of inflation and growth scenarios across these countries. Ideally, the best scenario for any government and central bank is to attain economic growth between 4-8 per cent and keep inflation below 4 per cent. The IMF's *World Economic Outlook* (April 2024) forecasts global growth at 3.2 per cent for both 2024 and 2025. Among the G-20 countries, only two seem to be in the ideal scenario—China and Indonesia, with real GDP growth rates of 4.6 and 5.0 per cent and average inflation of 1 per cent and 2.6 per cent, respectively, in 2024 (Figure 1.1). At the same time, average inflation in Turkey and Argentina was recorded at 59.5 per cent and 249.8 per cent, respectively, in the same year. Comparatively, India is projected to have a growth rate of 6.8 per cent, while inflation is projected to be 4.6 per cent in 2024. The overall projected inflation rate in India is lower than its historic average of 6.6 per cent (2004–05 to 2023–24 period) (MOSPI, 2023), although the period of rising inflation remains a concern for Indian policymakers.

The repercussions of inflation extend beyond economic dimensions, exerting significant social impacts. High inflationary pressure, particularly in essential commodities like food, acts as an implicit tax burdening consumers. Prolonged food inflation erodes the purchasing power of individuals, jeopardising their food security and nutritional well-being—a concern magnified for lower-income households, where a substantial portion of expenditure is allocated to food. Thus, understanding inflation and accurately forecasting it are important tasks for central banks, as these are critical inputs for an effective forward-looking monetary policy.

**Figure 1.1**

*Inflation vis-à-vis GDP Growth in G-20 Countries*




*Note*: Inflation and growth in some G20 countries such as Turkey (59.5, 3.1) and Argentina (249.8, -2.8) are outliers.

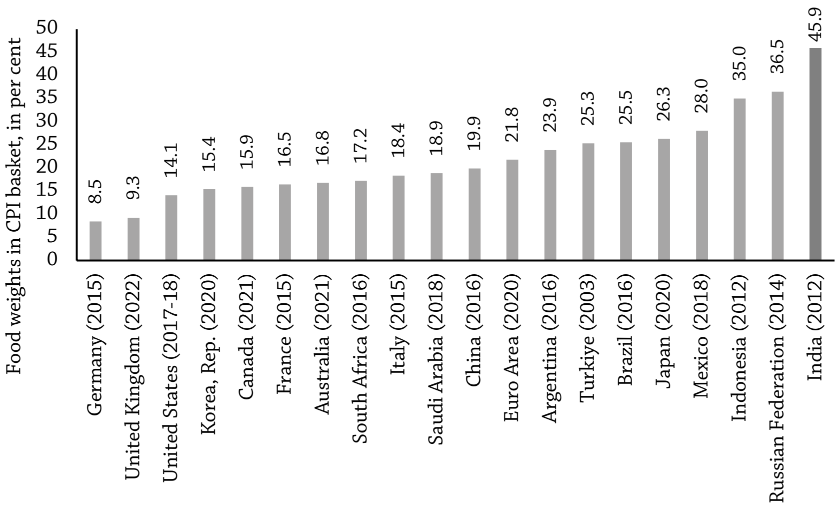
*Source*: World Economic Outlook (April 2024), International Monetary Fund (IMF).

Today, India is more integrated with the global economy, and its approach to tackling inflation has evolved over time, differing from the strategies employed by central banks in other major economies. Inflation targeting has been successfully practised in a number of countries, such as New Zealand, Canada, and the United Kingdom, over the past 20 years, and more countries are moving towards this framework. India adopted a formal inflation targeting (FIT) regime in 2016. Since then, reliable and unbiased predictions have been crucial for the central bank's objective of anchoring inflation expectations and maintaining price stability, as measured by the all-India Consumer Price Index (CPI)-Combined, published by the Central Statistical Office (CSO). Under the FIT framework, the Reserve Bank of India (RBI) is mandated to maintain an inflation target of 4 per cent over the medium term, with a tolerance level of ±2 per cent.

The adoption of the FIT regime poses several challenges. First, the CPI basket in India is unique and stands out internationally due to the high weightage of food and fuel, which are volatile components in headline inflation. Food and beverages, along with fuel, constitute 45.86[1] per cent and 6.84 per cent of the weight, respectively, in the combined-CPI (CPI-C). Specifically, food alone accounts for 39.06 per cent of the CPI basket in India. This structure of headline inflation differs from that of advanced economies, where food weights are much lower; for instance, in the UK (9.3 per cent), the US (14.1 per cent), Canada (15.9 per cent), and Germany (8.5 per cent) (Figure 1.2).

**Figure 1.2**

*Food Weight in CPI Basket with their Base Periods*




*Source*: Food weights from respective country's statistics department/central banks Press Release.

1. Food and beverages sub-group has a weight of 54.18 for calculating rural combined CPI and a weight of 36.29 for urban CPI (MoSPI, 2022).

A higher food weight in the CPI basket renders monetary policy to have little or no effect on taming food and fuel inflation, which is largely driven by supply-side factors. This poses a significant challenge in inflation targeting, as high volatility in food prices contributes to the overall inflation volatility (Benes et al., 2016). This makes it essential for the country's central bank to have consistently reliable forward projections of food inflation, as well as an understanding of its key sources and drivers, to facilitate the desired outcomes of monetary policy. With the integration of global markets, unanticipated demand and supply shocks, and various supply chain bottlenecks, arriving at accurate forecasts of inflation is becoming increasingly difficult for the central bank and policymakers. Additionally, the CPI weights are based on the Consumer Expenditure Survey of the National Sample Survey Office (NSSO), computed from the 68th round survey (2011–12). Since 2011–12, the CPI basket weights have not been revised.[2]

In the past two decades, between 2004–05 and 2023–24, annual inflation in India reached double digits in 2009–10 and 2012–13. Recent trends in overall inflation show that the central bank breached the upper tolerance level of the inflation target for three consecutive quarters between January and October 2022, making it answerable to the central government.

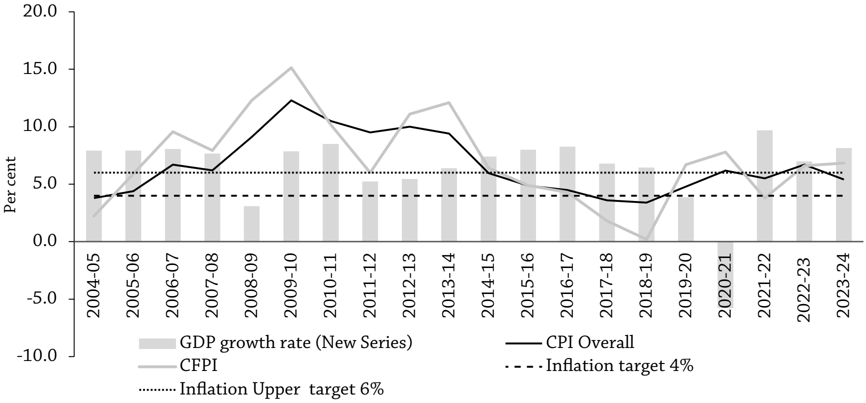
Similarly, India has faced high volatility in food inflation (measured by the Consumer Food Price Index (CFPI)), which averaged around 7.1 per cent between 2004–05 and 2022–23 (Figure 1.3). In the last two decades, there were four occasions of high and volatile retail food inflation exceeding the double-digit mark (more than 10 per cent). These four phases occurred during 2008–09, 2009–10, 2012–13, and 2013–14. Since then, food inflation has been moderate, especially after the adoption of FIT as the primary objective of the Reserve Bank's monetary policy in 2016.[3]

2. The latest unit-level Household Consumption Expenditure Survey for 2022-23 has been released; however, this study was completed prior to its release.

3. The Reserve Bank of India Act, 1934, was amended in 2016 to specify the primary objective of monetary policy as maintaining price stability while keeping in mind the objective of growth through a flexible inflation targeting (FIT) framework in India. Subsequently, the Government of India notified a medium-term inflation target of 4 per cent, with a band of +/- 2 per cent (Raj et al. 2019).

**Figure 1.3**

*CPI Inflation and Food Inflation in India*




*Note*: For data before 2011-12, Spliced using CPI-IW for Overall CPI and food inflation. GDP growth rate based on 2011-12 prices at market price.

*Source*: MOSPI, GoI; Labour Bureau.

High inflation requires immediate policy attention, as it reduces household purchasing power, especially for poorer consumers who spend a large share of their income on food. Against this backdrop, understanding price dynamics in food commodities, including factors affecting demand and supply, is critical for price stability. The present study aims to identify factors that impact food inflation and provide reliable forecasts. This forms a basis for formulating timely policies to keep food inflation within the RBI's tolerance band.

The book presents a commodity-wise analysis to comprehend the stakeholders in the value chain, construct balance sheets, examine alternative approaches to identify the determinants of food inflation, and provide forecasts for the short to medium term. This exercise is valuable in modelling inflation and delivering an accurate inflation prediction in terms of the CPI, which serves as an input for the monetary policy framework. The five food groups selected for the study are:

(i) Livestock (milk, poultry meat, and eggs)

(ii) Cereals (rice and wheat)

(iii) Pulses (*tur*, gram, and *moong*)

(iv) Vegetables (tomato, potato, and onions)

(v) Fruits (mango, banana, and grapes)

## 1.2 Objectives

The main objectives are as follows:

(i) To create a dynamic balance sheet for the selected 14 major commodities that explicates the state of supply and demand at a monthly frequency and study their market dynamics.

(ii) To empirically estimate the determinants of inflation for the selected commodities using the monthly balance sheet variables and other commodity-specific factors.

(iii) To forecast inflation in these commodities for up to 12 months and evaluate the performance of different forecasting models, both with and without the use of balance sheet variables.

(iv) To understand the complex value chains of the selected commodities to provide policy suggestions for stabilising prices and increasing the farmers' share in consumer spending.

The balance sheet approach of this study is unique, as we have computed monthly balance sheets from annual data to capture the depth and dynamism of agricultural markets and value chains. The underlying notion of computing monthly balance sheets was to account for the monthly demand and supply situation and monthly stock-to-use variables in the modelling framework, identifying and incorporating expectations about market tightness through future stocks that influence price discovery. To achieve this, the study built a network of market stakeholders, including farmers, traders, exporters, importers, millers, processors, and government officials across different Indian states. This exercise provided a dynamic, historical, and real-time evaluation of harvesting, production, consumption, trade (both export and import), stocking, and release patterns for the food commodities studied in the book. It is crucial to establish a robust, timely, and credible information base to improve the understanding of price dynamics and forecasting of prices. Additionally, the five commodity chapters assess the impact of macro policy actions and other external shocks on production, prices, and seasonality of the selected food items.

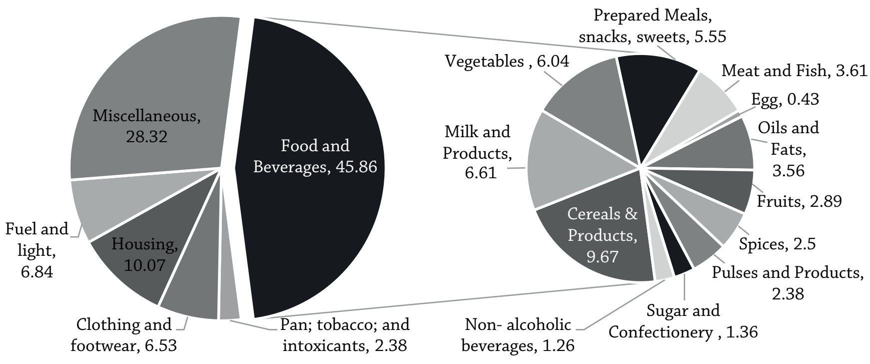
## 1.3 Overview of the Five Food Groups Selected for the Study

Given the significance of these food commodities in overall CPI inflation, it is important to identify the best possible ways to tame inflation. In this section, we briefly examine the profiles of the selected commodities to understand their relative significance in food inflation.

These 14 major food commodities have a combined weight of 19.5 per cent[4] in the CPI basket in India (Figure 1.4).[5] These commodities contribute considerably to the volatility in food inflation and overall inflation.

**Figure 1.4**

*Sub-group-wise Weightage in CPI basket*




*Source*: MOSPI.

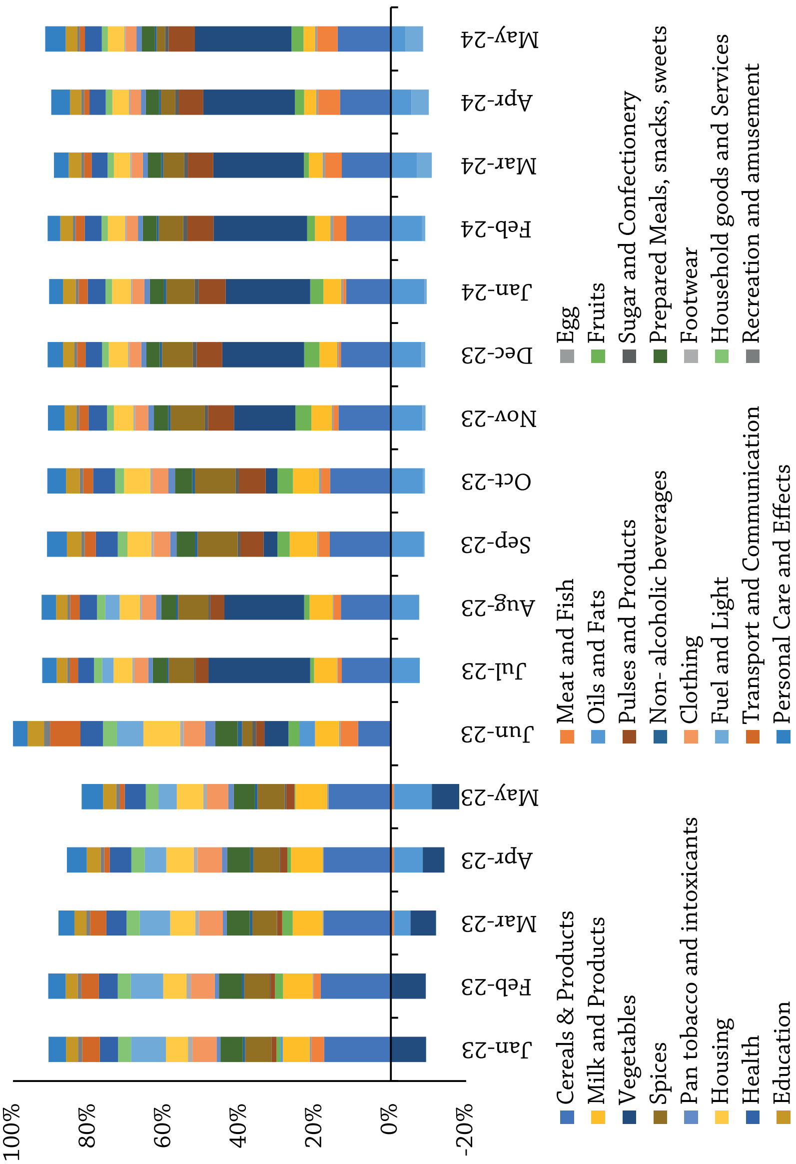
The relative significance of the five sets of commodity sectors can be derived from their contribution to overall CPI inflation. Two

4. The weights of the selected commodities in the CPI basket are 6.94, 8.08, 2.19, 1.24, and 1.03 for cereals, livestock, vegetables, pulses, and fruits, respectively (Annexure A 1.1).

5. Within the wholesale price index (WPI) basket, the food index accounts for 24.4 per cent of weight, whereas fuel and power constitute 13.2 per cent.

**Figure 1.5**

*Contribution of Major Sub-groups to CPI Inflation*




*Source:* MOSPI.

factors determine the contribution of different commodities to food inflation: the weight of each commodity in the overall food basket and the change in prices of these commodities. Taking the latest figures from May 2024, the contribution of cereals and products, pulses and products, livestock, vegetables, and fruits was around 70.9 per cent of the total CPI, compared to 26.5 per cent in January 2023. The largest contribution within the food group was from vegetables (30.91 per cent), followed by cereals (16.98 per cent) and pulses (8.33 per cent) in May 2024 (Figure 1.5).

The livestock sector has become a vital sub-sector of agriculture, generating lucrative employment opportunities in the rural sector, particularly among the landless, small and marginal farmers, and women. Between 2002–03 and 2018–19, income from the livestock sector (including dairy, poultry/duckery, piggery, and fishery) increased noticeably from 4 per cent to 16 per cent (NSSO, 2019). In terms of production volume, India has emerged as the largest producer of milk globally, surpassing the United States in 1998. The implementation of Operation Flood (1970–1996) expanded the presence of small farmers through dairy cooperatives and motivated the growth of organised private dairies, which helped dairy farmers gain better control over resources. Along with institutional development, technological advancements also played a role in increasing milk production from 127.9 to 230.6 million metric tonnes (MMTs) between 2011–12 and 2022–23. However, in international comparison, India's yield is much lower than that of other major producers like the USA, Australia, and New Zealand. Uttar Pradesh is the highest milk-producing state in India (with a share of 15.3 per cent), followed by Rajasthan (14.7 per cent) and Madhya Pradesh (8.6 per cent) in the triennium ending (TE) 2022–23 (Table 1.1).

Another important commodity within the livestock sector is poultry meat, whose value of output is growing at the highest rate of 10.1 per cent, compared to 6.2 per cent in eggs and 5.5 per cent in the milk group (2012–13 to 2021–22). Today, India is the fifth-largest producer of poultry meat globally, after the USA, China, Brazil, and Russia (FAOSTAT, 2022). Disaggregated state-wise analysis shows Maharashtra to be the highest poultry meat-producing state, accounting for 15 per cent, followed by West Bengal (13 per cent) and Haryana (12.5 per cent) in TE 2022–23 (BAHS, 2023). The demand for fresh meat from the live market, high tariffs on poultry meat imports, and inadequate processing make India uncompetitive in the global market.

Similarly, the egg sector has increased in both production and value terms. Egg production in the country improved from 63 to 138 billion numbers between 2010–11 and 2022–23 (BAHS, 2023). The top three egg-producing states in India are Andhra Pradesh (with a share of 20.3 per cent), Tamil Nadu (16 per cent), and Telangana (12.8 per cent) in TE 2022–23. India plays a minuscule role in the world egg trade due to large domestic consumption and stringent quality standards imposed by importing nations.

The next commodities selected for study are cereals, particularly rice and wheat. In cereals, India stands as the world's second-largest producer of rice and wheat, according to the FAO (2023). Out of the global cereal production of 3.0 billion tonnes in TE 2022, India accounted for a significant 11.5 per cent share, producing 350 million tonnes. Specifically, in wheat, India's production reached 109 MMTs, representing 13.9 per cent of the world's total wheat output. This places India behind China, which produced 136 MMTs and contributed 18 per cent to the global share in TE 2022. In terms of rice production, India's 192 MMTs constituted 25 per cent of the global share, trailing slightly behind China's 27 per cent contribution according to FAO (2023). In trade, India plays a significant role in the global wheat and rice markets. Over the past 15 years, India has become the world's largest rice exporter, accounting for 40 per cent of global rice exports in 2022–23, so changes in cereal trade policies have a significant impact on the international grains market.

In pulses, India is the largest producer (26 per cent of global production) and consumer (27 per cent of global consumption) worldwide. It often experiences price spikes, which have implications for poor consumers, as pulses are an affordable vegetarian source of protein. Among all the pulses grown in India, gram (*chana*/chickpea), a *rabi* crop, has the largest share in total production (49.5 per cent in TE 2023–24), followed by *tur* (14.1 per cent). In TE 2022–23, India produced 13.03 MMTs of gram, 4.1 MMTs of *tur*, and 3.16 MMTs of *moong*. However, for many years, domestic pulses production remained insufficient to meet annual consumption, leading to imports of 2.53 MMTs in 2022–23, as per the latest available data.

The next set of commodities studied in the book are vegetables and fruits. India's diverse agro-climatic zones and tropical climate make it conducive to growing a wide variety of fresh fruits. The country ranks second in fruits and vegetable production globally, after China. Within vegetables, tomatoes, onions, and potatoes (TOP vegetables) are the three principal crops in terms of production and consumption. India has now become the second-largest producer of TOP vegetables in the world. India is also the third-largest exporter of onions, with an 8.5 per cent share of world exports. In TE 2022-23 India exported 1.87 MMT fresh onion. However, India is not a major player in the trade of potatoes and tomatoes (2 per cent of global exports). According to the latest figures, the production of tomatoes, onions, and potatoes is 20.8 MMT, 29.5 MMT, and 57.5 MMT respectively. The sharpest increase of 63 per cent in production was experienced for onions between 2013–14 and 2021–22.

According to FAO (2022), among fruits, India ranks first in the production of bananas (26.45 per cent), mangoes (including mangosteens and guavas) (43.80 per cent), and second in table grape production (12 per cent) globally. This large production base allows India to be a global player with sufficient exports. During 2021–22, India exported fresh fruits and vegetables worth 1,527.60 million US dollars, of which fruits accounted for 750.7 million US dollars. In terms of volume, the share of fruit exports in total production is still meagre. Among the fruits studied in the book, grape production is regionally concentrated in the hot tropical peninsular region of India, with Maharashtra contributing 78 per cent of the production, followed by Karnataka (18 per cent) and Andhra Pradesh (1 per cent). Together, these states constitute 97 per cent of the total production (Table 1.1). Banana is the second most important fruit crop in India, with a total production of 35.4 in TE 2022-23. Unlike grapes, banana production is scattered across Andhra Pradesh (18.4 per cent), Maharashtra (13.1 per cent), Tamil Nadu (11.7 per cent), Gujarat

(12.4 per cent), Uttar Pradesh (10 per cent), Karnataka (8.9 per cent), and Madhya Pradesh (6 per cent), together contributing 80 per cent of the total production. Banana exports have steadily increased from 34.9 thousand MT in 2013–14 to 377 thousand MT in 2021–22. However, India still constitutes less than 1 per cent of world exports, as it is also the largest consumer of bananas.

India produced 20.7 MMT of mangoes in TE 2022-23, which accounts for 35.6 per cent of the total global mango production (FAOSTAT, 2022). The largest mango-producing states in India are Uttar Pradesh, Andhra Pradesh, Bihar, Karnataka, Gujarat, Tamil Nadu, and Telangana, which together comprise 75 per cent of the total production. Major varieties traded from India include *Kesar* (Gujarat), *Banganpalli* (Andhra Pradesh and Tamil Nadu), and Alphonso (Maharashtra), currently contributing around 6 per cent of global exports. However, India is a major consumer of mangoes, and a relatively small share of production is exported (DGFT, 2023).

**Table 1.1**

*Basic Statistics of Selected Commodities*

| | *Domestic Production (MMTs)* | *Global Production (MMTs)* | *Share in Global Production (per cent)* | *Export (MMTs)* | *Import (MMTs)* | *Major Producing States* |
|---|---|---|---|---|---|---|
| Milk | 221 (TE 2022-23) | 930.7 (TE 2022) | 23.09 (TE 2022) | 0.03 (TE 2022-23) | 0.0 (TE 2022-23) | UP, RJ, MP |
| Poultry Meat# | 4.0 (TE-2023) | 136.92 (TE 2023) | 2.92 (TE 2023) | 0.0 | 0.00 | MH, WB, HR |
| Egg* | 130 billion nos. (TE 2022-23) | 1649 billion nos. (TE 2023) | 7.3 (TE 2022) | 0.33 billion nos. (TE 2022-23) | 0.00 | AP, TN, TL |
| Rice | 128.2 (TE 2022-23) | 779.3 (TE 2022) | 24.7 (TE 2022) | 22.2 (TE 2022-23) | 0.01 (TE 2022-23) | WB, UP, Punjab |
| Wheat | 109.8 (TE 2022-23) | 779.4 (TE 2022) | 14 (TE 2022) | 5.3 (TE 2022-23) | 0.01 (TE 2022-23) | UP, MP, Punjab |
| Gram | 13.03 (TE 2022-23) | 16.3 (TE 2023) | 74 (TE 2022) | 0.21 (TE 2022-23) | 0.19 (TE 2022-23) | MP, MH, RJ |
| *Tur* | 4.06 (TE 2022-23) | 5.3 (TE 2022) | 78 (TE 2022) | 0.03 (TE 2022-23) | 0.73 (TE 2022-23) | MH, KA, UP |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Moong* | 3.16 (TE 2022-23) | 5.3 (TE 2017) | 36.0 (TE 2017) | 0.018 (TE 2022-23) | 0.10 (TE 2022-23) | RJ, MP, MH |
| Tomato | 20.8 (TE 2022-23) | 186.9 (TE 2022) | 11.1 (TE 2022) | 0.09 (TE 2022-23) | 0.0 (TE 2022-23) | MP, AP, KA |
| Onion | 29.5 (TE 2022-23) | 107.5 (TE 2022) | 26.1 (TE 2022) | 1.881 (TE 2022-23 | 0.0004 (TE 2022-23) | MH, MP, KA |
| Potato | 57.5 (TE 2022-23) | 372.6 (TE 2022) | 14.2 (TE 2022) | 0.44 (TE 2022-23) | 0.003 (TE 2022-23) | UP, WB, BH |
| Banana | 35.4 (TE 2022-23) | 131.3 (TE 2022) | 26.9 (TE 2022) | 0.323 (TE 2022-23) | 0.00 (TE 2022-23) | AP, MH, TN |
| Grape@ | 3.5 (TE 2022-23) | 30.43 (TE 2022) | 11.5 (TE 2022) | 0.26 (TE 2021-22) | 0.008 (TE 2021-22) | MH, KR |
| Mango& | 20.7 (TE 2022-23) | 58.2 (TE 2022) | 35.6 (TE 2022) | 0.14 MMT (TE 2022-23) | 0.00 MMT (TE 2022-23) | UP, AP, KA |

*Note*: * Production and trade data for egg is given in numbers. # In poultry meat, farmer's share is computed for integrator which is inclusive of per cent markup for farmers. The farmers share in consumer rupee for each of the commodities may vary for different harvest seasons and across states.
@Data is for table grapes (latest is available till TE 2021-22). & includes mango, guava, and mangosteens

*Source*: DES, GoI, FAOSTAT, DGFT, NHB, OECD-FAO Agricultural Outlook 2022-31 for poultry meat, Agmarknet, GoI, Establishing the International Mungbean Improvement Network (2022) and Field Survey.

## 1.4 Review of Literature: Analytical Framework to Understand Food Inflation

Understanding the drivers of commodity-specific inflation is crucial for generating accurate inflation forecasts and maintaining inflation targets on a sustained basis for monetary policy. High inflationary pressure attracts policy attention, as it affects household purchasing power, particularly among poor consumers who spend a significant portion of their income on food[6] (Bhattacharya and Sengupta, 2015). Bhattacharya and Jain (2020), citing theoretical literature, suggested that stabilising consumption by targeting the relative prices of food to non-food (Aoki, 2001), the real income of farmers (Anand et al., 2015), and the real exchange rate (Catao

6. Among the bottom 30 per cent of the population based on monthly per capita expenditure classes, food accounts for 60.3 and 55.0 per cent of the total expenditure in rural and urban households, respectively, in 2011-12 (MoSPI and WFP 2019).

and Chang, 2015) allows the economy to reach the optimal level of welfare. Anand et al. (2015) illustrate that targeting core inflation (excluding food and fuel) in a developing economy may not result in welfare improvement, especially when the share of food expenditure is high. Studies have shown that, in the long run, food inflation tends to be higher than non-food inflation, and food price volatility can lead to second-round effects (Anand et al., 2014; Benes et al., 2016; Walsh, 2011).

Several studies have empirically identified the factors contributing to food inflation in India, which can be broadly categorised into demand- and supply-side factors. The demand-side factors for food inflation include rising per capita income due to a sharp increase in rural wages, with the indexation of Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) wages coupled with pay commission awards to workers (Sekhar et al., 2018; Gulati and Saini, 2013), an increase in monthly per capita expenditure (Bhattacharya and Sengupta, 2018; Nair and Eapen, 2012), the level of Minimum Support Price (MSP) (Sonna et al., 2014; Nair and Eapen, 2015), the lagged impact of expansionary monetary and fiscal policy (Rangarajan and Sheel, 2013; Ganguly and Gulati, 2013; Gopakumar and Pandit, 2017), and diversification of the Indian diet towards high-value agricultural products (Nair and Eapen, 2012; Gokarn, 2011). Ganguli and Gulati (2013) examined a mix of demand-side factors, including rising rural wages with the expansion of MGNREGA and farm loan waivers, along with supply-side factors such as adverse weather conditions and climate change, for food price fluctuations. The authors also emphasised that subsidy bills and farm loan waivers, which increase the fiscal deficit, contributed to rising food inflation during the 2008–09 crisis. Studies such as Gulati et al. (2013) and Gulati and Saini (2013) have examined the impact of the fiscal deficit, international food prices, and various government policies on food inflation in India. Studies like Bhalla et al. (2011), Kapur and Behera (2012), and the RBI's Annual Report (2017–18) found a strong and positive relationship between MSP and food inflation in India. In contrast, Sonna et al. (2014) indicated a limited impact of MSP on food inflation and no significant impact of MGNREGA on inflation.

The supply-side factors include production shortfalls due to agro-climatic risks, drought, or flood (Mohanty, 2014), increasing production costs (Sonna et al., 2014) due to rising domestic oil prices and fertiliser costs (Bhattacharya and Sengupta, 2018; Nair and Eapen, 2012), disruptions in the agri-food supply chain due to the pandemic (Narayanan, 2022), and international prices and restrictive trade policies by major exporting countries (Bhattacharya and Sengupta, 2018). Abraham and Pingali (2021) found that non-price factors, including adverse weather and institutional issues related to market access, along with technological changes, have a relatively higher impact on supply than price factors in India. Chand et al. (2011) examined how various supply shocks, like droughts, contribute to the price inflation of different food commodities, including livestock. He noted that as the frequency of such shocks is expected to rise, India needs to have an effective food management strategy to address these issues. In a developing country like India, food inflation is driven by structural factors such as bottlenecks in the food supply chain. Another plausible supply-side factor for food inflation is restrictive trade policies in major exporting economies aimed at increasing food security.[7]

Some studies have incorporated supply chain issues and markups charged at different levels of the value chain, from 'farm to fork,' in determining factors for food inflation and its volatility (Bhattacharya, 2016; Bhattacharya et al., 2019; Bhoi et al., 2019). The multi-stage markups across crops, particularly the contribution of markups between farmgate and retail prices, constituents of those markups, and interlinkages between different market stakeholders—including traders, stockists, retailers, and farmers—have a significant effect on determining the magnitude of inflation (Banerji and Meenakshi, 2004; Bhattacharya, 2016; Pratap et al., 2021). Pratap et al. (2021) suggested that improving storage facilities, trade policies, accurate weather forecasts, reducing information asymmetry, and government steps for supply management can help keep food inflation in check.

7. The competitive storage model was first introduced in the seminal work of Gustafson (1958) and further developed in the work of Samuelson (1971) and Deaton and Laroque (1992).

Another significant determinant of commodity price behaviour, which can gauge inflationary pressure and is closely related to the demand and supply of a commodity, is stocks or inventories. Literature on competitive storage models[7] states that a higher stock level in a commodity tends to curb speculative tendencies in the market, dampen price volatility, and contribute to price stabilisation (Gokarn, 2011; Nair and Eapen, 2015). Stigler and Prakash (2011) use stock and stock-to-disappearance ratio forecasts rather than ex-post annual stock variables in the balance sheet for price determination, as they directly influence agents' current behaviour.

The study found that commodity prices are not affected by inventories in cases of higher expectations of future inventories or in the absence of market tightness. Conversely, stocks and the stock-to-disappearance ratio were estimated to influence commodity prices when inventories are low. Dawe (2009), in contrast to these studies, estimated that the link between commodity stock levels and price volatility in the global rice market is weak, whereas Roache (2010) found that commodity stock levels do not impact price volatility in the long term. Commodities such as pulses have a longer shelf life and can be stocked for more than a year, which renders pulse stocks important in explaining price and market volatility. Like cereals, the central government in India intervenes in the pulses market through procurement, stocking, and distribution policies to resolve supply and demand mismatches and ensure price stability.

There are numerous studies that delve into the commodity-specific factors of inflation. We review some of the important literature across selected food groups for this study:

### *Livestock*

Gandhi and Zhou (2010) found that the demand for milk and milk products has the greatest sensitivity to changes in income (proxied by expenditure) in India. According to them, inflationary pressures in milk since 2005 can be attributed to rising demand that has outpaced the increase in production. Mishra and Roy (2016) found that inflationary pressures in the dairy sector can be attributed to the surging demand, which has surpassed production growth.

Crucially, the imbalanced structure of dairy supply chains, favouring the informal sector, has resulted in challenges in maintaining a consistent supply of milk over time and across regions. The authors also highlighted that the government's long-standing trade policy for milk and its products has contributed to persistent inflationary pressures. Prior to 1990, trade protection primarily manifested through quotas and canalisation, with the National Dairy Development Board (NDDB) overseeing all imports.

Elliot and Dale (1980) examined the impact of changes in aggregate income, prices of close substitutes (pork and beef), and cost variables like the price of corn and soybean meal in the short and long run on the US poultry economy. They found that an increase in feed costs decreases broiler production, leading to a rise in broiler prices. At the same time, they found that during 1973, beef prices rose due to a short supply of beef, which increased the demand for broiler meat and, consequently, its price. Weimar et al. (1990) estimated an annual econometric model of the livestock and poultry sector and used it as a basis for a dynamic simulation model. The model provided a framework to estimate the long-term impact of policy or exogenous shocks, such as a rise in feed costs, on the livestock and poultry sector. Their results indicated that, for a rise in feed costs, broiler per capita consumption falls less than other meat items like pork and turkey. Broilers are better converters of feed, while pork and turkey are less efficient, and therefore the impact on broiler prices is less than on pork and turkey.

Westcott et al. (1987) developed a model incorporating both behavioural and biological factors to forecast US egg prices in the short and medium term for policy analysis. The paper derived feed cost, income, and broiler price multipliers to show their effect on egg prices and found that a change in disposable income directly impacts the demand for broiler meat and indirectly affects egg prices. As income rises, the demand for broiler meat increases, which, in turn, leads to an increase in broiler production. A 10 per cent rise in broiler production results in a change in egg production by 1 per cent, which affects its price. Ihsan et al. (2022) predicted the movements in egg prices in Indonesia on major holidays using the Multi-Layer

Perceptron (MLP) method. According to them, the price of necessities changes quite drastically during such times, and one of the main commodities experiencing drastic price movements during holidays is eggs.

### *Cereals*

Studies indicate that cereals consistently rank among the top 10 contributors to overall food inflation in India. In certain years, such as 2008 and 2013, rice emerged as the primary contributor to this inflationary trend (Mishra and Roy, 2016). With the dual market structure in cereals, the government intervenes extensively in cereal markets to keep inflationary pressures in check through pricing, procurement, stocking, and distribution controls. Gaiha and Kulkarni (2005) highlighted a significant positive correlation between the MSP set for rice and wheat and the WPI and CPI-AL, even after adjusting for time trends and income levels. While the MSP aims to incentivise farmers, it falls short of international price levels. This discrepancy implies that, with export regulations in place, it resembles an indirect tax burdening farmers. Additionally, as the fiscal implications of the procurement system have escalated, it has curtailed long-term public investments in agriculture. Some studies found that cereal prices are mainly driven by supply-side factors such as production, wage rates, and MSP (Sekhar et al., 2018; Ahirwar et al., 2018).

### *Pulses*

Gopakumar and Pandit (2017), while studying factors impacting high inflation in protein products, estimated that the lag of increased supply, growth of income, increased money supply, capital formation in the agricultural sector, and relative prices of substitute commodities significantly impact pulses inflation. The study highlighted that domestic demand for pulses is met through imports, and with no trade restrictions, international price movements can significantly impact domestic availability and price stability in pulses. Notably, the study recommended that inflation-targeting policies for pulses should focus on supply-side management by increasing availability.

While studying high-value commodities such as pulses, milk, meat, fruits, and vegetables with an income-elastic demand, Nair and Eapen (2012) emphasise that persistent price pressure is due to structural factors, i.e., a poor supply response to rapidly increasing demand. The literature emphasises that price stability in food necessitates an elastic demand or supply function. Sekhar et al. (2018) highlighted two short-run supply relations that are important for understanding farmers' production responsiveness to changing demand. The first supply function involves a time lag between the farmer's production decision and actual production. Studies such as Abraham and Pingali (2021) and Joshi et al. (2017) have shown that pulses have a weak supply response if there are no factors to offset production and marketing risks. For instance, high prices in pulses led to increased production in 2017–18. This book further reiterates that volatility in pulses' availability and price will persist in the country if pulses production remains semi-commercial, with limited market access for farmers and supply remaining responsive to exceptionally high prices. Sekhar et al. (2018) found that supply- and demand-side factors contributed equally to inflationary pressure in pulses. Specifically, production, wage rates, and monthly per capita expenditure were significant in explaining pulses inflation.

### *Vegetables*

In vegetables, Padhi et al. (2023) investigated horizontal and vertical volatility transmission, especially in tomatoes, onions, and potatoes (TOP), and found horizontal price volatility transmission from tomatoes to onions and potatoes in both the retail and wholesale markets. While the volatility transmission between wholesale and retail prices was unidirectional from wholesale to retail in the case of onions and tomatoes, it was bidirectional in potatoes, reflecting the vertical transmission mechanism. Birthal et al. (2019) found that even in months with no significant climatic shocks, market arrivals of onions showed ambiguity, indicating monopolistic trade practices in major markets as a reason for price pressure. The study also found that changes in export policies did not have a cooling effect on inflation. Saxena et al. (2022) tracked the price spread and volatility spillover effects in major wholesale markets in India. The study determined the degree to which price shocks and volatility are transmitted to other markets and concluded that continuous surveillance in strategic markets can prevent extreme volatility. Moreover, vegetable prices exhibit a recurring pattern, resembling a distinct instance of the price-production cobweb, where the same scenario unfolds every other year. The sharp decline in prices in one season leads to substantial losses for small farmers, forcing many to abandon cultivation. Due to low returns, farmers opt for other crops. The resulting supply shortage translates into higher prices in the subsequent season (Kundu et al., 2019).

### *Fruits*

Fruit crops have distinct seasonality, which impacts their prices, while demand remains relatively uniform throughout the year. Bhattacharya and Sengupta (2015) argued that the supply of fruit commodities (including exceptional drought years, 2009–10) exceeded domestic demand during 2006–13, resulting in moderate inflation in the sector. Fruit production is determined by the area under cultivation, environmental conditions, days of sunshine, rainfall, cyclones, and pest attacks. Temperature impacts fruit production; heatwaves, particularly during the fruiting stage, can lead to harvest loss.

Fruit production is also influenced by soil degradation, water shortages, and diseases. Due to climate change, supra-optimal temperatures and erratic rainfall impact horticultural production, distorting the crop cycle (Dutta, 2013). Post-harvest losses are a constraint on domestic fruit availability, with losses occurring due to inefficient infrastructural facilities in the supply chain, including an inadequate number of cold storages and phytosanitary measures. Post-harvest loss is estimated to be as high as 25 per cent, ranging from 18 to 37 per cent across different fruit crops, leading to a widening gap between production and availability (Bairwa et al., 2012). Due to improper handling of bananas, a lack of proper transport facilities, and an inadequate storage environment, post-harvest losses are high (Mohapatra et al., 2010). On the demand side, increases in per capita income have escalated the consumption of high-value, income-elastic commodities, including fruits (Rao et al., 2006). With economic growth and urbanisation, global trade in fruits and vegetables is growing rapidly. However, tariff rates are not uniform across importing countries, and higher import barriers result in inflation in the domestic market (Aksoy and Beghin, 2005). On the other hand, an increase in demand for Indian fruits in the global market puts price pressure in years of market shortages.

## 1.5 Organisation of the Book

This book is organised into eight chapters. This chapter introduces the rationale, background, scope, and overview of the commodities selected for the study.

Chapter 2 presents a comprehensive discussion of the methodological framework, including the balance sheet approach, model specification, and forecasting techniques. Chapters 3 to 7 explore commodity-specific price dynamics. Chapter 3 investigates the value chains of three major livestock products—milk, poultry meat, and eggs. Chapter 4 extensively examines cereal inflation and the factors impacting price formation in rice and wheat in India. Chapter 5 studies the price dynamics of three major pulses in India—gram, *tur*, and *moong*. Chapter 6 explores the three major vegetables in India (TOP), and Chapter 7 analyses three major fruits, focusing on grapes, bananas, and mangoes. The research findings are used to develop commodity-specific policy suggestions that could help address existing challenges and strengthen the value chains to bring about price stability.

Drawing from the research findings, the book offers commodity-specific policy recommendations aimed at addressing prevailing challenges and bolstering the value chains to ensure price stability. Chapter 8 discusses a path forward, presenting overarching policy suggestions pertinent to mitigating food inflation and improving the efficacy of the value chains.

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## 1.7 Annexure

**Table A1.1**

*Weightage in CPI basket*

| *Items* | *Weight* | | | *Items* | *Weight* |
|---|---|---|---|---|---|
| Livestock | Milk | 6.42 | Cereals | Rice | 4.38 |
| | Poultry chicken | 1.23 | | Wheat | 2.56 |
| | Egg | 0.43 | | | |
| Pulses | Gram whole | 0.09 | Vegetables | Potato | 0.98 |
| | Arhar/*Tur* | 0.80 | | Onion | 0.64 |
| | *Moong* | 0.35 | | Tomato | 0.57 |
| Fruits | Mango | 0.32 | | | |
| | Banana | 0.56 | | | |
| | Grapes | 0.15 | | | |

*Source*: MOSPI.

# 2

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## Methodological Framework for Understanding Food Inflation

### 2.1 Introduction

Modelling inflation and providing accurate inflation forecasts have always been challenging for economic agents in forming their inflation expectations. Comprehending inflation dynamics and accurately forecasting inflation are critical for an effective forward-looking monetary policy. As discussed in the introductory chapter, various factors have been studied in the literature that have led to food price surges and price volatility in agricultural commodities. These include sporadic global supply disruptions, rising rural wages, the monsoon and its vagaries, and a range of government policies, such as price supports and the rural unemployment guarantee scheme (Nair and Eapen, 2012; Sonna et al., 2014; Kapur and Behera, 2012; RBI's Annual Report, 2017–18). Some studies suggest that expansionary monetary and fiscal policies adopted to stimulate economic activity following the COVID-19 pandemic have contributed to higher food inflation in India. Understanding the factors that impact inflation is not enough; this must be substantiated with reliable and accurate forward projections of the key drivers of food inflation.

Approaches to inflation forecasting and dynamics have been extensively studied and have evolved over time. For example, Phillips curve models based on inflation expectations, as used by Kapur and Patra (2000), Patra and Kapur (2012), and Behera et al. (2017), argue that the Phillips curve has lost relevance due to the disconnect between inflation and output across countries (Hooper et al., 2020). Additionally, these countries have experienced significant declines in output with only mild effects on inflation (Kabundi et al., 2023).

Various time series models, including univariate (ARIMA-based) and multivariate models (VAR, VECM, ARIMAX, VARX), as well as structural models, have been employed for inflation forecasting (John et al., 2020; Stock and Watson, 2009; Aiolfi and Timmerman, 2006; Behera et al., 2017). Another alternative is the forecast combination approach, derived from the seminal work of Bates and Granger (1969), which has been utilised by central banks worldwide to improve forecasting performance (John et al., 2020; Altavilla & Ciccarelli, 2007). In the Indian context, only a few studies, such as Dholakia and Kadiyala (2018) and John et al. (2020), have applied the forecast combination approach.

Several studies have used different models to identify various demand- and supply-side factors contributing to food inflation dynamics. For instance, Bhattacharya and Sengupta (2015), using an SVAR model, found that rising per capita income on the demand side and a rise in prices of key inputs, MSP, and fiscal deficits on the supply side contributed to food inflation in India. Using the capital asset pricing model and Granger causality, Gilbert (2010) found that agricultural price booms can be better explained by common factors rather than market-specific factors such as supply shocks. The paper cited that index-based investment in agricultural futures markets is the major channel through which macroeconomic and monetary factors generated food price rises. Mohanty and John (2015) identified crude oil prices, the output gap, and fiscal and monetary policy as the determining factors of inflation in India using an SVAR model.

In addition to various demand- and supply-side factors, a number of studies have incorporated supply chain dynamics, including the contribution of mark-ups between farmgate and retail prices, the constituents of those mark-ups, and interlinkages between different market stakeholders, including traders, stockists, retailers, and farmers, to understand the sources of food inflation and its volatility

(Bhoi et al. 2019; Bhattacharya, 2016). In the RBI Bulletin (2019), using a pan-India survey of farmers, traders, and retailers and multivariate regression using ordinary least squares (OLS) across crops and states, the authors found that a better road network, mandi infrastructure, tele-density, and irrigation facilities help reduce mark-ups and, hence, the volatility of food inflation (Bhoi et al. 2019). Similarly, using monthly data and an SVAR framework, Bhattacharya (2016) showed that multi-stage mark-ups across crops played an important role in determining price volatility.

Although most studies have examined high food inflation in India and its determinants over the last two decades (Bhattacharya, 2016; Nair and Eapen, 2012; Gulati et al., 2013; Gulati and Saini, 2013; Bhalla et al., 2011), very few have conducted a comprehensive commodity-wise analysis to understand the reasons for price fluctuations (Gopakumar and Pandit, 2017; Nair and Eapen, 2012; Sekhar et al., 2018; Abraham and Pingali, 2021; Joshi et al., 2016). In their study, Gopakumar and Pandit (2017), using the structuralist approach for the period between 1980–81 and 2013–14, showed that food items like pulses, fruits, vegetables, eggs, meat, fish, and milk are not only driven by supply-side factors, such as capital stock prices, but also by demand factors, such as the rate of growth of real income, money supply, and relative prices, which significantly impact price surges. Another study by Sekhar et al. (2018) examined the determinants of food inflation across different food groups using a panel regression framework with crop-fixed effects to account for crop-specific unobservable factors, such as storability and movement restrictions across states. Understanding the drivers of commodity-specific inflation is equally important to generate accurate inflation forecasts and maintain inflation targets on a sustained basis for monetary policy. A wide range of literature discusses forecasting inflation using univariate as well as multivariate models. Even in the Indian context, there is growing interest in different approaches to accurately and reliably forecast inflation.

Although the Phillips curve (PC) approach has been successfully used to model and forecast inflation in a number of advanced countries, in the last decade, the view has gained ground that the

"Phillips curve is dead" (Hooper et al., 2020). In the Indian context, studies such as Kapur (2013) and Patra et al. (2014) have used backward-looking PC and hybrid PC for forecasting inflation. One of the most common forecasting approaches is ARIMA-based, which gives more weight to near-term outcomes. Lately, in short-term forecast performance, the ARIMA-based approach has been able to outperform complicated structural models (Dholakia and Kadiyala, 2018). Srivastava (2016) used ARIMA-based approaches and compared direct and indirect forecasts of food inflation, concluding that a disaggregated approach performed better in the case of food inflation. There are numerous multivariate models that have been used in the literature to forecast inflation, such as SVAR (Mohanty and John, 2015), vector autoregressive (VAR) models of various specifications (Bjørnland et al., 2010), including vector autoregressive with exogenous variables (VARX) (Dholakia and Kadiyala, 2018; John et al., 2020), Bayesian VARs, and time-varying parameter regression approaches. The study by Bhattacharya et al. (2003) on forecasting inflation highlighted that the forecast performance of a simple time-series estimation model can be significantly improved by supplementing it with an exogenous variable. In contrast, Stock and Watson (2009) suggested that models with a large number of predictors tend to fare poorly compared to parsimonious forecasting techniques.

Apart from these individual models, there is a large body of literature that has adopted alternative approaches for modelling—forecast combination approaches. The seminal work of Bates and Granger (1969) has shown how forecast combination is effective in enhancing the performance of individual models. For developing countries, Gomez et al. (2011) suggested that forecast performance can be more accurate with combination forecast methods than with individual models. In their study comparing combination forecasts for the US, Zhang (2019) suggests that models using equal weights for combining forecasts did not produce worse forecasts than those with time-varying weights. For the Euro area, the superiority of forecast combinations was confirmed for core inflation, with performance-based weighting combinations outperforming simple averaging (Hubrich and Skudelny, 2017). Only a few studies (RBI, 2017; Dholakia and Kadiyala, 2018) have discussed the inflation forecast combination approach in the Indian context. Dholakia and Kadiyala (2018) found that a combination of different econometric models based on mean square error improved forecasting accuracy over any individual model.

In the context of inflation modelling, central banks such as the Bank of England, Norges Bank, and the Reserve Bank of New Zealand have used a combination forecast approach. For Turkey, Öğünç et al. (2013) showed that forecast combinations reduced forecast errors compared to individual models. For Norway, Bjørnland et al. (2012) found that forecasts based on the combination approach outperformed individual models and even the central bank's (Norges Bank's) own forecasts for inflation at all horizons.

In the Indian context, studies such as RBI (2017) and John et al. (2020) found that combination forecasts are more accurate and reliable than individual models, including random walk (RW), autoregressive (AR), vector autoregression (VAR), and its various specifications with exogenous variables, and the PC approach. There are challenges related to combination forecasts, such as calibration and sharpness, that need to be considered when assessing or selecting a combination scheme (Gneiting et al., 2007). Although much of the research highlights that combining forecasts outperformed individual forecasts, Hibon and Evgenion (2005) showed that the best individual forecasts, chosen using the right model selection criteria, can perform just as well as a combination of forecasts.

Recent literature on forecasting is using news-based text data, especially in the form of sentiment indicators, to improve forecasts over and above other macroeconomic indicators (Banerjee et al., 2021; Pratap et al., 2021). For instance, Pratap et al. (2021) used news-based sentiment indicators combining high-frequency information and market intelligence to nowcast food inflation, particularly inflation in TOP commodities that contribute heavily to volatility in food inflation and headline inflation. The study found that a news-based index improves the forecasting accuracy of forecasting techniques.

The seminal work of Gustafson (1958) on competitive storage models, further developed by Samuelson (1971) and Deaton and Laroque (1992), considered stocks or inventories as a significant determinant of commodity price behaviour. High inventory/stock in a commodity tends to curb speculative price surges in the market, thereby dampening price volatility and contributing to price stabilisation (Gokarn, 2011; Nair and Eapen, 2015). Stigler and Prakash (2011) found that commodity prices are influenced by information on stock levels, particularly supply and demand gaps, which reduce STU ratios further when stock levels are low. The study highlighted that commodity prices are not influenced by inventories in the absence of market tightness. In contrast, Dawe (2009) estimated that the link between commodity stock levels and price volatility in the global rice market is weak, while Roache (2010) found that commodity stock levels do not impact price volatility in the long term. Briefly put, these studies provide credence to the use of the stock-to-use ratio as a variable to improve the forecasting performance of models.

As the objective of the book is to understand price dynamism, including factors affecting demand and supply in five sets of agricultural commodities, namely: (i) livestock (milk, poultry meat, and eggs); (ii) cereals (rice and wheat); (iii) pulses (*tur*, gram, and *moong*); (iv) vegetables (tomato, potato, and onions); and (v) fruits (mango, banana, and grapes), this methodological chapter aims to contribute to this strand of literature by analysing the alternative approaches to inflation analysis, including the balance sheet approach, structural modelling, and forecasting techniques to forecast commodity-wise inflation accurately. The monthly balance sheet for each commodity will capture the factors that determine/affect prices, thereby comprehending the players in the value chain and decoding how their behaviour influences market supply and demand at a given point in time. This exercise will further help identify the bottlenecks in the system and improve the accuracy of inflation forecasts.

## 2.2 Methodological Framework for Inflation Estimation

This section discusses the methodological framework, which is divided into four parts. First, we discuss the balance sheet approach and explain how to estimate monthly stock-to-use (STU) ratios, which are used as a proxy variable to understand price dynamics. Second, we explain the model specifications used for estimating the different factors that influence commodity-specific price volatility and inflation. Third, we detail the forecasting methodology employed in our study. Lastly, we outline the framework for performance evaluation and robustness checks.

### *2.2.1 Balance Sheet Approach*

Various studies have used the balance sheet approach to investigate agricultural commodity prices and inventories to explain price movements, including those conducted by the Food and Agricultural Organisation (FAO) under the Agricultural Market Information System (AMIS), the US Department of Agriculture's Production, Supply and Distribution (USDA), and the International Grain Council (IGC). The underlying concept of computing the balance sheet is to take into account the demand and supply situation within the modelling framework, identifying and incorporating expectations about market tightness through future stocks that influence price discovery. The literature review has provided ample evidence on the importance of stocks (inventories) in capturing price movements.

The balance sheet approach of this study is a novel exercise, as existing literature on balance sheets generally operates at the annual level. In contrast, we have computed monthly balance sheets, which requires depth and dynamism. For instance, for commodities such as pulses, livestock, and fruits, we have computed monthly balance sheets at the all-India level. In contrast, for vegetables (tomato, onion, and potato), the monthly balance sheets are computed at the state level for the major producing states. The rationale for computing monthly balance sheets at the state level is that the production of these three vegetables is spread not only throughout the country with some spatial concentration but also temporally through the crop seasons across the crop year. Additionally, it was observed that production shocks at the all-India level were too weak to explain price movements in these volatile commodities. Therefore, it was important to capture production variations in each season of the major producing states for the vegetable balance sheets. The state-level balance sheets for vegetables follow the same methodology used for the all-India balance sheets, as explained below.

This analysis has been conducted for each state across all commodities, resulting in the creation of five balance sheets for tomato, five for onion, and three for potato to determine the stock variables for each state.

### 2.2.2 Conceptual Framework of a Monthly Balance Sheet

The components of the commodity-specific balance sheet extend the elements of their value chain, capturing nuances of demand and supply, including the crop year, harvesting pattern, consumption pattern, and farmers' stocking and release patterns (Figure 2.1). The components of the balance sheet at the annual level are broken down into monthly numbers through dynamic and real-time evaluation. More specifically, the dynamic monthly balance sheet will:

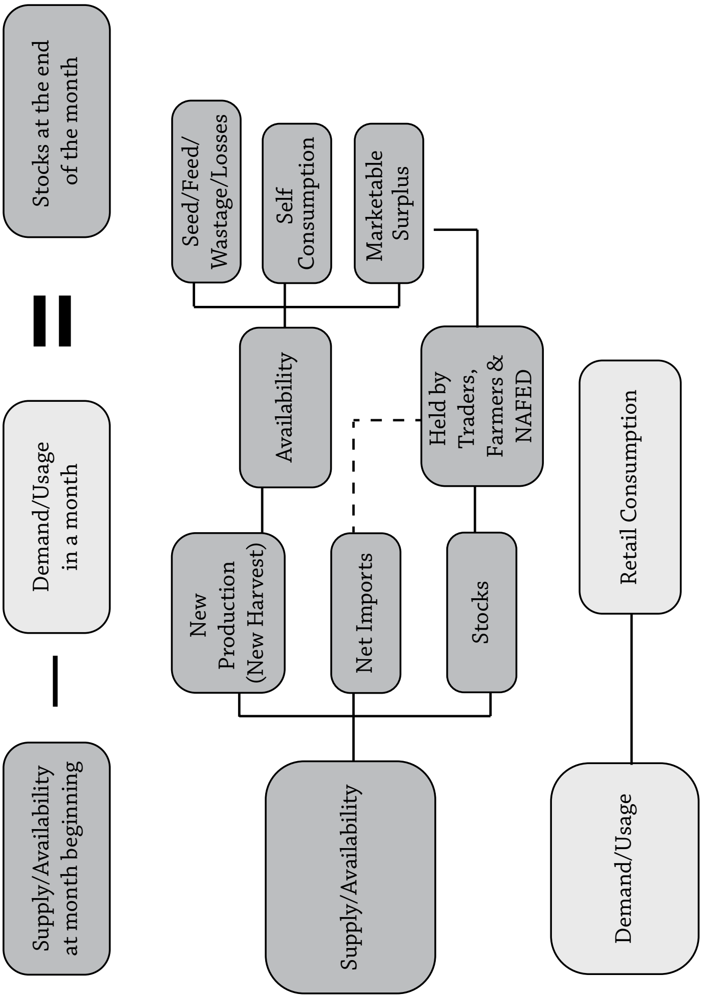
i. Capture the underlying patterns and trends of demand and supply.
ii. Identify the patterns in the behaviour of farmers, traders, importers, and consumers and incorporate them into the dynamic monthly balance sheet to understand how the market responds. These patterns include the harvesting, stocking, and releasing of farmers' produce, as well as the seasonality of prices.
iii. Use various components of the balance sheet to compute the monthly stock-to-use or availability-to-usage ratio, which will help capture price movements in the commodity market.

### 2.2.3 Components of the Monthly Balance Sheet

In this subsection, we discuss in detail the different components of the balance sheet. This analysis will not only shed light on the interplay of stakeholders—such as farmers, traders, stockists, and

**Figure 2.1**

*Flow Chart of Monthly Balance Sheet*




*Source*: Compiled from Field Survey.

the government—in price discovery and movements but will also help us compute monthly stock levels for the selected commodities. Although the value chain pattern of stakeholders in harvesting, sowing, and releasing crops varies significantly across commodities, we strive to generalise the nuances of different commodities in our balance sheet approach.

### Availability

Availability in any given month is the sum of the proportion of the new produce/crop sold in the market, the stocks (if available) carried forward from previous months, and the net imports in the current month, as shown in equation (1). However, for some commodities, such as vegetables, fruits, and poultry, which do not have a long shelf life, the availability variable does not include carry-forward stocks, as depicted in equation (2).

$$Availability_t = (Marketed\ surplus_t/Farmer's\ sale_t - Post\text{-}harvest\ Losses_t) + (Imports_t - Exports_t) + Stock_{t-1} \quad ...(1)$$

&

$$Availability_t = (Marketed\ surplus_t/Farmer's\ sale_t - Post\text{-}harvest\ Losses_t) + (Imports_t - Exports_t) \quad ...(2)$$

Cereals are characterised by dual markets operated by private trade and government procurement. The cereal balance sheet aims to understand price movements in the residual market (i.e., CPI wheat and CPI rice from other sources) and does not include any elements of the market controlled by the government. To compute the availability of rice and wheat in the residual market operated by private traders, we deduct the quantity of rice and wheat procured by the government from the total marketed surplus (MS). Availability also includes stocks offloaded into the market by the government through open market operations (OMSS) to private traders, as shown in equation (3).

$$Availability_t = (Marketed\ surplus_t - Procurment - Post\text{-}harvest\ Losses_t) + OMSS_t + (Imports_t - Exports_t) + Stock_{t-1} \quad ...(3)$$

### Marketed Surplus

To compute availability, we need to calculate the marketed surplus (MS) or farmer's sale, which is the proportion of the produce/crop that the farmer sells in the market. After the harvest, the farmer divides the produce/crop into two portions: one is kept to meet seed and feed requirements (in certain selected commodities) and household consumption needs, while the remaining produce is set aside for sale in the market. The Agricultural Statisitcs at a Glance (2014) provides the share of marketed surplus for some of the selected commodities and has been used in the construction of balance sheet.

$$MS_t = Production_t - (seed + feed + self\ consumption + farm\ losses)_t \quad ...(4)$$

Some of the commodities in our study have a longer shelf life and can be stored for several months, depending on their storage capacities. A farmer may hold back a proportion of the marketable surplus, anticipating better prices over time. The produce brought to market is the farmer's sale, which follows the market arrival pattern aggregated using Agmarknet (GoI) data across mandis at the all-India level. However, in the livestock balance sheet, we assume that farmers do not stock their products due to the short shelf life. Hence, farmer's sale is not included in their balance sheet.

For some commodities like potatoes, most of the produce is stored after harvest and released from cold storage according to market demand. Therefore, the market arrival pattern from Agmarknet does not reflect the true pattern. To address this inconsistency, the monthly release pattern for potatoes has been obtained through detailed discussions with cold storage owners and farmers.

### Losses

The availability of the produce/crop is affected by wastage along its value chain. Broadly, the total losses that a produce/crop incurs occur in (i) farm operations and (ii) storage channels. Losses in farm operations include those during collection, threshing, winnowing/cleaning, drying, packaging, and transport. Storage losses include those incurred during storage at the farm level, in warehouses, in storages at the wholesale and retail levels, and at the processor level. Our book has used the CIPHET-ICAR study (2016) and NABCONS (2022) for farm operation and post-harvest loss estimates.

Therefore, total post-harvest losses are estimated as:

$$\text{Total losses}_t = \text{Loss on farm operations}_t + \text{Storage loss}_t \quad ...(5)$$

**Net Imports**

The third component of the balance sheet is net imports. In our balance sheet analysis, imports in a year serve two purposes: (i) they are used to fill the domestic supply gap during months of shortages, and (ii) they are also imported to meet a likely future deficit in domestic markets. Net imports form part of the total availability in the economy in a particular month.

### *i. Demand/Usage*

An important component of the monthly balance sheet is the computation of demand/usage. In our balance sheet, usage in a particular month is defined as the total produce absorbed in the market, including both institutional and net consumption.

$$\text{Usage}_t = (\text{Net Consumption}_t + \text{Processing}_t) \quad ...(6)$$

**Net Consumption**

This refers to the consumption by individual households in the country after deducting consumption from home produce. The study projects these values using the behavioural approach method employed in the Working Group Report of NITI Aayog (2018). The NSSO provides per capita household consumption data for each commodity studied for the year 2011–12.[8] Therefore, we project consumption using: (i) the base period's (2011–12) per capita

8. The National Sample Survey Office (NSSO), Ministry of Statistics and Programme Implementation, Government of India, has released the summary results of the Household Consumption Expenditure Survey (HCES) conducted from August 2022 to July 2023, relating to estimated Monthly Per Capita Consumption Expenditure (MPCE), in the form of a factsheet in February 2024. The factsheet of HCES: 2022-23 is available at http://www.mospi.gov.in. The unit-level data of the Household Consumption Expenditure Survey: 2022-23 (HCES) was released in June 2024. However, the study uses NSSO 2011-12 data, as HCES 2022-23 was released after the completion of the study.

consumption data, (ii) the extrapolated/actual population level, (iii) the growth rate of per capita income, and (iv) the expenditure elasticity of selected commodities, as provided by NITI Aayog.[9]

The formula for estimating consumption is:

$$Q_{ijt} = q_{ijo} * P_{jt} * (1 + g_{jt} * e_{jt})^t \quad ...(7)$$

where $Q_{ijt}$ = household demand for the $i_{th}$ commodity during time period $q_{ij0}$ is the annual per capita quantity consumed of the $i_{th}$ commodity in the base year in rural or urban areas (NSSO 2011–12); $P_{jt}$ is the projected population in period $t$; $g_{jt}$ is the compound annual growth in per capita income (PCY) during the time period t; and $e_{jt}$ is the expenditure elasticity of the $i_{th}$ commodity.

To calculate the total annual household demand, we used the weighted averages of rural and urban per capita consumption of each commodity. The annual projected consumption of each commodity was then distributed monthly according to the pattern sourced from our primary survey. From the total consumption, we deducted consumption from home produce to arrive at net consumption.

### Institutional Consumption or Processing

The monthly consumption data computed based on the NSSO's consumption expenditure survey does not include consumption outside the home, nor consumption from hotels, restaurants, and cafés/catering (HORECA). Additionally, it does not provide proportions of commodities used for institutional processing. Therefore, we collected information on institutional consumption through a primary survey.

Institutional consumption in the balance sheet includes all commodities used for industrial purposes, the processing of value-added products, and in hotels, restaurants, and catering (HORECA), i.e., all consumption except direct household consumption.

## *ii. Stocks*

Stock levels play a critical role in our balance sheet, representing availability minus usage in a particular month. In basic terms, stocks

9. See Annexure Table A2.1 for elasticities for selected commodities.

provide an overview of the demand and supply gap, which is crucial for understanding expected price movements in the coming months. The total stocks for each commodity peak according to their monthly harvest and arrival patterns in the market.

Some of the selected commodities have a longer shelf life and are relatively non-perishable. Therefore, stakeholders like millers, traders, importers, farmers, and stockists maintain stocks that can move between years and within a year. For commodities like pulses, we compute the **Stock-to-Use (STU) Ratio,** which is an estimate of the level of carryover stocks for a given commodity at a specific point in time as a percentage of its total demand or use. It essentially measures the supply and demand interrelationships of commodities.

The mathematical formula for this relationship is as follows:

$$\textit{Stock to Use Ratio}_t = \frac{\textit{Total Stocks}_t}{\textit{Total Usage}_t} \qquad ...(8)$$

For our analysis, STU ratios provide a proxy for the supply of a particular commodity in the economy and help us understand price movements that can be attributed to deficient or abundant supply. Since our STU ratios are calculated on a monthly basis to ascertain the demand and supply gap at the end of a month, they capture the dynamic movement of stocks of produce in a year as they are harvested by farmers, sold in the market/mandi, and then to market players.

Many commodities in our study, such as tomatoes, eggs, meat, grapes, and bananas, do not have a long shelf life and are not stored for extended periods. For such commodities, we use supply elements of the balance sheet, such as the **Availability to Usage Ratio and Net Availability** (availability minus usage). Even in the balance sheets for onions and potatoes, we use Net Availability as the stock variable. Additionally, in the vegetable balance sheet, the all-India stock variables were obtained by summing the stock variables of the major producing states. In other words, we summed the state stock variables as our variable of interest to explain price movements, covering both production seasonality within a year and production shocks from year to year.

These varying stock variables are taken as key variables in our modelling to understand the percentage of consumption needs that can be met via available stocks at a given time. These stock variables are later used in our regression analysis to identify which best explains consumer prices.

## 2.3 Estimation of Commodity-Specific Determinants of Inflation

Drawing upon the literature review and the balance sheet approach, this study intends to identify an appropriate estimation framework for inflation dynamics and the forecasting of selected agricultural commodities. In this section, we discuss econometric models, including individual models and multivariate forecasting approaches identified in existing literature, along with the methodology for assessing the forecasting performance of these models across different time horizons. Before discussing the various forecasting techniques for inflation, we will examine the different model specifications that will be used to understand and identify various determinants of inflation for the selected commodities.

### *2.3.1 Stationarity and Seasonal Adjustment*

In time series analysis, stationarity is a key component where statistical properties, such as mean and variance, remain constant over time. Inferences drawn from a non-stationary process may lead to spurious results, showing significant relationships even if the variables are generated independently. Therefore, it is important to check for stationarity before conducting regression analysis and forecasting. There are several tests to examine the stationarity properties in time series data. The standard test for non-stationarity is the Augmented Dickey–Fuller (ADF) unit root test.

The equation is as follows:

$$\Delta y_t = \alpha+\beta_t+\gamma y_{t-1}+\delta_1\Delta y_{t-1}+\delta_2\Delta y_{t-2}+\ldots u_t \quad \ldots(9)$$

$$\text{Where } \Delta y_t = y_t - y_{t-1} \quad \ldots(10)$$

The null hypothesis for ADF tests is that the data is non-stationary, i.e., H0: $\gamma=0$ that the data generating process (DGP) for the series can be characterized as a non-stationary I(1) process, is tested against the stationary alternative H1: $\gamma < 0$ based on the t-statistic of the $\gamma$ estimate.

Our monthly balance sheet variables and the consumer price index for agricultural commodities are influenced by seasonal patterns due to weather, production, and consumption trends. When seasonal variations dominate month-on-month changes in the original series (or seasonally unadjusted series), it becomes difficult to capture non-seasonal effects, including long-term movements, cyclical variations, or irregular factors, which are important from a policy perspective. Forecasters often identify and remove seasonal influences from time series when they are statistically significant. Broadly, seasonal adjustment involves the removal of both within-a-year seasonal movements and the influence of festivities or cultural factors in a calendar year.

Several methods have been developed to remove seasonal patterns from a series, which can be classified as moving average (MA) methods and model-based methods. In the MA approach, the seasonally adjusted data is obtained by applying a sequence of MA filters to the original series and its transformation. Conversely, model-based techniques extract the underlying components using specialized time series models, often relying on autoregressive integrated moving average (ARIMA) models to improve forecast accuracy. Another method is the X-13 seasonal adjustment technique, a widely used statistical method developed by the U.S. Census Bureau for adjusting time series data to remove seasonal effects. This method helps forecasters and analysts isolate the underlying trend and cyclical components from seasonal fluctuations, making it easier to interpret data over time. In this study, we employ both the MA method and the X-13 seasonal adjustment technique. At the same time, unusual events need to be understood and modelled in the seasonal adjustment process through specific regression variables. It's worth noting that some information loss consistently occurs during the seasonal adjustment process, even when executed correctly (IMF, 2018).

### *2.3.2 Auto-Regressive Distributed Lag (ARDL)*

Given that the objective of this paper is to forecast inflation accurately, it is crucial to understand and identify the various drivers of inflation (price rise), which broadly include supply-side and demand-side factors, as discussed in many empirical studies. To understand the factors impacting inflation in selected commodities, we use the ARDL model. The ARDL cointegration technique is advantageous, as the variables used to define the factors in the regression model can be integrated in different orders.

This method is particularly robust when dealing with cases where a solitary long-term relationship exists between the fundamental variables, especially when the available sample size is small (Pesaran and Shin, 1999; Pesaran et al., 2001). The ARDL model adopts a single-equation framework, allowing it to incorporate an appropriate number of lags and effectively guide the data-generating process within a framework that transitions from general to specific modelling. This means the ARDL model can accommodate various data patterns to provide reliable insights in econometric analysis. ARDL is a parsimonious infinite lag-distributed model.

To illustrate the ARDL modelling approach, a general ARDL (p, q) model is given by:

$$Y_t = c + \sum_{i=1}^{p} \varphi_i Y_{t-i} + \sum_{i=0}^{q} \beta_i X_{t-i} + \varepsilon_t \qquad ...(11)$$

The error correction model (ECM) version of the ARDL model is given by:

$$\Delta Y_t = c_0 + \sum_{i=1}^{p-1} \alpha_i \Delta Y_{t-i} + \sum_{i=0}^{q-1} \delta_i \Delta X_{t-i} + \gamma ECM_{t-1} + u_t \qquad ...(12)$$

Where Δ is the first difference operator, $c_0$ is the constant, $Y_t$ is the CPI of a specific commodity expressed in log terms, $X_i$ are the 'k' explanatory variables, and $u_t$ is the white noise error term, p and q (which could be different across the 'k' explanatory variables) are the optimal lag lengths. The optimal lag length is obtained using Akaike Information Criterion (AIC) (Akaike, 1978). All the coefficients are non-zero. ECMt-1 ($\hat{\varepsilon}_{t-1}$) is the error correction term that measures the deviations from long-run equilibrium relationship, and the ECM coefficient γ denotes the speed of adjustment towards the long run equilibrium following any short-run deviation due to shocks within a period. The ECM coefficient (γ) is expected to be negative (γ<0) and statistically significant. The ECM integrates the short-run dynamics with the long-run equilibrium without losing long-run information and avoids problems such as a spurious relationship resulting from non-stationary time series data (Shrestha, 2018).The bounds test (Pesaran et al., 2001) is used to test for the presence of long run cointegration.

## 2.4 Forecasting Techniques

As discussed earlier, targeting inflation requires reliable forward estimates of expected inflation. Therefore, the importance of appropriate methodology and model specification to generate accurate forecasts can hardly be overemphasised. ARIMA models explain a given time series data based on its own past record, that is, its own lags and its lagged forecast errors, allowing the equation to be used for forecasting future values. ARIMA models assume that the time series has a constant variance of errors (homoscedasticity). An ARIMA (p, q, d) model characterises ppp as the order of the AR term, qqq as the MA term, and ddd as the number of differences required to make the time series stationary (Greene, 2012). The equation for ARIMA (p, q) is given as:

$$y_t = \mu + \sum_{i=1}^{p} \alpha_i y_{t-i} + \sum_{j=0}^{q} \beta_j \varepsilon_{t-j} \qquad ...(13)$$

In the ARIMA framework, seasonal effects are incorporated by introducing lags into the model elements. This equation represents the SARIMA model as a function of both non-seasonal and seasonal autoregressive terms:

$$y_t = \varphi_1 y_{t-1} + \varphi_2 y_{t-2} + ... + \varphi_p y_{t-p} + \phi_1 y_{t-s} + \phi_2 y_{t-2s} + ... + \phi_p y_{t-ps} + \varepsilon_t ...(14)$$

where $\phi_1$, $\phi_2$,...,$\phi_p$ are the non-seasonal autoregressive coefficients, $\Phi_1$, $\Phi_2$,..., $\Phi_P$ are the seasonal autoregressive coefficients with a seasonal lag s, and $\varepsilon_t$ is the white noise error term.

In multivariate models, a commonly used forecasting technique is the ARIMAX model, which involves regressing the dependent variable on a linear combination of multiple independent variables, along with an ARMA disturbance process. This allows for the inclusion of several exogenous variables to better explain the dependent variable (Hamilton, 1994). The model can be written as:

$$\Phi(L) y_t = \beta x_t + \theta(L) \varepsilon_t \qquad ...(15)$$

where $x_t$ represents exogenous variables, β are their coefficients, $\varphi(L) y_t$ is an AR model ($\varphi_1 y_{t-1}+\varphi_2 y_{t-2}+\varphi_3 y_{t-1}+\ldots+\varphi_p y_{t-p}$) and $\vartheta(L)\varepsilon t$ is the MA model ($\vartheta_1\varepsilon_{t-1}+\vartheta_2\varepsilon_{t-2}+ \vartheta_3\varepsilon_{t-3} +\ldots.+ \vartheta_q\varepsilon_{t-q}$)

SARIMAX is an extension of the conventional SARIMA model, where additional exogenous variables can be included. Similar to ARIMAX, SARIMAX incorporates autoregressive (AR), differencing (I), and moving average (MA) polynomials for each seasonal component of the model. Additionally, SARIMAX accounts for other independent variables, allowing for the modelling of multiple seasonal frequencies and their effects on the dependent variable.

The main hypothesis of the study is that computing the balance sheet variables will help improve forecasting accuracy and performance. Therefore, the paper explores these univariate models (SARIMA) and multivariate models (SARIMAX) to provide 12-month horizon predictions for the selected commodities. This approach is useful to gauge whether forecast performance improves by using exogenous variables, such as balance sheet variables, feed index, and policy variables, or if using only past error terms provides a better forecast.

## 2.5 Evaluating Forecasting Performance

Evaluating the forecast performance of univariate and multivariate forecasts is important to check the robustness of our results. The accuracy of the forecast is examined by computing forecast errors using the Root Mean Square Error (RMSE), which measures the differences between observed values and those predicted or estimated. It is computed as:

$$\text{RSME}=\sqrt{\frac{1}{N}\sum_{i=1}^{n}(y_i - y'')^2} \qquad \ldots(16)$$

*Robustness Analysis*

To evaluate the robustness of the individual and multivariate forecasting models discussed in the earlier section, we generate forecasts for full sample as well as forecasts for a year ahead using the 'pseudo-out-of-sample' forecasting approach. This exercise identifies how closely the forecasts of the different models resemble the actual outcomes of the true data-generating process underlying inflation. The 'pseudo-out-of-sample' forecasts are generated by restricting the sample period to a year before the forecast period—a period for which the data is directly available from official sources. The dynamic forecast generated for a year ahead is then compared with the actual data.

The forecasting exercise is useful for evaluating the accuracy of the models over a reasonable period, resembling the actual scenario that a forecaster would face in real-time (Bjornland et al., 2012). This exercise helps us assess the forecast performance and select the appropriate forecasting model over different horizons (one-, two-, three-, and four-quarter ahead) (Dholakia and Kadiyala, 2018; Jose et al., 2021). In this study, the forecasting performance is evaluated by examining the performance of the univariate model (SARIMA) and the multivariate model (SARIMAX) using forecasting errors such as RMSE.

Another method to evaluate robustness and accuracy is by expanding the models through rolling (using a moving data window of 60 months) model estimation to provide forecasts for a 12-month horizon for each selected commodity. This will evaluate the performance and accuracy of the forecasting models using the full sample period vis-à-vis the actual inflation of the selected commodity. Additionally, an out of sample forecast of shorter period of past one year is used to corroborate the findings of the full sample.

To compare the statistical significance of the differences forecast accuracy between the alternative models, we use the Diebold-Mariano (DM) test (Diebold and Mariano, 1995). Under the null hypothesis of the DM test, which posits that the forecast accuracy of any given two models is equal, we evaluate whether univariate or multivariate forecasts (using the balance sheet variables) outperform over the different forecast horizons.

## 2.6 Data Sources

For understanding the price dynamics and generating accurate forecasts of selected agricultural commodities, this study uses both secondary and primary data sources.

### 2.6.1 Secondary Data Sources:

The secondary data is sourced from the Government of India (GoI), state government websites, databases of state agriculture departments, and existing academic literature, including:

i) Ministry of Statistics & Programme Implementation (MOSPI) on Consumer Price Index (Rural/Urban/Combined), with the base year 2012 (CPI, CSO).

ii) Office of the Economic Advisor, Department for Promotion of Industry and Internal Trade (DPIIT), Ministry of Industry and Commerce on the Wholesale Price Index.

iii) NITI Aayog, for information on estimates of demand and supply of agricultural commodities.

iv) Directorate of Economics and Statistics (DES), Ministry of Agriculture and Farmers Welfare, GoI, for information on production, area, seasonality, etc.

v) Horticulture Division, Ministry of Agriculture and Farmers Welfare, GoI, for information on the production, area, and seasonality of fruits and vegetables. Information on production data is published annually in 'Horticulture Statistics at a Glance.'

vi) Department of Animal Husbandry and Dairying, GoI, for information on the production of milk, eggs, and poultry meat.

vii) CIPHET-ICAR study (2016) on post-harvest losses (Jha et al., 2015 and NABCONS, 2022).

viii) The present study uses the CPI, available at the commodity level from the CSO in MOSPI since 2011. For the CPI commodity-wise data prior to 2011, we have used commodity-wise CPI-IW data, available at the 2001 base year, and spliced it to the 2011 base year.

ix) Other sources include:

    a) The Agricultural and Processed Food Products Export Development Authority (APEDA) and Directorate

General of Commercial Intelligence and Statistics (DGCIS) for export and import data.

b) Agriculture Market Information System (AGMARK.NET.GOV.IN) and National Agriculture Market (e-NAM) for data on retail and wholesale prices, arrivals, and agricultural export and import data.

c) National Horticulture Board, which provides annual month-wise average wholesale and retail prices, along with arrival data.

d) Department of Consumer Affairs (DoCA), Ministry of Consumer Affairs, Food and Public Distribution for data on average retail and wholesale prices.

e) National Statistical Office (NSO), Ministry of Statistics & Programme Implementation, for the Consumption and Expenditure Survey (CES). The latest report pertains to the 2011-12 survey.

### 2.6.2 *Primary Survey Methodology*

This study utilises both qualitative and quantitative information to understand the price dynamics and workings of value chains in selected livestock, poultry, cereals, pulses, vegetables, and fruits. In conjunction with secondary data, primary data and real-time information are used to capture the dynamics of the demand and supply framework and the interplay of key components (on both the demand and supply sides) of the balance sheet approach. To access these stakeholders, a purposive sampling technique was followed. The snowball technique was also used to create a chain of respondents by seeking references from an initial list of experts.

The survey gathered information from 252 respondents through interactions with market informants, including farmers, traders, processors, millers, importers, exporters, stockists, and government officials, on a regular basis. This was valuable in the present study as the data were collated and verified via information collected from a cumulative list of experts.

Using structured and semi-structured interviews, along with focused group discussions, a method was devised to collate, process, and verify data from key market stakeholders through field visits and regular telephonic surveys. Separate questionnaires were used for each commodity and for different stakeholders. The survey covered key issues in the value chain, ranging from field-level information, cost of production, markup along the value chain, production, consumption, arrival and harvesting patterns, export and import patterns, efficiency of the value chain, and seasonality in production. The survey was conducted across major producing states for each of the agricultural commodities studied in the paper. The study area for the survey and the number of respondents for each commodity are illustrated in Table 2.1.

**Table 2.1**

*List of States and Study Area for Field Survey and Telephonic Survey*

| *Commodity* | *State* | *District/City/Town* | |
|---|---|---|---|
| Livestock | Milk (27) | Maharashtra | Pune, Kolapur |
| | | Gujarat | Banaskantha, Anand |
| | | Delhi-NCR | Noida |
| | | Karnataka | Bangalore |
| | | Bihar | Patna |
| | | Uttar Pradesh | Ghaziabad (Pilkhuwa) |
| | Egg (15) | Maharashtra | Pune |
| | | Haryana | Gurgaon, Barwala |
| | | Tamil Nadu | Namakkal, Coimbatore |
| | | Telangana | Hyderabad |
| | Chicken (16) | Maharashtra | Pune, Nasik |
| | | Delhi | Ghazipur |
| | | Punjab | Moga |
| | | Telangana | Hyderabad |
| | | Haryana | Gurgaon, Hisar |
| | | Uttar Pradesh | Kanpur |

*Contd...*

*.contd...*

| | | | |
|---|---|---|---|
| Cereals | Rice (10) | Punjab | Moga, Ludhiana |
| | | Uttar Pradesh | Meerut |
| | | Delhi | Central Delhi |
| | Wheat (10) | Punjab | Moga, Ludhiana |
| | | Haryana | Karnal |
| | | Uttar Pradesh | Meerut |
| | | Maharashtra | Mumbai |
| Pulses | Gram (13) | Maharashtra | Latur, Mumbai |
| | | Madhya Pradesh | Indore, Sehore |
| | | Rajasthan | Jaipur, Alwar, Kota |
| | | Delhi | South Delhi |
| | *Tur* (12) | Maharashtra | Latur |
| | | Delhi | South Delhi |
| | | Karnataka | Kalaburagi (Gulbarga), Bangalore |
| | *Moong* (15) | Karnataka | Bangalore |
| | | Rajasthan | Jaipur, Jodhpur |
| | | Gujarat | Kutch |
| | | Madhya Pradesh | Hoshangabad |
| | | Haryana | Panipat |
| | | Delhi | South Delhi |
| Vegetables | Tomato (22) | Maharashtra | Nashik, Mumbai (Vashi Mandi) |
| | | Karnataka | Kolar |
| | | Andhra Pradesh | Madanapalle |
| | Onion (25) | Maharashtra | Nashik, Dhule, Mumbai (Vashi Mandi) |
| | | Delhi | APEDA office, Azadpur Mandi |
| | | Madhya Pradesh | Mandsaur |
| | Potato (23) | Uttar Pradesh | Agra, Sikandara |
| | | West Bengal | Medinipur |
| | | Delhi | Azadpur Mandi |

| | | | |
|---|---|---|---|
| Fruits | Grapes (25) | Maharashtra | Nashik, Mumbai (Vashi Mandi) |
| | | Karnataka | Bijapur |
| | Banana (24) | Maharashtra | Jalgaon |
| | | Andhra Pradesh | Anantapur |
| | Mango (15) | Maharashtra | Jalna, Mumbai, Sindhudurg, Jalgoan |
| | | Gujarat | Gir |
| | | Uttar Pradesh | Lucknow |
| | | Andhra Pradesh | Chittoor |

*Source*: Field Survey

*Note*: The number in parentheses denotes the number of respondents for each of the commodities.

## 2.7 Limitations of the Study

This book aims to tame inflation in major food commodities using a balance sheet approach. The study's premise is to compute stock or net availability variables to capture price movements that can be used to estimate accurate forecasts. As mentioned earlier, understanding and forecasting food inflation is becoming increasingly difficult. This study, through its novel approach of using a monthly balance sheet, attempts to address the complexities of price dynamics. The monthly balance sheet model is primarily based on official data—production, net imports, per capita consumption, income growth, and population, available from secondary data sources, including government websites and databases of state agriculture departments.

For simplicity, minimal assumptions have been made based on information gathered from primary sources and existing academic literature. These assumptions include deductions from available stocks allocated for seeds, feeds, wastage, losses, conversion rates between whole and grains, seasonal patterns of arrival and consumption, and stocking and release patterns. These assumptions help break down annual data into monthly estimates.

The balance sheet can be extended for 12 months or more into the future, incorporating advance estimates provided by the government. Similarly, it can be extended back into the past as long as relevant official data are available.

The forward-looking nature of the balance sheet provides real-time utility, while the historical series make it ideal for forecasting exercises. The monthly frequency significantly enhances its value for empirical research and near- to medium-term assessments of potential price pressures. The balance sheet captures future availability, facilitating early identification of when demand-supply mismatches may lead to inflationary pressure. It broadly incorporates patterns related to seasonality, harvest, arrivals, and the behaviour of farmers, traders, importers, and consumers, using data from field surveys. However, since historical data on stocks is unavailable, monthly stock levels in the economy are estimated and used to compute stock-to-use (STU) ratios. Notably, patterns and trends identified during the field survey, conducted between 2020 and 2023, have been applied retrospectively for the past ten years. Capturing historical trends and stakeholder patterns is beyond the study's scope.

This book provides further scope for research to improve the monthly balance sheet approach, particularly regarding stock-to-use or supply variables for perishable commodities. It is important to note that commodity markets in India are not solely governed by traditional supply and demand dynamics; they are often influenced and distorted by governmental interventions. These interventions can limit the effectiveness of metrics like stock-to-use or other variables that capture the demand-supply gap. Additionally, information gathered through field surveys may not fully reflect the complexities of price fluctuations, government interventions, or external factors such as supply chain disruptions or weather anomalies, all of which significantly affect price dynamics. These limitations of the monthly balance sheet approach have been addressed to some extent through model specifications in the empirical analysis and forecasting techniques.

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## 2.9 Annexure

**Table A2.1**

*Expenditure Elasticity of Select Group of Commodities Commodity*

| *Commodity* | *Rural* | *Urban* |
|---|---|---|
| Cereals | -0.13 | -0.04 |
| Pulses | 0.55 | 0.36 |
| Milk | 0.82 | 0.40 |
| Meat | 0.82 | 0.40 |
| Fruits, Vegetables & Nuts | 0.85 | 0.42 |

*Source:* Niti Aayog

# 3

SHYMA JOSE, MANISH KUMAR PRASAD, SABARNI CHOWDHURY, BINOD B. BHOI, VIMAL KISHORE, HIMANI SHEKHAR and ASHOK GULAT

# Understanding Livestock Inflation in India

*A Study of Milk, Poultry Meat and Egg*[11]

## 3.1 Introduction

The livestock sector is an important sub-sector of agriculture, playing a significant role in generating gainful employment in the rural sector, particularly among landless, small, and marginal farmers and women. India has vast resources of livestock and poultry, with populations of over 537 million and 851 million, respectively, as per the 20th Livestock Census (2019).[12] In the last two decades, agricultural diversification in favour of the livestock sector has grown tremendously, as it generates more income per unit of area compared to food grains, oilseeds, and the sugar sector combined.

There has been significant growth in the value of output from the livestock sector, especially in dairy, poultry meat, and eggs. The contribution of livestock to the total agriculture and allied sector rose from 25.6 per cent in 2011-12 to 31.2 per cent in 2021-22. During this period, the value of output of the livestock sector grew on average by 5.6 per cent per annum, while the crop sector registered a

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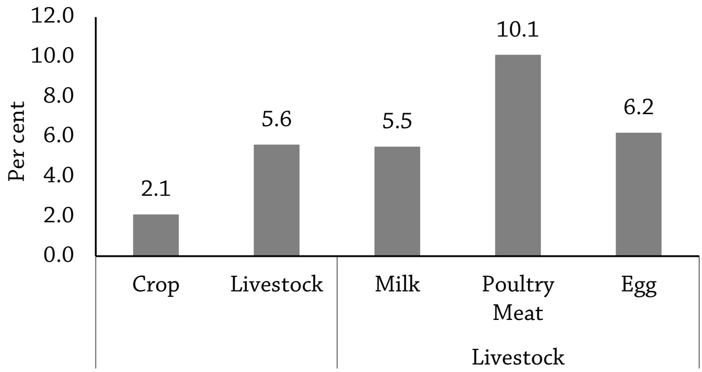
11. This study is part of a joint research project titled "Understanding Price Dynamics of Major Agricultural Commodities and Identifying Ways to Improve Value Chains", conducted by the Reserve Bank of India (RBI) and the Indian Council for Research on International Economic Relations (ICRIER). The findings are published as an RBI Working Paper, available at https://rbi.org.in/Scripts/PublicationsView.aspx?id=22720

12. There are about 303.76 million bovines (cattle, buffalo, mithun, and yak), 74.26 million sheep, 148.88 million goats, 9.06 million pigs, and about 851.81 million poultry, as per the 20th Livestock Census in the country (DAHD, 2021).

growth of 2.1 per cent (at constant prices). Notably, the production of poultry meat recorded double-digit growth during this period (10.1 per cent), followed by eggs (6.2 per cent) and milk (5.5 per cent) (Figure 3.1).

**Figure 3.1**

*Average Growth Rate of Livestock vis-à-vis Crop Sector during 2012-13 to 2021-22*




*Source*: MOSPI, 2023.

Despite the tremendous growth in output, animal protein-rich items, especially milk, eggs, and poultry meat, have come under focus in India due to rising prices, largely driven by increased input costs and demand. Given the high weightage of these livestock items in the food basket and their price volatility in recent years, understanding their market dynamics and the factors contributing to their inflation is crucial. Using data from January 2010 to December 2022, this study aims to contribute to the literature on livestock and poultry inflation in India by identifying factors that affect prices, as well as understanding the players in the value chain and how their behaviour influences market supply and demand at a given time.

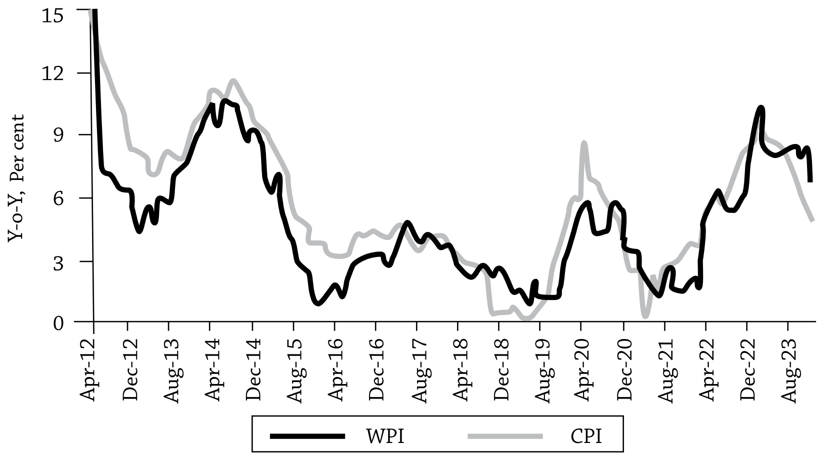
## 3.2 Stylised Facts about Livestock Inflation: A Timeline

In this section, we examine the price behaviour of livestock and poultry items, i.e., the trend of CPI inflation (YoY) in milk, eggs, and poultry meat over the last decade. Among these commodities, milk inflation, measured using both the wholesale price index (WPI)

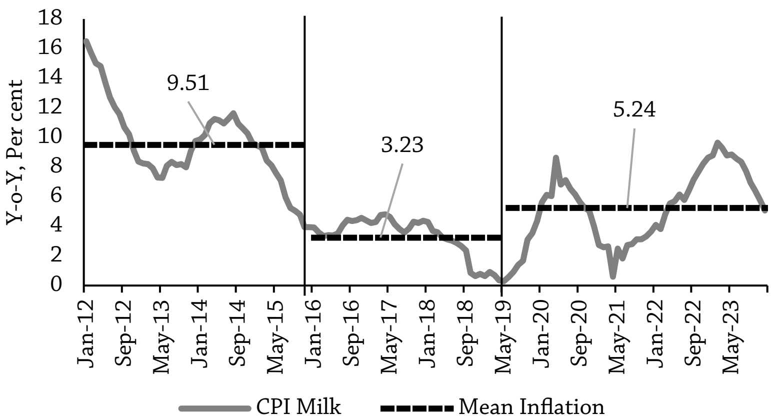
**Figure 3.2**

*Movement of WPI and CPI Inflation in Milk*

*a. WPI and CPI Milk Inflation*




*b. Phases in CPI Milk Inflation*




*Sources*: NSO, MOSPI; and OEA, GoI.

and CPI, has been relatively less volatile (Figure 3.2a). This could be due to the organised nature of the milk supply chain through cooperatives and the lag in passing through input cost increases, unlike in the poultry sector, where the transmission is faster. Notably, the correlation between WPI and CPI milk inflation is high, at 0.9. A structural break analysis indicates that CPI milk inflation, which averaged 6.1 per cent during January 2012 to December 2023, had two structural breaks—one in December 2015 and the other in May 2019—suggesting that milk inflation has moved through three different phases (Figure 3.2b).

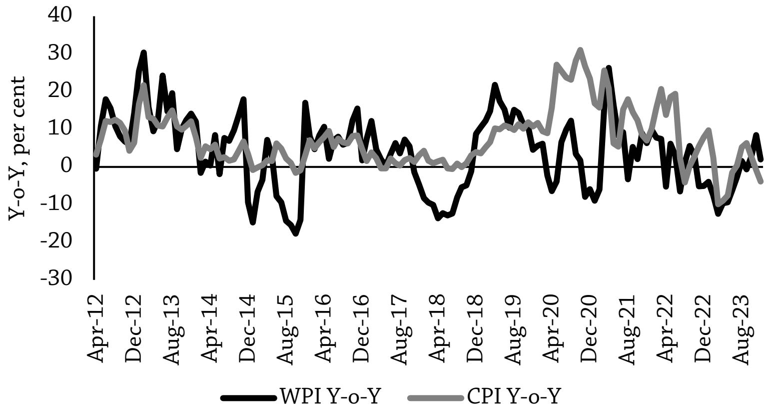
The first phase (January 2012 to December 2015) observed an average inflation of 9.5 per cent, reflecting rapidly rising demand due to increases in net disposable income and the high-income elasticity of milk. Surging global milk prices and rising feed costs (fodder) for smallholders further added to the inflationary pressure. The second phase (January 2016 to May 2019) experienced moderate inflation of 3.2 per cent, primarily due to a prolonged period of negative WPI fodder inflation, averaging -3.7 per cent. The third phase (June 2019 to December 2023) registered an uptick in milk inflation to 5.2 per cent, caused by a combination of factors such as the COVID-19 shock, lumpy skin disease, increased feed and fodder costs, and supply chain disruptions that resulted in lower procurement by milk cooperatives. The underfeeding of cattle during the pandemic affected milk prices due to lower cattle productivity. Additionally, during April–November 2022, India exported 16,206 tonnes of milk fat, driven by high international butter prices. This reduction in domestic availability further contributed to milk inflation.

In the case of poultry meat, the co-movement between CPI and WPI inflation is relatively weak, with a correlation of 0.39 during April 2012–December 2023, which further declined to 0.07 during the pandemic period (March 2020 to December 2022) (Figure 3.3a). A structural break analysis indicates that CPI poultry meat inflation, which averaged 7.4 per cent during January 2012 to December 2023, had two structural breaks—one in January 2014 and the other in April 2020 (Figure 3.3b). Therefore, the movement of CPI poultry meat inflation can be divided into three phases: the first phase, from January 2012 to January 2014, with an average inflation of 10.3 per cent; the second phase, from February 2014 to April 2020, with an average inflation of 4.5 per cent; and the third phase, from May 2020 to December 2023, with the highest average inflation of 10.9 per cent.

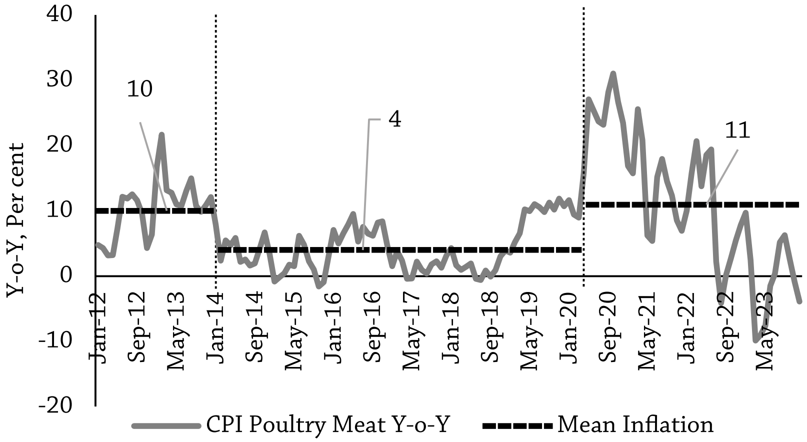
**Figure 3.3**

*Movement of WPI and CPI Inflation in Poultry Meat*

a. WPI and CPI: Poultry Meat Inflation




b. Phases in CPI Poultry Meat Inflation

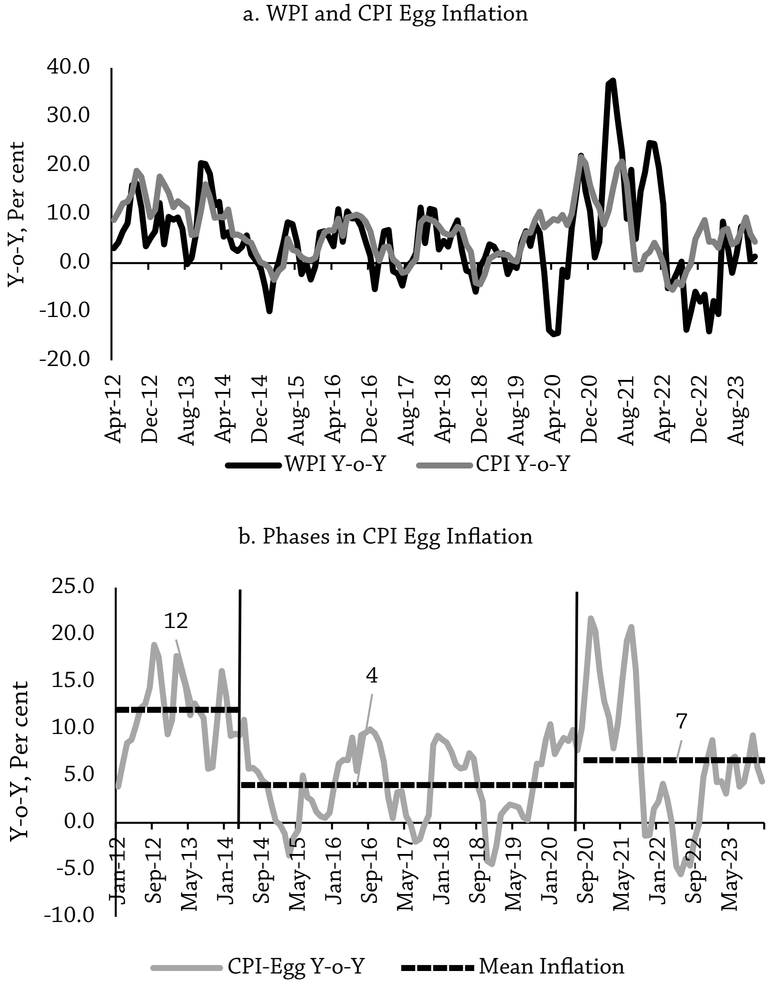



*Sources*: NSO, MOSPI; and OEA, GoI.

In the case of eggs, CPI and WPI inflation generally moved together, with a correlation of 0.52 during April 2012–December 2023, although WPI exhibited greater volatility, particularly after the pandemic (Figure 3.4a). CPI egg inflation averaged 6.3 per cent during

**Figure 3.4**

*Movement of WPI and CPI Inflation in Egg*




*Sources*: NSO, MOSPI; and OEA, GoI.

January 2012 to December 2023, with two structural breaks—one in April 2014 and the other in August 2020 (Figure 3.4b). Hence, the movement in CPI egg inflation can be divided into three phases: the first phase, from January 2012 to April 2014, with an average inflation of about 11.7 per cent; the second phase, between May 2014 and August 2020, with moderate inflation of 4.1 per cent; and the third phase, between September 2020 and December 2023, which coincided with the pandemic, with higher average inflation of 6.6 per cent. Notably, egg inflation peaked at 21.7 per cent in October 2020 and 20.8 per cent in July 2021.

High inflation in poultry meat and eggs during phase 1 coincided with the period of high inflation in soya and maize in both international and domestic markets. Increasing feed costs contributed to higher poultry inflation during this phase. The lower poultry inflation in the second phase was due to the moderation in domestic feed prices and rural wages, along with a fall in private consumption growth, which reduced the demand-side pressure on food inflation (Anand et al., 2016). The high inflation in the third phase, particularly in poultry meat, reflects the COVID-19 pandemic-induced shifts in demand and supply, along with disruptions in the poultry value chain. Furthermore, feed prices skyrocketed both globally and domestically, which further exerted pressure on retail inflation in poultry meat and eggs. Additionally, misinformation during the pandemic resulted in a reduction in poultry production due to the culling of poultry birds in the early phase.

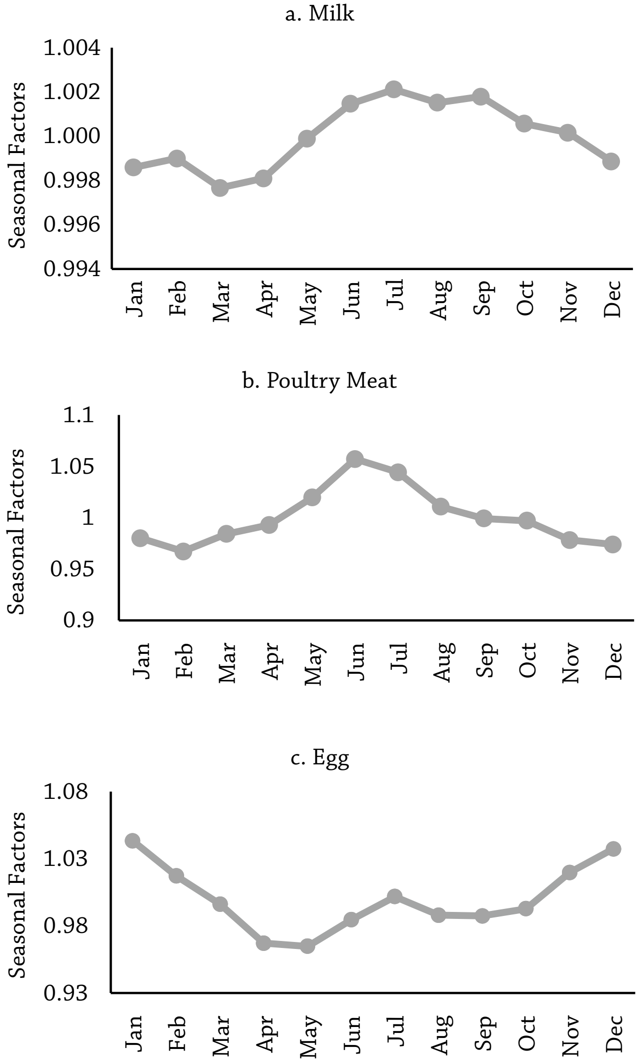
### *Seasonality*

An analysis of seasonality in prices indicates that livestock and poultry items exhibit different seasonal behaviours. Milk prices peak in July and reach their lowest point in March within a year (Figure 3.5a). Generally, the prices of poultry meat bottom out during the winter months (December–February) due to improved supply and pick up during the summer months, peaking in June (Figure 3.5b). In contrast, egg prices show seasonal peaks during the winter months (December–January) due to higher demand and fall to their lowest in the summer months of April–May when demand is lower (Figure 3.5c). Egg prices also tend to increase slightly during the monsoon season. Moreover, both poultry meat and eggs exhibit festival-related seasonality, with a seasonal decline in prices during Shravan (end of July and August) and Navaratri (September–October) due to reduced demand in some parts of India, as people avoid non-vegetarian diets during these times.

**Figure 3.5**

*Seasonality in CPI Livestock and Poultry*

*(Based on Seasonal Factors over the Last 10 Years)*



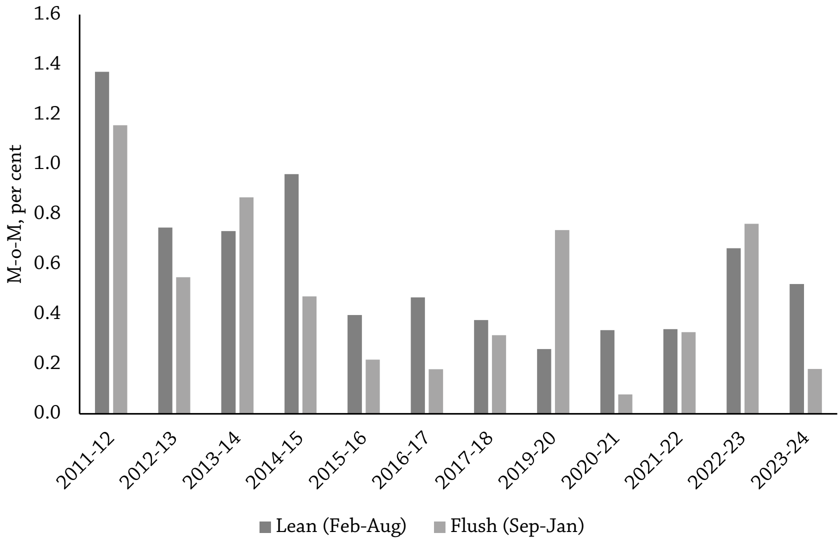

*Note*: Seasonality of milk is from January 2011 to December 2022, whereas for poultry meat and eggs it is from January 2010 to December 2022.

*Source*: NSO, MOSPI, GoI.

In the case of milk prices, seasonality is generally observed with an upward trend from April to July. Milk prices generally do not revert to the base level due to their downward rigidity. Therefore, it is essential to interpret their seasonality with caution because of the consistently increasing milk prices. To address this limitation, an alternative approach has been adopted to analyse the momentum (month-on-month [m-o-m] change) in milk prices by separately examining the lean season (February to August) and the flush season (September to January) (Figure 3.6).

**Figure 3.6**

*Milk Price Momentum over Lean and Flush Seasons*




*Note*: Lean season price momentum includes data from previous financial years.[13]

*Sources*: NSO, MOSPI, and Authors' calculations.

The lean and flush season patterns show that the average milk price momentum during the lean season is significantly higher compared to the flush season. There is an inflection point after the COVID-19 pandemic, during which a change in trend occurred, with the flush season exhibiting similar or higher momentum than

13. For instance, lean season data for 2023-24 includes February and March data from the financial year 2022-23.

the lean season (except in 2020–21 and 2023–24). This shift in momentum can be attributed to several factors, including the impact of rising demand during the COVID-19 period, the pass-through of higher input costs (feed and fodder), and lower yield due to the underfeeding of cows and the lumpy skin disease during COVID-19, leading to an upward revision in milk prices by many cooperatives in several rounds. The cooperatives also exported excess stock, which contributed to the shift in momentum. This analysis of milk price momentum provides a more comprehensive perspective on seasonal variations and helps to better understand the market's underlying dynamics.

## 3.3 Factors Determining Livestock Inflation: Demand-Supply Angle

Price fluctuations in livestock commodities could result from demand-supply imbalances due to trade policy changes, movements in international or domestic input costs (including feed and fodder), and market interventions. Since the global food crisis of 2008, it has become apparent that domestic food prices are integrated with world prices, although the degree of co-movement varies across commodities. The correlation for staples like rice and wheat is found to be weaker due to the robust procurement policy and public distribution system. In the case of staples, governments are particularly reluctant to allow significant pass-through from international to domestic prices (Mishra and Roy, 2016). Highly tradable products, such as edible oils, exhibit a high degree of co-movement between domestic and international prices. However, in livestock commodities, there is only moderate correlation between domestic and international prices. For instance, the correlation between world dairy indices reported by the IMF and domestic WPI milk is found to be 0.52, while that between international poultry meat indices and WPI poultry meat is 0.44.

### *3.3.1 Demand-side Factors*

India's growing food demand for livestock needs to be analysed to understand the inflation dynamics in livestock commodities. Robust economic growth with increasing per capita income in the last decade (5.4 per cent during 2010–11 to 2015–16 and 3.7 per cent during 2016–17 to 2022–23), coupled with a sizeable increase in population, has been shifting the food basket of the people away from staple foods to high-value horticulture and livestock commodities. This shift in consumption patterns among Indian households is corroborated by Bennett's law, which states that as income rises, people consume relatively fewer calorie-dense starchy staple foods and relatively more nutrient-dense foods such as meats, oils, sweeteners, fruits, and vegetables.

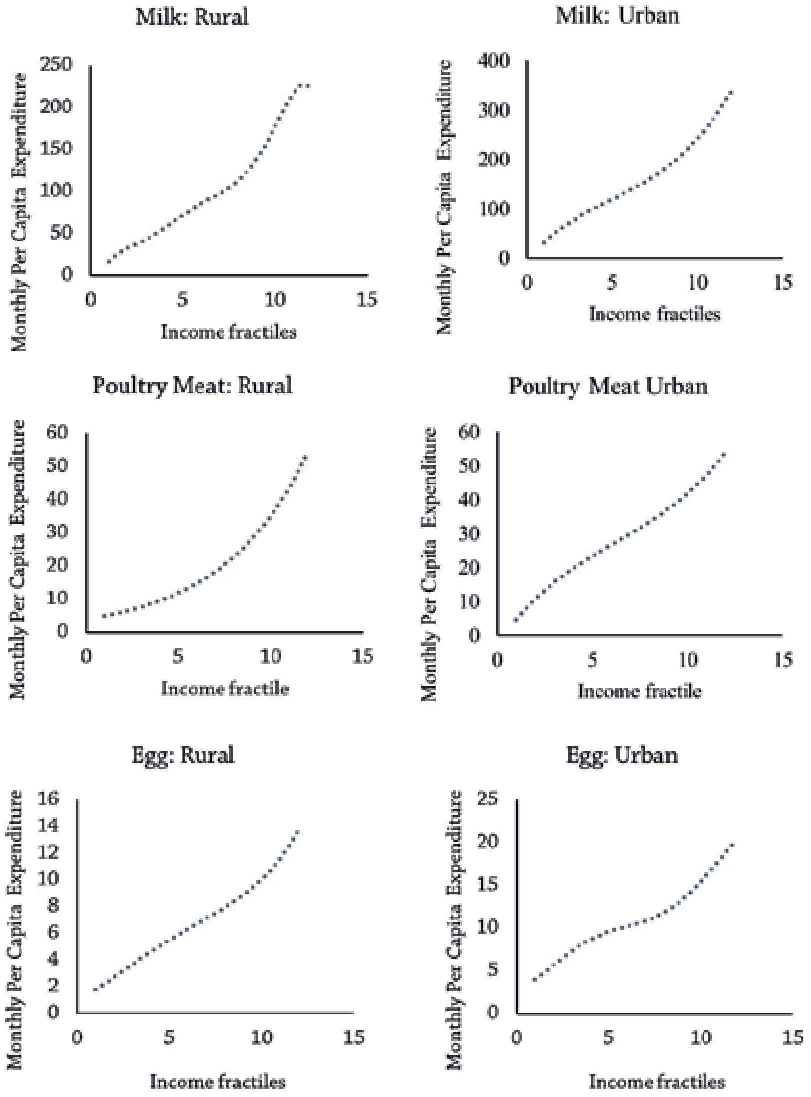
Using the various rounds of the Consumption Expenditure Survey of the NSSO, Gandhi and Zhou (2010) show that the demand for livestock products has risen significantly along with the expenditure share of livestock products. For example, in rural areas, milk consumption increased from 3.94 litres per capita per month to 4.33 litres per capita per month between 1993–94 and 2011–12, while the consumption of eggs (in numbers) increased from 0.64 per capita per month to 1.94 per capita per month, and poultry meat consumption increased from 0.02 kg per capita to 0.18 kg per capita over the same period. Similarly, in urban areas, milk consumption rose from 4.89 litres per capita per month to 5.42 litres per capita per month between 1993–94 and 2011–12, while egg consumption increased from 1.48 per capita per month to 3.18 per capita per month, and poultry meat consumption increased from 0.03 kg per capita to 0.24 kg per capita over the same period. This increase can be attributed to various factors, including the diversification of the food basket, changing lifestyles, and a rise in income (Mittal, 2008; Kumar et al., 2011).

As per Engel's law, with an increase in the average household income, the average share of food expenditure in total expenditure declines. Figure 3.7 plots the Engel curves for milk, poultry meat, and eggs for both rural and urban areas using the household survey (NSSO 68th round 2011–12).[14] The Engel curve shows monthly

14. The Factsheet of HCES 2022-23 was released by the NSSO in February 2024. However, the detailed results and unit-level data were released in June 2024 after the completion of the study.

**Figure 3.7**

*Engel Curve across Fractile-wise Monthly Per Capita Expenditure (in Rs) on Livestock and Poultry, 2011–12*



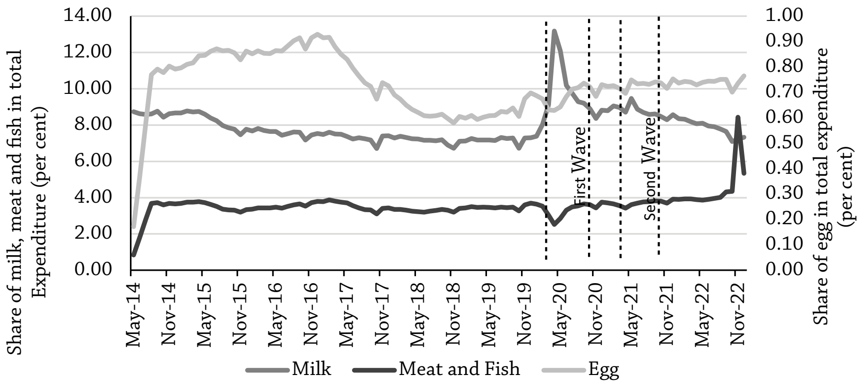

*Note*: Here X-axis is Monthly Per Capita Expenditure (MPCE) fractiles which have been taken as proxy for income fractiles and Y-axis denotes monthly expenditure on selected commodities.

*Sources*: NSSO, 2011-12 and Authors' calculations.

per capita expenditure on the selected livestock commodity on the y-axis and income fractiles on the x-axis (income fractiles have been deduced using household monthly expenditure). It suggests that for households that spend a lot on food (with a high weight on food expenditure), their income elasticity of food expenditure is also high. These findings are reiterated in studies (Anand et al., 2016; Gokarn, 2011) which show that milk, meat, and eggs tend to have high income elasticity, i.e., on average, expenditure on livestock commodities (across all households) rises proportionally more than the increase in total food expenditure. Furthermore, Mishra and Roy (2016) state that inflationary pressures, particularly in milk, are attributed to rising demand, which has outpaced the increase in production.

**Figure 3.8**

*Share of Livestock Expenditure in Total Household Expenditure in India*




*Source*: Authors' calculations using CMIE-CPHS data.

The demand patterns have changed since the COVID-19 pandemic. Recent studies have highlighted how the pandemic resulted in a significant increase in the share of food in total expenditure in both rural and urban areas (Kaicker et al., 2022). The Centre for Monitoring Indian Economy–Consumer Pyramids Household Survey (CMIE-CPHS) monthly expenditure data show changes in food expenditure shares for animal protein-rich items in India (Figure 3.8). The share of expenditure on milk in total household expenditure registered a sharp increase during the first wave of COVID-19 and a marginal increase during the second wave before moderating somewhat thereafter. In contrast, the share of expenditure on poultry meat saw a sharp decline during the first wave due to misinformation about the spread of COVID-19. Meanwhile, the share of expenditure on eggs had been declining since early 2017 but showed some increase during the pandemic, though its share in total expenditure remains low.

### *3.3.2 Supply-side Factors*

Supply-side factors of inflation include changes in production and productivity, input costs, and supply chain dynamics. Commodities experiencing higher demand growth generally have relatively higher supply growth (Anand et al., 2016). This study propounds that if the relatively higher supply growth of food commodities with higher expenditure elasticities, such as livestock products, can be sustained going forward, it will help contain relative food-price pressures. Several studies have incorporated supply chain dynamics, including the contribution of mark-ups between farm gate and retail prices, the constituents of those mark-ups, and inter-linkages between different market stakeholders, including traders, stockists, retailers, and farmers, to understand the sources of food inflation and its volatility (Bhoi et al., 2019; Banerji and Meenakshi, 2004; Bhattacharya and Sengupta, 2015).

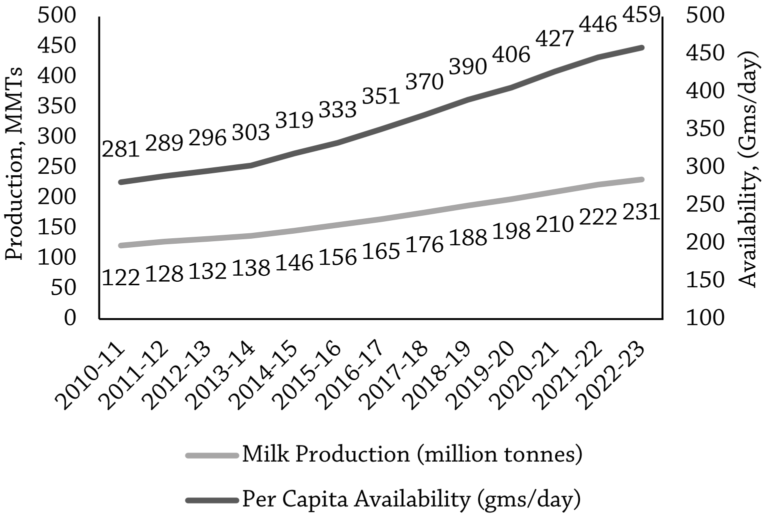
#### Production Trends of Milk, Poultry Meat, and Eggs

India is the largest milk producer globally, surpassing the United States in 1998. The three-phased implementation of Operation Flood (1970–1996), which expanded the presence of dairy cooperatives, and the subsequent expansion of organised private dairies, along with government initiatives to increase milk production, have ensured growth in milk production from 122 million metric tonnes (MMTs) in 2010–11 to 231 MMTs in 2022–23. This increase has raised the per capita availability of milk from 281 grams/day to 459 grams/day (Figure 3.9). Cows and buffaloes contribute 52 per cent and 45 per cent of total milk production, respectively, while the remaining 3 per cent comes from goats.[15]

The average yield of exotic/crossbred cows is 8.55 kg per day, while for indigenous/non-descript cows, it is 3.44 kg per day in 2022–23 (BAHS, 2023). Despite India being the largest producer, the USA's milk yield is more than five times that of India, Australia's is more than three times, and New Zealand's is more than double in the triennium ending (TE) 2022 (FAOSTAT). Uttar Pradesh is the highest milk-producing state in India (with a share of 15.3 per cent), followed by Rajasthan (14.7 per cent) and Madhya Pradesh (8.6 per cent) in TE 2022–23.

**Figure 3.9**

*Year-wise Estimates of Production and Per Capita Availability of Milk*




*Sources*: Basic Animal Husbandry Statistics (BAHS), 2023, Ministry of Fisheries, Animal Husbandry and Dairying, GoI.

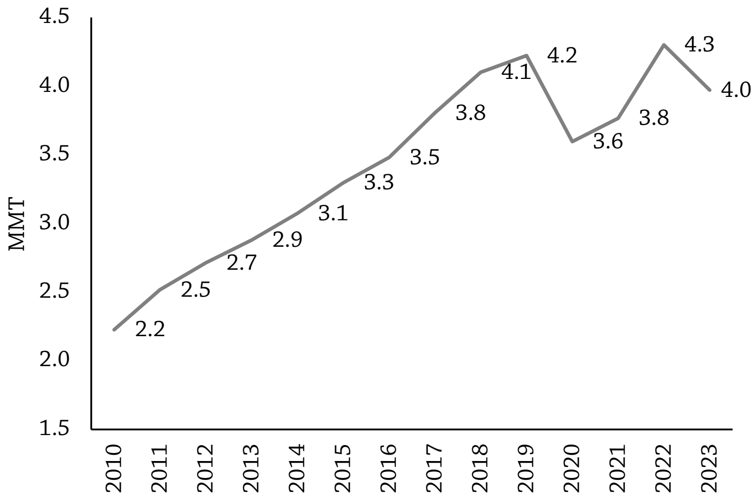
Within the livestock sector, poultry meat production (from the broiler industry) has grown steadily with the emergence of vertically

15. Indigenous buffaloes contribute 31.9 per cent of total milk production in the country, whereas crossbred cattle contribute 29.8 per cent. The rest of the milk production is contributed by indigenous cattle, non-descript cattle, non-descript buffaloes, exotic cows, and goats (BAHS, 2023).

integrated poultry producers. Today, India is the fifth-largest producer of poultry meat globally, after the USA, China, Brazil, and Russia (FAOSTAT, 2022). According to the OECD-FAO (2022–2031), India's poultry meat production increased from 2.2 MMTs to 4.6 MMTs between 2010 and 2023 (Figure 3.10). However, the annual per capita consumption of poultry meat in 2023 was 2.85 kg in India, which is low by global standards. For instance, the per capita consumption was highest in Israel (64.31 kg), followed by the USA (51.54 kg), Brazil (43.1 kg), and China (13.7 kg) in 2023 (OECD-FAO Agricultural Outlook 2022–2031). Nonetheless, the sector has seen a gradual growth in consumption over the last two decades, reflecting rising income, a rapidly expanding middle class, and the development of value chains. Among the states, Maharashtra is the highest poultry meat-producing state, accounting for 15 per cent, followed by West Bengal (13 per cent) and Haryana (12.5 per cent) in TE 2022–23 (BAHS, 2023).

**Figure 3.10**

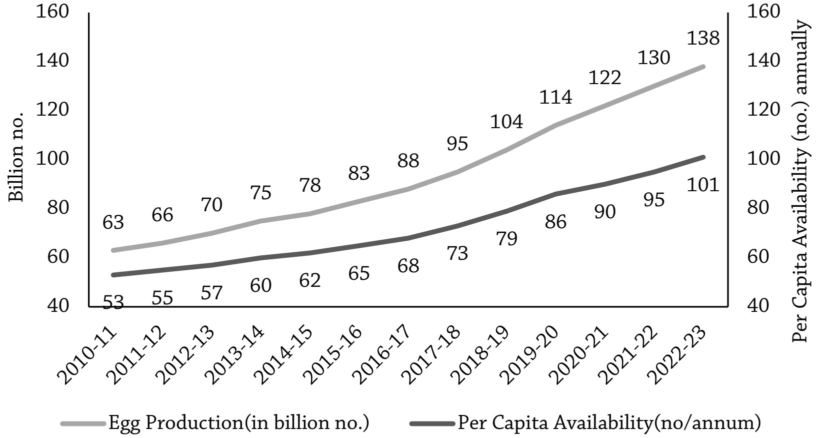
*Poultry Meat Production in India*




*Source*: OECD-FAO Agricultural Outlook (2022–2031).

**Figure 3.11**

*Production and Per Capita Availability of Eggs*




*Source*: BAHS, GoI, 2023.

Within the poultry sector, egg production has also grown both in volume and value terms over the last decade. India ranks third in global egg production after China and Indonesia in TE 2022 (FAOSTAT). The country's egg production increased from 63 billion to 138 billion between 2010–11 and 2022–23 (Figure 3.11). In 2022–23, improved fowls contributed 88.4 per cent of the total egg production, desi fowls contributed 10.7 per cent, while the remainder came from desi and improved ducks. There has been a steady increase in the per capita availability of eggs, rising from 53 to 101 eggs per annum during the same period (BAHS, 2023). However, egg consumption is still lower than in other countries. In 2023, annual per capita consumption was 288 eggs in Mexico, 284 in China, and 163.2 in Brazil (OECD-FAO Agricultural Outlook 2022–2031). The three highest egg-producing states in India are Andhra Pradesh (with a share of 20.3 per cent), Tamil Nadu (16 per cent), and Telangana (12.8 per cent) in TE 2022–23.

To enhance yield and supply in this sector and make livestock products accessible to consumers at affordable prices, the central government has launched various programmes aimed at improving breeding, feeding, and health status. In 2014–15, the central government implemented the National Livestock Mission (NLM) to generate employment opportunities and foster entrepreneurship in the livestock sector. This mission also seeks to increase per-animal productivity, promote feed and fodder development, and improve breeds to boost the production of meat, goat milk, eggs, and wool.

### *3.3.3 Role of Government Interventions in Supply Management of the Livestock and Poultry Sector*

In the dairy sector, the implementation of Operation Flood (1970–1996) was significant in expanding the presence of dairy cooperatives and organised private dairies, ensuring multifold growth in milk production. During Operation Flood, the major issue was the low productivity of Indian bovines in the dairy industry, with milk yield being less than 1 kg per day. Crossbreeding technology, initiated in 1961, resulted in an increase in average productivity from less than 1 kg per animal per day in the pre-Operation Flood era to 4.5 kg per (in-milk) animal per day. This increase in milk production led to competitive prices and eliminated the need for imported skimmed milk powder (SMP) to meet domestic demand. Before the completion of Operation Flood III (1985–1996), India relied on imported SMP to meet its domestic milk demand.

Similarly, to enhance milk production and the productivity of milk cattle, the Rashtriya Gokul Mission has been crucial for the development and conservation of indigenous breeds. Other important schemes for the dairy sector include the Integrated Dairy Development Scheme and the National Dairy Plan. These schemes primarily focus on promoting dairy development and providing financial assistance for activities such as breed improvement, feed and fodder development, and infrastructure development, thereby improving the productivity and profitability of the dairy sector.

In addition, the National Programme for Dairy Development (NPDD), Dairy Infrastructure Development Fund (DIDF), and Animal Husbandry Development Fund (AHIDF) are some of the government initiatives focusing on dairy infrastructure development, milk procurement, processing, marketing, and improving the quality of milk and milk products. The NPDD scheme aims to install approximately 8,900 bulk milk coolers, covering around 26,700 villages and benefiting more than 800,000 milk producers. This is expected to result in an additional procurement of 20 lakh litres of milk per day (LLPD). By improving milk procurement, processing, and marketing, these schemes will benefit millions of milk producers, strengthen the dairy value chain, and enhance the overall impact of the programme (DAHD, 2022).

At present, the poultry sector, especially poultry meat, is one of the fastest-growing sectors within agriculture in India. The revolution in this sector has primarily been driven by innovations in policies, institutions, and breeding stocks, particularly with the liberalisation of the import of improved genetic material. In 1993–94, the government reduced the import duty on grandparent poultry stock from 105 per cent to 40 per cent (Kabeer and Murthy, 1996). Until 2001, the import of poultry grandparent stock was controlled by permits and governed by a duty structure. However, since then, all quantitative restrictions on India's import of poultry items have been dismantled, allowing the import of grandparent stock without any barriers (Mehta et al., 2007).

This policy resulted in a massive increase in private investment in breeding operations using imported grandparent stock. It led to the production of day-old chicks under strict bio-secure conditions, improving the pure-line stock of enhanced parent lines (Emsley, 2006). Private enterprises have undertaken R&D of parent stocks and developed breeds suited to Indian environmental conditions. Innovations in watering systems and climate controls designed for the Indian market have ensured efficient poultry management. Furthermore, the egg productivity of improved fowls (e.g., Bowans, Hyline, Lohman LSL) has significantly increased. Simultaneously, technological breakthroughs with improved varieties of chicks for poultry meat, such as Cobb, Hubbard, and Lohman, have enabled the country to achieve high conversion ratios for chicken, allowing it to gain the required weight in a shorter period.

Under the NLM, the Innovative Poultry Productivity Project (IPPP) is another initiative aimed at transforming backyard poultry into a commercial economic model. The IPPP has implemented a pilot model to upscale subsistence backyard poultry farming to an entrepreneurial level.

An important concern impacting dairy and poultry production and its supply dynamics is losses or mortality due to susceptibility to various diseases. For example, foot and mouth disease (FMD), lumpy skin disease, and brucellosis in dairy cattle, as well as avian flu in poultry birds, significantly affect the productivity and production of the livestock sector, increasing price volatility. In this context, the government's Livestock Health and Disease Control programme aims to reduce the risk to animal health by building the capacity of veterinary services, enhancing disease surveillance, and strengthening veterinary infrastructure in the country. Recently, the central government allocated Rs. 9,800 crores to leverage a total investment of Rs. 54,618 crores for the next five years, starting from 2020–21 (DAHD, 2022).

### *3.3.4 Trade Policy and Price Dynamics in the Livestock and Poultry Sector*

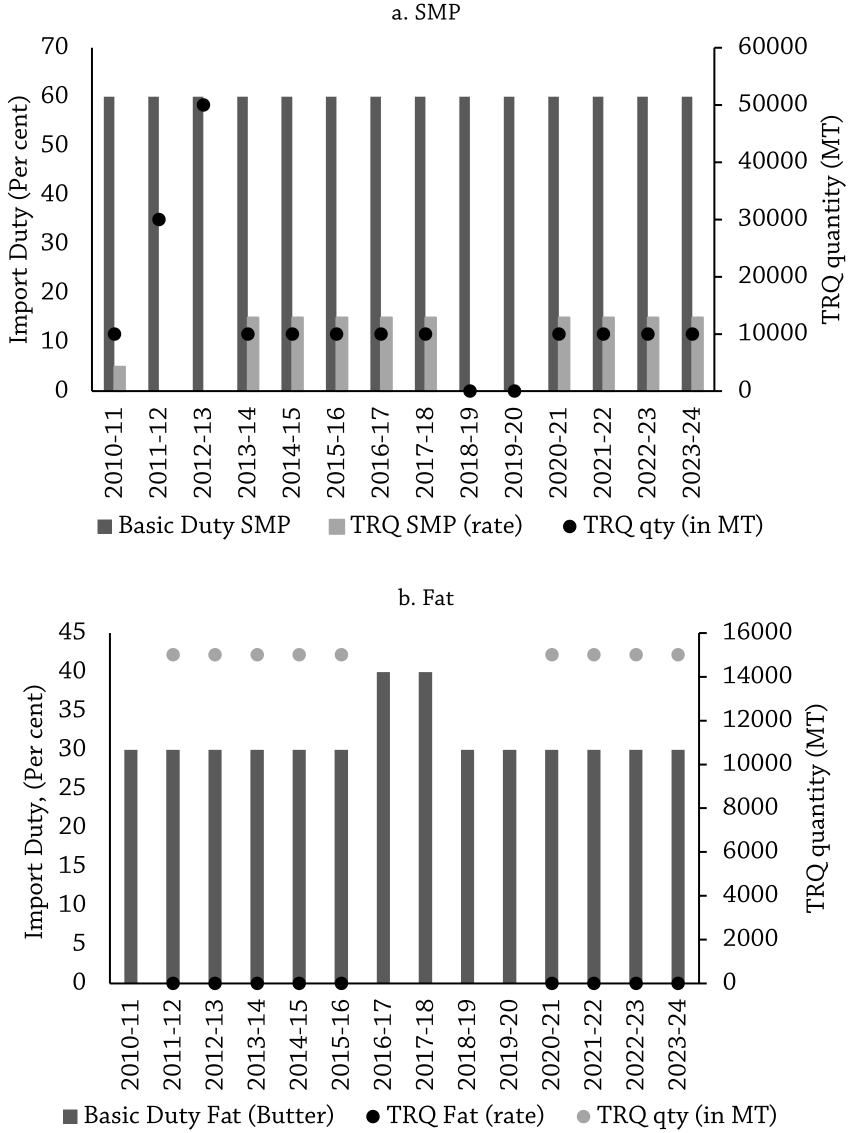
The supply and price dynamics of livestock produce depend on the trade policies adopted by the government. The central government employs a combination of trade policy tools, including customs duties, import quotas, import bans, and port restrictions, to manage supply and price dynamics.

The customs duty on SMP has remained at 60 per cent since 2010–11. India allowed imports of SMP/whole milk powder (WMP) under a tariff rate quota (TRQ) of 10,000 MT, with a 15 per cent import duty from 2020 to 2022. Outside the TRQ, imports are subject to a 60 per cent duty. Over the last ten years, the quantity under the TRQ for SMP has varied (Figure 3.12a). For instance, during 2011–12 and 2012–13, the TRQ quantity was around 30,000 and 50,000 tonnes, respectively, with a zero per cent import duty for both years. However, for the rest of the years, the import duty under the TRQ remained fixed at 15 per cent.

Similarly, fat has been imported at a basic customs duty of 30/40 per cent since 2011–12 (Figure 3.12b). India allowed the import of butter and other milk fats under a TRQ of 15,000 MT, with a zero

**Figure 3.12**

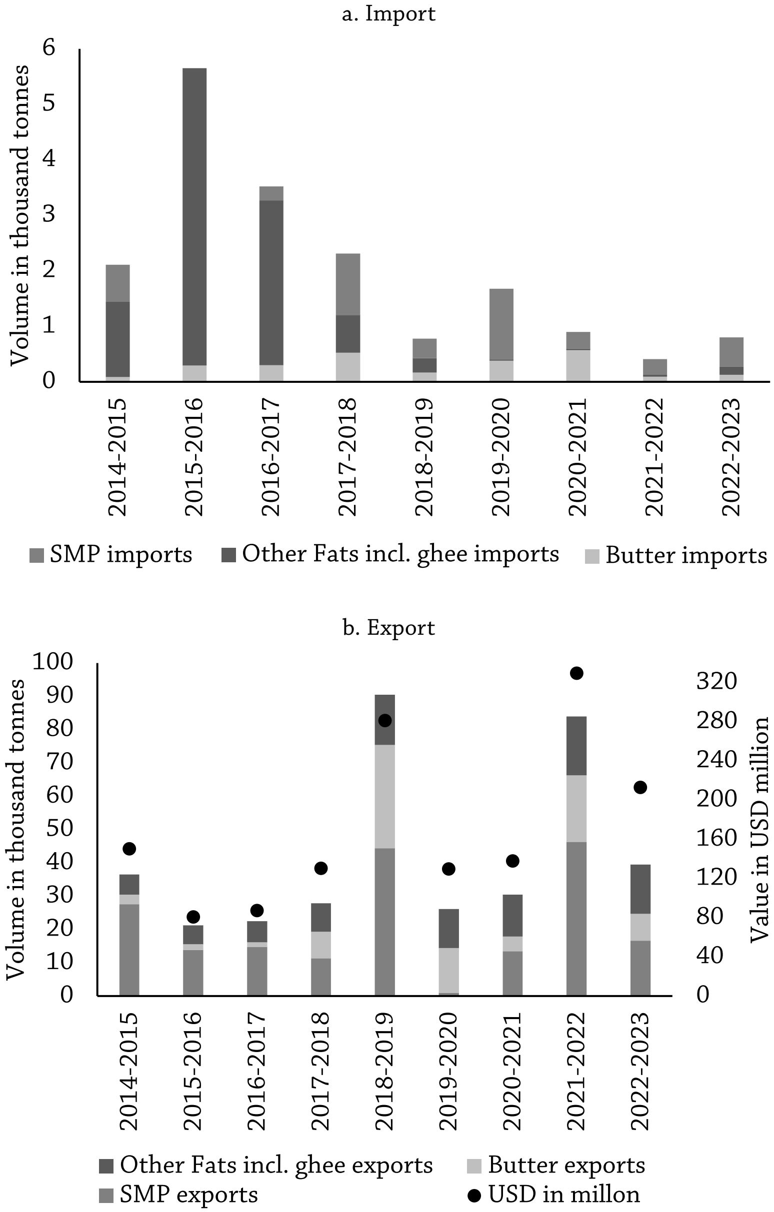
*Import Duty on SMP and Fat*




*Source*: Director General of Foreign Trade (DGFT), GoI.

**Figure 3.13**

*Imports and Exports of SMP, Butter and Milk Fats*



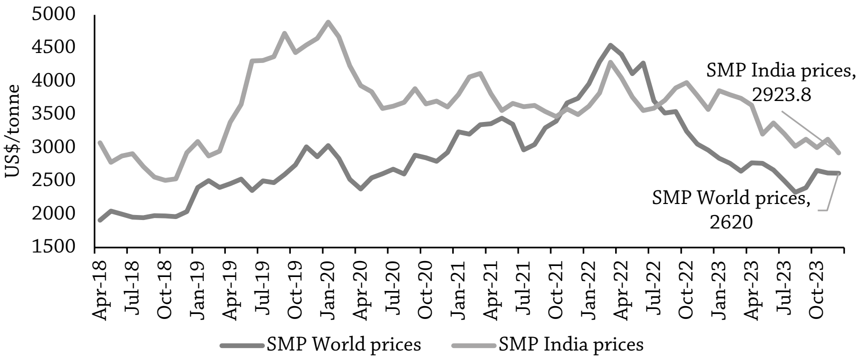

*Source*: Directorate General of Foreign Trade (DGFT).

per cent import duty from 2011–12 to 2015–16 and 2020–21 to 2023–24. A goods and services tax (GST) of 12 per cent is charged on fat imports, while SMP has a lower GST rate of 5 per cent. India's import of SMP and fat has been negligible over the last decade. In contrast, India exported about 19,963 tonnes of butter and 17,706 tonnes of other milk fats, including ghee, in 2021–22; 8,081 tonnes of butter and 14,796 tonnes of other milk fats, including ghee, during 2022–23; and 8,452 tonnes of butter and 11,042 tonnes of other milk fats, including ghee, during 2023–24 (till January). This compares with 4,449 tonnes of butter and 12,497 tonnes of other milk fats in 2020–21.

High exports of milk fat in the form of butter, ghee, and anhydrous milk fat can contribute to domestic shortages. Interestingly, India's exports of SMP during 2018-19 and 2021-22 were high, despite domestic SMP prices being higher than the world SMP price (Figure 3.14). The majority of these exports were directed to Bangladesh (about 45 per cent in 2018-19 and 60 per cent in 2021-22) due to lower freight costs. To enhance India's competitiveness in the SMP market, efforts must focus on making the dairy value chain more efficient and reducing production costs.

**Figure 3.14**

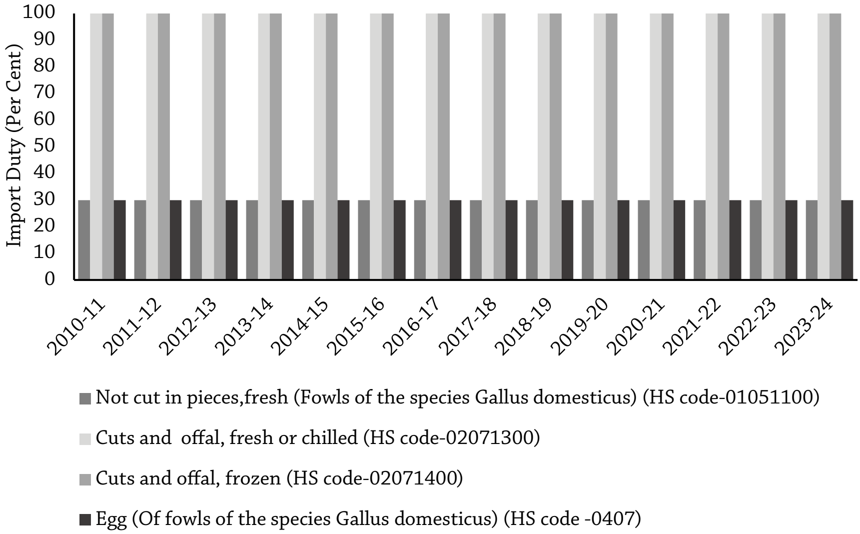
*SMP Prices: India vs. World*




*Sources*: Indian Dairy Association and Global Dairy Trade.

**Figure 3.15**

*Basic Customs Duty on Poultry Meat and Egg*




*Source*: Director General of Foreign Trade (DGFT), GoI.

In contrast, poultry meat imports are minimal,[16] while India exports small quantities to countries such as Bhutan, Bahrain, and Malaysia. In 2022-23, India exported only about 3 tonnes of poultry meat, compared to almost zero tonnes in 2019-20[17]. Domestic demand for poultry is not met through imports, as consumption in India is primarily driven by fresh meat from live markets (95 per cent), with processed/chilled or frozen meats accounting for only 5 per cent of market share (BAHS, 2021). Additionally, high tariffs on poultry meat imports and inadequate processing make India uncompetitive in the global market. The basic customs duty on imports of cuts and offal (frozen category) is 100 per cent, while the duty on "not cut in pieces, offal" (frozen category) is 30 per cent (Figure 3.15).

16. India generally imports leg chicken pieces from the USA.

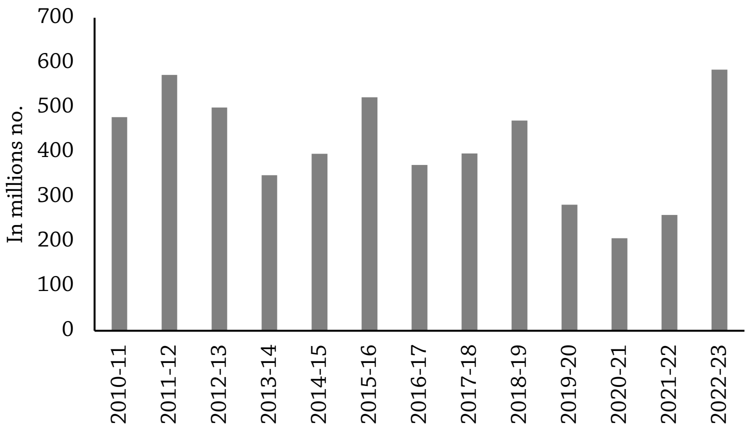
17. Poultry meat export includes meat/edible offal of fowls of the species Gallus domesticus not cut in pieces (fresh/chilled).

In case of eggs, India allows exports without any restrictions. The basic customs duty on imports of fresh eggs and egg powder has been 30 per cent for the past ten years. India imports a negligible quantity of eggs. On the other hand, India exports fresh eggs mainly to Oman, Maldives, and Middle Eastern countries like Kuwait, Qatar, Bahrain, Iraq, and Iran (Figure 3.16).

India also exports eggs and its by-products to African countries such as Liberia, Sierra Leone, Kenya, Uganda, Nigeria, Somalia, Malawi, and Sudan. Most of the eggs exported from India originate from Namakkal, Tamil Nadu, often referred to as India's hub of egg production. According to the Department of Animal Husbandry and Dairying (DAHD), the strength of these exports lies in the competitive cost of production, proximity to international markets, and the successful regaining of freedom from Highly Pathogenic Avian Influenza (HPAI).

**Figure 3.16**

*Trend of Egg Exports from India*




*Source*: APEDA

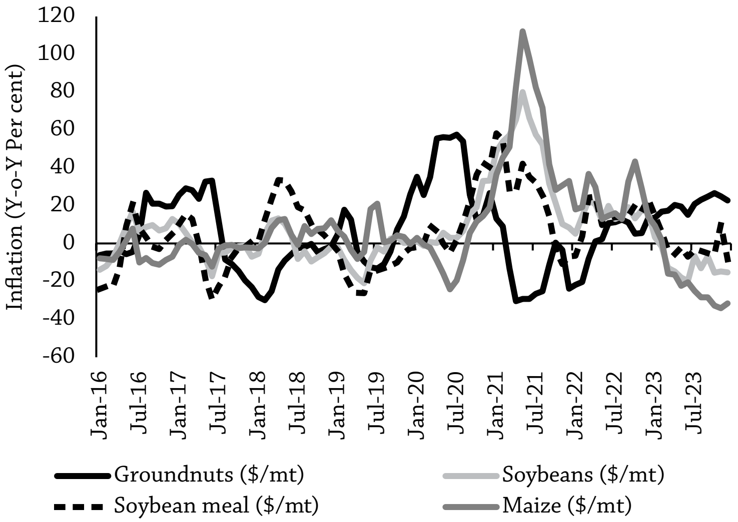
### *3.3.5 Role of Feed in Livestock Price Formation*

Another important factor impacting production and prices in the livestock sector is feed cost or feed availability. Literature indicates that feed cost is a significant component of the total cost of livestock production, accounting for around 60-70 per cent of total production

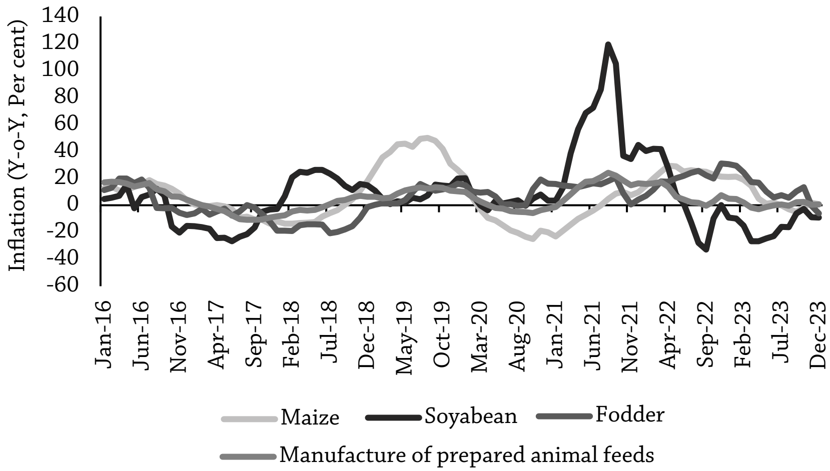
**Figure 3.17**

*Global and Domestic Prices of Livestock Feed*

a. Global Feed Inflation




b. Domestic Feed Inflation (WPI)




*Sources*: World Bank Pink Sheet Data and Office of the Economic Adviser, GoI.

costs in milk (Lawrence et al., 2008), 60–70 per cent of a broiler's production cost (Gulati et al., 2022), and 70–80 per cent of a layer's total production costs (Gunasekar, 2006; FAO, 2003; Mallick, 2020). There have been considerable price and production fluctuations in various components of feed for milk, poultry meat, and eggs.

Cow/buffalo feed consists of two major categories: roughages and concentrates (Udharwar, 2020). Roughages include dry roughage (e.g., hay, stovers like jowar kabdi, and straw from paddy, wheat, and karad) and green roughages[18] (e.g., cultivated fodder plants such as leguminous fodder like lucerne, berseem, cowpea, and non-leguminous fodder like Napier grass, para grass, maize, sorghum, tree leaves, and silage). The concentrate mixture comprises maize grain (ground), soybean meal, groundnut cake, cottonseed cake, rice polish, mineral mixture, and salt. The roughage requirement (dry matter) for cattle/buffalo is 2.5-3.0 kg per 100 kg of body weight per day. Studies suggest that green fodder is beneficial for maintaining good health and increasing yield. However, due to its lower availability in most regions, farmers often substitute green fodder with dry fodder and increase the content of concentrates in the total feed proportion. In the domestic market, fodder and manufactured prepared animal feed costs have experienced high inflation over the past three years, leading to an increase in prices of leading milk brands (Figure 3.17). For instance, rice bran extract and Gola cattle feed recorded WPI inflation of 27 per cent and 8.6 per cent, respectively, in December 2022, while fodder registered WPI inflation of 30.6 per cent in the same period.

In the poultry sector (layer and broiler), feed consists of maize (60 per cent), soya (25 per cent), de-oiled rice bran (8–15 per cent), and mustard extraction and groundnut cake (2 per cent each). Given India's dependence on feed imports, international feed prices also influence domestic feed prices. For example, global inflation in maize and soya spiked to nearly 112 and 80 per cent, respectively, in May 2021, causing domestic soya prices to rise by 119 per cent in August 2021. To address these soaring prices, growing demand from the

18. Out of the total, green-wet fodder of 25 per cent must be from leguminous species and 75 per cent from monocot grasses.

domestic animal feed industry, and increased oil meal exports, India imported approximately 0.65 MMT of soybean meal primarily from Argentina, Vietnam, and Thailand during 2021-22. Additionally, the Union government approved a 1.2 MMT quota for soybean meal derived from genetically modified soybeans to alleviate high animal feed prices impacting the industry (USDA, 2022). The elevated prices of soya meal, maize, and soybean have significant repercussions on the poultry industry.

## 3.4 Overview of Livestock Value Chain in India

To better understand the balance sheet approach, it is essential to examine the value chain of poultry meat, eggs, and milk, and the roles of various stakeholders involved. Understanding the commodity-specific value chain is crucial for computing balance sheet variables, dynamic monthly stock variables, and identifying measures to mitigate volatility in livestock production and inflation.

### *3.4.1 III.1. Dairy Value Chain*

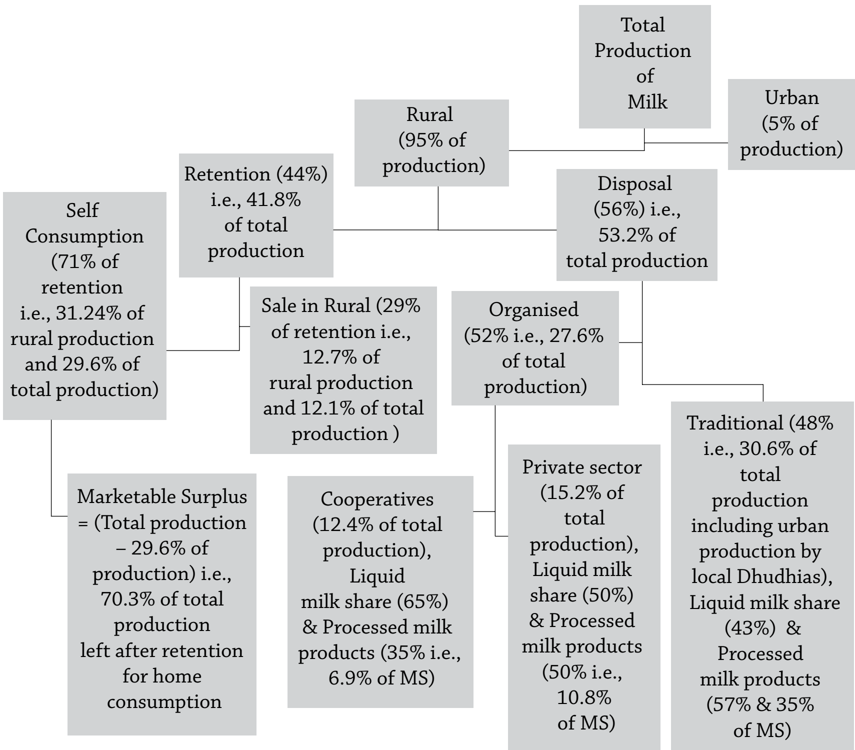
### *3.4.2 Dairy Value Chain*

The dairy sector in India provides a livelihood to more than 63 million households (NDDB, 2021-22), consisting mostly of small, marginal, and landless farmers with an average herd size of 3 animals (20th Livestock Census). Operation Flood led to the creation of a three-tier cooperative structure at the state level, significantly boosting India's milk production and processing capacity. This structure efficiently linked the milk distribution network across 700 cities and towns through a National Milk Grid. Since the 1990s, private sector participation in dairy processing has increased, with private sector dairy players surpassing cooperatives in processing capacities (Gupta, 2017).

Out of the total milk produced in India, 41.8 per cent is consumed at the rural level, with 29.7 per cent used for self-consumption and 12.1 per cent meeting the demand of those without milch animals (Figure 3.18). The remaining 58.2 per cent of the milk (inclusive of 5 per cent produced in urban areas) is available for sale to urban consumers. Of the total milk available for sale, about 52 per cent is handled or marketed by the organised sector (dairy cooperatives and organised private sector players), while the remaining 48 per cent is managed by the unorganised sector, commonly known as *Doodhwalas* (Gupta, 2017). Within the cooperative share of the total marketed milk surplus, 65 per cent is sold as liquid milk, and 35 per cent is processed into milk products. In the private sector, the split is 50 per cent each for liquid milk and processed milk products.

**Figure 3.18**

*Structure of Milk Value Chain in India*




*Source*: P. R. Gupta (2017), Dairy India.

At present, there are 28 functional state-level cooperatives. These cooperatives follow a three-tier structure: a dairy cooperative society at the village level, affiliated with the milk union at the district level, which is further federated into a milk federation at the state level. This structure was established to delegate various functions—milk collection is carried out at the Village Dairy Society, milk procurement and processing at the District Milk Union, and milk and milk product marketing at the State Milk Federation (Figure 3.19). State federations market their products under common brand names such as Amul, Nandini, Aavin, and Saras. This model is also known as the 'Amul Model' or the 'Anand Pattern' of dairy cooperatives, implemented during Operation Flood.

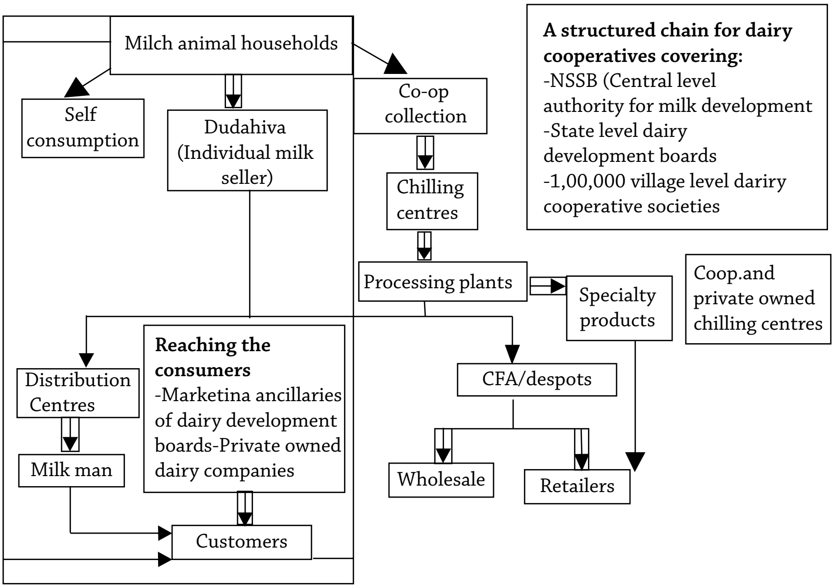
Currently, the top five cooperatives—Gujarat (Amul), Karnataka (Nandini), Tamil Nadu (Aavin), Rajasthan (Saras), and Bihar (Sudha)—handle more than 76 per cent of the total milk processed by cooperatives. The Anand Pattern is an integrated cooperative structure that procures, processes, and markets produce, owned and governed by farmers. There are around 25 major private dairies operating across various states in India. According to NDDB, the capacity created by private dairies in the last 20 years surpasses that set up by cooperatives over the past 30 years.

While the value chains of dairy cooperatives and organised private sector dairy companies follow a similar structure regarding procurement, processing, and marketing, ownership in dairy cooperatives rests with the members who supply milk to the procurement system. In contrast, farmers have no ownership in organised private dairies, as these companies are privately held (through shareholdings), with some listed on the stock market. In cooperatives, members of the village cooperative society supply milk to their system, whereas, in most private dairies, farmers are under no obligation to sell or supply milk to them, although some private players have agreements with dairy farmers for milk supply. Private dairies procure milk based on the demand and supply scenario, while cooperatives must procure and process milk brought in by their members regardless of market demand. However, during periods of high milk production, cooperatives' procurement may depend on their processing capacity.

For cooperatives, private dairies, and organised private players, the milk procurement price paid to farmers is based on fat and solids-not-fat (SNF) content. Industry estimates suggest that the private sector has more processing capacity than cooperatives. However, cooperatives have a significant presence in the liquid milk segment, while both private dairies and cooperatives hold substantial shares in the processed products market.

**Figure 3.19**

*Structure and Operations of Dairy Value Chains*




*Note*: CA/CFA: Carrying and Forwarding Agent.

*Source*: Shah (2016).

## 3.4.3 Poultry Value Chain

Poultry farming is classified into commercial and backyard sectors, with varying sizes measured by the number of birds (Table 3.1). Backyard poultry is mostly owned by small and marginal farmers, consisting of only a few birds primarily for personal consumption, with limited commercial sales. In contrast, poultry farmers engaged in commercial production sell eggs and meat on a larger scale, with farm sizes ranging from 5,000 to 100,000 birds. Within the broiler industry, the commercial sector accounts for 82 per cent of total poultry meat production, while in the layer industry, it contributes to 83 per cent of egg production. The remaining 18 per cent and 17 per cent are contributed by backyard poultry in the broiler and layer industries, respectively (BAHS, 2020).

**Table 3.1**

*Poultry Farm Classification*

| | | |
|---|---|---|
| 1. | Backyard Poultry (200–5,000 birds) | |
| 2. | Commercial Poultry (above 5,000 birds) | |
| | I. | Small (5,000–25,000 birds) |
| | II. | Medium (above 25,000–100,000 birds) |
| | III. | Large (above 100,000 birds) |

*Source*: Environmental Guidelines for Poultry Farms, MoEF&CC, GoI, 2021.

The poultry value chain consists of three main operations: (i) breeding (breeder farms), (ii) hatching (hatchery farms), and (iii) layer farming (for egg production) or broiler farming (for meat production). Breeder farms focus on producing fertilised eggs for either egg or broiler production, using specific ratios of male and female breeders to ensure the eggs are fertile for developing pure line broiler and layer birds or the grandparent stock. These fertilised eggs collected from breeder farms are sent to centralised hatcheries for incubation (MoEF&CC, 2021). After 21 days, the hatched chicks are vaccinated, assessed for uniform quality, and shipped to other locations for further rearing.

In the poultry value chain, the initial process encompasses the development of the great grandparent (GGP) stock to parent stock in the genetic value chain for both poultry meat and egg production.

### *3.4.4 Value Chain of Commercial Poultry (Broiler Bird/Meat)*

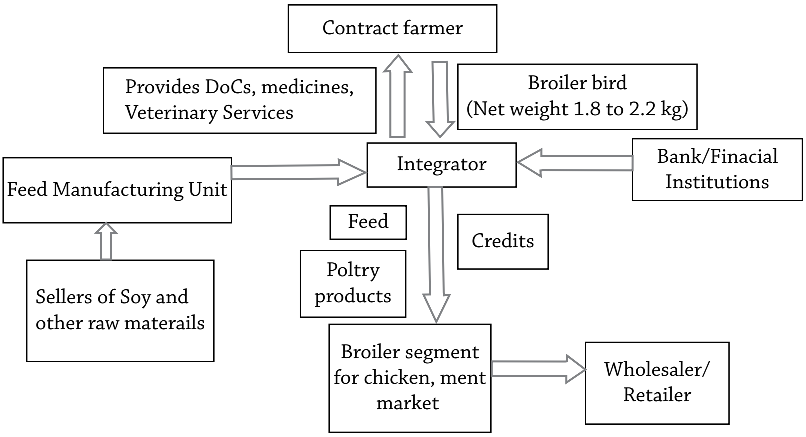
The second aspect of the value chain outlines the process from parent stocks to commercial bird production, which operates through two models: (i) the Integrator model and (ii) the Direct farmer model. Each of these models is explained below:

### i. Integrator Model

In the integrator model, a contract farming agreement is established between the integrator and the farmer. Approximately 65 to 70 per cent of commercial poultry meat production comes from this model (based on our field survey). The integrator provides day-old chicks (DoC), feed, veterinary services, and vaccines to the farmers. In turn, the farmer or farm owners bear the cost of the shed, electricity, and labour for poultry rearing. Essentially, all costs except for the growing cost are borne by the integrator. This contract farming system ensures price stability or assured returns for the farm owners, irrespective of market price volatility. The integrators assume most of the risk in the value chain, allowing farmers to focus on rearing broiler birds without involvement in marketing aspects (Figure 3.20).

**Figure 3.20**

*Value Chain from Parent Stock to Retailers*



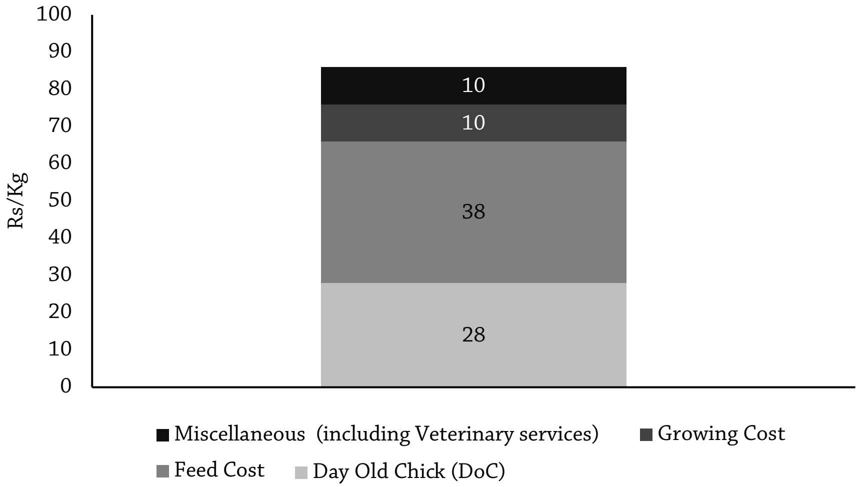

*Source*: Field Survey.

Several integrators or companies, such as Venkateshwara Hatcheries (Venky's), IB Group, and Suguna Chickens, currently follow the contract farming model. In contract farming of broiler chicks, farmers are remunerated based on a predetermined level of feed conversion ratio (FCR), weight, and mortality. For instance, the FCR ratio for large hatcheries was around 1.6 (as per our field survey conducted in December 2022). If this FCR and a mortality rate of 7–8 per cent are maintained, farmers are paid an average of Rs. 6.5–7/kg.

The feed, comprising maize and soybean meal, is the largest component of the total production cost, while the cost of DoCs is Rs. 25–30 (Figure 3.21). Integrators also bear additional costs such as medicines (approximately Rs. 2 per kg), transport, and other administrative expenses. Broiler chicks are typically reared for 35–40 days to reach a market weight of 1.8 to 2.2 kg. Integrators buy back 36–40-day-old broiler birds (approximately 2 kg in size) by paying an average of Rs. 7 per kg to farm owners.

**Figure 3.21**

*Cost of Production of Broiler Bird*




*Source*: Field Survey.

### ii. Direct Farmer Model

The second part of the value chain involves the remaining 30 per cent of farm owners who rear broiler chicks by investing their own resources. These farmers are responsible for the marketing aspects of the broiler birds, in addition to covering the costs of DoCs, feed, medicines, land, and labour. Traders sell the birds to retailers, who then sell the raw meat in the live market (as dressed or culled chicken meat). Farmers often prefer the integrator model, as it mitigates risk and provides assured returns regardless of market price fluctuations. Farmers outside the integration model face initial investment barriers and the risk of uncertain returns due to price volatility.

Interactions with officials from the Poultry Federation of India revealed that poultry meat is primarily sold through the wet market, where birds are culled and raw meat is sold to consumers, accounting for 95 per cent of the total production of broiler birds. Only 5 per cent of poultry meat production is processed into value-added products. Another segment of traders sources broiler meat or birds from farmers for institutional consumption, such as hotels, restaurants, catering services (HORECA), and the defence forces.

Approximately 18 per cent of poultry meat production comes from backyard poultry, mainly practised in rural areas. A portion of this production (around 5 per cent) is used for self-consumption. The unorganised and backyard poultry sector serves as a tool for supplementary income generation for many landless or marginal farmers and provides nutritional security to the rural poor.

### *3.4.5 Commercial Egg Value Chain*

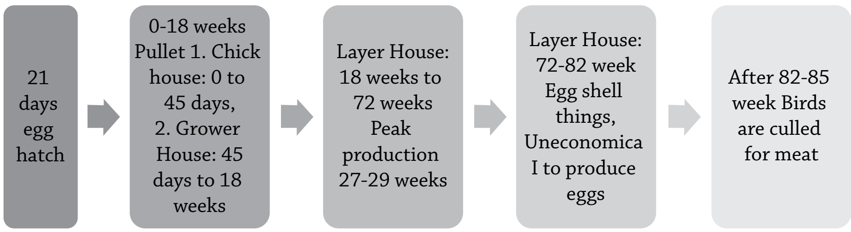
The marketing of eggs is dominated by traders who purchase eggs from layer farmers based on the region-specific daily prices announced by the National Egg Coordination Committee (NECC), an apex body of layer farmers.

The female parent stock (or the one-day-old chick) from hatcheries is sent to commercial egg layer farms for egg production. Based on inputs provided by NECC, commercial layer birds have a lifespan of approximately 72 weeks, during which they start laying eggs commercially from 18–19 weeks of age (as per the field survey). During the first 18 weeks, when the bird is not laying eggs (also called a pullet), it is kept in the chick house (0 to 45 days) and later moved to the grower house (45 days to 18 weeks). A one-day-old layer chick supplied by these companies costs between Rs. 37 and 40. Some intermediary farmers rear these one-day-old chicks until 18 weeks before supplying them to layer houses for egg production. The pullets cost around Rs. 300. During the bird's lifecycle, it lays eggs between

18 and 72 weeks, totalling 290 to 310 eggs (Figure 3.22). After 72 weeks, it becomes uneconomical for the poultry farmer to keep rearing the birds for eggs, as the yield decreases and the probability of breakage increases due to the thinning of the eggshell. However, small poultry farmers in India tend to keep birds until 80–85 weeks before selling them for meat.

**Figure 3.22**

*Lifecycle of Layer Birds*

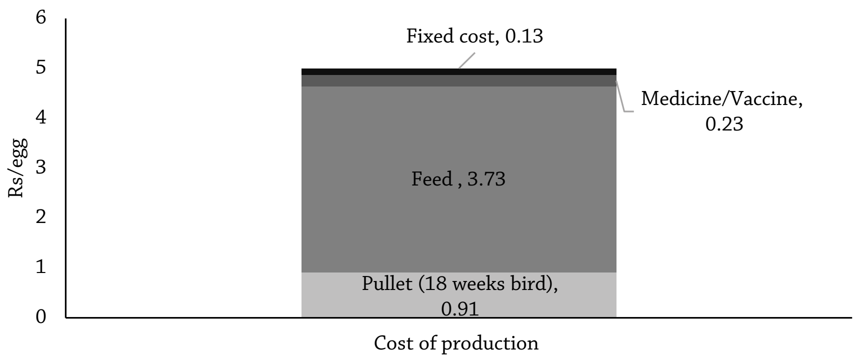



*Source*: Field Survey.

Based on the field survey conducted in December 2022, the cost of producing an egg is around Rs. 5, with feed accounting for 75 per cent of the total production cost. The pullet cost, adjusted per egg, amounts to approximately Re. 0.91. Other costs, such as medicines and fixed expenses (including electricity, cage, and labour), account for Re. 0.23 and Re. 0.13 per egg, respectively (Figure 3.23).

**Figure 3.23**

*Cost of Production of an Egg*

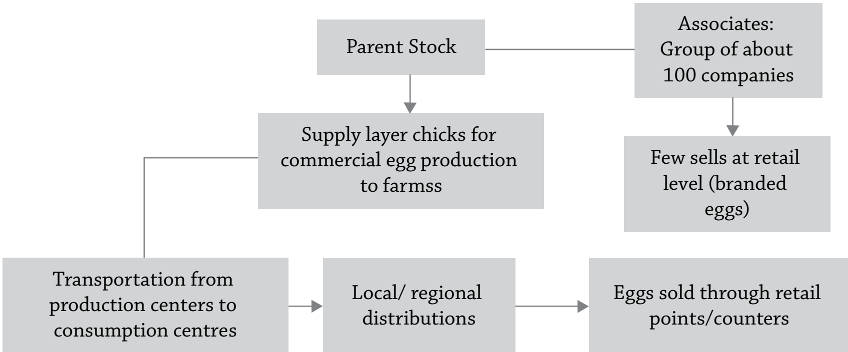



*Source*: Field Survey.

Eggs sourced from commercial layer farms are referred to as non-fertilised eggs. The commercial egg production process, from the farm gate to the retail consumer, follows various chains depending on transportation from production to consumption centres (Figure 3.24).

**Figure 3.24**

*Value Chain of Commercial (Non-fertilised) Eggs*




*Source*: Field Survey.

Due to the regional concentration of production in some states, such as Andhra Pradesh, Tamil Nadu, and Telangana, traders from consuming or deficient regions purchase eggs from surplus regions/states and transport them to the consumption points. Local traders then buy the eggs brought in from the producing regions and transport them to retail points, where local agents deliver them to retail outlets. In the case of backyard poultry, eggs are sold directly by farmers in the market or purchased directly by consumers at the farm gate. In addition to supplying layer chicks, major players also market their non-fertilised eggs, known as value-added eggs, directly to consumers through retail channels. Egg powder, prepared by dehydrating eggs through the spray drying process, contains the same amount of proteins as fresh eggs but has lower carbohydrates, cholesterol, and fats.

In backyard poultry, rearing layer birds and improved desi varieties in smaller numbers is carried out in a free-range system, where birds scavenge for food and the natural process of hatching is practised. Smaller backyard layer farms do not have the infrastructure or facilities to transfer eggs directly to consumption centres; hence, intermediaries aggregate and transport the eggs to markets. In the case of backyard poultry, eggs are sold directly by farmers in the market or purchased directly by distributors at the farm.

## 3.5 Estimating the Price Mark-ups in the Livestock Value Chain

### *Price Mark-ups in the Dairy Value Chain*

For this study, we have taken into account major dairy cooperatives based in Gujarat and Maharashtra. In terms of the realisation of the consumer's rupee by the farmers, the cooperatives are the most efficient, as they transfer about 70 per cent of the consumer rupee earned from selling liquid milk to retail consumers (Table 3.2). This makes the dairy value chain of cooperatives more inclusive.

### *Price Mark-up in Poultry Value Chain (Poultry Meat and Egg)*

For analysing the farmer's share in the consumer rupee, two chains are considered: (1) Pune and Mumbai chain for poultry meat and eggs, and (2) Barwala (Haryana) and Delhi chain for eggs. The mark-ups in the poultry value chain are detailed in Table 3.3.

## 3.6 Balance Sheet Approach

To understand livestock price dynamics and create a variable that captures supply-demand imbalances, we use the balance sheet approach. This paper analyses the supply and demand in the livestock and poultry sectors, including milk, poultry meat, and eggs. Milk can be stored for longer periods once processed into skimmed milk powder (SMP) and fat. However, commodities like eggs cannot be stored for long. In contrast, poultry meat is not stored and is primarily sold in the wet market. Therefore, we assume net availability or stock to be zero for poultry meat. After establishing the monthly total stocks (for milk and eggs) or availability (for poultry meat), we analyse the impact of various factors, including the balance sheet variable, on livestock prices.

**Table 3.2**

*Retail Price Mark-up in the Consumers' Rupee Spend on Milk*

| *Rs./litre* | *Payment to farmers* | *Procure-ment cost* | *Processing cost* | *Packaging cost* | *Transporta-tion cost* | *Pvt/ Co-operatives' mark-up* | *Distribu-tors' com-mission* | *Retailers' mark-up* | *Retail price* |
|---|---|---|---|---|---|---|---|---|---|
| Dairy 1(Dec. 2022)# Leading cooperative in Maharashtra in Rs/litre | 35 | 3 | 2 | 1 | 2 | 1 | 1.5 | 3.5 | 49 |
| Dairy 1: Per cent of retail prices | 71 | 6 | 4 | 2 | 4 | 2 | 4 | 7 | |
| Dairy 2(Dec. 2022)# Leading private dairy in Maharashtra in Rs/litre | 36 | 3.5 | 2 | 1 | 4 | 2 | 1 | 2.5 | 52 |
| Dairy 2: Per cent of retail prices | 69 | 7 | 4 | 2 | 7 | 4 | 2 | 5 | |
| Dairy 3 (March 2023) #Leading Co-operative in Gujrat in Rs/litre | 38 | 3.5 | 2 | 1 | 2 | 4 | 1.5 | 2 | 54 |
| Dairy 3: Per cent of retail prices | 70 | 6 | 4 | 2 | 4 | 7 | 3 | 4 | |

*Notes*:
- Private organised players, in addition to procuring milk from farmers at the procurement points, also receive milk in bulk from aggregators who use tankers to supply large quantities to the processing plants owned by private dairies.
- In the unorganised dairy sector, assessing the consumer rupee realised by dairy farmers remains challenging due to the lack of data.

*Source*: Information shared by officials of major cooperatives and private dairies in Maharashtra and Gujarat.

**Table 3.3**

*Mark-ups of Poultry Birds and Fresh Eggs from Commercial Sector*

| *Rs./litre* | *Farm gate prices* | *Transportation charges (by vendors/ traders) to retail (consumption) points* | *Transportation Losses (transit/ mortality/ weight loss)* | *Traders' mark-up* | *Wholesalers'/ distributors'/ local vendors' mark-up* | *Retailer's mark-up* | *Retail prices* |
|---|---|---|---|---|---|---|---|
| Poultry Bird: Rs/kg (Dec. 2022) #Pune region | 100 | 5 | 5.7 | 20 | 15 | 34.50 | 180 |
| Poultry Bird: Per cent of retail prices Pune region | 55.5 | 2.7 | 3.2 | 11.1 | 8.33 | 19.17 | |
| Rs/100 eggs (April 2021) Delhi region* | 381 | 15 | 5.52 | 55.2 | 40.08 | 55.2 | 552 |
| Per cent of retail prices Delhi region | 69 | 2.7 | 1 | 10 | 7.3 | 10 | |
| Rs/100 eggs (Dec. 2022)# Pune region | 535 | 20 | 5 | 10 | 10 | 20 | 600 |
| Per cent of retail prices, Pune region | 89 | 3.3 | 1 | 1.7 | 1.7 | 3.3 | |

*Note*: All Poultry meat prices are of live weight bird (in Rs. /kg) in December 2022 and for eggs, it is the average farm gate prices as recommended prices of NECC for *April 2021 and #December 2022.

*Sources*: Based on inputs provided by officials of Poultry Federation of India, large hatcheries and commercial layers and broiler farms based in *Haryana and #Maharashtra.

*Contd...*

*.contd...*

*Note*: All Poultry meat prices are of live weight bird (in Rs. /kg) in December 2022 and for eggs, it is the average farm gate prices as recommended prices of NECC for *April 2021 and #December 2022.

*Sources*: Based on inputs provided by officials of Poultry Federation of India, large hatcheries and commercial layers and broiler farms based in *Haryana and #Maharashtra.

**A. Notes for Broiler:**

- In poultry meat, approximately 70 per cent of farmers or farm owners follow an integrator model where the marketing of broiler birds is managed by companies or private entities. The realisation of the consumers' rupee is returned to the integrators.
- The mark-up in poultry meat is calculated at the integrator level and constitutes 55.5 per cent of the consumer rupee. This includes farmers' mark-up, which is about 5-6 per cent in contract farming. This percentage is lower because integrators bear most of the costs and risks.
- For the remaining 30 per cent of farmers or farm owners who market their broiler birds independently, the realisation of the consumers' rupee goes directly to them.
- Traders bear the freight or transportation cost from the farm gate.

**B. Notes for Layer Eggs:**

- Commercial layer farmers are registered with NECC, a national organisation with representative offices at key egg-producing points.
- NECC declares daily region-specific farm gate prices for eggs from commercial layers and coordinates with regional players.
- In the commercial eggs value chain, farmers' realisation of the consumer rupee varies by season, ranging from 69 per cent in summer to 89 per cent in winter. Three-year averages of Agmarknet's wholesale and Directorate of Economics and Statistics (DES) retail prices indicate that 75.2 per cent of the consumer rupee goes back to the egg farmer.
- Farmers' mark-up varies across the year. They generally incur losses in summer and make profits in winter.
- Variations in egg demand, particularly in summer, lead to fluctuations in retail prices. Egg production and the placement of day-old chicks adjust to these fluctuations.

### *Components of the Monthly Livestock Balance Sheet*

The livestock commodities discussed have unique value chain structures. The annual balance sheet data is transformed into monthly data based on factors such as production and release patterns and consumer/institutional demand, which are collated through primary surveys. The monthly patterns of production, consumption, and stocking have been generalised for the period January 2010 to December 2022 for milk, poultry meat, and eggs.

Key assumptions for generating the livestock balance sheets are:

i. The production year varies across the three commodities: This is based on how annual production data from secondary sources are distributed throughout the year. The egg and milk production years are April to March, whereas poultry meat follows a January-December cycle.

ii. Production pattern in a year: Livestock and poultry commodities are harvested throughout the year, though they exhibit varying monthly production patterns. For example, milk production increases from August onwards, peaking in October, November, and December, and decreases during the summer months, particularly in May and June. Poultry meat and egg production peak during the winter months, from October to March, and decline from April to September. This aligns with earlier research suggesting that changing temperature patterns or heat stress impact egg and poultry meat production (Bhadauria et al., 2014; Vandana et al., 2020; Kumar et al., 2021).

iii. Conversion rate among livestock and poultry products: Milk is consumed in different forms, including butter, ghee, SMP, and condensed milk. For milk containing 3.5 per cent fat and 8.5 per cent SMP, the conversion rate between a kilogram (kg) and a litre of milk is 1:0.96, while the conversion rate between SMP and milk (in kg) is 1:10.4. One kg of butter requires 23.4 kg of milk, one kg of ghee requires 29 kg of milk, and one kg of condensed milk requires 2.7 kg of milk. Other value-added milk products include whey, where 1 kg requires 11.7 kg of milk; cheese, where 1 kg requires 8.3 kg of milk; and buttermilk, where 1 kg of milk can produce 2.5 kg of buttermilk.[19]

To avoid double-counting, we ensured that SMP-butter and whey-cheese are converted correctly to liquid milk, as they are by-products of the same amount of liquid milk. Since 1 kg of milk contains 3.5 per cent fat and 8.5 per cent SMP,[20] we adjusted the imports and exports of SMP and fat accordingly, as well as for whey and cheese. Similarly, eggs are consumed and traded in various forms, such as egg powder and yolk powder. The conversion rate for 1 kg of whole egg powder is equivalent to 80 eggs, and 1 kg of egg yolk powder is equivalent to 110 eggs. We also assume that, on average, an egg weighs about 50-70 grams, depending on the hen's age (Travel et al., 2011). In poultry meat, the conversion ratio between 1 kg of live bird and raw meat is 1:0.65 (based on field survey data).

iv. Trade data for eggs: Before April 2013, trade data for eggs used only one HS code (407) and did not differentiate between hen eggs and other eggs. Since April 2013, the DGFT has provided separate data for hen eggs (fowls of the species Gallus domesticus (04072100)). Since 2013, an average of 85 per cent of total egg exports has been hen eggs. We assumed the same share for the period January 2010 to April 2013.

v. Poultry meat balance sheet: The poultry meat balance sheet is computed at the meat level, i.e., production figures are taken at the fresh meat level rather than the live bird level. The balance sheets for milk and poultry meat are computed in million tonnes, while the egg balance sheet is computed in million numbers.

19. For our balance sheet, we have considered buttermilk preparation from curd equivalent, i.e., 1 kg of curd is diluted with 1.5 litres of water to produce 2.5 kg of buttermilk.

20. For our balance sheet calculation, we have assumed that milk contains 3.5 per cent fat and 8.5 per cent SMP (Skimmed Milk Powder), which is the typical composition found in cow milk.

vi. Marketable surplus and self-consumption: From the monthly production, a portion is kept to meet the farmer's self-consumption needs, with the remainder sold in the organised or unorganised sector. For example, around 41.4 per cent of total milk production is retained by dairy farmers for self-consumption and sale in rural areas (Gupta, 2017). Of this, 11.2 per cent is sold to consumers and sweet shops in rural areas. The total marketable surplus for milk is 69.8 per cent (11.2 per cent sold in rural areas + 58.6 per cent disposed of in the organised and unorganised sectors). This pattern was applied from January 2010 to March 2020. Recently, this pattern has changed marginally, with the marketable surplus for milk now accounting for 70.3 per cent of total production (12.1 per cent sold in rural areas + 58.2 per cent in the organised and unorganised sectors) (Gupta, 2017). This updated pattern has been applied from April 2020 to December 2022.

    According to BAHS data, around 83 per cent of eggs produced in India come from commercial layer farms, while the remaining 17 per cent come from backyard poultry. In contrast, 18 per cent of poultry meat production is attributed to backyard poultry in rural areas. Backyard poultry farmers retain a portion of their produce for self-consumption, estimated at 50 per cent for eggs and 5 per cent for poultry meat (based on field survey data). The total marketed surplus for poultry eggs and meat (including commercial and remaining backyard produce) is around 91.5 per cent and 97 per cent, respectively.

vii. Household consumption of milk: To calculate the amount of liquid milk consumed annually by households, we used a weighted average of per capita consumption in rural and urban areas. The annual projected consumption was then distributed using the monthly pattern of CMIE consumption expenditure data. From monthly milk consumption, we deducted consumption from home produce to estimate net consumption. According to NSS unit-level consumption survey data, 45 per cent of milk consumption in rural areas and 6.01 per cent in urban areas are met from home produce.

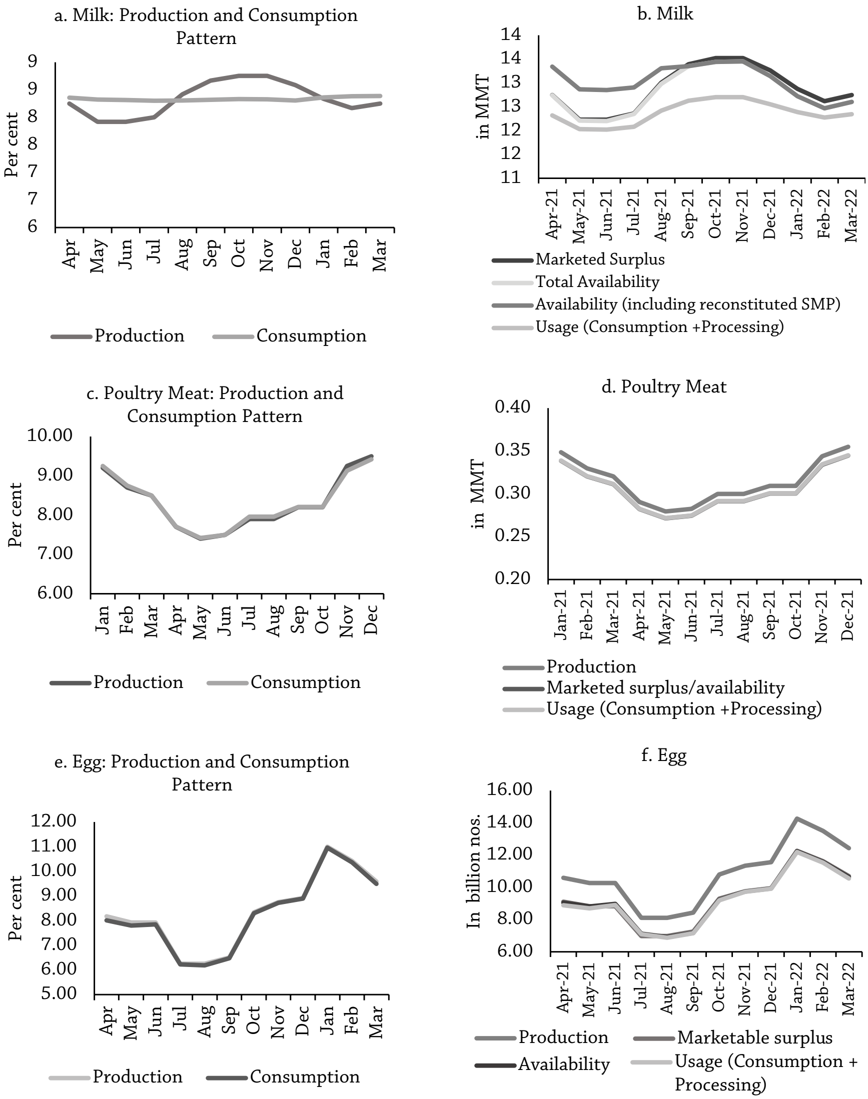
viii. Poultry meat consumption: Using a behavioural approach to project annual poultry meat consumption, estimates based on the NSS Consumption Expenditure Survey (CES) are higher than production figures for all the years from 2011-12 to 2022-23. However, annual consumption data from the OECD-FAO Agricultural Outlook 2022-2031 is relatively lower than the annual production figures. Therefore, for the poultry meat balance sheet, we used the OECD-FAO Agricultural Outlook 2022-2031 to compute production and consumption estimates. The annual poultry meat figures were then distributed monthly according to patterns sourced from our primary stakeholder survey (Figure 3.25). We assumed that 5 per cent of monthly consumption is met through home production.

ix. Egg consumption: Similarly to poultry meat, we found that annual egg consumption computed using a behavioural approach based on NSS's CES accounts for just 47 per cent of total production during 2010-11 to 2020-21, underestimating consumption as a proportion of production. Field surveys and interactions with NECC officials revealed that monthly usage and availability of eggs are nearly equal. During the Shravan and summer months, egg consumption falls short of availability, and eggs are stored in cold storage, which ranges from 1 to 2 per cent of total egg production, according to NECC experts. In some regions of India, surplus eggs are supplied to states with a stable year-round consumption, such as the North-East and Eastern states. Therefore, we distribute monthly consumption as a percentage share of monthly production in the egg balance sheet, with monthly patterns provided by our field interactions.

After compiling the balance sheet, we examine the trends and patterns of its various components (Figure 3.25). Production and consumption patterns were constructed through extensive assessments from key players in the dairy, broiler, and layer industries. For milk, based on trends from CMIE consumption

**Figure 3.25**

*Monthly Pattern of Balance Sheet Component within a Year*




*Source*: Author's calculations from the derived balance sheets of milk, eggs, and meat.

expenditure data, liquid milk consumption is almost constant throughout the year, except for a slight increase during January-April and October (Navratri). Availability peaks from August to December, and excess stocks from winter are used to meet demand from May to July when availability is lower. Usage, which includes processing, peaks during the same months as marketed surplus (since processing is a proportion of marketed surplus).

Similarly, poultry meat demand is lowest from March to June, increases slightly from July to September, and peaks in winter. During Shravan (end of July and August) and Navaratri (September/October), as well as in the summer, poultry meat consumption decreases. Availability peaks during the winter months (November to January), and usage peaks coincide with increased consumption. Since poultry meat is sold in the wet market, it is not stored, so net availability is assumed to be zero every month in the balance sheet.

Like poultry meat, egg consumption peaks around December to January and declines during the festivals of Shravan and Navratri, as well as in the summer. Egg availability peaks from December to March, coinciding with higher production.

### *3.6.1 Movement of Net Availability (Stocks) in a Month*

Livestock products generally have a shorter shelf life and cannot be stored for long. However, they can be processed into value-added products for longer storage. For example, excess milk produced during the flush season is processed and stocked as SMP (Skimmed Milk Powder) and fat, which can be reconstituted into milk and supplied during the summer months. The shelf life of SMP is around 12-18 months.

In India, due to inadequate infrastructure and cold chain facilities, the poultry meat market is dominated by live bird sales in wet markets. Consequently, the poultry meat balance sheet does not account for any stock. It is assumed that whatever poultry meat is available in the market in a particular month is fully demanded, with no carry-forward stocks to the following months. The share of frozen meat in poultry meat production is negligible and is included in the processing component of the balance sheet.

Eggs, on the other hand, have a shelf life of 15-21 days at room temperature but can be stored in cold storage for 3-4 months. However, once released from cold storage, eggs need to be consumed within 3-4 days. Unlike pulses, onions, or potatoes, the monthly stock or excess supply of eggs represents a relatively small percentage of the total marketable surplus.

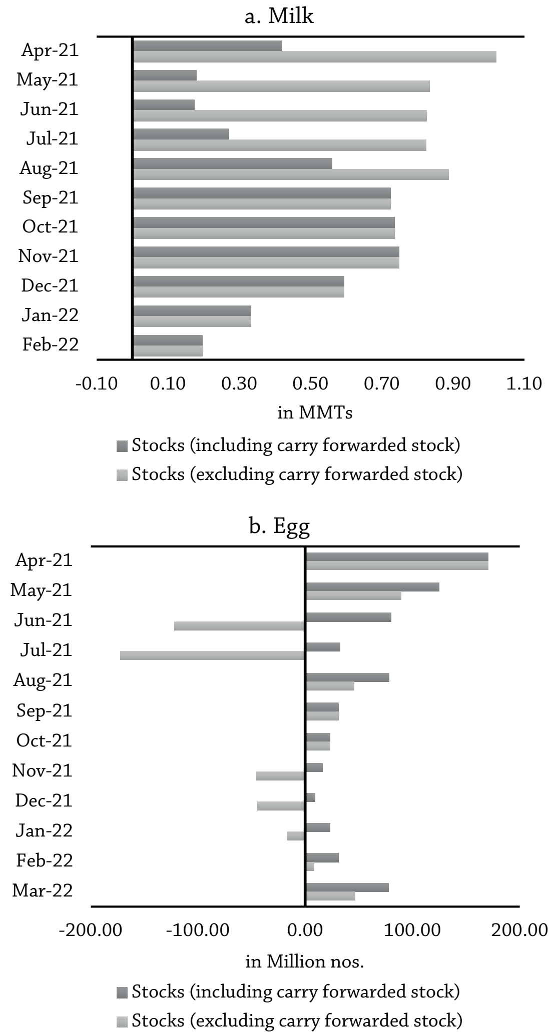
The excess supply, or net availability, serves as the stock variable in the balance sheet and plays a critical role in understanding price volatility. Figure 3.26 shows the movement of milk and egg stocks within a production year, illustrating instances when stocks are carried forward to later months. In the milk balance sheet, September to January is considered the flush season, during which milk production is higher than in the summer months. After the monsoon season, milk production increases due to improved green fodder availability and lower temperatures. The excess supply accumulated during these months is used to meet the demand from April to August of the following year. Thus, stocks accumulated in September are used in April of the next year, continuing in this manner until January stocks are used to meet demand in August (Figure 3.26(a)). Importantly, the study assumes that the excess milk stocks from the flush season are reconstituted into milk and milk products to address the increased demand from April to August.

Similarly, in the egg balance sheet, the excess supply of eggs in a given month is carried forward to the next month's availability. During the summer months and periods such as Shravan and Navaratri, when consumption declines and egg prices fall across the country, poultry farmers tend to store eggs in cold storage for 2-3 months. Hence, the excess supply of eggs in March and April is stored and then released in May, June, and July in a calibrated manner as demand recovers, often due to holidays. Excess eggs stored in August and September are released in November, December, and January. Figure 3.26(b) illustrates the utilisation of carry-forward stocks to meet excess demand (depicted by negative stocks in the figure) in June, July, November, and December.[21]

21. Negative stock levels (excluding carry-forward) indicate an excess demand during these months.

**Figure 3.26**

*Movement of Net Availability (Stock) in the Production Year*




*Source*: Author's calculations.

According to economic theory, we expect stocks or net availability to have a negative relationship with prices: more supply should result in lower prices, and vice versa. The correlation between the net availability of milk and CPI milk inflation from January 2012 to December 2022 was -0.43 (Table 3.4). For poultry meat, the correlation between CPI inflation and availability is -0.02. However, the correlation between CPI poultry meat inflation and the deviation of availability from a three-year moving average improves to -0.29.

**Table 3.4**

*Correlations of CPI for Milk, Egg, and Meat with Their Availability*

| *Commodity* | *Variables* | *At level* | *1-month lag* | *2-month lag* | *3-month lag* |
|---|---|---|---|---|---|
| **Milk** Jan. 2012 to Dec. 2022 | CPI YoY & availability | -0.60 | -0.60 | -0.60 | -0.60 |
| | CPI YoY & net availability | -0.43 | -0.39 | -0.36 | -0.33 |
| | CPI YoY & STU | -0.39 | -0.34 | -0.30 | -0.25 |
| **Egg** Jan. 2010 to Dec.2022 | CPI YoY & net availability | -0.10 | -0.10 | -0.10 | -0.10 |
| | CPI YoY & availability/usage Ratio | -0.01 | -0.02 | -0.02 | -0.01 |
| **Poultry Meat** Apr. 2012 to Dec. 2022 | CPI YoY and availability | -0.02 | -0.02 | -0.01 | -0.01 |
| | CPI and deviation of availability from 3-years moving average | -0.29 | -0.30 | -0.31 | -0.32 |

*Source*: Authors' calculations.

For eggs, we observe a correlation of -0.1 between CPI year-on-year (Y-o-Y) inflation and net availability. Given that the stock levels or net availability of eggs are relatively low, it is likely that stocks do not significantly influence egg prices. Therefore, we also examined the correlation between the availability-to-usage ratio (A/U ratio)[22] and CPI egg inflation from January 2010 to December 2022, which was around -0.01. The correlation of the A/U ratio with the month-on-month (MoM) CPI for eggs is approximately -0.41. In the case of eggs, the momentum of the CPI captures changes in stock levels better than Y-o-Y inflation.

22. This is another measure of the supply and demand interrelationship of commodities and is an estimate of the level of supply for a given commodity at a point in time as a percentage of its total demand or use.

## 3.7 Model Specification and Empirical Results

### *Milk Model Estimation*

After using the balance sheet approach to derive the net availability of milk in a month and finding an inverse correlation between net availability and CPI milk, the ARDL model was employed to estimate the impact of net availability on milk prices. The study uses the deviation of net availability from its 3-year moving average in this estimation. The stationarity of the variables was tested using the ADF test, which showed that some variables were I(0) (stationary at their level) and others were I(1) (integrated of order 1) (see Table 3.5).

**Table 3.5**

*ADF Test for Milk*

| *Variable* | *ADF test statistics (p-value)* |
|---|---|
| Log_CPI_Milk | -2.89 ** |
| LogNetAvailabilityDeviation | -3.89** |
| LogWPIFeed | -0.55 |
| Milk_Dummy | -8.74*** |
| ΔLog_CPI_Milk | -9.78*** |
| ΔLogNetAvailabilityDeviation | -10.26*** |
| ΔLogWPIFeed | -8.34*** |

*Note*: The ADF test statistic is reported. The critical values are the finite sample values suggested by MacKinnon (1991). *** p<0.01, ** p<0.05, * p<0.1.

*Source*: Authors' calculations.

The lag lengths of the variables in the ARDL model were chosen as (2, 12, 3, 0) based on the AIC criterion. For net availability deviation, 12 lags were used, as interactions during field surveys indicated that the previous year's stock levels played a significant role in determining current price pressure in milk. The ARDL bounds test confirmed the existence of a long-run relationship between CPI milk, net availability deviation, WPI feed-fodder, and the milk dummy (see Table 3.6). The description of the variables is provided in Annexure A3.2.

The estimates for the sample period April 2013 to December 2022 indicate that the log of the deviation of net availability (i.e., the deviation from the 3-year moving average of stocks after fulfilling

**Table 3.6**

*Bounds Test for Cointegration for Milk*

| F statistic | t-statistic |
|---|---|
| 10.09*** | -4.99*** |

*Notes*: ***, **, * denote significance at 1 per cent, 5 per cent, and 10 per cent levels, respectively. The F-statistic tests for the joint significance of the coefficients of the lagged levels in the ARDL-ECM. The t-statistic tests for the significance of the coefficient of the lagged dependent variable. All test statistics are significant at the 1 per cent level.

*Source*: Authors' estimation.

liquid and processed milk demand), the log of the weighted average of WPI feed and fodder, and the milk dummy (which captures unexpected extreme random shocks, including the COVID-19 shock[23]) are significant determinants of CPI milk prices in the long run. The results suggest a statistically significant negative relationship between net availability deviation and CPI milk; a 1 per cent increase in the deviation[24] of net availability can lead to a 0.33 per cent decrease in CPI milk, in line with the economic theory that increased stocks lead to lower prices. The input cost for milk (WPI feed and fodder) shows a positive relationship with CPI milk, where a 1 per cent increase in WPI feed and fodder can increase CPI milk by 0.74 per cent. The milk dummy shows a positive and significant impact, indicating a 0.23 per cent rise in CPI milk during COVID-19 or other extreme random shocks (Table 3.7).

The coefficient of the ECM term is negative and statistically significant, indicating that any disturbance in the long-run equilibrium is corrected by 2 per cent per month. The small size of the ECM term suggests a slow pace of convergence to the long-run equilibrium. Diagnostic tests for the ARDL model are satisfactory. The Breusch-Godfrey test for autocorrelation indicates no serial correlation in the residuals. The stability of the model was examined using the CUSUM test, which shows that the predicted values lie within the 95 per cent confidence interval, suggesting that the model is stable (see Annexure A3.3).

23. The shock period months include May 2021 to June 2021, December 2019 to April 2020, and October 2018 and June 2013.

24. The net availability deviation has been normalised.

**Table 3.7**

*ARDL Estimation Results for Milk*

Dependent variable: Log CPI Milk
ARDL (2, 12, 3, 0)
Sample period: April 2013 – December 2022

| *Variables* | *Coefficient* | *Std. Error* |
|---|---|---|
| **Long Run Equation** | | |
| Log Net availability deviation | -0.332* | 0.185 |
| Log WPI Feed | 0.742*** | 0.121 |
| Milk dummy | 0.233*** | 0.067 |
| **ECM** $\gamma$ | -0.022*** | 0.004 |
| **Short Run Equation** | | |
| Δ Log CPI Milk (-1) | 0.083 | 0.092 |
| Δ Log Net availability deviation | -0.012** | 0.005 |
| Δ Log Net availability deviation (-1) | 0.029*** | 0.005 |
| Δ Log Net availability deviation (-2) | -0.009 | 0.006 |
| Δ Log Net availability deviation (-3) | 0.020*** | 0.005 |
| Δ Log Net availability deviation (-4) | -0.002 | 0.006 |
| Δ Log Net availability deviation (-5) | 0.014*** | 0.005 |
| Δ Log Net availability deviation (-6) | 0.001 | 0.005 |
| Δ Log Net availability deviation (-7) | 0.014** | 0.005 |
| Δ Log Net availability deviation (-8) | 0.002 | 0.005 |
| Δ Log Net availability deviation (-9) | 0.014*** | 0.005 |
| Δ Log Net availability deviation (-10) | -0.004 | 0.004 |
| Δ Log Net availability deviation (-11) | 0.011** | 0.004 |
| Δ Log WPI feed | -0.023 | 0.018 |
| Δ Log WPI feed (-1) | 0.010 | 0.018 |
| Δ Log WPI feed (-2) | -0.021 | 0.018 |
| c_0 | 0.033** | 0.015 |
| Observations | 117 | |
| Adjusted R-squared | 0.50 | |
| Breusch Godfrey Test | 0.501 (0.478) | |
| RMSE | 0.0029 | |
| Log Likelihood | 528.33 | |

*Note*: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The figure in parentheses for the Breusch-Godfrey LM test for autocorrelation ($H_0$: no serial correlation) indicates p-values.

*Source*: Authors' estimation.

### Poultry Meat Model Estimation

Before applying the ARDL model, the stationarity of the variables in the poultry meat equation was checked using the ADF test, which confirmed that the included variables are both I(0) and I(1), making them suitable for ARDL regression (see Table 3.8).

**Table 3.8**

*ADF Test for Poultry Meat*

| *Variable* | *ADF (p-value)* |
|---|---|
| Log CPI_Poultry Meat | -0.071 |
| LogAvailability | -3.31** |
| LogFeedPrice | -1.30 |
| ResDummy | -6.14*** |
| Δ Log CPI_Poultry Meat | -10.85*** |
| ΔLogFeedPrice | -8.53*** |

*Note*: The ADF test statistic is reported. The critical values are the finite sample values suggested by MacKinnon (1991). *** p<0.01, ** p<0.05, * p<0.1.

*Source*: Authors' estimation.

For the estimation of the poultry meat equation, the deviation of total availability from its three-year moving average (LogAvailability) and the feed price index (LogFeedPrice) were used after log transformation and seasonal adjustment. We have used the log of the normalised deviation of total availability from its moving average as an explanatory variable, since net availability is assumed to be 'nil' in the case of poultry meat, as it cannot be stored. The normalised deviation of availability removes any seasonality in the monthly series. An increase in positive deviation from the long-run average of total poultry meat availability results in a fall in poultry prices, while a rise in feed prices leads to an increase in poultry meat prices. We used a ResDummy to capture random external shocks[25] and considered Shravan (Shravan_Dummy) and flu (Flu_Dummy) dummies as exogenous variables affecting CPI poultry meat. The sample period covers April 2012 to December 2022.

25. In poultry meat, there were four external shocks during March, April, and May 2020, as well as July 2021.

**Table 3.9**

*Bounds Tests for Cointegration for Poultry Meat*

| *F statistic* | *t-statistic* |
|---|---|
| 3.78* | -2.05* |

*Notes*: ***, **, * denotes significance at 1 per cent, 5 per cent and 10 per cent, respectively. The F-statistic is used to test for the joint significance of the coefficients of the lagged levels in ARDL. The t-statistic is used to test for the significance of the coefficient of the lagged dependent variable. All test statistics are significant at the 10 per cent level of significance.

*Source*: Author's estimation.

The ARDL bounds test shows a long-run relationship between CPI poultry meat and availability, feed price, and residual dummy. The lag lengths of the variables in the model are ARDL (5, 6, 4, 0), chosen using the AIC method (Table 3.9).

The results of the ECM equation indicate that the log of the deviation of total availability has a negative and significant relationship with CPI poultry inflation in the long run. Specifically, a 1 per cent increase in the deviation of total availability can lead to a 0.047 per cent decrease in CPI poultry meat prices. The results also suggest a significant and positive long-term relationship between CPI poultry meat and the log of feed prices: a 1 per cent increase in feed price leads to a 1.15 per cent increase in CPI poultry meat prices.

The coefficient of the ECM term is statistically significant and negative, indicating that, in the case of any deviation from the long-run equilibrium due to a shock, the system converges back to equilibrium, with 6 per cent of the disequilibrium corrected within a month (Table 3.10).

**Table 3.10**

*ARDL Estimation Results for Poultry Meat*

| Dependent variable: Log CPI Poultry Meat | | |
|---|---|---|
| Model ARDL (5,6,4,0) | | |
| Sample Period: April 2012 – December 2022 | | |
| *Variable* | *Coefficient* | *Std. Error* |
| **Long run Equation** | | |
| Log Availability | -0.047*** | 0.013 |

*Contd...*

*.Contd...*

| | | |
|---|---|---|
| Log Feed price | 1.152*** | 0.192 |
| Residual dummy | 0.362* | 0.217 |
| **ECM** $\gamma$ | -0.059** | 0.029 |
| **Short run Equation** | | |
| Δ Log CPI Poultry meat (-1) | 0.059 | 0.098 |
| Δ Log CPI Poultry meat (-2) | -0.434*** | 0.093 |
| Δ Log CPI Poultry meat (-3) | -0.079 | 0.091 |
| Δ Log CPI Poultry meat (-4) | -0.230** | 0.093 |
| Δ Log Availability | 0.0008 | 0.0011 |
| Δ Log Availability (-1) | 0.0014 | 0.0010 |
| Δ Log Availability (-2) | -0.0001 | 0.0009 |
| Δ Log Availability (-3) | -0.0006 | 0.0009 |
| Δ Log Availability (-4) | -0.0021** | 0.0009 |
| Δ Log Availability (-5) | -0.0003 | 0.0008 |
| Δ Log Feed price | -0.013 | 0.045 |
| Δ Log Feed price (-1) | 0.007 | 0.044 |
| Δ Log Feed price (-2) | 0.052 | 0.041 |
| Δ Log Feed price (-3) | 0.056 | 0.039 |
| Shravan dummy | -0.009 | 0.006 |
| Flu dummy | -0.007 | 0.006 |
| $c_0$ | 0.075 | 0.053 |
| Observations | 123 | |
| Adjusted R-squared | 0.298 | |
| Breusch Godfrey Test | 1.68 (0.193) | |
| RMSE | 0.019 | |
| Log Likelihood | 322.00 | |

*Note*: *** p<0.01, ** p<0.05, * p<0.10. Figures in parentheses for the Breusch-Godfrey LM test for autocorrelation ($H_0$: no serial correlation) indicate p-values.

*Source*: Authors' estimation.

The diagnostic tests for the ARDL model indicate satisfactory results. The Breusch-Godfrey test shows no serial autocorrelation. The poultry meat model is[26] stable as indicated by the CUSUM test (Annexure A3.3).

26. [No information provided for this footnote]

## Egg Model Estimation

In the case of eggs, the ADF test indicates that the included variables are I(0) and I(1), suggesting that the ARDL model can be used to estimate the factors impacting CPI egg prices.

For estimating the factors impacting egg inflation, the sample period covers March 2010 to December 2022. The variable of interest is the normalised deviation of availability-to-usage ratio from its three-year moving average (which partly addresses seasonality) as a proxy for the stock variable (Log Availability Usage Deviation). Other variables include real agricultural wages (Log Real Wages) and the weighted average of the soya bean and maize WPI, based on their composition in poultry feed (Log Soya Maize WPI Index), to measure input costs. These variables have been log-transformed and seasonally adjusted for estimation purposes. The model also includes a COVID dummy to capture the pandemic's impact on the poultry sector and a Residual Dummy to control for outliers and extreme events in the regression model.[27]

**Table 3.11**

*ADF Test Results for Egg*

| *Variables* | *ADF (p-value)* |
|---|---|
| Log CPI Egg | -0.71 |
| Log WPI Soya Maize | -0.75 |
| Log_Availability Usage Deviation | -12.59*** |
| Log Real Wages | -2.53 |
| COVID Dummy | -3.28 *** |
| Residual Dummy | -12.97**** |
| ΔLog CPI Egg | -10.06*** |
| ΔLog WPI Soya Maize | -9.10*** |
| Δ Log Real Wages | -13.24*** |

*Note*: *** p<0.01, ** p<0.05, * p<0.10.

*Source*: Authors' calculations.

27. In eggs, there were 12 external shocks during May 2010, September 2012, November 2012, December 2012, February 2013, June 2015, November 2017, July 2020, September 2020, April 2021, May 2021, and November 2022.

The ARDL bounds test confirms the existence of a long-run cointegrating relationship between CPI egg, availability-to-usage ratio, soya and maize WPI, COVID-19, and the Residual Dummy (Table 3.12). The optimal lag lengths for the egg model are ARDL (2, 2, 2, 0, 1), based on the AIC criterion.

**Table 3.12**

*Bounds Tests for Cointegration for Egg*

| F-statistic | t-statistic |
|---|---|
| 3.66* | -3.66* |

*Notes*: ***, **, * denote significance at 1 per cent, 5 per cent, and 10 per cent levels, respectively. The F-statistic tests the joint significance of the coefficients of the lagged levels in ARDL. The t-statistic tests the significance of the coefficient of the lagged dependent variable. All test statistics are significant at the 10 per cent level.

*Source*: Authors' calculations.

The estimates of long-run coefficients from the ARDL specification and the short-run dynamics are presented in Table 3.13. The results show that the availability-to-usage deviation (stock variable), real agricultural wages, and the soya and maize WPI index are significant determinants of CPI egg prices. The long-run estimates indicate a negative relationship between our stock variable and CPI egg prices, meaning that a 1 per cent increase in the deviation in the availability-to-usage ratio leads to a 0.02 per cent decrease in CPI egg prices. On the other hand, the soya and maize price index, a proxy for feed costs, is positively related to CPI egg prices; a 1 per cent increase in feed prices leads to a 0.61 per cent increase in CPI egg prices. Similarly, real agricultural wages show a positive relationship with CPI egg prices, with a 1 per cent increase in real wages (input costs) raising egg prices by 0.36 per cent. The coefficient of the ECM term is negative and statistically significant, indicating convergence, and suggests that 7 per cent of the disequilibrium (deviation from equilibrium) is corrected within a month.

The diagnostic tests for the ARDL model are satisfactory, with no indication of serial correlation in the estimated residuals. Moreover, the CUSUM test suggests that the estimated egg model is stable (Annexure A3.3).

**Table 3.13**

*ARDL Estimation Results for Egg*

| Dependent Variable: Log CPI Egg | | |
|---|---|---|
| ARDL (2, 2, 2, 0, 1) | | |
| Sample Period: March 2010 – December 2022 | | |
| *Variables* | *Coefficient* | *Std. Error* |
| **Long run Equation** | | |
| Log Availability Usage Deviation | -0.022* | 0.012 |
| Log WPI Soya Maize | 0.609*** | 0.135 |
| Log Real Wages | 0.359*** | 0.121 |
| COVID dummy | 0.128 | 0.099 |
| **ECM** $\gamma$ | -0.067*** | 0.018 |
| **Short run Equation** | | |
| Δ Log CPI Egg (-1) | 0.168** | 0.071 |
| Δ Log Availability Usage Deviation | 0.002*** | 0.001 |
| Δ Log Availability Usage Deviation (-1) | 0.001** | 0.000 |
| Δ Log WPI Soya Maize | -0.030 | 0.046 |
| Δ Log WPI Soya Maize (-1) | 0.069 | 0.046 |
| Δ COVID dummy | -0.043*** | 0.011 |
| Residual dummy | 0.026*** | 0.005 |
| $c_0$ | 0.004 | 0.030 |
| Observations | 154 | |
| Adjusted R-squared | 0.293 | |
| Breusch Godfrey Test | 1.222 [0.269] | |
| RMSE | 0.014 | |
| Log Likelihood | 437.33 | |

*Note*: *** p<0.01, ** p<0.05, * p<0.10. The figure in parentheses for the Breusch-Godfrey LM test for autocorrelation ($H_0$: no serial correlation) indicates p-values.

*Source*: Authors' calculations.

### *3.7.1 Inflation Forecasts for Milk, Eggs, and Chicken*

In this paper, we forecast the inflation for milk, poultry meat, and eggs over a 12-month horizon using time series-based univariate and multivariate models, following established literature and incorporating the balance sheet variables found to be significant in the ARDL model. Understanding the dynamics and trends in livestock

**Table 3.14**

*Forecasting Performance of Various Models for Milk, Poultry Meat and Egg (RMSE in per cent) over Different Horizons*

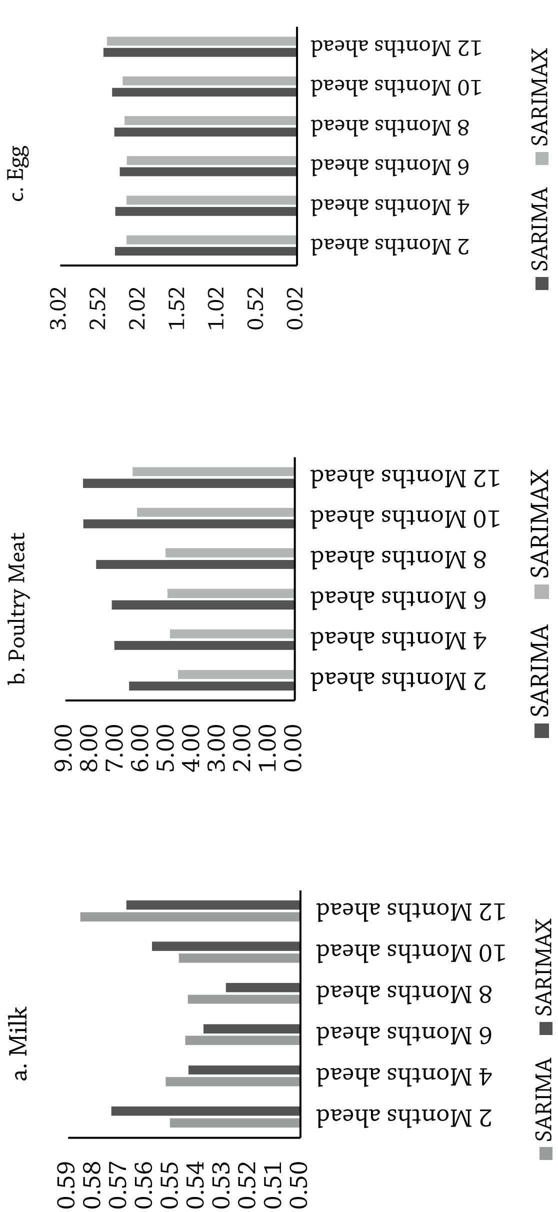
| *Month Ahead* | *Full Sample Forecasts* | | | | | | *Out of Sample Forecasts* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *2* | *4* | *6* | *8* | *10* | *12* | *2* | *4* | *6* | *8* | *10* | *12* |
| Milk | | | | | | | | | | | | |
| SARIMA | 0.53 | 0.59 | 0.74 | 0.95 | 1.26 | 1.62 | 0.43 | 1.45 | 2.27 | 3.02 | 3.91 | 4.82 |
| SARIMAX | 0.38 | 0.38 | 0.39 | 0.44 | 0.54 | 0.67 | 0.30 | 0.36 | 0.57 | 0.89 | 1.37 | 1.76 |
| Poultry Meat | | | | | | | | | | | | |
| SARIMA | 2.77 | 3.20 | 3.61 | 3.61 | 3.59 | 3.56 | 2.18 | 8.74 | 10.26 | 9.11 | 8.17 | 7.45 |
| SARIMAX | 2.73 | 3.20 | 2.62 | 2.74 | 3.62 | 3.61 | 2.34 | 9.02 | 10.75 | 9.46 | 8.50 | 7.81 |
| Egg | | | | | | | | | | | | |
| SARIMA | 2.32 | 2.33 | 2.41 | 2.42 | 2.41 | 2.52 | 0.92 | 2.34 | 3.79 | 3.65 | 3.36 | 4.11 |
| SARIMAX | 2.06 | 2.05 | 2.08 | 2.07 | 2.09 | 2.17 | 1.23 | 1.43 | 2.27 | 2.18 | 2.34 | 3.12 |

*Note*: The highlighted cell in each column in the table indicates the best performing individual model for the relevant forecast horizon. Lower RMSEs imply better forecast.

*Source*: Author’s estimation.

**Figure 3.27**

*Rolling Window (60 months) Forecast Comparison for Milk, Poultry Meat, and Egg based on RMSE (in per cent)*




*Source:* Authors' estimation.

inflation is crucial for economic policy due to its significant impact on overall food inflation. Livestock-related products contribute to food prices, and fluctuations in their inflation have cascading effects on consumers and their purchasing power.

While structural models like ARDL capture price dynamics well, they often underperform in forecasting, as observed in this study. We generated out-of-sample forecasts and evaluated them against actual inflation figures.

The RMSE of each forecasting model was evaluated for the 'full sample' and for 'out-of-sample' forecasts. For the 'full sample' forecast evaluation, RMSEs were computed for 2-, 4-, 6-, 8-, 10-, and 12-month horizons, starting from April 2012 for milk and poultry meat, and January 2010 for eggs, up to December 2022. For 'out-of-sample' forecasts, we computed RMSEs for the same horizons from January 2022 to December 2022 for all three commodities. The summary of results is presented in Table 3.14.

For milk, the SARIMAX model consistently shows lower errors (better forecasts) compared to the SARIMA model across all forecast horizons, for both 'full sample' and 'out-of-sample' evaluations. The exogenous variables used in SARIMAX forecasting for milk include net availability[28] and WPI feed and fodder[29]. For poultry meat, SARIMAX outperforms SARIMA in the 'full sample' across all horizons except the 10- and 12-month horizons. However, for 'out-of-sample' forecasts, the SARIMA model performs better across all horizons (Annexure A3.4). The exogenous variable used in SARIMAX forecasting includes availability[30] from the poultry balance sheet.

In the case of eggs, the SARIMAX model consistently outperforms the SARIMA model across all horizons for the 'full sample,' except for the 2-month horizon in the 'out-of-sample' forecast evaluation. The

28. Log of deviation of net availability.
29. Log of the Weighted Average of the WPI Feed and Fodder Index.
30. Log of Normalised Deviation of Availability from a 3-year Moving Average.

exogenous variables used in SARIMAX forecasting for eggs include the availability-to-usage ratio[31] and global soya and maize prices[32].

The Diebold and Mariano (DM) test for forecast accuracy suggests that SARIMAX performs better than SARIMA for the full sample (Annexure A3.5). The results support the premise that balance sheet variables (net availability, deviation of AVU ratio, or deviation of total marketed surplus), along with other macroeconomic variables (found through ARDL regression), can improve the forecast of inflation in milk and eggs both in-sample and out-of-sample, and in-sample for poultry meat.

We assessed the forecasting performance of SARIMAX over SARIMA using a rolling window of 60 months for the full sample period (from January 2010 to December 2022 for eggs, and April 2012 to December 2022 for milk and poultry meat) compared to actual CPI inflation for these commodities. The exogenous variables in SARIMAX vary across the three livestock commodities and were found to be significant in explaining CPI movement through the ARDL modelling approach. Sample forecasts were generated using a rolling window size of 60 months, and SARIMAX was found to be the best-performing model for eggs and poultry meat across all horizons, and for milk, except for 2- and 10-month ahead forecasts (Figure 3.27).

## 3.8 Conclusion and Policy Recommendations for Livestock

The post-COVID period saw a surge in inflation alongside increased volatility in animal protein-rich items, particularly milk, poultry meat, and eggs. This paper estimates the factors driving inflation in these commodities using structural models and incorporates key structural variables to improve inflation forecasting for up to 12 months. The study developed a dynamic monthly balance sheet to assess the real-time (monthly) demand-supply gap for

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31. 30 In egg forecasting, we used the Log of Availability Usage Ratio rather than the transformed variable (Log Availability Usage Deviation) to improve forecasting performance.
32. Similarly, the Log WPI Soya Maize was insignificant in forecasting. Therefore, we used Log Global Soya Maize Prices (weighted averages of soybean and maize world prices from the World Bank Pink Sheets) as a proxy for feed costs.

each commodity, which was then used for inflation modelling and forecasting.

Net availability for milk, availability for poultry meat, and the AVU ratio for eggs were computed using secondary data and market intelligence from key stakeholders, including farmers, traders, and processors. The ARDL models for each commodity found that, along with the balance sheet variables, supply-side factors such as WPI soybean and maize prices (as proxies for poultry feed or input costs) and WPI feed and fodder (input costs for milk) significantly impact inflation in milk, poultry meat, and eggs.

From a policy perspective, accurate forecasting of livestock inflation is important, as food inflation significantly drives headline inflation in India. This paper forecasts inflation in milk, poultry meat, and eggs over a 12-month horizon using time-series-based univariate and multivariate models, while incorporating balance sheet variables (availability/availability-to-usage ratio) and input cost variables found to be significant in the ARDL model. The forecasting performances of SARIMA and SARIMAX models were empirically evaluated for both out-of-sample forecasts and rolling forecasts. The findings showed that SARIMAX (which incorporates the balance sheet availability/availability-to-usage variable) performs better across most time horizons. Based on the research findings, the study proposes a range of policy measures to enhance the efficiency of the dairy and poultry value chains to stabilise inflation in the livestock sector, while promoting the sector's growth in the medium to long term.

### Policy Suggestions for Milk

The operational efficiency of the milk industry could be improved by creating a more efficient value chain, implementing dynamic milk procurement methods, strengthening the cooperative/organised sector, establishing a feed bank, increasing fodder productivity, implementing an integrated animal health plan, and rationalising trade policy measures.

### *Rationalising Trade Policy*

Rationalising the import policy regime through timely calibration of tariffs and duties is a short-term measure to stabilise inflation in milk. The import duty on SMP (skimmed milk powder) could be reduced from the current level of 60 per cent, and on butter from 40 per cent, to help reduce price pressures on milk at the retail level by augmenting milk supply during the lean season. However, these reductions should be carefully calibrated so as not to harm domestic dairy farmers' price realisation.

As a short-term measure, if necessary, the National Dairy Development Board (NDDB) and major cooperatives could be allowed to import milk fat and SMP to build a reasonable buffer stock for the lean season. SMP and butter could also be brought under an Open General License (OGL) scheme, with imports released in a calibrated manner to meet demand, without significantly affecting procurement prices paid to dairy farmers.

Imports of cattle/buffalo germplasm are currently restricted in India. However, the introduction of temperate breeds for crossbreeding with indigenous non-descript cattle has been accepted, given the strong demand for exotic germplasm. In the medium to long term, imports may be allowed to increase the availability of exotic breed semen across larger areas, helping to increase overall milk productivity.

### *Building an Efficient Value Chain*

To increase the efficiency of the value chain, the establishment of more Bulk Milk Chilling (BMC) centres across states should be prioritised to boost procurement. This will require investments in upgrading or building new dairy plants and small processing units within the cooperative sector to process milk into various forms for storage. Improved infrastructure for storing processed milk can promote the export competitiveness of the dairy industry and help tackle the challenge of low processing levels in the organised sector. Aligning SMP and butter prices in India with international (Oceania) prices would further strengthen this effort.

Technological advancements, such as the fabrication of insulated (non-refrigerated) rail containers for transporting milk and the installation of milk dispensing machines, would also strengthen milk distribution on a larger scale.

#### *Integrated Animal Health Plan for Increasing Productivity and Production*

To increase milch productivity, investments in artificial insemination for exotic and crossbreed cows/buffalo could be promoted. The private sector may also be encouraged to set up modern testing facilities in various regions to ensure quality control and augment stable supplies. Urgent action is needed to control frequent outbreaks of foot-and-mouth disease and lumpy skin disease through the establishment of rapid-response medical action boards.

#### *Feed Bank and Fodder Productivity*

A feed bank could be established by procuring feed on a large scale and building infrastructure for storing feed and fodder from various crops. This feed could be resold at affordable rates to help control feed and fodder inflation. Given the large shortages in green, dry fodder and roughages, appropriate steps should be taken to augment efficient supplies, as fodder is a major source of cattle feed. The area under forage crops has decreased in recent years due to a shift towards cash crops. Barren lands could be utilised for growing grasses that require less water and care, while genetically modified seed for forage crops could be introduced to increase productivity. Agricultural extension services and investment in promoting forage crops are essential.

### Policy Suggestions for Poultry

#### *Removing Trade Policy Distortions*

India has significant potential for poultry product exports; however, the country needs a freight advantage to compete with major exporters like Brazil and the USA. The basic customs duty on the import of cuts and offal in the frozen category is 100 per cent, while the duty on frozen cut pieces is 30 per cent. To meet seasonal demand and curb meat inflation in the short term, reducing the duty on cut pieces could promote competition and improve efficiency without affecting farmers' remuneration.

### *Infrastructural Development and Cold Chain Facilities*

Inadequate infrastructure, including processing and cold chain facilities that do not meet international quality standards, is impeding poultry sector exports. Hence, incentivising Foreign Direct Investment (FDI) or public-private partnerships (PPPs) in the poultry value chain to upgrade infrastructure, adopt better technology, and improve farm management practices could significantly boost the sector. Despite substantial private sector involvement, concerns about food safety standards remain, and these must be addressed.

### *Lowering Production Costs*

Feed costs constitute the major expense in poultry production, with maize and soybean accounting for 95 per cent of total feed costs. Thus, their prices directly influence production costs. Policy measures should focus on increasing the productivity of maize and soybean and making quality feed available at affordable prices.

### *Building Institutions for Incorporating Poor Producers*

Commercial poultry farming is a sustainable option for income generation for many rural producers. Therefore, collectivisation of smallholders could be encouraged. A poultry farming model similar to the Amul dairy model could help small farmers market their products across India. While subsidies in the form of institutional support exist for commercial poultry, small farmers often lack access to such support. Public investment in institutional development could help reduce transaction costs for small farmers while facilitating access to quality inputs and markets, enabling them to receive fair and remunerative prices for their produce.

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## 3.10 Annexure

**Table A3.1**

*Annual Production and Projected Consumption of Poultry Meat and Egg*

| Year | Poultry Meat | | | | Egg | | |
|---|---|---|---|---|---|---|---|
| | Production of Meat (BAHS) (MMT) | Consumption of Meat (NSS) (MMT) | Production of Meat (OECD) (MMT) | Consumption of Meat OECD (MMT) | Production of Egg BAHS (Billion) | Consumption NSS (Billion) | Consumption as a share of Production (per cent) |
| 2010-11 | 2.19 | 2.92 | 2.23 | 2.22 | 63.00 | 31.55 | 50.08 |
| 2011-12 | 2.48 | 2.88 | 2.52 | 2.51 | 66.45 | 33.94 | 51.07 |
| 2012-13 | 2.68 | 3.08 | 2.71 | 2.71 | 69.73 | 35.17 | 50.43 |
| 2013-14 | 2.23 | 3.25 | 2.88 | 2.87 | 74.75 | 36.74 | 49.15 |
| 2014-15 | 2.86 | 3.49 | 3.07 | 3.06 | 78.48 | 38.75 | 49.37 |
| 2015-16 | 3.26 | 3.74 | 3.3 | 3.29 | 82.93 | 40.97 | 49.41 |
| 2016-17 | 3.5 | 4.02 | 3.48 | 3.48 | 88.13 | 43.36 | 49.20 |
| 2017-18 | 3.82 | 4.25 | 3.81 | 3.8 | 95.20 | 45.46 | 47.75 |
| 2018-19 | 4.06 | 4.49 | 4.1 | 4.10 | 103.30 | 47.59 | 46.07 |
| 2019-20 | 3.8 | 4.62 | 4.22 | 4.22 | 114.38 | 49.36 | 43.15 |
| 2020-21 | 3.78 | 4.29 | 3.6 | 3.59 | 122.05 | 46.50 | 38.10 |

*Sources*: BAHS, GoI, NSSO (various years) and OECD-FAO Agricultural Outlook 2022-31.

**Table A3.2**

*Description of the Variables and Sources of Data for the Regression Analysis*

| Variables | Description | Sources |
|---|---|---|
| | *Milk* | |
| Log_CPI_Milk | Log of seasonally adjusted CPI index for milk | NSO, MOSPI |
| LogWPI Feed | Log of seasonalized weighted average of prepared animal feed (part of manufactured products) and fodder (part of primary articles) wholesale price index (WPI) in the ratio of their weights in WPI | Office of the Economic Adviser, GoI |
| Log Net availability Deviation | Log of seasonally adjusted deviation of normalized net availability from its three years moving average | Computed using milk balance sheet |
| Milk_Dummy | Takes the value for outlier or extreme events in Milk ARDL regression model as 1 and 0 otherwise | Regression model |

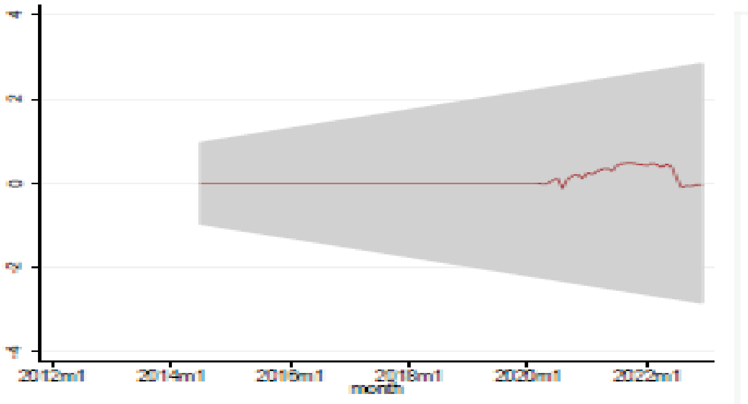
| | | |
|---|---|---|
| | *Poultry Meat* | |
| LogCPI_Poultry Meat | Log of seasonally adjusted CPI index for poultry meat | NSO, MOSPI |
| Log Availability | From the balance sheet, we have calculated the marketed surplus or the total availability and then 3 year moving average is calculated for the availability and the deviation for each month from this long run average | Computed using poultry meat balance sheet |
| Log Feed Price | It is a proxy for feed price index which is Log of seasonalized weighted average of soyabean and maize WPI in the ratio of 40: 60 | Office of the Economic Adviser, GoI |
| Shravan_ Dummy | We have created the variable by taking the value 1 for the Shravan months and 0 otherwise | Market intelligence |
| Flu_Dummy | We have created the variable by taking the value 1 for the months when there was outbreak of avian flu and 0 otherwise | Market intelligence |
| ResDummy | It is a dummy to capture outliers or extreme events in poultry meat | Regression model |
| | *Egg* | |
| Log CPI Egg | Log of seasonally adjusted CPI index for egg | NSO, MOSPI |
| LogSoya_Maize WPI | Log of seasonalized weighted average of soyabean and maize WPI in the ratio of 40: 60 | Office of the Economic Adviser, GoI |
| Log Availability Usage Deviation | Log of normalized deviation of availability to usage ratio from its three years moving average | Computed using egg balance sheet |
| Log Real Wages | Log of seasonally adjusted average daily wage rates (in Rs.) for rural men in agricultural activities deflated using CPI Agricultural Labour Labour Bureau, GoI | |
| Residual Dummy | Takes the value 1 for outlier or extreme events in egg ARDL regression model and 0 otherwise | Regression model |
| Covid Dummy | Dummy takes the value 1 for months which were affected due to COVID-19 in the first wave (February to September 2020) and 0 for other months | Media articles |

*Source*: Authors' estimation.

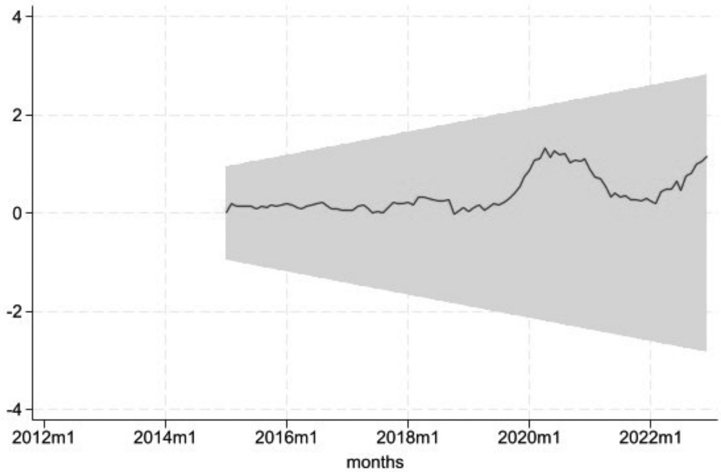
**Table A3.3**

*CUSUM test for Milk, Poultry Meat and Egg*

a. Milk




b. Poultry Meat



c. Egg

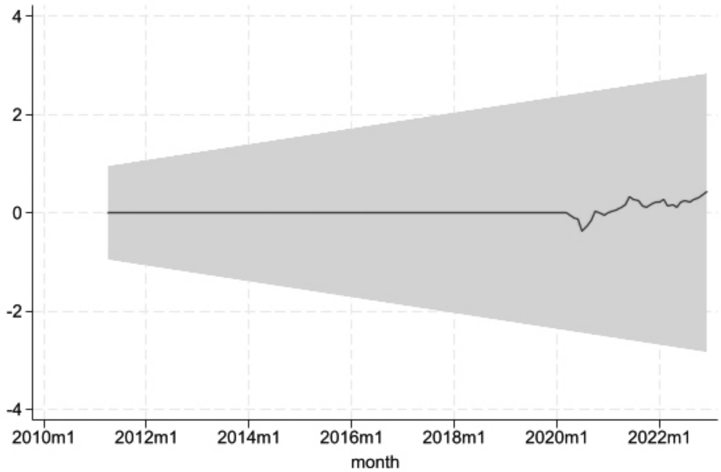

4
2
0
-2
-4
2010m1
2012m1
2014m1
2016m1
2018m1
2020m1
2022m1
month

**Table A3.4**

*SARIMAX Model Estimates*

*Milk SARIMAX Estimation (Dependent Variable: First Difference of Log Seasonally adjusted CPI Milk)*

| *D.log of CPI milk* | *Coef.* | *Std. Err.* | *p-value* |
|---|---|---|---|
| D log of net availability deviation | -.011 | .002 | 0 |
| L10D log of WPI feed and fodder | .058 | .02 | .003 |
| Constant | .004 | 0 | 0 |
| L AR | -.835 | .368 | .023 |
| L MA | .762 | .404 | .059 |
| Sigma | .004 | 0 | 0 |
| Mean dependent var | 0.004 | SD dependent var | 0.004 |
| Number of observations | 106 | Chi-square | 55.943 |
| Prob > chi2 | 0.000 | Akaike crit. (AIC) | -867.260 |

*Note*: D: Difference, L: Lag, LD: Lagged Difference

*Source*: Author's Estimation.

*Poultry Meat SARIMAX Estimation (Dependent Variable: First Difference of Log CPI Meat)*

| *D.log of CPI Meat* | *Coef.* | *Std. Err.* | *P value* |
|---|---|---|---|
| Log deviation of availability from 3year moving average | -0.002 | 0.006 | 0.002 |
| Constant | 0.06 | 0.02 | 0.003 |
| ARMA | | | |
| L1. AR | 0.85 | 0.04 | 0.00 |
| Sigma | 0.03 | 0.001 | 0.00 |
| Number of observations | 117 | | |
| Log likelihood | 338.65 | | |
| Prob > chi2 | 0.0000 | | |

*Note*: D: Difference, L: Lag, LD: Lagged Difference

*Source*: Author's Estimation.

*Egg SARIMAX Estimation (Dependent Variable: First Difference of Log CPI Egg)*

| *D.log of CPI Egg* | *Coef.* | *Std. Err.* | *P value* |
|---|---|---|---|
| D1. Log_Availabilty Usage ratio | -2.49 | 0.52 | 0.00 |
| D1. Log_Global Soya Maize Prices | 0.08 | 0.03 | 0.02 |
| Constant | 0.00 | 0.00 | 0.11 |
| ARMA | | | |
| L1. AR | 0.23 | 0.09 | 0.01 |
| ARMA12 | | | |
| L1. AR | 0.29 | 0.10 | 0.00 |
| Sigma | 0.02 | 0.00 | 0.00 |
| Number of observations | 156 | | |
| Log likelihood | 378.51 | | |
| Prob > chi2 | 0.0000 | | |

*Note*: D: Difference, L: Lag, LD: Lagged Difference.

*Source*: Author's Estimation.

**Table A3.5**

*DM Test Results*

| *Commodity* | *DM-Statistic* | *P- Value* | *SARIMA MSE* | *SARIMAX MSE* | *Remarks* |
|---|---|---|---|---|---|
| Milk | -2.243 | 0.02 | 0.0000285 | .0000146 | SARIMAX is better forecast |
| Meat | -.985 | 0.03 | .00133 | .00130 | SARIMAX is better forecast |
| Egg | -1.89 | 0.05 | .0013 | .0010 | SARIMAX is better forecast |

*Source*: Author's Estimation.

# 4

SHYMA JOSE, RAYA DAS, MANISH KUMAR PRASAD,
RANJANA ROY, SANCHIT GUPTA and ASHOK GULATI

# Understanding Cereal Inflation in India

*A Study of Rice and Wheat*

## 4.1 Introduction

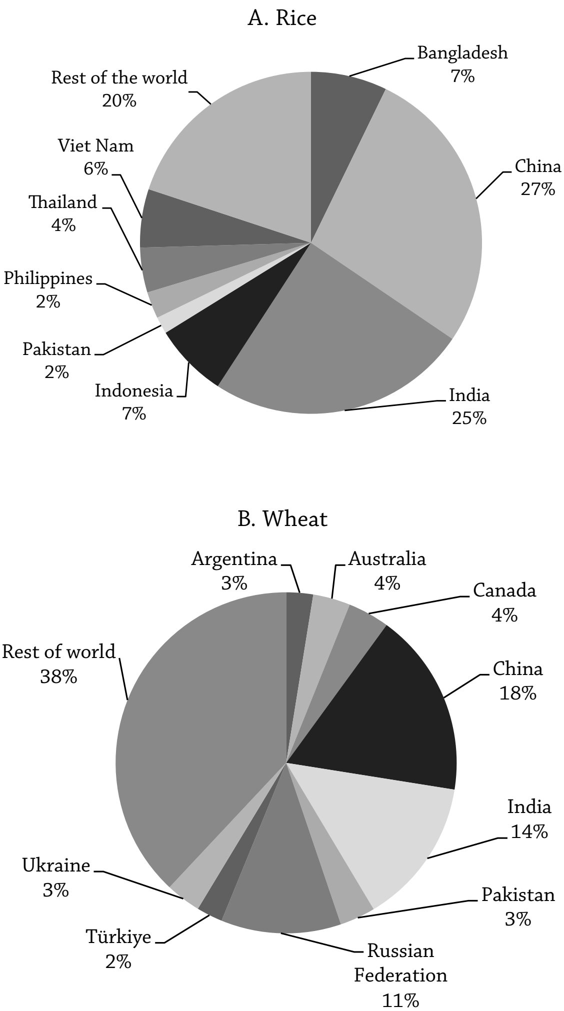
Cereals, particularly rice and wheat, are major staples in India, making them a key concern for the Government of India (GoI) in ensuring food security. Since independence, the government's strategy to ensure food security has been built on two foundational pillars: enhancing the availability of rice and wheat, and leveraging Green Revolution technologies. In the early post-independence years, India was on the verge of a massive famine, with two consecutive droughts in 1965-66 and 1966-67 causing declining food grain production. India had to rely on food imports, notably under the PL 480 agreement with the United States. Strategic interventions, including the adoption of Green Revolution technologies, played a pivotal role in bolstering India's food grain production. Today, the country's food grain production stands at 329.7 million tonnes during the 2022-23 crop year, according to the Department of Agriculture, Cooperation and Farmers Welfare.

Between 1951 and 2022, the per capita availability of food grains increased from 144 kg per annum to 187.8 kg per annum, while cereals increased from 122 kg per person to 168.2 kg over the same period. Increasing productivity in rice and wheat, surpassing the rate of population growth, is attributed to rising per capita availability of food grains and decreasing food grain prices in real terms.

Today, India is the world's second-largest producer of rice and wheat, according to the FAO (2023). Out of the global cereal production of 3.0 billion tonnes in TE 2022, India accounted for a significant 11.5 per cent share.

**Figure 4.1**

*Global Production of Rice and Wheat in TE 2022*




*Source*: FAOSTAT 2023

In the wheat sector, India's production reached 109 million tonnes (MMT), representing 13.9 per cent of the world's total wheat output in TE 2022. This places India behind China, which produced 136 MMT and contributed 18 per cent to the global share in TE 2022. In rice production, India constituted 25 per cent of the global share, trailing slightly behind China's 27 per cent contribution (Figure 4.1).

Given the significance of cereals in the consumption basket, any inflationary trends in cereals could have significant repercussions for the country's food security. Hence, it becomes imperative to understand their market dynamics and the factors contributing to their inflation. This study aims to contribute to the literature on cereal inflation in India, specifically for wheat and rice, by identifying factors that affect prices, comprehending the players in the cereal value chain, and decoding how their behaviour influences market supply and demand.

## 4.2 Stylised Facts about Cereal Inflation: A Timeline

In this section, we analyse the price trends of cereals, specifically focusing on the year-on-year (Y-o-Y) CPI inflation rates for rice and wheat over the past decade. Cereals and products, accounting for 20 commodities, weigh about 9.67 in the CPI basket (12.35 in rural areas and 6.69 in urban areas). Within cereals, rice-other sources and wheat-other sources weigh 4.37 and 2.56, respectively, in the CPI basket. On the other hand, rice-PDS and wheat-PDS weigh about 0.37 and 0.17, respectively. Given that prices of rice and wheat distributed through the PDS are subsidised and monitored by the government, inflation in these commodities is not a major concern for policymakers.[33] This study will therefore concentrate on factors impacting CPI inflation in rice and wheat from other sources and forecast their price movements.

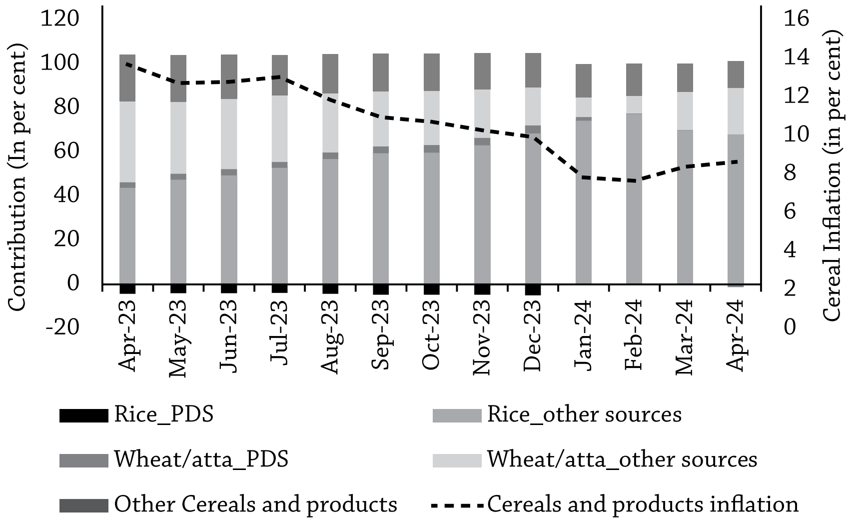
The cereal and product inflation between January 2014 and April 2024 averaged about 4.7 per cent, peaking at 16.7 per cent in February 2023. Since then, inflation has declined to 8.63 per cent

33. The provision of free food grains under the Pradhan Mantri Garib Kalyan Anna Yojana (PMGKAY) for five years with effect from 1st January 2024.

in April 2024. Figure 4.2 depicts the contribution of various cereal products to total cereal inflation over the last year. In April 2024, rice (68 per cent) and wheat (21 per cent) together accounted for 89 per cent of total cereal inflation.

**Figure 4.2**

*Contribution in Cereal and Products Inflation (per cent)*



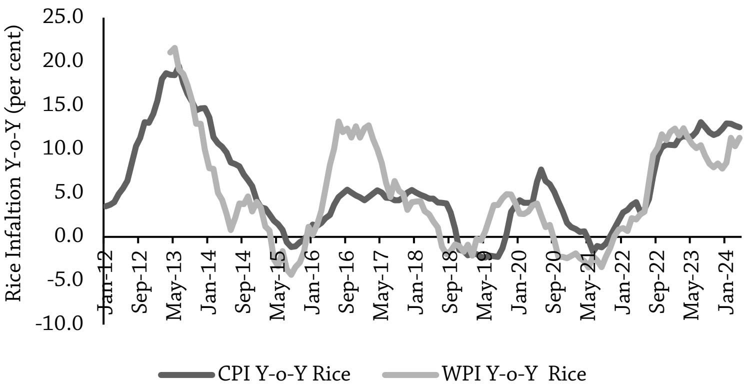

*Source*: MOSPI.

Within cereals, rice inflation, measured by the Wholesale Price Index (WPI) and the CPI, has exhibited significant volatility throughout the period. There is a strong correlation of 0.8 between WPI and CPI inflation rates for rice. Between January 2012 and December 2013, average inflation in rice stood at approximately 12.5 per cent. Domestic rice prices increased during this period, driven by substantial hikes in the Minimum Support Price (MSP) for paddy. This was exacerbated by tight domestic supplies due to robust government procurement and exports (Mishra and Roy 2016). MSP adjustments should be dynamic—lower during high-inflation periods to curtail excessive procurement, and higher during low-inflation periods to incentivise procurement and bolster stocks (Basu 2010). The absence of such revisions, coupled with an oversight in adjusting for inflationary pressures, emerged as a key factor exacerbating cereal inflation. These price hikes have been steeper during high-inflation years, sustaining procurement levels further (Mishra and Roy 2016).

Rice inflation significantly decreased to 3.0 per cent between January 2014 and December 2021. This was because, from August 2013 onwards, domestic prices began to soften due to a decline in export demand (Singh 2014). Interestingly, there has been an uptick in rice inflation, which rose to 9.4 per cent from January 2022 to April 2024. The recent surge in rice inflation is due to weather vagaries and erratic monsoons over the last two years (Figure 4.3).

**Figure 4.3**

*Movement of WPI & CPI Y-o-Y Inflation in Rice in the Last Decade*

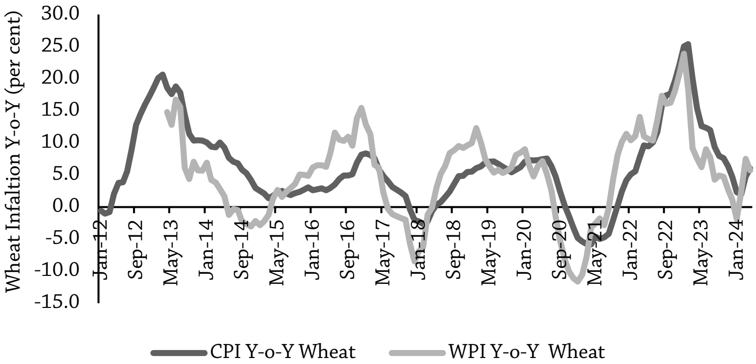



*Source*: NSO, MOSPI; OEA, GoI.

In the case of wheat, the co-movement between CPI and WPI is strong, with a correlation of 0.75 over the last decade. Similar to rice, wheat Y-o-Y inflation follows a similar peaking and low-inflation period. Wheat CPI inflation averaged around 11.3 per cent between January 2012 and December 2013, decreasing to 3.3 per cent between January 2014 and December 2021. However, there was a significant increase in wheat inflation, reaching 11.6 per cent between January 2022 and April 2024, due to heat wave-induced production decline, the Russia-Ukraine war, and high wheat exports (Figure 4.4).

**Figure 4.4**

*Movement of WPI & CPI Y-o-Y Inflation in Wheat in the Last Decade*

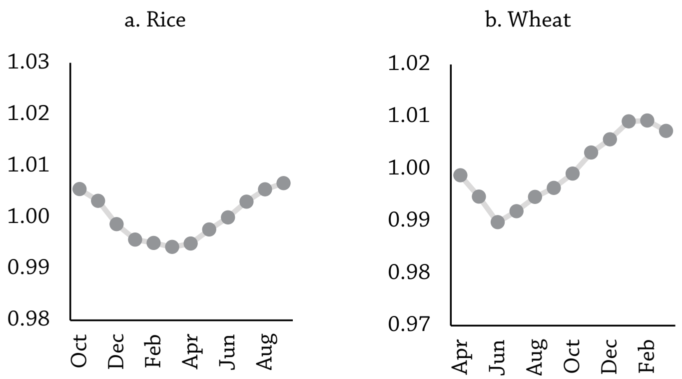



*Source*: NSO, MOSPI; OEA, GoI.

An analysis of seasonality factors, computed using the U.S. Census Bureau's X-13 seasonal adjustment methods in E-VIEWS, indicates that rice prices peak in September and fall between January and March. Wheat prices witness seasonal peaks during the winter months, just before the harvest period during January to March, and trough around June and July (Figure 4.5).

**Figure 4.5**

*Seasonality in CPI of Cereals (Based on Seasonal Factors over the Last 10 Years)*




*Note*: Seasonality of rice is from October 2011 to September 2022, whereas for wheat it is from April 2011 to March 2023.

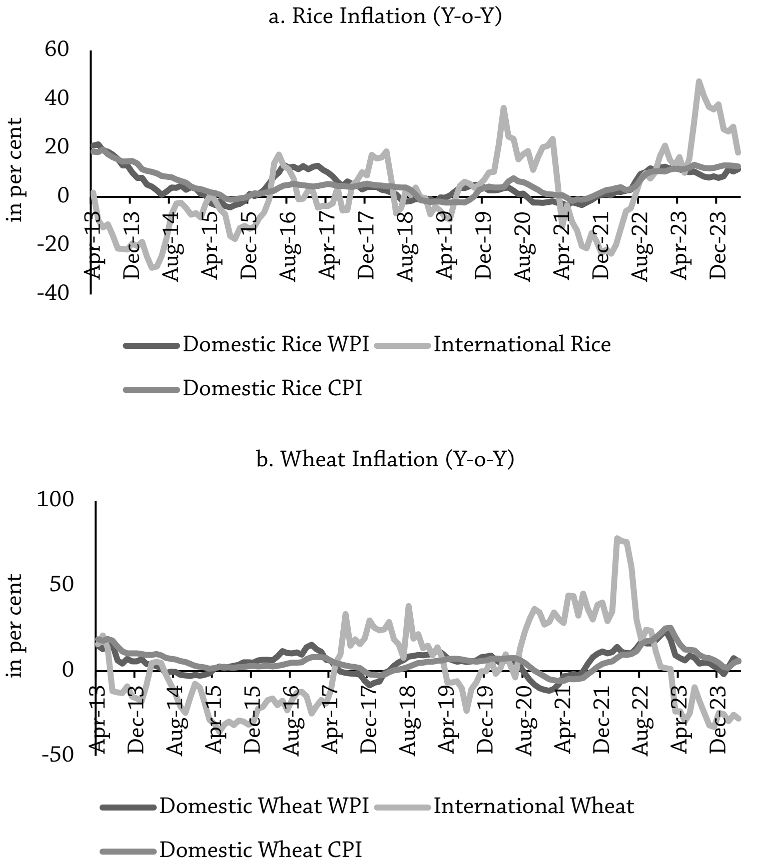
*Source*: NSO, MOSPI, GoI.

### 4.3 Factors Determining Cereal Inflation: Demand-Supply Angle

In this section, we explore the demand and supply side factors that impact cereal inflation. In staples like rice and wheat, literature suggests that the relationship between domestic and international prices tends to be weaker due to the robust procurement policy and the Public Distribution System (PDS). The government is reluctant to allow any significant pass-through from international to domestic prices (Mishra and Roy 2016). This is primarily because of the duality in the cereal market in the country, with the government-

**Figure 4.6**

*International and Domestic Inflation in Rice and Wheat (in Per cent)*




*Source*: World Bank Pink Sheet, OEA, GoI.

administered cereal market and the residual market operated by private traders. In rice, the correlation between the international price index and the domestic CPI rice index (from other sources/Non-PDS) is 0.21. In wheat, the correlation between the international price index and the domestic CPI wheat index (from other sources/Non-PDS) is 0.29 (Figure 4.6).

### 4.3.1 Demand-side Factors

Cereal demand has been increasing with the growing population. However, at the household level, with rising per capita income, the consumption basket has been shifting from staples to higher-value commodities (Jose 2016; Mittal 2008; Kumar et al. 2011). Using various rounds of the Consumption Expenditure Survey of the NSSO, we observe that the demand for cereals has fallen significantly, along with the expenditure share of cereals. For instance, the monthly per capita consumption of cereals in 2004-05 was 12.12 kg in rural areas and 9.94 kg in urban areas; this declined to 11.22 kg and 9.28 kg, respectively, in 2011-12[34]. A similar trend was witnessed in the consumption pattern of rice and wheat during the same period.

As stated in Engel's law, with an increase in average household income, the average share of food expenditure declines in total expenditure. Figure 4.7 plots the Engel Curves for rice and wheat for both rural and urban areas using the household survey (NSSO 68th round 2011-12). The Engel curve plots monthly per capita expenditure on selected cereal commodities on the y-axis, and income fractiles on the x-axis (income fractiles have been deduced using households' monthly expenditure). As income rises, Engel curves for rice and wheat increase steeply at lower income levels; however, the curve flattens at higher income levels.

### 4.3.2 Supply-side Factors

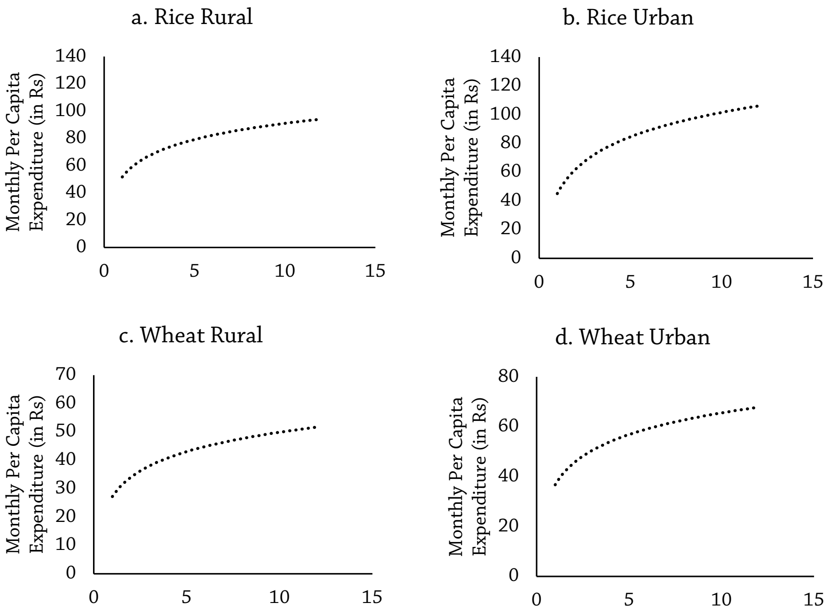
Supply-side factors affecting inflation include changes in production and productivity, input costs, and supply chain dynamics. In terms of production volume, India has increased cereal production

34. The unit-level data of the household Consumption Expenditure Survey: 2022-23 (HCES) was released in June 2024. However, the study uses NSSO 2011-12 data, as HCES 2022-23 was released after the completion of the study.

over the past decades due to government initiatives. In 2007, the National Food Security Mission (NFSM) was launched to increase the annual production of rice by 10 million tonnes, wheat by 8 million tonnes, and pulses by 2 million tonnes by the end of the Eleventh Plan in 2011-12.

**Figure 4.7**

*Engle Curve across Fractile-wise Monthly Per Capita Expenditure on Cereals, 2011-12*




*Note*: Here X-axis is Monthly Per Capita Expenditure (MPCE) fractiles which have been taken as proxy of income fractiles and Y-axis denoted monthly expenditure on selected commodities.

*Source*: NSSO, 2011-12

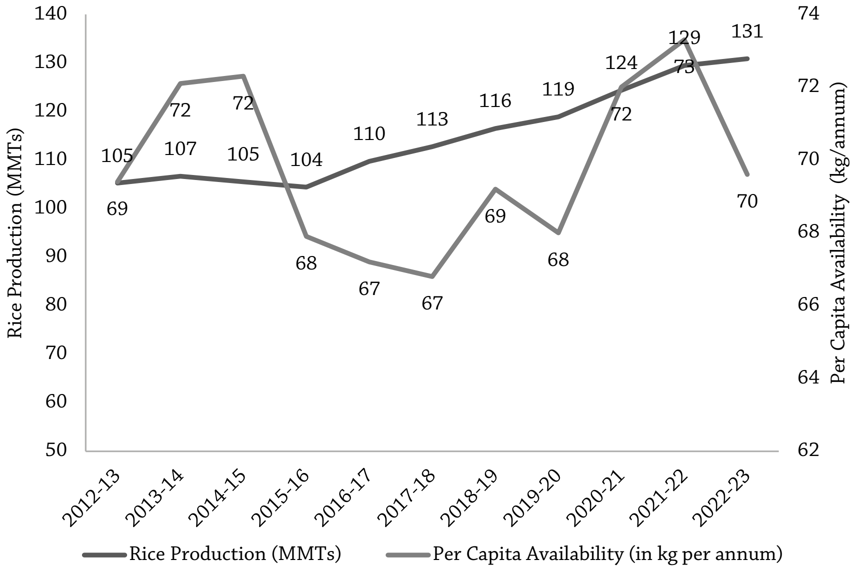
In TE 2022-23, rice production increased to 128.2 MMT, with per capita availability[35] rising to 71.6 kg per annum, according to the

35. Per capita availability of food grains in terms of kg/year is net availability of food grains divided by the population estimates for a particular year. Net availability of food grains is estimated as: Gross Production (-) seed, feed & wastage (-) exports (+) imports (+/-) change in stocks. Estimates of per capita net availability given above are not strictly representative of the actual level of consumption in the country, as they do not take into account any change in stocks held by traders, producers, and consumers.

latest Agricultural Statistics at a Glance (2022) (Figure 4.8). Of the total rice production, West Bengal (the largest producer) accounted for 13.2 per cent, followed by Uttar Pradesh (12.4 per cent) and Punjab (10.0 per cent) in TE 2021-22. Although West Bengal is the largest producer of rice in the country, the yield in Punjab is the highest at 4.3 tonnes/ha compared to other states.

**Figure 4.8**

*Year-wise Estimates of Production and Per Capita Availability of Rice*




*Source*: DES, GoI

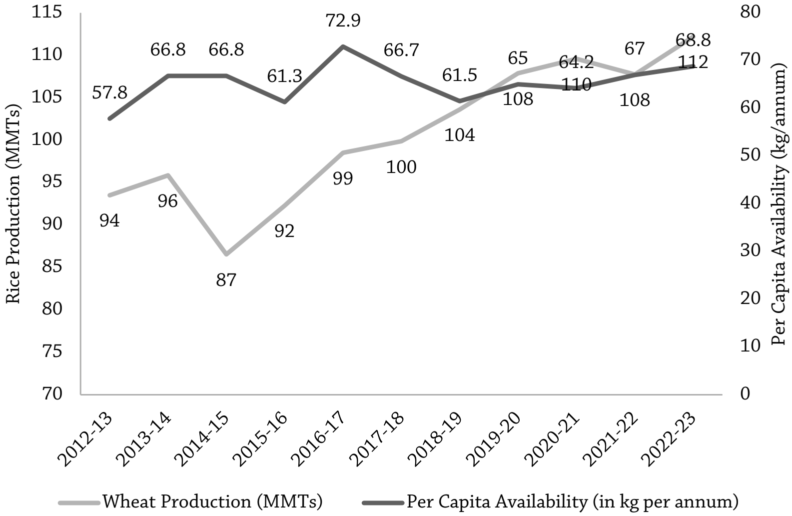
Similarly, wheat production increased to 109.8 MMT in TE 2022-23, with per capita availability accounting for 66.7 kg per annum in TE 2022-23. Among the states, Uttar Pradesh is the largest producer of wheat, accounting for 31.8 per cent of production, followed by Madhya Pradesh (18.6 per cent) and Punjab (15.3 per cent) in TE 2021-22 (Figure 4.9).

## 4.4 Duality of Cereal Markets: How Does the Government Control Cereal Prices?

The rice and wheat market in India is characterised by a high degree of government intervention, encompassing pricing,

**Figure 4.9**

*Year-wise Estimates of Production and Per Capita Availability of Wheat*




*Source*: DES, GoI

procurement, storage, and distribution. This results in the crowding out of the private sector, with an interplay of two forces—public and private. Since World War II, a dual market regime has existed in cereals (Krishna and Chhibber 1983); however, the proportion of food grains managed by the government has varied over the years. When India faced consecutive droughts in the 1960s, necessitating food aid imports from the United States, the central government devised policies aimed at achieving food security for the poor. These policies included stabilising consumer prices, reducing price disparities between states, ensuring fair support prices for farmers, and avoiding excessive price fluctuations through buffer stocking norms (Kumar et al. 2007). These measures became the foundation of India's current food grains policy framework. India's food grain production increased significantly from 74 million tonnes (MMT) in 1966-67 to 329.7 MMT in 2022-23 (DES, 2023), transforming the country from a food-deficient nation to one with surplus production.

The Food Corporation of India (FCI), established in 1965, focused on public procurement to stabilise prices and ensure buffer stocks. The Agricultural Price Commission (APC), later renamed the Commission for Agricultural Costs and Prices (CACP), played a crucial role in recommending the Minimum Support Price (MSP) based on production costs. The FCI managed food stocks, distributing them through the Public Distribution System (PDS) and various other welfare schemes. Reforms in the 1980s aimed to address criticisms, but liberalisation followed in the 1990s. The policy shift led to rising procurement, accumulating stocks, and challenges in meeting stock norms by the early 2000s. These stocks placed a significant financial strain on the state treasury and were reduced through subsidised exports, which drew considerable criticism due to low buffer stocks and high market prices for wheat, necessitating imports in 2006 (Chand 2009).

The primary instruments of government intervention include the price support mechanism for farmers through procurement and price stabilisation for consumers via buffer stocking norms and the Price Stabilization Fund (PSF). The CACP is responsible for setting the MSP for 23 crops, including wheat and rice. Government intervention commences before planting, marked by the announcement of the MSP. Grains are procured from farmers through open-end procurement, ensuring a guaranteed MSP intended to cover production costs and provide a reasonable margin for farmers. The FCI undertakes operations for the central government, including procurement, storage, transportation, and distribution of wheat and rice. The main objective of government interventions is to achieve food security. However, balancing these objectives is challenging, as it often incurs inefficiency and a heavy opportunity cost for the government.

The MSP policy protects and incentivises farmers to continue cultivating these crops, but it comes with a significant operational cost. This policy has hindered international trade of wheat, rendering Indian wheat uncompetitive in global markets. With annual increases in the MSP, the government procures more from farmers than is required for buffer stocking norms, further straining the state exchequer. These government interventions restrict the cereal market from functioning efficiently and crowd out potential gains from private trade.

The procured grains are distributed to the economically disadvantaged at heavily subsidised prices through the PDS under the National Food Security Act (NFSA), 2013. Since 2023, under the Pradhan Mantri Garib Kalyan Anna Yojana (PMGKAY), India has provided wheat and rice free of cost to approximately 806 million people, covering 67.2 per cent of its population. In addition to the NFSA, there are schemes specifically designed to ensure food security. In cases of excess stocks, the surplus can be released to the market through the Open Market Sales Scheme (OMSS) or exported. The government resorts to the OMSS for price stabilisation to contain cereal inflation, although such announcements are often reactive. The government sells below market prices and almost always below the economic cost, resulting in losses equal to the difference between the economic cost and the reserve price (the price at which open market sales occur). In summary, the government procures from farmers at a floor price, driving up market prices, and later sells these stocks at a price below their economic cost when prices begin to affect consumers. This policy framework is riddled with inefficiencies and spillover effects. Market prices are suppressed, hurting farmers who stored their produce instead of selling to the government. Additionally, it suppresses farmers' returns when export bans are imposed during high inflation, even though the government protects food security for at least 67 per cent of the population.

Apart from these measures, the government can impose restrictions on stocking limits under the Essential Commodities Act[36] for farmers, traders, and millers, keeping the grain market under its control.

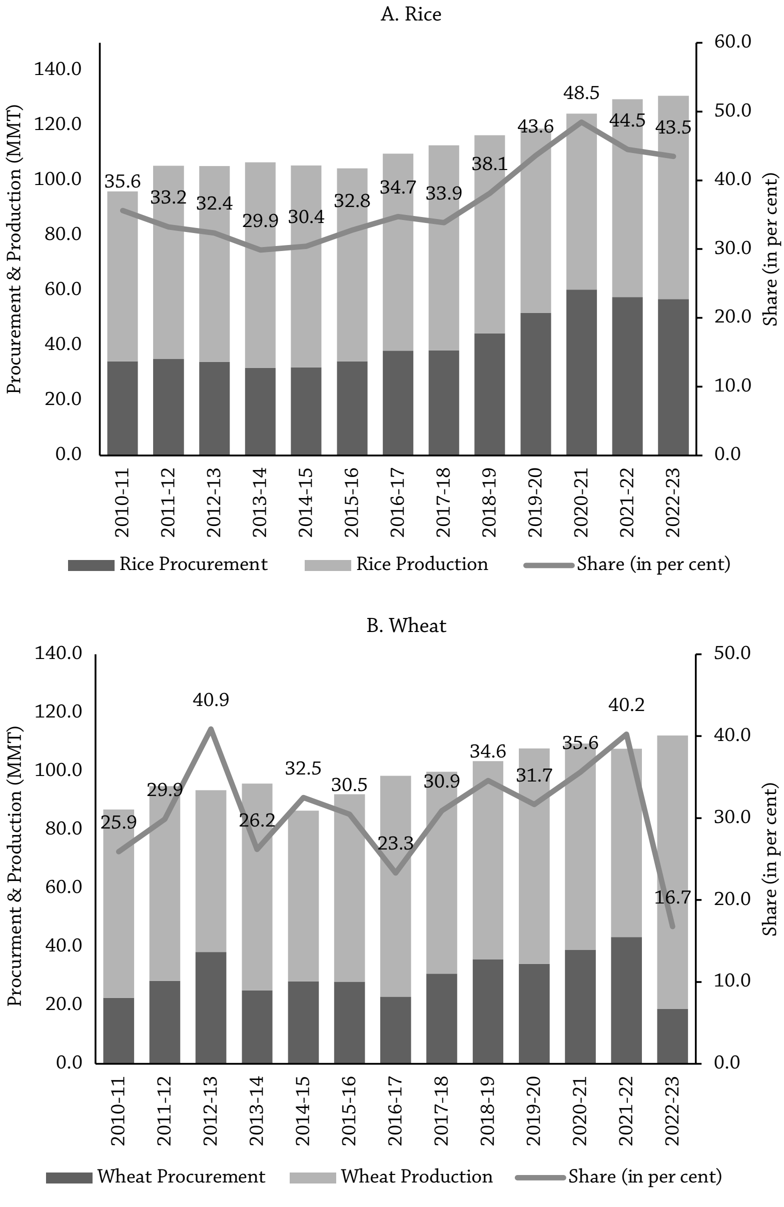
### *4.4.1 Trend in Rice and Wheat Procurement*

The FCI procures wheat or paddy directly from farmers at the MSP and rice from millers through owned and hired warehouses operated

36. Essential Commodities (Amendment) Act: This act removes food crops from the list of essential commodities. After the Independence of India, the government passed the Essential Commodities Act, 1955. The purpose of the act was to regulate the production, supply, and storage of essential commodities (including food crops, oilseeds, jute, seeds, etc.) and control hoarding. One of the three proposed Farmer Laws of 2020 sought to amend this act, intending to incentivise private players to invest in food processing and storage facilities.

**Figure 4.10**

*Trend in Rice and Wheat Procurement with Total Production (2010-11 to 2022-23)*




*Source*: Directorate of Economics and Statistics (DES), MoAFW, GoI and FCI.

by State Warehousing Corporations (SWCs), Central Warehousing Corporations (CWC), other state departments, and private storages.

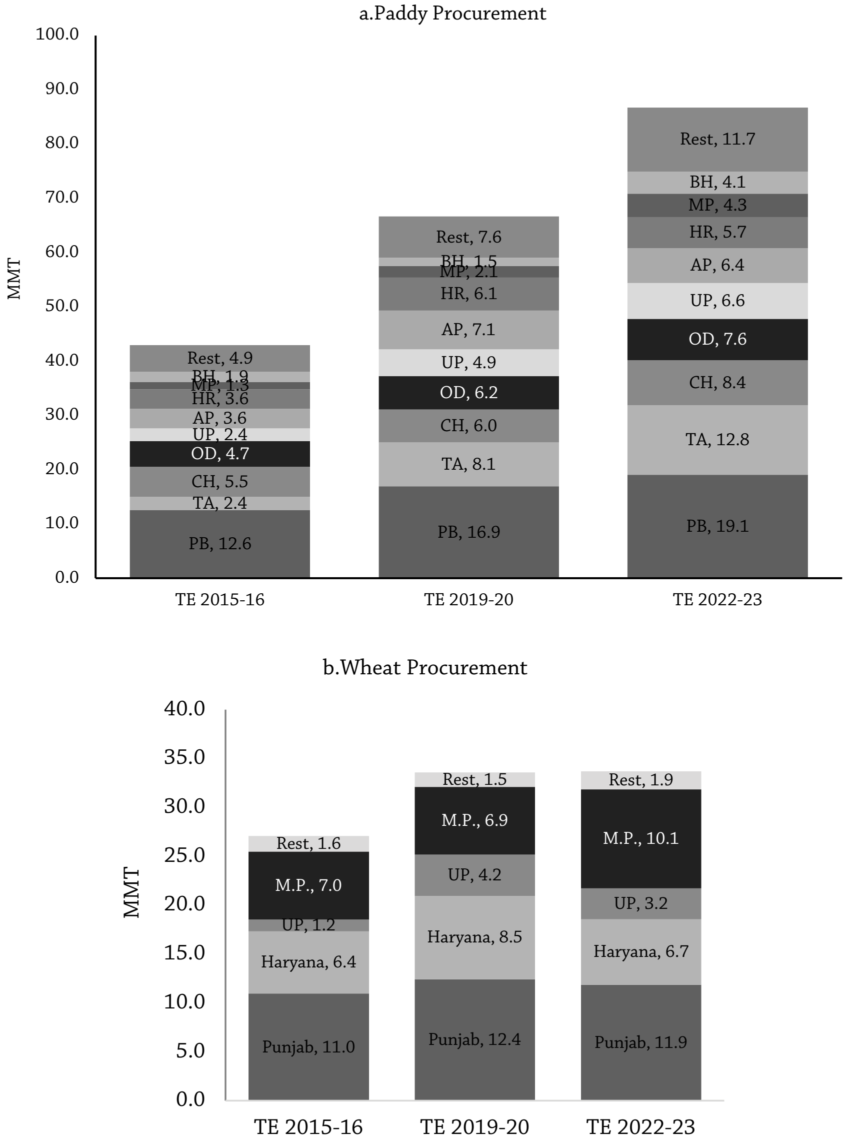
From 2010-11 to 2022-23, the FCI procured an average of 34 per cent of the total production of rice and wheat for the central government. In TE 2022-23, the FCI procured 33.7 MMT (31 per cent) of wheat out of an average production of 110 MMT (Figure 4.10). During the same period, the FCI procured 58.2 MMT (45 per cent) of rice out of an average production of 128 MMT. Paddy procurement at the national level increased significantly from 35.58 MMT to 84.77 MMT between 2013 and 2022-23, while wheat procurement has fluctuated due to varying harvests. The FCI copes with increased procurement and rising MSPs by hiring storage facilities from private enterprises. The rise in cereal production, attributable to power subsidies, free irrigation, chemical inputs, and assured procurement through the MSP, has led to a corresponding increase in procurement over the years.

Procurement approaches vary: Punjab and Haryana focus on centralised procurement, while states like Telangana, Andhra Pradesh, Odisha, and Chhattisgarh have expanded through decentralised systems. However, states like Bihar and West Bengal face challenges due to inadequate market infrastructure, and not all states operate Agricultural Produce Market Committee (APMC) mandis. Examining the spatial distribution of wheat and rice procurement within states reveals diversity in paddy procurement. From 2013-14 to 2022-23, paddy procurement grew at a compound annual growth rate (CAGR) of 9 per cent, increasing by 138 per cent during this period. In TE 2022-23, nine states—Punjab (22 per cent), Telangana (15 per cent), Chhattisgarh (10 per cent), Odisha (9 per cent), Uttar Pradesh (8 per cent), Andhra Pradesh (7 per cent), Haryana (7 per cent), Madhya Pradesh (5 per cent), and Bihar (5 per cent)—accounted for 86 per cent of total paddy procurement (Figure 4.11a).

In absolute quantity terms, all states recorded significant increases in paddy procurement from 2013-14 to 2022-23. Although Punjab, the state with the highest paddy procurement, saw a 52 per cent rise in absolute quantity terms from TE 2015-16 to TE 2022-23, its national share declined from 29 per cent to 22 per cent.

**Figure 4.11**

*State-wise Trend in Paddy and Wheat Procurement (TE 2015-16, 2019-20 and 2022-23)*




*Source*: FCI

Telangana's paddy procurement registered a 429 per cent increase. Similarly, between TE 2015-16 and TE 2022-23, Madhya Pradesh, Uttar Pradesh, Bihar, and Andhra Pradesh saw increases of 221 per cent, 180 per cent, 117 per cent, and 80 per cent, respectively. Excluding these eight states, which accounted for 86 per cent of total paddy procurement, the rest of India saw a 138 per cent increase in paddy procurement over the same period, benefiting more states and plausibly more farmers.

In wheat procurement, four states accounted for 95 per cent of the total in TE 2022-23: Punjab (35 per cent), Madhya Pradesh (30 per cent), Haryana (20 per cent), and Uttar Pradesh (9 per cent). This pattern has remained consistent over the last decade. Notably, these states are also the largest wheat producers. In TE 2020-21, they produced 77 per cent of the wheat but accounted for 95 per cent of the procurement.

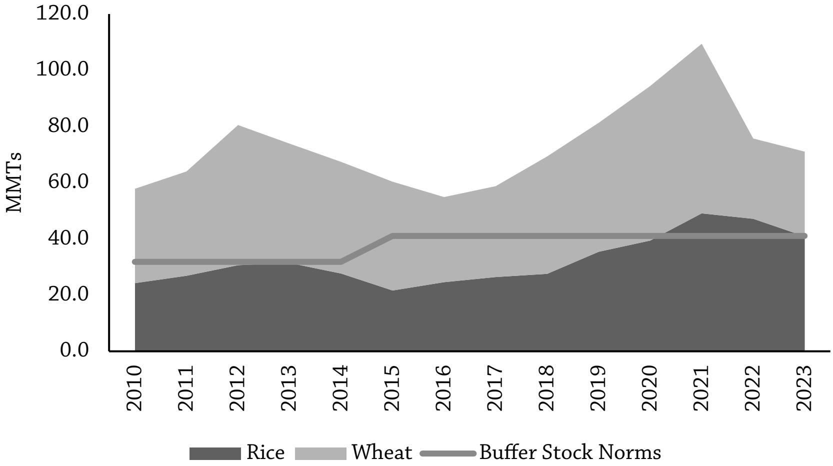
### Burden on Public Expenditure

The fiscal burden of these inefficient policies on the government is immense. First, the amount of capital locked in by the government in the form of buffer stocks has exceeded the norms for years. Figure 4.12a shows the stocks of rice and wheat held by the government in the central pool compared to the buffer stock norms. From 2010 to 2023, the government consistently held stocks at nearly twice the buffer stock norms. In addition to the capital locked in these stocks, there are annual carrying costs. Figure 4.12b illustrates that in TE 2021-22, the average annual carrying cost of buffer stocks was Rs.6.13 thousand crore. It is debatable whether maintaining such large buffer stocks and using open market sales as policy instruments helps in controlling inflation (Gulati et al., 2023). These actions influence market expectations, with market players setting their own expectations about government actions, often rendering such instruments ineffective. In TE 2021-22, storage charges, interest, and freight accounted for 82 per cent of the total carrying costs of buffer stocks.

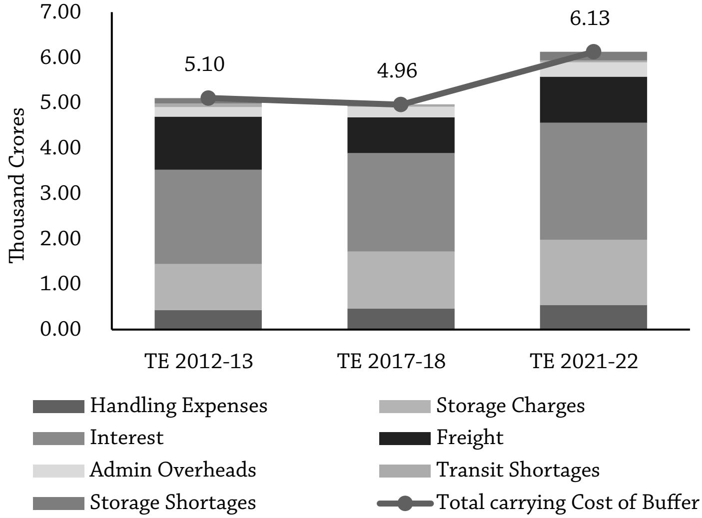
**Figure 4.12**

*Trend in Buffer Stocks Held and the Carrying Costs Incurred*

a. Opening Stocks of foodgrains with Central Pool as on 1st July each year [2010-2023]




b. Carrying Costs of Buffer Stocks



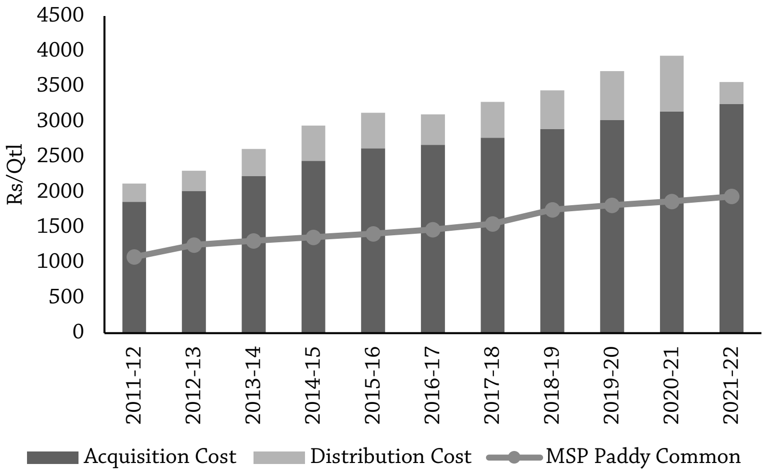

*Source*: FCI Annual Reports (various issues)

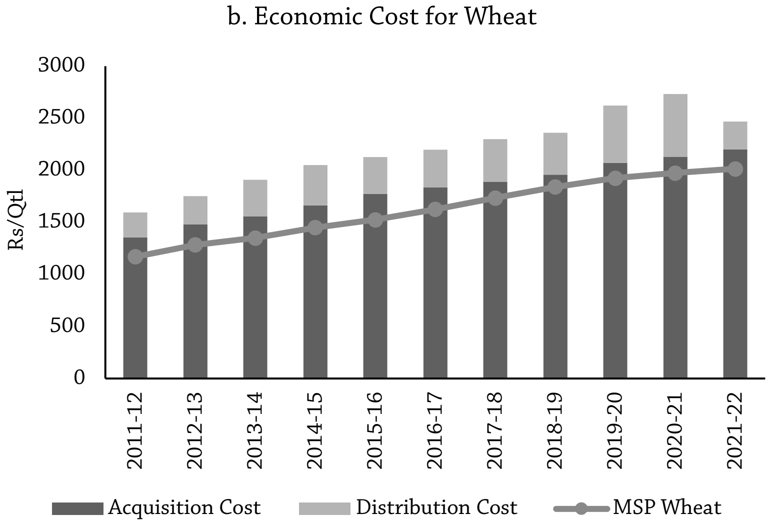
Second, the economic cost of rice and wheat far exceeds the MSP at which they are procured. Economic cost refers to the sum of the acquisition cost and distribution cost for a commodity. In TE 2021-22, the economic cost of wheat was, on average, 32 per cent above the MSP, and 100 per cent above the MSP for rice (compared with the MSP for common paddy). In TE 2021-22, distribution costs accounted for an average of 18 per cent and 16 per cent of the total economic cost for wheat and rice, respectively (Figure 4.13). These increasing economic costs place higher demands on the budget for price stabilisation and crowd out investments in areas with higher economic returns, such as research and development in agricultural techniques. Each year, the government increases the assured floor price for procurement to incentivise food grain production, a policy that has been successful. However, it also discourages diversification away from cereals.

**Figure 4.13**

*Economic Costs for Paddy+Rice and Wheat Compared to the MSP (2011-12 to 2021-22)*

a. Economic Cost for Paddy+Rice





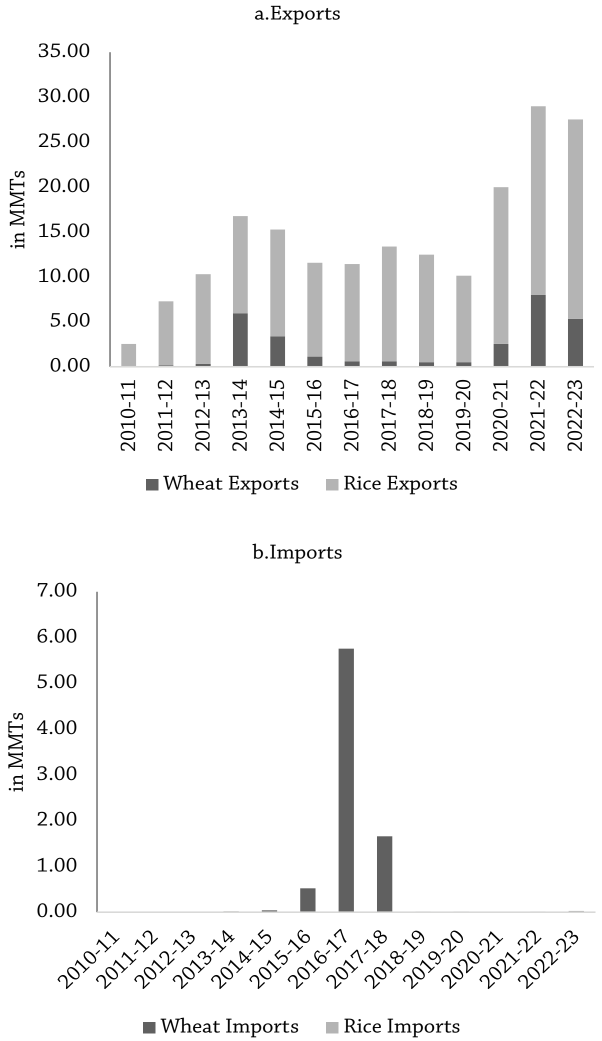

*Source*: FCI Annual Reports (various issues) and Commission for Agricultural Costs and Prices (CACP)

### *4.4.2 India's Trade Policy for Wheat and Rice*

India's trade policies on cereals, particularly wheat and rice, are driven by the objective of ensuring domestic consumer welfare and food security. India currently maintains a buffer stock of wheat and rice that is three times the prescribed norms. Trade policy in India is shaped by the quantity of 'residuals'—the amount of grains available after fulfilling food security needs. Policy instruments such as tariffs, quotas, and minimum export prices (MEP) are used to protect domestic consumers from high inflation in these staple foods. In the past, when India was not self-sufficient in cereals, such a trade policy was justified. Now, with production exceeding domestic requirements and larger-than-needed buffer stocks, India exports wheat and rice. The focus of trade policy should shift from consumer protection to enhancing global market competitiveness to maximise the welfare of Indian wheat farmers.

**Figure 4.14**

*Trend in Exports and Imports for Rice and Wheat (2010-11 to 2022-23)*




*Note*: Imports and exports for rice include Rice in Husk (Paddy or Rough) (HSC 100610), Rice Parboiled (HSC 10063010), Basmati Rice (HSC 10063020), Broken Rice (HSC 10064000), Husked Brown Rice (HSC 10062000), Rice Except Parboiled (excluding basmati rice) (HSC 10063090), and Semi/Wholly Milled Rice (whether or not Polished/Glazed) (HSC 100630). Imports and exports for wheat are calculated through the summation of Wheat (HSC 10019910), Wheat or Meslin Flour (HSC 11010000), Groats including Semolina (HSC 11031110), and Durum Wheat or Other (HSC 10011900) at a monthly frequency for financial years. Appropriate conversions applied.

*Source*: DGFT, various years

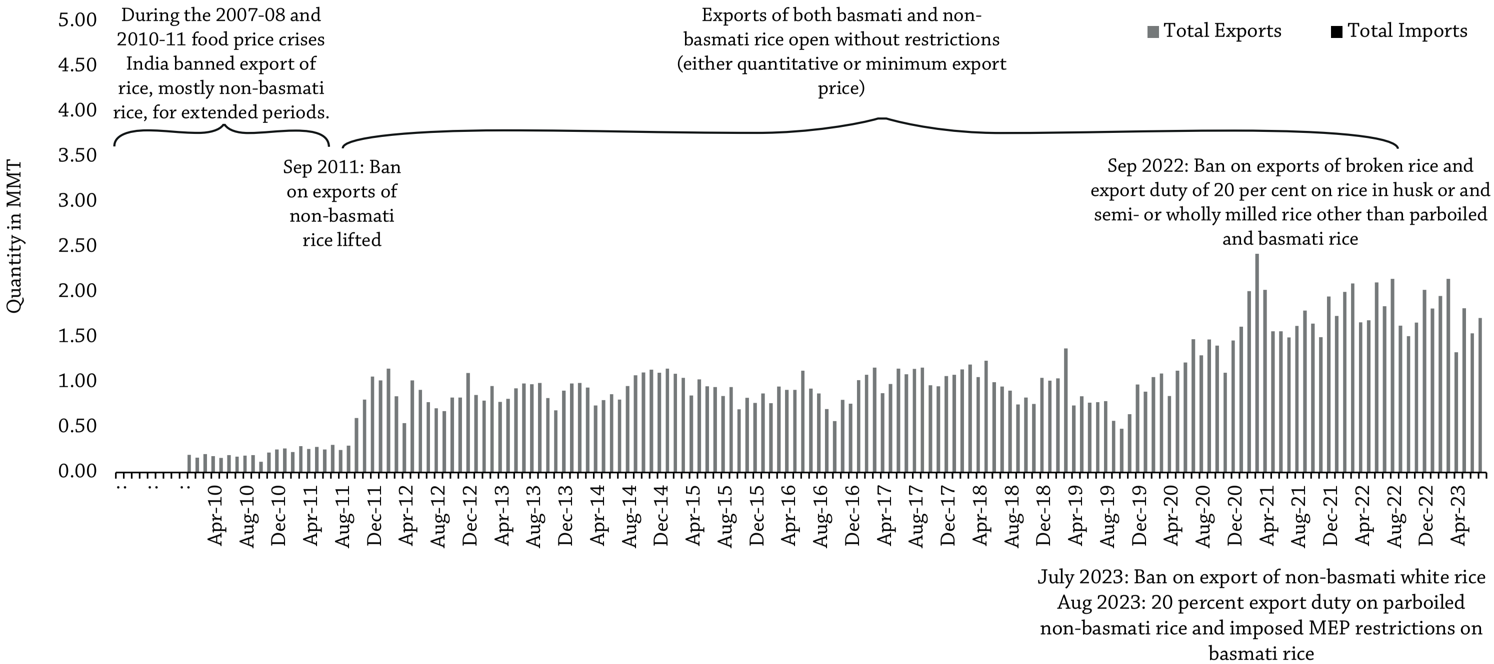
Common rice and wheat exports were banned until 1995-96, after which the bans were lifted, making India the world's second-largest exporter of rice. During the 2007-08 and 2010-11 food price crises, India imposed a ban on the export of wheat and rice (mostly non-basmati) until September 2011, with exceptions for humanitarian grounds and neighbouring countries like Nepal and Bangladesh. In September 2011, both wheat and non-basmati rice export bans were lifted. However, the export quota for wheat was set at 2 MMT due to concerns over domestic prices. Since 2011, India has allowed rice exports without restrictions on quantity or export price, but wheat exports and imports have been subject to tariff changes to control domestic inflation.

For rice, since September 2011, the government has adopted a free export policy. However, in 2022, with rising cereal inflation, the government imposed a ban on the export of broken rice and an export duty of 20 per cent on rice in husk and semi or wholly milled rice (excluding parboiled and basmati rice). Any changes in India's rice trade policy have a significant impact on global markets, as India is the largest exporter of rice in the world. Poorer countries are the most affected. In July 2023, India banned the export of non-basmati white rice, with some exceptions, and in August 2023, imposed an export duty of 20 per cent on parboiled non-basmati rice along with MEP restrictions on the export of basmati rice (Figure 4.15). India does not import rice for its domestic market, except for small quantities of specific varieties. It protects its farmers from international competition by imposing very high import duties on various rice varieties. Although import policy remains free for rice in husk (paddy or rough) and semi or wholly milled rice (polished/glazed), only state trading enterprises are allowed to import them at high duties of 80 per cent and 70 per cent, respectively. The import of rice for seed quality is restricted, while parboiled and basmati rice attract a 70 per cent import duty, and broken rice attracts an 80 per cent import duty.

The government faces the challenge of protecting wheat farmers when prices drop, which is addressed through adjustments in import tariffs. For instance, in 2016-17, when domestic wheat production

**Figure 4.15**

*Trend in Imports and Exports of Rice with Major Trade Policy Changes*




*Source*: Directorate General of Foreign Trade and various sources like DGFT, CBID, and USDA for policy changes.

reached a record high of 98.5 MMT and the government held 30.2 MMT, an import duty of 10 per cent was introduced in March 2017. This was increased to 20 per cent in November 2017, 30 per cent in May 2018, and finally to 40 per cent in April 2019. During these years, domestic production consistently rose year-on-year. Similarly, the government banned wheat exports in May 2022 when the expected production in 2022-23 was lower, despite sufficient buffer stocks (Figure 4.16).

## 4.5 Cereals Value Chain

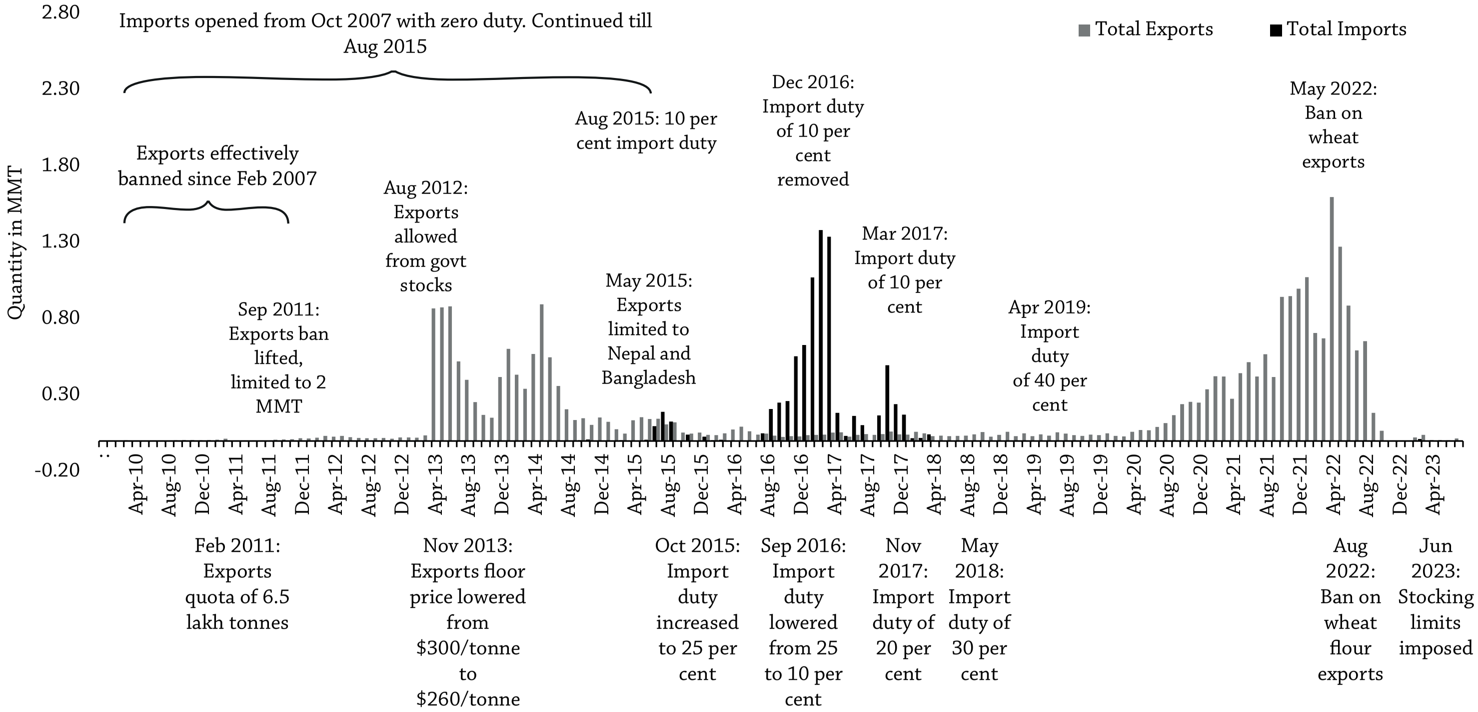
### *4.5.1 Rice Value Chain in India*

The rice value chain in India represents a complex network encompassing various stages from cultivation to consumption. India is a global leader in rice production, consumption, and exports. Managing the rice value chain is crucial as it directly impacts the livelihoods of millions of smallholder farmers, ensures food availability for the vast population, and addresses challenges related to technology, quality control, distribution channels, market access, and sustainability. Efficient management ensures food availability and affordability, particularly given rice's pivotal role in the diet of most Indians. Furthermore, effective management of the value chain tackles challenges like technological advancements, quality control, inventory management, distribution channels, market access, and sustainability. This is essential for ensuring optimal production, minimising losses, and meeting the growing demand for rice. Therefore, managing the rice value chain in India is crucial not only for economic growth but also for ensuring food security and livelihood sustainability across the nation (Abdulaziz et al., 2022).

The rice supply chain in India is primarily regulated by government involvement, with various agencies overseeing procurement, milling, stocking, and distribution to Fair Price Shops (FPS) or through government welfare schemes (Kumar et al., 2007). Both central and state governments play pivotal roles, shaped by policies such as Minimum Support Prices (MSPs), procurement levies, open market sales, buffer stocking, and determined issue prices within the Public Distribution System (PDS). While the central government handles

**Figure 4.16**

*Trend in Imports and Exports of Wheat with Major Trade Policy Changes*




*Source*: Directorate General of Foreign Trade and various sources like DGFT, CBID, and USDA for policy changes.

procurement, storage, and allocation to states, state governments are responsible for distributing grains through FPS and other channels. Agencies like the Food Corporation of India (FCI) and state-specific entities participate in procurement activities. The FCI procures mill levy rice at MSP, while state agencies acquire additional quantities at negotiated prices (McCarthy et al., 2008).

The demand for rice in India fluctuates seasonally, especially during festivals and cultural occasions. The primary challenge lies in meeting this demand within a profitable supply chain framework. The existing rice supply chain involves various stages, starting with paddy farmers (Pavithra et al., 2018). Large landholding farmers directly supply their produce to the government or processing units, whereas smaller farmers, with limited marketable output, sell through local marketplaces to aggregators or commission agents due to higher logistical costs. Paddy sold to the government is sent directly to rice millers who, on behalf of the FCI, mill the paddy at pre-specified rates and quality standards. Rice from the central pool is then distributed to states for public distribution programs. The rice processing phase includes cleaning, de-husking, polishing, and packing before being distributed to wholesalers or industrial buyers. In states with significant procurement, the milled rice goes to the FCI's storage units as part of the central pool stocks. However, inefficiencies arise due to the involvement of multiple intermediaries in the value chain (Sharma et al., 2013), reducing profit margins for farmers and increasing transactional and logistical costs.

The Indian rice sector faces challenges related to asymmetric information among stakeholders (farmers, millers, traders, wholesalers, retailers, commission agents) and erratic market expectations, resulting in supply chain issues and imperfect price formation. Efficient management of the rice supply chain requires timely and accurate information sharing among all stakeholders to enhance supply chain efficiency and address existing challenges.

### Stakeholders and Their Functions in the Rice Value Chain

The major stakeholders and their functions in the value chain include (see Figure 4.17):

- *Farmers*: Farmers play a crucial role in cultivating paddy, investing labour, land, and resources to produce high-quality rice crops. They supply their produce to small local traders or large traders, retaining a portion for self-consumption and seeding. Farmers face challenges such as access to credit, technology, and market information.
- *Local Traders & Commission Agents*: Acting as intermediaries, these agents assist small farmers in selling their produce to larger traders or at mandis. They provide logistical support and may offer financial assistance, helping farmers sell their produce efficiently. These traders have networks across regions and help transport rice to mills or distribution points.
- *Large Traders*: These significant market players purchase rice from local traders or directly from large farmers. Companies like ITC and Cargill aggregate large quantities of rice for processing and distribution.
- *State Procurement Agencies/FCI*: Government bodies like the FCI and state procurement agencies procure rice to meet national food security requirements. The FCI manages buffer stocks and distributes rice through government schemes like the PDS.
- *Millers*: Millers process paddy into rice, converting it into 66-70 per cent polished rice, 6-7 per cent broken rice, 5-6 per cent bran, and 17-21 per cent husk (Pavithra, 2018). They maintain quality standards and cater to both domestic and international markets.
- *Distributors (Social Welfare Schemes/Fair Price Shops/Open Market Sales):* Distributors, often state agencies, receive rice from the FCI or other sources. Rice procured by government agencies is distributed through social welfare schemes like the PDS and Fair Price Shops (FPS), making rice accessible to consumers in different categories (APL, BPL, AAY).
- *Wholesalers:* Wholesalers purchase rice in bulk from distributors or millers and supply it to retailers, institutions, and bulk buyers such as hotels and caterers. They play a crucial role

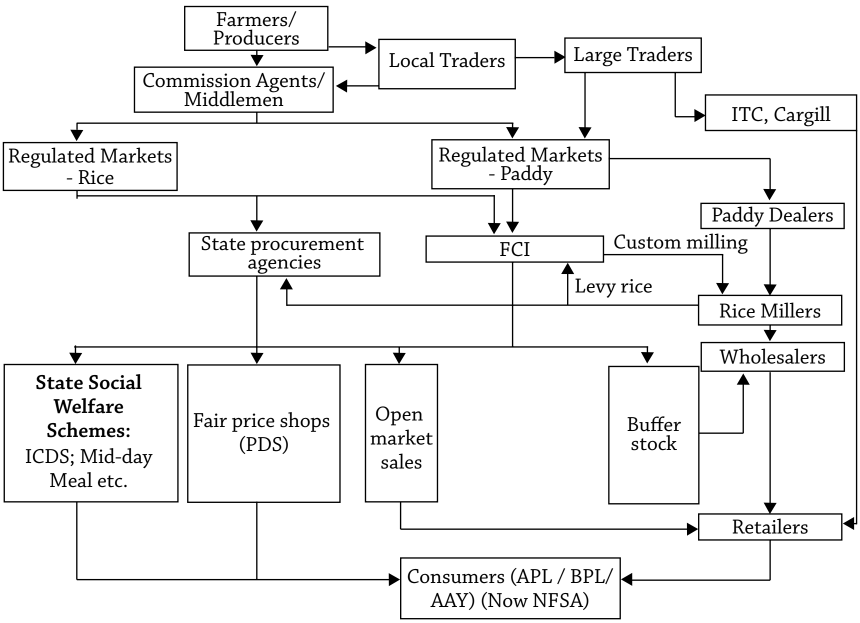
in maintaining stock and meeting the demands of various consumer segments.

- *Retailers*: Retailers are the final link before rice reaches consumers. They sell rice in various forms and packaging sizes through local grocery stores, supermarkets, or online platforms, managing inventory and consumer preferences.
- *Consumers*: Consumers are the endpoint of the rice value chain. They purchase rice for consumption in households, restaurants, canteens, and other food establishments. Consumer preferences, tastes, and purchasing power significantly impact rice market dynamics.

Each stakeholder in the rice value chain contributes to ensuring the smooth flow of rice from production to consumption, addressing challenges, and meeting the diverse demands of consumers across India.

**Figure 4.17**

*Rice Value Chain in India*




*Source*: Adapted from USAID (2006).

### *4.5.2 Wheat Value Chain*

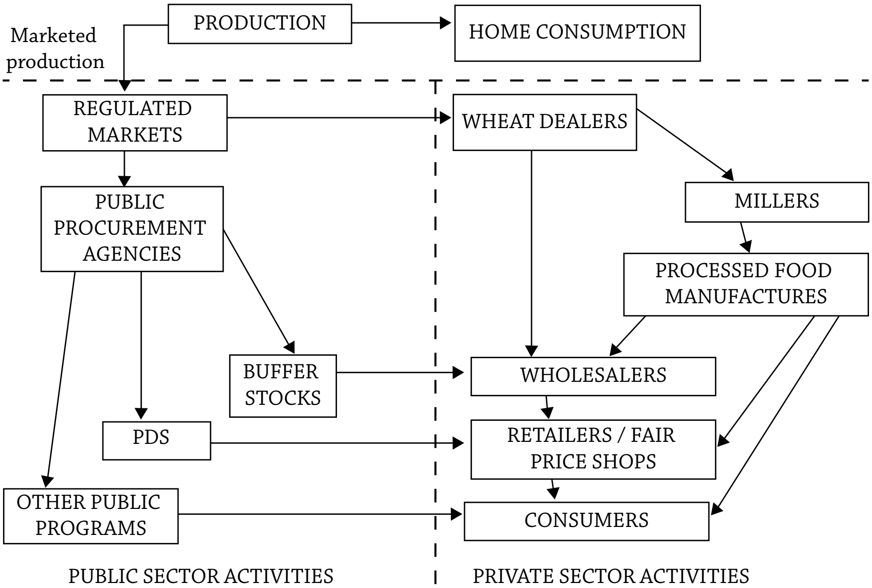
Similar to the rice value chain, the wheat value chain begins with the harvest by farmers. A substantial portion of the wheat produce is retained by farmers for self-consumption, seed, and feed purposes. Additionally, farmers hold back a portion for later sale to secure better prices. Losses are also incurred by farmers during on-farm operations. As indicated by the latest Agricultural Statistics at a Glance (2014-15), the marketed surplus for wheat is around 73.8 per cent of total production. This is primarily sold through regulated markets or mandis. The public sector plays a dominant role in procurement, with a minor share sold to private wheat traders.

Wheat procurement takes place in designated purchase centres or mandis, regulated by the State Agricultural Marketing Board, which oversees the Market Committees, all under the purview of the FCI. These regulated markets sometimes facilitate auction-based purchases to promote competition, transparency, and higher returns for farmers. Commission agents or arhtias handle the unloading, cleaning, and grading of food grains and earn a commission determined by the Mandi Board.

Purchases from the regulated market are predominantly stored in warehouses owned by the Food Corporation of India (FCI) or leased from state-level government agencies. While the central government is mainly responsible for procurement, handling, and storage, the distribution to consumers through Fair Price Shops rests with state governments. State agencies, including the State Civil Supplies Corporation and MARKFED, participate in procurement, supporting welfare programmes, specialised initiatives, and maintaining public buffer stocks. Portions of public buffer stocks are sold in the open market to wholesalers, depending on whether prevailing market prices are high and/or to dispose of surplus grain. The private sector's role in food grain storage is limited, with their purchases directed to wholesalers, retailers, millers, or consumers (Figure 4.18).

**Figure 4.18**

*Wheat Value Chain*




*Source*: Adapted from World Bank (1999).

### *4.5.3 Estimating the Price Mark-ups in the Cereal Value Chain*

To understand the price formation in cereals, the study estimates the price mark-ups across rice and wheat value chains and the share of farmers in a consumer's rupee. The examination of primary information collected from various major mandis is used to understand how prices are determined in cereals.

#### Price Mark-ups

For this study, we have taken into account the mark-up from paddy cultivation until it reaches the final consumers through the private channel (Table 4.1). As the final price paid by the consumer in the Public Distribution System (PDS) is subsidised, with the economic cost borne by the government, we have not computed the mark-up in the public channel, i.e. farmers to Agricultural Produce Market Committee (APMC) to rice miller to FCI channel to Fair Price

Shops (FPS) through PDS/welfare schemes, and finally to consumers. Similarly, for wheat we have computed mark-up in residual market only (Table 4.2) and not in the public channels. The paddy farmers get a share of 46.9 per cent of the consumer ruppees whereas wheat farmers are better off at 70.3 per cent.

**Table 4.1**

*Retail Price Mark-up in the Consumers' Rupee Spend on Rice*

| | *Markup at different stake holder* | *(Rs/quintal)* | *Per cent* |
|---|---|---|---|
| Paddy | Mandi price (which farmers receive) | 1854 | 46.95 |
| | Market fee/ Mandi charges (3per cent), Rural development fee (3per cent) & Arhatiya commission (Rs. 46/ quintal) | 157.24 | 3.98 |
| | Labour or mandi handling charges & packing material paid by processors | 26.6 | 0.67 |
| | Transportation charges from mandis to processing units | 8 | 0.20 |
| | Losses because of foreign matters or impurities | 2.22 | 0.06 |
| | Paddy cost to the miller | 2048.065 | |
| Rice | Processing or milling cost | 10 | 0.25 |
| | Packaging Cost | 5 | 0.13 |
| | Transportation from processing plants to wholesalers at the consumption points | 10 | 0.25 |
| | Miller Markup | 1210 | 30.64 |
| | Wholesaler markup | 315 | 7.98 |
| | Retailer markup | 351 | 8.89 |
| | Final retail price | 3949.294 | |

*Notes for Rice*:

- Mandi prices (wholesale price) of rice were around Rs. 1854/quintal during TE 2022, lower than the average Minimum Support Price (MSP) of these three years.
- Farmers received around 46.9 per cent of the consumer rupee realised through sales of rice.
- Private organised players, besides procuring paddy from the farmers, also receive paddy supplies from aggregators who have logistics to supply bulk quantities to the milling plants.
- The arhatiya commission was earlier 2.5 per cent until 2020, after which the FCI changed it to Rs. 46/quintal.
- The miller charges Rs. 10/quintal as milling charges, then adjusts it for a 67 per cent paddy-to-polished-rice transformation rate (i.e., 1kg of paddy = 0.67 kg of rice).
- The retail price is the average rice price of TE 2023 from the Department of Consumer Affairs (DoCA).

*Source*: Field Survey. Based on inputs provided by leading traders in Punjab and Haryana. The consumption centre is Delhi for the data collated. Mandi prices are taken from Agmarknet and represent an average of the top three producers (West Bengal, Punjab, Uttar Pradesh) for the period TE 2022. All the costs, expenses, and mark-ups are calculated as a share of retail prices (TE 2022-2023) for rice from the Department of Consumer Affairs (DoCA).

**Table 4.2**

*Mark-up in Wheat Value Chain*

| *Stages in Wheat Value chain* | *Rs/Quintal* | *Per cent share* |
|---|---|---|
| Mandi price (which farmers receive) | 2133 | 70.3 |
| Market fee & Arthia commission (Market/Mandi fees -3 per cent and Rural Development Cess-3 per cent) | 121.62 | 4.0 |
| Labour or mandi handling charges & packing material paid by Millers/processors | 25 | 0.8 |
| Transportation charges from mandis to processing units | 100 | 3.3 |
| Losses because of foreign matters or impurities | 1.62 | 0.1 |
| Cost of wheat to Miller | 2381.24 | |
| Processing or milling cost | 43 | 1.4 |
| Millers Markup | 200 | 6.6 |
| Transportation from processing plants to wholesalers at the consumption points | 10 | 0.3 |
| Wholesaler markup for atta | 160 | 5.3 |
| Retailer markup for atta | 238 | 7.8 |
| Final retail price | 3032 | |

*Notes for Wheat*:

- Market fees and Rural Development Cess vary across states. Some states also have an Infrastructure Development Cess. For our calculation, we have used the market fees and cess reported for Punjab.
- The mandi price for wheat is Rs. 2133, which is the average of the last two years in the major three producing states (Uttar Pradesh, Madhya Pradesh, and Punjab).
- Farmers received around 70.3 per cent of the consumer rupee realised through sales of wheat atta (flour).
- The retail price is the average atta price for the last two years for the Delhi consumption centre, from DES, GoI.
- The miller converts wheat into wheat flour (atta) at a conversion rate of 1kg of wheat = 750 grams of flour.

*Source*: Field Survey. Based on inputs provided by leading traders in Punjab and Uttar Pradesh. The consumption centre is Delhi for the data collated. Mandi prices are taken from Agmarknet and represent an average of the top three producers (Uttar Pradesh, Madhya Pradesh, and Punjab) for the period TE 2022-23. All the costs, expenses, and mark-ups are calculated as a share of retail prices (TE 2022-2023) for wheat from DES, GoI.

## 4.6 Balance Sheet Approach

To understand consumer price dynamics of cereals and create a representative variable that captures demand and supply imbalances, we used the balance sheet approach. This method analyses the supply and demand in the cereal sector, including rice and wheat. Conventional economic theory assumes free markets with certainty and full information, but this rarely reflects reality. In the cereal market, a dual structure exists: one segment is regulated by the government, while the other is an open residual market. In the government-regulated segment, grains are procured based on the Minimum Support Price (MSP) through centralised or decentralised systems and stored in Food Corporation of India (FCI) warehouses, which include both conventional facilities and modern silos. A portion of these grains is maintained as strategic reserves for emergencies like natural disasters or economic shocks, managed by the FCI under the Open Market Sales Scheme (OMSS). Through the Public Distribution System (PDS), rice and wheat are provided at subsidised rates to over 800 million beneficiaries. The residual market for rice and wheat operates outside the government's procurement and PDS system, with prices determined by supply and demand.

This balance sheet focuses on the residual market to track supply and demand dynamics, with adjustments for OMSS stocks to assess the impact of excess supply on inflation. Once we establish the monthly total stocks or the net available stock after monthly usage, or the ratio of available stocks with respect to their usage, we then analyse the impact of various factors on rice and wheat prices.

### *Components of the Monthly Balance Sheet*

Since we are computing the balance sheet for the residual market only, we deduct procurement from the supply side, i.e. total procurement is deducted from the total production of rice and wheat. On the demand side, we exclude PDS consumption of rice and wheat from our cereal balance sheet. In the residual market, the monthly production pattern (based on the market arrival pattern from Agmarknet) and consumption pattern have been obtained. To get the monthly availability data, monthly export and import data are also adjusted. The monthly patterns of production, consumption, and stocking have been analysed from October 2011 to September 2023 for rice, and from April 2011 to March 2024 for wheat.

### *Key Assumptions for Constructing the Cereal Balance Sheets*

*Production pattern in a year:* Wheat is a rabi crop in India, sown during the winter season. The cool and dry climate is ideal for wheat cultivation, as it requires low temperatures during sowing and the early growth stages. Harvesting occurs in northern India between March and May. However, recent years have seen an increase in the frequency and severity of heatwaves due to climate change. These heatwaves can lead to premature ripening, reduced grain filling, and ultimately lower wheat yields. Procurement begins on 1 April, marking the start of the Rabi Marketing Season (RMS) in India, although it varies by state. For the 2023–24 fiscal year, the share of procurement to production for wheat was 31.06 per cent.

Rice, a staple food for a significant portion of India's population, is cultivated extensively across the country. Production patterns are influenced by the monsoon, regional agro-climatic conditions, and irrigation availability. The rice production cycle is broadly categorised into three seasons: *Kharif*, *Rabi*, and Summer (also known as Boro). Notably, 85 per cent of rice production occurs during the *Kharif* Marketing Season (KMS). At the all-India level, the share of procurement to production for rice was 45 per cent in the 2022–2023 fiscal year. In the balance sheet, wheat production years are considered from April to March, while for rice, the period is from October to November, according to their marketing season (see Annexure A4.1). Since we are interested in the residual market, we deduct total procurement from total production to compute the marketed surplus.

*Marketed Surplus:* From the total production, which is the flow variable, some part of the cereal produce is kept for meeting the farmer's self-consumption needs, and the remaining is sold in the mandi or to the FCI. For rice, out of the total rice produced, around 18.5 per cent is retained by farmers for self-consumption, seed, feed, and wastages (SFW), leaving a marketable surplus of 81.5 per cent. In the case of wheat, around 26.9 per cent is retained by farmers for self-consumption and SFW needs, so the marketable surplus is 73.1 per cent. The annual marketed surplus is distributed monthly based on the Agmarknet mandi arrival pattern (Figure 4.19). From the marketed surplus, market-level losses are deducted, as per the latest NABCONS (2022) study. The total market-level losses for rice are 0.61 per cent, and for wheat, 0.56 per cent.

*Monthly availability for the residual market:* As this chapter examines the determinants of non-PDS rice and wheat inflation, monthly availability figures for the residual market have been obtained. The annual marketed surplus in the residual market, after excluding procurement from the total production, is distributed monthly based on Agmarknet mandi arrival patterns, adjusted for import and export data for both rice and wheat (Figure 4.19). Additionally, the sale of rice and wheat under the OMSS is included in the availability figures, as it enhances market supply and increases stocks held by private traders.

The monthly availability of cereals is calculated by summing the opening stocks of a given month with the net marketable surplus available in that month and adjusting for net exports/imports and OMSS sales. For rice, adjustments include exports and imports of broken rice, parboiled rice, basmati rice, non-basmati non-parboiled rice, and other rice products. For wheat, trade data encompasses wheat grain, wheat or meslin flour, groats (including semolina), and durum wheat. Semolina data is adjusted for double counting, as semolina is a by-product of milling wheat into flour.[37]

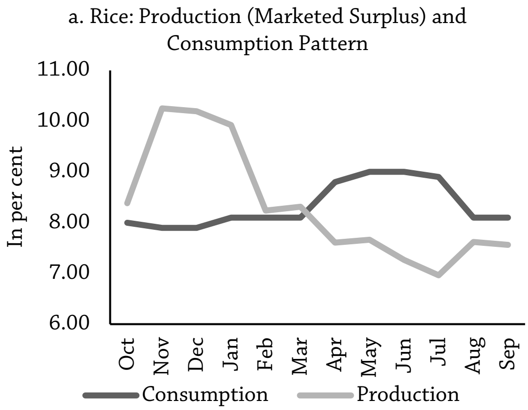
*Consumption pattern within a year:* To calculate the annual rice consumption by households in the residual market, we used a weighted average of per capita rice and wheat consumption from non-

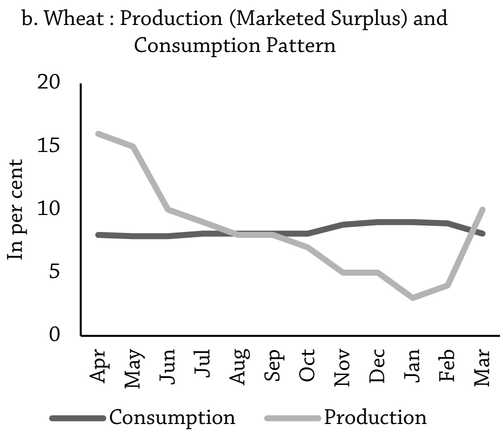
37. Wheat and rice are integral staples consumed globally in various forms. Understanding the conversion rates between different products derived from these cereals is crucial for agricultural planning and trade considerations. The conversion rate between a kilogram (kg) of wheat and its primary product, flour, varies based on milling efficiency and wheat variety. On average, it takes approximately 1 kg of wheat to produce around 0.75 kg of flour. The conversion rate for rice involves the transformation from paddy to milled rice. The typical conversion ratio is 1:0.67, indicating that 1 kg of paddy yields approximately 0.67 kg of milled rice; this can vary by variety and region. Beyond these primary products, value-added wheat products like semolina require additional quantities of wheat. For example, 0.40 kg of semolina may require around 1 kg of wheat. Similarly, rice-based products, such as rice flour, have their own specific conversion rates, contributing to the diverse array of food items derived from these essential cereals (from the Primary Survey).

PDS sources for rural and urban areas, based on the NSS Consumption Expenditure Survey (CES, 2011–12). Using a behavioural approach, we forecasted annual consumption and distributed it using monthly patterns derived from a survey of cereal market experts (Figure 4.19). The survey suggests that rice consumption is slightly lower in winter and higher in summer, while wheat consumption follows the opposite pattern (Figure 4.19).

**Figure 4.19**

*Monthly Pattern of Balance Sheet Components within a Year*




*Source*: Author's calculation from the balance sheet of rice and wheat.

To determine net consumption, we deducted home-produced consumption from the monthly cereal consumption, noting that 31.3 per cent of cereal consumption is from home produce (NSS CES 2011–12). An additional 10 per cent is deducted for processing by various sectors, based on market intelligence.

For rice, consumption remains relatively constant throughout the year, except for slight changes during winter and summer. Availability peaks in winter with fresh arrivals. Wheat consumption is lower from March to June and higher in winter, with availability peaking around April–May due to new arrivals. Wheat usage increases in winter, as consumers tend to shift from rice to wheat during these months.

*Variables of Interest—Stock-to-Usage:* All the above components are used to arrive at the variable of interest: the stock-to-usage ratio. Thus, the monthly stock-to-usage ratio is estimated as the ratio of availability in the residual market to the demand in the same market for a given month. This variable (STU) tends to have a negative impact on cereal inflation. Moreover, since we are accounting only for the residual market, which is separate from the government-administered cereal market, these stocks will include stocks with traders, millers, exporters, and importers.

According to economic theory, an increase in supply should lead to lower prices, indicating a negative relationship between stock levels (or net availability) and prices. In cereals, government policies play a significant role in controlling inflation. One such policy is the OMSS, which increases cereal supply in the market.

To assess the impact of government interventions like the OMSS, we computed two STU variables in our balance sheet: one that includes OMSS supply and another that excludes it. This approach helps gauge the effect of the OMSS, alongside other factors affecting cereal prices.

From October 2011 to September 2023, the correlation between STU (including OMSS) and the CPI for rice is -0.24 (Table 4.3). Similarly, the correlation between CPI for wheat and STU (including OMSS) from April 2011 to March 2024 is -0.28 (Table 4.3).

**Table 4.3**

*Correlations between CPI for Rice and Wheat*

| *Correlation* | *At Level* | *1-month lag* | *2-month lag* | *3-month lag* |
|---|---|---|---|---|
| CPI rice & STU | -0.24 | -0.21 | -0.18 | -0.16 |
| CPI wheat & STU | -0.28 | -0.32 | -0.29 | -0.26 |

*Note*: We have used STU inclusive of OMSS.

*Source*: Authors' calculations.

Using the balance sheet approach, this study derives the monthly Stock-to-Usage (STU) variable for rice, which is found to have an inverse correlation with the Consumer Price Index (CPI) for rice. This variable (STU), along with other factors, is used to empirically estimate its impact on rice inflation.

## 4.7 Model Specification and Empirical Results

### *Rice Model Estimation*

The study employs two regression models: Model 1 uses the explanatory variable STU with OMSS, while Model 2 includes STU without OMSS to determine the specific impact of OMSS on rice inflation, alongside other variables. An export ban dummy variable is used, taking the value of 1 if a ban was announced, and 0 otherwise. All variables are transformed to their logarithmic values and seasonally adjusted for the estimation process. The Augmented Dickey-Fuller (ADF) test (Pesaran et al., 2001) is applied to check for stationarity.

Table 4.4 presents the results of the ADF test for the variables used in analysing rice inflation, confirming that the variables are stationary at levels I(0) and I(1). Based on these findings, the study employs Autoregressive Distributed Lag (ARDL) models to estimate the factors impacting rice inflation. For a detailed description of the variables, see Annexure A4.2.

**Table 4.4**

*ADF Unit Test for Rice*

| *Variables* | *t-statistic* |
|---|---|
| Log Seasonally Adjusted CPI | -1.22 |
| ΔLog Seasonally Adjusted CPI | -4.13*** |
| STU with OMSS | -7.95*** |
| STU without OMSS | -7.59*** |

*Note*: The Dickey-Fuller test statistic is reported. The critical values are the finite sample values suggested by Mackinnon (1991). () indicates different levels of significance as follows: *** p<0.01, ** p<0.05, * p<0.1*

*Source*: Authors' calculation

The lag lengths of the variables in the ARDL model are chosen as (3,3,0) based on the optimal lag length method. The bounds test for rice is presented in Table 4.5. The bounds test confirmed the existence of a long-run relationship between the CPI of rice and the STU index with/without OMSS, and the export ban as an exogenous variable for both Model 1 and Model 2, respectively.

**Table 4.5**

*Bounds Tests for Cointegration for Rice*

| Model 1 | | Model 2 | |
|---|---|---|---|
| F statistic | t statistic | F statistic | t statistic |
| 2.16* | -1.77* | 2.29* | -1.93* |

*Notes*: The F-statistic tests for the joint significance of the coefficients of the lagged levels in the ARDL-ECM. The t-statistic tests the significance of the coefficient of the lagged dependent variable. All test statistics are significant at the 10 per cent level.

*Source*: Authors' estimation

In both models, the estimates show that the STU variable, whether including or excluding the OMSS, negatively impacts CPI rice prices in the long run (Table 4.6). The results indicate that a 1 per cent increase in the STU variable (including OMSS) leads to a 0.39 per cent decrease in CPI rice in Model 1, and a 0.33 per cent decrease in Model 2 when excluding OMSS supply. This aligns with economic theory, which suggests that higher supply results in lower prices. When controlling for all other variables and including only the OMSS in Model 1, the coefficient of the STU (inclusive of OMSS) improves marginally, suggesting that incorporating OMSS enhances the model's ability to explain rice inflation.

Regarding the impact of trade policy on rice inflation, both models include export ban episodes on non-basmati rice as explanatory variables. It is generally expected that an export ban would significantly affect the CPI of rice by increasing domestic supply and reducing inflation. However, this was not the case in our models, as the export ban variable was insignificant in both. As a major rice exporter, India's export ban triggered a sharp rise in global prices, but it failed to impact domestic inflation.

The estimate of the speed-of-adjustment coefficient (Error Correction Model, ECM term) indicates that any disturbance to the long-run equilibrium is corrected by 0.2 per cent within one month. The ECM term has a negative sign and is statistically significant, though it suggests a slow pace of convergence to long-run equilibrium in response to deviations from the equilibrium path. The diagnostic tests for the ARDL model are satisfactory, and the models are stable as per the CUSUM test (see Annexure Table A4.3).

**Table 4.6**

*ARDL Estimation Results for Rice*

| MODEL 1<br>Dependent Variable: Log CPI Rice other sources<br>ARDL (3,3,0)<br>Sample Period: October 2011-September 2023 | | | MODEL 1<br>Dependent Variable: Log CPI Rice other sources<br>ARDL (3,3,0)<br>Sample Period: October 2011-September 2023 | | |
|---|---|---|---|---|---|
| *Variables* | *Coefficient* | *Std. Error* | *Variables* | *Coefficient* | *Std. Error* |
| **Long run coefficient** | | | **Long run coefficient** | | |
| STU with OMSS | -0.39* | 0.23 | STU without OMSS | -0.33* | 0.17 |
| Export ban dummy (yes=1, no=0) | 0.42 | 0.36 | Export ban dummy (yes=1, no=0) | 0.35 | 0.3 |
| **ECM** | -0.002* | 0.001 | **ECM** | -0.002* | 0.001 |
| **Short run coefficient** | | | **Short run coefficient** | | |
| ΔLn CPI (-1) | 1.059* | 0.082 | ΔLn CPI (-1) | 1.059* | 0.082 |
| ΔLn CPI (-2) | -0.206 | 0.081 | ΔLn CPI (-2) | -0.206 | 0.081 |

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| | | | | | |
|---|---|---|---|---|---|
| ΔSTU with OMSS | 0.001 | 0.008 | ΔSTU without OMSS | 0.001 | 0.008 |
| ΔSTU with OMSS (-1) | 0.008 | 0.000 | ΔSTU without OMSS (- 1) | 0.008 | 0.000 |
| ΔSTU with OMSS (-2) | 0.008 | 0.000 | ΔSTU without OMSS (- 2) | 0.008 | 0.000 |
| Intercept | 0.014** | 0.007 | Intercept | 0.01** | 0.007 |
| Observations | 154 | | Observations | 154 | |
| Adj-R squared | 0.81 | | Adj-R squared | 0.81 | |
| RMSE | 0.003 | | RMSE | 0.003 | |
| Breusch Godfrey test | 5.015 (0.03) | | Breusch Godfrey test | 4.767 (0.03) | |
| Portmanteau's test for white noise | 0.30 (0.58*) | | Portmanteau's test for white noise | 0.3033 (0.58*) | |
| *** p<0.01, ** p<0.05, * p<0.10 | | | | | |

*Notes*: Figures in parentheses for Breusch-Godfrey LM test for autocorrelation (H0: no serial correlation) and Portmanteau's test for white noise (H0: series are white noise) indicate p-values.

*Source*: Authors' estimation.

### *Wheat Model Estimation*

To estimate the factors impacting wheat inflation, the sample period spans from April 2011 to March 2024. The explanatory variables used in the analysis are the STU ratio, global wheat prices, and an import duty dummy. The import duty dummy for wheat takes a value of 0 if the import duty is less than 10 per cent, and 1 if it is more than 10 per cent.

Two models are employed in the estimation: Model 1 uses the STU ratio inclusive of OMSS, while Model 2 uses the STU ratio excluding OMSS. The continuous variables have been transformed into their logarithmic values, and the price variables (CPI and global wheat price) have been seasonally adjusted for estimation.

Table 4.7 shows the ADF test results for variables used in analysing wheat inflation, confirming that the included variables are stationary at I(0) (stationary at their level) and I(1) (integrated of order 1). Hence, the study uses ARDL models to estimate the factors impacting wheat inflation.

**Table 4.7**

*ADF Unit Test for Wheat*

| *Variables* | *t-statistic* |
|---|---|
| Log Seasonally Adjusted CPI | -0.556 |
| Δ Log Seasonally Adjusted CPI | -0.725*** |
| STU with OMSS | -8.453*** |
| STU without OMSS | -8.92*** |
| Seasonally Adjusted Global Price | -2.67* |
| Δ Seasonally Adjusted Global Price | -7.042*** |

*Note*: The Dickey-Fuller test statistic is reported. The critical values are the finite sample values suggested by Mackinnon (1991). () indicates different levels of significance as follows: *** p<0.01, ** p<0.05, * p<0.1.*

*Source*: Authors' calculation.

The ARDL bounds testing approach has been used to test for the existence of a long-run cointegration relationship. The optimal lag lengths of the variables for the wheat model are ARDL (1, 3, 3, 0). The bounds test for wheat is presented in Table 4.8, which confirms the existence of a long-run relationship between CPI wheat, STU, global wheat price, and the import duty dummy for both Model 1 and Model 2.

**Table 4.8**

*Bounds Tests for Cointegration for Wheat*

| *Model 1* | | *Model 2* | |
|---|---|---|---|
| F-stat | t-stat | F-stat | t-stat |
| 16.82* | -2.36* | 17.08* | -2.77* |

*Notes*: The F-statistic tests for the joint significance of the coefficients of the lagged levels in the ARDL-ECM. The t-statistic is used to test for the significance of the coefficient of the lagged dependent variable. All test statistics are significant at the 10 per cent level.

*Source*: Authors' calculation.

The results (Table 4.9) indicate a statistically significant and negative relationship between the STU of wheat and CPI of wheat. A 1 per cent increase in STU can lead to a decrease in CPI wheat by 1.29 per cent in Model 1 in the long run. However, controlling for other variables, the coefficient value of STU without OMSS is substantially lower. Unlike rice, in the case of wheat, OMSS operations significantly impact wheat inflation.

Other important variables impacting wheat inflation include the global price of wheat and import duty on wheat. A 1 per cent increase in the global price of wheat can increase CPI by 2.8 per cent. Various instruments, such as export restrictions and tariffs implemented by major producers, significantly influence global prices. For example, when countries like India or Russia impose export restrictions, it can create supply shortages in the international market, leading to an increase in prices, which impacts domestic prices in residual market even after goverment interventions. In trade policy, if the import duty is less than or equal to 10 per cent, the CPI of wheat reduces by 0.89 per cent compared to months when the import duty was more than 10 per cent.

The ECM term is negative and statistically significant, indicating convergence. The coefficient suggests that 1 per cent of the disequilibrium (deviation from equilibrium) is corrected within a month. In the short run, the estimates depict that STU with OMSS and the global price of wheat significantly impact CPI wheat at the first level of difference. The diagnostic tests for the ARDL model are satisfactory, and the models are stable as per the CUSUM test (see Annexure Table A4.3).

**Table 4.9**

*ARDL Estimation Results for Wheat*

| Model 1<br>Dependent Variable: Log CPI Wheat other sources<br>ARDL (1,3,3,0)<br>Sample Period: April 2011 to March 2024 | | | Model 2<br>Dependent Variable: Log CPI Wheat other sources<br>ARDL (1,3,3,0)<br>Sample Period: April 2011 to March 2024 | | |
|---|---|---|---|---|---|
| *Variables* | *Coefficient* | *Std. Error* | *Variables* | *Coefficient* | *Std. Error* |
| **Long run coefficient** | | | **Long run coefficient** | | |
| STU with OMSS | -1.460** | 0.646 | STU without OMSS | -0.933** | 0.32 |
| Ln Global Price of Wheat | 2.810** | 1.345 | Ln Global Price of Wheat | 2.26** | 0.88 |
| Import duty dummy | -0.898* | 0.493 | Import duty dummy | -0.70** | 0.33 |
| **ECM** | -0.014** | 0.005 | **ECM** | -0.014** | 0.005 |
| **Short run coefficient** | | | **Short run coefficient** | | |

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| | | | | | |
|---|---|---|---|---|---|
| ΔSTU with OMSS | -0.016* | 0.002 | ΔSTU without OMSS | -0.015*** | 0.001 |
| ΔSTU with OMSS (-1) | -0.002 | 0.788 | ΔSTU without OMSS (- 1) | -.004 | .788 |
| ΔSTU with OMSS (-2) | -0.001 | 0.441 | ΔSTU without OMSS (- 2) | -.001 | .441 |
| ΔLn Global Price of Wheat | 0.074* | 0.033 | ΔLn Global Price of Wheat | 0.085** | 0.008 |
| ΔLn Global Price of Wheat (- 1) | -0.014 | 0.736 | ΔLn Global Price of Wheat (- 1) | -0.016 | 0.681 |
| ΔLn Global Price of Wheat (- 2) | -0.028 | 0.398 | ΔLn Global Price of Wheat (- 2) | -.0313 | 0.322 |
| Intercept | -0.138* | 0.01 | Intercept | -0.076** | 0.034 |
| N | 154 | | N | 154 | |
| R-squared | 0.73 | | R-squared | 0.75 | |
| Adj-R squared | 0.70 | | Adj-R squared | 0.73 | |
| RMSE | 0.0118 | | RMSE | 0.011 | |
| Bound test (f-test stat) | 12.904 | | Bound test (f-test stat) | 11.916 | |
| Breusch Godfrey test (Chi square) | 5.015 (0.03) | | Breusch Godfrey test (Chi square) | 5.018 (0.03) | |
| Portmanteau's test for white noise | 0.30 (0.58*) | | Portmanteau's test for white noise | 0.28(0.59*) | |
| *** p<0.01, ** p<0.05, * p<0.10 | | | | | |

*Note*: Figure in parentheses for Breusch-Godfrey LM test for autocorrelation ($H_0$: no serial correlation) and Portmanteau's test for white noise ($H_0$: series are white noise) indicates p-values.

*Source*: Authors' estimation.

## 4.8 Inflation Forecasts of Rice and Wheat

In this study, we forecast inflation for rice and wheat over a 12-month horizon using time series-based univariate and multivariate models. This approach follows the literature and incorporates balance sheet variables found significant in the ARDL model. A deeper understanding of the dynamics and trends in cereal inflation is imperative in economic policy, given its significant impact on overall food inflation. Rice and wheat products contribute substantially to food prices, and fluctuations in these commodities' prices can have cascading effects on consumers and their purchasing power. While structural models like ARDL capture price dynamics, they do not perform well in forecasting, as observed in this study. We generated out-of-sample forecasts and evaluated them against actual inflation.

The RMSE of each forecasting model is evaluated for the full sample. In the "Full Sample Forecast Evaluation", we computed RMSEs for 2-, 4-, 6-, 8-, 10-, and 12-month horizons, starting from October 2011 to September 2023 for rice, and from April 2011 to March 2024 for wheat (Table 4.10).

**Table 4.10**

*Forecasting Performance of Various Models for Rice and Wheat (RMSE in per cent) over Different Horizons (Full Sample)*

| *Wheat* | *2 months* | *4 months* | *6months* | *8months* | *10 months* | *12months* |
|---|---|---|---|---|---|---|
| SARIMAX | 4.0 | 2.9 | 2.5 | 2.2 | 1.9 | 2 |
| SARIMA | 6.1 | 5.3 | 3.7 | 3.3 | 3.0 | 2.0 |
| *Rice* | *2 months* | *4 months* | *6months* | *8months* | *10 months* | *12months* |
| SARIMAX | 4.2 | 3.3 | 2.9 | 2.6 | 2.3 | 2.4 |
| SARIMA | 6.3 | 6.0 | 5.5 | 3.4 | 3.1 | 2.9 |

*Note*: The highlighted cell in each column in the table indicates the best-performing individual model for the relevant forecast horizon.

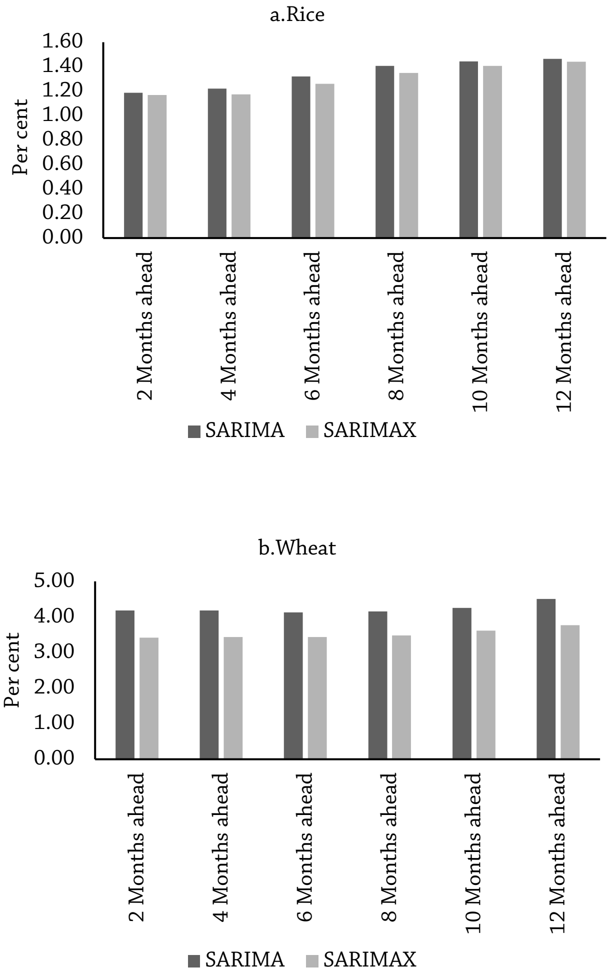
*Source*: Authors' estimation.

For rice and wheat, the "Full Sample Forecast Evaluation" reveals that the SARIMAX model consistently demonstrates lower error rates than the SARIMA model across all horizons. The SARIMAX model for rice incorporates an exogenous variable, STU, which includes OMSS. Similarly, for wheat, the performance evaluation indicates that SARIMAX outperforms the univariate SARIMA model across all horizons.

To assess the accuracy of these forecasting models, we employed a rolling window approach (with a 60-month moving data window) for the full sample period from October 2011 to September 2023 for rice, and from April 2011 to March 2024 for wheat, comparing forecasts against the actual CPI for these commodities. The analysis compares the univariate SARIMA model with the multivariate SARIMAX model that uses the balance sheet variable STU with OMSS for rice and wheat. The rolling window forecasts confirmed that SARIMAX consistently outperforms the SARIMA model across all horizons (Figure 4.20).

**Figure 4.20**

*Rolling Window (60 Months) Forecast Comparison for Rice and Wheat based on RMSE (per cent)*




*Source*: Authors' estimation.

## 4.9 Conclusion and Policy Recommendations for Cereals

Cereals, particularly rice and wheat, are crucial in the Indian context as essential daily staples. A significant portion of the population relies on cereals as their primary source of sustenance, making them integral to the nation's food security. The Minimum Support Price (MSP) regime plays a crucial role in ensuring assured income for farmers cultivating cereals. This mechanism provides a safety net, stabilising incomes and incentivising production, contributing to food security and economic stability. The post-COVID era has witnessed a surge in inflation and increased volatility in essential commodities, including cereals, posing a significant concern for Indian policymakers, with cereals having the highest weight of 9.67 per cent within the food category.

This study adopts an empirical approach to identify the driving factors behind cereal inflation and enhance predictive models for a 12-month horizon. Employing structural models, the research constructs a dynamic monthly balance sheet to evaluate real-time demand-supply dynamics for cereals. Metrics such as the STU ratio are computed using secondary data and insights from stakeholders in the cereal value chain.

The ARDL model reveals that the balance sheet variable plays a substantial role in influencing rice and wheat inflation. In light of these findings, accurate forecasting gains paramount importance for effective policymaking, recognising the pivotal role of cereal inflation in driving overall headline inflation in India. The study proposes forecasting models, including time-series-based univariate and multivariate approaches, integrating the significant availability variable derived from the balance sheet. The empirical evaluation suggests that incorporating the balance sheet availability/stock variable, as in the SARIMAX model, enhances forecasting performance across various time horizons.

### *Policy Recommendations*

The chapter has outlined several steps the government has taken to control inflation, including stabilising prices to promote food security for the poor, while simultaneously protecting farmers from bankruptcy during periods of precipitous price falls. Direct and temporary quantitative interventions are only employed when supply shocks reach extreme levels. The government adheres to a clearly articulated and transparent price stabilisation policy, primarily relying on a variable tariffs policy.

In the next section, based on our findings, we provide short-term and medium-to-long-term key recommendations to tame cereal inflation and improve the efficacy of the cereal value chain.

### *Short-Term Measures*

#### Tweaking Trade and Buffer Stocking Policies to Curb Cereal Inflation

In the short run, a calibrated trade policy can efficiently control rising cereal inflation. However, in response to cereal inflation during the 2022–23 period, the central government implemented protectionist trade policies, including a sudden export ban on wheat on 13 May, later extending to wheat flour on 25 August 2022. The objective was to raise domestic availability and mitigate inflationary pressures. However, these export bans proved ineffective in curbing wheat inflation, which surged to 25.4 per cent by February 2023, just before the harvest season. Our ARDL results show that there was no statistically significant impact of the export ban on taming rice inflation. Instead, the policy should have focused on addressing the market perception of wheat production through transparency and communication regarding government production estimates. Additionally, a reduction in the import duty on wheat, ideally from 40 per cent to 10 per cent, or even complete removal, can help tame wheat inflation. The ARDL model for wheat indicates that when the import duty is set to 10 per cent or lower, it significantly reduces wheat inflation. During periods of high inflation, importing around 5–6 MMT could be considered; however, the timing should not coincide with procurement, as it may adversely impact farmers' price realisation. Importing after the procurement season can help manage inflationary expectations, especially during the peak festive seasons (October to December) (Gulati et al., 2023).

Apart from wheat, the government, in September 2022, imposed a ban on the export of broken rice and levied a 20 per cent export duty on non-Basmati rice to augment domestic supplies. Subsequently, in July 2023, an export ban was imposed on non-Basmati white rice, along with a 20 per cent export duty on parboiled rice. Furthermore, in August 2023, a Minimum Export Price (MEP) of $1,200 per tonne was set for Basmati rice. According to traders, the MEP fixed is much higher than existing price quotations, impacting the competitiveness of India's Basmati rice in the global market. It is important to recognise that it takes years to build export markets, and sudden policy shifts like this can undermine India's reputation as a reliable exporter. Besides restricting exports to increase domestic supply, rice is being offloaded under OMSS (below economic cost) as an added measure to cool down rice prices. Thus, the policy approach is similar to that for wheat, although rice buffer stocks are in a comfortable position, being three times the buffer stocking norm as of 1 July 2023.

A prudent policy approach would have involved initially imposing a moderate export duty, ranging from 10 to 15 per cent, and later adjusting it gradually to gauge its impact on domestic prices. According to traders, the MEP set is considerably higher than existing price quotations, adversely affecting the competitiveness of India's Basmati rice in the global market. It's crucial to acknowledge that building export markets is a time-consuming process, and abrupt policy shifts can undermine India's reputation as a reliable exporter. In addition to restricting exports to boost domestic supply, rice is being offloaded under the OMSS at below economic cost to alleviate rice prices (Gulati et al., 2023).

These sudden bans on staples and essential commodities impact international rice prices and jeopardise the food security of countries dependent on Indian food exports. Adopting a stable and open export policy would provide an opportunity to secure better prices in the global market, thereby encouraging farmers to enhance productivity. During a surge in international prices, a liberal and consistent trade policy would help exporters plan effectively and contribute to the efficiency of the value chain by providing avenues to earn better remuneration.

### *Developing Cereal Futures for Optimal Price Discovery*

Introducing a cereal futures market, along with a competitive spot market, can help policymakers, farmers, traders, consumers, and the government make informed decisions on resource allocation for production and marketing, and take appropriate actions to mitigate risks associated with temporary shocks to foodgrain availability. A well-regulated foodgrain futures market will facilitate the delivery of required volumes and quality precisely where and when needed, with minimal marketing margins. This setup would ensure that producers receive attractive prices while consumers benefit from affordable prices. Additionally, it can serve as a catalyst for the adoption of electronic Negotiable Warehouse Receipts (e-NWR), helping farmers gain better access to financial credit for their produce. This could provide farmers with a system whereby their stored produce serves as collateral and can be sold or traded. With e-NWR, farmers need not sell their produce immediately after harvest and can store it, receiving a receipt from the warehouse that can be used for short-term borrowing to obtain working capital.

### *Medium- to Long-Term Measures*

#### Strengthening the Cereal Value Chain for Efficiency through Market Reforms

Coordination throughout the value chain could be strengthened by developing local markets and recognising the pivotal role of the private sector, including cooperatives and traders. Interventions to connect smallholder production with value-added food markets should encompass a market information collection and dissemination system. This should be implemented through a pluralistic and integrated strategy that seamlessly integrates marketing and value chain aspects. A public-private partnership insurance scheme could provide protection to crop farmers against various risks, such as disasters and the impacts of climate change. Establishing a facilitative regulatory environment for marketing, processing products, and ensuring food safety standards is crucial.

Reforms are needed in agricultural marketing, particularly in foodgrain marketing. The Government of India has introduced a model APMC Act that allows for contract farming, private investments in wholesale markets, and direct marketing between buyers and sellers. It is important to empower the private sector to handle the procurement and distribution of foodgrains. Public intervention should be redirected to areas where it is most needed. Private marketing can be reinforced through reform of the APMC Act, the abolition of the ECA, permission for direct purchases from farmers, elimination of movement and storage controls, facilitation of warehouse receipts, strengthening of futures markets, and opening up imports and exports to the private sector. Enhancing the efficiency of the FCI by fostering competition with the private sector on a level playing field is crucial. A gradual downsizing of the FCI should be considered, particularly in surplus states like Punjab, where FCI operations have ceased to yield benefits. Reorienting FCI operations toward eastern states, where public support for market development is required, could be a strategic move. Public procurement to meet PDS requirements and buffer stock needs should prioritise sourcing from eastern states, leveraging their immense potential and cost advantages in rice cultivation (Kumar et al., 2007).

Losses at different stages of the cereal value chain, from farm to storage, may impact per capita availability. At the storage level, especially for FCI and large private traders, there is a need to invest heavily in bulk storage through the use of steel silos and to move away from conventional covered warehouses. The advantages of employing steel silos are clear, as they incur minimal losses during storage and transit. Silos require only one-third of the space needed by conventional warehouses to achieve the same storage capacity. Labour costs are also reduced compared to conventional storage methods. Regulatory standards should be refined to minimise existing transit losses when transporting grains from silos to other state storage facilities.

### Reforming Food Safety Net Programmes

India has been providing subsidised food grains to approximately two-thirds of the country's population (800 million people) under the NFSA 2013. Beneficiaries of the PDS are entitled to 5 kilograms per person per month of cereals (rice at Rs.3 per kg and wheat at Rs.2 per kg). However, food-based safety nets account for a large chunk (5.1 per cent) of total budgetary expenditure in FY 2024, creating a pressing need for reforms and a reshuffling of their fiscal outlay to make a significant impact on nutritional outcomes. The in-built provision under the NFSA 2013 could be utilised to reform and provide states and households with a choice-based system to opt between subsidised food grains or conditional cash transfers. A centralised system could provide vouchers (inflation-indexed cash entitlements) distributed through the existing network of PDS outlets, granting beneficiaries greater autonomy to decide on their diverse diet plans according to their consumption needs. Transitioning from physical entitlements, such as those under the PDS, to food vouchers would improve the overall efficiency of the foodgrain management system and enhance welfare. This would reduce the size of public distribution, as well as the need for public procurement and storage, and limit public intervention in grain markets overall.

Another option could involve direct income transfers, enabling the poor to buy from the market at market prices the bundle of commodities they prefer. These mechanisms would not distort the market, have minimal or no effect on price determination, and would not crowd out private sector investments, while helping reduce post-harvest losses in marketing channels.

### Pricing Policy Reforms

The open-ended procurement at MSP is the government's foodgrain pricing policy, ensuring that market prices do not fall below a certain level. Studies have shown that this policy is not compatible with a liberal, market-friendly economic policy regime. Furthermore, domestic rice prices are driven by substantial hikes in MSP, especially for rice. The government should move away from providing income support to farmers through procurement at MSP by the FCI and should adopt crop-neutral pricing policies for agricultural diversification, based on market signals regarding demand and supply conditions. Price support should only be provided to farmers in the event of a precipitous fall in prices, at a level adequate to recover variable input costs.

### Investing in Research and Development to Improve Productivity and Climate Resilience

Cereal production in India has become increasingly susceptible to losses due to high temperatures resulting from climate change. Shortfalls in rice and wheat productivity could have cascading implications for global and domestic food security, potentially impacting India's substantial buffer stock reserves. Cereal productivity in India has also shown signs of stagnation over the years, lagging behind East Asian countries despite being the second-largest producer globally. Investments in high-yielding varieties are essential to enhance crop yields.

Among the major wheat- and rice-producing states, the short turnaround time between rice harvest and wheat planting, coupled with farmers' inclination for excessive preparatory tillage, tends to delay wheat planting.[38] This results in yield losses, with significant impacts noted in northwest India and other regions. The conventional cultivation system for the Rice-Wheat Cropping System has led to environmental challenges, including stubble burning. Agricultural mechanisation is necessary to reduce the cost of production and may contribute to lower cereal retail prices. Transitioning from manual harvesting to the use of powered reapers, threshers, and combine harvesters can be cost-effective.

Breeding wheat for high-temperature tolerance is essential for boosting production. The government should promote the use of heat-resistant varieties among farmers through public-private partnerships and provide seeds directly to farmers on a large scale. Wheat varieties like DBW187 and DBW222 have demonstrated superiority over HD-3086 in terms of heat tolerance[39] (MoA&FW, 2022).

38. Excessive preparatory tillage primarily delays wheat planting, resulting in yield losses of 32 kg $ha^{-1}$ $day^{-1}$ when planted after 15 November in northwest India, and even as high as 35 kg $ha^{-1}day^{-1}$ in other regions of the country (Tripathi et al., 2005).

39. During the crop season 2021–22, the varieties DBW187 and DBW222 have shown heat tolerance, with yield gains of 3.6 per cent and 5.4 per cent, respectively, compared to HD-3086 (MoA&FW, 2022).

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## 4.11 Annexure

**Table A4.1**

*Crop Calendar for Paddy and wheat*

| *States* | *Jan* | *Feb* | *Mar* | *Apr* | *May* | *Jun* | *July* | *Aug* | *Sept* | *Oct* | *Nov* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Kharif Paddy* | | | | | | | | | | | |
| WB | | | | ■ | ■ | | | ▨ | ▨ | ▨ | ▨ |
| UP | | | | | | ■ | ■ | | ▨ | ▨ | ▨ |
| PN | | | | | ■ | ■ | | | | ▨ | ▨ |
| *Wheat* | | | | | | | | | | | |
| UP | ■ | | ▨ | ▨ | | | | | | | ■ |
| PN | | | | | ▨ | ▨ | | | | ■ | ■ |
| MP | | ▨ | ▨ | | | | | | | | ■ |

*Note*: ■ is the sowing months and ▨ is the harvest months

*Source*: Agricultural Statistics at Glance, 2022

**Table A4.2**

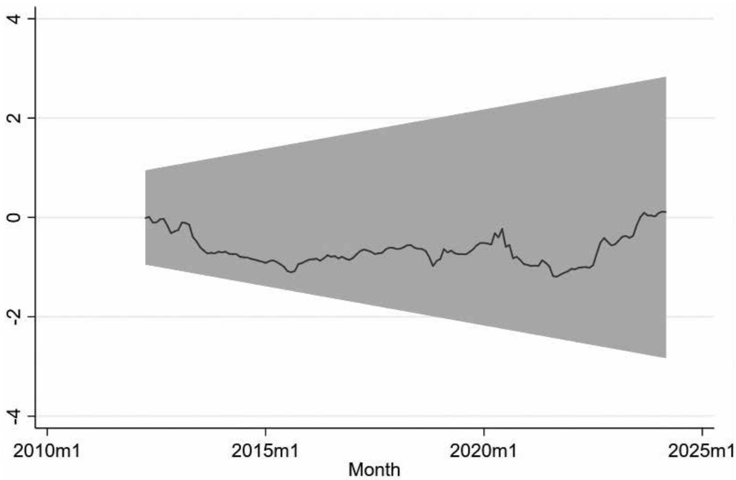
*Description of the Variables and Sources for Regression Analysis*

| *Variables* | *Description* | *Sources* |
|---|---|---|
| **Rice** | | |
| Log_CPI_Rice | Log of Seasonally adjusted CPI index for rice | NSO, MOSPI |
| STU with OMSS<br>STU without OMSS | The stock-to-usage ratio derived from the balance sheet in a particular month. Model 1 uses STU with OMSS offloading of rice in the open market and Model 2 uses STU without OMSS to assess the role of OMSS to tame inflation of rice. | Computed using Rice Balance sheet |
| Export ban dummy | Takes the value for export bans in Rice ARDL regression model as 1 and 0 otherwise. | DGFT |
| **Wheat** | | |
| Log_CPI_Wheat | Log of seasonally adjusted CPI index for wheat | NSO, MOSPI |
| STU with/without OMSS | The stock-to-usage ratio derived from the balance sheet in a particular month. Model 1 uses STU with OMSS offloading of wheat in the open market and Model 2 uses STU without OMSS to assess the role of OMSS to tame inflation of wheat. | Computed using wheat Balance sheet, monthly data on OMSS from FCI reports. |
| Wheat import duty | The monthly series of import duty have been used to compute the dummy which takes the value 0 for import duty less than 10 and 1 if duty is more than 10. | DGFT |

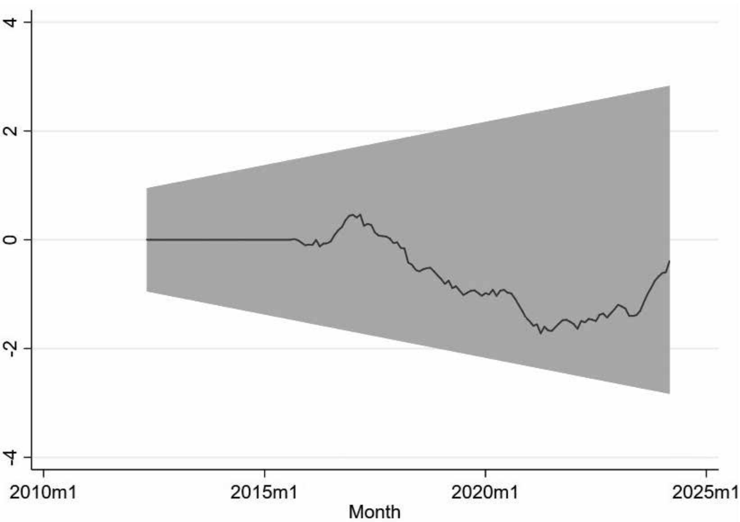
**Figure A4.3**

*CUSUM test for Rice and Wheat*

a. Rice




b. Wheat




*Source*: Author's Estimation from ARDL models

# 5

SHYMA JOSE, SANCHIT GUPTA, MANISH KUMAR PRASAD, SANDIP DAS, ASISH THOMAS GEORGE, THANGZASON SONNA, D. SUGANTHI and ASHOK GULATI

## Pulse Inflation in India

*A Study of Gram, Tur and Moong*[39]

### 5.1 Introduction

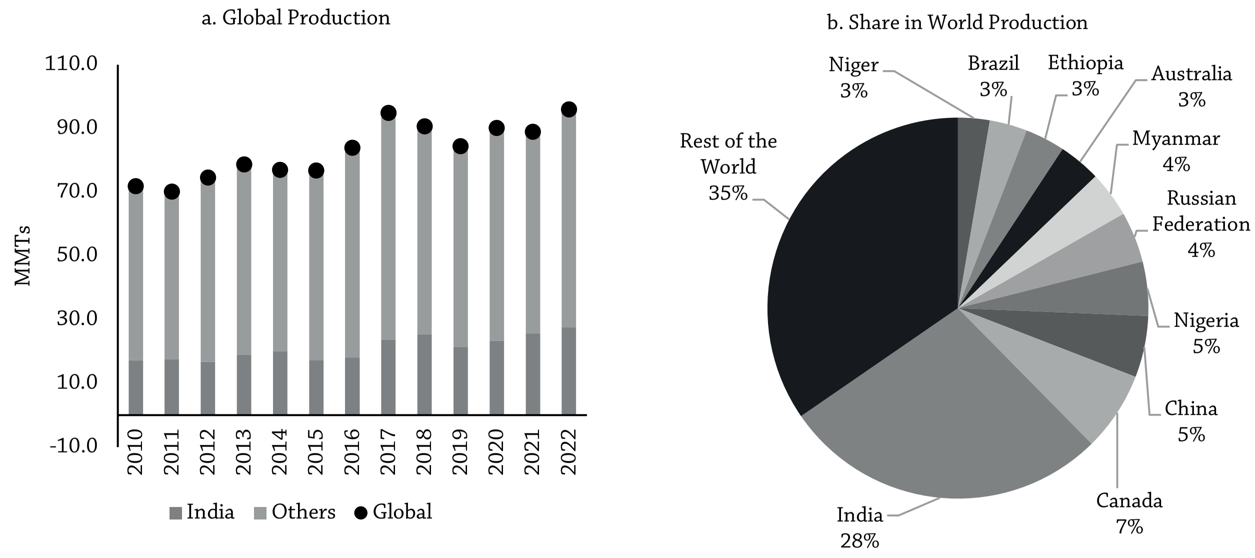
Pulses are one of the most volatile and price sensitive items in food and understanding their price inflation is critical. Pulses are an affordable dietary protein source in the country. Recent years, have witnessed spikes in their prices due to demand-supply gap leading to large imports. India is the largest producer of pulses, accounting for a quarter of the global pulses production (FAOSTAT) (Figure 5.1)[40] and the largest consumer of pulses (with a share of 27 per cent of world consumption (Mohanty and Satyasai, 2015). The demand for pulses has risen considerably in recent years (Abraham and Pingali, 2021; Rampal, 2017 and John et al., 2021). The total pulses consumption increased from 705 grams per capita per month to 783 grams per capita per month in the rural areas and from 824 grams to 901 grams per capita per month in the urban areas between 2004-05 and 2011-

39. This study is part of a joint research project titled "Understanding Price Dynamics of Major Agricultural Commodities and Identifying Ways to Improve Value Chains", conducted by the Reserve Bank of India (RBI) and the Indian Council for Research on International Economic Relations (ICRIER). The findings are published as an RBI Working Paper, available at https://rbi.org.in/Scripts/PublicationsView.aspx?id=22722

40. In 2022, the global production of pulses was about 96 MMTs and India contributed about 27.7 MMTs (about 26 per cent) (FAOSTAT 2022).

**Figure 5.1**

*Global vis-à-vis Domestic Production of Pulses in Triennium Ending (TE) 2022*




*Note*: Data are in calendar years.

*Source*: FAOSTAT.

12 as per the National Sample Survey Office (NSSO) (GoI, 2012)[41]. The estimated price elasticity of pulses varies from (-)0.70 for poor households to (-)0.35 for high income households, with an average value of (-) 0.46 that implies that in the case of a rise in prices, pulses consumption would decline, and poorer households could be adversely affected (Kumar, 2017).

For many years, the domestic pulses production remained inadequate compared to annual consumption, leading to recurring shortages met by imports. India was the largest importer of pulses, accounting for 13 per cent of the total global imports in TE 2022 (2.5 MMT) as per the latest FAOSTAT. Canada, Myanmar, USA, Russia and Australia are the major pulses exporters to India. In TE 2022-23, pulses imports were more than 9 per cent of the domestic production and the share had touched more than 35 per cent of the production during 2015-16 when domestic pulses production had declined to 16.3 MMT (See Annexure A5.1).

Pulses are grown in both *rabi* and *kharif* seasons. During TE 2023-24, *rabi* pulses contributed around 67 per cent of the total pulses production (as per the second advance estimates (SAE) of 2023-24). Among the major varieties, gram and lentil (masur) are exclusively *rabi* varieties, and *tur* is an exclusive *kharif* variety. Pulses require limited water and most of the area under pulses is rainfed[42] and contributes to improved soil quality through nitrogen fixing.

In the TE 2023-24, eight states – Madhya Pradesh, Rajasthan, Maharashtra, Uttar Pradesh, Karnataka, Andhra Pradesh, Gujarat and Jharkhand - contributed close to 90 per cent of the total pulses production in the country. In terms of yield, there has been progress between TE 2000-01 and TE 2023-24 from 0.56 to 0.90 tonnes per hectare (tonnes per ha). There are wide variations in yield across states. Against the country's average yield of 0.90 tonnes per ha in TE 2023-24, the top three states in terms of output – Madhya Pradesh,

41. NSSO released the factsheet for the Household Consumption Expenditure Survey (HCES) 2022-23 in February 2024. However, the detailed unit level data was released in June 2024 after the completion of the study.

42. Most *kharif* pulses like urad and *moong* have shallow root zones, while *tur* has slightly deeper rooting, which makes it tough enough to withstand droughts (SANDRP, 2015).

Rajasthan and Maharashtra (contributed more than 55 per cent of the total production of pulses) have a yield of 1.12 tonnes per ha, 0.66 tonnes per ha and 0.93 tonnes per ha, respectively.

Of all the pulses grown in India, gram (*chana*/chickpea) has the largest share in total production (49.5 per cent in TE 2023-24) followed by *tur* (14.1 per cent). Gram comes in several varieties, with the garbanzo bean (referred to as *kabuli chana* in India) is commonly found worldwide. Another type of gram produced in India, referred to as Bengal gram or *desi chana*, accounts for about 80 per cent of Indian gram production.[43] Madhya Pradesh, Maharashtra and Rajasthan contributed more than 65 per cent of the total gram production in TE 2023-24. Gram is mostly inter-cropped with mustard, sunflower, wheat, linseed and coriander.

The second important pulse, *tur* also referred to as pigeon pea is a *kharif* crop with a crop cycle of 160 to 180 days. *Tur* is grown under rainfed conditions in Maharashtra, Karnataka, Uttar Pradesh, Gujarat, Madhya Pradesh, Jharkhand and Telangana. *Tur* is mostly intercropped with cereals (sorghum, millets and maize), oilseeds, short-duration grain legumes (pulses) or cotton. Although India produced 3.6 million tonnes of *tur* annually in TE 2023-24, around 20 per cent of the domestic demand for *tur* were met through imports, mostly from Mozambique, Malawi and Myanmar.

*Moong* is the third important variety of pulses grown, accounting for 10.7 per cent of the total production in TE 2023-24 as per the SAE for 2023-24.[44] The crop is grown with maize, pearl millet, pigeon pea and cotton. *Moong* varieties are grown in three seasons – *kharif*, *rabi* and summer. Being a short duration crop, *moong* is suitable for crop rotations and is produced in Rajasthan, Madhya Pradesh, Maharashtra and Karnataka. Being a rainfed crop, *moong* and gram induce a degree of variance in its production in each state.

The distribution channels for raw pulses encompass both institutional and non-institutional avenues. These avenues encompass direct transactions between farmers and traders/processors, farmers

43. https://nipgr.ac.in/NGCPCG/Breedingsper cent20ofper cent20Chickpea.html

44. The SAE for 2023-24 does not include summer crop for *Moong*. In TE 2022-23, share of *moong* in total pulses production was 12.6 per cent.

selling their produce to traders/processors at mandis (local markets), and procurement activities executed by the farmers' cooperatives as well as NAFED. Non-institutional channels involve intermediaries, such as traders, wholesalers, commission agents, millers, and retailers. Over the years, the government has undertaken different strategies to manage domestic supplies of pulses and contain pulses inflation that includes augmenting supply by raising production incentives under programs like the National Food Security Mission (NFSM), incentivising domestic production by raising MSPs, creating a buffer stock of pulses by undertaking procurement of different pulses. This is later offloaded in the markets to contain price pressures; invoking the ECA and imposing stocking limits on pulses, and manoeuvring the trade policy while ensuring continued remunerative prices for farmers.

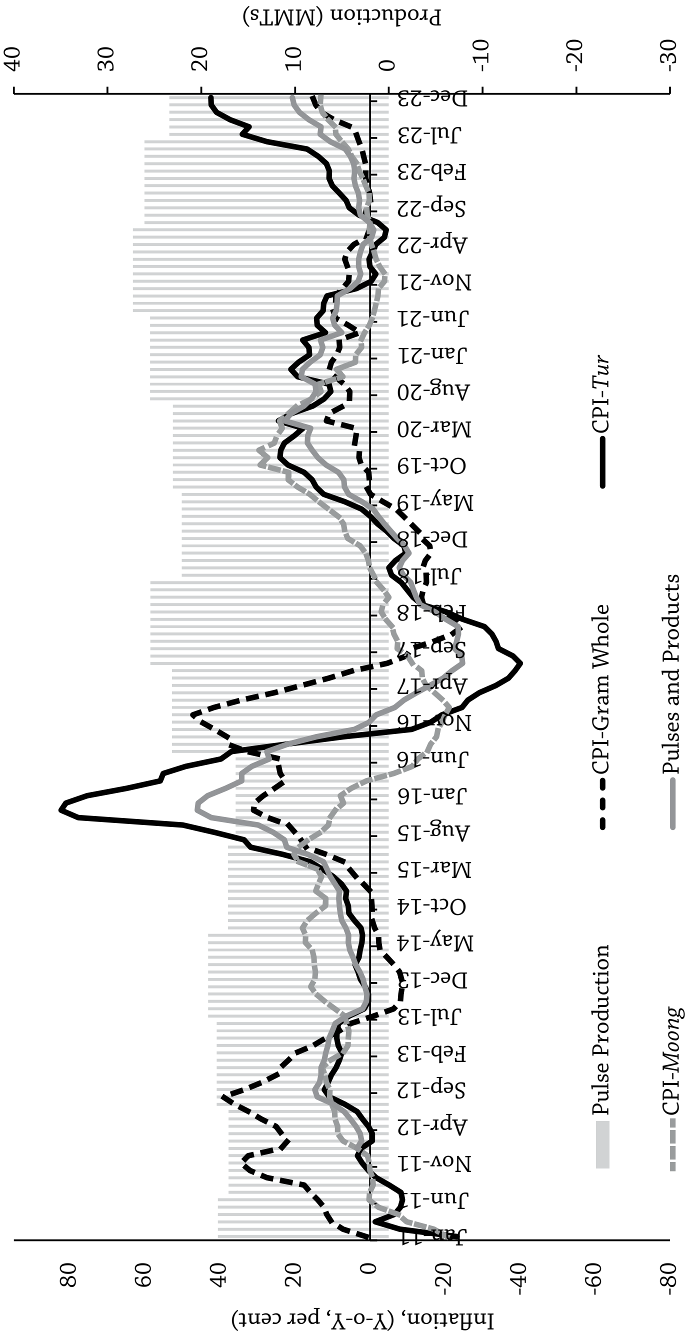
This study, therefore, aims to contribute to the existing literature on pulses inflation but also help deepen the understanding of pulses price dynamics with the view to strengthen short-term inflation forecasts of three major pulses (*tur*, gram and *moong*). This requires a comprehensive approach taking into account factors that affect the demand for and supply of pulses. Therefore, the study aims to build monthly balance sheets for each of the three pulses to capture the whole gamut of factors – supply and availability with all the processes involved like area sown, production, harvests and arrivals, climatic conditions, wastages and losses, imports, and seasonality on one hand, and consumption requirement of households, income, market dynamics, value chain and role of intermediaries and their behaviour on the other.

## 5.2 Stylised Facts about Pulses Inflation: Policy Measures and Price Behaviour

Over the last decade, pulses prices registered high volatility despite numerous supply management measures taken by the government to increase its availability in the country. During 2014-15 and 2015-16, India witnessed poor pulses production due to adverse weather conditions. Pulses inflation peaked registering Year-on-Year (Y-o-Y) inflation of about 46 per cent during November-

**Figure 5.2**

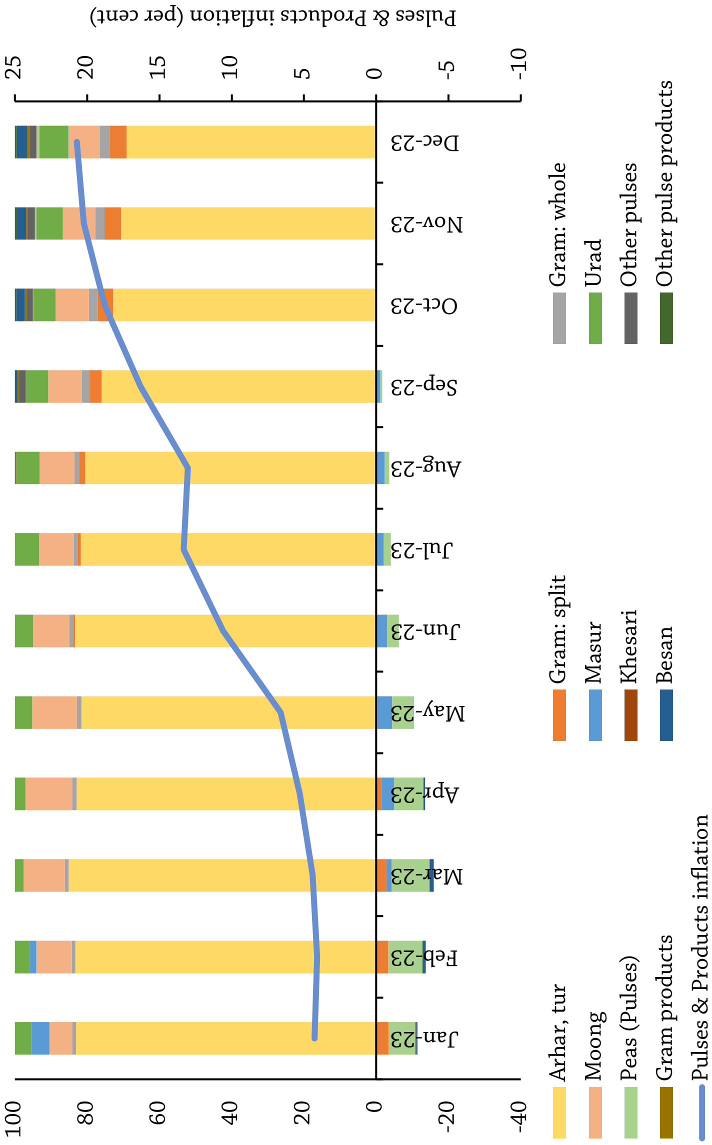
*CPI Inflation in Pulses and Pulses Production*




*Sources*: NSO, MoSPI, GoI and DES, Ministry of Agriculture and Farmers' Welfare, GoI.

**Figure 5.3**

*Pulses Inflation and its Contributors*




*Sources*: MoSPI, GoI and Authors' estimates.

December 2015. Inflation in *tur* rose to 82 per cent in November 2015 and gram-whole to 47 per cent in December 2016 (Figure 5.2). There has been significant moderation thereafter. This is attributed to augmentation in production and imports and increased scale of government intervention, particularly, procurement and disposal of pulses through NAFED. Even as government intervention assumed an increasing role, supply chain disruption due to COVID-19 outbreak and fluctuations in availability – domestic and imports lead to volatility in pulses inflation.

Recently, the pulses inflation has been increasing from January 2023, reaching 21 per cent in December 2023. Within the group, *tur* has been the major contributor to pulses inflation during the same period (Figure 5.3).

Typically, in a year, prices of a crop fall during harvest and rise a few months before the arrival of the new crop (as the stocks plummet to their lowest at that time). Figure 5.4 shows seasonality factors in the CPI of the three selected pulses estimates using the U.S. Census Bureau's X-13 seasonal adjustment procedures. The seasonality factors have been averaged over the last decade based on the crop year of gram, *tur* and *moong*. During the last decade, the CPI in gram whole has a trough around April, with the peak around November. In case of *tur*, CPI trough is around March; the prices increase around April to June with a slight stagnancy around June-July, before increasing further till October-November.

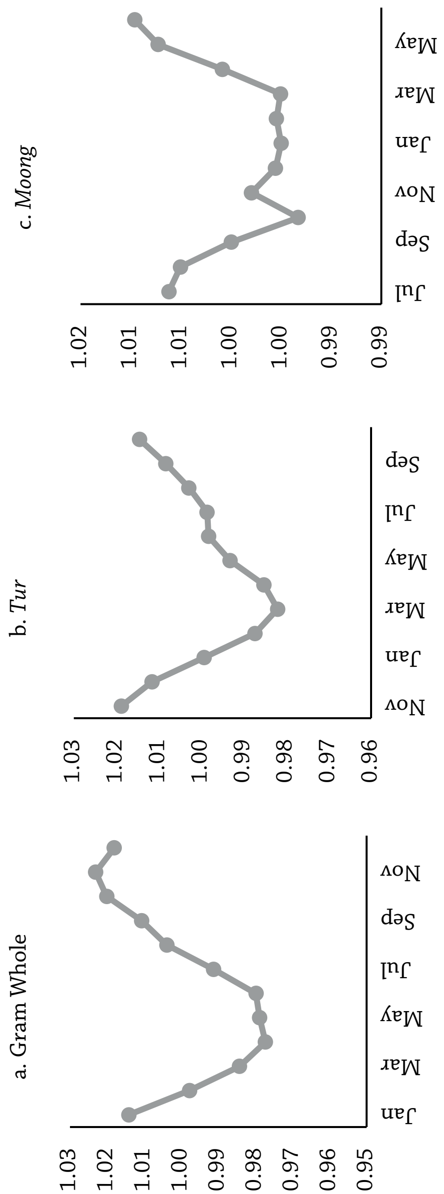
The *moong* crop is sown thrice a year, twice during *kharif* and once during *rabi* season. The *kharif* crop is sown during June to July and the *rabi* crop in September/October. The summer crop is sown during April. The harvesting of *moong* starts from August to December. *Moong* CPI tends to trough around September to March. The prices begin to rise marginally thereafter, reaching peak levels in June, right before the start of the next crop.

## 5.3 Role of Government Supply Management Measures in Containing Pulses Inflation

Over the years, the government has undertaken a pro-active strategy to augment domestic supplies of pulses and contain pulses inflation, which includes:

**Figure 5.4**

*Seasonality of CPI in Selected Pulses by Crop Year (January 2010 to December 2022) (Seasonal Factors)*




*Sources:* MoSPI, GoI and Authors' estimates.

(i) Incentives by raising production under programs like National Food Security Mission (NFSM);

(ii) Creating a buffer stock of pulses by undertaking procurement of different pulses, later offloaded into markets to contain price pressures;

(iii) Gradual liberalisation of import policy like bringing down applicable import tariff for some pulses, and bringing some pulses under OGL;

(iv) Invoking provisions of ECA like reporting of stock holdings, stock holding period, and imposing stocking limits on pulses from time to time; and

(v) Signing Memorandum of Understanding (MoU) with countries that are sources of imports.

The Government has been making continuous efforts to give a boost to domestic production and achieve domestic self-sufficiency in pulses. In 2007-08, GoI launched the NFSM to increase acreage under pulses cultivation. The area under pulses increased from 23.6 million hectares to 25.8 million hectares between 2007-08 and 2023-24. India's pulses production has risen consistently from 14.8 MMT in 2007-08 to 23.4 MMT in 2023-24 (as per SAE) while that of gram rose from 5.7 MMT in 2007-08 to 12.1 MMT in 2023-24 and *tur* from 3.1 MMT to 3.3 MMT. For *moong*, production increased from 1.5 MMT to 3.7 MMT in 2022-23.[45]

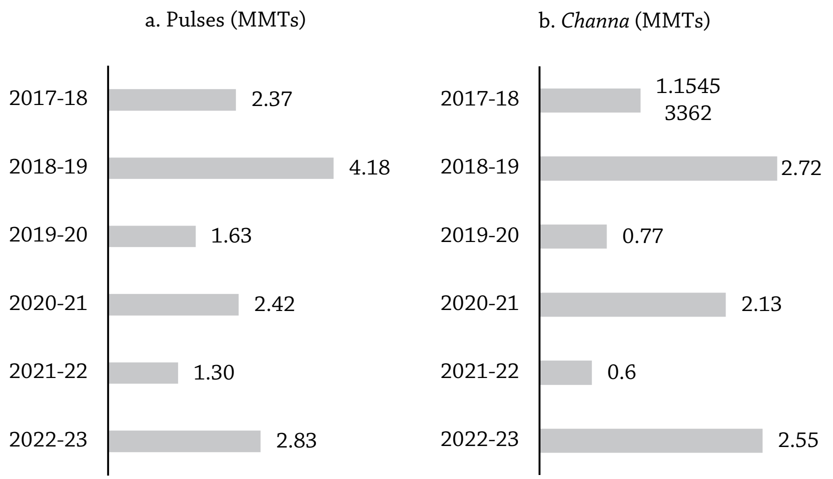
The government procures pulses at MSP and declares remunerative MSPs each year to incentivise farmers. As of 2023-24, *moong* had the highest MSP of Rs. 85.6 per kg, followed by *tur's* MSP of Rs. 70 per kg, while gram had the lowest MSP at Rs.54.4 per kg (see Annexure 5.2). When prices of pulses rose sharply during 2015-16, the government decided to create a buffer stock of two million tonnes of pulses to be held by NAFED under the Price Stabilisation Fund (PSF) (MoCAFPD, 2016). NAFED carries out procurement of pulses from farmers through MSP operations for creation of

45. The SAE for 2023-24 does not include summer crop for *moong* production.

the buffer stock.[46] The government has increased the pulses buffer stocks target from 1.95 million tonnes in 2020-21 to 2.3 million tonnes in 2021-22 and 2022-23. NAFED procured pulses close to about 4.2 MMT in 2018-19 and 2.8 MMT in 2022-23 under the Price Stabilisation Scheme (PSS) (Figure 5.5). Provision for procurement of pulses above MSP has been made in case need arises under PSF scheme. NAFED maintains this stock of pulses and releases the stock in a calibrated manner, generally at below MSP, in the open market to moderate price volatility. To keep in check the gram prices, in 2022, NAFED allocated 1.5 million tonnes of *chana* (gram) to the states at a discounted price of Rs. 8 per kg over the issue price for its distribution under various welfare schemes. The government recently launched the sale of subsidised *Chana Dal* under the brand name 'Bharat Dal' for Rs. 60 per kg for a one kg pack and Rs. 55 per kg for a 30 kg pack to make pulses available to consumers at affordable prices by converting *chana* stock to *chana dal*.

**Figure 5.5**

*Quantity of Pulses Procured under PSS/PSF*




*Sources*: NAFED Annual Report 2021-22 and PIB 2023 for total pulses procurement (as on 31.07.2023).

46. The buffer stock is created through the PSF and the PSS is being implemented by the GoI's Ministry of Agriculture and Farmers' Welfare.

To prevent hoarding and check sharp spikes in pulses inflation, the government has been invoking the ECA and imposing stock limits on pulses. For instance, stocking limits were imposed on all pulses (200 MT for wholesalers and importers, and 5 MT for retailers) except for *moong*, under the ECA in July 2021. Likewise, in June 2023, the government-imposed stock limits for *tur* and urad until 31st October 2023 to curb the rising inflation in the two pulses, which was further extended to 31st December 2023.

The government has adopted various strategies to implement provisions of ECA like temporary requirement of weekly reporting in specific markets, time limit for holding stocks for importer and millers, calibrated reduction of effective import duties and freeing pulses import by bringing those under general open licencing.

## 5.4 Trade Policy Instruments to Adjust Domestic Supply

As the domestic production falls short of demand, the government stabilises supply and price pressures in pulses by manoeuvring the trade policy while ensuring continued remunerative prices for the farmers. The government uses a combination of trade policy tools as short-term instruments to augment supply and contain price inflation. These measures encompass (i) customs duties, (ii) minimum import prices (MIP), (iii) import quotas, (iv) import bans, and (v) export restrictions.

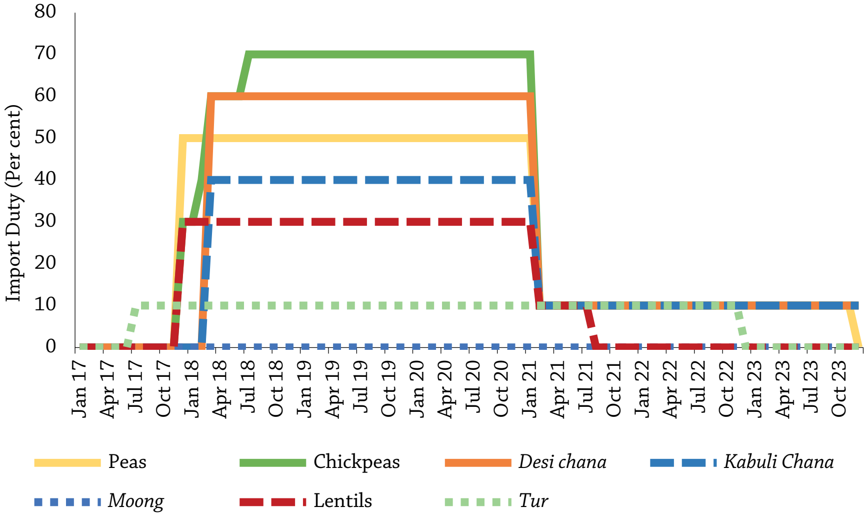
Before June 2017, pulses were imported on a zero-import duty structure, and there were export restrictions on pulses until 2015. Given the high dependence on imports and to protect the interests of farmers, the government increased the import duty on pulses from 2017 onwards. The basic import duty was raised from 0 per cent on all pulses to 10 per cent for *tur* in July 2017, and to 50 per cent for peas and 30 per cent for lentils and chickpeas in December 2017. However, the import duty on *moong* and urad remained 0over the last decade (Figure 5.6).

The import duties were raised for chickpeas to 60 per cent in March and later to 70 per cent in July 2018. Also, a separate duty structure was introduced for *kabuli chana* and *desi chana* (Bengal gram), with import duties of 40 per cent and 60 per cent, respectively.

India applies zero-duty imports for pulses imports from the least developed countries (LDCs) like Myanmar, Mozambique, Tanzania, Sudan, and Malawi.

**Figure 5.6**

*Import Duty Structure for Different Pulses since 2017*




*Source*: Directorate General of Foreign Trade (DGFT), various years.

The effective duty on *tur* was brought down from 10 per cent in March 2017, subject to a quantity restriction of 4 lakhs MT per fiscal year, to 0 per cent import duty on *tur* whole in March 2023 to cater to domestic shortages. The government also extended the free import of *tur* till March 2025. The import duty on *kabuli chana* and Bengal gram was brought down from 70 per cent in June 2018 to 10 per cent in February 2021. Since February 2021, Agriculture Infrastructure and Development Cess (AIDC)[47] has been introduced and levied on the import of pulses, particularly peas (40 per cent), *kabuli chana* (30 per cent), Bengal gram (30 per cent), and lentils (10 per cent)[48].

47. AIDC is levied to provide financial support for the development of agricultural infrastructure in India. It increases the effective taxes on the commodities it is levied on.

48. On February 12, 2022, the Ministry of Finance notified to remove the 10 per cent AIDC on imports of lentils with immediate effect, which further got extended till March 2024.

**Table 5.1**

*Current Trade Policy Measures for Different Pulses (as of December 2023)*

| *HS Code* | *Commodity* | *Basic Customs Duty (Notified) (%)* | *AIDC (%)* | *Import Policy* | *Export Policy* |
|---|---|---|---|---|---|
| 7131010 | Yellow Peas | 0 | 0 | Free up to 30.06.2024 | Free |
| 7131020 | Green Peas | 10 | 40 | Restricted (MIP of Rs. 200/kg) | Free |
| 7131090 | Other | 10 | 40 | Restricted (MIP of Rs. 200/kg) | |
| 7132010 | *Kabuli Chana* | 10 | 30 | Free | Free |
| 7132020 | Bengal gram | 10 | 50 | Free | Free |
| 7132090 | Other | 10 | 50 | Free | |
| 7133110 | Urad | 0 | | Import is free up to 31.03.2025. MoU with Myanmar for annual import of 2.5 lakh tonnes of urad during 2021-22 to 2025-26 | Free |
| 7133190 | *Moong* | 0 | | Restricted | Free |
| 7136000 | Pigeon Peas | 0/10 | | Import is free up to 31.03.2025.MoU with Myanmar for annual import of 1 lakh tonnes during 2021-22 to 2025-26. Another MoU with Mozambique for 2 lakh tonnes as well as with Malawi to import 50,000 tonnes of *tur* through private trade for each fiscal year of 2022-26 | Free |
| 7134000 | Lentils# | 0 | 0 | Free up to 31.03.2025<br>Tariff Rate Quota (TRQ) of 1.5 lakh tonnes under India-Australia ECTA with 50 per cent of the applied rate of duty | Free |

*Note:* # Basic duty for lentils for US is 20 per cent whereas SWC is 10 per cent, making the effective duty 22 per cent. Additionally, as per Notification No. 38/2015-2020 dated November 22, 2017, all varieties of pulses, including organic pulses, have been made 'free' for export without any quantitative ceilings, till further orders.

*Source*: DGFT.

Table 5.1 illustrates the import policy measures on different pulses as of December 2023. Given the high substitutability in pulses, the trade policy of competing pulses is calibrated to bring down the pulses inflation. A classic example is the case of yellow peas. The magnitude of gram imports in a year is significantly affected by yellow pea imports as it can be used as a substitute for *desi chana*, particularly for the processing of gram flour (besan). Over the last decade, pea imports have been significantly higher than gram imports (See Annexure A5.3)[49]. Due to lower import prices of yellow peas compared to domestic *chana* prices and to prevent pea imports from disrupting domestic market prices of *chana*, the imports of yellow peas were moved to the 'restricted' list from the 'open' category on April 25, 2018 (DGFT, 2018). Subsequently, the government effectively restricted imports of yellow peas by fixing a MIP of Rs. 200 per kg that includes cost, insurance and freight (DGFT, 2019), and did not allocate any import quota for yellow peas for 2020-21, 2021-22 and 2022-23 (DGFT, 2020). Before the restriction on the import of yellow peas, it was imported mostly from Canada, Australia, Russia and Ukraine. As per the discussions with the stakeholders in the pulses value chain, the imported price of yellow peas was in the range of Rs. 2000 to Rs. 2100 per quintal in 2018, while the MSP of gram or *chana* announced by the government was Rs. 4620 per quintal. Owing to such price disparities, the government adopted restrictive import policies like quantitative restriction (QR) and MIP on yellow peas to encourage gram production and improve domestic availability. On December 07, 2023, the government removed all restrictions on yellow pea imports including the import duty, MIP, and port restrictions to control high inflationary pressures and due to expectations of lower chickpea production in the country (DGFT, 2023).

Apart from trade policy instruments, the government has entered into supply agreements (MoUs) with three countries – Myanmar, Mozambique and Malawi in June 2021. Under this agreement, India

49. As the data on yellow pea imports is unavailable before the year 2019, we have taken the total pea imports as its proxy as more than 80 per cent of the total pea imports are that of yellow peas.

has made an annual commitment to import 2.5 lakh tonnes (urad) and one lakh tonne (*tur*) from Myanmar; 2 lakh tonnes (*tur*) from Mozambique; and 50,000 tonnes (*tur*) from Malawi during 2021-22 to 2025-26 (DGFT, 2021a and DGFT, 2021b).

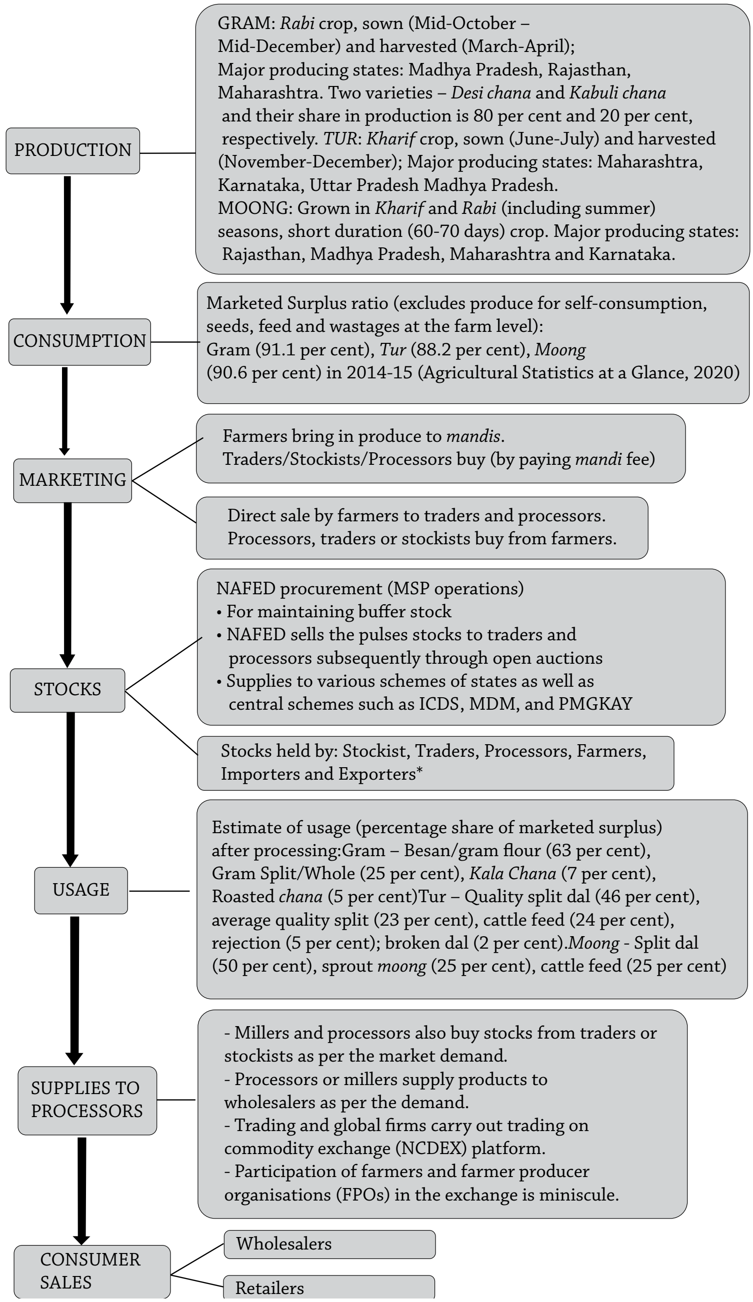
## 5.5 Pulses Value Chain in India

The value chain of pulses (gram, *tur* and *moong*) can be explained by elaborating on the roles of various stakeholders (farmers, traders, processors and others) involved in production, collection, packaging, transportation, processing, marketing and distribution of the produce to consumers (Figure 5.7). In the current value chain of pulses, small landholders grow pulses in rainfed conditions. The farmers produce these long-duration pulses variety considering the weather vagaries and other external factors like demand and supply in the market for price realisation. Out of the total production, farmers keep a share of the produce for self-consumption, seeds and feed that ranges between 10-12 per cent for *tur*, gram and *moong* (DES, 2020). The rest of the quantity produced by the farmers is considered as marketed surplus after deducting farm level wastages. The ICAR-CIPHET Report by Jha et al. (2015) estimated that the overall loss, i.e., losses in farm operations and storage, was 8.41 (±0.26) per cent in chickpeas, 6.36 (±0.30) per cent in pigeon peas, and 6.60 (±0.35) per cent in green gram. In the case of post-harvest losses, especially during milling and storage, traders said that losses have reduced in recent years due to the creation of storage facilities at processor's and wholesaler's levels.

of the produce. The marketing channels of the raw pulses are carried out through institutional and non-institutional channels from the producer to consumer. These channels consist of direct purchases from the farmers by traders and processors, commodities sold by farmers to traders and processors at the mandis, and procurement operations carried out by the farmers' cooperative NAFED. Institutional channels such as NAFED procure pulses for maintaining buffer stocks and ensuring supplies for various state-specific social sector schemes. It safeguards farmers when the mandi prices are below MSP. Although procurement through the cooperative network is not large in quantity, it helps protect farmers against price crashes.

**Figure 5.7**

*Value Chain of Pulses*




*Note*: ICDS: Integrated Child Development Schemes, MDM: Mid-Day Meal Scheme; NCDEX: National Commodity & Derivatives Exchange Limited, and PMGKAY: Pradhan Mantri Garib Kalyan Anna Yojana

*Source*: Based on inputs provided by leading processors in Maharashtra for gram and *tur* as well as Rajasthan for *moong* during August -September 2021 and May 2023.

*India's exports of pulses are not significant in terms of volume as it is the biggest producer as well as consumer of pulses in the world.

The commodity processors play a vital role in the marketing Non-institutional channels consist of intermediaries, such as traders, wholesalers, commission agents, millers and retailers. Millers play an important role in the value chain of pulses since a major portion of these pulses is used in processed form (for example, besan in the case of *chana*) or as split pulses. After pulses enter the market, stockists, traders, and processors retain a portion of the supply, in addition to the amount that farmers set aside before selling, to benefit from price fluctuations. This understanding of market fundamentals such as production, crop prospects, crop sowing pattern, imports and stocks held by the private sector and NAFED is important to bring stability in pulses prices.

Primary information collected from various mandis is used to understand how prices are formed in pulses. We estimate the price mark-ups across all three-value chains and estimate the share of farmers in a consumer's rupee. The supply chain dynamics and the contribution of mark-ups between farmgate and retail price are necessary to capture determinants of food inflation and its volatility. For estimating price mark-ups in the pulses value chain, the study has taken into account the prices prevailing in different mandis in Madhya Pradesh (for gram and *moong*) and Maharashtra (for *tur*).[50] In gram, around 75 per cent of the consumers' rupee for *chana* goes back to farmers, while in *moong* and *tur*, it is about 70 per cent and 65 per cent, respectively, as per our survey conducted in May 2023 (Table 5.2). The multi-stakeholders in these value chains, such as traders, processors, stockists, importers and farmers' cooperatives increase the competitiveness in the value chain.

Within the pulses value chain, a major share of the consumer rupee goes to the farmers that highlights the efficiency of the pulses value chain. Apart from farmers, retailers receive a large share of the consumer rupee. The reason is that retailers deal with smaller volumes and incur storage (display) costs at the sales points or

50. The gram and *tur* mark-ups are computed based on Latur mandi in Maharashtra, a key growing point for consumer prices at the urban centres like Mumbai, Indore, Hyderabad and Delhi, while *moong* mark-up is computed based on Jaipur, Rajasthan, a key growing point for consumer prices at the urban centres like Mumbai and Delhi.

outlets and have higher mark-up. In contrast, we observe that the processors' mark-up is relatively lower due to the large volume of trade they carry out throughout the year.

**Table 5.2**

*Value Chain of Pulses with Mark-ups (in Rs. per kg)*

| | *Gram* | | *Tur* | | *Moong* | |
|---|---|---|---|---|---|---|
| | *Rs. Per Kg* | *Share (per cent)* | *Rs. Per Kg* | *Share (per cent)* | *Rs. Per Kg* | *Share (per cent)* |
| Mandi price (which farmers receive) | 53 | 75 | 72 | 65 | 77 | 70 |
| Market fee (range of 0.8 to 1.5 per cent) and Arhathiya commission (2 per cent) | 2 | 3 | 2 | 2 | 2 | 2 |
| Labour or mandi handling charges and packing material paid by processors | 2 | 3 | 4 | 4 | 3 | 3 |
| Transportation charges from mandis to processing units | 1 | 1 | 1 | 1 | 1 | 1 |
| Losses due to foreign matters or impurities | 2 | 3 | 2 | 2 | 2 | 2 |
| Processing or milling cost | 1 | 1 | 5 | 5 | 5 | 5 |
| Packaging Cost | 1 | 1 | 3 | 3 | 2 | 2 |
| Transportation from processing plants to wholesalers at the consumption points | 1 | 1 | 3 | 3 | 1 | 1 |
| Wholesaler mark-up | 2 | 3 | 3 | 3 | 2 | 2 |
| Retailer mark-up | 6 | 8 | 16 | 14 | 15 | 14 |
| Final retail price (DoCA) | 71 | 100 | 111 | 100 | 110 | 100 |

*Notes*:1. Labour or mandi handling charges are over and above mandi fee and arhathiya commission.

2. In addition, the processors incur about Rs. 0.50 per kg per month as storage cost after the purchase of pulses from the mandis from farmers. (Also, processors spend about Rs. 3-4 per kg for brand promotion activities).

3. The wholesalers' mark-ups are smaller than the retailers' mark-ups as they deal with large volume compared to retailers or store owners.

4. The share may not add up to 100 due to rounding off.

*Sources*: Field Survey. Based on the inputs provided by leading processors in Indore for gram, Latur for *tur*, and Bhopal for *moong*. The consumption centre is Delhi for the data collated. All the cost or expenses or mark-ups are calculated from DoCA, GoI, May 2023. Figures in parentheses indicate percentage share of consumer rupees (in per cent).

## 5.6 Pulses Balance Sheet and Estimation

Moving to the empirical analysis, the present section presents our methodological framework and balance sheet approach. Before discussing the variable selection, model specification and methodology used for estimation and robustness check, the following section explains the balance sheet approach and how the monthly STU ratios have been constructed.

### *5.6.1 Components of the Monthly Pulses Balance Sheet*

The current study built conceptually on existing approaches to constructing balance sheets for agricultural commodities has gone beyond existing balance sheets in terms of scope, coverage and frequency. Unlike most existing balance sheets that are annual in frequency, the balance sheets constructed for gram, *tur* and *moong* in the study is monthly in frequency. While the balance sheet can be extended to a significantly long period in the past and into the future, attempts have been made to account for seasonal patterns of production, arrival, stocking and disposal, adjusting for population and income and behavioural aspect of intermediaries in the value chain.

Some key assumptions for generating the pulses balance sheets are:

i. With a view to keep the model simple, minimal assumptions have been adopted. For instance, *kharif* pulses are assumed to have arrived or entered the supply chain in December. Similarly, *rabi* pulses are assumed to have arrived or entered the supply chain in April. It is assumed that net production after adjusting for seeds, feeds, wastages, and losses is 90 per cent of gross or total production. We have assumed that the conversion ratio between whole and grains is 75:25, which is kept the same for all the pulses.[51]

51. Attempt was made to accommodate minor variations in specific pulses in terms of harvesting and arrivals time that differ across different agro-climatic regions, estimates of losses and wastages according to various studies and reports, conversion ratios for pulses, and consumption pattern across region and months. However, no significant improvement was observed in the robustness of the relationship between respective STUs and CPIs.

ii. Cumulative Consumption Series Estimates: For computing the demand of pulses, we followed a different method from the other selected commodities as pulses consumption was higher compared to the production figures in *tur*. We obtained the monthly per capita household consumption (MPCE) of pulses – both rural and urban, in volume terms as given by the NSSO quinquennial consumption and expenditure survey 2004-05 and 2011-12[52]. Using the MPCE for two rounds, we computed the annualized monthly compounded growth rate of consumption between 2004-05 and 2011-12. Since the NSS 2011-12 round is the latest round of expenditure survey, we used the same monthly growth rate (the growth rate between 2004-05 to 2011-12) for periods beyond 2011-12. To arrive at monthly all-India rural and urban pulses consumption, the per capita monthly consumption series is multiplied with the monthly rural and urban population series, respectively. The weighted sum of rural and urban consumption series using the rural-urban population weight of 7:3 give all-India monthly total consumption of pulses.

    The rural and urban series of monthly population is arrived at by applying annualized monthly compounded growth rate of population calculated using the 2001 and 2011 census population data of the Census Registrar General, India. In the absence of official census data, this computed growth rate of population is applied for periods beyond 2011 as was done for MPCE. The population figure arrived at is in the close proximity of that arrived at by the United Nations Organisation (UNO) for India.

    The consumption series obtained is adjusted with the real growth rate of Private Final Consumption Expenditure

52. The National Sample Survey Office (NSSO), Ministry of Statistics and Programme Implementation (MoSPI)), GoI has released the summary results and detailed data of Household Consumption Expenditure Survey (HCES) conducted during August 2022 to July 2023 relating to estimated Monthly Per Capita Consumption Expenditure (MPCE). However, this study was done prior to the realise of the detailed data and could not be included in the analysis.

(PFCE). This is done since there is no reliable estimate of monthly/quarterly/yearly income elasticity of demand for pulses. The real growth rate of PFCE, which is a quarterly series, is interpolated using standard splicing methodology to arrive at monthly PFCE series, in this case, Catmull-Rom-Spline. This exercise renders consumption or demand to be dynamic that changes with per-capita income. As Bennett's law observes, with a rise in incomes, people change their consumption patterns and consume relatively fewer calorie-dense, starchy staple foods and relatively more nutrient-dense meats, oils, sweeteners, fruits, and vegetables. Pulses being protein-dense, the Bennett's Law is presumed to be applicable.

The monthly cumulative consumption series is arrived at by adding-up monthly all-India consumption data of the current month with the preceding month/s starting January till December as below:

$$CC_{(i)} = C_{(i)};$$
$$CC_{(i+1)} = C_{(i)} + CC_{(i+1)};$$
$$CC_{(i+2)} = C_{(i)} + CC_{(i+1)} + CC_{(i+2)} \quad \ldots (4)$$

where $C_{(i)}$ - Consumption of $i^{th}$ month
$CC_i$ - Cumulative consumption till the $i^{th}$ month
i - Jan, Feb, Mar,........, Dec

iii. Stock-to-Use Ratio Estimates: A fair estimate of STU ratio should serve as an important gauge for the likely future price pressure; and is an integral component of any model that forecasts prices. STU ratios capture how much of the current need is met from available stock and how much is available for meeting future consumption needs. The three STU ratios calculated using the methodology elaborated above for the pulses under study are given in Table 5.3.

**Table 5.3**

*Correlations Between STU Ratios and CPI MoM for Gram, Tur, and Moong*

| *Time period* | *Jan-2013 to May 2023* | *Jan-2013 to May 2023* | *Jan-2013 to May 2023* |
|---|---|---|---|
| Commodity | Gram | *Tur* | *Moong* |
| CPI MoM-STU (Seasonally adjusted) | -0.51*** | -0.32*** | -0.05*** |

*Notes:* *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

*Source:* Authors' calculations.

In line with economic theory, the respective STU ratios estimated, have negative relationship with the respective prices, although with varying degrees of correlations. The differing correlation coefficient for the pulses may be attributed to a host of factors, extent of scarcity or sufficiency of the pulses, production level and flow of imports, role of millers and traders or the market dynamics, efficiency of price discovery mechanism, and prevailing intervention policies of the government. For instance, the negative but lower coefficient of correlation for *tur* – the relatively scarce and more price sensitive pulses compared with gram which has sufficient domestic supply may be indicating that other factors rather than only STU ratio are at play in determining prices. Similarly, *moong*, relatively less traded and more abundantly available, yet consumed in lesser quantity and lesser frequency was found to have negative but low correlation coefficient. Gram, the more relatively abundant and with the largest share in domestic production and consumption, has the strongest relation between its STU and price.

## 5.7 Model Specification

This study identifies various determinants of inflation in gram, *tur* and *moong* in an ARDL framework. Various supply side and demand side variables have been used to explain pulses inflation in many empirical studies. As the variables utilised to define factors in pulses regression may exhibit different levels of integration, the ARDL cointegration technique proves to be advantageous. It is suited for scenarios where the variables have different orders of integration—such as being integrated of order zero (I(0)), integrated of order one (I(1)), or even a combination of both.

The dependent variables, log of CPI gram, *tur* and *moong*, are specified using the seasonally adjusted log of *CPI* ($log\_CPI_t$), while the explanatory variables include seasonally adjusted series of private final consumption expenditure, STU ratios ($STU_t\_Pulse\_SA$), proxy for market dynamics (*Mark*) which is the difference between $CPI_t\_Pulse\_MoM$ and the margin between retail and wholesale price momentums. The information contained in this Mark variable, which is available one-and-half months in advance before the actual CPI print is made available, has a significant lead indicator value and is an important gauge for emerging price pressures. Since the Mark variable is deviation of margin from actual momentum, the variable can be assumed to reflect the market sentiment. The *Pulse_Dummy* captures the impact of lean season and the COVID-19 pandemic induced lockdowns on pulses prices. Seasonality is a dominant feature of fluctuations in food prices, and therefore, the U.S. Census Bureau's X-13 seasonal adjustment procedures in EVIEWS to remove seasonality from our monthly variables. The detailed variable description is given in Annexure Table A5.4.

### *Gram Estimation*

Before applying ARDL, stationarity check was done for all variables using the ADF test. Table 5.4 shows the ADF test for gram that confirmed that the included variables are stationary at I(0) and I(1).

**Table 5.4**

*ADF Test for Gram*

| *Variable* | *ADF test p value* |
|---|---|
| Log_Gram_CPI | 0.38 |
| Gram_STU | 0.18 |
| Gram_Mark | 0.15 |
| ΔLog_Gram_CPI | 0.00*** |
| ΔGram_STU | 0.00*** |
| ΔGram_Mark | 0.00*** |

*Notes:* The Dickey-Fuller test statistic is reported. The critical values are the finite sample values suggested by Mackinnon (1991). (*) indicates different level of significance as follows *** p<0.01, ** p<0.05, * p<0.1.

*Source:* Authors' estimation.

The lag lengths are chosen using the AIC criterion, which leads to the ARDL (2,1,4,4) model. The ARDL bounds test approach confirms the presence of a cointegrating relationship between Gram_CPI, stock-to-use of gram, Gram Mark and Gram dummy (Table 5.5).

**Table 5.5**

*Bounds Tests for Cointegration for Gram*

| *F-statistic* | *t-statistic* |
|---|---|
| 3.923** | 3.670** |

*Notes:* ***, **, * denotes significance at 1 per cent, 5 per cent and 10 per cent, respectively. The F-statistic is used to test for the joint significance of the coefficients of the lagged levels in the ARDL. The t-statistic is used to test for the significance of the coefficient of the lagged dependent variable. All test statistics are significant at the 1 per cent level.

*Source:* Authors' estimation.

The estimates of long-run coefficients from ARDL specification and the short-run dynamics are presented in Table 5.6. The coefficient between Gram_STU and log_CPI_gram was negative and significant. This was in line with the hypothesis of this study that stock helps control price pressure - higher the stock, lower the price pressure. The short-run analysis showed that the supply chain disruptions and seasonal impact, particularly, COVID-19 captured by Gram_Dummy, contributed to the price pressure. There was perceptible movement in the price of gram during COVID-19. Gram has been one of the most stable pulses in terms of price volatility. The impact of margins and market sentiment (represented by Mark) was negligible in the case of Gram. These observations are amenable to ground realities as regards gram, which is relatively more comfortable in supply, constituting around 50 per cent of total production. Though low, the speed-of-adjustment (coefficient of ECM term) for gram has been faster than that for *tur* (Table 5.6).

The diagnostic tests are satisfactory: the error term is white noise, i.e., independent and identically distributed with normality. The Breusch-Godfrey test for autocorrelation indicates that there is no serial autocorrelation. The CUSUM test shows that the errors remain within the 95 per cent confidence band suggesting that the estimated model is stable (Annexure A5.5).

**Table 5.6**

*ARDL Results for Gram*

| | | |
|---|---|---|
| **Dependent variable: Log_CPI_Gram** | | |
| **ARDL (2,1,4,4)** | | |
| **Sample period: March 2014 - May 2023** | | |
| *Variable* | *Coefficient (P-value)* | *Standard Error* |
| **Long-run equation** | | |
| Gram_STU | -0.025* | 0.016 |
| Gram_Mark | 0.003 | 0.006 |
| Gram_Dummy | -0.058 | 0.407 |
| C | 0.189*** | 0.062 |
| **ECM term** | | |
| Γ | -0.026** | 0.0012 |
| **Short-run equation** | | |
| Δ(log_Gram_CPI(-1)) | 0.478*** | 0.087 |
| Δ(Gram_STU) | -0.001 | 0.000 |
| Δ (Gram_Mark) | 0.0001 | 0.0003 |
| Δ (Gram_Mark (-1)) | 0.0001 | 0.0003 |
| Δ (Gram_Mark (-2)) | -0.0002 | 0.0003 |
| Δ (Gram_Mark (-3)) | -0.0007*** | 0.0002 |
| Δ (Gram_Dummy) | -0.009 | 0.007 |
| Δ (Gram_Dummy)(-1)) | 0.015*** | 0.006 |
| Δ (Gram_Dummy)(-2)) | 0.013*** | 0.005 |
| Δ (Gram_Dummy)(-3)) | 0.012*** | 0.005 |
| Observations | 106 | |
| Adjusted R-squared | 0.553 | |
| Breusch Godfrey Test {p(F-stats)} | Prob chi2 = 0.258 | |
| Test for white noise | Prob Q-Stats(36) > 0.05 | |
| RMSE | 0.0684 | |
| Log Likelihood | 295.66 | |

*Notes:* 1. *** p<0.01, ** p<0.05, * p<0.1.

2. Residual correlogram test up to 36 lags of p-value for Q-Stats was above 0.05 for indicating that the series is white noise.

3. Series are seasonally adjusted.

*Source:* Authors' estimation.

## *Tur Estimation*

The ADF unit root test confirms that the selected variables impacting *tur* inflation are stationary at I(0) and I(1) (Table 5.7).

**Table 5.7**

*ADF Unit Root Test for Tur*

| *Variable* | *ADF Test Statistic (p-value)* |
|---|---|
| Log_CPI_*Tur* | 0.48 |
| Log_CPI_Besan | 0.15 |
| *Tur*_STU | 0.27 |
| *Tur*_Mark | 0.00*** |
| ΔLog_CPI_*Tur* | 0.00*** |
| ΔLog_CPI_Besan | 0.00*** |
| ΔTur_STU | 0.00*** |
| ΔTur_Mark | 0.00*** |

*Notes:* 1. The Dickey-Fuller test statistic is reported. The critical values are the finite sample values suggested by Mackinnon (1991). (*) indicates different level of significance as *** p<0.01, ** p<0.05, * p<0.1.

2. Series are seasonally adjusted.

*Source:* Authors' estimation

The ARDL bounds test confirms the presence of a long-run cointegrating relationship between Log_CPI_*Tur*, STU, *Tur*_Mark, Dummy and Log_CPI_Besan (Table 5.8). The selected ARDL model is (2,0,0,4,4).

**Table 5.8**

*Bounds Tests for Cointegration for Tur*

| F-statistic | t-statistic |
|---|---|
| 4.37*** | 4.37*** |

*Notes:* ***, **, * denotes significance at 1 per cent, 5 per cent and 10 per cent, respectively. The F-statistic is used to test for the joint significance of the coefficients of the lagged levels in the ARDL. The t-statistic is used to test for the significance of the coefficient of the lagged dependent variable. All the test statistics are found to be significant at 1 and 5 per cent level, respectively.

*Source:* Authors' estimation

The estimates of long-run coefficients and the ECM are represented in Table 5.9. The coefficient of *Tur*_STU was negative as

**Table 5.9**

*ARDL Results for Tur*

| **Dependent Variable: Log_CPI_Tur** | | |
|---|---|---|
| **ARDL (2,0,0,4,4)** | | |
| **Sample period: January 2015 - May 2023** | | |
| *Variable* | *Coefficient (P-value)* | *Standard Error* |
| **Long-run equation** | | |
| *Tur*_STU | -0.109 | 0.448 |
| *Tur*_Mark | 0.190 | 0.541 |
| Log_Besan_CPI | -8.299 | 24.353 |
| *Tur*_Dummy | -1.271 | 3.322 |
| C | -0.287*** | 0.135 |
| **ECM term** | | |
| γ | -0.006*** | 0.001 |
| **Short-run equation** | | |
| Δ(Log_*Tur*_CPI(-1)) | 0.598*** | 0.067 |
| Δ(Log_Beasan_CPI) | 0.662*** | 0.132 |
| Δ(Log_Beasan_CPI(-1)) | -0.556*** | 0.170 |
| Δ(Log_Beasan_CPI(-2)) | -0.438*** | 0.161 |
| Δ(Log_Beasan_CPI(-3)) | 0.440*** | 0.134 |
| Δ(*Tur*_Dummy) | -0.011** | 0.005 |
| Δ(*Tur*_Dummy)(-1)) | 0.004 | 0.005 |
| Δ(*Tur*_Dummy)(-2)) | 0.008 | 0.005 |
| Δ(*Tur*_Dummy)(-3)) | 0.024*** | 0.005 |
| Observations | 101 | |
| Adjusted R-squared | 0.681 | |
| Breusch Godfrey Test {p(F-stats)} | Prob chi2 = 0.607 | |
| Test for white noise | Prob Q-Stats (36) > 0.05 | |
| RMSE | 0.382 | |
| Log Likelihood | 262.401 | |

*Notes:* 1. *** p<0.01, ** p<0.05, * p<0.1.

2. Residual correlogram test up to 36 lags of p-value for Q-Stats was above 0.05 indicating that the series is white noise.

*Source:* Authors' estimation

expected but statistically insignificant contrary to the hypothesis. This is reflective of continuing acute short supply in *tur*. Domestic production is not sufficient to meet the consumption requirement and there are limited sources of import, namely, Myanmar and a few African countries. *Tur* being the scarcest of all pulses exhibits the most volatile price behaviour. This is reinforced by the insignificance of most variables in the long-run. The price of besan—a close substitute of *tur* (processed from gram), showed a strong statistical relationship in the short-term indicating that substitution of *tur* by besan was effective and taking place continuously. The impact of seasonal variation and the COVID-19 period captured by the Dummy was limited to the short-run. The interplay of these dynamics resulted in a low speed of adjustment as captured by the coefficient of ECM term indicating that any deviation from the long-run normal will take a longer time to correct.

The diagnostic tests are satisfactory: the error term is white noise, and the model is stable as indicated by cumulative sum (CUSUM) test (Annexure A5.5).

### *Moong Estimation*

Similarly for *moong*, the ADF unit root test shows that included variables are stationary at I(0) and I (1) (Table 5.10) that supports the use of ARDL model for estimation.

**Table 5.10**

*ADF Unit Root Test for Moong*

| *Variable* | *ADF Test Statistic (p-value)* |
|---|---|
| Log_CPI_*Moong* | 0.61 |
| *Moong*_STU | 0.13 |
| *Moong*_Mark | 0.52 |
| ΔLog_CPI_*Moong* | 0.00*** |
| Δ*Moong*_STU | 0.00*** |
| Δ*Moong*_Mark | 0.00*** |

*Note:* The Dickey-Fuller test statistic is reported. The critical values are the finite sample values suggested by Mackinnon (1991). () indicates different levels of significance: *** p<0.01, ** p<0.05, * p<0.1.*

*Source:* Authors' estimation.

The ARDL bounds test confirms the presence of long-run cointegrating relationship between *log_CPI_Moong, STU, Mark* and the *Dummy* (Table 5.11).

**Table 5.11**

*Bounds Tests for Cointegration for Moong*

| F-statistic | t-statistic |
|---|---|
| 4.79*** | 4.67*** |

*Note:* ***, *, * denotes significance at 1 per cent, 5 per cent, and 10 per cent, respectively. The F-statistic is used to test the joint significance of the coefficients of the lagged levels in the ARDL. The t-statistic is used to test the significance of the coefficient of the lagged dependent variable. All test statistics are significant at the 1 per cent level.

*Source:* Authors' estimation.

The estimates of long-run coefficients from the ARDL specification and the short run dynamics are presented in Table 5.12. Despite adequate domestic supply and per capita consumption lower than other pulses, *moong* is actively traded since it is costlier. These features of *moong* have been captured by the model, according to which *Moong*_CPI and *Moong*_STU shared a statistically significant relationship. The positive coefficient may be indicating active trading in the commodity, possibly, including speculation. The importance of market dynamics regarding *moong* was captured by the positive and significance *Moong*_Mark coefficient. The higher ECM coefficient indicating faster rate of adjustment compared to other pulses also point to active market dynamics for *Moong*.

The diagnostic tests for the ARDL model are satisfactory and the model is stable as per the CUSUM test (Annexure A5.5).

## 5.8 Inflation Forecasts of Gram, *Tur* and *Moong*

As observed in the literature, while models like ARDL capture the price dynamics well, they do not necessarily perform better at forecasting. The same was observed in this study. Therefore, the present study uses univariate time series models while introducing some important balance sheet variable and market variable identified in the structural model, mainly STU and Mark, to improve short-term forecasting. We attempt to forecast inflation for gram, *tur*, and *moong* for a 12-month horizon using time series-based univariate

**Table 5.12**

*ARDL Results for Moong*

| **Dependent Variable: Log_CPI_*Moong*** | | |
|---|---|---|
| **ARDL (3,4,0,0)** | | |
| **Sample period: January 2015 - May 2023** | | |
| *Variable* | *Coefficient (P-value)* | *Standard Error* |
| **Long-run equation** | | |
| STU_*Moong* | 0.004*** | 0.002 |
| *Moong*_Mark | 0.016*** | 0.004 |
| *Moong*_Dummy | -0.001 | 0.069 |
| C | 0.183*** | 0.053 |
| **ECM term** | | |
| γ | -0.039*** | 0.011 |
| **Short-run equation** | | |
| Δ(Log_*Moong*_CPI(-1)) | 0.461*** | 0.092 |
| Δ(Log_*Moong*_CPI(-2)) | -0.154* | 0.089 |
| Δ(STU_*Moong*) | -0.0002 | 0.000 |
| Δ(STU_*Moong* (-1)) | -0.0001 | 0.0002 |
| Δ(STU_*Moong* (-2)) | -0.0004** | 0.0002 |
| Δ(STU_*Moong* (-3)) | 0.0005** | 0.0002 |
| Observations | 101 | |
| Adjusted R-squared | 0.47 | |
| Breusch Godfrey Test {p(F-stats)} | Prob chi2 = 0.745 | |
| Test for white noise | Prob Q-Stats (36) > 0.05 | |
| RMSE | 0.035 | |
| Log Likelihood | 306.227 | |

*Note:* *** p<0.01, ** p<0.05, * p<0.1.

*Source:* Authors' estimation.

and multivariate models such as SARIMA and SARIMAX. This will be helpful to check if the robustness of forecast performance improves while using the balance sheet variables: STU ratio (SARIMAX) or if past error terms provide a better forecast (SARIMA). As the variables used in the forecasting analysis are integrated of different order, the non-stationary variables were transformed using the first difference transformation to make them stationary.

### *5.8.1 Empirical Analysis of Forecasts*

Using pseudo out-of-sample RMSE of individual models and multivariate models, we evaluated the performance and accuracy of various inflation forecasting techniques for horizons of up to 12 months ahead. The evaluation was done by stopping the full sample period in February 2022 and generating forecasts for 2, 4, 6, 8, 10, and 12 months until February 2023, which were compared with actual price momentum of the pulses.

The RMSEs of each forecasting model were evaluated using both in-sample (full sample) and out-of-sample (smaller sample) forecasts. The RMSE for full sample gives a measure to evaluate model's accuracy in a historical time frame. We also evaluated the accuracy of the pseudo out of sample forecasts up to 12 months ahead, generated between February 2022 and February 2023 that gives an overview of the range of forecast errors in one year ahead of the sample. The evaluation of RMSE of univariate and multivariate model forecasts for gram, *tur* and *moong* is given in Table 5.13.

**Table 5.13**

*Forecasting Performance (RMSE) of Models for CPI Gram, Tur, and Moong (MoM, Per cent)*

| *Model* | *Full sample forecasts (January 2013 to January 2022)* | | | | | | *Out of sample forecasts (February 2022 to February 2023)* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Number of months* | | | | | | *Number of months* | | | | | |
| | *2* | *4* | *6* | *8* | *10* | *12* | *2* | *4* | *6* | *8* | *10* | *12* |
| **Gram** | | | | | | | | | | | | |
| SARIMA | 5.59 | 5.53 | 5.48 | 5.42 | 5.37 | 5.32 | 0.48 | 0.80 | 0.76 | 0.66 | 0.66 | 0.71 |
| SARIMAX | 2.50 | 2.47 | 2.45 | 2.43 | 2.40 | 2.38 | 0.34 | 0.50 | 0.62 | 0.64 | 0.59 | 0.68 |
| ***Tur*** | | | | | | | | | | | | |
| SARIMA | 2.36 | 2.33 | 2.32 | 2.33 | 2.31 | 2.32 | 0.67 | 0.78 | 0.86 | 1.68 | 1.56 | 1.82 |
| SARIMAX | 2.22 | 2.20 | 2.17 | 2.19 | 2.17 | 2.15 | 0.46 | 0.43 | 0.64 | 1.47 | 1.40 | 1.29 |
| ***Moong*** | | | | | | | | | | | | |
| SARIMA | 1.47 | 1.45 | 1.44 | 1.43 | 1.42 | 1.40 | 0.65 | 0.54 | 0.69 | 0.64 | 0.60 | 0.55 |
| SARIMAX | 1.14 | 1.13 | 1.12 | 1.11 | 1.11 | 1.10 | 0.38 | 0.41 | 0.54 | 0.50 | 0.49 | 0.46 |

*Source:* Authors' estimates.

For gram, the SARIMAX forecasts outperform SARIMA across all forecast horizons in ‘Full sample forecast evaluation’ and in the ‘Out-of-sample forecast evaluation’. The exogenous variable used in SARIMAX forecasting for gram include seasonally adjusted STU of gram (STU) and gram mark (which captures the market dynamics).

In *tur*, similarly, the SARIMAX model outperforms all other models over each horizon in ‘Full sample forecast evaluation’ and in the ‘out of sample forecasts.’For forecasting SARIMAX of *tur*, the exogenous variables used are seasonally adjusted STU, Mark and *BesanCPI*.

In the case of *moong*, SARIMAX outperforms SARIMA in the ‘Full sample forecast evaluation’ and in the ‘Out of sample forecast evaluation’. For forecasting SARIMAX of *moong*, the exogenous variables used are seasonally adjusted STU and *Mark*. Annexure A5.6 and A5.7 provides the forecast results of gram, *tur* and *moong*.

These observations support the study’s hypothesis that the balance sheet variable (stock or STU ratio) along with other variables like market dynamics can improve the forecasting performance of inflation in *gram*, *tur* and *moong*.

## 5.9 Conclusion and Policy Recommendations

Volatility in inflation of pulses over the last decade has been a concern for policymakers. In periods of sharp increase in pulses prices such as 2015-16 and 2016-17 and the post-pandemic period, the government has taken various supply management measures, such as de-regulating trade policy instruments, incentivising production and creating a buffer stock of pulses by NAFED to boost domestic supplies and contain inflation. Select provisions of the ECA have been applied in the recent period though sparingly in a more transparent and targeted manner. There is unanimity that though the country is still not fully self-reliant in pulses production, large fluctuations in prices of pulses could adversely affect consumption and the supply gaps can be tackled to a large extent with a better policy response.

This study creates a dynamic monthly balance sheet to evaluate the demand-supply gap of each of these pulses on a real-time basis and computes the STU ratio of the selected pulses using inputs provided by key stakeholders. They include farmers, traders and processors in the pulses value chain and the official data. The hypothesis is that the STU helps explain inflation better in each of these pulses after controlling for other demand and supply-side factors. Estimates using the ARDL framework confirm that STUs and market dynamics, have important bearings on the price for these pulses. Incorporation of these variables in multivariate framework under the SARIMAX set-up aided in improving the forecasting accuracy.

Based on the findings, the study suggests several policy measures for stabilising pulses prices as set out below.

## Short-run Measures

### *Rationalising Trade Policy for Containing Inflation in Pulses*

A prudent policy to moderate and stabilise pulses inflation could be by modulating the trade policy through timely calibration in applicable duties. For instance, during domestic shortages, a liberal and consistent trade policy helps importers plan accordingly, preventing a surge in pulses prices. By adjusting import duties proactively, the domestic supply-demand situation could be addressed effectively. Similarly, during surplus production when prices plummet, trade policies could be dynamic to respond to market conditions effectively, hence, averting price crashes. The opportunity to fetch better prices in the global market could encourage farmers to upgrade productivity.

Additionally, the minimum export prices and transparent export duties may effectively manage exports in the short-term. Some of these measures were introduced recently to contain the pulses inflation.

Advance production estimates and pattern in market arrivals could be used to adjust the import and export of pulses to prevent the situation of massive price crashes that may hurt the farmer interests.

## Long-term Measures

### *Improving Productivity and Production through Innovations*

For the country to achieve self-sufficiency in pulses, investment in long-run agricultural productivity and production growth in pulses along with infrastructural investments, such as warehouses and efficient storage facilities that can enhance supply responses is needed. It is important to consolidate production at the farmers' levels through FPOs or collectives so that farmers can realise better prices for their produce and be incentivised to use modern agricultural inputs and technology.

Reduction in pre-and post-harvest losses of farmers would improve their price realisation. At the same time, processing losses can be reduced through better varietal development. Distributing seed storage bins to farmers and increasing awareness about adoption of scientific methods of storage of pulses at the farm level through agricultural extension services can significantly reduce losses at the storage level.

Additional emphasis is needed for varietal development to suit the local agro-climatic conditions that are climate resilient and are of short-duration. For instance, the traditional varieties of *tur* seeds, such as Laxmi, Bahar, Gwalior 3 and C11, sown in rainfed conditions, require around 180 days for maturity. However, the ICAR's new short-duration variety, Pusa Arhar-16, has reduced the maturity period to around 120 days while increasing the yield by around 15 per cent compared to the traditional varieties. There is a need to introduce new seed varieties for gram, *moong* and other pulses for large-scale commercial cultivation so that farmers' remuneration could get a boost because of the short crop duration and higher yield of the *tur* variety.

### *Enhancing Efficiency in Marketing System and Value Chain*

The access to an efficient marketing system and strengthening the fragmented and weak supply line can facilitate better price discovery and transparency. It can address price fluctuation in pulses in a number of ways:

First, the integration of the e-NAM, especially in key producing regions of pulses, may bring much-needed transparency to the pulses trade. Improving the grading facilities at the mandis as envisaged under e-NAM would help processors access quality and graded produce at the *mandi* level, thus, improving the efficiency of the value chain. For instance, some APMC mandis in Andhra Pradesh, Telangana and Karnataka have initiated the trading of pulses.

Since, most of the farmers producing pulses belong to the small holder category, they depend on the *mandi* system for marketing their produce. The direct purchases by processors from an aggregator/ FPOs/farmer at the farmgate level would reduce transportation costs to bring the produce to mandis and provide bargaining power to the farmers. Under the current system, farmers bring in their produce to mandis and sell their produce to traders and processors while incurring the cost of transactions (mandis and arhathiya or commission agents' fees). Additionally, the direct purchase would help cut down on intermediaries and reduce transaction costs and provide benefits to farmers, traders and processors.

At the processing level, more technological interventions are needed to improve the conversion ratio of whole pulses into split or processed dal or pulses products. The processing of pulses is mostly done in the private sector; therefore, installing small pulses mills or processing units at the village level can reduce the cost of processing as highlighted in the literature.

There is a need to scale-up and operationalise procurement of pulses – domestic and import - in sufficient quantities for market intervention and maintaining strategic buffer reserves. Government procurement and disbursal from NAFED stock and strategic buffer have helped contain inflation in the recent past. The scheme may have to assume a greater role and acquire increased efficiency to ensure greater stability in pulses prices given the seasonality of supply - lean and glut, and the continuing inadequacy of domestic supply in meeting domestic requirements fully.

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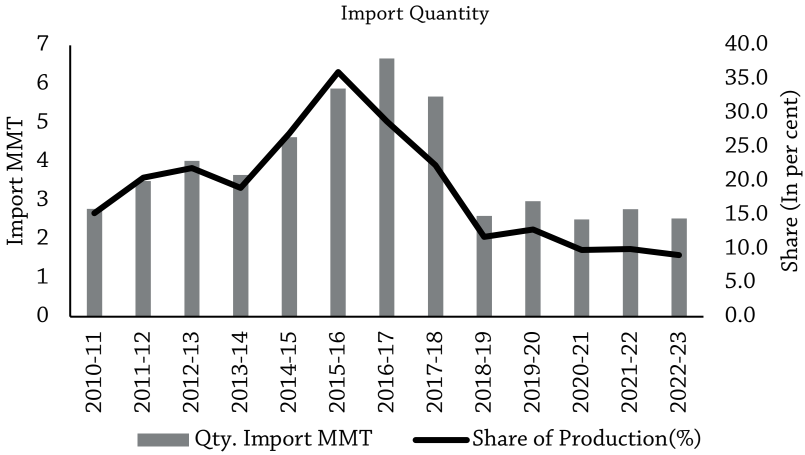
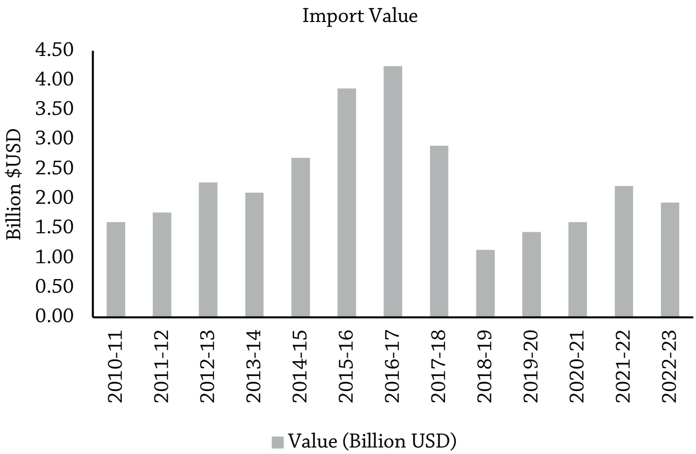
## 5.11 Annexure

**Annexure A5.1**

*Import of Pulses in Volume and Value in India*

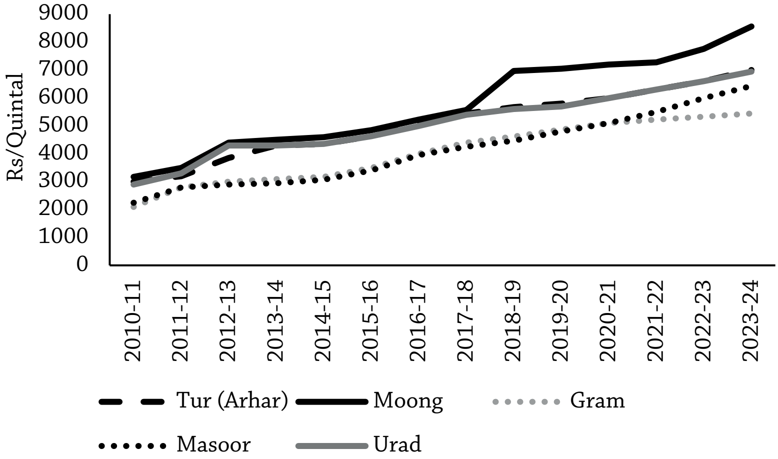



*Sources*: DGFT, GoI; DES GoI.

**Annexure A5.2**

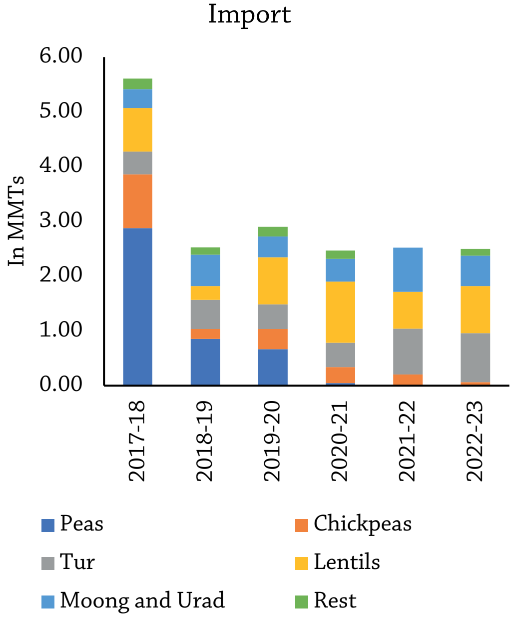
*MSP of Major Pulses*

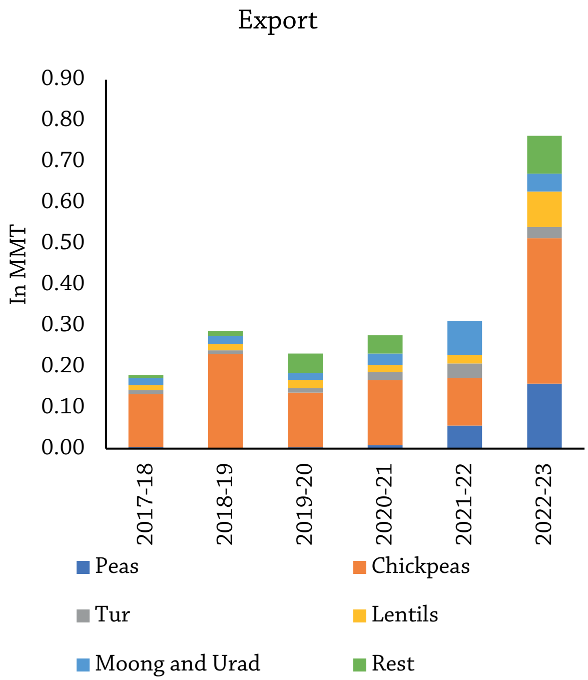



*Source*: CACP, GoI.

**Annexure A5.3**

*India's Import and Export of Pulses*






*Source*: DGFT, GoI.

**Annexure A5.4**

*Description of Variables and Data Sources*

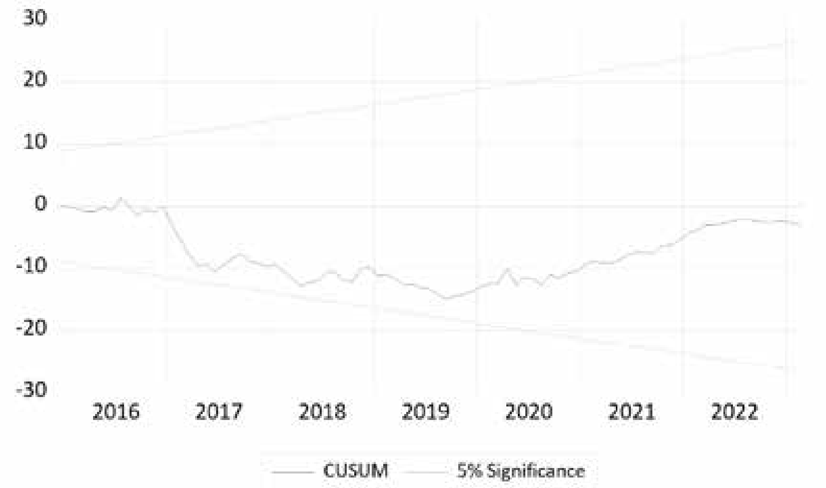
| *Variable* | *Description* | *Source* |
|---|---|---|
| | ***Tur*** | |
| CPI *TUR* MOM | | |
| | Seasonally adjusted *Tur* CPI (Log) | MOSPI<br>Consumer Price Index |
| *TUR* DUMMY | Lean season and COVID Dummy | Media articles |
| STU_*TUR*_SA | Seasonally and private final consumption expenditure adjusted *Tur* STU | Balance shee<br>Computed by the authors |
| CPI BESAN MOM | Seasonally adjusted Besan CPI (Log) | MOSPI<br>Consumer price Index |
| *TUR* _MARK | *Tur* CPI MoM (minus) MoM of DoCA retail-wholesale margin – all seasonally adjusted | MOSPI<br>Consumer Price Index<br>& DoCA, GoI |
| | **Gram** | |
| GRAM CPI SA MOM | Seasonally adjusted Gram CPI (Log) | MOSPI<br>Consumer price Index |
| STU GRAM SA | Seasonally and private final consumption expenditure adjusted Gram STU | Balance sheet Computed by the authors |
| GRAM MARK | Gram CPI MoM (minus) MoM of DoCA retail-wholesale margin – all seasonally adjusted | MOSPI<br>Consumer Price Index<br>& DoCA, GoI |
| GRAM DUMMY | Lean season and COVID Dummy | Media articles |
| | ***Moong*** | |
| *MOONG* CPI SA MOM | Seasonally adjusted *Moong* CPI (Log) | MOSPI<br>Consumer Price Index |
| STU *MOONG* IYA SA | Seasonally and private final consumption expenditure adjusted *Moong* STU | Balance sheet Computed by the authors |
| *MOONG* MARK | *Moong* CPI MoM (minus) MoM of DoCA retail-wholesale margin – all seasonally adjusted | MOSPI<br>Consumer Price Index<br>& DoCA, GoI |
| *MOONG* DUMMY | Lean season and COVID Dummy | Media articles |

*Source*: Authors' estimation

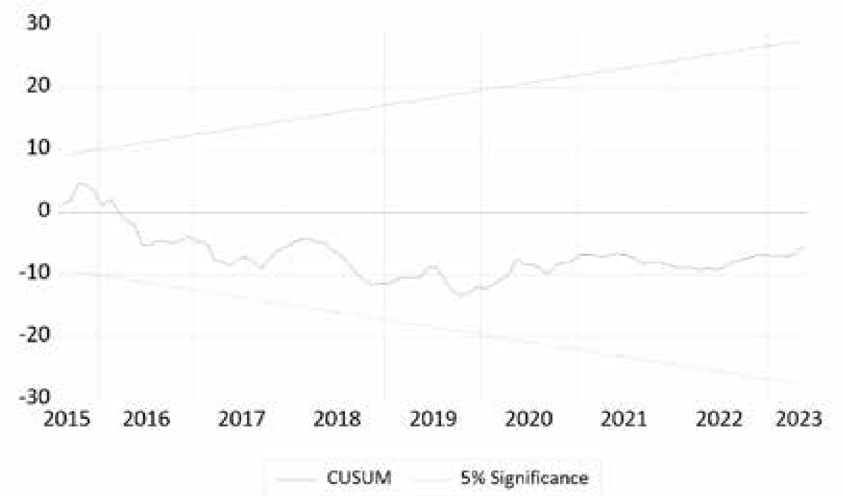
**Annexure A5.5**

*CUSUM Test for Stability in Pulses*

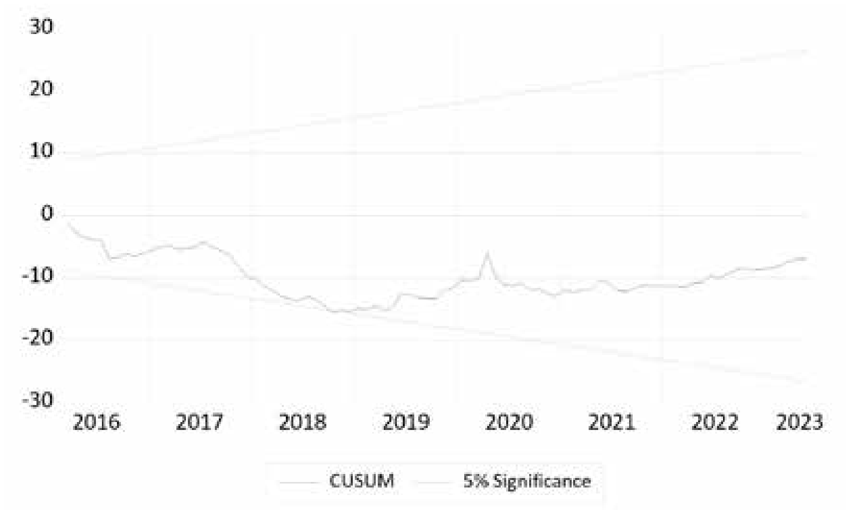
a. Gram




b. *Tur*



c. *Moong*




*Source*: Authors' estimation

**Annexure A5.6**

*Gram: SARIMAX Model for Gram (Dependent Variable: First Difference of Seasonally Adjusted Log CPI of Gram)*

| | *Coef.* | *Std. Error.* | *Significance* |
|---|---|---|---|
| First difference of Seasonally Adjusted STU of Gram | 0.045 | 0.029 | * |
| First difference of lag of Gram Mark | -0.000 | 0.0002 | |
| Constant | 0.004 | 0.006 | |
| First lag of Auto regressive term | 0.649 | 0.073 | *** |
| Second lag of Moving Average | 0.064 | 0.099 | |
| Constant | 1.922 | 0.119 | *** |
| | | | |
| Mean dependent var. | 0.001 | SD dependent var. | 2.112 |
| Number of obs. | 104 | Chi-square | 136.72 |
| Prob. > chi2 | 0.000 | Akaike crit. (AIC) | 393.453 |
| *** p<0.01, ** p<0.05, * p<0.1. | | | |

Gram: SARIMAX Model for CPI Gram (Dependent Variable: First difference of Seasonally Adjusted Log CPI of Gram)

*Source*: Authors' estimations.

*Tur: SARIMAX Model for Tur (Dependent Variable: First Difference of Seasonally Adjusted Log CPI of Tur)*

| | *Coef.* | *Std. Error* | *Significance* |
|---|---|---|---|
| First difference of Seasonally Adjusted STU of *Tur* | 0.025 | 0.023 | * |
| First difference of *Tur* Mark | 0.0003 | 0.0003 | |
| First difference of Besan MoM | -0.0014 | 0.005 | |
| Constant | 0.004 | 0.007 | |
| First lag of Auto regressive term | 0.533 | 0.128 | *** |
| First lag of Moving Average | 0.132 | 0.190 | |
| Constant | 2.24 | - | |
| | | | |
| Mean dependent var. | -0.016 | SD dependent var. | 3.052 |
| Number of obs. | 118 | Chi-square | 189.59 |
| Prob. > chi2 | 0.000 | Akaike crit. (AIC) | 433.771 |
| *** p<0.01, ** p<0.05, * p<0.1. | | | |

*Source:* Authors' estimations.

*Moong: SARIMAX Model for Moong (Dependent Variable: First Difference of Seasonally Adjusted Log CPI of Moong)*

| *Coef.* | *Std. Error* | *Significance* | |
|---|---|---|---|
| First difference of Seasonally Adjusted STU of *Moong* | -0.009 | 0.007 | * |
| First difference of *Moong* Mark | 0.004 | 0.0003 | *** |
| Constant | -0.0001 | 0.0004 | |
| First lag of Auto regressive term | 0.269 | 0.149 | * |
| Constant | 1.567 | 0.067 | *** |
| | | | |
| Mean dependent var. | -0.014 | SD dependent var. | 1.682 |
| Number of obs. | 115 | Chi-square | 402.90 |
| Prob. > chi2 | 0.062 | Akaike crit. (AIC) | 365.015 |
| *** p<0.01, ** p<0.05, * p<0.1. | | | |

*Source:* Authors' estimations.

## Annexure A5.7

*Diebold Mariano Test Results*

| *Commodity* | *DM-Statistic* | *P- Value* | *SARIMA MSE* | *SARIMAX MSE* | *Result* |
|---|---|---|---|---|---|
| Gram | 3.384 | 0.0007 | 5.897 | 2.364 | SARIMAX is better forecast |
| *Tur* | 3.993 | 0.0001 | 2.446 | 1.525 | SARIMAX is better forecast |
| *Moong* | 1.543 | 0.1228 | 1.433 | 1.122 | SARIMAX is better forecast |

*Source:* Authors' estimations.

# 6

RANJANA ROY, SANCHIT GUPTA, HARSH WARDHAN, SUVENDU SARKAR, SOUMASREE TEWARI, ROHAN BANSAL, SHELJA BHATIA and ASHOK GULATI

## Vegetables Inflation in India

*A Study of Tomato, Onion and Potato (TOP)*[53]

### 6.1 Introduction

Top are amongst the largest produced and consumed vegetables in India. They exhibit significant volatility in prices due to short seasonal crop cycles, perishability, and regional concentration of production and sensitivity of the crops to the evolving weather conditions. Despite a combined weight of just 4.8 per cent in the CPI food and beverages group and 2.2 per cent in CPI combined (Base: 2012=100), TOP contributes substantially to the variance of food and headline inflation, and there is a growing interest in understanding their price dynamics. There are supply side factors that affect the price movement due to agro-climatic risk, drought or flood, level of MSPs and fluctuations in key input costs like oil and fertilisers. The demand side factors include rising per capita income, increase in monthly per capita expenditure, relative prices of a substitute or complementary good, etc.

The outbreak of COVID-19, followed by the country-wide lockdown in 2020, exposed the bottlenecks in the supply chains and marketing infrastructure in the country for TOP (Estupinan et al., 2020). In the flush season, farmers are seen discarding their

53. This study is part of a joint research project titled "Understanding Price Dynamics of Major Agricultural Commodities and Identifying Ways to Improve Value Chains", conducted by the Reserve Bank of India (RBI) and the Indian Council for Research on International Economic Relations (ICRIER). The findings are published as an RBI Working Paper, available at https://www.rbi.org.in/scripts/PublicationsView.aspx?id=22723

crops or resorting to distress sale when prices drop way below their production costs. In the lean season, consumers face higher price pressures. This boom-and-bust cycle of TOP is due to the inefficient marketing system and lack of well-integrated value chains with a widening gap between what farmers receive and what consumers pay (Gulati and Wardhan, 2019; Chengappa et.al. 2012 and Birthal et.al. 2019). The study by Gulati and Saini (2013) emphasised the need to increase the supply responses and correct the anomalies in the supply chains by allocating large investment in agriculture research and development (R&D) in the areas of high yielding varieties of seeds, irrigation, logistics, processing plants and so on. Another study by Ganguly and Gulati (2013) pointed out that rising price pressures of high value commodities resulting from increasing demand can be corrected by streamlining the supply chains.

In this context, the chapter attempts to identify key factors determining prices of tomato, onion and potato, and provide insights into the changing market scenario and the role of supply management measures to contain inflation. Better assessment of TOP inflation assumes greater importance for forecasting food and headline inflation, as they contribute the most to their volatility. Accordingly, the main objectives of the chapter are:

a) To create a dynamic balance sheet for TOP covering supply and demand on a monthly basis and to evaluate patterns of market responses, particularly the behaviour of farmers, traders, importers, stockists' and consumers;

b) To empirically estimate determinants of TOP prices using the balance sheet variable along with macro and commodity specific variables;

c) To forecast inflation in TOP for up to 12 months ahead and assess the performance of the different forecasting models;

d) To understand the value chains of the three TOP vegetables for stabilizing prices and raising farmers' share in the consumer rupee.

The chapter constructs state-wise monthly balance sheets of major producing states using annual production data, monthly harvest, sales pattern, and post-harvest losses on the supply side, and estimating monthly demand series from the annual consumption expenditure data, available up to 2011-12[54] and extrapolated by using the behavioural approach of the Working Group Report of NITI Aayog (2018), on the demand side. The balance sheet variables are used in ARDL models for the three vegetables to study their underlying price dynamics controlling for input costs, rainfall and wages. The results show that availability inversely impacts the CPI of onions and potatoes, while the availability to usage ratio negatively influences the CPI of tomatoes. In case of onion, the rainfall deviation from the long-term average in the major producing region (i.e., Nashik) significantly impacts onion prices. An increase in the relative price of other vegetables measured using the vegetable price index increases the prices of potatoes and onions. The study also attempts to forecast inflation for TOP using univariate and multivariate time series models, integrating variables that are identified as significant in the ARDL model. The analysis finds that SARIMA-X models incorporating the balance sheet variables perform better compared to other models in forecasting inflation over different forecast horizons. The value chain analysis of the three vegetables suggests that farmers are getting around one third of the price that a consumer is paying; the rest is apportioned by the wholesalers and retailers. Marketing reforms, storage solutions, enhancing processing capacity and raising yields through higher R&D investments in developing climate resistant varieties and innovative cultivation techniques is critical for improving the value chains, increasing farmers' share in consumer rupee and containing the price volatility.

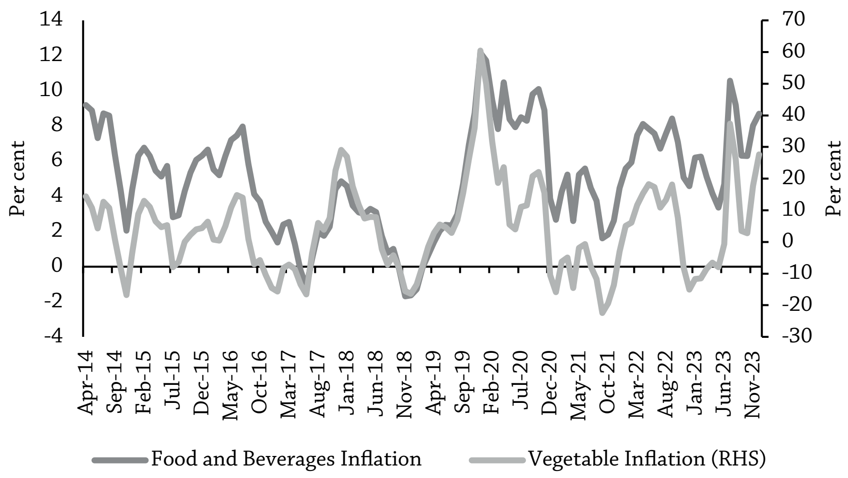
The rest of the chapter is organised into six sections. Section 6.2 discusses TOP vegetables trends in production, consumption, and trade. Section 6.3 discusses the price dynamics and seasonality of their prices. Section 6.4 provides an overview of supply management

54. The National Sample Survey Office (NSSO), Ministry of Statistics and Programme Implementation, Government of India has released the summary results of Household Consumption Expenditure Survey (HCES) conducted during August 2022 to July 2023 relating to estimated Monthly Per Capita Consumption Expenditure (MPCE) in the form of a factsheet in February 2024. The factsheet of HCES: 2022-23 is available at http://www.mospi.gov.in. The detailed unit level data was released after the completion of the study in June 2024.

measures adopted by the government in the last decade. To analyse factors that affect prices, there is a need to understand the stakeholders in the value-chain and decipher the way their behaviour impacts market supply and demand. Section 6.5 traces the stakeholders in the TOP value-chain and records their activities and calculates price mark-ups in the value chain. Section 6.6 discusses the data sources used in the analysis and the methodological framework for the balance sheet approach. Section 6.7 specifies the model and explains factors that influence TOP prices and generates inflation forecasts for these over the 12-month horizon. Section 6.8 provides policy recommendations to contain the TOP price volatility.

**Figure 6.1**

*Food and Vegetable Price Inflation in India*



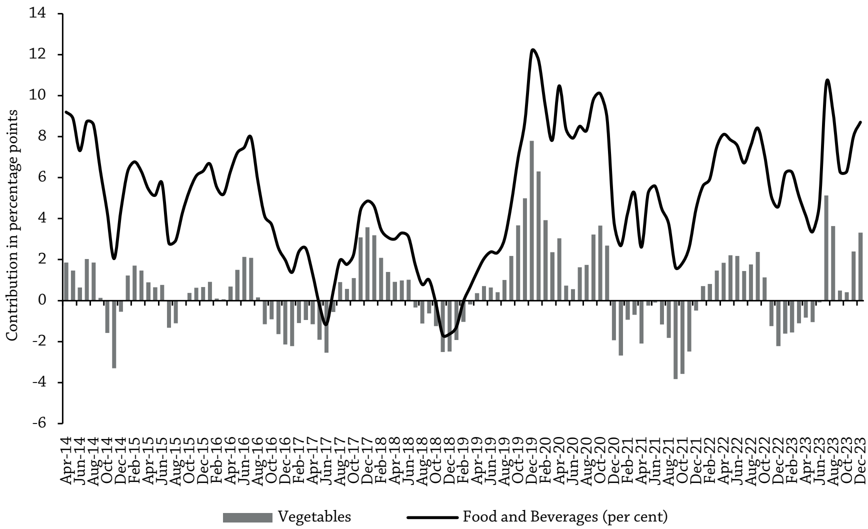

*Source*: National Statistical Office (NSO), Ministry of Statistics and Programme Implementation (MoSPI).

## 6.2 Price Dynamics and Commodity Profile of TOP

Food inflation has remained one of the most volatile components of headline inflation making it extremely challenging to forecast the inflation path (Figure 6.1). Volatility in food inflation has often mirrored fluctuations in vegetable prices, one of the major contributors in food inflation in India (Figure 6.2).

**Figure 6.2**

*Contribution of Vegetables to Food and Beverages Inflation in India (Y-o-Y)*



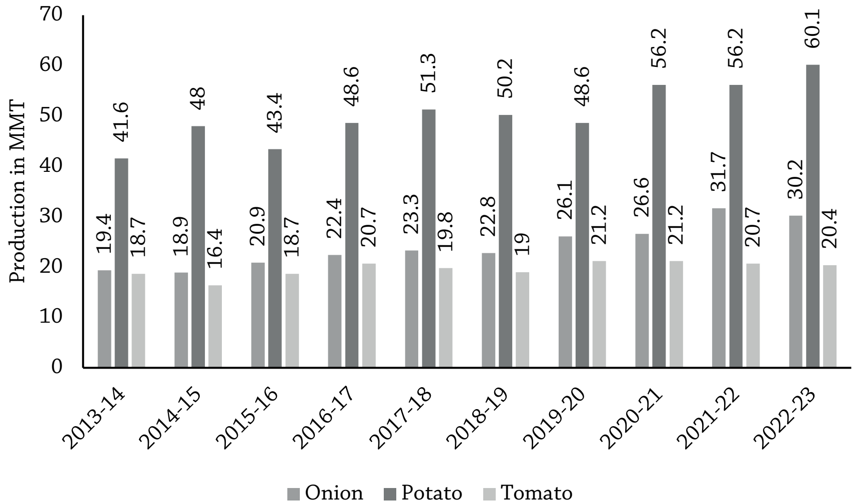

*Source:* NSO, MoSPI and Authors' calculations.

## *6.2.1 Domestic Production and Consumption of Vegetables*

In vegetables, TOP are the three principal crops in terms of production and consumption. There has been a dramatic increase in the production of these three crops in the past few years. In 2022-23, the production of tomato, onion, and potato was 20.4 million metric tonne (MMT), 30.2 MMT and 60.1 MMT, respectively (Figure 6.3) owing to area as well as yield expansion. India has now become the second largest producer of tomato and potato in the world, contributing 11 per cent, and 15 per cent of world production in 2022, respectively (FAO, 2024). In 2021, India surpassed China as the largest onion producing country in the world and retained its position in 2022 with a share of 28.6 per cent in global production (FAOSTAT, 2024). The sharpest increase of 63 per cent in production was seen in onions from 2013-14 to 2021-22.

**Figure 6.3**

*Production of TOP Vegetables in India*

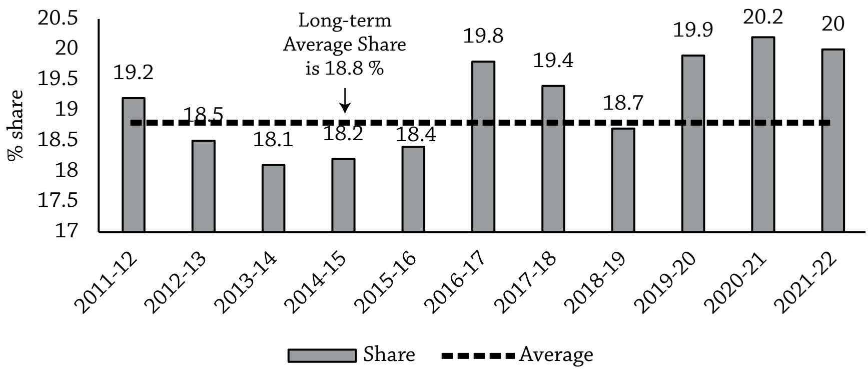



*Source*: Horticulture Statistics, Department of Agriculture and Farmers' Welfare, Ministry of Agriculture and Farmers' Welfare, GoI.

There has been a significant increase in the share of TOP in the gross value of output (GVO) of fruits and vegetables in real terms, underscoring the importance of these three principal crops in India's output (Figure 6.4).

**Figure 6.4**

*Share of TOP in Fruits and Vegetables GVO at Constant (2011-12) Prices*

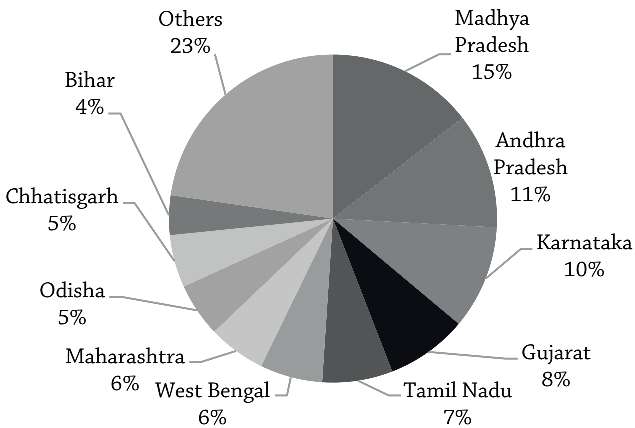



*Source:* Ministry of Agriculture and Farmers' Welfare (MoA&FW) and NSO, MoSPI.

Production of TOP is diverse across states and impacts the supply dynamics and overall availability, influencing their prices. The major tomato producing states, Andhra Pradesh, Madhya Pradesh, Karnataka, Gujarat, Tamil Nadu and West Bengal together account for 57 per cent of the total production (Figure 6.5). The transplanting and harvesting months also vary across states, with major production (67 per cent) coming from the *rabi* months. In Andhra Pradesh, Gujarat and Maharashtra, tomato is produced almost round the year. In other producing states like Karnataka and Madhya Pradesh, the peak season is in August-October and October-December respectively, while in West Bengal and Uttar Pradesh most of the harvesting takes place during November-January. Between 2014-15 to 2022-23, tomato yield increased from 21.3 tonnes per hectare to 24.0 tonnes per hectare. State wise, while yield in Andhra Pradesh increased from 27.3 tonnes per hectare to 43.3 tonnes per hectare, other major producing states witnessed a decline in yield.

**Figure 6.5**

*State-wise Contribution in Total Production of Tomato, TE 2022-23*



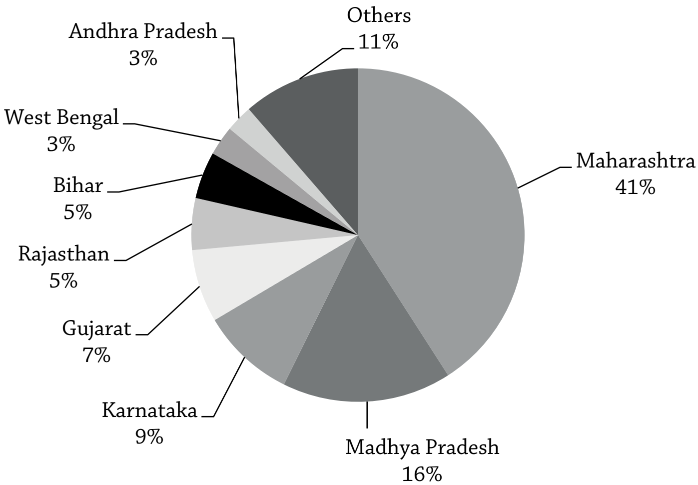

*Source*: Horticulture Statistics, Department of Agriculture and Farmers' Welfare, MoA&FW, Government of India (GoI).

There has been a sharp increase in the production of onion from 18.9 MMT in 2014-15 to 30.2 MMT in 2022-23. This is due to in the area under production from 11.7 lakh hectare (ha) in 2014-15 to 17.4 lakh ha in 2022-23. The major onion producing states are

Maharashtra [with a share of 41 per cent in the triennium (TE) ending 2022-23], Madhya Pradesh (16 per cent), Karnataka (9 per cent), Gujarat (7 per cent), and Rajasthan (5 per cent), and these states together contribute about 80 per cent of India's production (Figure 6.6). Onion has three crop harvesting cycles, March to May (*rabi*), October to December (*kharif*) and January to March (late *kharif*), with the major crop (77 per cent) arriving in the *rabi* season.

**Figure 6.6**

*State-wise Contribution in Total Production of Onion, TE 2022-23*



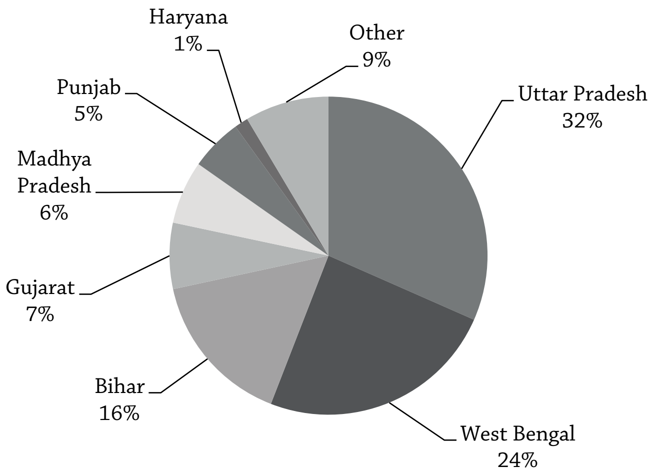

*Source:* Horticulture Statistics, Department of Agriculture and Farmers' Welfare, MoA&FW, GoI.

Potato production in India increased from 48.0 MMT in 2014-15 to 60.1 MMT in 2022-23. The major share of the harvest is concentrated in the *rabi* months with Uttar Pradesh (32 per cent), West Bengal (24 per cent), Bihar (16 per cent) and Gujarat (7 per cent) being the highest producing states, contributing around 80 per cent of the total production (Figure 6.7). There has been an increase in the area under production from 20.7 lakh ha in 2014-15 to 23.3 lakh ha in 2022-23.

On the demand side, vegetables are an essential part of household consumption basket and have consistently been a stable source of private consumption expenditure, reflecting a steady demand commensurate with the changing expenditure pattern over the years (Figure 6.8).

**Figure 6.7**

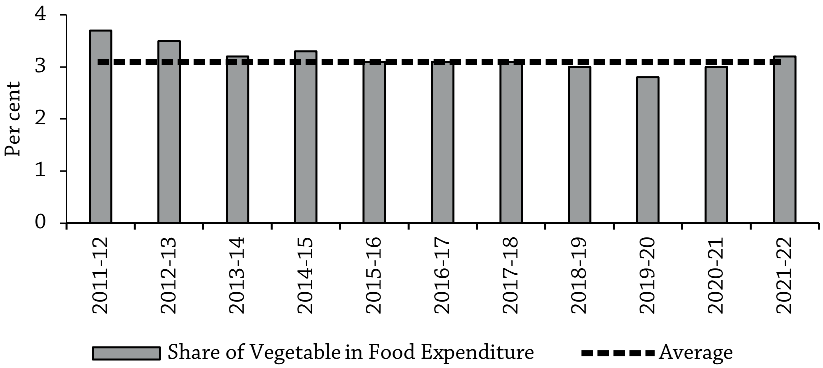
*State-wise Contribution in Total Production of Potato, TE 2022-23*




*Source:* Horticulture Statistics, Department of Agriculture and Farmers' Welfare, MoA&FW, GoI.

**Figure 6.8**

*Share of Vegetables in Private Final Consumption Expenditure at Constant (2011-12) Prices*



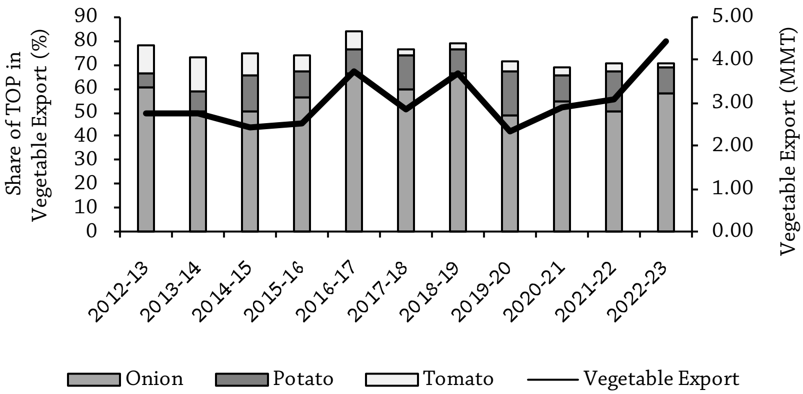

*Source:* Consumer Pyramid Household Survey (CPHS), Centre for Monitoring Indian Economy (CMIE).

### *6.2.2 External Trade in Vegetables and TOP*

Significant growth in domestic production has led to an increase in vegetable exports with a contribution of 70 per cent from TOP exports, particularly, onion exports of 2.6 MMT in 2022-23 (Figures 6.9 and 6.10). Onion exports account for 8.6 per cent of the total production, with main export destinations being Bangladesh, Nepal, Sri Lanka and Singapore. However, potato and tomato account for only 2 per cent of global exports, as they mostly cater to the domestic demand.

**Figure 6.9**

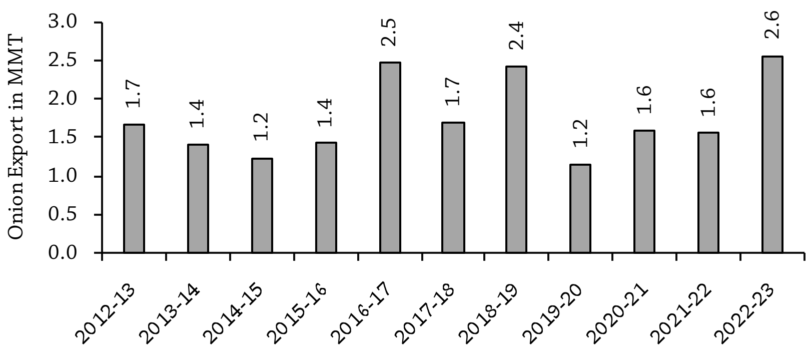
*TOP Exports Share in Vegetables Exports*




*Source:* Directorate General of Foreign Trade (DGFT), Ministry of Commerce, GoI.

**Figure 6.10**

*Volume of Onion Exports*



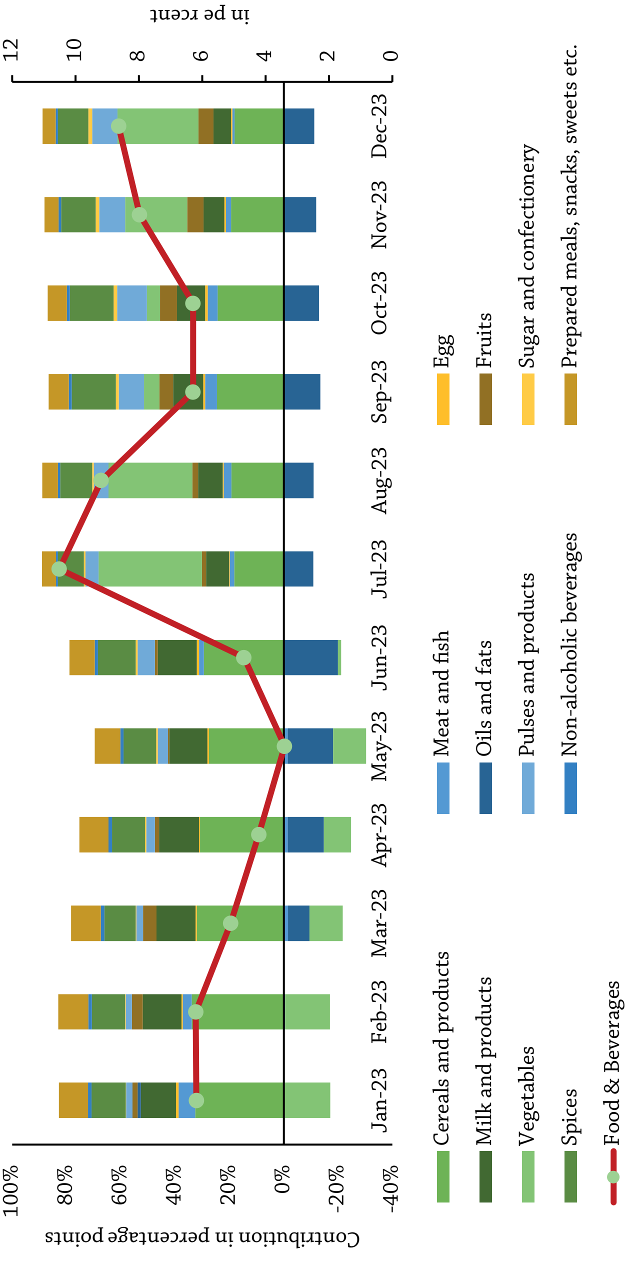

*Source:* DGFT, Ministry of Commerce, GoI.

## 6.3 TOP Price Behaviour and Trend of Inflation

Vegetable inflation is one of the primary drivers of food and beverages inflation with the largest contribution in December 2023,

**Figure 6.11**

*Sub-group wise Contribution to Food and Beverages Inflation (Y-o-Y)*

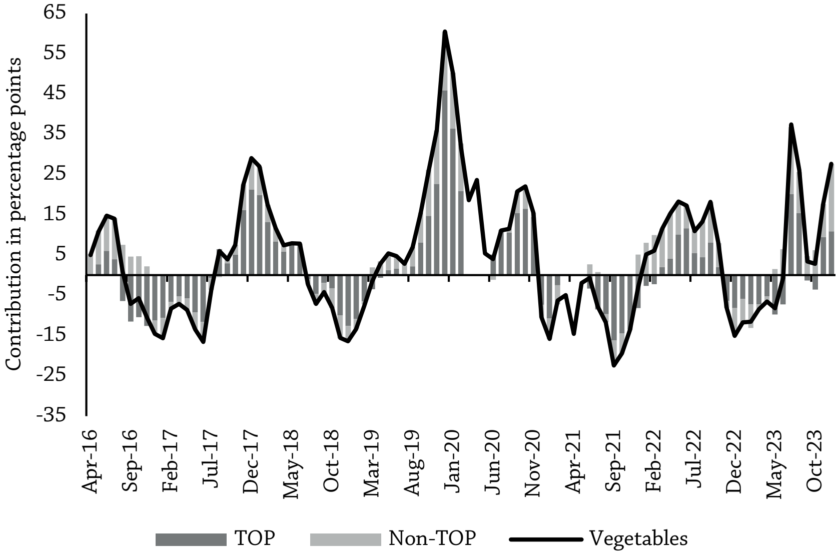



*Source:* NSO, MoSPI, GoI and authors' calculations followed by cereals, spices and pulses. In July and August, the sharp increase in food and beverages inflation was driven by vegetables as the TOP momentum reached an unprecedented peak following extreme weather events (Figure 6.11).

Volatility in vegetable inflation has been primarily driven by fluctuations in the TOP prices that have experienced frequent inflationary pressures due to seasonal fluctuations, weather related disruptions and demand-supply mismatches (Figure 6.12).

**Figure 6.12**

*Drivers of Vegetables Inflation (Y-o-Y)*



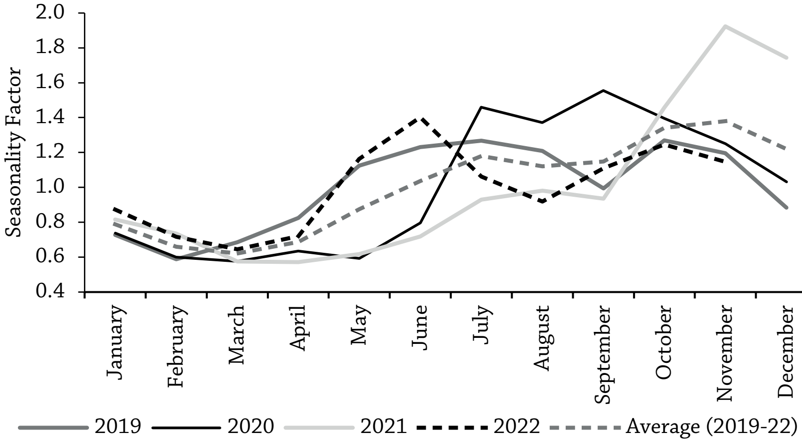

*Source:* NSO, MoSPI, GoI and authors' calculations.

Crop prices follow a typical seasonal[55] pattern, plummeting during harvest time and rising a few months prior to the arrival of the new crop as can be observed from the seasonality factors. Tomato is a short duration crop and the supply side shock gets translated to prices very fast causing volatility in retail prices (Figure 6.13).

55. To calculate the seasonality graph, the seasonality factor which is the ratio of monthly retail prices to that year's average retail price is used. The seasonality features have been averaged over the last four years based on the crop year of tomato, onion, and potato.

**Figure 6.13**

*Seasonality of Tomato Prices*

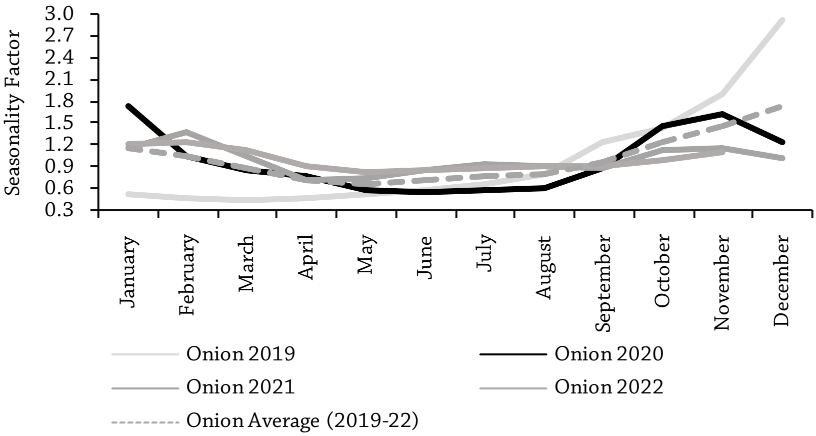



*Source:* Department of Consumer Affairs (DCA), Ministry of Consumer Affairs, Food, and Public Distribution, GoI and Authors' calculations

In case of onion, since 77 per cent of the total production is cultivated during the *rabi* season, prices peak in September-December, right before the onset of the late *kharif* and *rabi* season (Figure 6.14).

**Figure 6.14**

*Seasonality of Onion Prices*

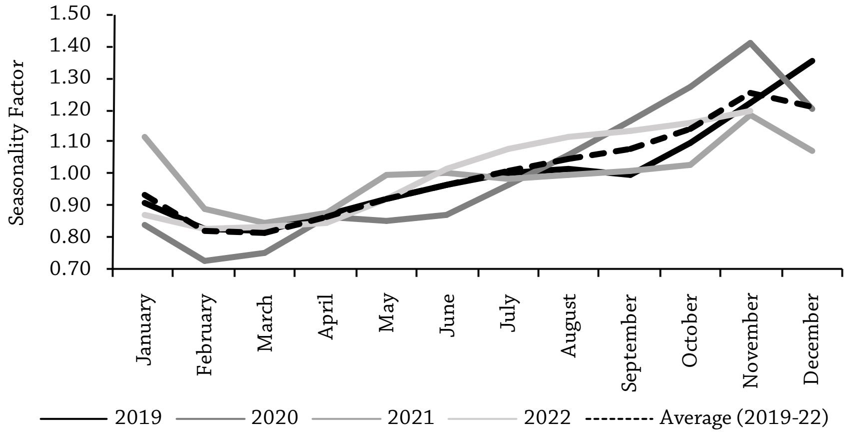



*Source:* DCA, Ministry of Consumer Affairs, Food, and Public Distribution, GoI and Authors' calculations

Similarly, retail prices of potato peak during October-November, right before the major *rabi* harvest reaches the market and stocking of potato begins (Figure 6.15).

**Figure 6.15**

Seasonality of Potato Prices




*Source*: DCA, Ministry of Consumer Affairs, Food, and Public Distribution, GoI and Authors' calculations.

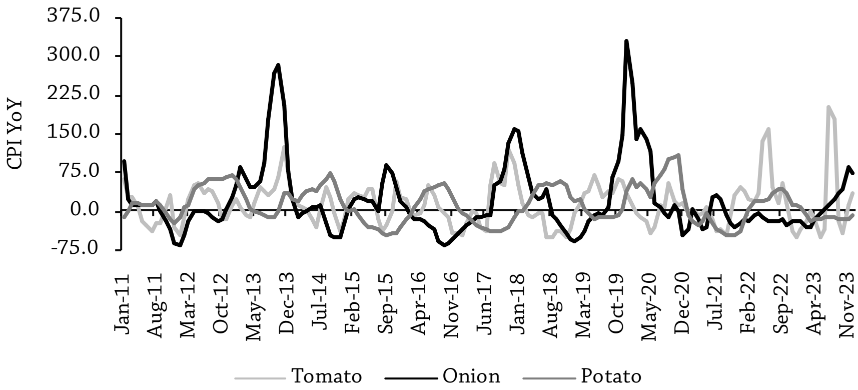
Tomato prices follow a repeated spiral of high and low prices every alternate year. In July, August and September 2021, there was negative inflation in the wholesale prices of tomato. In July, the average wholesale prices in *Kolar mandi* (largest wholesale market for tomato) plummeted to Rs. 5.80 per kg with minimum price reaching as low as Rs. 2.60 per kg (Agmarknet, 2023). The fall in prices results in losses for farmers, leading to lower sowing acreage under the crop and a shift towards other crops with better returns. As tomato is a short-duration crop, the impact of supply deficiency gets translated into the prices within a short span of time. In 2022, the heatwave in the northern part of India, and heavy rainfall in Karnataka caused productivity to fall. CPI tomato inflation spiked to a high of 158.4 per cent in June 2022 and 202.1 per cent in July 2023. In July 2023, the average retail price of tomato was Rs. 109.5 at the all-India level and tomato contributed 18.9 per cent to inflation among the 299 commodities in the CPI basket.

A similar trend was observed in onion during September 2019 to April 2020, with onion CPI inflation reaching as high as 327 per cent in December 2019 and 246 per cent in January 2020 (Figure 6.16). A hike in onion prices is seen during September-December almost every year due to seasonality, but the hike is very steep every alternate year. Retail prices of onion touched Rs. 60 per kg and Rs. 75 per kg in September and October 2013 respectively, Rs. 70 per kg in September 2014, and Rs. 55 per kg in September 2019 (DES). Wholesale prices witnessed sharp drops frequently. For instance, during January-May 2019, the wholesale prices in *Lasalgaon* market hovered between Rs. 4-10 per kg. Thus, oscillation in prices becomes damaging for both producers and consumers.

A similar cyclical phenomenon is seen in potato. In 2008-09, the potato production plummeted in West Bengal due to pest attacks. This led to lower stocks in the cold storages and by November-December, the prices picked up sharply. Price oscillations in potato were observed in 2018, 2020 and 2022, with CPI inflation reaching 107 per cent in November 2020 (Figure 6.16[56]).

**Figure 6.16**

*CPI Inflation (Y-o-Y) in TOP*




*Source:* NSO, Ministry of Statistics and Programme Implementation (MoSPI), GoI.

56. The item-wise monthly CPI data is unavailable for March, April, and May 2020. To address this gap, the study has imputed commodity-wise CPI values using the available sub-group CPI data for those months.

## 6.4 Role of Government Supply Management & Trade to Adjust Domestic Supply

TOP is an integral part of Indian cooking. The continuous volatility in TOP prices led to undisputed policy prescription of making the TOP value chain more efficient. In 2018-19, a scheme "Operation Greens" was launched by MoFPI for TOP with the main objectives of ensuring better value realisation for TOP farmers, minimising post-harvest losses, and reducing price volatility for producers and consumers. The scheme started with an outlay of Rs.500 crore with provision for both long term and short-term interventions. The scheme focused on developing FPOs, agri-logistics and processing facilities and the scheme is demand-driven where projects are authorised on the basis of applications received from investors. For both transportation and storage, 50 per cent subsidy is contributed by MoFPI. The long-term measure target to build an integrated value chains for TOP where grants-in-aid of 50 per cent (70 per cent in case of FPOs) is issued to project implementing agencies. However, this has not brought much relief for the stakeholders of vegetables in India. The current market scenario of horticulture crops is still plagued by a fragmented value chain, price volatility, post-harvest loss and other market inefficiencies.

The production of onion has increased steadily since 2002-03 and fluctuations in production have also minimised (Chand and Saxena, 2017), but onion prices have seen extreme volatility across time and space. It has been observed that onion prices spike around September almost every year due to production seasonality, with this acceleration observed to be more severe every alternate year. A similar trend is seen for tomato and potato. During the *rabi* season of 2022, the Government built a buffer stock of 2.50 lakh MT of onion with the objective of stabilising retail prices during the lean season. Out of this stock, around 54,000 tonnes of onion were distributed in several markets across 14 States/Union Territories. Moreover, onion was supplied to various retail outlets like Mother Dairy, Safal, Kendriya Bhandar, etc. Other steps included setting up of the PSF for TOP vegetables with a dual objective of protecting consumers' and farmers' interests. The buffer stock helps in moderating prices during the lean season. In contrast to this, in the aftermath of the sharp plunging of the late *kharif* onion prices owing to the massive production, the Maharashtra government declared ex-gratia of Rs. 300 a quintal to the onion farmers in March 2023 and bore the burden of Rs. 340 crore for the procurement of 18.9 million quintals.

The Government has also imposed stocking limits for onion and potato from time-to-time under the Essential Commodities Act, 1955 to fight inflation. This addresses the artificial scarcity created by hoarders. The steady increase in production of TOP has helped fight price rise owing to supply shocks. However, the production shock alone cannot fully explain inflation in TOP prices. The post-harvest value chain is fragmented with many intermediaries. Such an inefficient marketing chain gives opportunity to the intermediaries to exploit supply-induced scarcity.

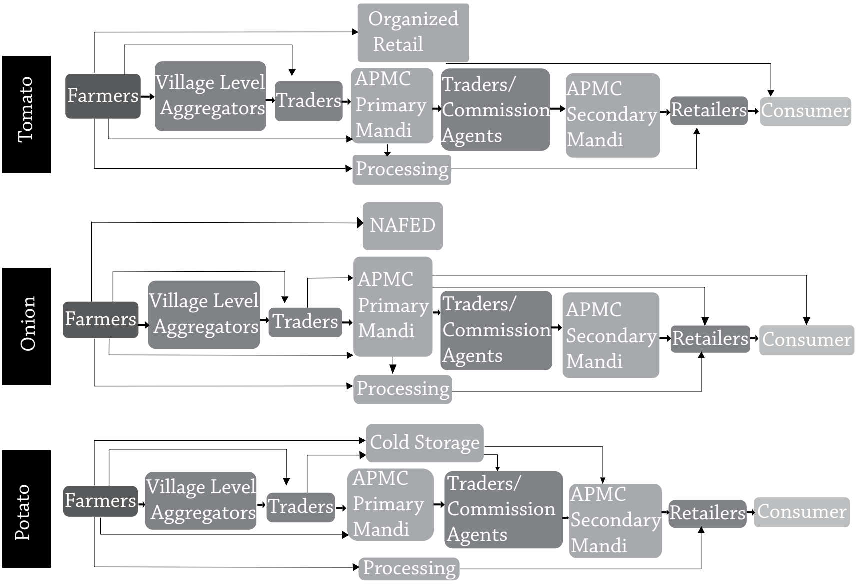
### 6.5 Overview of TOP Value Chains in India

The markets for TOP vegetables in India are highly fragmented. Agricultural markets are administered by respective states that have APMCs that fix the *mandi* fees, official commission charges, and user charges, etc. Unlike cereals and dairy products, where procurement and marketing is relatively developed, TOP vegetables lack an efficient value chain system. This is attributed to the perishable nature of the crop, regional and seasonal concentration, lack of adequate storage facilities, and presence of large number of intermediaries (Gulati et al., 2022). An analysis of farmers' share in consumer rupee for the three TOP vegetables suggests that farmers are getting only one third of the price that a consumer is paying; the rest is apportioned by the wholesalers and retailers – unlike other sectors like dairy, where farmers are getting around 70 per cent of the final price.

This section discusses the value chains of TOP from the producers to the final consumers and estimates the farmers' share in consumer rupee for the three vegetables. This will help understand the role of different market participants and their contribution to price inflation. A typical value chain for the three TOP vegetables is presented in Figure 6.17.

**Figure 6.17**

*A Typical Value Chain of TOP in India*




*Source:* Compiled based on information from primary survey and various market sources.

### *6.5.1 Tomato Value Chain in India*

In India, tomato is majorly grown in the southern and western region but many other states also produce tomato for local consumption. The top 10 tomato producing states account for about 75 per cent of the all-India production. However, only the major tomato producing states have surpluses that are transported to deficit states and metropolitan cities for consumption. Tomato has mainly two seasons: *rabi* which accounts for 67 per cent of the production and is harvested between December and June, and *kharif* which accounts for 33 per cent of the production and is harvested between July and November. The major producing clusters of tomato and major consumption centres are listed in Table 6.1. The tomato value chain consists of several intermediaries between the farmers and consumers.

**Table 6.1**

*List of Production and Consumption Centres of Tomato*

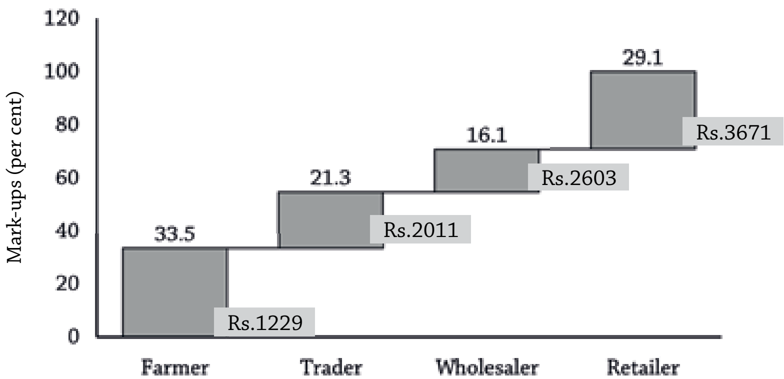
| *State* | *Production Belt* | *Consumption Centres* | *Harvesting Months* |
|---|---|---|---|
| Andhra Pradesh | Chittoor, Anantpur | Delhi, Maharashtra, Southern India | Round the year |
| Madhya Pradesh | Shivpuri | Delhi, Maharashtra, Central India | October-March |
| Karnataka | Kolar, Chikkabal-lapur | Delhi, Maharashtra, West Bengal, Sothern, Northern India | July-December March-May |
| Odisha | Mayurbhanj, Keonjhar | East India | November-December |
| Gujarat | Sabarkantha, Anand, Kheda | Western India | November-May |
| Maharashtra | Nashik | North India, West India | August-December March-May |

*Source:* DES (2022), Ministry of Food Processing Industries (MoFPI) (2022) and Market Intelligence.

Tomato cultivation involves marginal and small farmers who account for 82.1 per cent of the total land holdings (DoA&FW, 2020). With a crop duration of 3 to 4.5 months, tomato is sowed on raised beds. There has been an improvement in yield in the last decade

**Figure 6.18**

*Mark-ups in the Tomato Value Chain*




*Source:* Authors' calculation using data from Agmarknet (2022), DoCA (2022) and field visits.6.5.2 Onion Value Chain in India.

due to introduction of hybrid seeds and marketing and processing of tomato. Tomato cultivation in India is predominantly open field cultivation rather than polyhouse cultivation that can help multiply the yield levels by vertical farming. The other intermediate costs have been collected through market intelligence and field visits conducted in January 2023.

Farmers usually bring their produce to the *mandi* (APMC). The first level of sorting and grading in three grades is done by the farmer at the farm gate itself. The farmer also has an option of selling to organised retailing such as Horticultural Producers' Co-operative Marketing and Processing Society Ltd (HOPCOMS, SAFAL Market, and Namdhari Fresh. Processing units procure tomato from mandis or directly from the farmers. In Kolar *mandi*, which is the largest tomato *mandi* in India, farmers from Anantapur, Bangalore Rural, Tumkur and Chittoor sell their produce. At APMC *mandis*, tomato is auctioned in the presence of traders, commission agents and *mandi* officials. Traders pay *mandi* fees, commission charges and transportation costs which then passes on from wholesalers to retailers and finally to the end consumer.

To study the tomato price discovery from farmers to consumers, a case study of the value chain from major supplying regions to Delhi has been considered. While the farmers' price is the weighted average wholesale price for triennium (TE) 2021-22 taken from Agmarknet, retail price of Delhi was taken from the Department of Consumer Affairs (DoCA). As the biggest consumption center, Delhi receives tomato throughout the year from different parts of the country including Maharashtra, Karnataka, Himachal Pradesh, Madhya Pradesh, adjoining regions of Haryana, Rajasthan and Uttar Pradesh. The other costs have been collected through market intelligence and field visits conducted in January 2023 in the Nashik region of Maharashtra.

The estimated share of each stakeholder in the tomato value chain shows that tomato farmers on an average receive 33.5 per cent of the consumer's price in Delhi (Figure 6.18). This includes overhead costs of labour and transportation over and above his cost of cultivation. Traders' mark-up of 21.3 per cent also includes transportation cost, mandi fees, commission charges, and loading/unloading charges (i.e., mark-ups include costs plus margin). As per calculations, traders earn an average of 5.3 per cent margin. The same is true for wholesaler in the secondary market. The highest margin is apportioned by the retailer who bears the maximum risk of perishability and wastage, given that tomatoes are mostly sold in unorganised markets, and they have to incur transportation costs and shop rentals.

### *6.5.2 Onion Value Chain in India*

Onion production is concentrated in the western and southern states of India, particularly, Maharashtra, Madhya Pradesh, Karnataka, Gujarat, and Rajasthan that contribute to about 80 per cent of the total production. Major production and consumption clusters of onion have been presented in Table 6.2. Onion production is spread across three seasons: *rabi* harvested in March and May and accounts for about 77 per cent of the total production; *kharif* harvested between October and December accounts for 14 per cent of the production, and the late *kharif* harvested between January and March accounts for 9 per cent of the production as of TE 2021-22[57].

Out of the three seasons, only *rabi* onion can be stored between March and October in onion storage units. The bulbs harvested from *Rabi* season have better storage life than *kharif* and late *kharif* onion. These are scientific storage structures made using bamboo, asbestos that are three-side open and may have ventilation at the bottom on a raised platform (Gulati et al., 2022). Most farmers in Nashik Maharashtra are using these structures for storing their produce. Storing of onion during this period is key to controlling inflation in India. The government through NAFED procures onion during the peak harvesting months to maintain a buffer stock to tackle onion inflation. The stock is released during later months when fresh arrivals are low in the market. The duration of onion crop is around 5 months from sowing to harvesting and as per the 2021-22 estimates, the cost of onion cultivation varies widely across states from a minimum of Rs. 341.07 per quintal in Madhya Pradesh to a

57. Season wise production data is available only up to 2021-22.

maximum of Rs. 2305.29 per quintal in Tamil Nadu. Among other states, the A2 +FL[58] cost was Rs. 1312.57 per quintal in Karnataka, Rs. 965.27 per quintal in Andhra Pradesh, Rs. 782.35 per quintal in Rajasthan, Rs. 697.33 per quintal in Gujarat and Rs. 602.67 per quintal in Maharashtra (DES, MoA, 2023). Around 70.4 per cent of the onion farmers are small and marginal having an area less than 2 hectares (DoA&FW, 2020).

**Table 6.2**

*Major Production and Consumption Centres of Onion in India*

| *State* | *Production Belt* | *Consumption Centres* | *Harvest Months* |
|---|---|---|---|
| Maharashtra | Nashik, Ahmednagar, Aurangabad, Pune | Delhi, Maharashtra, Eastern India | March-May (*Rabi*) October-December (*Kharif*) January-March (Late *Kharif*) |
| Madhya Pradesh | Shajapur, Indore, Ujjain, Khandwa | Delhi, Maharashtra, Central India | March-April (*Rabi*) |
| Karnataka | Bijapur, Dharwad, Chitradurg | Southern India, Eastern India | March-May (*Rabi*) September-November (Kharif) |
| Gujarat | Bhavnagar, Amreli | Delhi, North India, Maharashtra (Processing) | March-May (*Rabi*) January-February (late *Kharif*) |
| Rajasthan | Jodhpur, Sikar | Delhi, Western India | March-May (*Rabi*) November-December (*Kharif*) |

*Source:* Directorate of Economics and Statistics (DES) (2022), Ministry of Food Processing Industries (MoFPI) (2022) and Market Intelligence.

A considerable amount of onion is also exported from India. During 2015-16 and 2018-19, India exported 9 per cent of its production on an average. However, in TE 2021-22, only 5 per cent of onion production was exported as government restricted exports and prescribed a MEP whenever the wholesale prices of onion crossed Rs. 50 per kg mark, but it increased again to 8.5 per cent in 2022-23.

58. (A2+FL) includes value of hired human labour, hired bullock labour, owned bullock labour, owned machinery labour, hired machinery charges, seeds, insecticides, pesticides, manure, fertiliser, depreciation on implements and farm buildings, irrigation charges, land revenue, cess, other taxes, interest on working capital, miscellaneous expenses, rent paid for leased land, imputed value of family labour

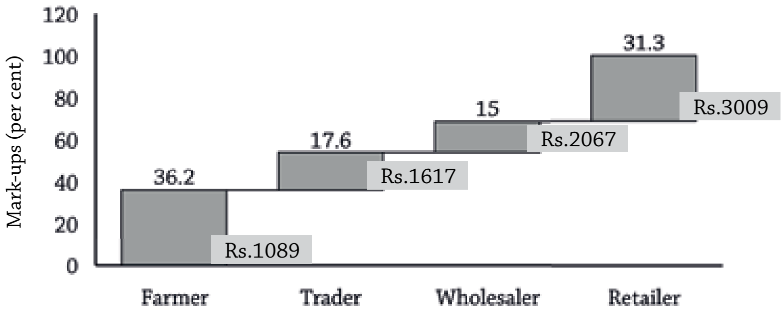
About 2-3 per cent of the onion production is also processed in dehydrated form such as onion flakes, granules and powder. Most of the onion dehydration plants are located in Mahuva region of Bhavnagar district, Gujarat, a white onion growing region. Due to low demand for dehydrated onion in India, it is exported to other countries. However, there is no contract farming arrangement between white onion growing farmers and the dehydration units. On the other hand, farmers in and around Jalgaon (Maharashtra) have contractual arrangements with dehydration plants for procuring onion for dehydration. Farmers are provided with seeds, drip irrigation, sprinkler and extension services and receive pre-determined procurement price. To provide insurance, farmers are given 60 paise less than the market price in case of any increase in market price (Gulati et al., 2022).

In the case of onion, farmers sell their produce in the APMC where prices are determined in an open auction system. Farmers incur overhead costs such as labour charges, and charges for transportation to *mandis*. Once the auction is successful, it is bought by a trader with the help of commission agents, who pay the *mandi* fees (1 per cent), commission charges (4 per cent) and loading/unloading charges (Rs. 9.02 per quintal). Further they incur packaging charges and costs due to weight loss, around 10 per cent for *kharif* and late *kharif* onion, and 5 per cent for *rabi* onion. The traders get into an agreement with traders/wholesalers of secondary APMC *mandis* such as Azadpur *mandi* in Delhi and depending on the arrangement, transportation cost of about Rs. 240 per quintal is paid by either the primary trader or the secondary trader/wholesaler. *Mandi* fees and commission charges are also paid by the seller. After the consignment reaches the secondary *mandi*, the produce is bought by retailers who sell it in the neighbourhood markets in urban areas.

To estimate the share of each stakeholder, Delhi has been considered as the main consumption centre, where onions arrive from different states *viz.*, Maharashtra, Madhya Pradesh, Rajasthan and Gujarat during different times of the year. Farmers' price is the weighted average wholesale price based on the arrivals from these states during peak harvesting months of TE 2021-22. Delhi wholesale prices reached the maximum among all the markets during this period as the onion reaching Delhi are of 'A' grade quality and fetch the highest price. The other costs have been collected through market intelligence and field visits conducted in January 2023 in the Nashik region of Maharashtra. Margins have been estimated by subtracting the cost from the price.

**Figure 6.19**

*Mark-ups in the Onion Value Chain*




*Source:* Authors' calculation using data from Agmarknet (2022), DoCA (2022) and field visits.

Estimated mark-ups show that farmers on an average receive 36.2 per cent of the consumers' rupee that includes cultivation and overhead costs. Traders' mark-up of 17.6 per cent and wholesalers' mark-up of 15.0 per cent also include their costs of transportation, mandi fees, commission charges, packaging, and labour charges. The retailer has the mark-up of 31.3 per cent (Figure 6.19).

### *6.5.3 Potato Value Chain in India*

Potato is majorly grown in the Indo-Gangetic plains of Northern India stretching from Punjab to West Bengal with *rabi* crop accounting for around 90 per cent of total production. A small *kharif* crop is also grown and harvested during September and November in Maharashtra, Karnataka, Uttarakhand, Himachal Pradesh and Tamil Nadu. The major potato belts and the consumption centres are listed in Table 6.3. Produced mostly by small and marginal farmers who account for 86.7 per cent (DoA&FW, 2020), potato is a three-month crop and requires 4-5 irrigation cycles. The average cost of cultivation for potato farmers in 2019-20 was about Rs. 411.6 per quintal in UP, Rs. 525.5 per quintal in West Bengal and Rs. 434.9 per quintal in Bihar (DES, 2022b).

**Table 6.3**

*Major Production and Consumption Centres of Potato in India*

| *State* | *Production Belt* | *Consumption Centres* | *Harvest Months* |
|---|---|---|---|
| Uttar Pradesh | Agra, Firozabad, Hathras, Aligarh, Farukkhabad, Meerut | Delhi, Maharashtra and Southern India | December-March (Fresh) Mid-February-December (Stored) April onwards (Release) |
| West Bengal | Hooghly, Burdwan, Midnapur and Bankura | Eastern India, (Processing) | December-March |
| Bihar | Nalanda, Patna, Vaishali | Bihar, Jharkhand | December-March |
| Punjab | Jalandhar, Ludhiana | Delhi and North India (Seeds) | November-February |
| Gujarat | Banaskantha, Sabarkantha | Western India (Processing) | January-March |
| Madhya Pradesh | Indore, Ujjain, Chhindwara | Central India (Processing) | December-March |
| Karnataka | Hasan, Chikmangalur, Belgaum, Chikballapur | Local | September-October |

*Source:* DES (2022), Ministry of Food Processing Industries (MoFPI) (2022) and Market Intelligence.

The potato season starts from November, when potato from Punjab (mid-November onwards) starts arriving in the market. Potato arrivals from UP start from February and storage begins from mid-February and goes on till end-March. The storage cycle normally ends in November but often continues till December. Interestingly, potato stocks at the end of March are one of the important determinants of the pricing pattern in the latter part of the year. If the stored crop is less than 70-80 per cent of the normal storage capacity, prices can be expected to rise by the end of September, October and November.

Potato trading happens mostly in cold storages and in APMC *mandis*. Potato farmers sell their produce to village level aggregators or traders. They bring their produce to cold storage and store it between March and November at an average cost of Rs. 250 – 260 per quintal. Farmers do the first level of sorting and grading. Based on the size, potato produced in Agra is classified into three categories: *Chhatha* (Large), *Gulla* (Medium) and *Kirri* (Small). Farmers who have contract farming with corporations such as PepsiCo, Balaji, Haldirams sell it directly to the processors. They usually keep a fraction of their produce (about 10 per cent) for self-consumption and for seed purposes (Marketed Surplus Ratio (MSR) for potato: 89.5 per cent in TE 2014-15)[59]. They can also withdraw potato for seed from storage before next season's sowing.

Cold storages are the most important selling point for farmers in the potato belt of western Uttar Pradesh. Farmers borrow from cold storage owners at high interest rate. They start releasing their stored produce based on market prices starting April. Open auction is performed at the cold storage with storage owner being a mediator between the farmer and trader. The potato traded at primary APMC *mandis* are sold to local retailers within the district/states.

Traders have to pay mandi fees and development cess (1 per cent and 0.5 per cent, respectively in Sikandra *Mandi, Agra*[60]). Also, loading and unloading charges, commission charges to commission agents, etc., are added. Transportation cost is shared between the primary trader and wholesaler based on their arrangement.

Once the consignment reaches the secondary APMC *mandi* (For example, Azadpur *mandi* in Delhi, Vashi mandi in Mumbai), it changes more hands. The produce is bought by traders at secondary mandi with the help of commission agents. *Mandi* fees and commission charges are paid again for the same produce. The traders in these mandis sell to retailers who then sell it in metropolitan cities and other tier 'A' cities in the neighbourhoods. In this supply chain, there are costs and margins of each stakeholder and the final price at which consumer purchases almost doubles or triples.

To estimate the farmers' share in consumer rupee for potato, average wholesale prices of Agra between February and June during

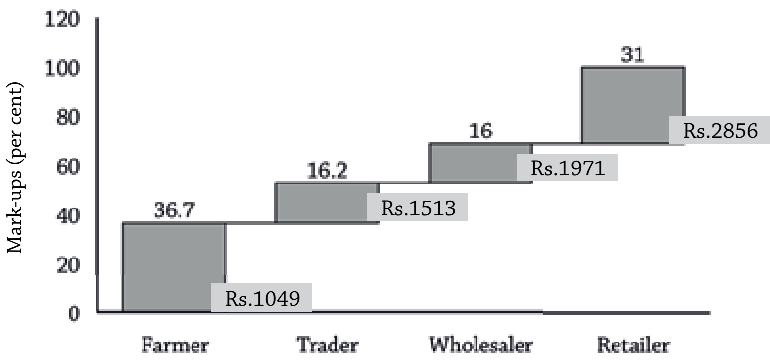
59. Agricultural Statistics at a Glance, 2014-15.
60. Major arrival comes to these manids.

TE 2022 were used to estimate farmers price (as a proxy for farmgate price). The retail price of a major consumption centre (in this case, Mumbai) was taken as the price paid by the consumer. The wholesale price for secondary mandi was taken from DoCA. Other costs of intermediaries were collected after interactions with different stakeholders during the field visits conducted in Agra, Uttar Pradesh in December 2022.

The estimated mark-ups (costs and margins) of each stakeholder show that farmers receive a share of 36.7 per cent of the consumer rupee (Figure 6.20). This includes transportation costs. The average costs borne by the farmers consists of cost of transportation (Rs. 30 per quintal), packaging (Rs. 80 per quintal), labour (Rs. 100 per quintal) and storage (Rs. 250-260 per quintal). In terms of margins, retailers earn the highest margin as their cost is minimal and they deal with smaller volumes. Their costs including rental price for sale point and transportation cost is much lower than their margins.

**Figure 6.20**

*Mark-ups in the Potato Value Chain*




*Source:* Authors' calculation using data from Agmarknet (2022), DoCA (2022) and field visits.

### 6.6 Data Source

The study uses data from secondary sources that include Central and State government websites and databases of the state agriculture departments, and available literature. The period of analysis is from

July 2012 to June 2022 for tomato and July 2014 to June 2022 for onion and potato[61]. The report uses CPI data released by the NSO, MoSPI and GoI. Monthly data on CPI for tomato, onion and potato is used for analysing the patterns of inflation and volatility. The data on WPI is collected from the Office of Economic Advisor, Ministry of Commerce and Industry and used wherever needed.

To compile the balance sheet, information is sourced from several published reports and government data sources such as Ministry of Agriculture (for production related information), Agmarknet (for data on market arrivals), ICAR-CIPHET report on post-harvest loss, and Directorate General of Commercial Intelligence and Statistics (DGCI&S) database of the Ministry of Commerce and Industry for trade related information. The consumption of various items is available in various rounds of National Sample Survey (NSS) Reports on Consumer Expenditure Survey. Here 2011-12 survey is used for consumption data[62]. Consumption figures for the subsequent years are estimated using the behavioural approach of agricultural commodities for demand predictions.

### 6.7 Methodological Framework of Balance Sheet and Estimation

In this study, monthly balance sheets for each of the three vegetables have been constructed, considering both demand and supply side dynamics. State-wise balance sheets of major producing states together accounting for majority of total production of each of these crops are considered for each of the three vegetables. The availability variable for India is derived by adding state-wise availability.

Many international organisations like FAO and International Grain Council have adopted the balance sheet approach. Within India also some private agencies follow the balance sheet approach for

61. Since, balance sheets for onion and potato are constructed considering season wise (*rabi* and *kharif*) data, the period considered is July 2014 to June 2022, as state wise and season wise data is only available from 2014.

62. NSO released the factsheet for the Household Consumption Expenditure Survey (HCES) 2022-23 in February 2024. However, the detailed results were released after the completion of the study. Hence the analysis is based on HCES data for 2011-12.

monitoring prices of different agri-commodities. Most agricultural balance sheets are prepared at the annual level and do not serve the purpose of short-term forecasting. The monthly balance sheet approach, which is the primary contribution of this study, gives more information that can explain the short-run fluctuations in the TOP prices.

### *6.7.1 Conceptual Framework of Monthly Balance Sheet*

Since price movements of a commodity especially an agricultural commodity depends on various other market mechanisms, this study tries to identify those factors to provide a structural framework for understanding the price dynamics on a monthly frequency. Creating this availability variable requires an in-depth understanding of the value chain of the commodity and how it moves from the farmer to the retailer to incorporate the entire value-chain mechanisms which consequently determine the availability in the economy and prices in any particular month.

To reproduce the complex value chain mechanism of the three vegetables, state-wise (for tomato, onion, potato) and season-wise (for onion and potato), balance sheets have been constructed and finally an all-India level availability variable for each of these vegetable crops at a monthly frequency is derived. As discussed in the previous section, both secondary and primary sources of information have been used for the construction of the balance sheet. There are a few components in the balance sheet for which no secondary information is available and the study had to rely on market intelligence. The monthly figures are impacted by seasonality, weather change, and demand pattern.

Broadly, the monthly balance sheet will help us inspect the following aspects:

1. The supply situation of TOP in India.
2. A monthly supply variable that helps in understanding the price behavior of TOP.

### *6.7.2 Rationale for State-Wise Balance Sheets*

There is spatial distribution in the production of TOP commodities i.e., a major proportion is concentrated in a few states and a small proportion is distributed in the other states. The distribution of production indicates that the variations in the total availability are caused by seasonal variations and/or variation in the production in each state. For instance, in December 2019, WPI inflation in onion was at 456 per cent though the production in 2019-20 had increased by 14 per cent from the previous year with a 30 per cent increase in *rabi* production. This was because of a 20 per cent reduction in its *kharif* production and 27 per cent reduction in its late *kharif* production from previous year, even though the overall production numbers saw an increase. The above arguments set our rationale for building state-and season-wise balance sheets to arrive at economy-wide availability variables for these commodities to capture variations in the availability.

For onion, the analysis covers five states (Maharashtra, Madhya Pradesh, Karnataka, Gujarat and Rajasthan) accounting for 79 per cent of total production in TE 2022-23. For tomato, the study includes five states (Madhya Pradesh, Andhra Pradesh, Karnataka, Odisha and Gujarat) covering 55 per cent of the production. For potato, three states (Uttar Pradesh, West Bengal and Bihar) are considered with a share of 70 per cent of the total production.

### *6.7.3 Components of Monthly Balance Sheet*

#### **Availability**

In this study, monthly availability is defined as the crop sold in the market either from fresh harvest or stored produce during that month adjusted for the import and export of that crop.

$$Availability_t = (Farmers'\ Sale_t - Total\ Losses_t) + (Imports_t - Exports_t) \quad ...(1)$$

To construct monthly balance sheet from the annual production figures, a way to calculate the monthly harvest figures was needed. Monthly harvest production pattern was generated for the three crop years 2019-22 and distributed state-wise and season-wise. Applying that to the annual production figures, monthly production series was generated. As monthly harvest data is not available in the public domain, information was gathered through detailed discussion with the officials of Directorate of Economics and Statistics, Ministry of Agriculture.

Onion is produced in three seasons, *rabi* (March-May), *kharif* (October-December) and late *kharif* (January-March). The monthly distribution of production is given by:

$$Y_{mki} = \delta_{mk} * Y_i \qquad ...(2)$$

where $Y_{mki}$ is the production in month m of season k, which can be either *rabi*, *kharif* or late *kharif* in year i (for onion). δ is the percentage of annual harvest in that month and $Y_i$ is the annual production. The total production is distributed into two parts: (a) seed, feed, wastage, and (b) marketed surplus. After adjusting production for the seed, feed, and wastages, annual marketed surplus is obtained. The MSR for onion is taken as 91 per cent (Agricultural Statistics at a Glance, 2014)[63] , and the rest is seed, feed and wastage.

In both onion and potato, the harvest is stored for a few months depending upon the shelf life of the harvest and the infrastructure capacity in a state and in the country. A certain percentage of the harvest in some states gets stored for sale in later months till the new harvest arrives. This percentage of storage out of *rabi* harvest in both the commodities have been verified with the market players through interviews. For onion, 65 per cent of *rabi* harvest in Maharashtra, the largest onion producing state, gets stored for sale from July to December. However, onion storage starts from April and release starts from June depending up the prevailing market prices. *Kharif* and the late *kharif* harvest of onion do not get stored significantly as they don't have as long a shelf life as *rabi* onion. These numbers vary year to year, conditional on the prevailing market prices.

For potato, around 70 per cent of the potato harvest is stored in the two largest producing states of Uttar Pradesh and West Bengal

63. As MSR is not available for tomato in Agricultural Statistics at a Glance (2014), only 3 per cent of harvest level wastage data from CIPHET study for tomato has been applied.

(Market Intelligence). The stored stocks in the case of potato gets released from May to November in which October sees the largest release as the *rabi* potato starts to perish by that month.

Tomato being highly perishable cannot be stored, and it is assumed that the produce comes to the market right after harvest. As the supply is coming from different states throughout the year, monthly production is calculated for the crop year and not segregated season-wise.

$$MS_t = Production_t - (seed+feed+selfconsumption+farm\ losses) \quad ...(3)$$

**Sale**

One of the primary determining factors of price variability in these commodities is how and when the produce is sold and especially the stored produce in case of onion and potato. There is endogeneity in this mechanism as the release of stored produce by farmers or traders depend upon the market prices and these releases determine the prices. A monthly pattern of sale needed to be determined that can be applied to all the years in our analysis. This pattern determines how much of the produce, fresh or stored, comes to the market.

The monthly mandi arrivals as a percentage of total annual arrivals gives us a close estimate of the monthly sales pattern for each state. This data is available from Agmarknet.

Then the monthly sale of fresh harvest is given by:

$$S_{mki} = y_{mk} * MS_{ki} \quad ...(4)$$

i.e., sale S in each month m of season *k* of year *i* is *y* per cent of annual marketed surplus for that season, $MS_{ki}$. L is the sale pattern derived from Agmarknet data for onion and tomato.

For potato, most of the produce gets stored right after harvest, and eventually released from the cold storages as per the market demand. As a result, the market arrival pattern from Agmarknet does not reflect the true pattern. To address this inconsistency, monthly release pattern for potato has been obtained based on survey of the cold storage owners and farmers.

Sale of stored stocks takes the form:

$$S(t)_{mi} = \gamma_m * T_{i-1} \quad ...(5)$$

i.e., the sale of stored stocks S(t) in each month *m* in a year *i* is γ per cent of annual stored stocks T in the previous year.

Tomato is a short duration crop of perishable nature produced throughout the year. The period considered for the balance sheet is July 2012 to June 2022. GoI releases production data on an annual basis, i.e., crop year July-June. Applying monthly harvest pattern to the annual production figures, annual production has been distributed to monthly production. As the supply is coming from different states throughout the year, monthly production is calculated for the crop year and not segregated season wise. Due to its short duration nature, it is assumed that the harvest pattern adequately mirrors the sale pattern. Monthly sale quantity is generated across months for each state. All-India sale figures are generated by summing up the state-level sale volumes.

### Losses Along the Value Chains of TOP

Crop wastages at different levels of the value chain can lead to reduction in availability. Total loss in the value chain can be divided into two groups: losses in (i) farm operations and (ii) storage channels. The MSR provided by the Ministry of Agriculture considers all these losses. For storage loss, CIPHET-ICAR study (2015) on post-harvest losses has been considered. Storage channels include farm, godown/cold store, wholesaler, retailer, and processing unit. Total storage losses for potato, onion, and tomato are taken as 0.78 per cent, 2.16 per cent, and 3.03 per cent, respectively. The storage losses are calculated on total stock of previous month for potato and onion. A total loss of around 12 per cent is assumed for tomato based on the CIPHET study of post-harvest loss.

### Net Import

Among the three vegetables, a considerable share of onion is exported, as noted earlier. Government policy interventions of restricting exports or imposing MEP when the market prices are high partially ensures that exports have a minimal effect on the availability of onion in the domestic market especially when there has been a negative supply shock. For this reason, exports adjustments are not considered in the balance sheet approach for onion.

At present, tomato exports account for less than 1 per cent of the total production, hence no adjustments have been made in the balance sheet.

Even though India is the second largest producer of potato in the world, its share in world trade is negligible. In TE 2022-23, India exported 0.47 MMT of potato (fresh/chilled). As trade does not alter the amount of availability much, this component is not incorporated in the study.

### Usage/Demand of TOP

In the balance sheet, usage in a particular month is defined as total crop demand in the market which includes consumption by individual households as well as institutional consumption. As the detailed data on consumption is available up to 2011-12[64], we projected the household consumption using the behavioural approach method used in the Working Group Report of NITI Aayog (2018).

The annual demand for India is calculated by taking a weighted average of rural and urban per capita consumption, weight being the population share in each of these categories. The annual projected consumption of tomato, onion, and potato is distributed monthly as per the pattern obtained from our market information which is almost stable each month. As these vegetables are an important part of the staple diet in the basket of households, their consumption pattern varies less across the year. From the total consumption of each of these vegetables, consumption out of the home produce has been deducted to arrive at their net consumptions.

### Institutional Consumption

The monthly consumption data computed based on NSSO's consumption expenditure survey does not include consumption outside home or the magnitude of produce used by institutions.

64. NSO released the factsheet for the Household Consumption Expenditure Survey (HCES) 2022-23 in February 2024. However, the detailed results were relased after the completion of the study. Hence the analysis is based on HCES data for 2011-12.

Therefore, information on institutional consumption is collected from interaction with different stakeholders in the TOP value chain. Onion is processed to make dehydrated onion and tomato is processed to make puree and juice but its use in industries as a percentage of total onion/tomato production is negligible at present. Potato is used in various industries, especially potato chips. Each month around 7.5 per cent of the sale of potato goes into institutional processing (Central Potato Research Institute, ICAR).

### *Availability Variable*

Monthly state availability variable:

$$Availability_{mki} = [S_{mki} + S(t)_{mi}] - [Loss_{m}] \qquad ...(6)$$

i.e., availability in a month is equal to total sale in that month minus the losses incurred in that month. In case of onion, there are dehydration losses for the produce that get stored and results in decreased quantity of the produce. Based on market players' and farmers' response, the study found that for the storage of *rabi* produce i.e., harvest stored in April, the losses can go as high as 30 per cent of the weight by November/December. Accordingly, dehydration losses have been applied as increasing percentages of the sale of stored stocks as the months move forward, for July (10 per cent), August (14 per cent), September (18 per cent), October (22 per cent), November (26 per cent) and December (30 per cent). There are also storage losses for both the commodities that have been taken from the CIPHET report on post-harvest losses. This availability variable of a state gives us a supply side view for that state. For example, for Maharashtra we see that availability each month is very high and are traded across states, which is not being captured empirically in our analysis. Trade forms a major determinant in price formation. Lower stocks in the state of Maharashtra or Madhya Pradesh get translated into higher prices country wide.

This exercise has been repeated for each state in our analysis for all the commodities, i.e., in total five balance sheets for tomato, five for onion and three for potato are created to obtain stock variables for each state. The robustness of each state's balance sheet has been tested by checking the correlation of this availability variable with that state's wholesale prices and as an all-India CPI and WPI Y-o-Y inflation. The negative correlation of each of the availability variable with prices helps us construct our all-India availability variable. All-India availability variable is created by summation of these state availability values. Our analysis focuses on all-India availability variable as the variable of interest to explain the price movements covering both the production seasonality in a year and the production shocks year to year.

The study also analyses the factors that affect prices of these vegetables using balance sheet variables that highlight the determination of prices through interaction of stakeholders in the vegetables value chain. The study describes the missing links in the value chain that play an important role in price volatility in the vegetables market. The description and sources of the data used in this analysis is given in Annexure A6.1.

## 6.8 Model Specification and Empirical Results

In the study, the dependent variable for each equation is defined using the seasonally adjusted CPI of the TOP while the set of explanatory variables includes seasonally adjusted availability variable. The description and source of the data used in our regression analysis are given in Annexure Table A6.1 and A6.2.

### *Estimation of Tomato*

For estimating the factors impacting the CPI tomato, the sample period is considered from July 2012-June 2022. The explanatory variables used are availability-usage ratio of tomato (Log AVU), rainfall dummy as it impacts tomato production heavily, and agro-chemical price index (Log AgroChemical Index) as it constitutes a major share in the cost of cultivation of tomato. Before estimating the ARDL model, the stationarity of the variables is checked using the ADF test. The results show that Log CPI Tomato is stationary in level, while Log AVU and log agro-chemical index are stationary in first differences (Table 6.4).

**Table 6.4**

*ADF Unit Root Test for Tomato*

| *Variable* | *ADF (p-value)* |
|---|---|
| Log CPI Tomato | -5.289 (0.000)*** |
| Log AVU | -2.513 (0.1125) |
| ΔLog AVU | -14.394 (0.000)*** |
| Log Agro-Chemical Index | -0.614 (0.8678) |
| ΔLog Agro-Chemical Index | -9.782 (0.000)*** |

*Note:* The Dickey-Fuller test statistic is reported. The critical values are the finite sample values suggested by Mackinnon (1991). (*) indicates different level of significance as *** p<0.01, ** p<0.05, * p<0.1.

*Source:* Authors' estimation.

The bounds test for tomato confirms the existence of a long-run relationship between CPI tomato and availability-usage, rainfall dummy, and agro-chemical index (Table 6.5).

**Table 6.5**

*Bounds Test for Cointegration for Tomato*

| *F-statistic* | *t-statistic* |
|---|---|
| 11.304*** | -5.134*** |

*Note:* ***, **, * denotes significance at 1 per cent, 5 per cent and 10 per cent, respectively. The F-statistic is used to test for the joint significance of the coefficients of the lagged levels in the ARDL. The t-statistic is used to test for the significance of the coefficient of the lagged dependent variable. Both F and t statistics are significant at the 1 per cent level of significance.

*Source:* Authors' estimation.

The estimate of long run coefficients from the ARDL specification and the short run dynamics are presented in Table 6.6[65].

The ARDL model of order (2,2,0,0) shows that in the long run, there is a negative relationship between CPI tomato and AVU. The founding hypothesis of this study is that the AVU ratio of tomato at any given point determines the prices of that commodity. The negative coefficient of (-)0.72 indicates that one unit increase in the availability decreases the CPI tomato by 0.72 per cent. There is a significant and positive long-term relationship of prices with rainfall

65. As the balance sheet for onion and potato are created using season wise production data, the time period of the balance sheet is up to June 2022. Season wise data is not available for 2022-23.

dummy that indicates that excess/deficient rainfall has a positive and significant impact on the prices of tomato.

**Table 6.6**

*ARDL Model Results for Tomato*

| | | |
|---|---|---|
| Dependent variable: Log CPI Tomato | | |
| Model ARDL (2,2,0,0) | | |
| Sample period: July 2012 – June 2022 | | |
| *Variable* | *Coefficient* | *Std. Error* |
| **Long-run Coefficients** | | |
| Log AVU | -0.721** | 0.364 |
| Rainfall Dummy | 0.190** | 0.093 |
| Log AgroChemical Index | -0.406 | 0.685 |
| **ECM** | -0.332*** | 0.065 |
| **Short-run Coefficients** | | |
| ΔLogCPI(-1) | 0.353*** | 0.088 |
| ΔLogAVU | -0.119 | 0.162 |
| Δlog AVU(-1) | -0.355** | 0.147 |
| Intercept | 2.454** | 1.21 |
| Observations | 112 | |
| Adjusted R-squared | 0.31 | |
| Breusch Godfrey Test | 0.73 (0.39) | |
| Portmanteau's test for white noise | 51.44 (0.11) | |
| RMSE | 0.13 | |
| Log Likelihood | 76.49 | |
| *** p<0.01, ** p<0.05, * p<0.1 | | |

*Note:* Figure in parentheses for Breusch-Godfrey LM test for autocorrelation ($H_0$: no serial correlation) and Portmanteau's test for white noise ($H_0$: series are white noise) indicates p values.

*Source:* Authors' estimation.

The estimate of the coefficient of the ECM term, which is significant and negative, indicates that any deviation from the long-run equilibrium is corrected by 33 per cent within a month. In other words, it signals a strong correction back to the equilibrium path from any deviation.

The diagnostic tests for the ARDL estimates for tomato indicate a white noise, i.e., independent and identically distributed error term with homoskedasticity and normality. Further, the Breusch-Godfrey test indicates that there is no autocorrelation in the estimated residuals. The stability of model is tested using CUSUM test that shows that the predicted values lie within the 95 per cent confidence interval (Annexure A6.3).

### *Estimation of Onion*

For estimating the factors impacting the CPI onion, the sample period is considered from July 2014 to June 2022 based on data availability. The explanatory variables used are log of the availability of onion *(LogAV)* and log of composite weighted index of all the vegetables included in the CPI basket excluding onion *(Log VegIndex)*. The ADF test shows that Log availability is stationary in level, while Log CPI onion and log vegetable index excluding onion are stationary in first differences (Table 6.7)

**Table 6.7**

*ADF Unit Root Test for Onion*

| *Variable* | *ADF (p-value)* |
|---|---|
| Log CPI Onion | -2.433 (0.362) |
| ΔLog CPI Onion | -7.954 (0.000)*** |
| Log AV | -3.606 (0.029)** |
| Log Veg Index | -2.620 (0.270) |
| ΔLog Veg Index | -6.691 (0.000)*** |

*Note:* The Dickey-Fuller test statistic is reported. The critical values are the finite sample values suggested by Mackinnon (1991). (*) indicates different level of significance as *** p<.01, ** p<.05, * p<.1.

*Source:* Authors' estimation.

The Bounds test confirms the existence of a long-run relationship between CPI onion and monthly supply of onion (Table 6.8).

The estimated long run and short run coefficients from the ARDL (2,2,0) model are presented in Table 6.9. The results show that in the long run, monthly availability has a negative relationship with CPI onion. A one per cent increase in availability in a month decreases the CPI onion by 1.3 per cent. The coefficient of ECM (-0.155) is

**Table 6.8**

*Bounds Test for Cointegration for Onion*

| *F-statistic* | *t-statistic* |
|---|---|
| 5.332* | -3.379* |

*Notes:* ***, **, * denotes significance at 1 per cent, 5 per cent and 10 per cent, respectively. The F-statistic is used to test for the joint significance of the coefficients of the lagged levels in the ARDL. The t-statistic is used to test for the significance of the coefficient of the lagged dependent variable. All test statistics are significant at the 10 per cent level of significance.

*Source:* Authors' estimation.

**Table 6.9**

*ARDL Model Results for Onion*

Dependent variable: Log CPI Onion

Model ARDL (2,2,0)

Sample period: July 2014 -June 2022

| *Variable* | *Coefficient* | *Std. Error* |
|---|---|---|
| **Long run Coefficients** | | |
| Log AV | -1.33* | 0.779 |
| Log Veg Index | 4.559*** | 1.651 |
| **ECM** | -0.155*** | 0.046 |
| **Short run Coefficients** | | |
| Δlog CPI(-1) | 0.191* | 0.103 |
| Δ Log AV | 0.027 | 0.193 |
| Δlog AV(-1) | 0.186 | 0.190 |
| Intercept | -2.215** | 0.945 |
| Observations | 94 | |
| Adjusted R-squared | 0.14 | |
| Breusch Godfrey Test | 2.042 (0.15) | |
| Portmanteau's test for white noise | 39.798 (0.48) | |
| RMSE | 0.123 | |
| Log Likelihood | 66.86 | |
| *** p<0.01, ** p<0.05, * p<0.1. | | |

*Note:* Figure in parentheses for Breusch-Godfrey LM test for autocorrelation ($H_0$: no serial correlation) and Portmanteau's test for white noise (H0: series are white noise) indicates p values.

*Source:* Authors' estimation.

negative and statistically significant at 1 per cent level of significance, which indicates that any disturbance in the long-run equilibrium is corrected by 15 per cent in one month. A one per cent increase in the prices of other vegetables is associated with 4.6 per cent increase in the CPI of onion indicating common driving factors leading to spill over across vegetables prices.

The model residuals are stationary at 1 per cent level of significance. Further, the Breusch-Godfrey test indicates that there is no autocorrelation in the estimated residuals. The stability of model is tested using the CUSUM test that shows that the predicted values lie within the 95 per cent confidence interval (Annexure A6.3).

### *Estimation of Potato*

The ADF test shows that the Log CPI Potato and Log real wage (Log RW) are stationary in levels, while Log availability and Log Veg index are stationary in first differences (Table 6.10).

**Table 6.10**

*ADF Unit Root Test for Potato*

| *Variable* | *ADF (p-value)* |
|---|---|
| Log CPI Potato | -2.599 (0.093)* |
| ΔLog CPI Potato | -5.136 (0.000)*** |
| Log AV | -1.921 (0.322) |
| ΔLog AV | -6.977 (0.000)*** |
| Log Veg Index | -2.097 (0.245) |
| ΔLog Veg Index | -6.553 (0.000)*** |
| Log RW | -2.769 (0.062)* |
| ΔLog RW | -6.229 (0.000)*** |

*Note:* The Dickey-Fuller test statistic is reported. The critical values are the finite sample values suggested by Mackinnon (1991). (*) indicates different level of significance as *** $p<0.01$, ** $p<0.05$, * $p<0.1$

*Source:* Authors' estimation.

The Bounds test confirms the existence of a long-run relationship between CPI potato and monthly supply of potato and other vegetables price index (Table 6.11).

**Table 6.11**

*Bounds Test for Cointegration for Potato*

| *F-statistic* | *t-statistic* |
|---|---|
| 7.396* | -3.420* |

*Note:* ***, **, * denotes significance at 1 per cent, 5 per cent and 10 per cent, respectively. The F-statistic is used to test for the joint significance of the coefficients of the lagged levels in the ARDL. The t-statistic is used to test for the significance of the coefficient of the lagged dependent variable. All test statistics are significant at the 10 per cent level of significance.

*Source:* Authors' estimation.

For estimating the factors impacting CPI potato, the sample period considered is from July 2014 to June 2022 based on data availability as mentioned earlier. The explanatory variables used are

**Table 6.12**

*ARDL Model Results for Potato*

| Dependent variable: Log CPI Potato<br>Model ARDL (2,0,0)<br>Sample period: July 2014 – June 2022 | | |
|---|---|---|
| *Variable* | *Coefficient* | *Std. Error* |
| **Long run Coefficients** | | |
| Log AV | -2.700* | 1.492 |
| Log VegIndex | 3.380*** | 1.146 |
| **ECM** | -0.099*** | 0.029 |
| **Short run Coefficients** | | |
| ΔLogCPI(-1) | 0.326*** | 0.099 |
| LogRW | 0.587* | 0.349 |
| Intercept | -2.921** | 1.292 |
| Observations | 88 | |
| Adjusted R-squared | 0.33 | |
| Breusch Godfrey Test | 0.236 (0.63) | |
| Portmanteau's test for white noise | 34.15 (0.73) | |
| RMSE | 0.064 | |
| Log Likelihood | 119.51 | |
| *** p<0.01, ** p<0.05, * p<0.1. | | |

*Note:* Figure in parentheses for Breusch-Godfrey LM test for autocorrelation (H0: no serial correlation) and Portmanteau's test for white noise ($H_0$: series are white noise) indicates p values.

*Source:* Authors' estimation.

log of availability of potato *(LogAV),* log of composite weighted index of all the vegetables included in the CPI basket excluding potato *(Log VegIndex)* and log of real wages *(LogRW ).*

The estimated long run and short run coefficients from the model are presented in Table 6.12. The results indicate that in the long run, there is a negative relationship of potato prices with the monthly availability of potato. A one per cent increase in the availability of potato at the all-India level decreases the CPI potato by 2.7 per cent. Similarly, the increase in prices of all other vegetables (CPI vegetables ex-potato) constitute a pull effect on the prices of potato. The price of potato is positively related to real wages in the short-run, i.e., increase in real wages pull the prices up by raising the cost of cultivation for the farmers. In this model, the error correction term indicated by the adjusted coefficient (-0.099) is negative and significant at 1 per cent level of significance, indicating that any deviation from the long-run equilibrium gets corrected by about 10 per cent within a month (Table 6.12).

The diagnostic test for the ARDL estimates for potato indicates that the model residuals are stationary at 1 per cent level of significance and satisfy the white noise test. Further, the model has no serial correlation at 1 per cent level of significance as per the Breusch-Godfrey test. The stability of model is tested using CUSUM test which shows that the predicted values lie within the 95 per cent confidence interval (Annexure A6.3).

## 6.9 Inflation Forecasts of TOP

Various studies have been undertaken to better understand and forecast food price inflation in the Indian context (Duvvuri, 2011; Sonna et al., 2014 and Raj et al., 2019). In the present chapter, an attempt has been made to forecast inflation for TOP for a 12-month horizon using time series-based univariate and multi-variate models such as seasonally adjusted ARIMA and ARIMA-X (StataCorp, 2013). The SARIMA model is based on its own past values and the lagged forecast errors under the assumption that the time series has a constant variation of errors (Gujarati and Sangeeta, 2007). In SARIMA-X, the additional explanatory variable is the availability variable derived as part of the balance sheet and found to be a significant determinant of CPI index of respective variables in the ARDL model.

The study considers two individual models to provide 12-months horizon prediction for each of the selected vegetables (onion, potato, tomato). Rolling (using a moving data window of 60 months) model estimation is considered to check the performance and accuracy of the forecasting models using the full sample period from July 2014 to June 2022 for onion and potato, and from July 2012 to June 2022 for tomato vis-à-vis actual inflation of these vegetables. Since the CPI index of vegetables and the balance sheet variables are seasonal in nature, these variables have been seasonally adjusted before using them for forecasting.

### *6.9.1 Analysis of Forecasts*

The RMSEs of each forecasting model are evaluated for the full sample (i.e., July 2012 to June 2022 for tomato, and July 2014 to June 2022 for onion and potato based on the availability of data) that gives an overview of the forecast errors of a model working over different time lags. The evaluation was done by stopping the sample period in June 2021 and generating forecasts for 2, 4, 6, 8, 10, and 12 months ahead until June 2022, which were then compared with the corresponding actual inflation outcomes.

The following tables report the RMSEs so obtained for all three commodities. We check the RMSEs on 6 forecast horizons of 2, 4, 6, 8, 10 and 12 months to see how well the model forecasts the CPIs over different horizons. For tomato, potato and onion, SARIMA-X, where the availability variable is used as an exogeneous variable, generally outperforms SARIMA for the full sample as reflected in their relatively lower RMSEs (Tables 6.13-6.15).

**Table 6.13**

*RMSE for Tomato (Full Sample Forecasts) (per cent)*

| | *2 months* | *4 months* | *6 months* | *8 months* | *10 months* | *12 months* |
|---|---|---|---|---|---|---|
| SARIMA | 25.43 | 28.95 | 29.06 | 29.72 | 29.76 | 30.01 |
| SARIMAX | 26.16 | 28.86 | 28.98 | 29.46 | 29.46 | 29.55 |

**Table 6.14**

*RMSE for Onion (Full Sample Forecasts) (per cent)*

| | *2 months* | *4 months* | *6 months* | *8 months* | *10 months* | *12 months* |
|---|---|---|---|---|---|---|
| SARIMA | 38.7 | 38.2 | 37.7 | 37.2 | 36.7 | 36.4 |
| SARIMAX | 34.6 | 34.1 | 33.7 | 33.2 | 32.8 | 32.5 |

*Source:* Authors' estimation.

**Table 6.15**

*RMSE of Potato (Full Sample Forecasts) (per cent)*

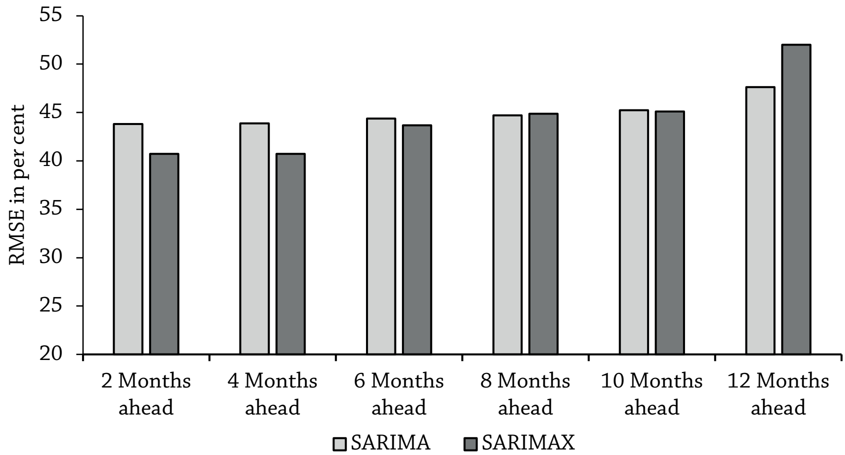
| | *2 months* | *4 months* | *6 months* | *8 months* | *10 months* | *12 months* |
|---|---|---|---|---|---|---|
| SARIMA | 13.44 | 13.29 | 13.36 | 13.49 | 13.37 | 13.23 |
| SARIMAX | 12.61 | 12.49 | 12.38 | 12.63 | 12.56 | 12.41 |

*Source:* Authors' estimation.

In case of forecasts based on the rolling method (i.e., in a 60-months rolling window), SARIMA-X performs better for onion and potato for all the time horizons (except 12 months ahead for potato), while it performs better only up to 6 months horizons for tomato (Figure 6.21-6.23)).

**Figure 6.21**

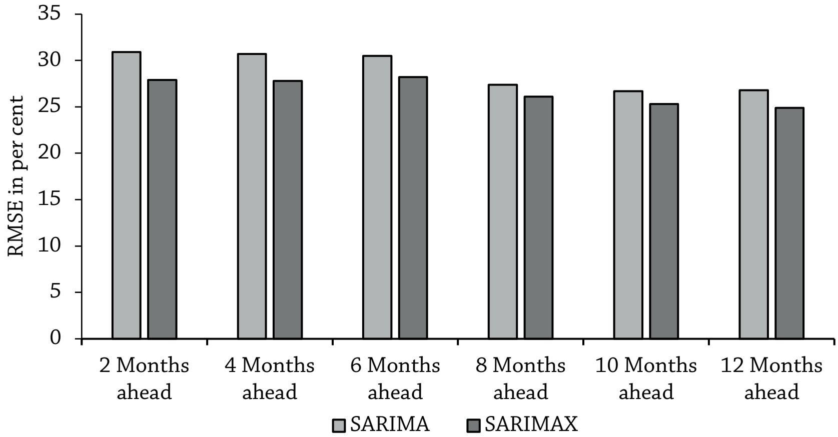
*Rolling RMSE for Tomato (July-2012 to June-2022)*




*Source:* Authors' estimation.

**Figure 6.22**

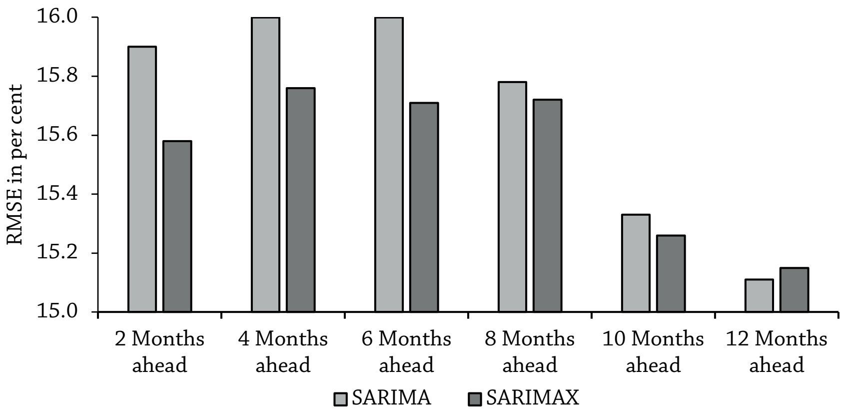
*Rolling RMSE for Onion (July-14 to June-22)*




*Source:* Authors' estimation

**Figure 6.23**

*Rolling RMSE for Potato (July-14 to June-22)*




*Source:* Authors' estimation.

## 6.10 Conclusion and Policy Suggestions

The study has attempted to identify the key determinants of TOP prices in an ARDL framework and undertake short-term price forecasting of monthly retail inflation using time series models. For this, both monthly balance sheet analysis for TOP and perception surveys with various value chain stakeholders for forward-looking, reliable and credible market intelligence have been carried out. The empirical analysis suggests that there is merit in including balance sheet variable like availability/availability usage ratio to better understand the price dynamics of TOP vegetables and for improving forecasts of TOP price inflation in India.

Price fluctuations in TOP are witnessed frequently due to the existing value chain bottlenecks that adds to volatility in food inflation. To improve the value chains and increase the farmers' share in consumer rupee for the three vegetables, the following policy measures are suggested:

### *Marketing Reforms*

Agricultural marketing reforms: As vegetables are perishable commodities, private mandis may be increased to improve transparency in marketing TOP vegetables. This will provide farmers with a wider choice of selling their produce. Also, due to competition, there may be improvement in the APMC infrastructure.

*Leveraging e-NAM*: The electronic linking of national agricultural markets (e-NAM) was envisioned to streamline trading procedure and bring transparency in APMC mandis and allow farmers and traders to trade online. If e-NAM is leveraged to achieve spatial integration of TOP markets, this could help reduce the current inefficiencies in the markets and increase prices received by farmers and reduce the prices paid by consumers.

*Promoting FPOs in TOP*: As on June 30, 2023, 10,000 FPOs have been allocated to various implementing agencies; of this, 6319 FPOs have been registered across the country. As vegetable farmers are mostly small and marginal, scaling up farmer collectives and empowering them with incentives may help increase their bargaining power. They can also benefit in terms of economies of scale in procuring inputs.

*Re-launching futures trading:* Potato was traded on the Commodity Exchanges in India till 2014 after which it was banned. Relaunching of potato futures and launching futures trading in onion especially for the *rabi* variety can be explored for optimal price discovery and risk management.

### Storage Solutions

*Spatial distribution of storages*: There is a spatial concentration of potato cold storage infrastructure and onion storage structures. While cold storages for potato are concentrated in UP, onion storages are concentrated in Maharashtra. There isa need to resolve the spatial distribution and capacity deficit of storage structures. Addressing the spatial concentration and capacity deficit of storage infrastructure for potatoes and onions would result in a more balanced distribution of storage facilities across regions, reducing post-harvest losses and improving the efficiency of the supply chain. This would enhance farmers' access to storage, stabilize prices, and potentially reduce regional disparities in storage availability, leading to a more resilient agricultural market.

*Solar-powered cold storage:* The efficiency of cold storages can be improved by setting up energy-efficient, solar-powered cold storages. From the field survey and focussed group discussion with the cold storage owners conducted in December 2022, it is found that there is a 35 per cent decline in electricity cost for a cold storage with a capacity of 1.71 lakh quintals of potato storage. At present, UP has a few cold storages partly run by solar power but such facilities may be promoted by incentivising investment in solar-powered cold storages. Once most of the cold storages start using solar power, the benefits through reduced operation costs can be passed on to the farmers. The government provides large subsidies on the construction of cold storages; a separate slab of subsidy for cold storage that will install solar panel for energy supply may be introduced as an incentive.

### Processing of TOP

*Awareness among consumers:* There is a need for creating greater awareness about the usage of processed forms of TOP: potato flakes, dehydrated onion and tomato puree among Indian consumers. Using dehydrated onion/tomato puree can be a substitute for fresh onion/ tomato especially when the prices rise. This will also help farmers as their incomes will rise and consumers can purchase onion/tomato at reasonable prices throughout the year. To increase awareness about the use of processed forms of TOP, several strategies can be implemented:

- Retail Promotions: Encourage supermarkets and grocery stores to run promotions and offer discounts on processed TOP products. Product sampling, in-store demonstrations, and informative packaging can further familiarize consumers with these alternatives.
- School and Community Programs: Introduce these items in mid-day meal schemes, army canteen, hostel messes to significantly broaden their usage.
- Partnerships with Food Service Industry: Collaborate with restaurants, catering services, and food delivery platforms to include dishes made with processed TOP products. Highlighting these options on menus can drive consumer interest and acceptance.

*Enhance processing capacity:* While the dehydration industry in Mahuva (Gujarat) is already large, it can be leveraged for enhancing dehydrated form of TOP. On the other hand, there is negligible processing of potato in UP and Bihar, the first and third largest potato growing states. There is a need for increasing potato processing in these states to help farmers during the glut period. Also, small scale processing units may be opened by FPOs to produce tomato pulp and puree to supply to large-scale ketchup manufacturing plants.

Increasing awareness and usage of processed TOP products like potato flakes, dehydrated onion, and tomato puree can stabilize consumer prices, especially during price spikes, while boosting farmers' incomes by creating additional demand and reducing post-harvest losses. These products offer convenience, longer shelf life, and help reduce food wastage, contributing to improved food security and market diversification. Overall, it benefits both consumers and farmers, ensuring affordable access to essential ingredients year-round.

### *Enhancing TOP productivity*

*Research and Development (R&D) for varietal development:* There is a need to promote R&D in varietal development of table varieties of potato, processing varieties of potato, exportable varieties of onion, etc. This could enhance the yield of TOP per hectare and ensure adequate supply of crops with more stabilised prices.

*Polyhouses for tomato:* There is a need to promote usage of polyhouse cultivation of tomato to enhance tomato yield. This will ensure a steady supply of tomato crop and help stabilise tomato prices. To help FPOs and farmers afford such capital-intensive technology, some incentives could be provided for technology adoption.

### *Adequate availability of data*

*Private stock data:* Data on private stocks of onion and potato cold storages are not readily available. Real time information on private stocks of onion and cold storage stock position for potato will strengthen the assessment of the evolving demand-supply balance and facilitate appropriate and timely policy responses to stabilise prices of these commodities.

*Statistical data:* There are several agencies that collect data on acreage (Land Use Statistics and Horticulture Statistics), and wholesale and retail prices (NHB, Department of Consumer Affairs, NHRDF). Availability of real time data on acreage for TOP crops and their stock positions will help in better estimation of market supply for these crops and for calibrating necessary policy interventions.

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## 6.12 Annexure

### Annexure A6.1

*Data Sources*

| *Data for:* | *Source and details* |
|---|---|
| CPI and WPI | CPI extracted from MoSPI website for each vegetable. CPI series is available from January 2014. The series have been spliced to get data from January 2010 onwards by changing base. WPI extracted from the Office of Economic Advisor, GoI. |
| Import and Export | Sourced from Directorate General of Foreign Trade (DGFT) Trade Statistics website. |
| Retail Prices | Retail Prices taken from Department of Consumer Affairs (DoCA) and Directorate of Economics and Statistics (DES) MoAFW. |
| Wholesale Prices | Wholesale Prices are from Agmarknet i.e., mandi prices |
| Mandi Arrivals | At all-India level and state-wise monthly mandi arrivals taken from Agmarknet. |
| Real wage | Data from RBI database on Indian economy. Calculated as average monthly rural wage for men at the all-India level for three activities: ploughing/tilling, sowing, harvesting/winnowing, and taken as a ratio with the CPI Combined. |
| Losses | Percentages for harvest and post-harvest losses taken from CIPHET report on post-harvest losses for 2016. |
| Consumption | Annual consumption projected forward using NSSO 2011-12 round of consumption expenditures on food and using the NITI Aayog behavioural approach (2018). |
| Veg Index | A composite index of all CPI indices under the vegetable category excluding the respective commodity of concern. |

*Source:* Authors' Compilation.

**Annexure A6.2**

*Variable Descriptions*

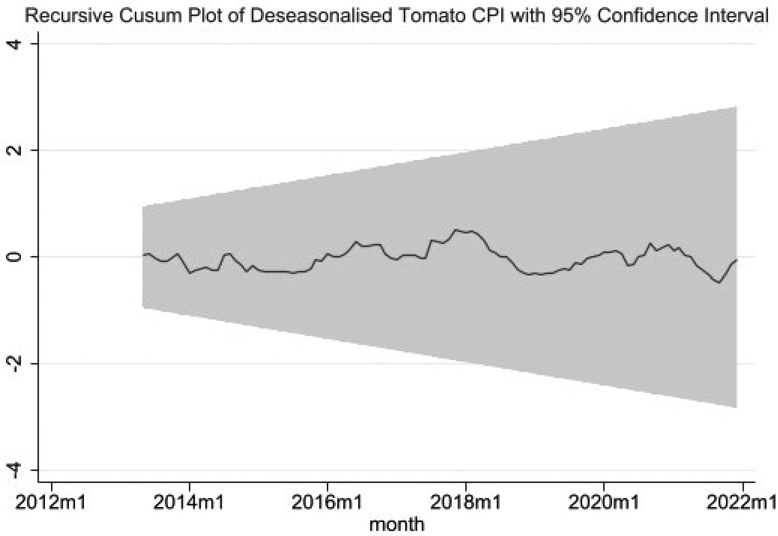
| *Variables* | *Definition* | *Comments* |
|---|---|---|
| CPI | CPI extracted from MoSPI website for each vegetable. | Dependent Variable. |
| Availability Usage Ratio (AVU)/ Availability | Monthly series are generated based on secondary data and Market Intelligence. | Primary Explanatory Variable. |
| Real Wage | Data from RBI database on Indian economy. Calculated as average monthly rural wage for men at the all-India level for three activities: ploughing/ tilling, sowing, harvesting/ winnowing, taken as a ratio with the CPI Combined. | It constitutes a major component in the cost of cultivation of all the crops. State wise variation in wage and availability of labour may impact the prices of some commodities more than the others. |
| Agro-Chemical Index | WPI of Agro-Chemicals obtained from Office of Economic Advisor, GoI. | Agro chemicals are major inputs in vegetables production, especially for tomato. But similar results were not found for the other two crops. |
| Vegetable Index | A composite index of all CPI indices under vegetable category excluding the respective commodity of concern. | Potato, onion and tomato are often used with other vegetables. Hence any increase in their prices get translated to others. |
| Rainfall Dummy | A rainfall dummy has been created for excess/deficient rainfall in the major producing districts of the selected commodities. | It has been observed that rainfall impacts tomato the most, among the three commodities. As potato is a *rabi* crop, rainfall does not play that major a role in the commodity. In case of onion, rainfall in Nashik was a significant variable in the original data. |

*Source:* Authors' estimation.

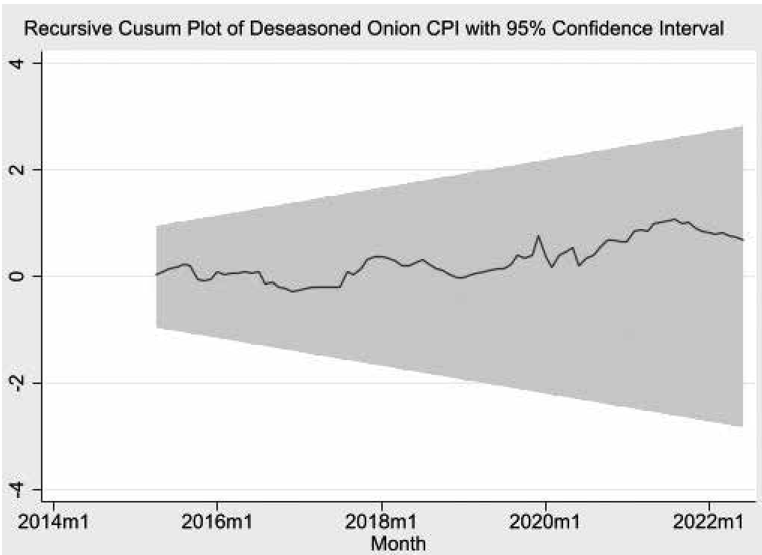
## Annexure A6.3

*CUSUM Plot for Vegetables*

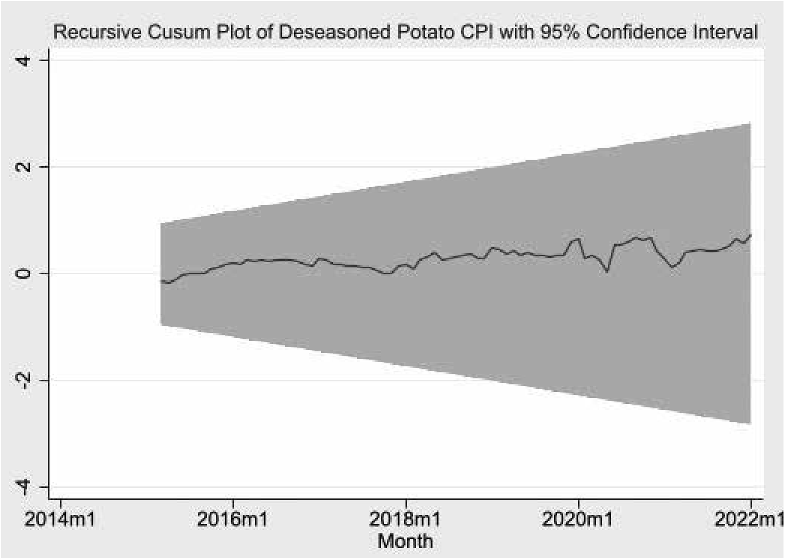
*Tomato*




*Onion*




*Potato*




*Source*: Authors' estimation.

# 7

RAYA DAS, RANJANA ROY, SANCHIT GUPTA,
SANJIB BORDOLOI, RISHABH KUMAR,
RENJITH MOHAN and ASHOK GULATI

# Price Dynamics and Value Chain of Fruits in India

## *A Study of Grapes, Bananas, and Mangoes*[65]

### 7.1 Introduction

The horticulture sector in India has witnessed remarkable growth in recent years, with a substantial share of 36 per cent in the GVO of agriculture and fruits constituting 37 per cent of horticulture output as of 2022-23[66]. The surge in horticulture production has been driven by an expansion in area from 23.2 million hectares (Mha) in 2011-12 to 28.4 Mha in 2022-23. For fruits, the increase in production is also attributed to a rise in yield from 11.4 metric tonnes (MT) per hectare in 2011-12 to 15.7 MT in 2022-23. The same period saw an increase in overall fruit production from 76.4 million metric tonnes (MMT) to 110.2 MMT.

The United Nations General Assembly (UNGA) declared 2021 as the *International Year of Fruits and Vegetables* to raise awareness about the nutritional benefits of fruits and vegetables, promote environmental sustainability, and secure the livelihood of farmers. Nevertheless, the marketing of fruits and vegetables, particularly in developing countries, faces multiple challenges, including transport

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65. This study is part of a joint research project titled "Understanding Price Dynamics of Major Agricultural Commodities and Identifying Ways to Improve Value Chains", conducted by the Reserve Bank of India (RBI) and the Indian Council for Research on International Economic Relations (ICRIER). The findings are published as an RBI Working Paper, available at https://www.rbi.org.in/scripts/PublicationsView.aspx?id=22721

66. Derived from National Accounts Statistics, 2024.

costs, seasonal gluts, supply shocks, quality checks, labour-intensive production systems, and post-harvest losses—all impacting inflation and price volatility (FAO, 2020). Fruits are high-value agricultural crops, and volatility in their prices affects household purchasing power and consumption patterns.

In India, fluctuations in inflation are often driven by volatile food prices. Such swings in the inflation trajectory pose challenges for forward-looking monetary policy since food prices can impact inflation expectations. In light of overlapping supply shocks since the onset of the pandemic, the large fluctuations seen in food prices underscore the need for a deeper understanding of food price dynamics and value chains in Indian agriculture.

Supply shocks to agricultural production in India result in high inflation volatility due to the significant share of food and beverages in the CPI basket (45.9 per cent in CPI-combined, 2012 base). The three fruits selected for this study—grapes, bananas, and mangoes—constitute approximately 36 per cent of the CPI-fruits basket[67] and contribute significantly to the inflation volatility of the group. Rainfall, input prices, rural wages, supply-chain measures, and government policies all influence agricultural commodity price inflation (Gulati & Saini, 2013). Nair & Eapen (2015) analysed factors impacting agricultural commodity inflation between 2009 and 2013, finding that rising cultivation costs are the primary factor.

On the demand side, consumption patterns have shifted from cereals to protein-rich foods, although the pace of transition to nutrient-rich fruits has been slow and varies by region (Agrawal & Kumaraswamy, 2014; Tak et al., 2019). This study also found that the rate of non-consumption of fruits is highest in eastern states (30 per cent) followed by northern states (20 per cent), as per the 2011-12 recall period.

Against the backdrop of changing consumption and production patterns and price volatility, this study analyses the price dynamics and determinants of fruit prices. It adopts a comprehensive balance-sheet approach designed to capture the interplay of demand

67. The weight of the fruits group in the CPI-C is 2.89 per cent, and the combined weight of the three selected fruits—grapes, banana, and mango—is 1.03 per cent.

and supply factors. This approach uses the Availability-to-usage (AVU) variable, derived from the monthly balance sheet, as a key explanatory factor and employs time series models to generate short-term inflation forecasts. Given the crucial role of the supply chain in stabilising prices, the study also explores value-chain efficiency and its impact on the farmer's share of the consumer rupee for fruits, suggesting interventions for improved supply-chain management. The chapter constructs balance sheets for selected fruits using secondary data sources and market intelligence from primary surveys. The broad objectives of the study are:

i. To construct a monthly balance sheet to understand the market availability and demand dynamics of the three fruits—grapes, bananas, and mangoes—which can be used to explain their price dynamics.
ii. To empirically estimate the determinants of these three fruits' prices, using the balance sheet variable along with other commodity-specific variables.
iii. To forecast inflation in the selected fruits for up to 12 months ahead and assess the performance of various forecasting models.
iv. To understand the complex value chains of the three fruits and provide policy suggestions for stabilising prices and increasing farmers' share of the consumer rupee.

The empirical findings suggest that the monthly availability or AVU ratio negatively impacts retail prices of the selected fruits. Input prices (proxied by pesticides and agrochemicals) also influence fruit price dynamics. The study assesses the value chain's impact on fruit price dynamics to recommend necessary policy interventions. Based on survey data, the farmer's share in the retail prices of these fruits is estimated to range between 30 and 43 per cent, varying across marketing channels.

The remainder of the chapter is organised into eight sections. Section 7.2 provides an overview of grapes, bananas, and mangoes. Section 7.3 examines the price dynamics of these fruits along with their seasonality. Section 7.4 reviews supply and demand factors to trace key determinants of fruit prices in India, which are used in the econometric models. Section 7.5 maps the value chain for grapes, bananas, and mangoes and estimates the farmer's share of the consumer rupee to assess value-chain efficiency. It also includes a brief profile of market intelligence and key informants from primary field surveys. Section 7.6 details the methodological framework for constructing monthly balance sheets to understand fruit price dynamics. Section 7.7 specifies the model and presents the empirical results, highlighting important structural drivers of fruit prices. It generates inflation forecasts for the selected fruits for a horizon of up to 12 months and evaluates the forecasting performance of alternative econometric models. Section 7.8 concludes the study and provides policy recommendations to improve the supply chain and curb fruit price inflation.

## 7.2 Commodity Profile

India's varied agro-climatic regions and tropical location enable the cultivation of a wide variety of fresh fruits. The country ranks second in fruit and vegetable production worldwide, after China. According to the FAO (2022), India ranks first in the production of bananas (26 per cent of global production) and mangoes, including mangosteens and guavas (44 per cent), and second in fresh/table grapes (12 per cent). This vast production base offers India significant export opportunities. During 2022-23, India exported fresh fruits and vegetables worth US$1,789 million, of which fruits accounted for US$863 million.

### *7.2.1 Grapes*

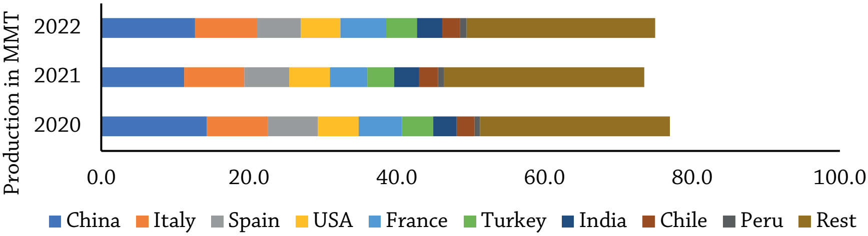
#### ***Production***

Global grape production is divided into pressed grapes (37.3 MMT in 2022) and unpressed grapes (35.5 MMT)[68]. According to the FAO, China is the largest producer of total grapes (fresh/table, raisin, and wine), with 12.6 MMT, followed by Italy (8.4 MMT), France (6.2 MMT), Spain (5.9 MMT), and the US (5.3 MMT). India ranks seventh, producing 3.4 MMT in 2022, accounting for 4.5 per cent of total global grape production (Figure 7.1).

68. Pressed grapes include wine grapes (34.1 MMT) and juice and concentrates (3.1 MMT), while unpressed grapes comprise 30.1 MMT of table grapes and 5.4 MMT of dried grapes.

**Figure 7.1**

*Production of Grapes of Major Countries (2020-22)*

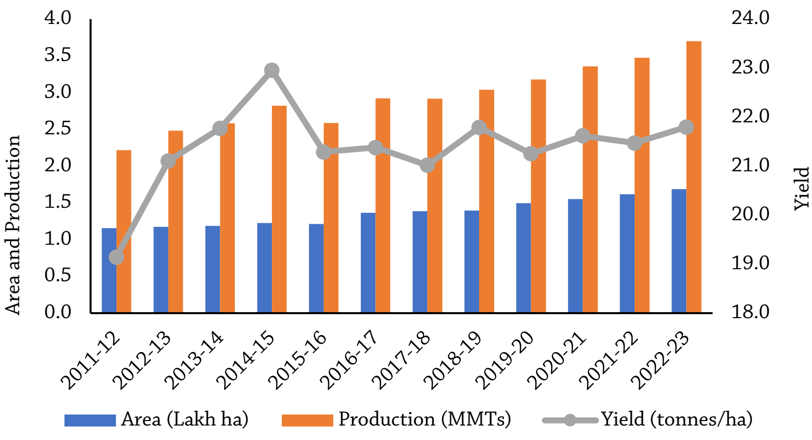



*Source:* Food and Agriculture Organisation Statistics (FAOSTAT) 2022.

As per the NHB, India's production of total grapes increased from 2.2 MMT in 2011-12 to 3.7 MMT in 2022-23, driven by both higher area and yield (Figure 7.2).

**Figure 7.2**

*Production and Yield of Grapes*




*Source:* NHB, Ministry of Agriculture and Farmers Welfare (MoA&FW), Government of India (GoI).

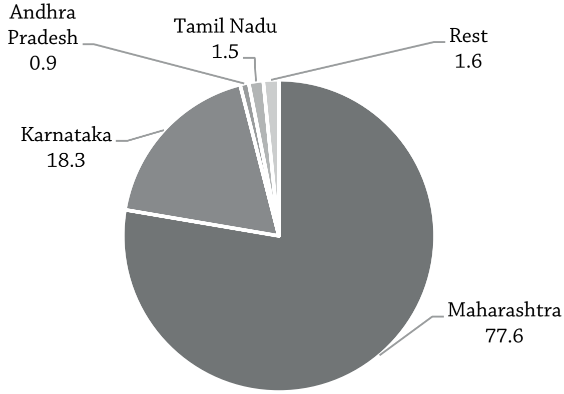
Global table grape production is approximately 31.5 MMT (42.0 per cent of total grape production), with India being the second-largest producer of table grapes after China (International Organisation of Vine and Wine (OIV) Report, 2022). Unlike the expansive growth of the winery sector in the EU and the US, as indicated by the FAO (2022), India has emerged as a prominent producer of table grapes—

those intended for direct consumption. Since the 1960s, with the introduction of seedless varieties, grape production (viticulture) has flourished in Maharashtra, which accounts for 78 per cent of total grape production in the country, followed by Karnataka at 18 per cent in the triennium ending (TE) 2022-23 (MoA&FW, 2023) (Figure 7.3). Among total grape production in India, fresh grapes constitute 77 per cent, followed by raisin (20 per cent), wine grapes (2 per cent), and juice and concentrates (1 per cent) (Agricultural and Processed Food Products Export Development Authority (APEDA), 2021).

Grape production is regionally concentrated in tropical peninsular India. The major growing districts are Nashik, Sangli, Solapur, Pune, Satara, Latur, and Osmanabad in Maharashtra, and Bijapur, Bagalkot, Belgaum, and Gulbarga in Karnataka. A small amount of grape cultivation also occurs in select sub-tropical regions, including Bhatinda, Gurdaspur, and Ludhiana districts of Punjab, and Hissar and Jind districts of Haryana. However, the annual growth rate of grape production in Maharashtra has declined from 8 per cent in TE 2014-15 to 2 per cent in TE 2022-23. In contrast, Karnataka's share in terms of area and production has increased over the years. Karnataka also has a higher share of grapes used for wine processing and raisin production, while Maharashtra remains the epicentre of fresh grape production.

**Figure 7.3**

*State-Wise Share of Grape Production in TE 2022-23 (Per cent)*

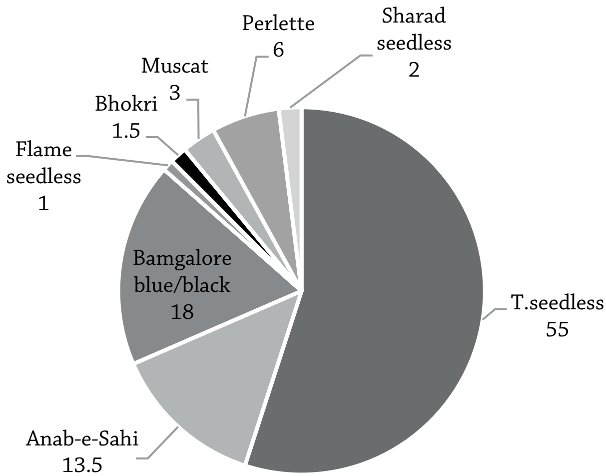



*Source:* NHB, GoI.

In terms of variety, the Nashik cluster is the major producer of the *Thompson seedless* (T. seedless) variety, which comprises 55 per cent of total table grape production (Figure 7.4). In the sub-tropical regions, the *Perlette* variety is cultivated on a limited scale due to a short growing season. Regional demand in Punjab and Haryana is relatively high, and this variety caters to local demand during the pre-monsoon months of May-June. *Bangalore Blue, Anab-e-Sahi, Muscat, and Bhokri* are prominent varieties in Karnataka, which experiences two harvest seasons: January-March and September-December. In Maharashtra, the primary grape production area, harvesting occurs in a single season from January to May.

**Figure 7.4**

*Cultivar-Wise Share of Grape Production in 2021-22 (Per cent)*




*Source:* APEDA, GoI.

India is also the third-largest consumer of table grapes, after China and Turkey, according to OIV, 2022. Per capita grapes consumption, however, shows rural-urban disparities: monthly consumption was 38 grams in rural areas and 84 grams in urban areas in 2011-12. Although market intelligence suggests higher grape consumption (150-160 grams per capita in rural-urban combined areas), the study uses the consumption data from NSS 2011-12[69] due to the large sample size of this survey. Approximately 7 per cent of rural households and 13 per cent of urban households reported grape consumption during that year. Regional patterns reveal very low grape consumption in eastern states, with much higher levels in southern, western, and north-western states. In rural areas, Kerala has the highest per capita consumption (100 grams per month), while major consumption centres in urban areas include Delhi, Mumbai, and Hyderabad. According to class-wise monthly per capita consumption expenditure (MPCE) deciles, the top income class in rural areas consumes 138 grams per capita per month, compared to 25 grams in the sixth decile class. In urban areas, per capita consumption is 246 grams per month in the highest MPCE class, compared to 66 grams in the middle MPCE class (NSSO, 2011-12).

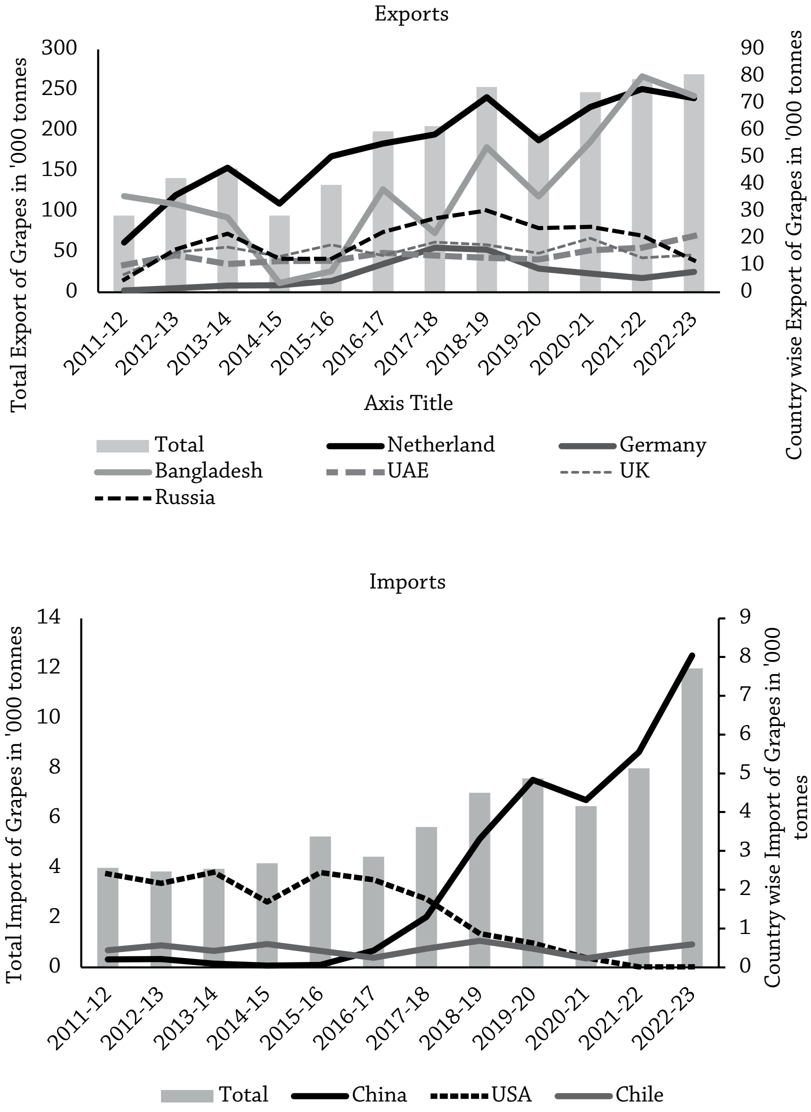
### External Trade

World trade in fresh grapes was 5.2 MMT in 2022, with Chile being the largest exporter (despite being the 8th largest producer in TE 2021-22), followed by Peru and Italy. India imports grapes primarily from China, while its main export destinations are the Netherlands and Bangladesh (Figure 7.5). Seccia et al. (2015) highlighted India's emergence as a major competitor in the northern hemisphere alongside China, Egypt, Mexico, and Turkey. However, the unit value of export (UVE) for Indian grapes has generally been lower than that of Chile, owing to production shortages and high shipping costs (Annexure A7.3). India's export value rose more than fourfold, from Rs. 5.1 billion to Rs. 23.0 billion over the last decade. Grape imports also increased from around 4,000 tonnes in 2011-12 to 12,000 tonnes in 2022-23, though there was a dip during the pandemic. Since 2015, the import of coloured grape varieties has shifted from the USA to China. Export quantity has risen due to

69. The NSSO, Ministry of Statistics and Programme Implementation (MoSPI), Government of India, has released the summary results of the Household Consumption Expenditure Survey (HCES) conducted from August 2022 to July 2023 in the form of a factsheet in February 2024. The factsheet for HCES: 2022-23 is available at http://www.mospi.gov.in. The detailed unit-level data was released after the completion of the study.

**Figure 7.5**

*Sources of India's Imports and Exports of Grapes*



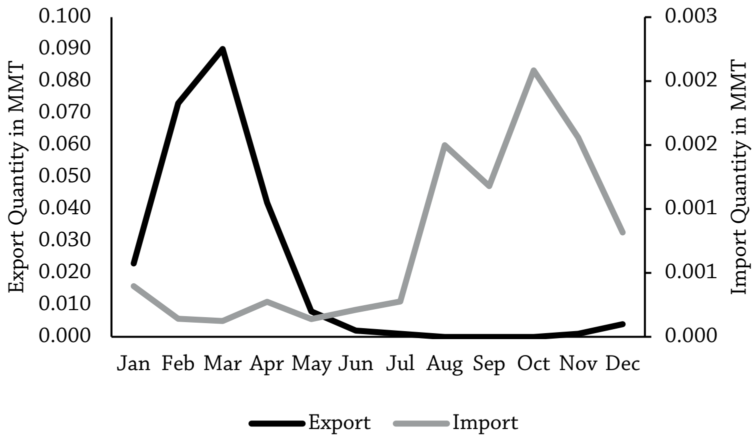

*Source:* Trade Statistics, Directorate General of Foreign Trade (DGFT), Ministry of Commerce and Industry, GoI.

improvements in EurepGAP[70] compliance and production increases (Phadke et al., 2022). For the first time, after a consignment rejection by the EU in 2021, export quantities to Bangladesh surpassed those to the EU. However, Bangladesh imposed a high import duty (25 per cent) on Indian grapes in January 2023 (Market intelligence, APEDA).

Following the peak production period (February-March), India exports the maximum quantity of grapes in March, while the peak of imports occurs in October. Demand generally increases during September-October due to the festive season in India. However, during the lean season, when domestic production does not fully meet domestic demand, the shortfall is covered through imports (Figure 7.6).

**Figure 7.6**

*Import and Export Window for Grapes in India during TE 2021-22*




*Source:* DGFT, GoI.

## *7.2.2 Banana*

### Production

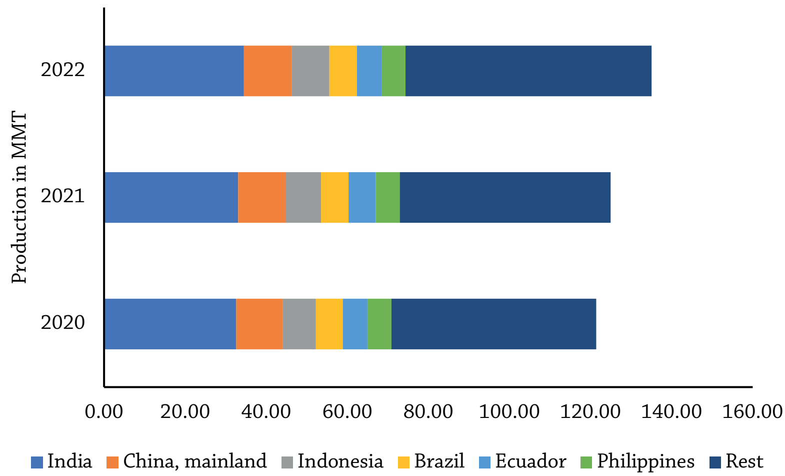
Bananas are predominantly produced in Latin America, Asia, and Africa. In 2022, India was the largest producer of bananas (34.5 MMT,

70. EurepGAP (Euro Retailer-Produce Good Agricultural Practices) and later Global-GAP started in 1997 in response to consumers' awareness about food safety and cropping practices.

or 26.3 per cent of global production), followed by China, Indonesia, Brazil, Ecuador, and the Philippines (Figure 7.7). In India, production mostly caters to the domestic market. The most popular commercial variety, the *Cavendish* cultivar, is grown in Maharashtra, Gujarat, Bihar, West Bengal, Tamil Nadu, Karnataka, and Andhra Pradesh. Other varieties include *Robusta, Rasthali, Poovan, Nendran, Red Banana, Ney Poovan, Virupakashi, Pachanadan, Monthan, Karpuravalli, and Safed Velchi Musa,* which are mainly produced and consumed locally.

**Figure 7.7**

*Global Banana Production (MMT) (2020-22)*

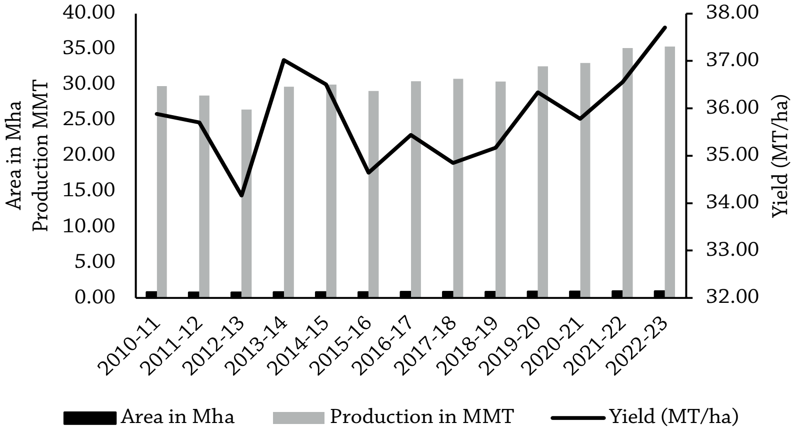



*Source:* FAOSTAT 2022.

Banana is the second most important fruit in India, with about 13 per cent of total fruit area allocated to banana cultivation. Of the total value of fruit output, bananas contribute the second largest share (24 per cent), following mangoes (29 per cent). Banana production increased from 26.5 MMT in 2012-13 to 36.6 MMT in 2022-23, while the area under banana cultivation rose from 0.78 Mha to 0.99 Mha over the same period (Figure 7.8).

**Figure 7.8**

*Trends in Area and Production of Banana (2010-11 to 2022-23 )*

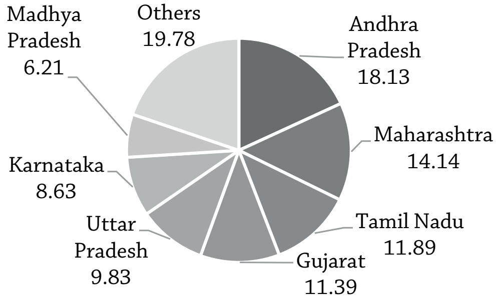



*Source:* MoA&FW, GoI.

The major banana-producing states are Andhra Pradesh (18.1 per cent), followed by Maharashtra, Tamil Nadu, Gujarat, Uttar Pradesh, Karnataka, and Madhya Pradesh, which together account for around 80 per cent of total production in TE 2022-23 (Figure 7.9). Banana is a perennial crop, available throughout the year. In states like Gujarat, Uttar Pradesh, Bihar, and Jharkhand, the peak harvest season for bananas is September-November, whereas in Maharashtra, peak harvest months are April-May. In South Indian states, planting can be done at any time except during the peak summer months.

**Figure 7.9**

*State-Wise Production of Banana (TE 2022-23) (Per cent)*




*Source:* MoA&FW, GoI.

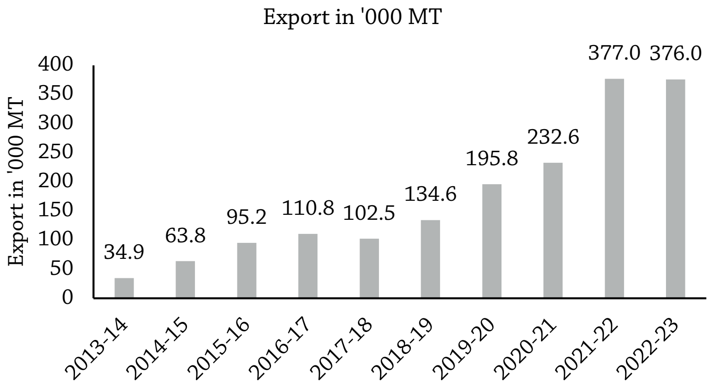
## External Trade

World trade in bananas has expanded in recent years, with estimated exports of 21 MMT in TE 2021-22. The leading exporting regions are Latin America and the Caribbean, accounting for 75 per cent of global exports, followed by Asia (21 per cent) and Africa (3 per cent). Major banana-exporting countries include Ecuador, the Philippines, Costa Rica, Guatemala, Colombia, and the Dominican Republic. Leading importers are the European Union (26.3 per cent of total imports), the USA (21.3 per cent), China (10.6 per cent), the Russian Federation (7.4 per cent), and Japan (5.7 per cent). According to the FAO, banana shipments from Asia have declined post-pandemic, with the Philippines, Asia's largest exporter (60 per cent of Asian exports), heavily affected by Tropical Race 4 (TR4) banana disease in 2020-21.

Banana exports from India increased from 35 thousand MT in 2013-14 to 376 thousand MT in 2022-23 (Figure 7.10). However, India's exports constitute less than 2 per cent of global exports, as it is also the largest consumer of bananas (Figure 7.11). Domestic farmgate banana prices in India doubled from Rs. 14-15 per kg in 2021-22 to Rs. 27-28 per kg in 2022-23 (Market Intelligence, 2023), contributing to a decline in export shipments in 2022-23.

**Figure 7.10**

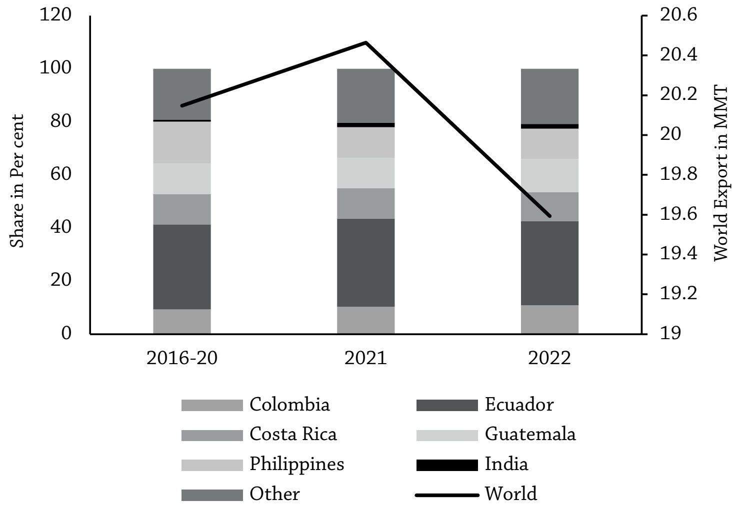
*India's Banana Exports*




*Sources:* Department of Commerce, Ministry of Commerce and Industry, Banana Market Review, Preliminary Results, 2022; and FAO.

**Figure 7.11**

*Quantity and Share of Countries in Global Exports of Banana*




*Sources:* Department of Commerce, Ministry of Commerce and Industry, Banana Market Review, Preliminary Results, 2022; and FAO.

### *7.2.3 Mango*

#### Production

India is the largest producer of mangoes globally (Figure 7.12)[71]. In TE 2022-23, India produced 25.3 MMT, accounting for 44.6 per cent of total global mango production (FAOSTAT, 2022). Other top-producing countries include China (3.8 MMT), Indonesia (3.8 MMT), Pakistan (2.6 MMT), Mexico (2.4 MMT), and Brazil (2.1 MMT). India is also the largest consumer of mangoes worldwide. The yield of mangoes in India stood at 9.5 tonnes/ha[72] in 2021, which is on par with the global average (FAOSTAT, 2022). However, yields are

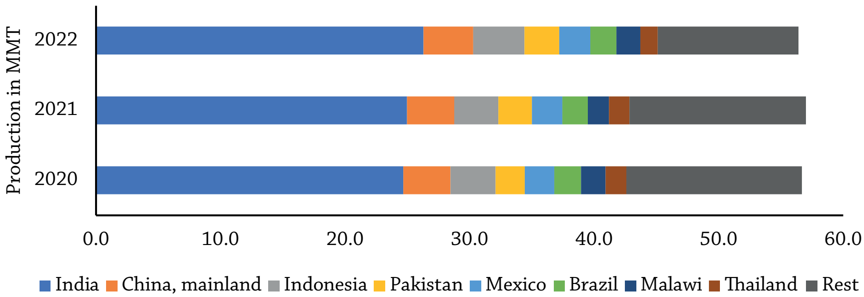
71. Data on global mango production is available on FAOSTAT under the commodity group "Mango, mangosteen, and guava." The FAO states that, on average, mango accounts for approximately 75 per cent of total production volume, guava for 15 per cent, and mangosteen for the remaining 10 per cent (FAO: Major Tropical Fruits: Market Review 2018).

72. For the "Mango, mangosteen, and guava" category.

higher in China and Indonesia, at 10.2 tonnes/ha and 13.4 tonnes/ha, respectively.

**Figure 7.12**

*Global Mango Production in MMT (2020-22)*

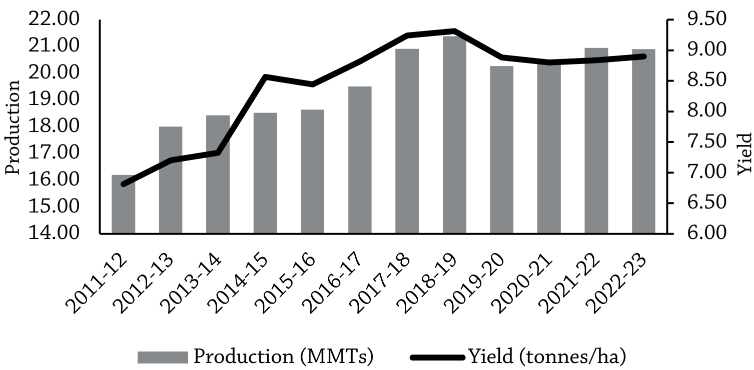



*Source:* FAOSTAT 2022, FAO of the United Nations.

Mango production in India has increased at a CAGR of 2 per cent, from 16.2 MMT in 2011-12 to 20.9 MMT in 2022-23. The area under mango cultivation, however, has declined to 23.4 lakh hectares (Lha) in TE 2022-23 from 24.6 Lha in TE 2013-14 (NHB, 2022). This increase in production was driven by an improvement in domestic yield, from 6.8 tonnes/ha in 2011-12 to 8.9 tonnes/ha in 2022-23 (Figure 7.13). Andhra Pradesh and Uttar Pradesh dominate

**Figure 7.13**

*Production and Yield of Mango in India*

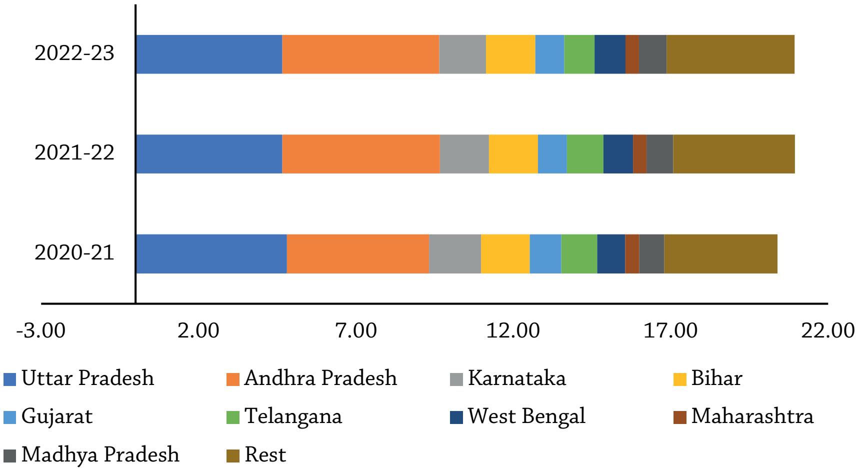



*Source:* MoA&FW, GoI.

mango acreage in India, with shares of 17 per cent and 12 per cent, respectively. These states also have a dominant share in total production, around 23 per cent each (Figure 7.14). Mango cultivation in Uttar Pradesh, Andhra Pradesh, Bihar, Karnataka, Gujarat, Tamil Nadu, and Telangana constitutes 75 per cent of total production and has a higher degree of commercialisation compared to other mango-producing states.

**Figure 7.14**

*State-wise Mango Production in MMT*




*Source:* MoA&FW, GoI.

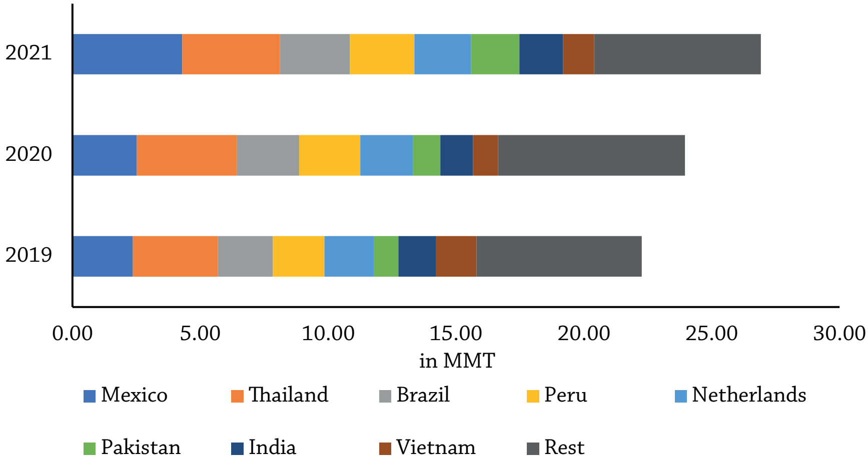
## External Trade

Some key mango varieties traded globally include *Tommy Atkins* (Latin America), *Kent* (Florida), *Keitt* (Florida), *Palmer* (Israel), Amélie (Africa), and *Irwin* (Latin America). In 2021, Mexico had the largest share of global exports at 16 per cent, followed by Thailand with 14 per cent (Figure 7.15).

India is a net mango-exporting country, with a 6 per cent share of global exports in 2021. *Alphonso* (Maharashtra), *Kesar* (Gujarat), and *Banganpalli* (Andhra Pradesh and Tamil Nadu) are the leading export varieties from India. Despite reduced acreage, Maharashtra continues to play a vital role in India's *Alphonso* exports. Other major exporting

**Figure 7.15**

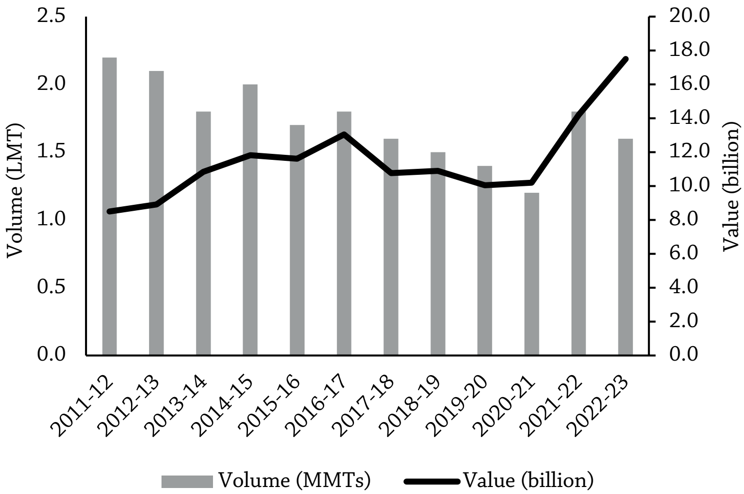
*Country-wise Mango Exports in MMT (2019-21)*




*Source:* World Integrated Trade Solutions (WITS) Database, World Bank.

**Figure 7.16**

*Quantity and Value of Mango Exports from India*




*Source:*Trade Statistics, Directorate General of Foreign Trade (DGFT), GoI.

states are Gujarat, Tamil Nadu, West Bengal, Karnataka, and Andhra Pradesh. Although India is a top global producer, its exports remain low (0.8 per cent of its total production in 2021-22), as a significant portion of the total production is consumed domestically (DGFT, 2023) (Figure 7.16).

Mango exports from India are primarily in three forms: (i) fresh mangoes, (ii) mango pulp, and (iii) mango slices. Mango pulp comprises the largest share (78 per cent) of mango exports from India as of TE 2022-23, followed by fresh mangoes (17 per cent) and mango slices (5 per cent). This distribution has changed slightly from TE 2013-14, when the shares of mango pulp, fresh mangoes, and mango slices were 73 per cent, 25 per cent, and 2 per cent, respectively (DGFT, 2023).

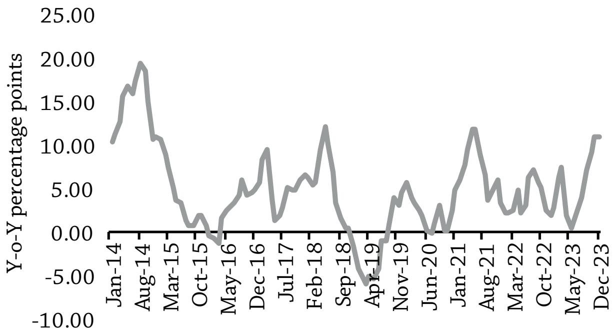
The export volume for all three mango forms has declined over the last decade, with mango pulp experiencing a steady decrease with little recovery. Major destinations for fresh mango exports include the UAE, the UK, the US, Oman, Qatar, and Nepal. Mango pulp is exported mainly to Saudi Arabia, Yemen, the Netherlands, Kuwait, the UK, and the US. Although the UAE is the top destination for fresh mango exports, its share in India's total mango exports declined from 54.3 per cent in 2015-16 to 46.4 per cent in 2021-22 (APEDA, 2022). Conversely, the shares of exports to Bangladesh and Oman increased from 0.9 per cent to 5.6 per cent, and from 2.5 per cent to 6.6 per cent, respectively.

### 7.3 Price Dynamics of Fruits

Fruits, like other horticultural crops, have experienced price volatility due to weather fluctuations, rising cultivation costs, pandemic-related shocks, and supply chain disruptions. Fruit items make up only 6.3 per cent of the CPI-Food and Beverages weights, with bananas holding the largest share (19.4 per cent), followed by apples (16.3 per cent), mangoes (11.1 per cent), coconuts (9.1 per cent), and grapes (5.3 per cent). Although fruits occupy a modest portion of the CPI basket, their prices exhibit significant volatility (Figure 7.17).

**Figure 7.17**

*CPI Fruits Inflation*

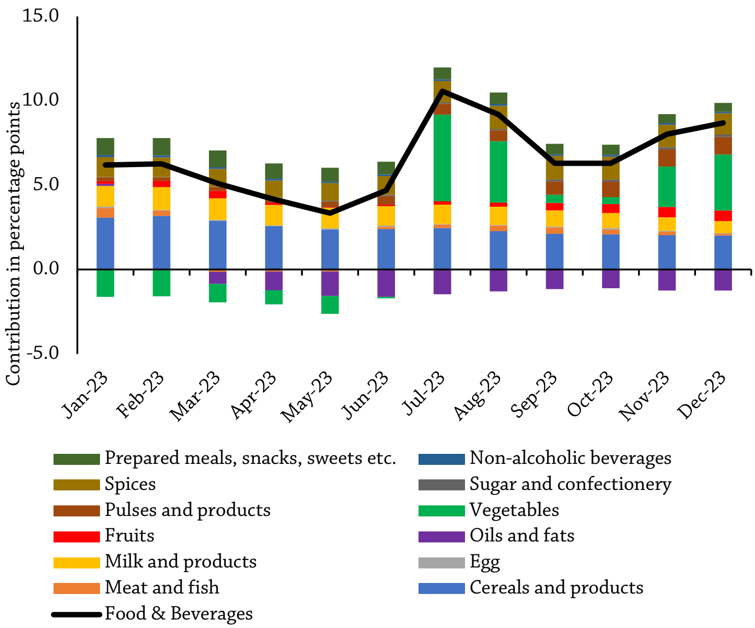



*Source:* NSO, MoSPI, GoI.

Between January 2023 and December 2023, fruit inflation contributed approximately 1-9 per cent to overall food and beverage inflation (Figure 7.18). Climatic challenges frequently lead to supply constraints, exerting upward pressure on fruit prices.

**Figure 7.18**

*Commodity-Wise Contribution to Food and Beverages Inflation*

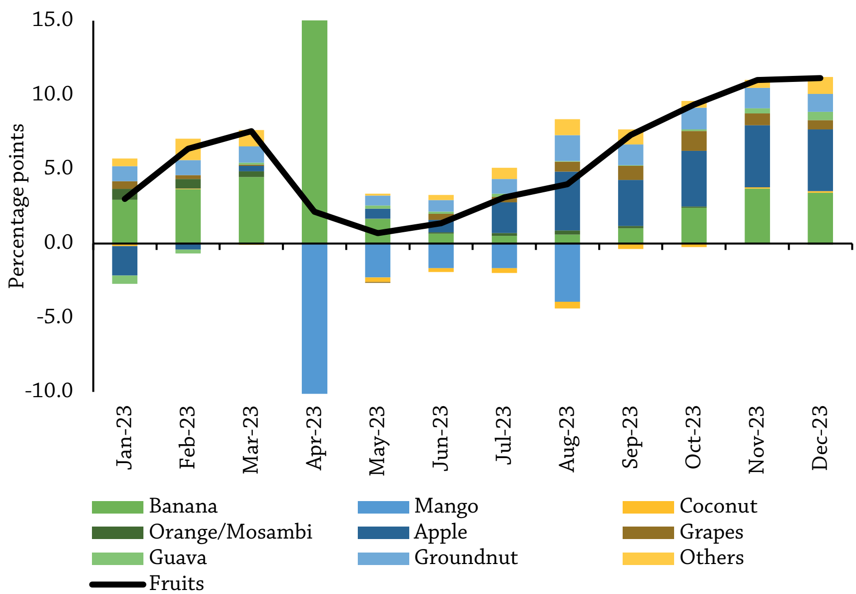



*Sources:* NSO, MoSPI; and authors' calculations.

During the summer months, mango contributes the most to CPI fruits inflation, reflecting its seasonality and heightened demand at the start of the harvest season. In 2022, mango prices surged due to a low harvest but moderated in 2023 with normal crop production. Banana's contribution to CPI fruits inflation remained elevated throughout 2023, while apple was the major contributor from June to December 2023 (Figure 7.19).

**Figure 7.19**

*Contribution to CPI Fruits Inflation (Y-o-Y)*




*Sources:* NSO, MoSPI, GoI; and authors' calculations. April 2023 contributions are only partly reflected in the figure.

Grapes experienced high inflation in May 2014, May 2018, and August 2021, with increases of 22.1 per cent, 26.2 per cent, and 17.2 per cent, respectively. Generally, price rises from June onwards due to seasonality, as this marks the end of the fresh grape harvest season and the reduced market arrivals cannot meet summer demand. During the summer months, the brix value (a measure of sugar content) of grapes also increases, raising market demand. The crop calendar indicates peak arrivals from February to March (Table 7.1), when 75 per cent of the produce reaches the market (as per market sources). In Karnataka, coloured varieties, particularly *Bangalore Blue,* are grown; these are more expensive than *Thompson Seedless*, resulting in higher prices in June-July.

**Table 7.1**

*Crop Calendar for Grapes Arrival across States*

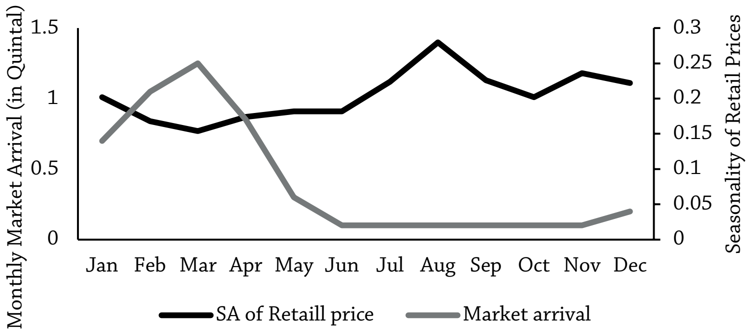
| | *Jan* | *Feb* | *Mar* | *Apr* | *May* | *Jun* | *Jul* | *Aug* | *Sep* | *Oct* | *Nov* | *Dec* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Maharashtra | Lean | Peak | Peak | Lean | Lean | | | | | | | Lean |
| Karnataka | Lean | Peak | Peak | Lean | Lean | | Lean | | | | | Lean |
| Andhra | Lean | Peak | Peak | Lean | Lean | | Lean | | | | | Lean |
| Tamil Nadu | | | | | Lean | Lean | Lean | | Lean | Lean | Lean | Lean |
| Punjab | | | | | Lean | Lean | Lean | | | | | |
| Haryana | | | | | Lean | Lean | Lean | | | | | |

*Source:* APEDA, 2022.

The ratio of monthly retail price of grapes to the all-India monthly average retail price (as of TE 2021-22) is used to gauge the seasonality of retail prices. Prices are lowest during February-March, the peak harvest months (Figure 7.20). The average price during TE

**Figure 7.20**

*Seasonality of Grape Prices and Market Arrivals (TE 2021-22)*




*Note:* The ratio of the retail price of each month to the annual average retail price is calculated, and the three-year average of that ratio represents the seasonality of retail prices.

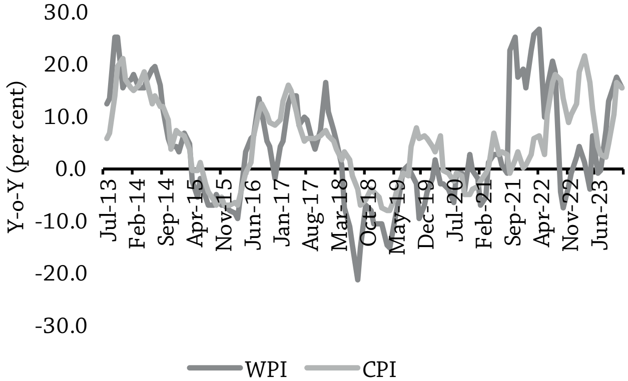
*Source:* NHB, GoI.

2021-22 shows a decrease from Rs. 109 per kg in January to Rs. 83 per kg in March. Retail prices and market arrivals exhibit a distinct inverse relationship, with seasonality peaking in August, when the three-year average price for the *Thompson Seedless* variety reaches Rs. 155 per kg. The higher retail price during July-November reflects limited market presence and increased import quantity, which includes the more expensive *Red Globe* variety, contrasting with the domestically prevalent *Thompson Seedless*.

Banana retail price inflation spiked to 18 per cent between September and December 2013, due to monsoon deficiency and a decline in cultivation area (Figure 7.21). The area under banana cultivation dropped from 0.83 Mha in 2010-11 to 0.80 Mha in 2011-12 and further to 0.78 Mha in 2012-13. Since banana cultivation requires substantial water, depleted water levels drive growers to shift to other crops. Banana crops are also vulnerable to pest attacks, which can severely impact harvests. For instance, a widespread *'banana skipper'* pest attack in Karnataka in 2015-16 resulted in almost a 30 per cent weight loss (Prabhu, 2015). Regular pest monitoring and agro-chemical applications inflate cultivation costs. In 2017-18, an outbreak of Panama disease/TR4 affected over 10,000 ha of plantations, impacting retail banana inflation. A sharp price

**Figure 7.21**

*Inflation in Banana (CPI and WPI)*



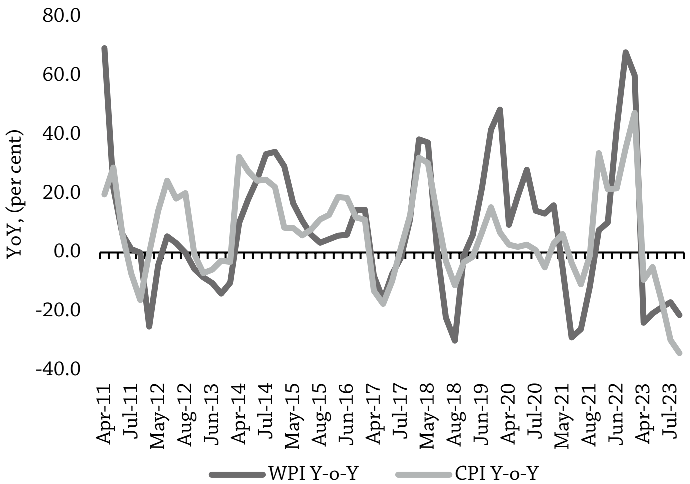

*Sources:* NSO, MoSPI; and Office of Economic Adviser, GoI.

increase was observed in March 2023 across major urban centres. Traders attributed this spike to rising transport and storage costs and an increased demand-supply gap caused by heavy rains in Gujarat, Maharashtra, and Andhra Pradesh.

Mango, being a summer fruit, the CPI for mango is available seasonally from April to August every year. Prior to 2018-19, data was released for every month. This section examines mango price behaviour over the five-month production period in India. A comparison of CPI and WPI inflation for mangoes reveals significant gaps, potentially attributable to inefficiencies in the value chain, high retailer margins, or differences in data collection methods. At times, the indices move in opposite directions, possibly due to variety differences when price quotations are collected for index construction (Figure 7.22). Nevertheless, the correlation between CPI and WPI inflation for mangoes is 0.69.

**Figure 7.22**

*Inflation in Mango (CPI and WPI)*



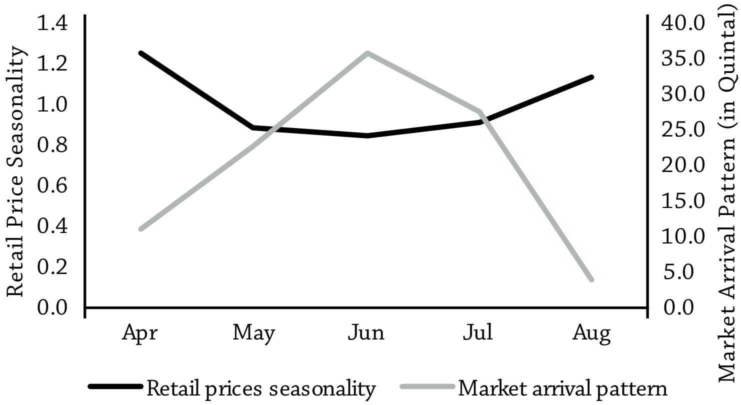

*Note:* CPI data for mango is available from April to August.

*Sources:* NSO, MoSPI; and Office of Economic Adviser, GoI.

Each year, mango arrivals begin in March, peak in June (particularly from Uttar Pradesh), and decline in August. The seasonality in retail prices, along with the mandi arrival pattern for mangoes in India, indicates an inverse relationship between them (Figure 7.23). In May and June, mango arrivals overlap for different varieties, as north Indian varieties like *Dusheri* and *Chausa* enter the market alongside *Alphonso, Kesar,* and others.

**Figure 7.23**

*Seasonality of Mango Prices and Market Arrivals (TE 2021-22)*




*Note:* The ratio of the retail price of each month to the average retail price for the year was calculated, and the three-year average of that ratio is used to present the seasonality of retail prices in this figure.

*Sources:* NHB; and Agmarknet.

Mango prices vary significantly by variety, and the difference between retail and wholesale prices across varieties indicates retail margins. The concentration of mango production and the logistical requirements for interstate trade contribute to large price variations for the same produce across different geographical locations (different consumption centres). Though the mango value chain involves numerous participants, and transportation and quality maintenance costs are high, on average, the *Alphonso* variety has a 62 per cent retail margin during April-August, while *Chausa*, *Dusheri*, and *Kesar* have margins of 52 per cent, 44 per cent, and 45 per cent, respectively.

## 7.4 Role of Supply and Demand Factors in Identifying Key Determinants of Fruit Inflation

With changing dietary patterns and rising incomes, India's fruit sector has a strong capacity to meet growing demand, enhance farmers' income, and increase foreign exchange reserves. Studies have identified fruits and vegetables as dominant indicators explaining food inflation in India (Mishra and Roy, 2012). Inflation in food commodities, especially pulses, milk, vegetables, and fruits, is driven by shifts in dietary patterns, trade policy, and rising rural wages (Ball et al., 2016). Bhattacharya and Sengupta (2015) argued that, from 2006 to 2013, the supply of fruits generally exceeded domestic demand, resulting in moderate inflation in the sector. Fruit production is influenced by cultivation area, environmental conditions (including sunlight, rainfall, cyclones, and pest attacks), and temperature. Heatwaves, particularly during the fruiting stage, reduce harvest yields. Climate change, temperature anomalies, and erratic rainfall disrupt horticulture production, distorting crop cycles (Dutta, 2013).

The cost of production has escalated since the 1990s due to rising agricultural wages and input costs (Narayanmoorthy, 2013). Increasing pest attacks on tropical fruits have led to greater pesticide use in India, with the highest usage recorded in Punjab (0.74 kg per ha in 2016-17), further inflating cultivation costs. Chemical growth regulators are also more commonly used in tropical fruits to enhance yield. Post-harvest losses impact domestic availability, often creating supply shortages that lead to inflationary pressures. These losses are largely due to inefficient infrastructure in the supply chain, including an inadequate number of cold storage facilities and phytosanitary measures, widening the gap between production and availability (Bairwa et al., 2012).

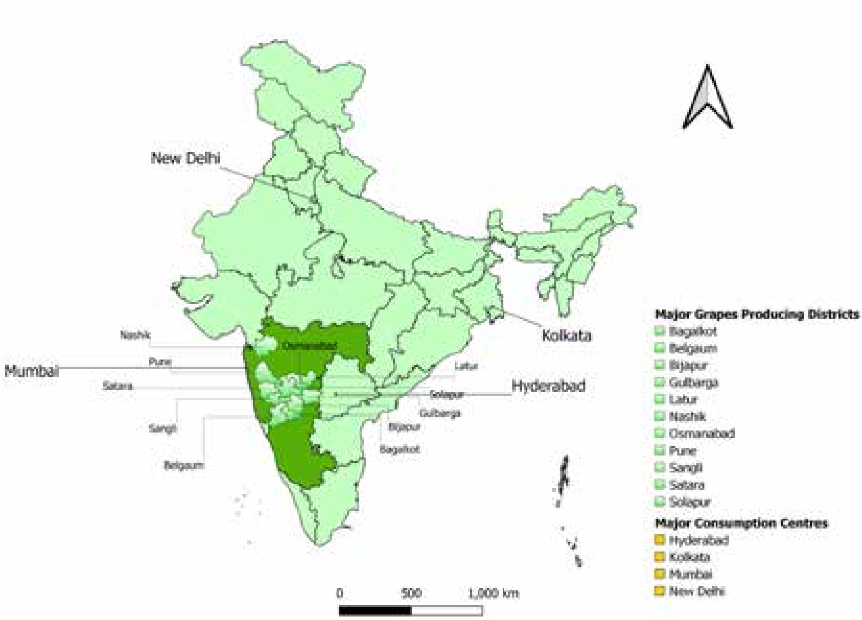
Fruit prices are also affected by post-harvest quality losses. For bananas, high post-harvest loss is attributed to improper handling, inadequate transport facilities, and storage conditions (Mohapatra et al., 2010). However, post-harvest loss for mangoes decreased from 12.7 per cent in 2005-07 to 9.2 per cent in 2015-16. In Karnataka and Andhra Pradesh, the post-harvest loss rate for grapes was 21.3

per cent in 2011 (IIHR, 2014). According to a CIPHET-ICAR (2015) study, the total loss of grapes at the all-India level rose from 5 per cent in 2005-06 to 8.6 per cent in 2015-16. A similar trend was observed for bananas, with losses increasing from 6.6 per cent to 7.8 per cent during the same period. A more recent study by NABCONS (2022) found that the total loss rates for grapes, bananas, and mangoes were 7.2 per cent, 7.6 per cent, and 8.5 per cent, respectively.

On the demand side, higher per capita income has driven increased consumption of high-value, income-elastic commodities, including fruits (Rao et al., 2006). Economic growth and urbanisation have boosted global trade in fruits and vegetables. However, import tariffs vary across countries, and high import barriers can lead to inflation in domestic markets (Aksoy and Beghin, 2004). Conversely,

**Figure 7.24**

*Production Cluster of Grapes and Inter-State Trade to Major Consumption Centres*




*Source*: NHB, 2021.

rising global demand for Indian fruits puts price pressure on the domestic market during years of limited availability.

## 7.5 Value Chain Analysis of Fruits

The institutional arrangements of fruit value chains differ from those for cereals and vegetables (e.g., potato and onion) due to higher perishability and marketing risks. Among fruits, post-harvest loss is highest for mangoes (9.2 per cent), followed by grapes (8.6 per cent) and bananas (7.8 per cent). To strengthen the fruit sector and increase its global competitiveness, the MoA&FW, GoI initiated a Cluster Development Program (CDP), implemented by NHB, to identify regional centres of fruit crops. This programme aims to promote holistic value-chain development, from cultivation practices to technological advancements in supply chains, fostering a climate-resilient and economically viable horticulture sector. Of the 12 clusters, two are dedicated to bananas (Theni, Tamil Nadu and Anantpur, Andhra Pradesh); three for mangoes (Mahbubnagar in Telangana, Lucknow in Uttar Pradesh, and Kutch in Gujarat); and one for grapes (Nashik, Maharashtra).

This section analyses the value chains of these three commodities in terms of global competitiveness, farmers' share of the consumer rupee, and sustainability. The purpose of value chain analysis (VCA) is to map all economic players in a commodity's market who impact the final price (FAO, 2014). This study uses secondary sources and primary data from field surveys conducted using non-parametric purposive sampling, including personal interviews with key informants, focus group discussions, and telephone surveys to gather market intelligence. Data sources are detailed in Annex-Table 4. The study period is April 2012-December 2022 for grapes, July 2012-June 2022 for bananas, and January 2011-August 2022 for mangoes, depending on crop seasonality and data availability.

### *7.5.1 Grapes Value Chain*

Grapes, both fresh and processed, are among the most traded fruits globally. As a fresh fruit, grapes are delicate and vulnerable to harvest and post-harvest losses, particularly due to shattering and discolouration in retail chains (Nanda et al., 2012; Jha et al., 2015). Grape production is concentrated in Maharashtra and Karnataka, with domestic demand primarily met by the Nashik region of Maharashtra, which has a significant share of total fresh grape production (Figure 7.24)[73]. Therefore, a forward and backward linkage analysis of the value chain in this region is conducted to assess its efficiency and impact on price dynamics.

The black soil with low pH and hot tropical climate in this region favours grape growth. The average landholding for grapes in Maharashtra is 1-2 acres (SAS, NSO, 2019), meaning most growers are small producers. Technological advancements in distribution remain limited in developing countries, including India. To assess the value chain's efficiency, focused group discussions (FGDs) were held with domestic traders, grower-exporters, farmers, and merchant traders in Maharashtra, alongside detailed interviews with farmers, domestic traders, exporters, cold storage owners, APMCs (Vashi, Pimpalgaon APMC, private fruit mandi), transport associations for perishable goods, raisin processing unit owners, and farmer producer companies. The following analysis of value chain components is based on field survey data and secondary sources. The grape value chain in the Nashik region is mapped in Figure 7.25.

In the backward linkage of the value chain, farmers typically purchase rootstock from nurseries and plant it after setting up a trellis for growth. Grape is a perennial crop, and after planting, it takes two years to bud for the first time. The plant's lifespan is 7-8 years. Pruning[74] of grape plants occurs in September-October, and

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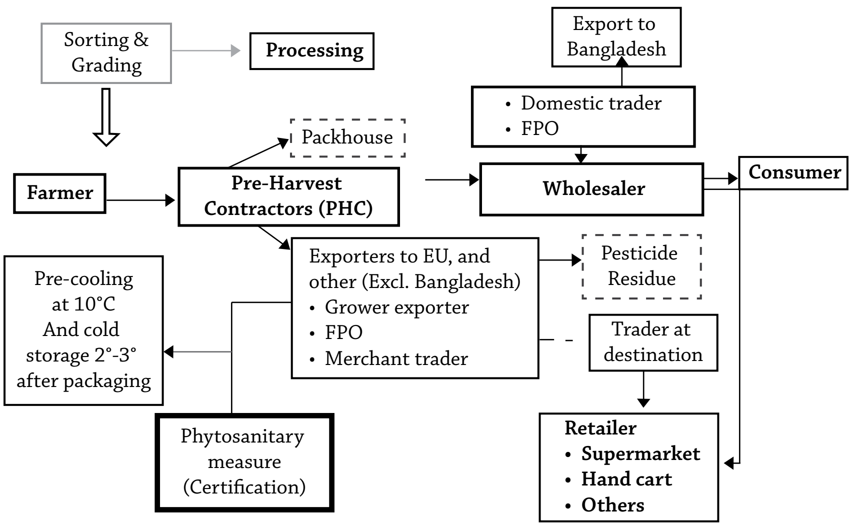
73. For fresh grapes, the Nashik cluster caters to major domestic demand, accounting for 80 per cent of production. The region also falls under the agri-export zone for grapes, with geographical indicators (GI). Nashik district is at the heart of grape production in India, along with Sangli and Solapur districts of Maharashtra. Since the 1990s, after the expansion of drip irrigation, horticulture production has expanded in water-stressed districts as well. Grape farmers could recover the cost of installing drip irrigation within a year of harvest, even without considering subsidies (A. Narayanamoorthy, 1997). Fruit production in the region has been boosted by the expansion of the horticulture cluster program since 2012 and the promotion of the area as an agri-export zone.

74. Pruning involves cutting vegetation to promote specific types of growth. The first pruning in Maharashtra takes place in October, and the second pruning occurs after harvest. In Punjab and Haryana, single pruning occurs in January-February.

within 90-120 days, the grapes are ready for harvest. The timing of pruning is critical; farmers ideally aim for early October, as prices remain high at the beginning of the harvest season (January). Due to rainfall, pruning was delayed by a month for three consecutive years (2018-2021), resulting in limited arrivals in January. Early grape harvest occurs in November in Satana taluka, Nashik district. Although the quantity is small, it meets festive demand alongside imported grapes. Late monsoon rainfall affects grape harvests during this period. Farmer interviews highlighted that climate change-related weather anomalies increasingly impact the grape production cycle. Low temperatures, reduced daylight, hailstorms, and unseasonal rain in January affect the quality and quantity of grape bunches, impacting market arrivals.

**Figure 7.25**

*Grapes Value Chain*




*Source:* Field survey by authors in Nashik belt, Maharashtra, January 2023.

Grape cultivation is capital- and labour-intensive. Due to high capital costs, farmers require significant margins over variable costs. Establishing a trellis structure and preparing the field costs around Rs. 1.5 lakh per acre. Once built, the structure lasts 7-8 years, so farmers' acreage decisions reflect a seven-year lag, based on average returns over this period.

In terms of variable costs (Cost $A_2$)[75], pesticides (approximately 33 per cent), labour (30 per cent), and fertilisers (20 per cent) constitute the largest shares of total grape cultivation costs. Farmers must frequently spray pesticides from the pruning period through harvest to protect crops from various diseases. Plant growth hormones and pesticides (such as Gibberellic Acid, Uracil Solvent, Grape booster, Actosol, HCN for bud break, Sangh Prophyto) are intensively used in grape cultivation. Rising agrochemical prices drive up cultivation costs, impacting grape prices. Labour is another major cost, requiring around 220 labour days for tasks like pruning, harvesting, and pesticide spraying, accounting for 30 per cent of total cultivation costs (Table 7.2).

**Table 7.2**

*Structure of Cost of Cultivation of Grapes*

| *Capital cost* | *Cost per acre (In Rupees)* | *Variable cost* | *Cost per acre (In Rupees)* |
|---|---|---|---|
| Plantation | 1,50,407 | Foundation pruning labour after harvest (June-July) | 3,500 |
| Land preparation | 38,135 | Fruit pruning labour | 20,500 |
| Rotavator and cultivation | 4,237 | Harvesting labour | 40,500 |
| Steel structure | 1,51,483 | Total labour | 64,500 |
| Drip | 44,642 | Crop testing | 13,630 |
| Construction | 3,12,500 | Certification (GAP) | 5,000 |
| Bed preparation | 2,542 | Chemicals | 48,305 |
| Grafted plant | 10,000 | Growth hormones | 22,723 |
| Plantation labour | 34,500 | Fertiliser | 42,857 |
| Nutrition | 9,523 | Diesel | 10,516 |
| Crop protection | 4,237 | Irrigation | 8,050 |
| Organic fertilizer | 30,000 | - | - |
| Mulching | 18,000 | - | - |
| **Total capital cost** | **8,10,206** | **Paid-out cost** | **2,15,261** |

*Source:* Collated by authors from primary surveys, January 2023.

75. Cost A2 comprises all out-of-pocket expenses incurred by farmers for buying chemicals, fertilizers, seeds, and hired labor involved in crop production.

Table 7.3 presents the productivity and returns from grape farming in the Nashik belt of Maharashtra.

**Table 7.3**

*Productivity and Returns from Farming*

| | |
|---|---|
| Yield (tonnes per acre) | 12-14 |
| Total capital cost (Rs. Lakh) | 8.1 |
| Paid-out cost in (Rs. Lakh) | 2.2 (Rs. 17.80 per kg for Thompson seedless) |
| Farmers' selling price | Rs. 30 per kg (Margin Rs. 12.20 per kg) |

*Note:* Selling price is mid-January rate in the Nashik belt; the selling price drops from the end of January due to fresh harvest arrivals.

*Source:* Collated by authors from primary surveys, January 2023.

The forward linkages in the grape value chain are complex. The main stakeholders include farmers, pre-harvest contractors (PHCs), wholesalers, grower-exporters, merchant traders, and retailers. Various institutions, including the Maharashtra State Agriculture Marketing Board, Mahagrapes (a grape cooperative), Maharashtra Draksha Bagaytdar Samiti (MRDBS), the Grape Grower Association, and APEDA, play roles in grape marketing in the Nashik belt. Since 1958, producer cooperatives like MRDBS and, later, Mahagrapes (established in 1991) have helped small farmers adopt improved cropping practices for export-oriented agriculture.

According to our survey of stakeholders, there are primarily four marketing channels in the region. Farmers sell either directly to PHCs, traders, farmer producer companies (FPCs), or exporters. Value addition after selling is highest at the trader stage, followed by the retailer, as traders bear sorting, packing, and branding costs. Amid the COVID-19 pandemic, PHC value addition escalated while farmers received low prices for their produce, leading to severe losses in this major grape production belt (Ravi Kumar & Babu, 2021).

For grapes, farmers do not bring their produce to market. PHCs pre-book the orchards, assessing quality days before harvest, and the price is fixed by both parties. After sorting and grading at the farm, traders pack and attach brand labels to the harvest. Grape prices vary based on colour variety, quality, and market arrivals on a given day. For export, fresh grapes undergo packaging[76] and quality checks. After packaging, grapes are stored at 2-3°C following pre-cooling at 10°C. Storage requires 95 per cent relative humidity, with corrugated boxes for air circulation. Pesticide residue is measured at the packhouse by Agmarknet, and certification is attached for export-quality grapes. Domestic trade lacks such storage facilities, so losses are higher due to berry dehydration. Currently, merchant traders purchase from farmers by pre-booking orchards and sell to other countries. The export value chain for Indian grapes to the EU (a major importer) is outlined in Table 7.4.

**Table 7.4**

*Value Chain Markup in Grape Exports to the European Union*

| *Cost* | | *Rs. Per kg* |
|---|---|---|
| 1. | Farmgate price | 45.00 |
| 2. | Packaging | 25.32 |
| 3. | Labour | 8.00 |
| | a. Laboratory expenses | 2.12 |
| | b. AGMARK Certification | 0.11 |
| | c. Phytosanitary measures | 0.08 |
| 4. | Total laboratory expenses (a+b+c) | 2.31 |
| 5. | Excise/custom | 0.12 |
| 6. | Insurance | 0.20 |
| 7. | Transportation from field to packhouse | 1.75 |
| 8. | Transportation from packhouse to JNPT | 4.40 |
| **Freight charge** (average sea freight US$ 7,500; 2022 export season) | | **51.40** |
| **Total cost of grapes to reach Netherlands's port** | | **138.50** |

*Source:* Authors' calculations based on primary survey-based information from stakeholders in Maharashtra, January 2023.

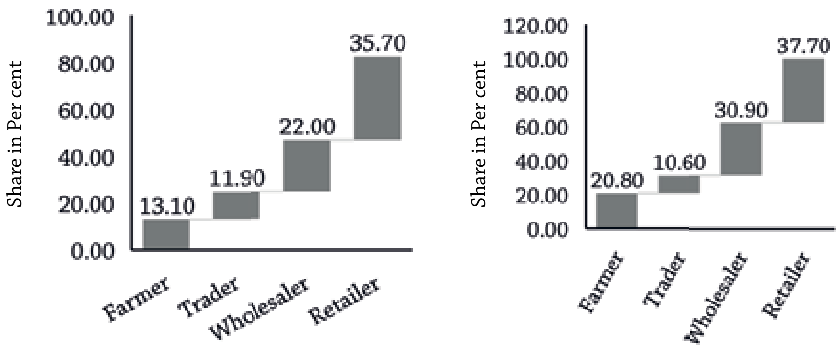
We now turn to estimates farmers' share in the consumer rupee based on primary survey of *grapes* VC. Supply-chain improvements might reduce margins from farmers to retailers and lower the inflation pressures. For perishable commodities, improved

76. Packaging is an important aspect of commodity production, and the cost of packaging directly impacts the cost of the final product. The price of packaging increased from Rs. 17 per kg in January 2021 to Rs. 25 per kg in January 2023.

infrastructure facilities and high density of communication networks increase farmers' access to the market (Negi et al., 2018). The gap between wholesale and retail prices for TE 2019 indicates that the margin hovers around 58 per cent. Even though the export VC of grapes is efficient, the realisation of price largely depends on the shipment cost of consignment, grape varieties and export subsidies. Our survey results indicate that farmers' share in consumer rupee is higher in exports VC. Farmers reported that only 50-60 per cent of the total grape production gets sorted for exports by quality check due to incidences of berry cracking or size parameters. *Sharad seedless* variety grapes (Rs. 55 per kg in January 2023) were sold in the EU retail market at Rs. 256 per kg (calculated by authors based on information provided by an exporting unit and FPO in Nashik belt of Maharashtra. Export value chain is complex and lengthy; farmers get a lower share in terms of mark-up (21 per cent), compared to around 35 per cent in domestic VC, but the realised price by farmers is higher in exports VC in comparison to domestic VC of grapes[77] Figure 7.26).

**Figure 7.26**

*Share of Mark-ups for Fresh Grapes (Thompson Seedless) in Azadpur Mandi, Delhi (LHS) and Fresh Grapes (Sharad Seedless) in EU (RHS)*




*Note:* Weekly retail price data for grapes in the EU market is provided by an exporting unit in Nashik. The share of farmers in the export value chain (VC) is also confirmed by a grape cooperative in Maharashtra.

*Source:* Collated by authors from a primary survey of stakeholders in Maharashtra, January 2023.

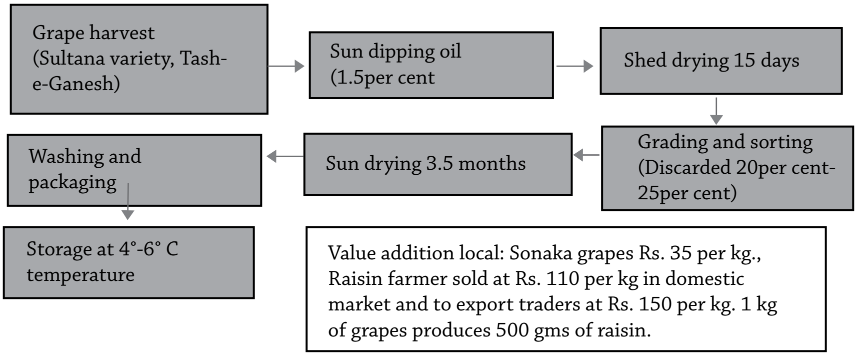
77. The mean selling rate of table grapes was Rs. 26.83 in 2019 at the farm gate (SAS, 2018-19) in Maharashtra, while the average retail price of the same was Rs. 75, indicating farmers' share of 35 per cent in the consumer rupee, which aligns with our findings from the field survey.

## Raisin Processing

While 77 per cent of grapes are consumed as fresh fruit, nearly 20 per cent are used for raisin production. India produced 0.69 MMT of raisins in 2021-22. The share of raisin processing varies, from 30 per cent in Karnataka to 15-18 per cent in Maharashtra. Raisin processing is higher in Karnataka due to its distance from ports, making fresh exports challenging (Market Intelligence, 2023). Grape processing is more common in March, as low humidity and high temperatures (35°-40°C) expedite the drying process, allowing shed drying in 10-15 days and achieving high Total Suspended Solids (TSS) content (above 22° Brix value). After drying, raisins reach a 25° Brix value (Figure 7.27). Although various grape varieties are used for raisin processing, *Thompson* clone cultivars—*Super Sonaka, Tas-e-Ganesh*—are primarily used for their high sugar content and 14-16 mm size.

**Figure 7.27**

*Raisin Processing Value Chain*



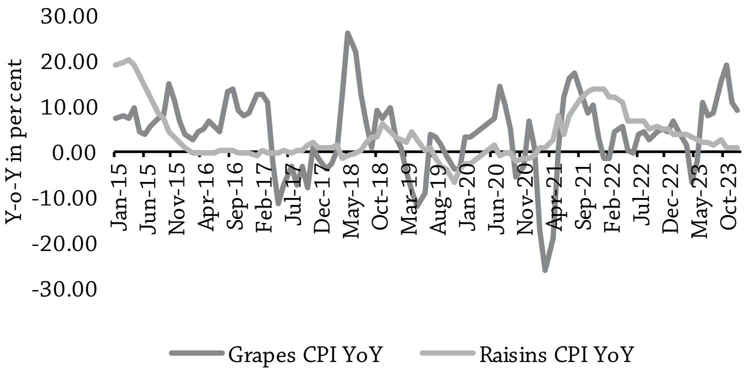

*Source*: Collated by authors from a primary survey in Maharashtra.

Raisin storage presents a significant challenge, especially as Karnataka lacks large-scale storage facilities. Raisins are hygroscopic, making them susceptible to fermentation and hardening. Value addition for raisins is 1.5 times that of 1 kg of grape production. During the pandemic, many grape growers began producing raisins due to lockdowns and a price crash for fresh grapes. Although CPI inflation (Y-o-Y) for grapes is volatile and turned negative in 2020, price volatility is lower for raisins due to their longer shelf life (Figure

7.28). Therefore, expanding the processing sector may alleviate inflationary pressures on the commodity.

**Figure 7.28**

*CPI Inflation in Raisins and Grapes*




*Source:* NSO, MoSPI.

Regarding the scalability of the value chain, expanding grape cultivation to different agro-climatic zones or introducing late-variety cultivars may reduce price pressures during the lean season and decrease reliance on imports. While the hot-tropical zone (Maharashtra's Nashik-Satana-Sangli belt) is extensively used for grape cultivation, production could expand into the sub-tropical zone (Punjab, Haryana, Uttar Pradesh) and mild tropical regions (Karnataka, Andhra Pradesh) by shifting cropping patterns towards high-value crops (APEDA, 2021). The area under grape cultivation in Maharashtra has marginally declined due to the high cost of capital investment and a shift towards tomato and onion production (Market Intelligence, 2023).

### *7.5.2 Banana Value Chain*

Banana is a tropical crop that requires a moderate temperature (temperatures above 120°C can damage the crop), adequate monsoon rainfall (650-750 mm), and well-aerated soil with good drainage, moisture, and pH balance for optimal growth. In India, bananas are grown year-round, primarily in the Southern and Western regions, though other states produce bananas for local consumption (Table 7.5). The top six banana-producing states account for about 75 per cent of total production.

**Table 7.5**

*State-Wise Production Centres for Banana*

| *State* | *Production Belt* |
|---|---|
| Andhra Pradesh | East Godavari, West Godavari, Kurnool, Cuddapah |
| Maharashtra | Jalgaon, Ahmednagar, Buldhana, Pune, Wardha, Dhule, Nanded, Parbani, Nandurbar, Satara, Sangli, Osmanabad, Buldhana, Akola, Yeothmal, Amravati, Thane, Kulara, Alibag |
| Tamil Nadu | Thoothukudi, Tiruchirapalli, Coimbatore, Tirunelveli, Karur, Erode, Kanniyakumari |
| Gujarat | Surat, Vadodara, Anand, Kheda, Junagadh, Narmada, Bharuch |
| Karnataka | Bangalore, Chitradurga, Shioroga, Hassan, Chikkamagaluru |
| Uttar Pradesh | Lakhimpur Kheri, Kushinagar, Maharajganj, Allahabad, Kaushambi |
| Madhya Pradesh | Khandwa, Badwani, Khargaon, Dhar |

*Source:* APEDA

A forward and backward linkage analysis of the banana value chain (VC) has been conducted using primary and secondary sources of information. Bananas are classified as both dessert and culinary types; they are consumed as starchy fruit and used in their unripe form as vegetables. While a large variety of bananas is grown throughout the country, the commercially important variety is the Dwarf Cavendish[78].

The traditional method of banana cultivation faces challenges such as susceptibility to wind damage and vulnerability to pests and diseases. Additionally, traditional varieties do not allow for intercropping, limiting farmers' opportunities for diversified income. Variations in the age of planting material can result in uneven growth, leading to a prolonged harvest period. This extended harvest timeframe increases cultivation and selling costs, as produce cannot

78. A new variety called Grand Nine (G-9), imported from Israel, is gaining acceptance among farmers due to its tolerance to abiotic stresses and high yield.

be sold in bulk. To mitigate these costs, tissue culture cultivation[79] is being increasingly adopted by farmers in India. In-vitro clonal propagation offers numerous benefits, including disease-free seedlings, uniform plant growth, better yield, and earlier maturity. It also facilitates intercropping, with crops such as vegetables (in Tamil Nadu), cucumber and amaranth (in Karnataka), and beans, maize, and sweet potato (in Kerala) commonly grown alongside bananas.

The primary variable cost components (paid-out cost and depreciation on working capital) include machine labour, human labour, costs of suckers, manures, fertilisers, plant protection, and irrigation (Rede et al., 2021). Significant fixed costs incurred during banana cultivation comprise depreciation of equipment and machinery, land revenue, rent, fencing, and interest on capital (Kumari et al., 2021). The average variable cost of banana cultivation is Rs. 1.3 lakh per hectare (Rs. 3.48 per kg) (Table 7.6). The major components of variable costs are suckers, fertilisers, and labour.

**Table 7.6**

*Break-up of Cost of Cultivation for Banana*

| *Category* | *Cost of Cultivation (Rs. Per hectare)* |
|---|---|
| Labour | 28,125 |
| Cost of Sucker | 27,000 |
| Machinery | 10,000 |
| Manures | 15,000 |
| Fertilisers | 24,000 |
| Plant Protection Cost | 8,000 |
| Irrigation Cost | 10,700 |
| Stakes & Staking | 6,000 |
| **Total Variable Cost** | **1,28,825** |

*Source:* Focused group discussions conducted by authors in January 2023.

79. Tissue culture, the proliferation of a plant using a plant part, single cell, or group of cells in a test tube under highly controlled lab conditions, is a method used to propagate plants (NABARD, 2020-21).

### Domestic Banana Value Chain

For our analysis of farmers' share in the consumer rupee, we considered Jalgaon as the production centre and Delhi as the consumption centre for bananas. Maharashtra is the major supplier of bananas to the northern region throughout the year. For farmers' selling prices, the average wholesale prices from Jalgaon were used from Agmarknet, while retail prices in Delhi were obtained from NHB for the months of April-July[80]. We visited Jalgaon district, known as the banana capital of India, and participated in a focused group discussion (FGD) with the Cooperative Jalgaon Fruits Sale Society *(Pikheda, Dapore)*, farmers, traders, two APMCs (Vashi, Pimpalgaon *fruit mandi*), the transport association for perishable commodities, and one FPO (Sahyadri) to understand the banana VC.

**Figure 7.29**

*Share of Mark-ups in the Banana VC (Jalgaon to Delhi)*


*Note:* Farmers' share in the consumer rupee increases to 35 per cent after the peak harvest period, while it ranges between 20 per cent and 35 per cent during other times.

*Source:* Authors' calculations using data from Agmarknet, NHB, and field visits, January 2023.

In the banana VC, the farmers' share in the consumer rupee is estimated to be 30.8 per cent (Figure 7.29). The mark-ups for each

80. The analysis is conducted for an average of three years, i.e., 2016-17, 2017-18, and 2018-19. Information on the transitional costs was collected during our field visits.

intermediary include their margin plus costs incurred at each stage. The major cost for traders is transportation of bananas from Jalgaon to Delhi. Similarly, wholesalers bear the costs of labour, ripening, and transportation from the *mandi*. Retailers assume the risk of loss due to the perishable nature of the crop (Gulati et al., 2022).

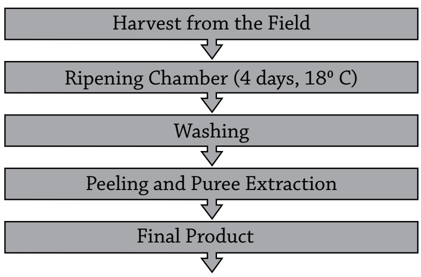
### *Banana Processing Value Chain*

Given the restricted shelf life of fresh bananas, processing them into diverse value-added products is essential to extend their availability and stabilise prices during glut seasons. A portion of fresh bananas is processed into banana puree, concentrate, powder, and chips. Puree is prepared by crushing the banana pulp, while concentrate is made by removing water from the puree. Banana powder is commonly used in baby food, creating additional demand in the baby food industry. Approximately 10 per cent of fresh bananas go into processing (MoFPI Report, 2021). The steps involved in processing bananas into puree and chips are illustrated in Figures 7.30 and 7.31. Other value-added products include banana flour, banana sauce, and banana drinks.

With increasing urbanisation and globalisation, the demand for banana chips in international markets is likely to rise further, which will impact the food processing sector as a whole. Emphasising banana chips as a product could secure a significant share in the food market, offering substantial rural employment opportunities. Maharashtra has small-scale banana chip processing units, but

**Figure 7.30**

*Banana Puree Processing Flow-Chart*




*Source:* MoFPI.

**Figure 7.31**

*Banana Chips Processing Flow-Chart*


*Source:* MoFPI.

without quality standardisation and branding, capturing export markets remains challenging (Gulati et al., 2022). Our survey also revealed that processing units lack vertical integration within the value chain (VC).

Banana is a water-intensive crop, but drip irrigation can improve its cultivation efficiency. Drip irrigation not only conserves 58-60 per cent of water but also increases productivity by 15-30 per cent. Using this irrigation system, fertilisers can be applied efficiently through fertigation. Maharashtra has adopted drip and sprinkler irrigation for banana cultivation, which could be implemented in other states to promote sustainable agriculture and enhance farmers' income.

The banana crop is vulnerable to many diseases, such as *Panama Wilt, Sigatoka, Anthracnose, Mosaic virus,* Banana *Streak Virus,* and Bunchy Top Virus, which compel farmers to use large quantities of insecticides and pesticides. This not only increases their cost burden but also has serious environmental implications. Effective extension services are needed to train farmers in timely pesticide and fertiliser application, while increased R&D expenditure should focus on developing environmentally friendly chemicals.

Bananas produce significant waste, which can be converted into high-value products. On average, 70-80 MT of waste per hectare is generated from stem removal. If banana pseudo-stems—the central core, fibre, and waste—are processed into value-added products, farmers can gain additional income in a sustainable way. Various food products, such as candies, pickles, and soft drinks, can be made from the core. Banana fibre can be used to produce currency paper, fabric, and handicrafts. Bio-fertilisers and vermicompost can be created from other waste parts. As bananas are cultivated year-round, a continuous supply of raw materials supports the production of a wide range of products. A holistic approach could help increase farmers' share in the consumer rupee.

### *7.5.3 Mango Value Chain*

#### Domestic Value Chain for Mango

As with other agricultural commodities, mango farmers do not sell their produce directly to the market. To supply fresh mangoes to the domestic market, the first interaction for mango farmers is typically with Pre-Harvest Contractors (PHCs), who act as aggregators in the crop market (Figure 7.32).

**Table 7.7**

*Farmers' Share in Consumer Rupee for Domestic VC of Mango*

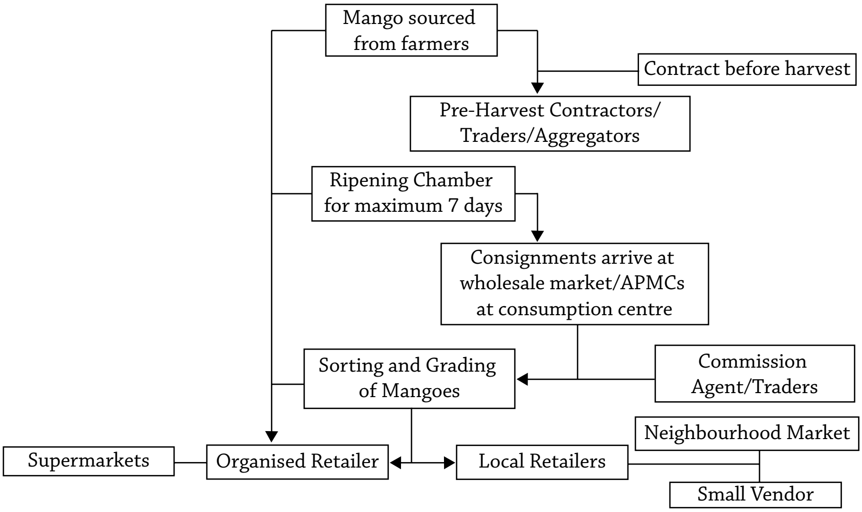
| *Particulars* | *Prices (Rs./kg)* | *Share (in per cent)* |
|---|---|---|
| Farmgate (Farmer) | 62 – 67 | 42 – 43 |
| Pre-harvest contractor/aggregator/ traders' margins | 15 – 15.5 | 10 |
| Transportation to ripening chambers | 7.5 | 5 |
| Labour costs | 3 – 3.1 | 2 |
| Wholesalers & commission agents | 10 – 11 | 7 |
| Value Loss (weight & grading loss, sorting & packaging) | 12 | 8 |
| Retailer margin | 40 – 42 | 27 |
| Retail price* | 149 – 155 | |

*Note:* * Mark-ups are calculated on the basis of retail prices prevailing as on April 28, 2021.

*Source:* Calculations based on interactions with farmers, traders, retailers, April 2021.

**Figure 7.32**

*Domestic Mango Value Chain*




*Source:* Market intelligence from interactions with farmers in Uttar Pradesh, Maharashtra, and Gujarat.

PHCs enter into contracts with farmers based on mango tree flowering prior to the harvest season, setting prices, purchase quantities in tonnage, and offering support to farmers in orchard maintenance. PHCs work with multiple farmers to achieve economies of scale by aggregating produce. Many orchard owners and small-scale mango growers depend on PHCs to market their produce. After harvesting, PHCs place mangoes in ripening chambers for a maximum of seven days at room temperature. Once ripened, mangoes are sold directly to the market without further storage, as storage impacts pulp quality. Commission agents or traders at wholesale markets or APMCs (consumption points) buy mango consignments from PHCs. Commission agents handle sorting and grading of mangoes, which are then supplied to retailers for sale to consumers. While small vendors and neighbourhood markets are the primary outlets for mango sales, organised retailers and supermarkets also source mangoes from wholesale or APMC markets.

To gain a deeper understanding of the VC, a case study was conducted in Malihabad, Lucknow, Uttar Pradesh, known as the mango capital of India and home to the popular Dusheri variety. Based on interactions with farmers, traders, commission agents, and retailers, markups in the fresh mango VC were calculated from Malihabad to Azadpur in New Delhi.

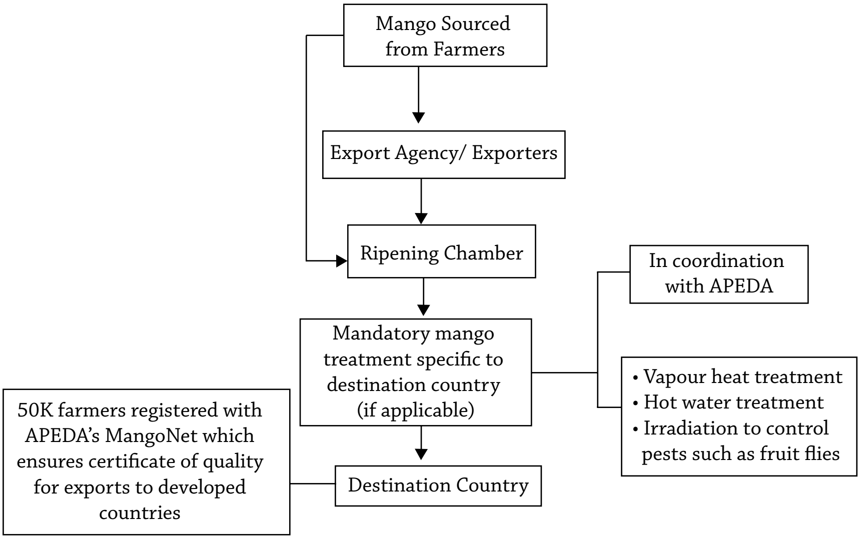
The VC analysis of mango reveals that farmers receive about Rs. 62-67 per kg, while the retail price is Rs. 149-155 per kg (Table 7.7). In other words, farmers receive around 42-43 per cent of the consumer rupee, the highest share across the fruit VCs. Although this share is significant, it is worth noting that the domestic VC incurs minimal costs and losses before mangoes reach wholesale markets. Retailers, who receive the second-highest share in the consumer rupee (27 per cent), occasionally face losses due to spoilage of unsold stock.

### Export Value Chain for Mango

Exporters or exporting agencies purchase mangoes at prevailing market rates (Figure 7.33). Once purchased, these agencies bear all costs until the product reaches its destination country. They transport mangoes from the farm gate to ripening chambers, after which the fruit undergoes various treatments as per the import regulations of destination countries. These treatments include vapour heat treatment, hot water treatment, and irradiation to control pests, such as fruit flies. All exports to the EU, South Korea, Japan, and the US must undergo these processes, coordinated by APEDA. Over 50,000 Indian farmers who produce mangoes for export are registered through Hortinet (MangoNet), an APEDA initiative aimed at ensuring traceability and improving VC efficiency.

**Figure 7.33**

*Mango Value Chain for Exports*



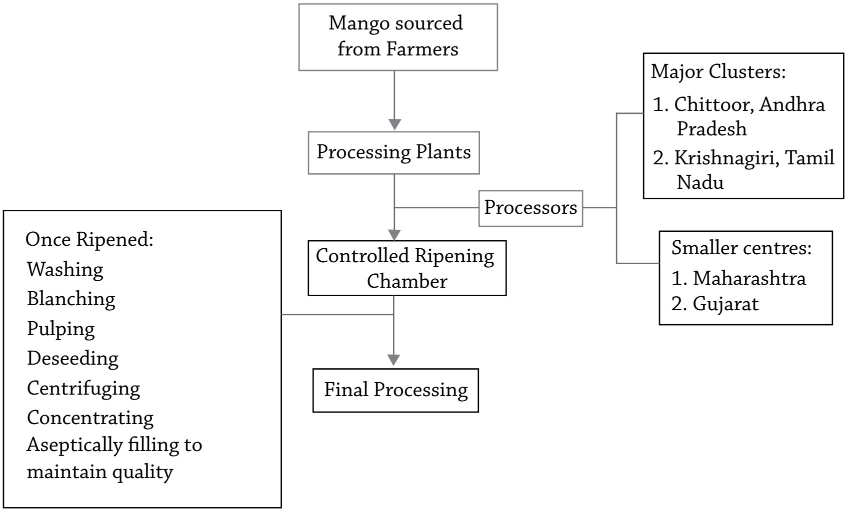

*Source:* Market survey.

## Mango Processing

India commercially grows about 30 varieties of mangoes, but only three varieties—Totapuri, Alphonso, and Kesar—are primarily used in processing. Mango processing units are concentrated in two main clusters: Chittoor district in Andhra Pradesh and Krishnagiri district in Tamil Nadu, with smaller clusters across Maharashtra and Gujarat. This section focuses on mangoes sourced and processed in the Chittoor district (Figure 7.34).

**Figure 7.34**

*Value Chain for Processed Mango*




*Source:* Market survey.

According to key mango processors, mature mangoes are harvested and transported to processing plants, where they are sorted and graded. Following this, they are placed in controlled ripening chambers. Fully ripened mangoes are then washed, blanched, pulped, deseeded, centrifuged, concentrated, and aseptically filled to maintain quality. Mango pulp has a shelf life of 24 months when stored below -18°C. Aggregators, vendors, or traders in the mango pulp value chain act as commission agents between farmers and processing plants, ensuring an uninterrupted supply of fruit during the limited harvesting window from April to August.

To analyse the processing VC, the Totapuri variety of mango from Chittoor, Andhra Pradesh, was considered. Retail prices in this analysis are based on the retail price of mango pulp, adjusted using the ratio 1:0.5 to make them comparable with farm gate prices. Table 7.8 maps the margins at each level of the VC from Chittoor district in Andhra Pradesh to New Delhi.

**Table 7.8**

*Mark-ups in the Value Chain of Mango Processing*

| *Particulars* | *Prices (Rs. /kg)* | *Share (per cent)* |
|---|---|---|
| Farmer/Farmgate price of raw mango | 14 – 16* | 46 -47 |
| Aggregators/vendors/commission agents | 1.2 – 1.4 | 4 |
| Transportation to ripening chambers by processors | 2 – 3 | 6.6 – 8.5 |
| Labour costs | 2 – 3 | 6.6 – 8.5 |
| Ripening by processor/Value loss | 0.5 – 1 | 1.66 – 2.85 |
| Processing/extraction of mango pulp/packaging | 3 – 4 | 10 – 11 |
| Processor Margin | 6.6 – 7.3 | 19 – 24 |
| Retail Price (Rs. /0.5 kg) | 30 – 35 | |

*Note:* Farmgate prices are from April 2021 for Totapuri mango in Chittoor.

*Source:* Based on interactions with mango processors in Chittoor district, Andhra Pradesh.

Farmers receive about 46-47 per cent of the retail price of mango pulp. Since mango pulp processing is regionally concentrated, the value chain has evolved around these clusters. Continued development of these clusters and expansion of processing units could improve farmers' share of the consumer rupee across regions.

Mapping the three VCs and estimating margins at the aggregator, wholesaler, and retailer levels highlights the key participants at various stages of the chain and explains how distribution margins are allocated among them. This insight helps identify gaps for improvements in VC efficiency, potentially reducing price pressures in retail markets.

## 7.6 Methodological Framework and Estimation

To provide a comprehensive picture of monthly demand and supply for forecasting price trends, we have constructed separate monthly balance sheets for grapes, mangoes, and bananas. The commodity balance sheets use data from various sources. Drawing from official data, we compiled annual production and consumption figures, deriving monthly harvest and consumption patterns from primary sources. Our methodology includes multiple interactions with major stakeholders to ensure robust findings. The balance sheet aims to quantify demand-supply imbalances and assess their impact on prices. Other components, including loss, wastage, and institutional consumption, are based on large-scale surveys, secondary studies, and market intelligence.

### Components of the Monthly Balance Sheet

The following sections outline each balance sheet component along with the type and time period of the data used.

i. Time period of the balance sheet: The agricultural year (July-June) serves as the balance sheet year for all three crops. However, mango is a seasonal fruit with no availability during the off-season months. Mango CPI data is available from January 2011 to September 2018, but since 2019-20, monthly CPI data is available only from April to August. For the econometric analysis, a continuous monthly CPI series for mango has been constructed from January 2011 to August 2022 using regression adjustment to fill missing data. A simple OLS regression of the seasonal CPI series was applied to mandi wholesale prices, yielding a complete CPI series. For grapes, production is negligible from May to December, with imports and scattered domestic production meeting market demand. However, CPI data is available year-round, allowing for a full-year balance sheet for grapes. The banana balance sheet also spans all months of the study period.

ii. Data on harvest for arrival: Since fruits are perishable, monthly arrival data has been used to estimate the crop's monthly harvest pattern. None of the three crops can be stored for more than two weeks; hence, the balance sheets lack a stock component. This means that once the produce is harvested, it quickly appears in the market, reflecting monthly availability—the primary variable of interest.

### Availability

The availability variable in our balance sheet indicates the domestic market availability of each commodity for retail consumption in a given month, adjusted for imports, exports, losses, and industrial processing. The following equation provides an overview of how availability is formulated across all iterations of our balance sheets:

$$AV_{ti} = MP_{ti} + IMP_{ti} - EXP_{ti} - L_{ti} - PRO_{ti} \quad ...(1)$$

where availability in month t of year i is the sum of production in month t and year i ($MP_{ti}$) and imports ($IMP_{ti}$), minus its exports ($EXP_{ti}$), losses in the value chain ($L_{ti}$), and industrial processing or institutional consumption ($PRO_{ti}$). Each component is explained in detail below.

To estimate availability, annual production data from NHB for 2011-2022 has been collated. For fruits, commercialisation is high, as farmers typically sell their entire produce, with negligible storage for household consumption.

### *Monthly Production*

The monthly distribution of production is given by:

$$Y_{mi} = \delta_m * Y_i \quad ...(2)$$

where $Y_{mi}$ represents production in month m of year i, δ denotes the percentage of annual harvest in that month, and $Y_i$ is the annual production. We assume that the monthly mandi arrival pattern in a state for these fruits reflects the harvest pattern in that state, as the produce must be brought to market soon after harvest. A caveat is that mandi arrivals may not represent total production, as some produce is traded outside APMC mandis. However, given data limitations, we use a weighted mean of the last three years' arrivals in major producing states to infer harvest patterns.

For grapes, correlations between all-India *mandi* arrivals and retail prices over the past three years inform our arrival pattern, using data from market intelligence and Agmarknet. In the balance sheet, the monthly production pattern for fresh grapes in Maharashtra—which accounts for about 80 per cent of national output—has been used to estimate national production. Karnataka, the second-largest producer, primarily focuses on raisin processing rather than fresh grapes. Harvest pattern data from Maharashtra, sourced from the Grape Grower Association and Sahyadri FPO, has been used.

For mango, we use an all-India *mandi* arrival pattern to derive monthly harvests from annual production. Given the geographical distribution and overlap of mango varieties, a robustness check was conducted by distributing state-wise annual production monthly according to each state's mandi arrival pattern. Correlations of each state's monthly production with wholesale prices were also checked. For bananas, the weighted mean of mandi arrival patterns from Uttar Pradesh, Maharashtra, and Tamil Nadu was used to estimate monthly availability.

### Net Imports

Since our goal is to capture the dynamics of monthly supply and demand, we adjust for monthly imports and exports in our availability calculation. In TE 2021-22, exports of grapes, mangoes, and bananas accounted for 7 per cent, 0.7 per cent, and 0.8 per cent, respectively, of domestic production, while imports are negligible for all three fruits. For mango and banana, exports are not significant enough to impact domestic supply, whereas grape exports have a distinct impact during harvest months.

### Consumption

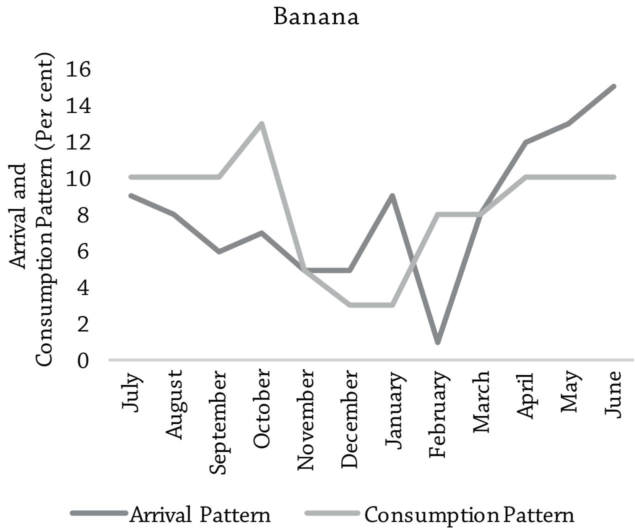
Literature indicates that changing dietary patterns have increased fruit consumption. We forecast consumption of the three fruits using the behavioural approach in the NITI Aayog 2018 Working Group Report. Consumption for rural and urban areas is calculated separately using Equation 3. The total demand is a weighted average of rural and urban per capita consumption, with weights based on population share. Projected annual consumption is distributed monthly based on market intelligence patterns for grapes and bananas, while the mandi arrival pattern determines monthly consumption for mangoes. Consumption for all three fruits[81] is

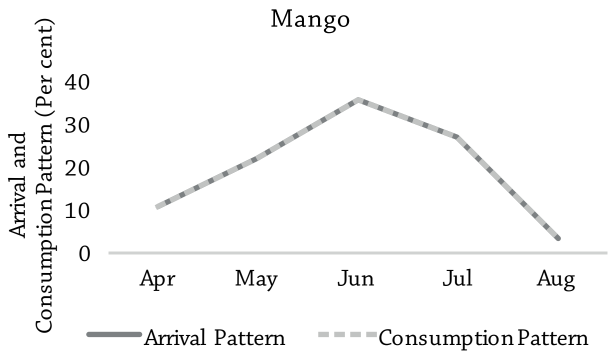
81. However, we noticed that the NSS 68th round consumption per capita, when calculated annually for the entire population, is substantially lower for mangoes, amounting to only 17 per cent of total annual production. Thus, in the balance sheet, we used a market intelligence figure for household consumption, which is 45 per cent of total mango production. For robustness, in the regression analysis, the availability component is solely used to explain the Mango CPI, as there is no consumption or availability during off-season months, making the availability-usage ratio undefined.

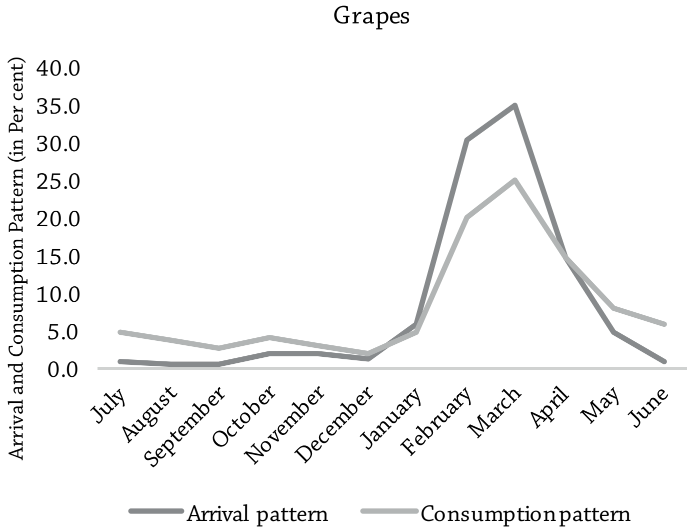
closely tied to their harvest patterns due to their perishable nature. The monthly arrival/harvest and consumption pattern for grapes, bananas, and mangoes is shown in Figure 7.35.

**Figure 7.35**

*Monthly Harvest/Arrival and Consumption Pattern*






*Source:* Balance-sheet derived from Agmarknet and market intelligence.

### Institutional Consumption and Processing

Consumption comprises both household and institutional use. For example, about 23 per cent of India's grape production is processed into wine and raisins. Similarly, 10 per cent of banana production is assumed to go to institutional consumption, including hotels, restaurants, and banana processing for pulp and puree. Around 10 per cent of mango production is processed into pulp and slices, for both domestic consumption and export. These percentages were determined through consultations with major market participants and processors. In our balance sheet, these percentages are deducted from overall monthly availability.

## 7.7 Variable of Interest

Our variable of interest is the availability and usage of each fruit in the domestic market on a monthly basis. For grapes and bananas, we have used availability, where usage includes household consumption, imports, and the quantity allocated to institutional consumption or industrial processing. For mangoes, however, due to the absence of arrivals and consumption data during the non-arrival months, the AVU ratio variable is unsuitable despite the imputation of CPI for time-series analysis. Instead, an availability deviation variable has been constructed, quantifying deviations from the average monthly availability (three-year moving average) from January 2011 to August 2022. This distribution is normalised over a year to allow for log transformation.

The correlation coefficient between the AVU ratio and CPI for grapes is (-) 0.29 for April 2012 to December 2022 [(-) 0.17 on a seasonally adjusted basis], indicating an inverse relationship as expected. This signifies that a supply shortage tends to exert upward pressure on prices, and vice versa.

Similarly, for bananas, the inverse relationship between CPI and AVU ratio yields a correlation coefficient of (-) 0.15 [(-) 0.13 on a seasonally adjusted basis], suggesting that a decrease in the AVU ratio is associated with price increases, reflecting supply scarcity's potential impact on price movement. Seasonality also plays a role, with prices tending to rise during the low production months of September-October, coinciding with the festive season.

Mango, a seasonal fruit, has arrivals from April to August, with seasonality strongly influencing price trends. On average, mango arrivals begin in March, increase through April and May, peak in June, and then decline by August. Each year, the harvested area provides the initial signal to the market, shaping expectations of arrivals and prices for the season. Another crucial determinant is yield, which is often anticipated based on tree flowering, although this is not always accurate. Weather events impacting produce quality also affect prices. Price variations due to mango varieties and their seasonal quality further complicate empirical analysis, as data on these quality variations is unavailable.

## 7.8 Model Specifications and Empirical Results

This chapter estimates the determinants of prices for the three selected fruits using an ARDL framework, which is appropriate for variables with different integration orders, I(0) or I(1), or a combination of both. First, the variables' stationarity was checked using the ADF test, which indicated that variables for our regression analysis were integrated at different orders [I(0) and I(1)] for all three commodities (grapes, bananas, and mangoes). Accordingly, the ARDL cointegration technique was applied.

In the ARDL models for grapes, bananas, and mangoes, the dependent variable is the seasonally adjusted CPI, with the monthly availability-to-usage (AVU) ratio as an explanatory variable. The month-wise AVU ratio was derived from the balance sheet, as detailed previously. The model hypothesises that the AVU ratio inversely impacts price—higher availability relative to usage lowers the commodity's price, and vice versa. Other exogenous variables were included based on the nature of each commodity. Details of the variables used in the ARDL and their data sources are provided in Annex Table A4. Given the inherent seasonality in monthly CPI and AVU ratio data, seasonally adjusted data were used for modelling and price prediction.

## 7.9 Estimations and Results of the Drivers of Grapes, Banana, and Mango Prices

### *Estimation for Grapes*

The ADF tests for stationarity indicate that the CPI for grapes and agro-chemical prices are stationary in first differences, while the AVU ratio is stationary at level (Table 7.9).

**Table 7.9**

*ADF Unit Root Test for Grapes*

| *Variable* | *ADF (p-value)* |
|---|---|
| Log CPI Grapes | -2.41 |
| Log AVU ratio | -2.82* |
| Log Agro-Chemical Price | -1.12 |
| ΔLog CPI Grapes | -10.05*** |
| Δ Log Agro-Chemical Prices | -9.35*** |

*Notes:* The Dickey-Fuller test statistic is reported. The critical values are the finite sample values suggested by MacKinnon (1991). Significance levels are indicated as *** p<0.01, ** p<0.05, * p<0.1.

*Source:* Authors' estimation.

To analyse the factors influencing grape prices, the sample period spans April 2012 to December 2022. The dependent variable is the seasonally adjusted log of CPI for grapes (Log CPI Grapes). The explanatory variables are the log of AVU ratio and input costs represented by the log of agro-chemical prices, based on WPI. Additionally, positive and negative residual dummies were included to control for supply imbalances at specific time point as exogenous variables. The Pesaran, Shin, and Smith (2001) Bounds test confirms a long-run relationship between CPI grapes, the AVU ratio, and agro-chemical prices (Table 7.10).

**Table 7.10**

*Bounds Test for Cointegration for Grapes*

| *F-statistic* | *t-statistic* |
|---|---|
| 6.859*** | -4.51*** |

**Notes:* ***, *, * denote significance at the 1 per cent, 5 per cent, and 10 per cent levels, respectively. The F-statistic tests for joint significance of the coefficients of the lagged levels in the ARDL, while the t-statistic tests for the significance of the lagged dependent variable's coefficient. All test statistics are significant at the 1 per cent level.

*Source:* Authors' estimation.

Table 7.11 presents the long-run coefficients from the ARDL specification and the short-run dynamics for grapes. The results show a negative long-run relationship between CPI grapes and the AVU ratio, where a 1 per cent increase in the AVU ratio reduces grape prices by approximately 0.44 per cent. A 1 per cent increase in agro-chemical prices raises retail grape prices by about 0.87 per cent, consistent with field study findings that approximately 33 per cent of cultivation costs are attributable to chemical inputs (Table 7.11).

**Table 7.11**

*ARDL Results for Grapes*

Dependent variable: Log CPI Grapes
ARDL (3,0,1)
Sample Period: April 2012- December 2022

| *Variables* | *Coefficients* | *Standard Error* |
|---|---|---|
| **Long-run equation** | | |
| Log AVU Ratio | -0.44*** | 0.16 |
| Log Agro-Chemical Price | 0.87*** | 0.11 |
| | | |

| | | |
|---|---|---|
| **Short-run equation** | | |
| ΔLog CPI Grapes (-1) | 0.21*** | 0.07 |
| ΔLog CPI_Grapes (-2) | -0.13* | 0.07 |
| ΔLog Agro-Chemical Price | -0.18 | 0.11 |
| Intercept | 0.26*** | 0.12 |
| *Residual dummy 1* | 0.08*** | 0.01 |
| *Residual dummy 2* | -0.05*** | 0.01 |
| **ECM (γ)** | -0.20*** | 0.04 |
| Observations | 126 | |
| Adjusted R-squared | 0.39 | |
| Breusch Godfrey Test | 1.30(0.25) | |
| Portmanteau's test for white noise | 52.82(0.08) | |

*Notes:* Significance levels are indicated as *** p<0.01, ** p<0.05, * p<0.1. Figures in parentheses for the Breusch-Godfrey LM test for autocorrelation ($H_0$: no serial correlation) and the Portmanteau's test for white noise ($H_0$: series are white noise) indicate p-values.

*Source:* Authors' estimation.

The estimate of the coefficient for the error correction (ECM) term is statistically significant and negative, indicating that in case of any deviation from the long-run equilibrium due to a shock, the system reverts to equilibrium; approximately 20 per cent of the adjustment occurs within a month. Positive and negative dummy variables capture exogenous factors, such as pest attacks in major producing states and quality deterioration due to incessant rainfall, which can cause sudden price movements. For instance, a pest attack on grapes in Maharashtra during harvest months led to a steep price rise in August 2016. Diagnostic tests indicate that the error term is white noise and independent and identically distributed with homoscedasticity and normality. Additionally, the Breusch-Godfrey LM test suggests an absence of autocorrelation in the residuals. The CUSUM plot, representing the cumulative sum of deviations from actual data following the ARDL model for grapes, consistently stays within the 95 per cent confidence band, suggesting model stability (Annexure A7.6).

### *Estimation for Banana*

The ADF results suggest that the CPI for bananas is stationary in first difference, while the AVU ratio is stationary at level (Table 7.12).

**Table 7.12**

*ADF Unit Root Test for Banana*

| *Variable* | *ADF (p-value)* |
|---|---|
| Log CPI Banana | -1.59 |
| Log AVU ratio | -10.23*** |
| Δ Log CPI banana | -10.77*** |

*Notes:* The Dickey-Fuller test statistic is reported. The critical values are the finite sample values suggested by Mackinnon (1991). (*) indicates different level of significance as *** p<0.01, ** p<0.05, * p<0.1.

*Source:* Authors' estimation

For estimating the factors impacting banana prices, the sample period covers July 2012 to June 2022. The dependent variable is the seasonally adjusted log of CPI for banana (Log CPI Banana), with the log of the AVU ratio as the explanatory variable. Two dummy variables, the positive dummy (Residual Dummy 1) and the negative dummy (Residual Dummy 2), control for exogenous shocks, particularly pest attacks and irregular rainfall events that cause sudden price fluctuations. The Pesaran, Shin, and Smith (2001) Bounds test confirms a long-run relationship between retail banana prices and the AVU ratio (Table 7.13).

**Table 7.13**

*Bounds Test for Cointegration for Banana*

| *F-statistic* | *t-statistic* |
|---|---|
| 8.336*** | -3.84*** |

*Notes:* ***, **, * denotes significance at 1 per cent, 5 per cent and 10 per cent, respectively. The F-statistic is used to test for the joint significance of the coefficients of the lagged levels in the ARDL. The t-statistic is used to test for the significance of the coefficient of the lagged dependent variable. All test statistics are significant at the 1 per cent level.

*Source:* Authors' estimation.

Table 7.14 presents the long-run coefficients from the ARDL model and the short-run dynamics for bananas. The results suggest a negative relationship between CPI bananas and the AVU ratio, with a 1 per cent increase in the AVU ratio reducing banana prices by approximately 0.21 per cent in the long run.

**Table 7.14**

*ARDL Results for Banana*

| Dependent variable: Log CPI Banana<br>Model ARDL (4,2)<br>Sample Period: July 2012 to June 2022 | | |
|---|---|---|
| *Variables* | *Coefficients* | *Standard Error* |
| **Long-run equation** | | |
| Log AVU ratio | -0.21** | 0.10 |
| **Short-run equation** | | |
| ΔLog CPI Banana (-1) | 0.10 | 0.08 |
| Δ Log CPI Banana (-2) | 0.03 | 0.08 |
| Δ Log CPI Banana (-3) | 0.09 | 0.08 |
| ΔLog AVU Ratio | 0.004 | 0.004 |
| ΔLog AVU Ratio (-1) | 0.01 | 0.004 |
| Intercept | 0.30*** | 0.08 |
| *Residual dummy1* | 0.02*** | .005 |
| *Residual dummy2* | -0.03*** | .005 |
| **ECM ($\gamma_1$)** | **-0.06*** ** | **0.02** |
| Observations | 116 | |
| Adjusted R-squared | 0.37 | |
| Breusch Godfrey Test | 0.17 (0.68) | |
| Portmanteau's test for white noise | 49.47 (0.14) | |

*Notes:* The Dickey-Fuller test statistic is reported. The critical values are the finite sample values suggested by MacKinnon (1991). Significance levels are indicated as *** p<0.01, ** p<0.05, * p<0.1.

*Source:* Authors' estimation.

The estimate of the coefficient of ECM term is statistically significant and negative indicating that any deviation from the long run equilibrium is corrected by approximately 6 per cent within a month. The diagnostics tests are satisfactory: the error term is white-noise and independent and identically distributed with homoscedasticity and normality. According to the CUSUM test, the errors remain consistently within the confines of the 95 per cent confidence band suggesting the stability of the model (Annexure A7.6).

### *Estimation for Mango*

The ADF test shows that the CPI mango and availability deviation are stationary in their levels while the agro-chemical price is stationary in first difference (Table 7.15).

**Table 7.15**

*ADF Unit Root Test for Mango*

| *Variable* | *ADF (p-value)* |
|---|---|
| Log CPI Mango | -3.92*** |
| Log Availability Deviation | -4.69*** |
| Log Agro-Chemical Price | -1.01 |
| ΔLog Agro-Chemical Price | -11.31*** |

*Notes:* The Dickey-Fuller test statistic is reported. The critical values are the finite sample values suggested by Mackinnon (1991). (*) indicates different level of significance as *** p<0.01, ** p<0.05, * p<0.1.

*Source:* Authors' estimation.

To analyse the factors impacting retail mango prices, the sample period covers April 2012 to August 2022. The dependent variable is the seasonally adjusted log of CPI for mango, with the normalised availability deviation variable and log agro-chemical prices (Agro_Chemical_Price) as explanatory variables. This is relevant as agro-chemicals constitute a significant portion of input costs for mango cultivation.

The Pesaran, Shin, and Smith (2001) Bounds test confirms a long-run cointegrating relationship between CPI mango and availability, and input costs represented by agro-chemicals (Table 7.16).

**Table 7.16**

*Bounds Test for Cointegration for Mango*

| *F-statistic* | *t-statistic* |
|---|---|
| 13.72*** | -6.28*** |

*Notes:* ***, **, * denotes significance at 1 per cent, 5 per cent and 10 per cent, respectively. The F-statistic is used to test for the joint significance of the coefficients of the lagged levels in the ARDL. The t-statistic is used to test for the significance of the coefficient of the lagged dependent variable. All test statistics are significant at the 1 per cent level.

*Source:* Authors' estimation

For the empirical analysis, a continuous monthly CPI series for mango has been constructed using available monthly CPI data for mango from April 2012 to September 2018 by regressing it with mandi wholesale prices. However, there are certain limitations with both the CPI series for mango in general and the imputed series in particular. First, there are significant quality-wise price variations across mango varieties in the Indian market, and the monthly quoted prices and arrivals may not accurately represent each other. Second, multiple mango varieties enter the market simultaneously, often with substantial price differentials, such as *Kesar* and *Alphonso* in March and *Dusheri* and *Langra* in June. For example, in June 2022, the price of Dusheri mangoes in Uttar Pradesh was Rs. 2,706 per quintal, compared to Rs. 2,269 per quintal for the *Langra* variety. Similarly, in May, the *Kesar* mango in Gujarat was priced at Rs. 8,500 per quintal, while *Alphonso* in Maharashtra sold for Rs. 10,877 per quintal. Although each variety has a defined arrival period, overlap in arrivals is common. Third, spatial variations in prices exist, with the same variety commanding a higher price in some states than in its primary production state, though the CPI series is constructed at the all-India level.

The prices for each mango variety can often be explained by the production levels in the state where it is primarily grown. For example, Kesar prices tend to have an inverse relationship with production in Maharashtra and Gujarat[82]. Similarly, prices for *Langra* and *Chausa* varieties have a negative relationship with production in Uttar Pradesh; Totapuri with production in Andhra Pradesh; and *Alphonso* with production in Maharashtra. Interstate trade also plays a key role in determining prices across different varieties and consumption centres, resulting in notable state-to-state price deviations. For instance, in July 2020, the wholesale price for the Dusheri variety was Rs. 2,245 per quintal in Bhopal, Rs. 3,768 in Raipur, and Rs. 5,503 in Mumbai.

82. These relationships have been established through simple OLS regressions of each variety's all-India monthly wholesale prices against the monthly production of the primary state of production.

The estimated long-run and short-run coefficients from the ARDL equation are presented in Table 7.17. The results show an inverse relationship between CPI mango and the normalised availability deviation variable in the long run—an upward shift of 1 per cent in the availability deviation (from a three-year moving average) can lead to a 0.43 per cent decline in retail mango prices. Additionally, agro-chemical prices, such as those of pesticides and insecticides, are positively and significantly related to mango prices in the long run—a 1 per cent increase in agro-chemical prices can result in a 1.23 per cent increase in mango prices. The ECM term coefficient is negative and statistically significant, indicating that deviations from the long-run equilibrium path are corrected rapidly, with approximately 44 per cent of the adjustment occurring within a month.

As with other food commodities in India, mango prices are highly sensitive to exogenous shocks such as cyclonic winds or other weather

**Table 7.17**

*ARDL Results for Mango*

| | | |
|---|---|---|
| Dependent variable: Log CPI Mango. no _ | | |
| Model ARDL (1,0,0) | | |
| Sample Period: April 2012 to August 2022 | | |
| *Variables* | *Coefficients* | *Standard Error* |
| **Long-run equation** | | |
| Log Availability Deviation | -0.43* | 0.24 |
| Log Agro-chemical Price | 1.23*** | 0.16 |
| **Short-run equation** | | |
| Intercept | -0.05 | 0.45 |
| Residual dummy | 0.29*** | 0.08 |
| **ECM** (γ) | -0.44*** | 0.07 |
| Observations | 116 | |
| Adjusted R-squared | 0.31 | |
| Breusch Godfrey Test | 0.12 (0.73) | |
| Portmanteau's test for white noise | 36.03 (0.65) | |

*Notes*: (*) indicates different level of significance as *** p<0.01, ** p<0.05, * p<0.1.

Figure in parentheses for Breusch-Godfrey LM test for autocorrelation ($H_0$: no serial correlation) and Portmanteau's test for white noise ($H_0$: series are white noise) indicates p values.

*Source*: Authors' estimation.

disruptions. To control for such shocks, a dummy variable was used. Outliers can typically be attributed to events like cyclonic or wind disturbances during peak mango harvesting periods in certain states, affecting produce quality rather than quantity. Government production figures, which are unadjusted for shocks, reflect these production quantities in the econometric analysis. The mango price discovery process in India heavily depends on produce quality, as revealed through the value chain study. However, due to limited data, quality-induced price variations could not be incorporated into the model.

The ARDL model's diagnostic tests are satisfactory, with the error term exhibiting white-noise properties and independence, homoscedasticity, and normality. The CUSUM plot also lies within the 95 per cent confidence band (Annexure A7.6).

### 7.10 Forecasting of Fruits Inflation

This section examines forecasting inflation in grapes, banana, and mango using univariate and multivariate time series models incorporating the balance sheet variable found significant in the ARDL model. Forecast model performance evaluation shows that combining diverse model types yields improved predictive outcomes (John et al., 2020). Time series forecasting models often outperform more complex structural models. Recognising seasonality in the fruit price data, we employ a 12-month horizon forecasting approach using SARIMA (as a benchmark model) and SARIMAX, enabling us to assess the effectiveness of the availability or AVU ratio variable, shown to be significant in the ARDL model, in predicting fruit prices.

### 7.11 Empirical Results

The root mean square error (RMSE) for each forecasting model is evaluated over the full sample to gauge historical model performance. We check RMSEs at 6 horizons of 2, 4, 6, 8, 10, and 12 months to assess model accuracy in forecasting CPI. In-sample evaluation shows that for grapes, SARIMAX with AVU ratio as an explanatory variable yields lower RMSEs than SARIMA across forecast horizons, indicating the superiority of SARIMAX forecasts (Table 7.18). We generated a sample forecast for January 2022 to December 2022 based on a 60-month rolling window to compare forecast accuracy against actual CPI data. Results confirm that SARIMAX with the AVU ratio provides a better fit for grapes than SARIMA **(Figure 7.36).**

**Table 7.18**

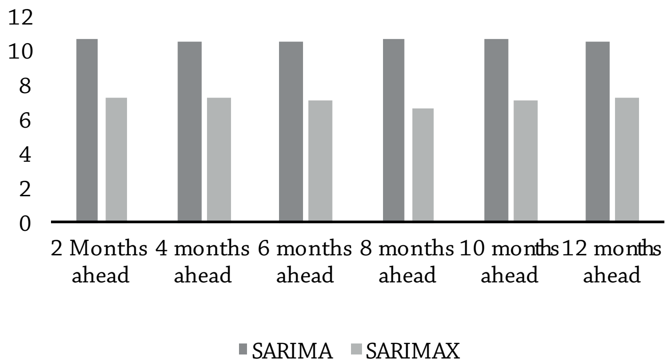
*RMSEs of Various Models for Grapes (full sample) (per cent)*

| *RMSE* | *2 months* | *4 months* | *6 months* | *8 months* | *10 months* | *12 months* |
|---|---|---|---|---|---|---|
| **Full sample forecasts RMSE (July 2012- December 2022)** | | | | | | |
| SARIMA | 8.52 | 8.45 | 8.37 | 8.36 | 8.35 | 8.34 |
| SARIMAX | 7.60 | 7.71 | 7.76 | 7.72 | 7.69 | 7.62 |

*Source:* Authors' estimations.

**Figure 7.36**

*60-months Window Rolling Forecasting Results for Grapes (April 2012 to December 2022)*




*Source*: Authors' estimations.

In case of banana, the forecast performance of SARIMAX with AVU ratio as exogeneous variable is broadly in line with SARIMA (there is no improvement in forecast accuracy) (Table 7.19). On a rolling window of 60 months basis, however, the SARIMAX model performs better over all the forecasting horizons (Figure 7.37). This improved performance could be due to better anticipation by the market about the expected arrival of the harvested crop in subsequent months.

**Table 7.19**

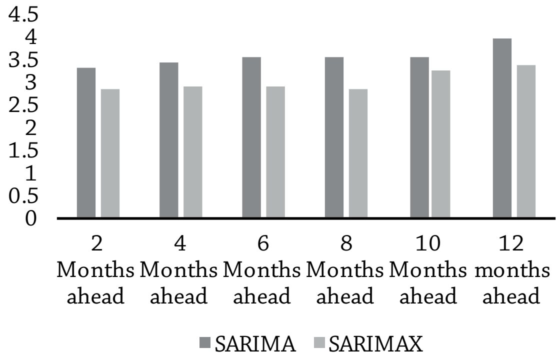
*RMSEs of Various Models for Banana (full sample) (per cent)*

| *RMSE* | *2 months* | *4 months* | *6 months* | *8 months* | *10 months* | *12 months* |
|---|---|---|---|---|---|---|
| **Full sample forecasts RMSE (July 2012- December 2022)** | | | | | | |
| SARIMA | 6.57 | 6.50 | 6.50 | 6.47 | 6.43 | 6.39 |
| SARIMAX | 6.71 | 6.75 | 6.69 | 6.62 | 6.55 | 6.49 |

*Source:* Authors' estimations.

**Figure 7.37**

*60-months Window Rolling Forecasting Results for Banana (July 2012- June 2022)*




*Source:* Authors' estimations.

For mango, the forecasting performance of SARIMAX model, i.e., SARIMA with our availability variable and agro-chemical price WPI series as exogeneous variables, outperforms the SARIMA forecasts over all the forecast horizons.

**Table 7.20**

*RMSEs of Various Models for Mango (full sample) (per cent)*

| **RMSE** | *2 months* | *4 months* | *6 months* | *8 months* | *10 months* | *12 months* |
|---|---|---|---|---|---|---|
| **Full sample forecasts RMSE (January 2011 – August 2022)** | | | | | | |
| SARIMA | 19.8 | 20.2 | 20.5 | 20.5 | 20.5 | 20.7 |
| SARIMAX | 16.7 | 17.5 | 17.7 | 17.7 | 17.7 | 17.6 |

*Note:* For mango due to discontinuity in the data, rolling window forecasts like other fruit commodities has not been performed.

*Source:* Authors' estimations.

## 7.12 Conclusion and Policy Suggestions

We analysed the value-chain frameworks of three fruits—grapes, banana, and mango—and their impacts on price dynamics. Our findings emphasised that the monthly availability or AVU ratio variable is useful in explaining retail prices of these fruits. Behavioural changes, driven by economic growth and urbanisation, have increased demand for high-value crops like fruits. Although production has increased, price volatility remains a challenge due to seasonality and weather uncertainties. Another issue is post-harvest losses and inefficiencies in the supply chain. Input prices (proxied by pesticides and agro-chemicals) also affect price dynamics. Our survey indicates that farmers' share in retail prices across these fruits varies between 30 and 43 per cent, depending on marketing channels. To enhance value-chain efficiency and contain fruit price volatility, the following policy measures are recommended:

### *Strengthening the Supply Chain*

The value chains of all three fruits are fragmented and complex. Farmers typically sell their produce immediately post-harvest due to limited storage and reliance on advance credit, leading to lower price realisation. Given the perishable nature of these fruits, they must be sold within a 15-day window. The shelf life varies, with grapes having the shortest, followed by mango and banana. Farmers' modest share in consumer prices reflects high transaction costs within the value chain. Expanding cold storage facilities at source and major consumption centres could significantly reduce post-harvest losses. For instance, Nashik district has 40–50 cold storage units, each with an average capacity of 5,000 tonnes. Developing modern cold storage facilities specialised for exports can bolster grape storage during lean seasons. Additionally, expanding ripening centres in major consumption hubs could reduce transport losses and enhance banana durability. Employing dedicated transport vehicles for fruit transportation is crucial for reducing post-harvest losses. Innovation in sustainable packaging is also essential to protect these fragile crops throughout the value chain. Efficient marketing through agro-business firms, B2B models, processing units, and more farmer producer organisations (FPOs) is crucial for growth in the horticulture sector.

### *Diversity and Varieties of Fruit Crop Cultivars*

In Maharashtra, high temperatures and soil conditions limit the production of coloured grape varieties. Expanding R&D investment to diversify grape production could address global demand for coloured varieties. In banana production, tissue culture has expanded, offering advantages like disease resistance, higher yields, and uniform plant growth. Bananas are well-suited for drip irrigation, which saves water by about 60 per cent and increases productivity by 15–30 per cent. This system also allows efficient fertiliser application through fertigation. However, many farmers employ traditional sucker-propagation alongside tissue culture due to higher costs. Irregular ripening and non-uniform bunch size can increase harvesting difficulties and cause fluctuations in market arrivals. Effective extension services are needed to train farmers in pesticide and fertiliser use, and R&D should focus on environmentally friendly chemicals.

### *Crop Insurance to Control Price Volatility*

Climate-induced weather vagaries have heightened production uncertainty, increasing price pressures. High rainfall and hailstorms at harvest stage damage grape crops. Once the required brix values[83] are reached, inclement weather can cause cracks on grape skin. Thrips, flea beetles, and mealy bug attacks have also increased as soil has become acidic in the Nashik region. Maximum Residue Limit (MRL) restrictions limit pesticide usage; therefore, farmers need extension support to implement preventive measures (e.g., season-long neem oil) to stabilise production. Effective insurance schemes to protect farmers from crop loss, and shade net cultivation[84] can reduce losses and protect crops from adverse weather.

83. Brix value, or degrees Brix (°Bx), is a measure of the sugar content in a liquid solution.

84. Shade nets are lightweight, knitted polyethylene fabrics used to protect people and plants from the sun. They can be used in various settings, including greenhouses and home gardens.

### *Increasing Processing and Boosting Export*

Approximately 10 per cent of the fruit produce is processed in India, which is higher than other horticulture crops. There is significant potential to reduce post-harvest losses and increase processing during peak harvest months to expand market presence. Banana generates considerable waste that can be converted into high-value products. On average, 70–80 MT of waste per hectare results from stem removal. Converting pseudo stems into value-added products could provide extra income for farmers sustainably. A pseudo stem can be divided into three parts: central core, fibre, and waste. Several food products like candies, pickles, and soft drinks can be made from the core. Fibre can be used for currency paper, fabric, and handicrafts, while bio-fertilisers and vermicompost can be produced from waste. Banana fibre application is underexploited due to inadequate awareness and lack of research on its organisational and physical properties.

Since banana is cultivated year-round, raw material supply is consistent, supporting a wide range of products through appropriate incentives. In grape processing, India primarily produces table grapes, while wine processing remains nascent. The wine industry has expanded in Maharashtra and Karnataka but faces challenges achieving economies of scale due to limited demand and capital investment. Marketing, inter-state trade, and taxation issues constrain industry growth. Raisin storage is a challenge, especially in Karnataka, due to inadequate infrastructure. Mango is seasonal, and increasing its shelf life requires proper packaging and hygiene to restrict microbial contamination. Expanding processing unit clusters, especially for mango pulp, may improve farmers' share of consumer prices across regions.

### *Dovetailing Trade Policy with Domestic Price Dynamics*

Fruits are seasonal and susceptible to weather-induced supply shortages, so calibrating tariff structures in response to domestic supply can help manage inflation. For instance, the basic import duty on fresh grapes, mangoes, and bananas, currently at 30 per cent or more, could be reduced during lean seasons or in years of production shortfall to improve supply through imports and ease price pressures. Demand peaks during festive months and seasonality in supply affect fruit prices, so imported fruits can cater to domestic demand during such periods and stabilise prices.

*Digital Transformation of the Supply Chain to Improve Traceability*

Maintaining quality standards in fruit exports through phytosanitary measures (controlling MRLs) is a significant challenge. While the grape export value chain from Nashik has improved with standardisation and good agriculture practices (GAP) via GrapeNet, challenges persist due to soil acidity, frequent pest attacks, and limited cultivar diversity. Traceability is not widely practised for bananas, resulting in minimal global trade presence for Indian bananas. MangoNet and GrapeNet integrate all stakeholders in the mango and grape supply chain, from farmers to state governments and horticulture departments. However, coverage in terms of area and farmers should be increased. Registering more farmers on these platforms could enhance traceability across the value chain. Expanding GrapeNet and MangoNet coverage would provide better information about pruning and budding/flowering patterns to assess domestic market arrival patterns and manage fruit price volatility in India.

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## 7.14 Annexure

**Table A7.1**

*Shares of Different Fresh Fruits in Total Fruits (Based on weights in the CFPI Basket)*

| *Fruit item* | *Share in total fruit weight (in %)* |
|---|---|
| Banana | 19.4 |
| Apple | 16.3 |
| Mango | 11.1 |
| Grapes | 5.3 |
| Coconut | 9.1 |
| Orange, Mosambi | 4.3 |
| Other fruits | 34.6 |
| Total | 100 |

*Source:* NSO, MoSPI.

**Table A7.2**

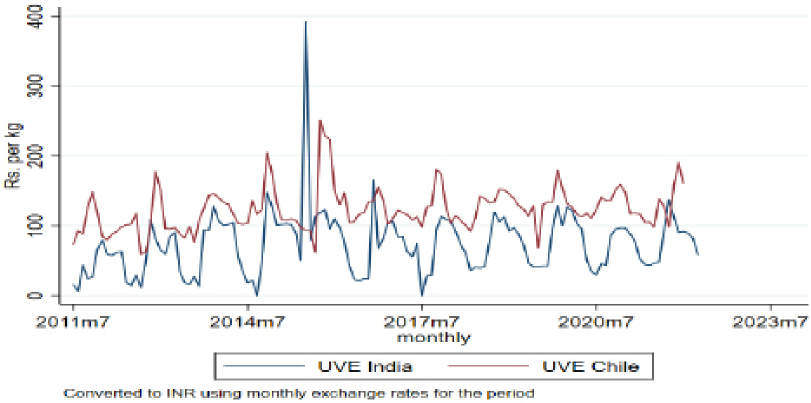
*Grapes Variety and TSS Value*

| *Variety* | *Yield (T/ha)* | *TSS value in per cent* |
|---|---|---|
| Thompson seedless (January-April) 70 per cent of harvest (Sonaka, Tas-e-Ganesh) | 25 | 15-16 |
| Sharad seedless (early harvest) for export | 35 | Max 24 |
| Bangalore blue | 40 | 16-18 |
| Perlette | 40 | 18 |
| Anab-e-Sahi | 35 | 14-16 |

*Source:* NHB, GoI.

**Figure A7.3**

*Comparison of Unit Value of Export (UVE) between India and Largest Exporter of Grapes (Chile)*




*Source:* Authors' calculations.

**Table A7.4**

*Harvest and Post-harvest Losses*

| *Operations* | *Banana* | *Mango* | *Grapes* |
|---|---|---|---|
| Harvesting | 1.62 | 2.09 | 1.77 |
| Collection | 0.26 | 0.3 | 0.3 |
| Sorting and Grading | 2.06 | 3.26 | 3.36 |
| Packaging | 0.19 | 0.23 | 0.1 |
| Transport | 1.91 | 1.04 | 0.98 |
| **Total loss in farm operation** | **6.04** | **6.92** | **6.52** |
| Farm | 0.03 | 0.11 | 0.01 |
| Godown | 0.08 | 0.01 | 0 |
| Wholesaler | 1.16 | 0.69 | 0.78 |
| Retailer | 0.45 | 1.18 | 1.24 |
| Processing unit | 0 | 0.25 | 0.09 |
| **Total loss in storage** | **1.72** | **2.24** | **2.11** |
| **Total** | **7.76** | **9.16** | **8.63** |

*Source:* CIPHET-ICAR Study, 2015.

**Table A7.5**

*Data Sources*

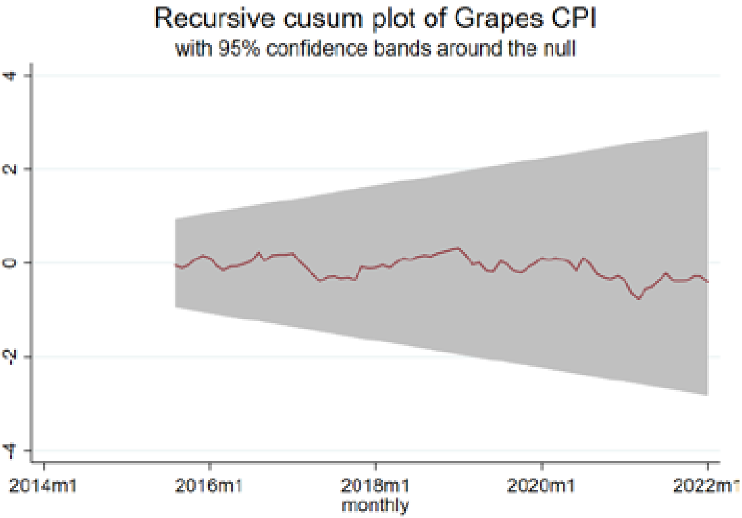
| *Variable* | *Source and other details* |
|---|---|
| CPI and WPI | CPI series (Base: 2012=100) is extracted from MoSPI. As item level CPI is available only from January 2014, the series is spliced to get data from January 2010. WPI data is sourced from Office of Economic Advisor, GoI. |
| Import and Export | Sourced from the Directorate General of Foreign Trade (DGFT). HS Code for fresh mango was discontinued from April 2018, but full series with same HS Codes are available for slices and pulp. Fresh mango merged with "GUAVAS, MANGO/ MANGOSTEENS FRESH OR DRIED" category from April 2018. We deducted guavas and mangosteens from the broad category to derive data on fresh mango. |
| Retail Prices | Retail prices are taken from the National Horticulture Board (NHB) for grapes and mango, and from the Directorate of Economics and Statistics, MoAFW, GoI, for banana. Mango-variety wise prices are taken from NHB. Grapes retail prices at NHB are available for Thompson (T. seedless) variety only. |
| Wholesale Prices | Wholesale prices for mango, banana and grapes are taken from Agmarknet for India and selected states. Mango variety-wise prices are taken from NHB. |
| Mandi Arrivals | At all-India level and state-wise, monthly mandi arrivals are taken from Agmarknet. |
| WPI Agro-chemical formulation | Sourced from Office of Economic Advisor, GoI. |
| Fertiliser Index | This is a weighted composite index of WPI of urea, nitrogenous fertilisers, mixed fertilisers and superphosphate/phosphatic fertilisers. |
| GDP per capita | Monthly GDP per capita extrapolated from quarterly data using money supply (M3) variable as an indicator variable. GDP data are sourced from the NSO and M3 from the RBI database. |
| Maharashtra wage index | Data is sourced from the RBI Database on the Indian economy. Wage data represents average monthly rural wages for men from Maharashtra covering three activities: ploughing/tilling, sowing, harvesting/ winnowing. |
| Losses | Harvest and post-harvest losses in percentages are taken from CIPHET report on post-harvest losses 2016. |
| Processing | Processing as a percentage of total production is taken from MoFPI for grapes and from APEDA for banana. For mango, the market intelligence has been relied upon. |
| Consumption | Annual consumption is projected forward using NSSO 2011-12 round of consumption expenditures on food and the NITI Aayog behavioural approach. The NSSO has released the summary results of the 2022-23 round of the household consumption expenditure survey but the details are not yet available. |

*Source:* Authors' compilation.

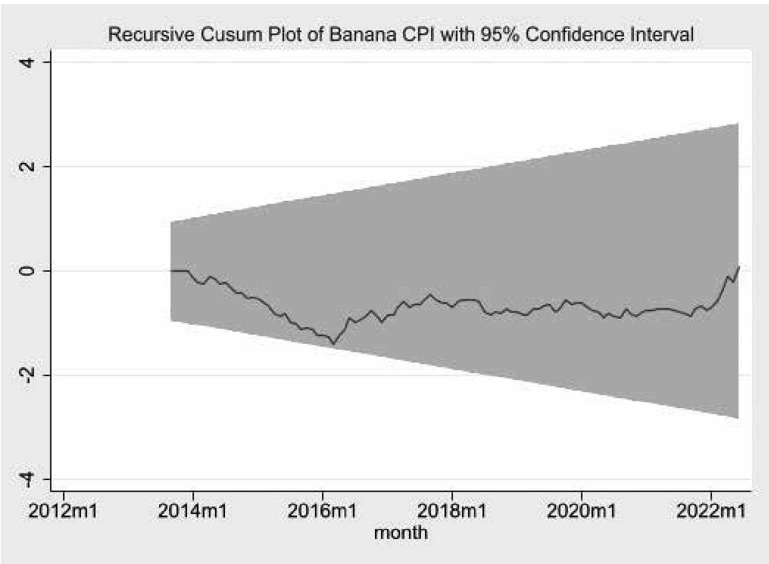
**Figure A 7.6**

*CUSUM Test for Fruits*

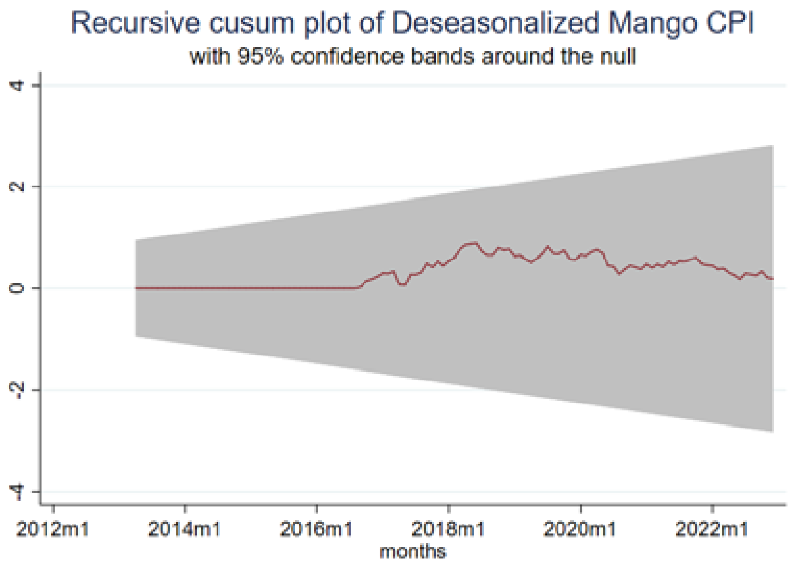
*a. Grapes*




*b. Banana*



*c. Mango*




*Note:* With 95 per cent confidence band around the null.

*Source:* Authors' Estimation.

# 8

ASHOK GULATI, SHYMA JOSE, RANJANA ROY

# Summary and Way Forward

## 8.1 Introduction

Food inflation has remained one of the most volatile components of headline inflation, making it extremely challenging to understand and predict its path. This book delves into the nuances of price dynamics in major food commodities, namely: (i) livestock (milk, poultry meat, and eggs); (ii) cereals (rice and wheat); (iii) pulses (*tur*, gram, and *moong*); (iv) vegetables (tomato, potato, and onions); and (v) fruits (mango, banana, and grapes).

The analysis in this book highlights the diverse factors on both the demand and supply side, coupled with government policy measures, that can significantly contribute to controlling food inflation. Apart from identifying these key sources and drivers of food inflation, it is crucial to provide reliable forecasts that form a basis for formulating timely policies to keep food inflation within the RBI's tolerance band. In other words, these forward projections of food inflation will help facilitate the central bank's desired monetary policy outcomes.

This study hypothesises that a balance sheet approach can investigate agricultural commodity markets and their inventories to explain price movements. Importantly, the book adds to the existing literature on understanding food inflation better through the monthly balance sheet approach. This novel exercise of computing monthly balance sheets from annual ones required an in-depth understanding of agricultural markets and value chains, taking into account the monthly demand and supply situation and monthly stock-to-use variables within the modelling framework. The underlying purpose of computing monthly balance sheets was to identify and incorporate expectations about market tightness based on future stocks or availability, which could influence price discovery. This study collated real-time information on harvesting cycles, production levels, consumption patterns, and trade dynamics, including both exports and imports, captured through a comprehensive network of market participants, such as farmers, traders, exporters, importers, millers, processors, and government officials across various states in India.

The book delves into commodity-specific chapters, highlighting challenges in the value chain of these commodities and strategies to stabilise price movements. Notably, each commodity chapter provides detailed policy recommendations to address commodity-specific inflation.

In this chapter, we briefly summarise the book's major findings. Broadly, this exercise will help build the premise for formulating short-term and medium-to-long-term policy interventions to control food inflation and improve the efficacy of value chains for major food commodities.

## 8.2 Summary of Major Findings

### *8.2.1 Understanding Price Dynamics of Food Inflation*

Over the last two decades, from 2004-05 to 2023-24, food inflation, as measured by the consumer food price index, has averaged around 7.1 per cent. In the overall CPI basket, the food and beverages group constitutes close to 45.9 per cent, making it susceptible to supply and weather shocks, which pose a major challenge to inflation targeting. The price dynamics of food commodities are shaped by their inherent characteristics, input compositions, production levels, and global factors. Additionally, the 14 commodities studied in this book together account for a combined weight of 19.5 per cent in the CPI basket and contribute to volatility in food inflation.

Among all the commodities, livestock—particularly milk and eggs—show lower average inflation and lower volatility. This may be because milk and eggs can be stored, though only for a limited period. In contrast, poultry meat cannot be stored for long and exhibits greater volatility among livestock products. Between January 2012 and June 2024, poultry meat inflation averaged around 7.4 per cent, while egg and milk inflation averaged around 6.32 and 5.98 per cent, respectively. Price fluctuations in livestock commodities are due to demand-supply imbalances, trade policy changes, rising international or domestic input costs, including feed and fodder, and market interventions.

In cereals, India is self-sufficient and is the world's second-largest producer of rice and wheat. Despite this, cereal prices have been volatile. Literature indicates that substantial hikes in MSP, supply-side bottlenecks, and adverse weather conditions impact cereal prices. Between January 2012 and June 2024, rice inflation averaged around 5.86 per cent with a CV of 1. For wheat, CPI inflation averaged around 6.21 per cent over the same period. Wheat inflation has seen a recent surge primarily due to a combination of factors such as heat wave-induced production falls, the Russia-Ukraine war, and high wheat exports.

Pulses are relatively non-perishable and have a longer shelf life, yet they exhibit high price volatility. The higher inflation pressure in pulses is largely due to demand outpacing domestic production. In pulses, especially *tur*, domestic demand is met through imports. During 2014-15 and 2015-16, poor pulses production coupled with adverse weather conditions led to inflation peaks, with CPI Y-o-Y inflation for pulses reaching about 46 per cent in November and December 2015. Similarly, year-on-year inflation for gram rose to 47 per cent in December 2016, and *tur* saw inflation of 82 per cent in November 2015. Between January 2012 and June 2024, *tur* and gram inflation averaged around 9.95 and 7.58 per cent, with CVs of 2.29 and 2.00, respectively. By contrast, *moong* Y-o-Y inflation averaged 5.73 per cent. Such spikes in pulse prices adversely impact farmers and consumers, making it difficult for policymakers to ensure price stability and market efficiency.

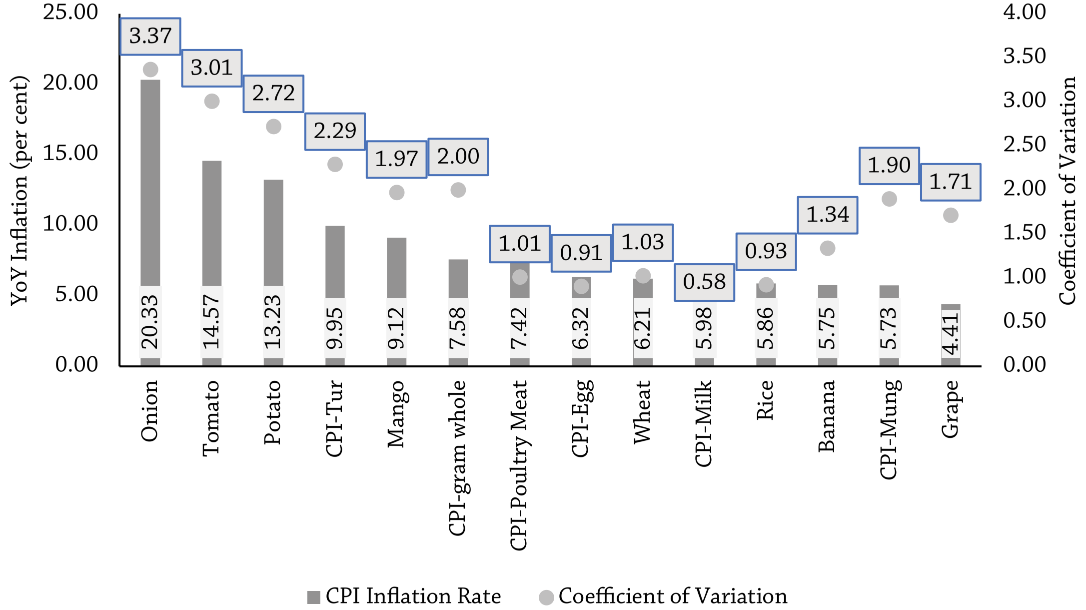
Among vegetables, the highly perishable nature of tomatoes often forces farmers to dump their produce in times of excess supply, resulting in major price drops. Due to its low shelf life, farmers cannot store tomatoes for periods of low production, leading to price spikes during shortages. For instance, tomato inflation in retail prices spiked to a Y-o-Y high of 135.6 per cent in May 2022 and then again to 158.6 per cent in June 2022. The WPI in these months was 219 per cent and 281 per cent, respectively. In July 2022, tomatoes had the highest contribution among the 299 commodities in the CPI basket. A similar trend was observed in onions from September 2019 to April 2020, with CPI inflation reaching as high as 327 per cent in December 2019 and 245 per cent in January 2020.

A hike in onion prices is observed almost every year during September-October due to seasonality in production. Similar cyclical patterns are seen with potatoes. Price fluctuations in potatoes were observed in 2018, 2020, and 2022, with CPI inflation reaching a high of 138 per cent in November 2020. The cobweb pattern in vegetable prices, especially in TOP, has become a cyclical phenomenon. Additionally, due to the perishable and cyclical production structure of vegetables, average inflation has remained highest in these crops. From January 2012 to June 2024, onions, tomatoes, and potatoes saw double-digit CPI Y-o-Y inflation rates of 20.33 per cent, 14.57 per cent, and 13.23 per cent, respectively (Figure 8.1). Due to high volatility in their inflation rates, the coefficient of variation is highest among these three vegetables.

On the other hand, fruits have a low weight of 2.9 per cent in the CPI basket. Consequently, fluctuations in fruit prices are not as prominently mirrored in CPI inflation compared to essential food items such as cereals, pulses, or vegetables. From January 2012 to June 2024, studied fruit commodities, particularly bananas and grapes, experienced CPI Y-o-Y inflation in the range of 5-7 per cent with moderate volatility. As per capita income rises and dietary preferences shift towards high-value commodities, fruits are anticipated to carry a more substantial weight in the CPI basket in the future.

**Figure 8.1**

*Average CPI Inflation (Y-o-Y) and their Coefficient of Variation (CV)*




*Note*: Average inflation and CV have been computed for the period from January 2012 to June 2024.

*Source*: MOSPI.

### *8.2.2 Value Chains and Their Efficacy Among Food Commodities*

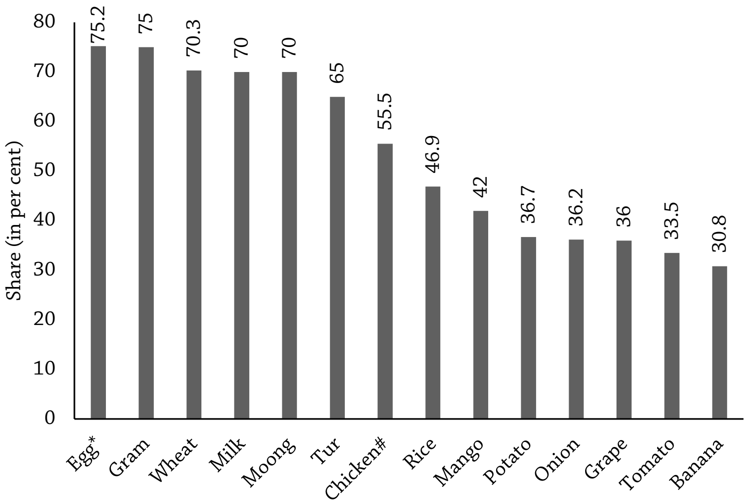
As highlighted in the book, an in-depth understanding of the value chain is crucial not only for computing the variables of balance sheets and dynamic monthly stock or availability variables but also for developing strategies to mitigate production volatility and its resulting inflation. Several studies reviewed in this book delve into the intricacies of supply chain dynamics, including an exploration of mark-ups occurring between the farm gate and retail price, an analysis of the components of these mark-ups, and an examination of the interlinkages between various stakeholders, such as traders, stockists, retailers, and farmers. This study investigates the value chains of these commodities, providing insights into the estimation of mark-ups by different stakeholders in the agricultural supply chain.

Today, India is the largest producer of milk, pulses, bananas, and mangoes; the second-largest producer of rice, wheat, tomatoes, onions, and potatoes; and one of the leading contributors to the global supply of eggs and meat. However, this commendable achievement in production levels does not guarantee stable returns for farmers. Farmers often struggle to find markets for their produce, especially during times of surplus, leading to distress sales, crop wastage, and even the dumping of produce on roads. Conversely, during times of scarcity, consumers bear the brunt of soaring retail prices. Despite farmers receiving meagre returns for their produce, retail prices frequently experience significant spikes in many urban centres across the nation. Although India has diversified its agricultural production from cereals to a variety of high-value commodities, the value chains supporting these commodities have remained relatively fragmented.

Among the 14 commodities examined, egg farmers tend to receive the highest share of the consumer rupee. Using secondary data from Agmarknet's wholesale and DES retail prices for major centres, we found that 75.2 per cent of the consumer rupee goes back to the egg farmer. According to our field survey, farmers' realisation of the consumer rupee in the commercial egg value chain varies across seasons, ranging from 69 per cent in summer months to 89 per cent in winter months. The farmer's markup fluctuates between seasons, with farmers generally experiencing losses during the summer and turning a profit during the winter months (Figure 8.2).

**Figure 8.2**

*Farmers' Share in Consumer Rupee (per cent)*




*Note*: The farmers share in consumer rupee for each of the commodities may vary for different harvest seasons and across states. # In poultry meat, farmer's share is computed for integrator which is inclusive of per cent markup for farmers. * The farmers' share in consumer rupee for egg ranges between 72 per cent-79 per cent (based on TE 2022 NECC monthly rates and TE 2022 DES retail prices)

*Source*: Authors' Calculation

The commercial poultry meat value chain is quite different from that of eggs. Production is usually undertaken through two models: the integrator or contract farming model, where integrators bear the major share of the cost, and the direct farmer model, where farmers rear broiler chicks by investing their own resources. A field survey of the integrator model in the poultry value chain finds that the integrators' share of the consumer rupee was about 55.5 per cent.

Similarly, the milk sector operates under a different model that includes dairy cooperatives, organised private players, the unorganised sector, and direct selling by farmers in rural areas. Analysis of the value chain of the Amul cooperative reveals that farmers receive a 70 per cent share of the final retail price of milk. Notably, as the livestock sector's value chain is more organised, the study finds better returns for livestock farmers compared to those in the crop sector.

Among cereals, wheat farmers claimed the largest share of the final consumer rupee, amounting to 70.3 per cent, while the farmers' share in the consumer rupee was comparatively lower for rice at 46.9 per cent. Wheat and rice in India are subject to comprehensive regulation, with the government actively participating in large-scale procurement at predetermined MSP. Wheat procurement has substantially increased in the major producing states of Punjab, Haryana, Madhya Pradesh, and Uttar Pradesh. Since the analysis is undertaken based on major wheat-producing states, farmers' share in the consumer rupee is estimated to be high compared to other crops as a result of the assured price. On the other hand, procurement operations for paddy are active in Punjab, Haryana, Chhattisgarh, and Telangana, but they are less satisfactory in the largest producing states of West Bengal and Uttar Pradesh. For instance, the MSP for common paddy was fixed at Rs. 2183/quintal in *kharif* 2023. The wholesale price of paddy reached as high as Rs. 2634 and Rs. 2239 in Punjab and Haryana, respectively, during the harvest months, as MSP acts as a floor price in these states. Conversely, in West Bengal, a major producer of paddy, the wholesale price (Rs. 2126/quintal) remained much lower than the MSP. Since returns are calculated based on the prevailing prices in major producing states, the farmers' share in the consumer rupee for rice is lower compared to wheat.

In pulses, marketing includes both institutional and non-institutional channels from producer to consumer. These alternate channels comprise direct purchases from farmers by traders and processors, commodities sold by farmers to traders and processors at the *mandis*, and procurement operations carried out by farmers' cooperatives and NAFED. Institutional channels such as NAFED procure pulses to maintain buffer stocks and ensure supplies for various state-specific social sector schemes. However, procurement by public agencies is insufficient to significantly impact farmers' returns. Our study reveals that farmers receive around 65-75 per cent of the consumer rupee, depending on the pulse variety. The non-perishable nature of the commodity, longer shelf life, and processing potential enable farmers to reap better returns compared to perishable fruits and vegetables.

The markets for high-value vegetables, often referred to as TOP in India, exhibit a high degree of fragmentation. In contrast to cereals and dairy products, where procurement and marketing systems are relatively well-developed, high-value vegetables like TOP face challenges in establishing an efficient value chain. The perishable nature of these crops, combined with regional and seasonal concentration, a lack of storage facilities, and the prevalence of numerous intermediaries, adds complexity to the value chain for TOP vegetables. Among vegetables, tomatoes are highly perishable, while potatoes and onions can be stored for months. However, the markup (cost + margin) for farmers remains similar for these three vegetables, at 33-38 per cent.

The nature of fruit commodities is quite different from cereals, pulses, potatoes, and onions due to their perishable nature and associated marketing risks. Moreover, fruit cultivation is more capital- and labour-intensive. Due to high capital costs, farmers require a substantial margin over variable costs to repay interest on loans borrowed from banks. For grapes, bananas, and mangoes, the farmers' share in the consumer rupee hovered around 30-45 per cent. The primary reasons for low returns to fruit and vegetable farmers are inefficient and fragmented value chains and a lack of storage facilities.

## 8.3 Determinants of Food Inflation

What are the key determinants of inflation across the 14 selected commodities? We found varying levels of markup received by farmers across the 14 commodities' value chains, indicating inefficiencies prevalent in these sectors. Apart from these, there are supply-side factors affecting price movements, such as production shortfalls due to agro-climatic risks, droughts or floods, and increasing production costs driven by rising domestic crude oil and fertiliser prices. On the demand side, factors such as rising per capita income, a sharp increase in rural wages, increased monthly per capita expenditure, the level of MSP, and the relative prices of substitute or complementary goods all impact food inflation.

In addition to these supply-side, demand-side, and macroeconomic factors, the study posits that inventories of a commodity (quantifying the demand-supply gap), a key variable computed using the monthly balance sheet approach, have a substantial influence on inflation. In line with economic theory, we expect that stock, supply, or net availability will have a negative relationship with prices (Table 8.1). More supply or stock should yield lower prices and vice versa.

Given that our analysis uses time series data, the unit root was tested using the ADF test. It suggests that variables selected for our regression analysis for each of the 14 commodities are integrated of different orders, justifying the use of ARDL models.

In the livestock sector, the study finds that input costs, particularly feed—which accounts for a major proportion of production costs—are strongly associated with CPI inflation. In milk, a weighted average of feed and fodder costs positively impacts milk inflation. Similarly, a weighted average of domestic soybean and maize wholesale prices tends to directly impact poultry meat and egg inflation. Apart from feed, balance sheet variables such as net availability (stock = supply − demand) for milk and the availability-to-usage ratio for eggs tend to have an inverse relationship with CPI. In poultry meat, where stocks don't play a role, availability (supply) tends to have a negative relationship with poultry meat inflation.

The cereals sector, comprising wheat and rice, constitutes major staples, and any price pressure in these commodities has significant repercussions for the population. In rice, the major factor is the stock-to-use (STU) ratio, which tends to have a negative relationship with rice inflation. In wheat, the key determinants are STU, global prices, and an import duty dummy variable. The study finds a positive relationship between global and domestic prices of wheat. Additionally, import duty tends to have a negative and significant relationship with wheat prices, i.e., lowering the import duty on wheat reduces price pressure.

In pulses, including gram, *moong* and *tur*, the study finds that STU is significant in explaining pulses inflation as it directly influences stockists' behaviour. For *tur*, the study finds that CPI for besan (made from gram, a substitute for *tur*) has a significant negative relationship with *tur* inflation. Additionally, markups in the value chain of pulses significantly and positively impact pulse inflation.

**Table 8.1**

*Determinants of Inflation in Selected Commodities*

| | *Commodity* | *Determinants of Inflation* |
|---|---|---|
| Livestock | Milk | Lag of CPI Milk, Net Availability, Weighted average of WPI Feed & Fodder, and Milk Dummy (capturing extreme random shocks such as COVID-19) |
| | Poultry Meat | Lag of CPI Poultry Meat, Availability, Weighted Average of Soyabean and Maize wholesale price index, Residual Dummy |
| | Egg | Lag of CPI Egg, Availability to usage ratio, Weighted Average of Soyabean and Maize wholesale price index, Log Real Wages, Residual Dummy (capturing random shocks), Covid Dummy |
| Cereals | Rice | Lag of CPI Rice, Stock to Use (STU) |
| | Wheat | Lag of CPI Wheat, STU, Log of Global Prices, Import Duty Dummy |
| Pulses | Gram | Lag of CPI Gram, STU, Mark up in Gram, Gram Dummy |
| | *Tur* | Lag of CPI *Tur*, CPI Besan and *Tur* Dummy |
| | *Moong* | Lag of *Moong*, Stock to Use (STU), Mark-up in *Moong* |
| Vegetables | Tomato | Lag of CPI tomato, Agro-chemical Index, Availability to Usage Ratio, Rainfall Dummy |
| | Onion | Lag of CPI Onion, Availability, Vegetable Index (excluding Onion) |
| | Potato | Lag of CPI Potato, Availability, Vegetable Index (excluding Potato), Real Agri wages |
| Fruits | Grape | Lag of CPI Grapes, Availability to usage ratio, Agro-Chemical Price Index |
| | Banana | Lag of CPI Banana, Availability to usage |
| | Mango | Lag of CPI Mango, Availability, Agro-Chemical Price Index |

*Source:* Author's calculation

The vegetable sector including tomato, potato and onion are most volatile among all the 14 commodities studied as their production is susceptible to supply shocks, weather vagaries and change in government policies. The study finds that monthly availability (supply variable) tends to have a negative impact on vegetable inflation. In vegetable sector, the share of agro-chemicals constitutes the largest share in the cost of cultivation and any hike in prices of chemicals inflates the input cost that in turn results in higher prices of these crops. The study finds that inputs like the agro-chemical index in tomatoes and real agricultural wages in potatoes significantly impacts their respective CPIs. Additionally, an increase in the relative price of other vegetables measured using vegetable index increases the prices of potatoes and onions. Fluctuations in the prices of one vegetable can have a cascading effect on others, as consumer demand tends to shift towards alternative vegetables in response to price hikes. Also, excessive rainfall, for instance, tends to exert upward pressure on tomato prices, as heavy rainfall frequently leads to crop losses.

In fruits, including bananas, grapes and mango, CPI is less volatile as compared to vegetables. Among all the three fruits, the study finds input cost particularly the agrochemical price index strongly and positively impacts inflation. Among the supply variables, the study finds, AVU ratio in a month inversely impacts CPI of banana and grapes whereas the availability has negative relation with the mangoes CPI.

This examination of the determinants of food inflation including balance sheet variable and other commodity-specific factors provide an appropriate estimation framework to accurately forecast inflation for the selected agricultural commodities. Using pseudo out of sample forecast for 2, 4, 6, 8, 10 and 12 months, the performance and accuracy of various forecasting techniques are examined. The study finds the SARIMAX model inclusive of the balance sheet variables outperforms univariate forecasting techniques among the 13 of the 14 selected commodities (banana is the exception). This proves the study's hypothesis that the balance sheet variable (stock or AVU ratio or STU ratio or availability) which is used as the exogenous variable along with macro variables in SARIMAX can accurately forecast inflation across all horizon with the least error in full sample forecast.

## 8.4 Policy Recommendation for Price Stability and to Contain Inflation

Evidently, the 14 commodities in our study contribute significantly to CPI inflation and its volatility. Based on extensive analysis of their value chain and their inherent inefficiencies, changing market scenario, supply management measures and determinants of inflation, we put forward key short term, medium to long-term policy recommendations to bring down inflation below the RBI's upper tolerance level. So, there is a need to revamp the entire policy matrix in the light of climate change, and boost reforms in marketing and trade policies, moving away from outdated export restrictions and pro-consumer agriculture price policies, often at the cost of farmers.

### *8.4.1 Short Term measures*

The centre can take major steps to regulate domestic supplies by various supply management measures.

#### Building Buffer Stocks for Non-perishables

Institutional channels such as NAFED in pulses and onion and the NDDB and major cooperatives in milk can procure during the peak season to maintain buffer stocks. This will ensure supplies during shortages and lean season. During high inflationary pressure, the buffer stocks can be offloaded in markets to stabilise prices. For instance, NAFED procured pulses close to about 4.18 MMT in 2018-19 and 1.30 MMT in 2021-22 under PSS and PSF. In the 2020 *Rabi* marketing season (RMS), NAFED procured 2.1 MMT of gram pulses that was later allocated to the States at a discounted price of Rs. 8 per Kg over the issue prices for its distribution under various welfare schemes in 2022.

NAFED is also tasked with the responsibility of ensuring price stability in the onion market. In onions, NAFED procures a minimum of 2-3 lakh tonnes during the *rabi* harvest period (April-May), ensuring that farmers receive a fair price of at least Rs. 12-15/kg compared to the lowest rates of Rs. 4-8/kg. This intervention is crucial to shield onion farmers from a market downturn, providing them with adequate remuneration and fostering increased production and exports. The stored onions can be gradually released from August through the first half of October, strategically timed before the onset of the *kharif* harvest. This could effectively regulate retail prices in September-October, keeping them below Rs. 30 per kg. In the recent past during the 2022 RMS, the NAFED built a buffer stock of 2.50 lakh MT of onions to stabilize onion retail prices during high price pressure. Out of this stock, around 50,000 tons of onion were distributed in several markets across 14 states/Union Territories to bring down the onion prices.

#### Liberalize Trade Policies by Decreasing Tariffs and Duties

A prudent short-term policy to curb inflation would be to rationalise the import regime through a reduction in tariffs and duties across the board to improve domestic supplies. For example, during high inflationary pressure periods in pulses, the government reduced the effective duty on *tur* and *urad* to 0 per cent currently from 10 per cent in March 2017 and 40 per cent in June 2018, respectively. At the same time, duty on *Kabuli chana* and Bengal gram has been brought down from 70 per cent in June 2018 to 10 per cent currently.

In addition to these measures government also took reduced import duties on edible oils that were instrumental in bringing down the domestic prices of palm oil and soft oils such as soybean and sunflower over the past year. Notably, the effective import duty on crude sunflower oil and crude soybean oil were brought down from 30.25 per cent in August 2021 to 5.50 per cent in October, 2021 and further to duty-free with each oil receiving a 2 MMT tariff-rate quota for the coming two financial years from May 2022.

Similar rationalisation of import duty can be adopted for other essential food commodities such as milk that faced high inflation during 2022 and 2023. The import duty on skimmed milk powder and butter can be brought down in a calibrated manner to 15 per cent that will help reduce the price pressure on milk and products. In contrast, the government is protecting domestic dairy industry by putting a high import duty on SMP at 60 per cent. India permitted imports of SMP/whole milk powder under a tariff rate quota (TRQ) of 10,000 MT, with a 15 per cent import duty from 2020 to 2022. However, outside of the TRQ, imports are still subjected to a 60 per cent import duty. Similarly, milk fat is imported at a basic duty of 40 per cent. India permitted imports of butter and other milk fats under a TRQ of 15,000 MT, with a 0 per cent import duty from 2020 to 2022.

Import of cattle/buffalo germplasm falls under India's restricted list. The introduction of temperate breeds into India, for crossbreeding with indigenous non-descript cattle, has long been accepted given the strong demand for exotic germplasm. In the medium to long term, imports can increase the availability of exotic breed semen in larger areas that can help increase the overall productivity.

Similarly, in poultry meat, the basic customs duty on the import of cuts and offal, frozen is exceptionally high at 100 per cent and not cuts in pieces offal, frozen is 30 per cent. To cater to the seasonal demand and contain meat inflation in the short run, the duty on cut pieces should be brought down significantly to promote competition and improve efficiency.

In fruits, imported fruits can cater to domestic demand during the lean period. Due to increase in income and rise in middle income population, consumers are willing to pay more for imported fruits; however, high import duty increase the price of the commodity. The basic import duty (BD) on fresh grapes, mango and banana are presently at 30 per cent, which can be reduced during lean season or in year of shortage in production to reduce price pressure. During lean period import duty can be brought down to reduce domestic inflation of fruits.

### Foster Import of Essential Commodities via Supply Agreements

If the Government anticipates domestic supply deficits of food commodities in future, the centre can import a substantial amount or enter into supply agreements (memorandum of undertaking (MoU)) with other countries to build up a buffer stock. In case of pulses, domestic production remained highly inadequate compared to the annual consumption leading to recurring shortages that were met by rising imports. In 2021-22, the imports accounted for close to 10 per cent of total pulse production. Subsequently, the government has already entered into MoU to import 2.5 lakh tonnes (*urad*) and one lakh tonne (*tur*) from Myanmar; 2 lakh tonnes (*tur*) from

Mozambique and 50,000 tonnes (*tur*) from Malawi through private trade during 2021-22 to 2025-26.

In the short run, the NDDB and major cooperatives may be allowed to import milk fat and SMP to build up a reasonable buffer stock necessary for the lean season. Furthermore, SMP and butter could be brought under an OGL to contain milk inflation. However, imports should be released in a calibrated manner to prevent drastic falls in procurement prices paid to dairy farmers.

### Rationalise Export Policy Measures

Adoption of stable and open export policy will provide an opportunity to fetch better prices in the global market, thereby encouraging farmers to upgrade productivity. During a surge in international prices, a liberal and consistent trade policy would help exporters plan accordingly that may also help improve the efficiency of the value chain by providing avenues to earn renumerations.

However, it is surprising that the government export policy measure to contain inflation are contrasting for different commodities such as in the case of cereals, onions and milk products. For example, in the wake of high inflation in milk and products (with Amul raising its prices three times and Mother Dairy even more in a single year 2022), the government did not impose any export restrictions. Rather, there was a spike in exports attributed by high export subsidy of 300 crores in 2018 and 150 crores in 2021 that was given by the Gujarat government to the Gujarat Cooperative Milk Marketing Federation (GCMMF). Interestingly, the exports of SMP from India during 2018-19 and 2021-22 were high despite India being uncompetitive in the SMP market as its domestic SMP prices were higher than the world SMP price.

Contrarily, in case of cereals inflation during 2022-23, there was knee-jerk policy response from the centre in the form of export ban on wheat on May 13th and later, wheat flour on Aug 25th, 2022 to enhance domestic availability and contain inflation. These export bans failed to contain wheat inflation that accelerated to 25.4 per cent by February 2023, just before the harvest season.

Besides wheat, in September 2022, the government also banned the export of broken rice and imposed a 20 per cent export duty on non-Basmati rice to increase domestic supplies. Later, the Centre imposed export ban on non-basmati white rice in July 2023, export duty of 20 per cent on parboiled rice along with setting a MEP of $1200 per tonne for basmati rice in August 2023. Similar policy measures were adopted in onions during high inflationary pressure in August 2023 by imposing export duty of 40 per cent. Given India is the largest exporter of onion, such export restriction tends to negatively impact farmers' price realization. A rational policy action would have been to impose an export duty of say 10 to 15 per cent, and then gradually increasing it to calibrate the impact on domestic prices. Such sudden bans in staples and essential commodities impacting international rice prices jeopardizes the food security of countries dependent Indian agricultural exports.

### Developing Agri Futures for Optimal Price Discovery and Risk Management

Another important policy action likely to gauge food inflation in India is to induct future market of agriculture commodities to operate effectively. However, the government has halted future trading of several agriculture commodities including wheat, paddy (non-basmati), soya bean, *chana*, potato, mustard seed, crude palm oil and *moong* due to sheer ignorance about how future market functions. The ban on future contracts of agricultural commodities distorts market mechanism of derivative markets. Commodities that are not traded in the future market including TOP crops faces most volatility and skyrocketing inflation. In the absence of any future signals, the reaction of our policy makers is often abrupt, crude and irrational. Futures market in vegetables can help in optimal price discovery and risk management. This will ensure that farmers and FPOs take their sowing decisions based on futures price and not backward-looking price.

Reintroducing these major food commodities into commodity derivatives markets holds the potential to significantly benefit farmers by improving price recovery and fostering greater participation from FPOs. Additionally, it can serve as a catalyst for the adoption of e-NWR, facilitating advantageous intertemporal trading for perishables such as potatoes. The revival of potato futures stands as a viable avenue to establish a market-driven price discovery mechanism, providing farmers with a more robust and dynamic pricing structure. Simultaneously, revisiting and amending restrictive legal provisions can further enhance farmers' access to alternative markets, empowering them with diversified options for price discovery.

### *8.4.2 Long-Term Measures*

**Correcting Inefficiencies in Value Chain through Processing in Perishables**

There is an urgent need to enhance the processing capacity in vegetables, livestock and fruits to substantiate any increase in their demand or short fall in their production. In vegetables, the MoFPI should extensively promote the use of dehydrated onions (flakes, powder, granules) among domestic households and institutions like the armed forces, hospitals, restaurants and schools (mid-day meals). This will take the pressure off fresh onions during the lean season. Currently, India exports 85 per cent of its dehydrated onions, and is the largest exporter of dehydrated onions in the world. Dehydrated products are much cheaper to store and are more durable. They can help check the spikes in onion prices. This will reduce wastage and help farmers get a fair price and consumers can switch to these dehydrated onions in the lean season at affordable prices.

Encourage the widespread adoption of processed tomato/potato products such as paste, puree, chips by launching extensive campaigns to stimulate market demand. Notably, there is a need for increasing potato processing in the largest producing states which will help farmers during glut period. Small scale processing units should be opened by FPOs to produce tomato pulp and puree to supply to large-scale ketchup manufacturing plants. Simultaneously, increasing processing capabilities to ensure that a minimum of 10 per cent of the total production is directed towards processing in fruits and vegetables. This will address excess supply during peak seasons, allowing for preservation and consumption during lean periods.

In pulses, the processing of pulses is mostly done in the private sector; so, installing small pulses mills or processing units at the village level can reduce the cost of processing to improve the conversion ratio of whole pulses into split or processed dal or pulses products. The demand of these processed items can be increased through large scale distribution in mid-day meal scheme, government run hostels, army canteens and so on. The schools in Gujarat distribute banana candy, rich source of vitamin and iron since 2013. This can be adopted in other states too.

Unlike onions and potatoes, tomatoes have a limited storage capacity, making processing an effective method for creating a buffer stock to mitigate inflation. To incentivize and promote processing, consider a reduction in the GST for processed tomatoes from the existing 12 per cent to 5 per cent, enhancing affordability and further encouraging the industry's growth. The processing rate for the grapes, mango, and banana in India stands at approximately 10 per cent, surpassing that of other horticulture crops. This disparity in processing levels may contribute significantly to the observed lower price volatility in these fruits. Technological interventions are needed to reduce losses and wastages during the processing stages.

### Reforming Agricultural Markets through e-NAM and Promoting FPOs in Agricultural Commodities

Access to an efficient marketing system and strengthening the fragmented and weak supply line can facilitate better price discovery and transparency. It can address price fluctuation in food commodities in a number of ways.

First, the integration of the e-NAM, especially in key producing regions, may bring the much-needed transparency to the domestic agricultural trade. Improving the grading facilities at the *mandis* as envisaged under e-NAM would help processors access quality and graded produce at the *mandi* level, thus improving the efficiency of the value chain.

Secondly, most of the farmers belong to the small holder category and depend on the mandi system for marketing their produce. The direct purchases by processors from an aggregator at the farmer level would reduce the transportation costs incurred by farmers to bring the produce to mandis and provide bargaining power to the farmers. Under the current system, farmers bring in their produce to *mandis* and sell their produce to traders and processors while incurring the cost of transactions (*mandis* and arhathiya or commission agents' fees). The direct purchase would also help cut down on intermediaries, leading to lesser transaction costs that would benefit farmers, traders and processors. Our findings show that a major chunk of the consumers' rupee realized goes back to farmers, thus making the value chain fairly efficient.

It is essential to provide a policy for farmers that encourages the collectivisation of smallholders especially in fruits and vegetables. A model similar to *Amul* will help small farmers market their products across India. Public investment for institutional development can help small farmers reduce their transaction costs while accessing quality inputs and markets for fair remunerative prices. Ensuring the quality standards of fruits through phytosanitary measures, particularly in managing Maximum Residue Limits (MRLs), poses a significant challenge in the global export market. Expanding the enrolment of farmers onto a registered platform is essential to enhance traceability throughout the entire value chain. On the lines of MangoNet and GrapeNet, vegetable farmers should be brought under a registered platform to increase traceability across the value chain.

### Enhance the Resilience of the Supply Chain: Building Storage Infrastructure and Cold Chain Facilities.

Constrained by limited storage facilities and reliance on advance credit, farmers often opt for immediate post-harvest sales, leading to diminished price realization. The perishable nature of some of the commodity's studies such as vegetables, fruits, livestock products necessitate a narrow 15-day selling window, though the shelf life varies by commodities. A concerning issue is the low share of the consumer rupee that reaches the farmers, indicative of elevated transaction costs within the value chain. Our field survey aligns with existing literature, highlighting significant farm losses in the livestock, fruit and vegetable sector. Addressing this challenge involves expanding cold storage facilities at both the source and major consumption centres, a move with the potential to substantially curtail post-harvest losses. Dedicated transport vehicles designed for efficient transportation are vital to mitigate perishability and reduce losses after harvest. Additionally, fostering innovation in sustainable packaging solutions is crucial to safeguard the fragility of these food commodities throughout the entirety of the value chain.

There is also a spatial mismatch in storage infrastructure and cold storage facilities across the agricultural and livestock commodities. In case of vegetables, cold storages for potatoes are concentrated in UP while onion storages are situated in Maharashtra. This puts other major producing states in a disadvantageous position. Thus, there is a requirement to resolve the issue of spatial disparity and capacity deficit of storage structures.

Additionally, storage infrastructure and cold chain facilities in poultry and dairy do not match the international quality standards. Foreign Direct Investment (FDI) or Public private partnership in the livestock value chain to upgrade infrastructure, improve technology, improve farm management practices can boost the sector. To increase the efficiency of the dairy value chain, the establishment of more BMC centres across all states should be prioritized to increase procurement. This will require investment in upgrading or building new dairy plants and small processing units in the cooperative sector to process milk into different forms for storage. This will also help India build more infrastructure to store milk in processed form that can be done by upgrading/modernising/setting up new dairy plants in the cooperative sector across different states. This will promote export competitiveness of the dairy industry and help tackle the challenges of low processing in the organised sector. This will also enable in aligning SMP and butter prices in India at par with Oceania prices.

Widespread adoption of solar power in cold storage facilities has the potential to extend cost-saving benefits to farmers. While the government currently offers a 35 per cent subsidy for cold storage construction, considering a separate subsidy tier for facilities incorporating solar panels can further incentivize the adoption of sustainable energy solutions in the agricultural storage sector.

### Dissemination of Weather Prediction and Promote Crop Insurance

Climate change induced weather vagaries have increased production uncertainty resulting in price pressure. At the harvest stage, high rainfall and hailstorms can damage the crops. The rising prices of tomato, grapes, banana are often attributed to plant viruses resistant to most pesticides. Vegetables and fruits farmers have struggled to control viruses and are being affected by newer pests and diseases resulting in high input costs and hence, are shifting to other crops when they incur losses. Therefore, farmers require assistance from extension services to proactively adopt preventive measures such as season-long neem oil application to stabilize production. The implementation of robust insurance schemes is crucial to shield farmers from potential crop losses. The adoption of the Shade Net method in cultivation can significantly diminish instances of crop loss and provide protection against unpredictable weather variations.

### Integrated Animal Health Plan and Feed Management for Livestock Sector

Increasing price of milk is attributed to lumpy skin diseases. The government and NDDB should take urgent action to control outbreaks of foot and mouth disease and lumpy skin disease that could reduce supplies by setting up fast medical action boards.

The feed cost (cattle feed, maize and soyabean, fodder) constitutes a major cost of production in the livestock sector ranging from 65 to 75 per cent across poultry and dairy sector. In medium to long term, an important policy measures to augment productivity and improve good quality of feed supplies available for livestock sector at affordable prices should be a priority. Creation of a feed bank is equally important. In this regard, incentivising private sector to build infrastructure for feed and fodder for different crops that can be resold at affordable rates to help control livestock inflation over time. Maize and soybean prices have a direct bearing on the cost of production and any policy measure affecting their prices will have implications for the farmers in the poultry sector. Therefore, policy measures to increase the productivity of maize and soyabean and to make quality feed available at affordable prices should be a priority.

The shortage in green, dry fodder and roughages is high and appropriate steps need to be taken to augment efficient supplies of fodder as it is a major source of cattle feed. The area under forage crops has decreased in recent years due to a shift towards cash crops. So, the barren lands can be utilised for growing grasses that require less amount of water and care and the seed for the forage crops should also be genetically modified to increase the productivity of these grasses. This requires agricultural extension services for farmers and investment for promotion of forage crops.

### Investing in Research and Development to Improve roductivity and Resilience

Technological breakthrough is crucial for streamlining, strengthening and improving the efficiency of value chain and helps in containing prices.

In the dairy sector, the challenges of low productivity of Indian bovines were addressed by importing high genetic merit bulls, cross breeding technology and production and import of high-quality semen that helped in increasing the overall milk production in the country. Higher investments are required in artificial insemination (AI) for female exotic and crossbreed cows/buffalo to improve yield efficiency. Also, sexed semen techniques need to be propagated to increase the probability of female offspring and reduce the risk of diseases in offspring.

Similarly, in the poultry sector, higher investment in genetic process and improved bird varieties can increase productivity in egg sector for India to reach high conversion ratio and required weight in lesser time period in poultry meat.

In vegetables and fruits, encouraging R&D in the creation of diverse varieties, such as table varieties for potatoes, processing varieties for potatoes, and exportable varieties for onions and grapes is critical. Emphasizing R&D efforts on developing seeds that are resistant to pests and heat is crucial. This approach not only boosts crop yields and ensures a consistent supply of these crops, consequently contributing to price stabilization in the market.

In pulses, the use of improved drought-tolerant seeds could sustainably increase pulse productivity and meet the increasing demand to feed the growing population and stabilise pulse inflation. Additional emphasis is needed for varietal development to suit the local agro-climatic conditions that are climate resilient and short-duration. There is a need to introduce new seed varieties for gram, *moong* and other pulses for large-scale commercial cultivation so that the farmers' remuneration could get a boost because of the short duration and higher yield of the *tur* variety.

### Curbing Information Asymmetry for Price Stabilisation

A robust collection of production or output data of agricultural commodities and its release on a quarterly frequency by the Ministry of Agriculture and Farmers' Welfare is important for price stabilisation. This systematic approach ensures that market participants are well-informed, helping to mitigate price volatility and stabilize the agricultural sector. There are several agencies that collect data on acreage (Land Use Statistics and Horticulture Statistics), and wholesale and retail prices (NHB, Department of Consumer Affairs, NHRDF). Real time data on acreage for major crops and their stock position will help to better estimate market supply for crops.

Also, real time availability of stock of private stocks of stored commodities will strengthen the assessment of the evolving demand-supply balance and facilitate appropriate timely policy responses to stabilise price inflation. The centre in collaboration with states needs to strengthen existing mechanisms for data compilation on a real-time basis. This would help in a realistic assessment of the evolving demand and supply scenarios in the country in advance. This would enable the policymakers to undertake appropriate decisions on imports and procurement in a timely manner to meet domestic demand and manage prices.

### Revise the CPI Basket

India's current CPI weights are based on modified mixed recall period (MMRP)[81] from the Consumer Expenditure Survey (CES) of the NSS 2011-12. This is 10-year-old and needs immediate revision to give us a true picture of the CPI inflation. Our premise is that CPI inflation is being over-estimated due to very high weightage of F&B in the CPI basket. Specifically, the F&B component constitutes 45.86 per cent of the CPI basket and within that, the consumer food price index (CFPI) constitutes 39.06 per cent.

What we know from the famous Engel's Law is that with increasing levels of household income, the percentage of income spent on food decreases. During 1992-93 to 2019-20, the per capita income in India grew at 5.1 per cent annually at 2011-12 constant prices. Even if one accounts for increasing inequality in income distribution between urban and rural areas, one can look separately at the economic situation of agricultural households. The data from Situation Assessment of Agri-HHs depicts that at all India level CAGR of real income has also been on the upward trend, which was 3.5 per cent between 2002-03 and 2012-13 and hovered around 2.8 per cent (3 per cent if we include rental income) between 2012-13 and 2018-19 with an overall period CAGR of 3.3 per cent between 2002-2019 using CPI-AL deflators. However, farmers are also producers so the real income growth figures based on WPI deflators have been higher at 4.9 per cent and 5.8 per cent during the two periods with an overall CAGR of 5.2 per cent.

Under the NFSA 2013, India has been providing subsidised food grains to approximately two-thirds of the country's population (800 million). Under the provisions of the Act, beneficiaries of PDS are entitled to 5 kilograms per person per month of cereals (rice at Rs. 3 per kg and wheat at Rs. 2 per kg). However, the current CPI basket (2011-12) assigns weights of 0.37 and 0.174 to PDS rice and PDS

81. Under MMRP, the consumption expenditure on edible oil, eggs, fish and meat, vegetables, fruits, spices, beverages, refreshments, processed food, pan, tobacco, and intoxicants is recorded for a reference period of the "last 7 days"; expenditure on items of clothing and bedding, footwear, education, institutional medical care, and durable goods is recorded for a reference period of the "last 365 days"; and expenditure on all other items is recorded with a reference period of the "last 30 days."

wheat respectively, although the share of the population getting free food has increased drastically since NFSA 2013. Despite that, CPI estimation is based on the 2011-12 weighting diagram which is overestimating cereal inflation.

The share of food in total consumption expenditure has been falling over time in various rounds of NSSO consumption surveys. With the release of the latest Household Consumption Survey 2022-23, it is important to revise the weights of the CPI basket so that revised weighting diagram could capture the food inflation better.

## 8.5 Summing Up

Today, India is increasingly integrated with the global economy, and its approach to tackling inflation, especially food inflation, and keeping it within acceptable limits involves a range of activities that extend beyond the traditional scope of monetary policy, particularly in the current environment.

While global supply disruptions are driving food price surges worldwide, in India, factors such as the monsoon and its unpredictable patterns play a significant role in affecting prices and supply chains. To create a more resilient agricultural system, India needs strategies that address immediate food inflation while also establishing a foundation for sustainable growth. This approach would stabilize prices by addressing both supply-side constraints and demand-side pressures, thereby reducing price volatility.

Therefore, policy perspectives must adopt a proactive approach by integrating both short- and long-term measures. At the same time, various institutions, including those focused on fiscal policy, trade, infrastructure, agriculture, and food management, should work in harmony and coordination to control inflation while supporting economic growth.

A comprehensive strategy that fosters innovation, builds robust supply chains, and empowers stakeholders is essential not only to tackle immediate challenges but also to promote long-term agricultural development, improve farmer livelihoods, and ensure sustained food security. Through these efforts, India can achieve a stable and prosperous future for its agricultural sector.

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Understanding price dynamics in food commodities, including the factors influencing demand and supply, is critical for policy actions aimed at achieving price stability. This book provides a comprehensive analysis of price dynamics and value chains within India's agricultural sector, focusing on key commodities that significantly impact food inflation and market stability.

Employing robust methodological frameworks, including monthly balance sheets and various forecasting techniques, the book examines the factors driving price formation across livestock products, cereals, pulses, vegetables, and fruits, while also providing medium- to short-term forecasts. By addressing commodity-specific challenges, the analysis highlights inefficiencies within agricultural value chains and their role in exacerbating price volatility.

Drawing from extensive research, the book offers targeted policy recommendations aimed at addressing these challenges and enhancing the efficiency of agricultural value chains. The findings emphasize strategies to stabilize prices, improve supply chain resilience, and strengthen the linkages between production and markets. This book serves as an essential resource for policymakers, researchers, and stakeholders seeking to mitigate food inflation and foster a more efficient and stable agricultural economy in India.

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