Policy Paper 45

Food Price Volatility in India

Purushottam Sharma
Md Yeasin
Ranjit Kumar Paul
Dinesh Chand Meena
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ICAR – National Institute of Agricultural Economics and Policy Research
New Delhi - 110 012

Purushottam Sharma, Md Yeasin, Ranjit Kumar Paul, Dinesh Chand Meena, Md Ejaz Anwer. 2024. Food Price Volatility in India. Policy Paper No. 45, ICAR-National Institute of Agricultural Economics and Policy Research (NIAP), New Delhi.

Published
September, 2024

Published by
Dr P S Birthal
Director
ICAR-National Institute of Agricultural Economics and Policy Research (NIAP), New Delhi-110012

Purushottam Sharma, Dinesh Chand Meena and Md. Ejaz Anwer are Principal Scientist, Senior Scientist and Research Associate, respectively at ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi; Md. Yeasin and Ranjit Kumar Paul are Scientist and Senior Scientist, respectively at ICAR-Indian Agricultural Statistics Research Institute, New Delhi. The views expressed in this paper are those of the authors and need not necessarily reflect the official policy or position of the institutes to which they are affiliated.

Printed at
M/s Chandu Press, 469, Patparganj Industrial Estate, Delhi 110 092.

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Preface

Frequent fluctuations in food prices are a matter of significant policy concern. The rising food prices affect the food and nutrition security of the poor. Farmers although benefit from the rising food prices, they also suffer when the prices fall. The high price volatility induces uncertainty in farmers' decisions regarding crop choice, input use, and farm investment. Prices of perishable commodities are more volatile than prices of non-perishable commodities. Amongst non-perishables, the prices of the commodities with significant government intervention, in terms of price support and procurement, are the least volatile.

No size fits all. Managing food price volatility requires differentiated strategies for different commodities. Nonetheless, the need for a market intelligence system for all the commodities to foresee likely changes in production and prices and to track commodity flows and inter-market trade cannot be undermined. I hope this study will be helpful for farmers in deciding their cropping patterns, traders and processors in deciding the stocking and processing levels, and policymakers in taking appropriate measures to contain food price inflation. I congratulate authors for their important contribution.

Pratap Singh Birthal
Director, ICAR-NIAP

Acknowledgments

Authors express their sincere gratitude to Dr Pratap Singh Birthal, Director, ICAR-NIAP, for guidance and support in bringing out this policy paper in the present shape. His painstaking efforts in improving the manuscript and sharpening the interpretations are gratefully acknowledged. We are grateful to Dr Shiv Kumar, Principal Scientist and Head, Division of Agricultural Markets and Trade, and Dr Raka Saxena, Principal Scientist and Head, Division of Technology and Sustainable Agriculture, for their help and support during this study. We sincerely thank Dr K. J. S. Satyasai, Chief General Manager (Retd.), NABARD, Mumbai, and Prof C. S. C. Shekhar, Professor, Institute of Economic Growth Delhi, for their insightful comments and suggestions.

Authors

Executive Summary

Managing the high volatility in food prices is a significant policy challenge in food-deficit developing countries. High food prices affect food consumption, especially for the poor, who spend a sizable proportion of their income on food. On the other hand, producers benefit from the rising prices but not necessarily from the high price volatility. Volatility creates uncertainty in production decisions regarding the choice of crops, spending on inputs, adoption of technologies and practices, and long-term investment in land improvements, water management, and farm assets. It also makes it difficult for value chain actors, including traders, processors, and manufacturers, to decide on appropriate levels of procurement, stocks, processing, and distribution. The high volatility in prices, thus, leads to suboptimal outcomes for all, from upstream to downstream. A persistent rise in food prices leads to inflation, exacerbates food insecurity, malnutrition, and poverty, and affects the trade balance. The high volatility in food prices occasionally becomes politically sensitive, causing social unrest and political instability.

This study has examined the price volatility for 19 food commodities, including perishables and non-perishables, and its causes. The main findings are as follows:

Price volatility is higher for perishable commodities: Price volatility is the highest for vegetables, followed by spices, pulses, oilseeds, and cereals. Seasonality is the most significant factor in the price volatility of vegetables.

The trend in volatility in prices of different commodities is mixed: Prices of onions, mustard, sunflower, and maize became more volatile over time. Price volatility for tomatoes, potatoes, coriander, cumin, blackgram, lentil, and pigeon pea first increased and then decreased.

Prices are higher during the pre-harvest period: Prices of most commodities are higher during the growing or the pre-harvest period because of supply shortage. Prices are the lowest immediately after the harvest.

Prices have no definite relationship with market arrivals: Market arrivals play an important role in price determination, but not for all commodities. Prices of vegetables, soybean, and maize are inversely related to market arrivals, as expected, but not in the case of other food commodities.

Climatic shocks influence price volatility: Current and lagged rainfall significantly influence price volatility through weather-induced price expectations.

Market interventions help stabilize food prices: Prices of rice and wheat, which the government procures at minimum support prices in large quantities, are more stable than prices of other non-perishable food commodities.

Price adjustment is faster in larger markets: Price discovery occurs in major trading centers, but the price adjustment to their long-run equilibrium is also faster there.

These findings have some important implications for agri-food price policy. The causes of price volatility differ across commodities; hence, no size fits all. Managing volatility in prices of different food commodities, therefore, requires a differentiated approach.

Vegetables:

- Breeding varieties for cultivation in different climatic conditions that are resistant to insect pests and diseases and ideal for processing should be the key priority for research to ensure their round-the-year supply.
- Promote farmers' access to markets through cooperatives and contract farming to incentivize them to diversify their product portfolio into vegetables and to ensure fair prices for their produce.
- High post-harvest losses are one of the important causes of price volatility. Investment in refrigerated transportation, cold storage, and processing will reduce post-harvest losses and stabilize prices.

Spices:

- Breeding for stress tolerance, including insect pests, diseases, droughts, floods, heat, and frosts.

- Promote the cultivation of spices in non-traditional areas.
- Strategically regulate exports depending on the domestic demand and supply conditions.

Pulses and edible oils:

- India has a deficit in pulses and edible oils and is significantly dependent on imports for domestic demand. A technological breakthrough is essential for improving their yields.
- About 12 million hectares of Kharif rice-cultivated area remains fallow in the subsequent season. Possibilities should be explored for cultivating pulses and oilseeds in rice-fallow areas.
- Engage in bilateral trade with countries surplus in pulses and edible oils.

Market intelligence: Price discovery occurs in major commodity markets, and prices adjust faster to their long-run equilibrium there. Hence, it is imperative to enforce market regulations and develop a market intelligence system for production and price forecasts and tracking market arrivals, trade flows, and prices to contain price volatility.

1 Introduction

Volatility in food prices alters the constraints and incentives for value chain actors, including producers, traders, manufacturers, processors, distributors, and consumers. Managing price volatility is, therefore, crucial for improving the efficiency, inclusiveness, and sustainability of food value chains.

High food prices reduce disposable income and thus influence food consumption and nutrition, especially for the poor, who spend a sizeable proportion of their incomes on food. When food prices rise, they adopt several measures to maintain the previous level of consumption — reduce non-food expenditure, substitute high-value nutritious foods with energy-intensive low-priced staples, and reallocate food among family members (FAO 2008; Dev 2011).

Farmers, on the other hand, benefit from the rising food prices. However, they also suffer more when prices fall. Often, food prices exhibit a cobweb phenomenon — falling during the bumper harvest and rising during the poor harvest. Thus, the volatility in food prices induces uncertainty in production decisions regarding choice of crops, spending on inputs, adoption of technologies and practices, and long-term investment in land and farm assets (Kulkuhl et al. 2016; UNCTAD 2023).

For value chain actors such as traders, processors, and manufacturers, the high price volatility makes it difficult to decide on appropriate levels of procurement, stocks, processing, and distribution. Thus, the high food price volatility leads to suboptimal outcomes for all, from upstream to downstream (Díaz-Bonilla 2016).

Persistent increases in food prices lead to inflation, exacerbate food insecurity, malnutrition, and poverty, and affect trade balance, especially in food-deficient developing countries. High food prices occasionally become politically sensitive, causing social unrest and political instability (Kalkuhl et al. 2016). Therefore, to protect domestic markets from price fluctuations, the governments resort to price stabilization measures, including trade restrictions, such as export bans, minimum export prices, import tariffs and quotas, etc.

Price volatility results from a significant disequilibrium in demand and supply caused by several time-varying natural and man-made factors. One of the leading causes of imbalance is the production shocks due to extreme climate events (i.e., droughts, floods, and heatwaves) and outbreaks of insect pests and diseases. Seasonality in production is another cause of fluctuations in prices. Apart from natural causes, several other factors, such as asymmetries in information on trade flows, poor storage, transport and communication facilities, changes in energy and input prices, market speculations, government interventions (i.e., subsidies and price support), trade policies, and supply chain disruptions cause distortions in food prices.

Several studies have investigated the causes of volatility in food prices in India (Gopakumar and Pandit 2014; Bhattacharya and Sengupta 2015; Sekhar et al. 2018). They identify different causes of price volatility in different commodities. Volatility in prices of cereals and edible oils is attributed to supply-side factors, such as production levels, wages, and government interventions in terms of minimum support prices. On the other hand, volatility in prices of perishable commodities, such as vegetables and fruits, is more explained by demand-side factors. Volatility in pulse prices is due to supply as well as demand-side factors.

Price volatility also occurs due to frequent changes in trade policy (Gupta and Rajib 2012) and government interventions like input subsidies and output price support (Chand 2010; Mishra and Roy 2011; Nair and Eapen 2012; Nair, 2013). Market power or anti-competitive trade practices (i.e., hoarding, speculation, and market manipulations) have also been responsible for high volatility in food prices (Chengappa et al. 2012; Birthal et al. 2019).

Demand for most food commodities is inelastic. Nevertheless, on occasions, for example, during festivals, demand for some food commodities significantly outstrips their supply, leading to a rise in their prices, *albeit* for a short period. Likewise, supply chain disruptions, such as during the COVID-19 pandemic and the Russia-Ukraine War, also lead to a significant rise in food prices.

Given the significant socio-political and economic implications of food price volatility, it is essential to '*adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility*' (United Nations 2015).

Since factors influencing food price volatility are interconnected, a sound understanding of the trends and causes of price volatility is essential to adopt a comprehensive approach to mitigate it. Volatility in food prices often originates upstream. Therefore, in this study, we assess the volatility in wholesale prices of food commodities and identify key factors influencing it. The findings of this study will be of significant utility to policymakers in taking appropriate measures to manage volatility in food prices.

2 Data and methods

2.1 Data

This study estimates the volatility in wholesale prices of 19 important food commodities. The monthly wholesale prices of these commodities from January 2010 to December 2022 from major commodity-specific markets have been extracted from http://agmarknet.gov.in, the website of the Directorate of Marketing and Inspection, Ministry of Agriculture & Farmers Welfare, Government of India. Food commodities studied include three cereals (i.e., rice, wheat, and maize), three vegetables (i.e., potato, onion, and tomato), five oilseeds (i.e., soybean, groundnut, mustard, safflower, and sunflower), five pulses (i.e., chickpea, pigeon pea, lentil, blackgram, and greengram), and three spices (i.e., cumin, coriander, and turmeric). Table 2.1 lists major market centers for these commodities.

Table 2.1. Major market centers for selected commodities

Crop group	Crops	Markets
Vegetables	Tomato	Bangalore, Chintamani, Kolar and Mysore (Karnataka); Delhi (Delhi); Indore (Madhya Pradesh); Mulakchheru (Andhra Pradesh)
	Onion	Ahmednagar, Lasalgaon, Pimplegaon and Solapur (Maharashtra); Dewas, Gwalior and Indore (Madhya Pradesh); Delhi (Delhi); Alwar (Rajasthan); Bangalore (Karnataka)
	Potato	Agra, Farrukhabad and Kanpur (Uttar Pradesh); Delhi (Delhi); Burdwan, Hoogly and North 24 Pargana (West Bengal)
Spices	Turmeric	Bangalore (Karnataka); Erode (Tamil Nadu); Basmat, Hingoli, Nanded and Sangli (Maharashtra)
	Coriander	Agar and Sheopurkalan (Madhya Pradesh); Gondal and Rajkot (Gujarat); Baran, Bhawani Mandi, Chhabra, Kota and Ramganj Mandi (Rajasthan)
	Cumin	Amreli, Dhanera, Gondal, Patan, Rajkot, Thara and Vankaner (Gujarat); Madanganj and Merta City (Rajasthan)

Contd.

Table 2.1 contd.

Crop group	Crops	Markets
Pulses	Chickpea	Dewas (Madhya Pradesh); Amrawati, Hinganghat, Khamgaon and Latur (Maharashtra); Bidar and Gulbarga (Karnataka); Alwar, Baran, Bikaner and Ramganj Mandi (Rajasthan)
	Pigeon pea	Bhopal, Jabalpur and Vidisha (Madhya Pradesh); Akola, Jalna, Latur, Nagpur, Udgir and Washim (Maharashtra); Kanpur (Uttar Pradesh)
	Blackgram	Akola and Jalgaon (Maharashtra); Gulbarga (Karnataka); Ajmer and Kota (Rajasthan); Lalitpur (Uttar Pradesh)
	Greengram	Akola, Shegaon and Jalna (Maharashtra); Amreli (Gujarat); Gadag, and Gulbarga (Karnataka); Jodhpur, Kekri and Madanganj (Rajasthan)
	Lentil	Banda (Uttar Pradesh); Ganjbasoda, Narsinghpur, Sagar and Vidisha (Madhya Pradesh)
Oilseeds	Groundnut	Bikaner and Chomu (Rajasthan); Gondal, Himmatnagar and Rajkot (Gujarat); Tirukovilur (Tamil Nadu)
	Mustard	Alwar, Baran, Khairthal, Kherli, Kota, Niwai, Srigangnagar and Tonk (Rajasthan); Satna (Madhya Pradesh)
	Soybean	Amrawati, Karanja, Khamgaon and Latur (Maharashtra); Dewas and Ujjain (Madhya Pradesh); Baran, Bhawani Mandi and Kota (Rajasthan)
	Sunflower	Bellary, Gadag, Kushtagi, Lingasugur and Mundragi and Rennebenur (Karnataka)
	Safflower	Bellary, Gadag and Gulbarga (Karnataka); Latur (Maharashtra)
Cereals	Rice	Burdwan, Murshidabad, Kolkata, Darjiling and Jangipur (West Bengal); Bolangir, Mayurbhanj, Kalahandi, Navrangpur and Puri (Odisha); Behraich, Mainpuri, Kanpur, Sitapur and Shahjahanpur (Uttar Pradesh)
	Wheat	Ratlam, Satna, Ujjain and Vidisha (Madhya Pradesh); Baran, Bundi, Hanumangarh, Kota and Srigangnagar (Rajasthan); Agra, Hardoi, Kheri Lakhimpur, Lalitpur and Shahjahanpur (Uttar Pradesh)
	Maize	Bellary, Davangere, Hassan, Haveri, Shikaripura and Shimoga (Karnataka); Indore (Madhya Pradesh)

2.2 Methods

2.2.1 Quantifying volatility

Coefficient of variation, CV= s/u, is a commonly used measure to quantify variability in the variable of interest, where s is the variable's standard deviation (SD) over a given time, and u is the variable's mean value. It, however, is not an appropriate measure of variability for agricultural prices because these are often non-stationary, exhibiting a unit root or random walk.

A more appropriate measure of volatility is estimating the standard deviation of returns (r_t), i.e., the difference in the logarithm of price (p_t) from period t-1 to the next period t:

$$r_t = \ln p_t - \ln p_{t-1} \qquad (1)$$

The standard deviation of returns is termed unconditional volatility and can be written as:

$$SD(r_t) = \sqrt{\frac{1}{n-1}\sum_{t=1}^{n}(r_t - E(r_t))^2} \qquad (2)$$

The volatility is unconditional because it does not consider any prior information or condition and is based on the observed variation in returns. Nonetheless, we have also estimated conditional variability using the generalized autoregressive conditional heteroskedasticity (GARCH) model:

$$r_t = \mu + \epsilon_t$$

$$\epsilon_t = \sqrt{\sigma_t^2} e_t \,; \quad \epsilon_t | \Psi_{t-1} \sim N(0, \sigma_t^2) \qquad (3)$$

$$\sigma_t^2 = \omega + \sum_{i=1}^{p} \alpha_i \epsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2$$

Where, ω is the constant term in the variance equation, α_i is the ARCH coefficient and β_j are the GARCH coefficient. $\omega > 0$, $\alpha_i \geq 0$ for $i = 1,2,\dots,p$ and $\beta_j \geq 0$ for $j = 1,2,\dots,q$. p and q are the order of ARCH and GARCH terms, respectively. It satisfies the condition $\sum_{i=1}^{p}\alpha_i + \sum_{j=1}^{q}\beta_j < 1$. Here, Ψ_{t-1} denotes the available information up to time t-1, e_t is the white noise and σ_t^2 is the conditional variance of the series.

The model allows the variance (or volatility) to vary over time as a function of lagged squared residuals (ϵ_{t-i}^2). The conditional volatility is the estimated value of σ_t^2.

2.2.2 Contribution of seasonality to food price volatility

Food prices exhibit considerable seasonality due to one or the other factors. To quantify the contribution of seasonality to volatility, a trigonometric method is used, which is parsimonious, i.e., requires a smaller number of parameters and explains a sufficient amount of information. The seasonality (Ghysels and Osborn 2001) can be measured as:

$$s_m = A\cos\left(\frac{m\pi}{6}\right) + B\sin\left(\frac{m\pi}{6}\right) \tag{4}$$

Equation with trending data is estimated using the least squares:

$$lr_{mt} = \gamma + A\cos\left(\frac{m\pi}{6}\right) + B\sin\left(\frac{m\pi}{6}\right) + \varepsilon_{mt} \tag{5}$$

Seasonality, s_m, may be a pure cosine function expressed as:

$$s_m = \lambda\cos\left(\frac{m\pi}{6} - C\right) \tag{6}$$

Where, m represents the month (m=1, 2, 3.., 12); $\lambda = \sqrt{A^2 + B^2}$ measures the seasonal amplitude, and $C = \tan^{-1}\frac{A}{B}$, the phase of seasonal cycle. The seasonal gap is estimated as 2λ. In conjunction with the stochastic trend (γ), seasonal parameters λ and C can be estimated using the Ordinary Least Squares (OLS) technique.

The coefficient of determination (R^2) of equation (6) provides the contribution of seasonality to volatility.

2.2.3 Speed of price adjustment

There is a long-run equilibrium in prices if markets are integrated. Before estimating the cointegration, the price series was tested for unit root using the Augmented Dickey-Fuller (ADF) unit root test (Dickey and Fuller 1979). Then, the Johansen test (Johnsen, 1988) is applied to test the cointegrating relationships between non-stationary price series. Johansen's method of cointegrated system is a restricted maximum likelihood method with rank restriction on matrix Π. The hypothesis of the test is, $H_0: rank(\Pi) = R$ against $H_1: rank(\Pi) > R$, where R is the number of cointegration relations.

Then, the vector error correction model (VECM) is estimated. The VECM of k variables with lag one can be represented as:

$$\begin{bmatrix} \Delta P_t^1 \\ \Delta P_t^2 \\ \vdots \\ \Delta P_t^k \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \\ \vdots \\ c_k \end{bmatrix} + \begin{bmatrix} a_1 \\ a_2 \\ \vdots \\ a_k \end{bmatrix} ECT + \begin{bmatrix} b_{11} & b_{12} & \dots & b_{1k} \\ b_{21} & b_{22} & \dots & b_{2k} \\ \vdots & \vdots & \vdots & \vdots \\ b_{k1} & b_{k2} & \dots & b_{kk} \end{bmatrix} \begin{bmatrix} \Delta P_{t-1}^1 \\ \Delta P_{t-1}^2 \\ \vdots \\ \Delta P_{t-1}^k \end{bmatrix} + \begin{bmatrix} \varepsilon_t^{P^1} \\ \varepsilon_t^{P^2} \\ \vdots \\ \varepsilon_t^{P^k} \end{bmatrix} \qquad (6)$$

Where, $c_1, \dots, c_k$ are the intercepts, ECT is the error correction term related to long-run cointegrating relationships, and $a_1, \dots, a_k$ are the ECT parameters. Superscripts 1, 2, ..., k stand for different variables, i.e., price series from different markets and P_t^1 is the price of a commodity in one market and P_t^2 is the price in another market, and so on. ECT shows how a variable reacts to the deviations from the long-run equilibrium. Alternatively, it is called the speed of adjustment.

2.2.4 Factors influencing food price volatility

Several factors influence volatility in food prices. Since we estimate volatility in food prices upstream, our focus is on capturing the effect of natural factors, mainly rainfall on price volatility. Rainfall influences production, which, in turn, determines the size of the marketed surplus. Here, we consider the arrivals of a commodity in markets synonymous to its supply.

To estimate the effects of rainfall and market arrivals on price volatility, we estimate a fixed effects model, including month- and year-fixed effects:

$$r_{imyt} = \alpha_0 Rf_t + \alpha_1 Rf_{t-1} + \alpha_2 Rf_{t-2} + \alpha_3 Rf_{t-3} + \alpha_4 \Delta logArrival_t + \alpha_5 Markets_{it} + \alpha_6 Months_{mt} + \alpha_7 Years_{yt} + \varepsilon_{imyt} \qquad (7)$$

Where, r_{imyt} is the log return of price in ith market in mth month and yth year at time t, ε_{imyt} represents error term, and Rf is the rainfall. Equation (7) has been estimated using the generalized least square method. The sign and magnitude of regression coefficient on a variable indicate the direction and effect size on price volatility.

3 Volatility in Prices of Vegetables

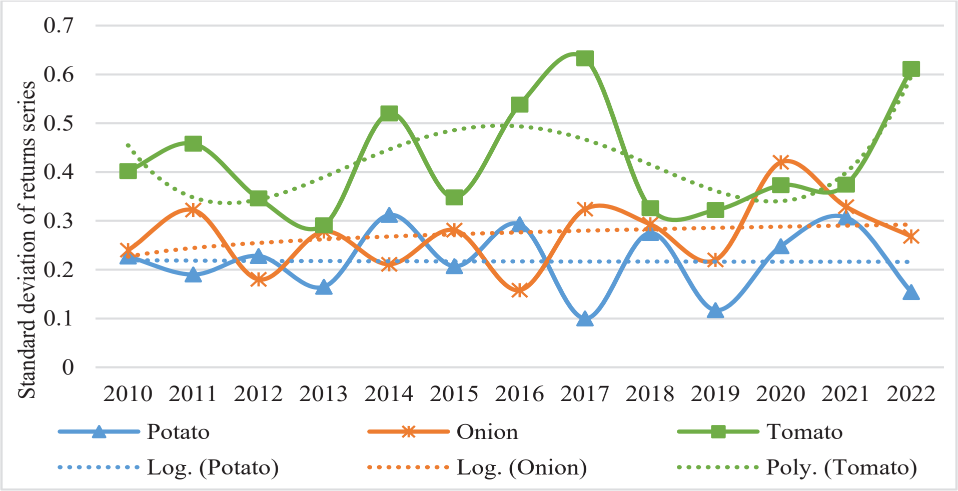
Tomatoes, onions and potatoes are indispensable components of the Indian diet. These are regularly consumed in most households. These are perishable; hence, they are prone to production (i.e., insect pests and diseases, and weather aberrations) and post-production (transportation and market) risks, leading to price fluctuations.

3.1 Trend in price volatility of vegetables

Figure 3.1 presents the annual unconditional volatility in prices of tomatoes, onions, and potatoes. Unconditional price volatility is the highest for tomatoes and the lowest for potatoes. Prices of tomatoes are twice as volatile as those of potatoes and 1.5 times of onions. Estimates of conditional price volatility also exhibit a similar pattern.

However, there are significant inter-year fluctuations in unconditional price volatility. It has been more for tomatoes, ranging from 0.29 to 0.63. It ranges from 0.16 to 0.42 for onions and 0.10 to 0.31 for potatoes. Notably, there is no significant correlation in the price volatility across commodities. The pair-wise correlation coefficient is insignificant: -0.15 for tomatoes-potatoes, -0.08 for tomatoes-onions, and 0.12 for potatoes-onions. This implies that the prices of any of these do not affect the prices of others.

Figure 3.1. Trend in unconditional price volatility of vegetables



Further, we look for changes in price volatility over time. Price volatility for tomatoes and potatoes increased significantly during 2014-2018 but declined marginally later. On the other hand, onion prices became more volatile.

Next, we compare price volatility across markets. Table 3.1 shows the unconditional price volatility for tomatoes, onions, and potatoes in the major trading centers. There is a significant inter-market difference in price volatility for tomatoes, ranging from 0.44 in Indore (Madhya Pradesh) to 0.63 in Mysore (Karnataka). Volatility in onion prices is the lowest (0.26) in Delhi and the highest in Pimpalgaon in Maharashtra (0.35). Interestingly, price volatility for potatoes does not differ much across markets.

Table 3.1. Inter-market differences in price volatility of vegetables

Tomatoes		Onions		Potatoes	
Market	**Volatility**	**Market**	**Volatility**	**Market**	**Volatility**
Mulakchheru	0.614	Pimpalgaon	0.346	Kanpur	0.224
Indore	0.444	Lasalgaon	0.331	Agra	0.218
Kolar	0.477	Solapur	0.308	Farrukhabad	0.223
Chintamani	0.537	Ahmednagar	0.337	North 24 Pragana	0.216
Mysore	0.627	Indore	0.327	Hoogly	0.243
Bangalore	0.585	Dewas	0.306	Burdwan	0.232
Delhi	0.465	Gwalior	0.281	Delhi	0.243
		Bangalore	0.276		
		Alwar	0.288		
		Delhi	0.257		

3.2 Production seasonality and price volatility

Production of agricultural commodities is seasonal; hence, price volatility depends on their production cycles. Vegetables are perishable and have short shelf-life, and therefore, seasonality in their production is likely to contribute significantly to their price behavior.

Figure 3.2 shows the month-wise unconditional volatility in prices of tomatoes, onions, and potatoes during 2010-2022. Tomato prices are more volatile from June to July and December to February. Tomatoes are grown twice a year — during the Rabi and the Kharif seasons. The sowing of Rabi tomatoes is spread from October to February, and harvesting takes place from December to June. Rabi tomatoes account for 70% of the annual production. Kharif tomatoes are transplanted from May to July and harvested from July to November. Their staggered sowing and picking influences their market arrivals, hence their prices. Generally, their supply is less during summers (June-July) and higher during winters (December-January).

Potatoes are harvested from December to March, accounting for about 95% of annual production. Volatility in prices of potatoes is higher in pre-harvest months and lower in post-harvest months, which is expected.

Rabi onions, harvested from the end of March to May, account for 70% of the total production. Kharif onions, harvested from October-December, contribute 20%. Onion prices are more volatile during February-March (Rabi pre-harvest) and during August-October (pre-Kharif harvest), and less during April-July (post-Rabi harvest).

Figure 3.2. Seasonality in price volatility of vegetables

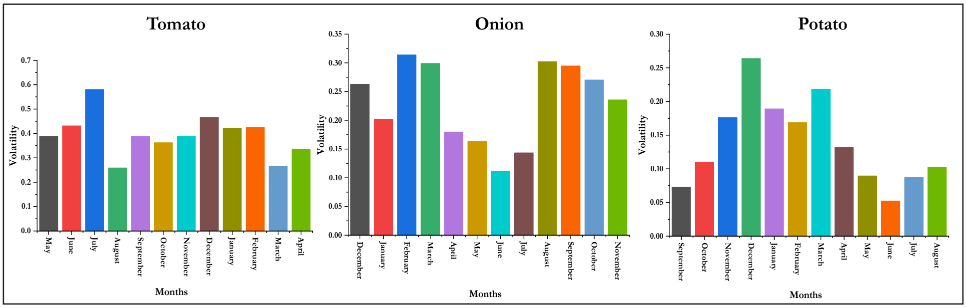


Table 3.2 provides the estimates of the seasonal gap (i.e., the difference between peak and trough volatility), and the contribution of seasonality (seasonal R^2) to the volatility. There is a high seasonal gap in price volatility — the highest for onions and the lowest for tomatoes. Seasonality explains 26% of the volatility in the prices of onions and potatoes and 14% of tomatoes. This is expected as tomatoes are grown round-the-year (except for a few months), while onions and potatoes are not.

Table 3.2. Contribution of seasonality in price volatility of vegetables

Crop	Seasonal gap (%)	Contribution to volatility (%)
Tomatoes	54.511	14.375
Onions	80.209	26.327
Potatoes	70.434	25.541

3.3 Causes of price volatility

3.3.1 Production shocks and market arrivals

Effects of rainfall and market arrivals on prices is investigated by applying a fixed effects regression. The regression equation also includes dummies for months, years, and markets.

Weather aberrations adversely affect crop production, which, in turn, induces volatility in prices (Kishore and Shekhar 2022). Our findings show that the current month's rainfall has a significant positive effect on the prices of potatoes and onions, not tomatoes (Table 3.3). However, three-month lagged rainfall has a negative and significant influence on the prices of tomatoes and onions. Note that most vegetables have short production cycles; hence, these can be replanted in case of an early or mid-season rainfall shock.

Expectedly, prices are negatively and significantly associated with market arrivals. The relationship, however, varies across markets, as is indicated by the market-fixed effects.

Table 3.3. Estimates of fixed effects model for variation in prices of vegetables

Variables	Tomatoes	Onions	Potatoes
Intercept	0.2256* (0.1096)	-0.0017 (0.0449)	-0.2104*** (0.0345)
Rainfall	-0.0066 (0.0115)	0.0129* (0.005)	0.0131** (0.004)
$Rainfall_{t-1}$	0.0162 (0.0115)	0.0179*** (0.005)	0.0029 (0.004)
$Rainfall_{t-2}$	-0.0164 (0.0115)	0.0135** (0.005)	-0.005 (0.004)
$Rainfall_{t-3}$	-0.0603*** (0.0114)	-0.0134** (0.005)	-0.001 (0.004)
Arrival	-0.1358*** (0.0218)	-0.0264*** (0.0077)	-0.0387*** (0.008)
Markets			
Chintamani	0.003 (0.0559)	Alwar -0.006 (0.0291)	Burdwan -0.0121 (0.0215)
Delhi	-0.0558 (0.0582)	Bangalore -0.0307 (0.0306)	Delhi -0.0031 (0.0195)
Indore	-0.0672 (0.0592)	Delhi -0.0101 (0.0292)	Farrukhabad 0.0008 (0.0194)
Kolar	0.0474 (0.0582)	Dewas 0.0001 (0.0292)	Hoogly -0.0108 (0.0212)
Mulakchheru	0.0214 (0.0562)	Gwalior -0.0104 (0.0292)	Kanpur 0.002 (0.0194)
Mysore	-0.0005 (0.0559)	Indore -0.0031 (0.0291)	North 24 Pragana -0.013 (0.02)
		Lasalgaon 0.014 (0.03)	
		Pimpalgaon 0.013 (0.03)	
		Solapur -0.008 (0.0293)	

Contd.

Table 3.3 contd.

Variables	Tomatoes	Onions	Potatoes
Months			
February	-0.2481** (0.0773)	-0.1097** (0.034)	0.1305*** (0.0275)
March	-0.038 (0.0812)	-0.1079** (0.0345)	0.4516*** (0.0276)
April	0.1617 (0.0848)	-0.068* (0.0346)	0.3853*** (0.0269)
May	0.1499 (0.0855)	0.0204 (0.0345)	0.3641*** (0.0272)
June	0.2448** (0.0865)	0.2088*** (0.0373)	0.2793*** (0.0286)
July	0.3025*** (0.0903)	0.0838* (0.0422)	0.2593*** (0.0322)
August	-0.2293* (0.0926)	0.1259** (0.0455)	0.2082*** (0.0347)
September	0.0811 (0.0931)	0.0115 (0.047)	0.2194*** (0.036)
October	0.3093*** (0.0898)	0.1044* (0.0443)	0.2878*** (0.0344)
November	0.1404 (0.0827)	0.0718 (0.0392)	0.2723*** (0.0315)
December	0.0083 (0.0771)	-0.0617 (0.0346)	-0.0234 (0.028)
Years			
2011	-0.1593 (0.0848)	-0.1897*** (0.0372)	-0.0796** (0.0296)
2012	-0.0465 (0.0852)	-0.0189 (0.0373)	0.0185 (0.0296)
2013	-0.0283 (0.0848)	-0.0631 (0.037)	-0.0212 (0.0295)
2014	-0.0891 (0.0849)	-0.1048** (0.037)	-0.0429 (0.0295)
2015	-0.0517 (0.0848)	-0.1131** (0.0372)	-0.0911** (0.0295)
2016	-0.2024* (0.0854)	-0.1297*** (0.0371)	-0.0636* (0.0296)
2017	-0.0008 (0.0847)	0.0312 (0.0371)	-0.0557 (0.0295)
2018	-0.107 (0.0848)	-0.1994*** (0.0372)	-0.0266 (0.0296)
2019	-0.0683 (0.0847)	0.0654 (0.037)	0.0147 (0.0294)
2020	-0.0366 (0.0848)	-0.148*** (0.0371)	-0.0338 (0.0296)
2021	0.0365 (0.0853)	-0.1317*** (0.0373)	-0.0967** (0.0295)
2022	-0.1663 (0.0849)	-0.1184** (0.0371)	-0.0373 (0.0295)
R^2	0.2144	0.3281	0.4613

Note: Standard errors in parentheses. *,**, and *** denote level of significance at 10, 5 and 1%, respectively.

Month-fixed effects are significant and positive for potatoes. For onions and tomatoes, month-fixed effects are heterogeneous in their direction and magnitude. For onions, month-fixed effects are negative and significant from February to April, the harvest period. Market arrivals of tomatoes are low during June-July, hence higher prices during this period. These findings indicate the crucial role of seasonality in production in price volatility.

Heterogeneity in month-fixed effects also indicates possibilities of arbitrage and market manipulation by market intermediaries (Birthal et al. 2019).

As expected, year-fixed effects are significant for onions and potatoes, indicating the role of stocks or storage in explaining volatility in their prices. Onions and potatoes are semi-perishable and can be stored for a longer period. The year-fixed effects are negative and significant, especially in years of higher supplies.

3.3.2 Internal trade and market integration

How long does it take to restore prices to their equilibrium? The negative coefficient on error correction terms (ECT) indicates the speed of adjustment. The bigger coefficient of ECT indicates less time for restoration to long-run equilibrium. In other words, it suggests higher market efficiency. Table 3.4 presents the ECTs. In most markets, ECT is negative and significant for onions and tomatoes. However, there is a significant difference in the speed of adjustment. In the case of tomatoes, it ranges from as low as 7% in Kolar (Karnataka) to 68% in Chintamani (Karnataka), meaning that 7 to 68% of the disequilibrium in tomato prices gets corrected within a month. The speed of market correction is relatively higher for onions — 26-78%. In general, the speed of price adjustment is faster in markets where market arrivals or price volatility is higher.

Table 3.4. Speed of error correction in vegetable markets

Tomatoes		Onions		Potatoes	
Markets	ECT	Markets	ECT	Markets	ECT
Mulakchheru	-0.322** (0.123)	Pimplegaon	-0.647* (0.291)	Kanpur	-0.375 (0.240)
Indore	-0.274* (0.115)	Lasalgaon	-0.750* (0.378)	Agra	-0.234 (0.239)
Kolar	-0.073 (0.219)	Solapur	-0.457* (0.197)	Farrukhabad	-0.185 (0.195)
Chintamani	-0.682* (0.27)	Ahmednagar	-0.483** (0.171)	North 24 Pragana	-0.210 (0.117)
Mysore	-0.598* (0.300)	Indore	-0.677** (0.255)	Hoogly	-1.461* (0.599)
Bangalore	-0.648** (0.220)	Dewas	-0.658*** (0.146)	Burdwan	0.603 (0.709)
Delhi	-0.488** (0.187)	Gwalior	-0.299 (0.172)	Delhi	0.038 (0.267)
		Bangalore	-0.396 (0.290)		
		Alwar	-0.262 (0.146)		
		Delhi	-0.256 (0.181)		

Note: Standard error in parentheses. *, **, and *** denote the level of significance at 10, 5, and 1%, respectively.

3.3.3 Government interventions

The Government of India runs a 'Price Stabilization Fund' to manage volatility in prices of important agri-horticultural commodities, including onions and potatoes. Onions and potatoes are storable, *albeit* for a short period of 3-4 months. Therefore, the government maintains their buffers for calibrated release to moderate prices and discourage hoarding and speculations. For building buffers, the scheme provides for their direct purchases from farmers and farmers' associations. In 2018-19, the government announced the 'Operation Greens Scheme' for tomatoes, onions, and potatoes, and it subsequently extended to all fruits and vegetables. The scheme provides financial incentives for their transportation from surplus to deficit regions and storage. It occasionally imposes stock limits under the Essential Commodities Act (ECA) to rein their rising prices.

Evidence indicates that trade policy changes also influence price volatility considerably (Brander et al. 2023; Ceballos et al. 2017). For onions, the Government of India often imposes the minimum export price (MEP) condition to stabilize domestic prices (Table 3.5). The Merchandise Export from India Scheme (MEIS) for fresh and chilled onions exports was introduced in December 2016 but withdrawn in June 2019. Export bans and duty-free imports are also frequently used to rein in rising prices. Trade policy for potatoes has mostly been consistent.

Table 3.5. Trade policy changes for onions and potatoes

Period	Policy changes
	Onions
2010	22.12.2010: Prohibition on export of all varieties of Onions
2011	10.02.2011: Export of Bangalore Rose and Krishnapuram onions restricted and their export permitted under license. Prohibition on other varieties of onions, with exclusions, continue. 11.02.2011: Exemption on Export of Onion in cut, sliced or broken in powder form 15.02.2011: Prohibition on export of Onions – Exemption for Bangalore rose and Krishnapuram onions - Export permitted under license subject to Minimum Export Price (MEP) of US$ 1400/MT 18.02.2011: Export of onions allowed through State Trading Enterprises (STEs) subject to applicable MEP depending upon the variety of onions. The export of onions (i) in cut form (ii) in sliced form and (iii) broken in powder form has been made freely exportable without any MEP. MEP onions revised at US$ 600/MT and for Bangalore rose and Krishnapuram onions at US$ 1400/MT 01.03.2011: MEP of onions (other than Bangalore Rose and Krishnapuram) reduced to US$ 450/MT F.O.B. from US$ 600/MT

Contd.

Table 3.4 contd.

Period	Policy changes
	08.03.2011: MEP of onions (other than Bangalore Rose and Krishnapuram) reduced to US$ 350/MT F.O.B. 16.03.2011: MEP of onions reduced to US$ 275/MT 23.03.2011: MEP of onions reduced to US$ 225/MT; MEP of Bangalore Rose and Krishnapuram onions reduced to US$ 600/MT F.O.B. from US$ 1400/MT 31.03.2011: MEP of onions reduced to US$ 170/MT 13.05.2011: MEP of Bangalore Rose and Krishnapuram onions reduced to US$ 350/MT 08.06.2011: MEP of onions increased to US$ 200/MT 15.07.2011: MEP of onions increased to US$ 230/MT 12.08.2011: MEP of onions increased to US$ 275/MT; MEP of Bangalore Rose and Krishnapuram onions increased to US$ 400/MT 24.08.2011: MEP of onions increased to US$ 300/MT 07.09.2011: MEP of all varieties of onions increased to US$ 475/MT 09.09.2011: Export of all varieties of onions prohibited except transitional arrangements 20.09.2011: Prohibition on export withdrawn and export of onions allowed through STEs subject to MEP 18.09.2011: MEP of onions reduced to US$ 350/MT; MEP of Bangalore Rose and Krishnapuram onions reduced to US$ 400/MT 28.09.2011: MEP of onions reduced to US$ 250/MT; MEP of Bangalore Rose and Krishnapuram onions reduced to US$ 300/MT
2012	11.01.2012: MEP of onions reduced to US$ 150/MT; MEP of Bangalore Rose and Krishnapuram onions reduced to US$ 250/MT 15.02.2012: MEP of onions reduced to US$ 125/MT 08.05.2012: Export of onions allowed without any MEP up to 2nd July 2012
2013	14.08.2013: MEP of all varieties of onions increased to US$ 650/MT 19.09.2013: MEP of all varieties of onions increased to US$ 900/MT 01.11.2013: MEP of all varieties of onions increased to US$ 1150/MT 16.12.2013: MEP of all varieties of onions reduced to US$ 800/MT 19.12.2013: MEP of all varieties of onions reduced to US$ 350/MT 26.12.2013: MEP of all varieties of onions reduced to US$ 150/MT
2014	04.03.2014: Requirement of MEP on export of onions removed 12.03.2014: Export of onion made free, earlier export permitted through STEs 17.06.2014: MEP of all varieties of onions increased to US$ 300/MT 02.07.2014: MEP of all varieties of onions increased to US$ 500/MT 21.08.2014: MEP of all varieties of onions reduced to US$ 300/MT

Contd.

Table 3.4 contd.

Period	Policy changes
2015	07.04.2015: MEP of all varieties of onions reduced to US$ 250/MT 26.06.2015: MEP of all varieties of onions increased to US$ 425/MT 24.08.2015: MEP of all varieties of onions increased to US$ 700/MT 11.12.2015: MEP of all varieties of onions reduced to US$ 400/MT 24.12.2015: Export of all varieties of onions allowed to be exported without any MEP.
2016	30.12.2016: Extended MEIS benefit for export of 'Onions Fresh and Chilled' up to 31.03.2017.
2017	31.03.2017: Extended MEIS benefit for export of 'Onions Fresh and Chilled' up to 30.06.2017 30.06.2017: Extended MEIS benefit for export of 'Onions Fresh and Chilled' up to 30.09.2017 23.11.2017: MEP of all varieties of onions increased to US$ 850/MT till 31.12.2017 29.12.2017: MEP of US$ 850/MT extended till 20.01.2018
2018	19.01.2018: MEP of all varieties of onion reduced to US$ 700/MT till 20.02.2018 02.02.2018: MEP requirement removed, all varieties of onions can be exported without any MEP. 26.02.2018: Export of all varieties of onions allowed to be exported without any MEP till further orders.
2019	11.06.2019: Rate of MEIS benefits for export of 'Onions Fresh and Chilled' made zero (0) from 10% earlier 13.09.2019: MEP of all varieties of onion increased to US$ 850/MT 29.09.2019: Export of all varieties of onions prohibited 28.10.2019: Export of Bangalore Rose onion, up to a 9000 MT, allowed up to 30.11.2019 02.12.2019: Import of onions allowed
2020	06.02.2020: Export of Krishnapuram onion, up to a 10000 MT, allowed up to 31.03.2020 02.03.2020: Export of all varieties of onion made free without Letter of Credit (LC) and MEP 14.09.2020: Export of all varieties of onion prohibited 09.10.2020: Export of Bangalore Rose and Krishnapuram onion, up to 10000 MT, allowed up to 31.03.2021 29.10.2020: Export of onion seeds prohibited 28.12.2020: Export of all varieties of onion made free from 01.01.2021

Contd.

Table 3.4 contd.

Period	Policy changes
2022	13.05.2022: Export of onion seeds put under Restricted category
2023	19.08.2023: Imposed export duty on onions @40% up to 31.12.2023
Potatoes	
2014	26.06.2014: Export of Potatoes permitted subject to MEP of US$ 450 per MT
2015	20.02.2015: Minimum Export Price (MEP) on export of Potato has been removed
2016	26.07.2016: Export of Potatoes permitted subject of MEP of US$ 360 per MT 27.12.2016: Export of potatoes permitted without MEP
2020	30.10.2020: Import of potatoes 'fresh or chilled' allowed for from Bhutan without license up to 31.01.2021, notifies the procedure for import (tariff rate quota quantity) of 10,00,000 MT of Potatoes, at in quota tariff of 10% till 31.01.2021
2021	28.06.2021: Import of potatoes 'fresh or chilled' allowed from Bhutan without license up to 30.06.2022
2022	04.07.2022: Import of potatoes 'fresh or chilled' allowed from Bhutan without license up to 30.06.2023
2023	03.07.2023: Import of potatoes 'fresh or chilled' allowed from Bhutan without license up to 30.06.2024

4

Volatility in Prices of Spices

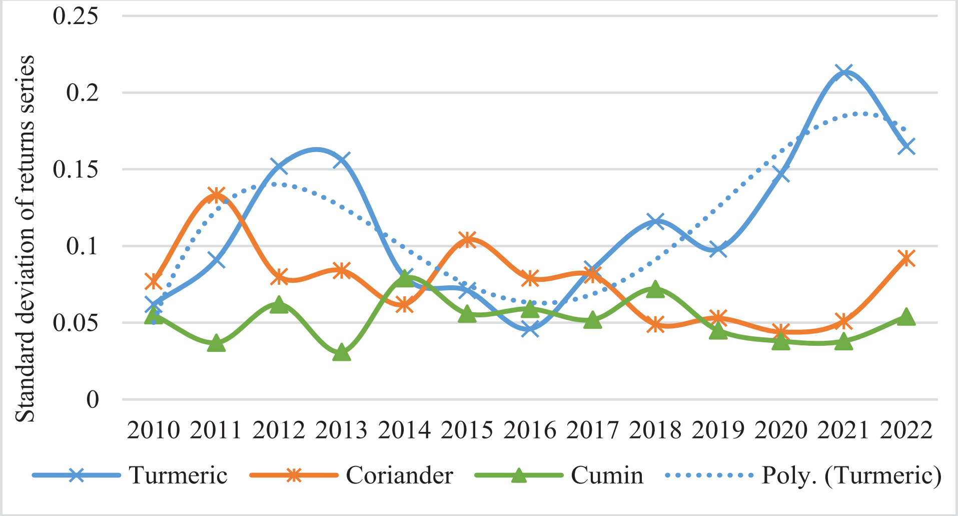
India is a leading producer and exporter of spices. Spices are indispensable in Indian culinary. This Chapter discusses the volatility patterns in the prices of turmeric, coriander, and cumin.

4.1 Trend in price volatility of spices

The unconditional volatility in annual prices of turmeric, cumin, and coriander is presented in Figure 4.1. Price volatility is the highest for turmeric and the lowest for cumin. Turmeric prices are twice as volatile as that of cumin and 1.6 times that of coriander. The conditional price volatility also shows similar behavior.

There is significant fluctuation in unconditional volatility in the prices of spices. Price volatility is higher for turmeric —the coefficient of unconditional volatility varies from 0.05 to 0.21. For coriander, it ranges from 0.04 to 0.13, and for cumin from 0.03 to 0.08. Turmeric has diverse uses as a condiment, dye, drug, and cosmetics; hence, its prices are more volatile than other spices. Price volatility has a heterogeneous trend, except for coriander and cumin after 2018.

Figure 4.1. Trend in unconditional price volatility of spices



Has price volatility changed over time? Volatility in turmeric prices has reduced significantly during 2014-18, but became more volatile afterward due to its increasing export demand post-COVID pandemic. On the contrary, volatility in cumin prices increased considerably during 2014-18, but decreased afterward. Interestingly, volatility in coriander prices has declined continuously.

Table 4.1. Inter-market differences in price volatility of spices

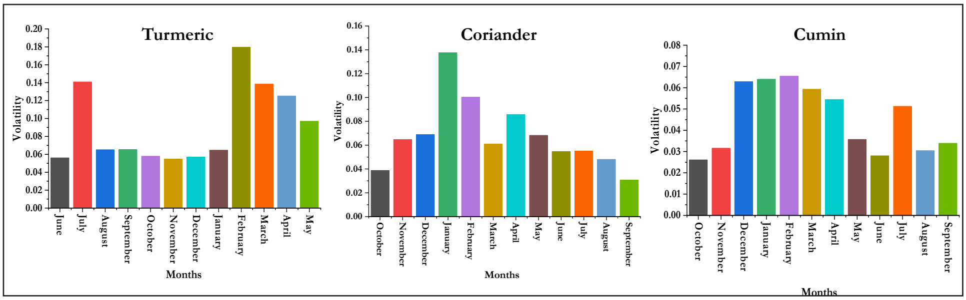
Turmeric		Coriander		Cumin	
Market	**Volatility**	**Market**	**Volatility**	**Market**	**Volatility**
Bangalore	0.097	Agar	0.110	Amreli	0.063
Basmat	0.084	Baran	0.092	Dhanera	0.066
Erode	0.078	Bhawani Mandi	0.120	Gondal	0.053
Hingoli	0.091	Chhabra	0.110	Madanganj	0.076
Nanded	0.128	Gondal	0.088	Merta City	0.114
Sangli	0.120	Kota	0.094	Rajkot	0.054
		Rajkot	0.112	Vankaner	0.064
		Ramganj Mandi	0.079	Patan	0.086
		Sheopurkalan	0.109	Thara	0.061

Table 4.1 presents the unconditional price volatility at the market level. There is a significant heterogeneity in price volatility across markets. For cumin, it varies from 0.053 in Gondal (Gujarat) to 0.114 in Merta city (Rajasthan). For coriander, it is the lowest (0.079) in Ramganj Mandi (Rajasthan) and the highest (0.12) in Bhawani Mandi (Rajasthan). Volatility in turmeric prices ranges between 0.078 (Erode in Tamil Nadu) and 0.128 (Nanded in Maharashtra).

4.2 Production seasonality and price volatility

The production of spices has a significant seasonal concentration. Hence, their prices also exhibit considerable seasonal fluctuations. Figure 4.2 shows the month-wise unconditional price volatility starting from the month of sowing. Turmeric prices are more volatile towards the end of sowing (i.e., July) and the harvest (February to March). Volatility in cumin prices is higher during December to April, i.e., the pre-harvest period. Cumin production is susceptible to frost and diseases, affecting production, hence price expectations. Coriander prices are also more volatile during the pre-harvest period (January - February).

Figure 4.2. Seasonality in price volatility of spices



The seasonal gap and contribution of seasonality to price volatility are presented in Table 4.2. The seasonal gap is significantly higher for turmeric than for cumin and coriander. Accordingly, seasonality in production contributes the highest to volatility in its price.

Table 4.2. Contribution of seasonality in price volatility of spices

Crops	Seasonal gap (%)	Contribution to volatility (%)
Turmeric	31.480	13.524
Coriander	1.925	0.034
Cumin	7.048	1.625

4.3 Causes of price volatility

4.3.1 Production shocks and market arrivals

Table 4.3 presents the estimates of fixed effects regression. One-month rainfall lag has a significant and negative impact on turmeric prices, but not on the prices of cumin and turmeric. Higher rainfall lags positively and significantly influence the prices of coriander. Cumin prices are unresponsive to rainfall. Market arrivals have a positive and significant influence on turmeric prices but not on the prices of cumin and coriander.

Month-fixed effects are significant for the harvest and post-harvest periods but heterogeneous in direction and magnitude, indicating the role that seasonality plays in price volatility. Expectedly, month-fixed effects are negative and significant for harvest and post-harvest periods. Further, year-fixed effects are also significant, indicating the role of stocks in predicting prices or volatility therein.

Table 4.3. Estimates of fixed effects model for variation in prices of spices

Variables	Turmeric	Coriander	Cumin
Intercept	0.0782*** (0.0209)	0.0077 (0.0163)	0.0167 (0.0126)
Rainfall	-0.0012 (0.0023)	-0.004 (0.0021)	-0.0021 (0.0016)
$Rainfall_{t-1}$	-0.0046* (0.0023)	-0.0005 (0.0021)	0.0026 (0.0016)
$Rainfall_{t-2}$	0.0004 (0.0023)	0.0062** (0.0021)	-0.0009 (0.0016)
$Rainfall_{t-3}$	0.0015 (0.0023)	0.0077*** (0.0022)	0.0016 (0.0016)
Arrival	0.0186*** (0.003)	0.0027 (0.003)	0.0024 (0.0019)
Markets			
Basmat	-0.0066 (0.0101)	Baran -0.0005 (0.0105)	Dhanera 0.0024 (0.0019)
Erode	-0.0064 (0.01)	Bhawani Mandi -0.0012 (0.0105)	Gondal 0.0012 (0.0078)
Hingoli	-0.0059 (0.0101)	Chhabra -0.0011 (0.0105)	Madanganj 0.0008 (0.0078)
Nanded	-0.009 (0.0103)	Gondal 0.0027 (0.0106)	Merta city 0.0002 (0.0077)
Sangli	-0.0064 (0.0102)	Kota -0.0018 (0.0105)	Patan 0.0003 (0.0077)
		Rajkot 0.0029 (0.0106)	Rajkot 0.0008 (0.0078)
		Ramganj Mandi -0.0018 (0.0105)	Thara 0.0007 (0.0078)
		Sheopurkalan -0.0009 (0.0105)	Vankaner 0.0017 (0.0078)
Months			
February	-0.0392** (0.0151)	-0.0514*** (0.0129)	-0.0408*** (0.0095)
March	-0.035* (0.016)	0.0703*** (0.0129)	-0.0438*** (0.0102)
April	-0.0604*** (0.0167)	0.0854*** (0.0126)	0.023* (0.0096)
May	-0.0659*** (0.0162)	-0.0371** (0.0124)	0.0093 (0.0095)
June	-0.048** (0.017)	-0.0096 (0.0144)	0.0081 (0.011)
July	0.0217 (0.0175)	0.0416* (0.0185)	0.0399** (0.0136)
August	-0.0253 (0.0181)	-0.0051 (0.0215)	0.0013 (0.0153)
September	-0.0672*** (0.018)	-0.0648** (0.0222)	-0.0309 (0.0158)
October	-0.0174 (0.0176)	-0.0491* (0.0208)	-0.0312* (0.0145)
November	-0.0001 (0.0161)	-0.0318 (0.0177)	0.0129 (0.0123)
December	-0.0129 (0.0148)	-0.0433** (0.0143)	0.0132 (0.0102)
Years			
2011	-0.1331*** (0.0165)	-0.0062 (0.0141)	-0.0165 (0.0106)
2012	-0.0288 (0.0164)	0.0053 (0.0141)	-0.0124 (0.0107)
2013	-0.0235 (0.0163)	0.0115 (0.014)	-0.0286** (0.0104)
2014	-0.0054 (0.0164)	0.0153 (0.0141)	-0.0148 (0.0105)

Contd.

Table 4.3 contd.

Variables	Turmeric	Coriander	Cumin
2015	-0.0061 (0.0164)	-0.0339* (0.0141)	-0.003 (0.0105)
2016	-0.0476** (0.0163)	-0.0429** (0.014)	-0.0005 (0.0106)
2017	-0.0368* (0.0163)	-0.04** (0.0141)	-0.0053 (0.0106)
2018	-0.04* (0.0163)	-0.006 (0.0141)	-0.0267* (0.0109)
2019	-0.0413* (0.0163)	-0.0085 (0.0141)	-0.0257* (0.0104)
2020	-0.0399* (0.0163)	-0.0304* (0.0141)	-0.0324** (0.0104)
2021	-0.0046 (0.0164)	0.0061 (0.0142)	-0.0015 (0.0104)
2022	-0.0418* (0.0163)	-0.0202 (0.0143)	0.0282** (0.0105)
R^2	0.2301	0.202	0.1626

Note: Standard error in parentheses. *, **, and *** denote significance levels at 10, 5, and 1%, respectively.

4.3.2 Internal trade and market integration

Table 4.4 presents the coefficients of ECT. These are negative and significant for cumin in most markets. However, there is a considerable inter-market difference. The speed of adjustment varies from 9% to 91%. Price adjustment is faster in markets with higher volatility or arrivals. For coriander and turmeric, the coefficient of ECT is not significant in most markets.

Table 4.4. Speed of error correction in spices markets

Turmeric		Coriander		Cumin	
Markets	**ECT**	**Markets**	**ECT**	**Markets**	**ECT**
Bangalore	-0.087 (0.045)	Agar	-0.140 (0.078)	Amreli	-0.911*** (0.219)
Basmat	-0.326 (0.180)	Baran	-0.239 (0.129)	Dhanera	-0.381 (0.243)
Erode	-0.008 (0.131)	Bhawani Mandi	-0.170* (0.081)	Gondal	-0.276 (0.278)
Hingoli	-0.246* (0.118)	Chhabra	-0.034 (0.064)	Madanganj	-0.351** (0.117)
Nanded	-0.407** (0.136)	Gondal	-0.216 (0.174)	Merta City	-0.847*** (0.144)
Sangli	-0.083 (0.249)	Kota	-0.341 (0.230)	Rajkot	-0.086 (0.332)
		Rajkot	-0.168 (0.126)	Vankaner	-0.297 (0.236)
		Ramganj Mandi	-0.119 (0.064)	Patan	-0.600** (0.193)
		Sheopurkalan	-0.034 (0.075)	Thara	-0.439 (0.282)

Note: Standard error in parentheses. *, **, and *** denote the significance level at 10, 5, and 1%, respectively.

India is the largest exporter of spices, and the export demand and international prices also affect domestic prices and speed of adjustment.

5 Volatility in Prices of Pulses

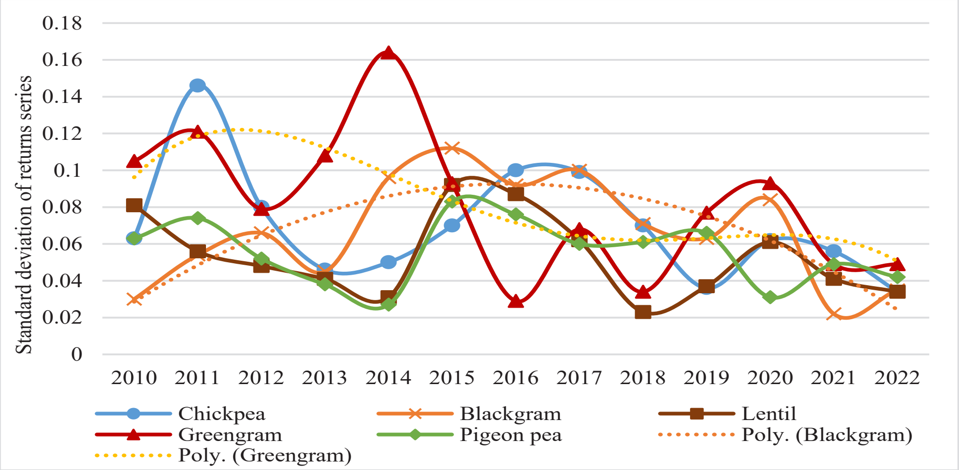
India is the largest producer, importer, and consumer of pulses. Pulses are grown mostly under rainfed conditions; hence, their production depends on rainfall. Domestic production of pulses in India is short of their demand, leading to their imports. Volatility in prices of pulses is, thus, a complex interplay of several demand- and supply-side factors.

5.1 Trend in price volatility of pulses

Figure 5.1 presents the annual unconditional volatility in the prices of pulses. Interestingly, volatility in prices of different pulses is not significantly different. It ranges between 0.06 for lentils and 0.09 for greengram. A similar pattern is observed in conditional price volatility.

Nevertheless, there is a significant fluctuation in annual price volatility. Between 2010 and 2022, unconditional volatility varied from 0.03 to 0.15 for chickpea, 0.02 to 0.11 for blackgram, 0.02 to 0.09 for lentils, 0.03 to 0.16 for greengram, and 0.03 to 0.08 for pigeon pea. Conditional price volatility also shows a similar pattern. Pair-wise correlation coefficients are pretty high: 0.57 for lentil-pigeon pea, 0.53 for chickpea-pigeon pea, 0.40 for chickpea-lentil, 0.34 for blackgram-lentil, -0.33 for greengram-pigeon pea and 0.25 for chickpea-blackgram. The correlation coefficient indicates a high probability of their substitution.

Figure 5.1. Trend in unconditional price volatility of pulses



Prices of pulses were highly volatile until 2015-16. Prices of greengram and blackgram have been more volatile than others. The recent decline in price volatility is attributed to the significant increase in their production, from 16.32 million tons in 2015-16 to 26.06 million tons in 2022-23. The cobweb phenomenon is prominent in pulses, i.e., prices in previous year significantly affect farmers' current year production decisions.

Table 5.1. Inter-market differences in price volatility of pulses

Chickpea		Lentil		Blackgram		Greengram		Pigeon pea	
Market	Volatility	Market	Volatility	Market	Volatility	Market	Volatility	Market	Volatility
Alwar	0.070	Banda	0.077	Lalitpur	0.079	Akola	0.105	Akola	0.071
Bidar	0.087	Ganjbasoda	0.062	Kota	0.088	Amreli	0.100	Jalna	0.071
Bikaner	0.065	Sagar	0.065	Ajmer	0.096	Gadag	0.136	Latur	0.067
Dewas	0.111	Vidisha	0.060	Akola	0.099	Gulbarga	0.072	Udgir	0.073
Gulbarga	0.075	Narsinghpur	0.059	Jalgaon	0.138	Jalana	0.082	Nagpur	0.079
Ramganj Mandi	0.079			Gulbarga	0.117	Jodhpur	0.137	Washim	0.085
Baran	0.081					Kekri	0.084	Vidisha	0.160
Latur	0.086					Madanganj	0.093	Bhopal	0.113
Hinganghat	0.093					Shegaon	0.123	Jabalpur	0.080
Amrawati	0.253							Kanpur	0.047
Khamgaon	0.081								

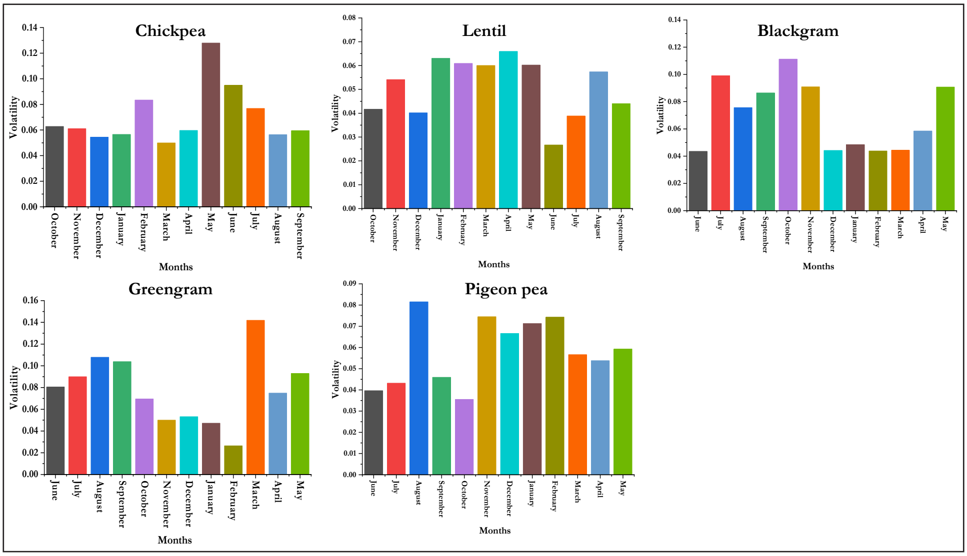
However, price volatility differs across markets (Table 5.1). Volatility in chickpea prices varies from 0.07 in Bikaner and Alwar in Rajasthan to 0.25 in Amrawati in Maharashtra. Volatility in pigeon pea prices is the lowest (0.05) in Kanpur (Uttar Pradesh), and the highest (0.16) in Vidisha (Madhya Pradesh). For greengram, it is the lowest (0.07) in Gulbarga (Karnataka), and the highest (0.14) in Jodhpur (Rajasthan). Prices of blackgram are more volatile in Jalgaon (Maharashtra). However, there is no significant inter-market difference in the volatility of lentil prices.

5.2 Production seasonality and price volatility

Figure 5.2 shows the month-wise unconditional price volatility during 2010 to 2022. There is a significant difference in price volatility across months for all pulses.

Prices of chickpea are less volatile during March-April, the harvest period. However, these are more volatile during May-June. Lentil prices remain volatile most of the time. Prices of blackgram are more volatile during the pre-harvest period from July to November.

Figure 5.2. Seasonality in price volatility of pulses



Greengram prices are highly volatile in March (summer sowing period) and during the rainy season (sowing of Kharif pulses). Pigeon pea prices are more volatile in August and from November to February.

Table 5.2 shows the seasonal gap and its contribution to price volatility. There is a contrast in the seasonal gap of chickpea and pigeon pea, the two major pulses. It is the highest for chickpea, and the lowest for pigeon pea. However, it explains only a fraction of price volatility. One of the reasons for this is that India imports a significant quantity of pulses to moderate the domestic prices.

Table 5.2. Contribution of seasonality in price volatility of pulses

Crops	Seasonal gap (%)	Contribution to volatility (%)
Chickpea	10.474	1.469
Blackgram	4.843	0.246
Lentil	9.103	1.346
Greengram	7.732	1.473
Pigeon pea	2.192	0.082

5.3 Causes of price volatility

5.3.1 Production shocks and market arrivals

Pulses are grown mostly under rainfed conditions in the Rabi as well as in the Kharif season. Only about one-fourth of the pulse-cropped area in the country receives irrigation.

Estimates of the fixed-effects regression are presented in Table 5.3. Rainfall has no significant effect on the prices of most pulses, except lentils. The coefficient on market arrivals is also not significant for most pulses, except greengram. These findings imply that production shocks and market arrivals are not significant determinants of pulses prices, a finding contrary to our expectations.

Month-fixed effects are heterogeneous in their size, direction, and significance. These, however, are not significant for most pulses, except lentils and pigeon pea. Month-fixed effects are negative and significant during harvest and post-harvest months for pigeon pea and summer harvest months of greengram. On the other hand, year-fixed effects are significant and positive, indicating the crucial role of stocks in explaining price volatility. Note that lentils and pigeon pea dominate India's import basket; hence, volatility in their prices is influenced by the timing of imports and available stocks.

Table 5.3. Estimates of fixed effects model for variation in prices of pulses

Variables	Chickpea	Blackgram	Lentil	Greengram	Pigeon pea
Intercept	-0.0054 (0.0178)	-0.0528* (0.0212)	-0.017 (0.0128)	-0.0524** (0.018)	-0.0081 (0.0152)
Rainfall	0.0021 (0.0021)	0.0009 (0.0026)	0.0003 (0.0016)	-0.0014 (0.0021)	0.0031 (0.0018)
Rainfall$_{t-1}$	0.0019 (0.0021)	-0.0047 (0.0026)	0.0033* (0.0016)	-0.0002 (0.0021)	-0.003 (0.0018)
Rainfall$_{t-2}$	0.0022 (0.0021)	0.0015 (0.0026)	0.0005 (0.0016)	0.0026 (0.0021)	-0.0019 (0.0018)
Rainfall$_{t-3}$	-0.0003 (0.0021)	-0.0001 (0.0026)	0.0019 (0.0016)	0.002 (0.0021)	-0.0027 (0.0018)
Arrival	-0.0002 (0.0023)	0.0059 (0.0031)	-0.001 (0.0026)	0.0073*** (0.0021)	-0.0004 (0.0018)
Markets					
Amrawati	-0.0011 (0.0121)	Akola -0.0016 (0.0116)	Ganjbasoda 0.0004 (0.0062)	Amreli 0.0004 (0.0113)	Bhopal -0.0001 (0.009)
Baran	0.0008 (0.0121)	Gulbarga 0.0032 (0.0124)	Narsinghpur 0.0004 (0.0062)	Bhagat 0.0008 (0.0114)	Jabalpur 0.0023 (0.01)
Buldhana	-0.0034 (0.0123)	Jalgaon 0.0009 (0.0116)	Sagar -0.0009 (0.0062)	Gadag -0.001 (0.0116)	Jalna -0.0003 (0.009)
Bikaner	0.0029 (0.0122)	Kota 0.0009 (0.0117)	Vidisha 0.0008 (0.0062)	Gulbarga -0.0015 (0.0116)	Kanpur 0.0004 (0.009)
Dewas	0.0011 (0.0121)	Lalitpur 0.0026 (0.0117)		Jalna 0.0009 (0.0113)	Latur 0.0019 (0.01)
Gulbarga	-0.0025 (0.0122)			Kekri 0.0002 (0.0114)	Nagpur 0.0023 (0.01)
Hinganghat	-0.0016 (0.0121)			Madanganj -0.0002 (0.0114)	Udgir 0.0021 (0.01)
Khamgaon	0.00 (0.0121)			Shegaon 0.0006 (0.0113)	Vidisha 0.0004 (0.009)
Latur	-0.002 (0.0121)				Madanganj 0.0011 (0.009)
Ramganj Mandi	0.0007 (0.0121)				

Contd.

Table 5.3 contd.

Variables	Chickpea	Blackgram	Lentil	Greengram	Pigeon pea
Months					
February	0.0024 (0.0137)	-0.0162 (0.0172)	-0.0639*** (0.011)	-0.0221 (0.0138)	-0.0281* (0.0119)
March	0.0267 (0.014)	0.0037 (0.0175)	0.0081 (0.011)	-0.0238 (0.0142)	-0.0466*** (0.012)
April	0.0583*** (0.0136)	0.0479** (0.0173)	0.045*** (0.010)	0.0392** (0.0142)	-0.0291* (0.0121)
May	0.0182 (0.0135)	0.0152 (0.017)	-0.0052 (0.01)	-0.0326* (0.0143)	-0.0356** (0.012)
June	-0.0097 (0.0151)	0.0277 (0.0192)	-0.0241* (0.0112)	-0.0654*** (0.016)	-0.0549*** (0.013)
July	0.0434* (0.0177)	0.0183 (0.0224)	-0.0157 (0.0137)	-0.0096 (0.0177)	-0.0206 (0.0156)
August	-0.0008 (0.0196)	0.0349 (0.025)	-0.0344* (0.016)	0.0141 (0.0197)	-0.0126 (0.0173)
September	0.0061 (0.0202)	0.0616* (0.0265)	-0.0398* (0.0165)	-0.0208 (0.0204)	-0.0246 (0.0172)
October	0.0036 (0.0188)	0.0119 (0.0244)	-0.0613*** (0.015)	-0.0066 (0.0186)	-0.0265 (0.0162)
November	-0.0003 (0.0164)	0.0336 (0.0209)	-0.0476*** (0.014)	-0.0155 (0.0163)	-0.024 (0.0143)
December	-0.0473*** (0.014)	-0.003 (0.018)	-0.0393*** (0.011)	-0.0268 (0.0142)	-0.0196 (0.0122)
Years					
2011	0.0115 (0.0146)	0.0339 (0.019)	0.027* (0.0111)	0.0578*** (0.0153)	0.0482*** (0.0125)
2012	-0.0021 (0.0146)	0.0414* (0.019)	0.0404*** (0.0113)	0.0832*** (0.0153)	0.0562*** (0.0125)
2013	-0.0479** (0.015)	0.06** (0.0189)	0.0411*** (0.0111)	0.0676*** (0.0152)	0.0551*** (0.0125)
2014	0.00 (0.0146)	0.06** (0.019)	0.0445*** (0.0111)	0.0802*** (0.0152)	0.0612*** (0.0126)
2015	0.0114 (0.0147)	0.0901*** (0.019)	0.0303** (0.0112)	0.065*** (0.0152)	0.1003*** (0.0126)
2016	0.0296* (0.0146)	-0.0049 (0.019)	0.0076 (0.0111)	0.021 (0.0152)	-0.0017 (0.0125)
2017	-0.0767*** (0.015)	0.0024 (0.019)	-0.0008 (0.0112)	0.066*** (0.0152)	0.0216 (0.0125)
2018	-0.0073 (0.0147)	0.0465* (0.0191)	0.0381*** (0.0112)	0.0667*** (0.0154)	0.0532*** (0.0125)
2019	-0.0211 (0.0146)	0.0562** (0.0189)	0.0412*** (0.0112)	0.0749*** (0.0152)	0.0524*** (0.0125)
2020	-0.0124 (0.0147)	0.046* (0.019)	0.0334** (0.0111)	0.0449** (0.0153)	0.0578*** (0.0126)
2021	-0.0142 (0.0147)	0.0326 (0.019)	0.0497*** (0.0112)	0.0669*** (0.0152)	0.0475*** (0.0126)
2022	-0.0175 (0.0146)	0.0447* (0.019)	0.0169 (0.0111)	0.0713*** (0.0152)	0.0607*** (0.0125)
R^2	0.1208	0.1036	0.2599	0.1204	0.107

Note: Standard error in parentheses. *, **, and *** denote significance at 10, 5, and 1%, respectively.

5.3.2 Internal trade and market integration

The error correction term (ECT) is negative and significant for most pulses (Table 5.4). For chickpea, the speed of adjustment is relatively high (>75%) in Alwar and Baran (Rajasthan) and Dewas (Madhya Pradesh), followed by Latur, Khamgaon, Hinganghat (Maharashtra), and Gulbarga in Karnataka (44-50%). For pigeon pea, Vidisha (Madhya Pradesh) and Akola (Maharashtra) markets are more efficient, where 50-70% of the long-term price disequilibrium gets corrected within a month. Prices of greengram get corrected faster in Akola (Maharashtra), Jodhpur (Rajasthan) and Jalana (Maharashtra). For other pulses, the speed of price adjustment is low. The speed of adjustment is faster in markets where either price is more volatile or market arrivals are higher.

Table 5.4. Speed of error correction in pulses markets

Chickpea		Blackgram		Lentil		Greengram		Pigeon pea	
Markets	**ECT**	**Markets**	**ECT**	**Markets**	**ECT**	**Markets**	**ECT**	**Markets**	**ECT**
Alwar	-0.846*** (0.214)	Lalitpur	-0.310** (0.114)	Banda	-0.249 (0.199)	Akola	-0.656*** (0.157)	Akola	-0.530 (0.279)
Bidar	-0.329** (0.098)	Kota	-0.302* (0.145)	Ganjbasoda	-0.333 (0.334)	Amreli	-0.398*** (0.111)	Jalna	-0.469* (0.190)
Bikaner	-0.211 (0.175)	Ajmer	-0.414** (0.125)	Sagar	-0.437* (0.193)	Gadag	-0.382*** (0.094)	Latur	-0.124 (0.176)
Dewas	-0.733** (0.223)	Akola	-0.076 (0.115)	Vidisha	-0.318 (0.202)	Gulbarga	-0.269** (0.096)	Udgir	-0.446* (0.211)
Gulbarga	-0.465** (0.160)	Jalgaon	-0.413*** (0.111)	Narsinghpur	-0.666 (0.403)	Jalana	-0.477** (0.161)	Nagpur	-0.260 (0.229)
Ramganj Mandi	-0.287 (0.247)	Gulbarga	-0.241* (0.094)			Jodhpur	-0.650*** (0.138)	Washim	-0.471 (0.285)
Baran	-0.746* (0.289)					Kekri	-0.304*** (0.076)	Vidisha	-0.692*** (0.133)
Latur	-0.494 (0.301)					Madanganj	-0.113* (0.045)	Bhopal	-0.362*** (0.080)
Hinganghat	-0.443* (0.207)					Shegaon	-0.095 (0.083)	Jabalpur	-0.391* (0.183)
Amrawati	-0.241** (0.090)							Kanpur	-0.256*** (0.063)
Khamgaon	-0.490* (0.245)								

Note: Standard error in parentheses. *, **, and *** denote significance levels at 10, 5, and 1%, respectively.

Imports accounted for 15-22% of the total domestic availability of pulses during 2011-12 to 2017-18, which declined to 10% afterward. India depends on a few countries for pulses import. Hence, the quantity of imports and the timings affect domestic prices and speed of price adjustment. The hoarding by processors and other market intermediaries also influences the speed of adjustment (Abraham and Pingali 2021).

5.3.3 Government interventions

The Government of India maintains buffer stocks of pulses for price stabilization. Pulses are procured under the Price Stabilization Fund (PSF) and Price Support Scheme (PSS). The government also imposes stock limits under the Essential Commodities Act 1955 to discourage hoarding.

India's pulses trade policy is anchored to providing affordable access to consumers and protecting farmers from cheap imports. India has been chronically deficient in pulses, and most of the time, import tariffs on these have been kept low (Roy et al. 2022). However, after a significant increase in their production in 2016-17, pulses imports have been restricted, and tariffs have been raised. Restrictions on exports have also been lifted (Table 5.5). Frequent changes in import quotas and tariffs are the commonly used instruments to rein in pulses inflation.

Table 5.5. Trade policy changes for pulses

Year	Pulses trade policy
2006-2017	No import duty (June 2006 to February 2017) April 2008: Prohibition on exports of Pulses (except Kabuli Chana), extended every year until 2016 March 2011: Prohibition on exports of Pulses exempted for 10,000 tonnes of organic pulses & lentils, extended to 50,000 MT in April 2017 Jan 2016: Permitted export of Roasted Gram (whole/split) in consumer packs of 1 Kg
2016-17	10% import duty on lentils and pigeon pea in March 2017
2017-18	August 2017: 200,000 tons import quota for pigeon pea August 2017: 300,000 tons import quota for blackgram and greengram (150,000 tons each) November 2017: Import duty on peas increased to 50% November 2017: All varieties of pulses, including organic pulses, made 'free' for export without any quantitative ceilings December 2017: Import duties on lentils and chickpea increased to 30% February 2018: Import duty on chickpea further increased to 40% March 2018: Import duty on desi chickpea increased to 60%, 40% on Kabuli chickpea
2018-19	Quota restriction (QR) on blackgram and greengram: 150,000 tons each QR on pigeon pea: 200,000 tons QR on peas: 100,000 tons June 2018: Import duty on Kabuli and desi chickpea increased to 60%, and on lentils to 30%
2019-20	April 2019: Restricted import of peas and pulses QR on peas, blackgram and greengram: 150,000 tons QR increased to 400,000 tons on blackgram in December 2019 QR on pigeon pea: 200,000 tons, and increased to 400,000 tons in July 2019 June 2019: Basic import duty on lentils increased to 50%.

Contd.

Table 5.5 contd.

Year	Pulses trade policy
2020-21	QR on peas and greengram: 150,000 tons each QR on pigeon pea and blackgram: 400,000 tons each June 2020: Basic import duty on lentils reduced to 10% (June to August 2020) February 2021: imposed–AIDC: chickpea 50%, bengal gram 30%, kabuli Chana 50%, Yellow peas 40%, lentils 20%.
2021-22	QR on greengram: 150,000 tons QR on pigeon pea: 400,000 tons QR on blackgram: 400,000 tons Import policy: QR removed on greengram, blackgram and pigeon pea) up to 31.10.2021, but import duty remained July 2021: Basic import duty on lentils reduced to zero, AIDC lowered from 20% to 10%, Social Welfare surcharge of 10% remained unchanged
2022-23	March 2022: Import policy: No QR on blackgram and pigeon pea up to 31.03.2023, subject to existing import duties, and further extended up to 31.03.2024 in December 2022.

Note: AIDC: Agriculture Infrastructure Development Cess; Quantitative restrictions do not apply to Governments' import commitments under any Bilateral or Regional Agreement or Memorandum of Understanding.

Source: Sharma et al. 2023.

6 Volatility in Prices of Oilseeds

India is the fifth-largest producer of oilseeds and the largest importer of edible oils. Its dependence on imports has increased from 44% of the domestic demand in 2010-11 to more than two-thirds in 2015-16. Still, it imports more than half of its edible oils requirement.

6.1 Trend in price volatility of oilseeds

The annual unconditional price volatility from 2010 to 2022 is the highest for groundnut and the lowest for safflower and mustard (Figure 6.1). Groundnut prices are more than twice as volatile than of safflower and mustard. A similar pattern is observed in conditional price volatility.

Figures 6.1 and 6.1A (in the appendix) show the trend in price volatility. Throughout the years, prices of groundnut and soybean have been more volatile than others. Pair-wise correlation coefficient is higher for soybean-mustard (0.46), groundnut-mustard (0.38), soybean-sunflower (0.32), and sunflower-safflower/ mustard/ soybean (0.30), and insignificant for groundnut-safflower (0.01) and soybean-groundnut (0.03). This indicates considerable substitution between different edible oils.

Figure 6.1. Trend in unconditional price volatility of oilseeds

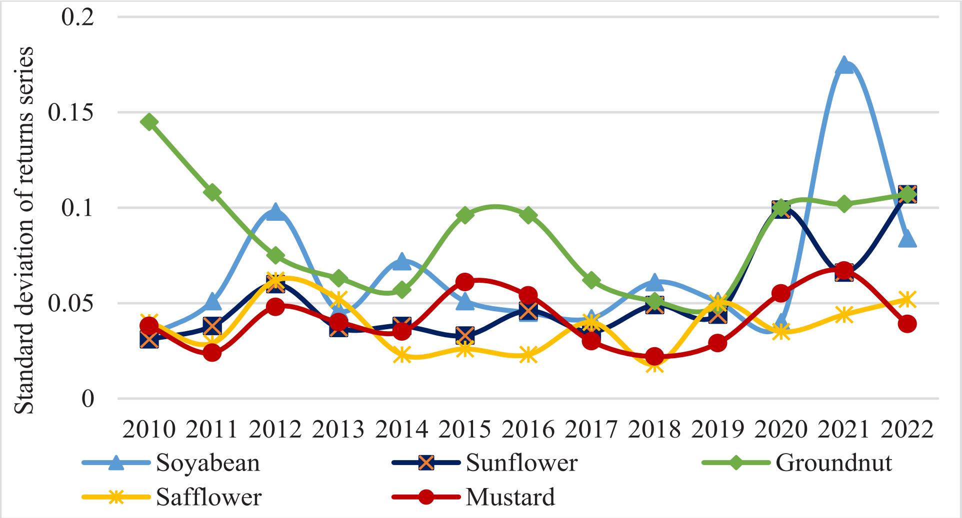


Table 6.1 shows the price volatility in different markets. It varies significantly across markets for most crops. For soybean, it ranges from 0.08 in Karanja and Latur (Maharashtra) to 0.15 in Bhawani Mandi (Rajasthan), for groundnut from 0.06 in Rajkot (Gujarat) to 0.14 in Tirukovilur (Tamil Nadu), for sunflower from 0.06 in Bellary (Karnataka) to 0.11 in Mundragi (Karnataka) and for safflower from 0.03 in Latur (Maharashtra) to 0.10 in Bellary (Karnataka). There is no significant inter-market difference in volatility in mustard prices.

Table 6.1. Inter-market differences in price volatility of oilseeds

Soybean		Sunflower		Groundnut		Safflower		Mustard	
Market	**Volatility**	**Market**	**Volatility**	**Market**	**Volatility**	**Market**	**Volatility**	**Market**	**Volatility**
Latur	0.079	Mundragi	0.105	Gondal	0.066	Gadag	0.064	Baran	0.047
Khamgaon	0.083	Bellary	0.061	Rajkot	0.062	Bellary	0.100	Kota	0.044
Amrawati	0.093	Gadag	0.094	Himmatnagar	0.093	Gulbarga	0.046	Niwai	0.048
Karanja	0.076	Rennebenur	0.099	Bikaner	0.075	Latur	0.032	Satna	0.044
Kota	0.078	Lingasugur	0.063	Chomu	0.087			Tonk	0.046
Baran	0.077	Kushtagi	0.067	Tirukovilur	0.135			Srigangnagar	0.045
Bhawani Mandi	0.151							Kherli	0.048
Ujjain	0.084							Khairthal	0.049
Dewas	0.081							Alwar	0.050

Note: Vol. denotes unconditional price volatility.

6.2 Production seasonality and price volatility

Figure 6.2 presents the monthly unconditional price volatility. Soybean prices are more volatile in October, the harvest month. Weather aberrations during the harvest season affect its production forecasts, and therefore prices. Groundnut prices are more volatile during the pre-harvest period.

Mustard prices are more volatile in December-January (pre-harvest) and March-May (post-harvest). Sunflower prices are more volatile in August-September (pre-Kharif harvest), December and March (pre-Rabi harvest). Price volatility is higher for safflower during October (sowing period) and February to April (harvest period).

Seasonal gap and contribution of seasonality to volatility are higher for groundnut, mustard, and soybean (Table 6.2). Seasonality explains 7% of the variability in groundnut prices and 3% in mustard prices.

Figure 6.2. Seasonality in price volatility of oilseeds

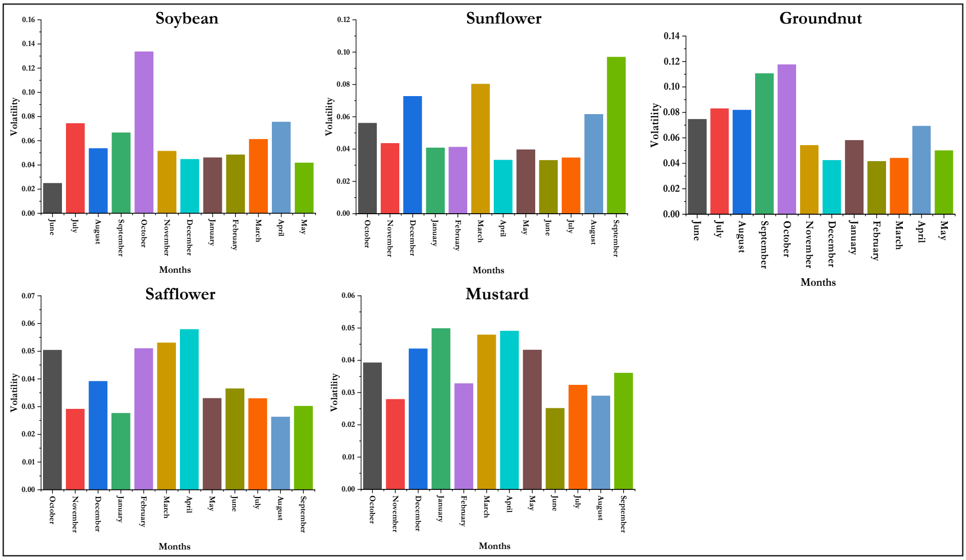


Table 6.2. Contribution of seasonality in price volatility of oilseeds

Crops	Seasonal Gap (%)	Contribution to volatility (%)
Soybean	9.584	1.126
Sunflower	2.863	0.151
Groundnut	17.995	6.933
Safflower	3.259	0.211
Mustard	13.650	2.667

6.3. Causes of price volatility

6.3.1 Production shocks and market arrivals

Effects of rainfall and market arrivals on prices estimated by applying the fixed effects regression are presented in Table 6.3. Rainfall has a differential impact on the prices of different oilseeds. The current month's rainfall and its three-month lag do not significantly affect prices. A one-month lag of rainfall has no effect on the prices of soybean and mustard, while it has a negative but weak effect on prices of sunflower and safflower. Its effect is negative and significant for groundnut. Two-month lagged rainfall positively and significantly affects groundnut and soybean prices.

Expectedly, soybean prices are negatively and significantly associated with market arrivals. On the other hand, the effect of market arrivals is positive and significant on the prices of sunflower, safflower, and groundnut, which is counter-intuitive.

Table 6.3. Estimates of fixed effects model for variation in prices of oilseeds

Variables	Soybean	Sunflower	Groundnut	Safflower	Mustard
Intercept	0.0443** (0.0149)	0.0567* (0.0221)	0.0189 (0.0184)	0.0193 (0.0191)	-0.0201** (0.0069)
Rainfall	-0.0032 (0.0019)	0.0006 (0.0029)	-0.0031 (0.0021)	0.0008 (0.0024)	0.0017* (0.0008)
$Rainfall_{t-1}$	0.0008 (0.0019)	-0.0069* (0.0029)	-0.0082*** (0.002)	-0.0053* (0.0024)	-0.0004 (0.0008)
$Rainfall_{t-2}$	0.0073*** (0.0019)	0.0007 (0.0029)	0.0074*** (0.0022)	0.0023 (0.0024)	-0.0001 (0.0008)
$Rainfall_{t-3}$	0.0009 (0.0019)	0.0026 (0.0029)	-0.0017 (0.0021)	0.0002 (0.0024)	-0.0005 (0.0008)
Arrival	-0.0093*** (0.002)	0.0073*** (0.0017)	0.0096*** (0.0018)	0.0066** (0.0024)	-0.0012 (0.0014)

Markets

Baran	0.0009 (0.0094)	Gadag 0.001 (0.0094)	Chomu 0.0067 (0.0105)	Gadag 0.0012 (0.0075)	Baran 0.00 (0.0045)
Bhawani Mandi	0.0018 (0.0094)	Kushtagi 0.0002 (0.0094)	Gondal 0.00 (0.0098)	Gulbarga 0.0021 (0.0075)	Khairthal -0.0005 (0.0045)
Karanja	-0.0007 (0.0094)	Lingasugur 0.001 (0.0095)	Himmatnagar 0.0021 (0.0099)	Latur 0.0002 (0.0075)	Kherli -0.0001 (0.0045)
Khamgaon	0.0007 (0.0094)	Mundragi 0.0006 (0.0094)	Rajkot -0.0002 (0.0098)		Kota -0.0002 (0.0045)
Kota	0.0005 (0.0094)	Rennebenur -0.0003 (0.0096)	Tirukovilur 0.0101 (0.011)		Niwai 0.00 (0.0045)
Latur	-0.0016 (0.0095)				Satna 0.0004 (0.0045)
Dewas	0.0013 (0.0094)				Srigangnagar 0.0003 (0.0045)
Ujjain	-0.0002 (0.0094)				Tonk -0.0005 (0.0046)

Months

February	-0.0058 (0.0116)	-0.0128 (0.016)	0.0015 (0.0146)	-0.0354* (0.0148)	-0.0201*** (0.0055)
March	0.0012 (0.0118)	-0.015 (0.019)	0.0193 (0.0148)	0.0032 (0.0164)	-0.008 (0.0061)
April	0.0291 (0.0116)*	-0.0172 (0.0209)	0.0305* (0.015)	-0.0086 (0.0177)	0.0466*** (0.0054)
May	-0.0181 (0.0115)	-0.0046 (0.0224)	0.0117 (0.015)	0.0069 (0.0176)	0.0449*** (0.0053)
June	-0.0379 (0.013)**	-0.0041 (0.023)	0.0199 (0.0164)	-0.0012 (0.0187)	0.0274*** (0.0056)
July	-0.0094 (0.0159)	0.001 (0.0225)	0.0441* (0.0177)	-0.0064 (0.0189)	0.0379*** (0.0062)
August	-0.0416* (0.0178)	0.0014 (0.0231)	0.0193 (0.0186)	0.0023 (0.0198)	0.032*** (0.0066)
September	-0.0992*** (0.018)	-0.0043 (0.0235)	-0.0122 (0.0191)	-0.0061 (0.02)	0.0215** (0.0067)
October	-0.1356*** (0.017)	-0.025 (0.0234)	-0.0017 (0.0186)	0.0021 (0.0197)	0.0328*** (0.0068)
November	-0.0095 (0.0146)	-0.0052 (0.0201)	-0.0338* (0.0162)	0.0093 (0.0171)	0.0447*** (0.0064)
December	-0.0246* (0.0123)	-0.0114 (0.0158)	0.0125 (0.0148)	-0.0108 (0.0146)	0.0166** (0.0058)

Years

2011	-0.0197 (0.0127)	-0.0366* (0.0157)	-0.0064 (0.0162)	0.0028 (0.0151)	0.0112 (0.0061)
2012	-0.0018 (0.0126)	-0.0355* (0.0157)	0.0145 (0.0163)	0.0179 (0.015)	0.0178** (0.0061)
2013	-0.0183 (0.0126)	-0.0436** (0.0156)	-0.054*** (0.0162)	-0.0217 (0.0151)	-0.0183** (0.0061)
2014	-0.0395** (0.0127)	-0.0428** (0.0155)	-0.0075 (0.0162)	-0.0244 (0.0151)	0.0046 (0.0061)
2015	-0.0238 (0.0128)	-0.0322* (0.0155)	-0.0048 (0.0162)	-0.0097 (0.0151)	0.0103 (0.0062)

Contd.

Table 6.3 contd.

Variables	Soybean	Sunflower	Groundnut	Safflower	Mustard
2016	-0.0475*** (0.013)	-0.0484** (0.016)	-0.0227 (0.0163)	-0.0056 (0.015)	-0.013* (0.0061)
2017	-0.0272* (0.0126)	-0.0517*** (0.0156)	-0.0262 (0.0162)	0.00 (0.015)	-0.0124* (0.0061)
2018	-0.0167 (0.0127)	-0.0174 (0.0157)	-0.014 (0.0163)	-0.0021 (0.015)	-0.0018 (0.0061)
2019	-0.0121 (0.0126)	-0.0398* (0.0155)	-0.0084 (0.0161)	0.0017 (0.015)	0.0041 (0.0061)
2020	-0.0259* (0.0127)	-0.0124 (0.0155)	-0.0107 (0.0162)	-0.0185 (0.0151)	0.0155* (0.0061)
2021	0.0029 (0.0127)	-0.0417** (0.0155)	-0.0078 (0.0161)	0.0093 (0.0151)	0.0199** (0.0061)
2022	-0.0445*** (0.013)	-0.0271 (0.0157)	-0.008 (0.0162)	-0.0069 (0.0151)	-0.0165** (0.0061)
R^2	0.2282	0.0727	0.1215	0.074	0.2958

Note: Standard error in parentheses. *, **, and *** denote significance levels at 10, 5, and 1%, respectively.

Month-fixed effects are insignificant except for mustard during the post-harvest period (April to December) and soybean from sowing until harvest. Year-fixed effects are negative and significant for soybean and sunflower. These are insignificant for groundnut, and positive as well as negative for mustard. Mostly, year-fixed effects are negative during higher production levels.

6.3.2 Internal trade and market integration

The speed of price adjustment of oilseeds is shown in Table 6.4. As expected, the coefficient of ECT is negative in most markets. However, there is a significant inter-market difference. For soybean, it ranges from 7% in Dewas (Madhya Pradesh) to 83% in Bhawani Mandi (Rajasthan). On the other hand, sunflower prices get corrected at a faster rate of 41 to 129%. However, the speed of adjustment is slow for safflower (29-36%) and groundnut (6-54%). The ECT for mustard is negative but not significant. As in the case of other commodities, the speed of adjustment is related to market arrivals and the degree of price volatility.

Table 6.4. Speed of error correction in oilseeds markets

Soybean		Sunflower		Groundnut		Safflower		Mustard	
Markets	ECT	Markets	ECT	Markets	ECT	Markets	ECT	Markets	ECT
Latur	-0.251*** (0.092)	Mundragi	-1.288*** (0.149)	Gondal	0.070 (0.059)	Gadag	-0.290** (0.098)	Baran	-0.585 (0.316)
Khamgaon	-0.112* (0.049)	Bellary	-0.428** (0.150)	Rajkot	-0.053 (0.066)	Bellary	-0.358*** (0.102)	Kota	-0.097 (0.253)
Amrawati	-0.106 (0.116)	Gadag	-0.414** (0.128)	Himmatnagar	-0.543*** (0.110)	Gulbarga	-0.290*** (0.081)	Niwai	-0.409 * (0.177)
Karanja	0.029 (0.026)	Rennebenur	-0.442*** (0.115)	Bikaner	-0.063** (0.021)	Latur	-0.075 (0.045)	Satna	-0.219 (0.117)
Kota	0.137 (0.084)	Lingasugur	-0.168 (0.080)	Chomu	0.007 (0.023)			Tonk	-0.064 (0.259)

Contd.

Table 6.4 contd.

Soybean		Sunflower		Groundnut		Safflower		Mustard	
Markets	**ECT**	**Markets**	**ECT**	**Markets**	**ECT**	**Markets**	**ECT**	**Markets**	**ECT**
Baran	-0.792** (0.274)	Kushtagi	-0.602*** (0.123)	Tirukovilur	-0.181* (0.072)			Srigangnagar	0.044 (0.219)
Bhawani Mandi	-0.834** (0.180)							Kherli	-0.261 (0.263)
Ujjain	-0.143 (0.078)							Khairthal	-0.353 (0.182)
Dewas	-0.073* (0.033)							Alwar	-0.826* (0.335)

Note: Standard error in parentheses. *, **, and *** denote significance levels at 10, 5, and 1%, respectively.

Note that India is a chronic importer of edible oils, especially palm oil, which is often used to blend other edible oils. Hence, the timing of imports and the quantity imported significantly influence the speed of adjustment in oilseed prices. Besides, inventory holding by processing firms also influences the speed of adjustment (Bathla and Srinivasulu 2011).

6.3.3 Government interventions

India imports huge quantities of edible oils; hence, imports significantly impact price volatility. The import policy is tweaked as per the domestic requirement through changes in import tariffs. The changes have become more frequent in recent years, affecting domestic prices of edible oils, hence prices of oilseeds.

The export of edible oils was banned in March 2008 and extended time and again. The export of groundnut, sesame, and soybean oils was allowed in March 2017. Export of all edible oils, except mustard oil, was made tariff-free and without quantitative ceiling and pack size in April 2018. Mustard oil exports were permitted in packs of up to 5 Kg with a Minimum Export Price (MEP) of US$ 900/ton. Imports of edible oils are under the Open General License.

Fluctuating production of oilseeds, increasing demand, and high import dependence have added to price volatility. Further, the production and market conditions of oilseeds in exporting countries and other importing countries influence the domestic prices of oilseeds.

7 Volatility in Prices of Cereals

Rice, wheat, and maize are the dominant cereals in production as well as consumption. Rice and wheat are used primarily as food, and maize as poultry feed and starch. Hence, these commodities are at the center of India's agri-food policy.

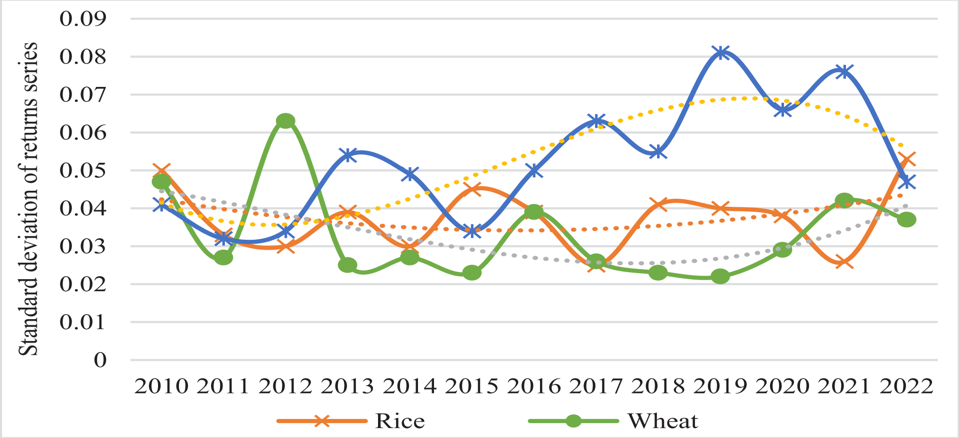
7.1 Trend in price volatility of cereals

Figure 7.1 presents the mean unconditional volatility in rice, wheat, and maize prices. Cereals have the lowest price volatility amongst the 19 food commodities studied in this paper. However, maize prices are more volatile than other rice and wheat prices. A similar pattern is observed in conditional price volatility.

Price volatility is highly fluctuating for maize, followed by wheat. For maize, it ranges between 0.03 to 0.08. Notably, volatility in maize prices has increased significantly after 2015. On the other hand, volatility in prices of rice and wheat has remained steady.

The pair-wise correlation coefficient of prices is highly negative for wheat-maize (-0.31), followed by rice-maize (-0.25) and rice-wheat (-0.06). Rice and wheat are primarily consumed as food; hence, there is considerable substitution between them.

Figure 7.1. Trend in unconditional price volatility of cereals



Relatively low volatility in prices of rice and wheat is due to government intervention. The Government of India procures a significant proportion of rice and wheat output at their pre-announced minimum support prices (MSP) for public distribution and buffer stocking for price stabilization. Note that the MSP acts as a floor price. The MSP is announced for maize also, but it is not procured. Thus, MSP without procurement is not effective in checking volatility in food prices.

There is considerable inter-market difference in price volatility (Table 7.1). For rice, it ranges from 0.02 in Behraich (Uttar Pradesh) to 0.30 in Navrangpur (Odisha). Volatility in maize prices varies from 0.06 in Haveri and Bellary (Karnataka) and 0.11 in Shimoga (Karnataka). On the other, price volatility in wheat is almost similar in all markets.

Table 7.1. Inter-market differences in price volatility of cereals

Rice		Wheat		Maize	
Market	**Volatility**	**Market**	**Volatility**	**Market**	**Volatility**
Burdwan	0.027	Shahjahanpur	0.050	Haveri	0.057
Murshidabad	0.026	Kheri Lakhimpur	0.043	Davangere	0.061
Kolkata	0.042	Hardoi	0.040	Bellary	0.059
Darjiling	0.128	Kota	0.037	Hassan	0.107
Shahjahanpur	0.031	Agra	0.041	Shikaripura	0.077
Sitapur	0.018	Lalitpur	0.046	Shimoga	0.114
Mayurbhanj	0.065	Satna	0.041	Indore	0.086
Jangipur	0.041	Baran	0.040		
Mainpuri	0.018	Bundi	0.044		
Kanpur Grain	0.037	Srigangnagar	0.042		
Behraich	0.019	Hanumangarh	0.044		
Kalahandi	0.06	Ratlam	0.052		
Bolangir	0.035	Ujjain	0.049		
Navrangpur	0.304	Vidisha	0.052		
Puri	0.040				

7.2 Production seasonality and price volatility

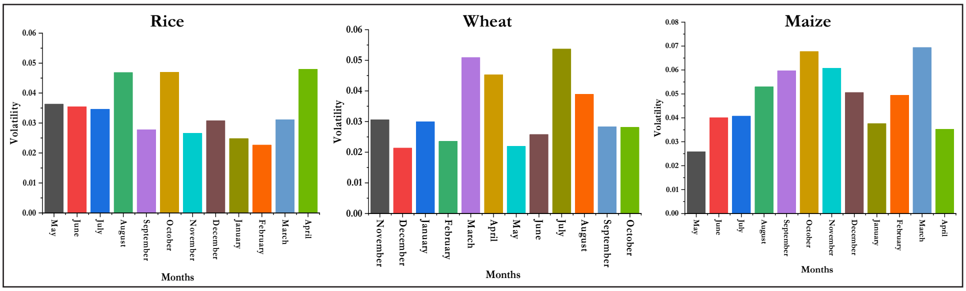
In India, rice is grown in three seasons: Kharif, Rabi, and Zaid (summer). Kharif rice is sown from May to July and harvested from September to November. Kharif rice accounts for 85% of the total rice production. Rabi rice is sown from November to January and harvested in April to May. Rice prices are more volatile from April to August and October (Figure

7.2). The quantum of rainfall and its spatial distribution affect rice sowing, hence price expectations.

Wheat is a Rabi crop sown during November-December and harvested during March-April. Volatility in wheat prices is higher during the harvest and post-harvest months (July-August). Higher price volatility during harvest can be attributed to terminal heat stress, which influences its production and price expectations.

Kharif maize, sown in June-July and harvested from September to November, contributes nearly 65% to the production of maize. Rabi maize, sown during October-November and harvested in February-March, accounts for the rest. Maize prices are volatile during February-March (Rabi harvest) and August to December (Kharif harvest). Persistently high volatility in maize prices could be due to inventory holding by feed and starch manufacturers.

Figure 7.2. Seasonality in price volatility of cereals



The seasonal gap and contribution of seasonality to price volatility are presented in Table 7.2. Maize has the highest seasonal gaps (8.85%), and wheat has the lowest (5.45%). However, seasonality does not explain much of the price volatility in any cereal crop.

Table 7.2. Contribution of seasonality in price volatility of cereals

Crops	Seasonal Gap (%)	Contribution to volatility (%)
Rice	5.510	0.992
Wheat	5.454	1.029
Maize	8.854	1.840

7.3 Causes of price volatility

7.3.1 Market arrivals and production shocks

Results of the fixed effects regression are presented in Table 7.3. The current month's rainfall has no significant effect on prices. Its lagged effects are also insignificant, except for a three-month lag in the case of wheat and maize. Rice and wheat are grown under irrigated conditions; hence, rainfall has a negligible effect on price volatility. About 65% of the rice and 96% of the wheat area is irrigated. The proportion of maize irrigated area is only 29%.

Expectedly, prices are negatively associated with market arrivals, but the association is significant for maize only. Market-fixed effects are also not significant. This is because of the considerable government intervention in rice and wheat markets. Month-fixed effects are negative and significant for wheat, particularly during the harvest and post-harvest periods. Month-fixed effects for rice are insignificant. Year-fixed effects are significant for wheat.

Table 7.3. Estimates of fixed effects model for variation in prices of cereals

Variables	Rice	Wheat	Maize
Intercept	0.0169 (0.0143)	0.0139* (0.006)	0.0338 (0.0183)
Rainfall	0.002 (0.0015)	0.0011 (0.0007)	0.0012 (0.0023)
$Rainfall_{t-1}$	-0.0008 (0.0015)	-0.0005 (0.0007)	-0.0028 (0.0023)
$Rainfall_{t-2}$	0.0009 (0.0015)	-0.0013 (0.0007)	0.0029 (0.0023)
$Rainfall_{t-3}$	-0.0015 (0.0015)	0.0017* (0.0007)	-0.0045* (0.0022)
Arrival	-0.005 (0.003)	-0.0008 (0.0008)	-0.0045* (0.0019)
Markets			
Bolangir	0 (0.0107)	Baran -0.0003 (0.0046)	Davangere 0.001 (0.009)
Burdwan	-0.0019 (0.0108)	Bundi -0.0009 (0.0046)	Hassan 0.0004 (0.0097)
Darjiling	-0.0046 (0.0112)	Hanumangarh 0.00 (0.0046)	Haveri -0.0002 (0.0092)
Jangipur	0.0008 (0.0107)	Hardoi -0.0005 (0.0046)	Indore -0.0038 (0.0093)
Kalahandi	0.001 (0.0107)	Kheri Lakhimpur -0.0013 (0.0047)	Sikaripura 0.002 (0.0098)
Kanpur	-0.0016 (0.0108)	Kota -0.0015 (0.0046)	Shimoga 0.0025 (0.0098)
Kolkata	-0.0029 (0.0109)	Lalitpur -0.0002 (0.0046)	
Mainpuri	0.0001 (0.0108)	Ratlam -0.0007 (0.0046)	
Mayurbhanj	-0.0003 (0.0109)	Satna -0.0005 (0.0046)	
Murshidabad	-0.0014 (0.0107)	Shahjahanpur 0 (0.0046)	
Navrangpur	-0.0031 (0.0107)	Srigangnagar -0.0002 (0.005)	
Puri	-0.001 (0.0107)	Ujjain -0.0019 (0.0046)	
Shahjahanpur	-0.001 (0.0107)	Vidisha -0.0018 (0.0046)	
Sitapur	-0.0007 (0.0107)		

Contd.

Table 7.3 contd.

Variables	Rice	Wheat	Maize
Months			
February	0.0009 (0.0104)	-0.0192*** (0.0045)	0.0003 (0.0132)
March	-0.0098 (0.0105)	-0.018*** (0.0045)	-0.0214 (0.0149)
April	-0.0089 (0.0104)	-0.0252*** (0.0047)	-0.012 (0.0159)
May	-0.0161 (0.0106)	-0.0085* (0.0043)	-0.0324* (0.0162)
June	-0.0086 (0.0116)	-0.0251*** (0.0047)	-0.0128 (0.017)
July	-0.0181 (0.0127)	-0.0074 (0.0056)	0.0068 (0.0178)
August	0.004 (0.0135)	-0.0009 (0.0063)	-0.0129 (0.0187)
September	-0.0137 (0.0139)	-0.0112 (0.0066)	-0.0343 (0.0189)
October	-0.0063 (0.0132)	-0.0084 (0.0064)	-0.0682*** (0.0183)
November	-0.0082 (0.0119)	0.0119* (0.0057)	-0.0183 (0.0159)
December	-0.0216* (0.0105)	-0.0157** (0.0048)	0.0052 (0.0131)
Years			
2011	-0.0094 (0.0111)	-0.0152** (0.0049)	0.008 (0.0138)
2012	0.001 (0.0111)	0.0217*** (0.0049)	0.0112 (0.014)
2013	0.0015 (0.0111)	0.0025 (0.0049)	-0.0189 (0.0138)
2014	-0.0067 (0.0111)	-0.0113* (0.005)	-0.0128 (0.0138)
2015	-0.0091 (0.011)	-0.0017 (0.005)	0.0159 (0.0138)
2016	-0.0016 (0.0111)	0.0087 (0.0049)	-0.0098 (0.0142)
2017	-0.0148 (0.0111)	-0.0156** (0.0049)	-0.0209 (0.0139)
2018	0.0007 (0.0111)	0.0091 (0.0049)	0.0151 (0.0139)
2019	-0.0024 (0.0111)	-0.001 (0.0049)	0.0046 (0.0138)
2020	-0.0111 (0.0111)	-0.0236*** (0.005)	-0.0357** (0.0138)
2021	-0.0071 (0.0111)	0.0096 (0.005)	0.008 (0.0139)
2022	-0.0033 (0.0111)	0.0155** (0.005)	0.0175 (0.0139)
R^2	0.0146	0.1567	0.1289

Note: Standard error in parentheses. *, **, and *** denote significance levels at 10, 5, and 1%, respectively.

7.3.2 Internal trade and market integration

Table 7.4 shows the speed of adjustment of prices. There is a significant difference in the speed of adjustment across markets. For rice, it is as low as 3% in Mainpuri (Uttar Pradesh) and as high as 87% in Navrangpur (Odisha). In other markets, it ranges between 20 to 30%. For wheat, the speed of adjustment is the highest (61%) in Hanumangarh (Rajasthan) and the lowest (18%) in Vidisha (Madhya Pradesh). The speed of adjustment in maize prices ranges between 24% to 78%. Price adjustment is faster in larger markets.

Table 7.4. Speed of error correction in cereals markets

Rice		Wheat		Maize	
Markets	**ECT**	**Markets**	**ECT**	**Markets**	**ECT**
Burdwan	-0.175** (0.061)	Shahjahanpur	-0.561** (0.204)	Haveri	-0.236* (0.118)
Murshidabad	-0.211** (0.063)	Kheri Lakhimpur	-0.507*** (0.145)	Davangere	-0.682*** (0.184)
Kolkata	-0.261*** (0.071)	Hardoi	-0.396* (0.176)	Bellary	-0.080 (0.145)
Darjiling	-0.463*** (0.097)	Kota	-0.315 (0.192)	Hassan	-0.780*** (0.145)
Shahjahanpur	-0.263** (0.082)	Agra	-0.442** (0.168)	Shikaripura	-0.496*** (0.109)
Sitapur	-0.281*** (0.065)	Lalitpur	-0.369** (0.130)	Shimoga	-0.524*** (0.109)
Mayurbhanj	-0.410*** (0.095)	Satna	-0.386** (0.124)	Indore	-0.423*** (0.103)
Jangipur	-0.421*** (0.115)	Baran	-0.222 (0.152)		
Mainpuri	-0.030 (0.037)	Bundi	-0.324 (0.188)		
Kanpur	-0.285* (0.111)	Srigangnagar	-0.309 (0.157)		
Behraich	-0.229** (0.076)	Hanumangarh	-0.610*** (0.174)		
Kalahandi	-0.208** (0.067)	Ratlam	-0.455* (0.181)		
Bolangir	-0.219** (0.070)	Ujjain	-0.486*** (0.129)		
Navrangpur	-0.865*** (0.158)	Vidisha	-0.182* (0.077)		
Puri	-0.243*** (0.057)				

Note: Standard error in parentheses. *, **, and *** denote significance levels at 10, 5, and 1%, respectively.

Studies have reported that the collusive behavior of traders and hoarding lead to the discovery of non-transparent prices (Banerji and Meenakshi 2004; 2008). Jha et al. (2005) and Shekhar (2012) reported incomplete integration of rice markets due to inter-state movement restrictions and excessive government interference. Government interventions in rice and wheat markets, in terms of procurement at MSP and of stock limits, influence the speed of adjustment.

7.3.3 Government interventions

India is the largest rice exporter, accounting for around 40% of global exports. India follows an on-and-off trade policy as a knee-jerk reaction to domestic prices (Subramanian, 2014), causing uncertainties in domestic and international markets. The trade policy changes for cereals are given in Table 7.5.

Table 7.5. Trade policy changes for cereals

Period	Policy
	Wheat
2010	09.02.2010: Prohibition on export of wheat and wheat products – exemption for export of 50,000 MT of wheat to Nepal through FCI 12.05.2010: Exemption for export of 4,00,000 MT of wheat to Bangladesh through FCI 06.08.2010: Exemption for export of wheat to Bangladesh through FCI reduced to 2,00,000 MT
2011	28.02.2011: Exemption for export of 1,00,000 MT of wheat to Afghanistan through FCI up to 31.03.2011 20.04.2011: Exemption for export of 32,094.70 MTs wheat flour to Maldives under the Bi-lateral Trade Agreement through MMTC for the year 2011- 12 02.05.2011: Permission to export (as a donation) of 2,50,000 MTs of wheat, in the year 2011-12, to Afghanistan, up to 31.03.2012 07.06.2011: Exemption for export of wheat flour to Maldives for the years 2011-12 (32,095 MT), 2012-13 (35,304 MT) and 2013-14 (38,835 MT) through MMTC 20.07.2011: Validity of extension for export of 6,50,000 tons of wheat products up to 31.03.2012 09.09.2011: Removal of ban on export of wheat 05.12.2011: Exemption of Bhutan from the application of export bans by India on export of Milk Powder, Wheat, Edible Oils, Pulses and Non-Basmati Rice
2012	23.02.2012: Permission for export of wheat through Land Custom Stations (LCS) on Indo-Bangladesh and Indo-Nepal border 02.04.2012: Validity of extension for export of 6,50,000 tons of wheat products up to 31.03.2013
2017	19.04.2017: Exemption of application of quantitative ceiling and export bans on export of organic wheat, non-basmati rice, edible oils, sugar, and enhancement of quantitative ceiling on export of pulses & lentils
2022	13.05.2022: Prohibition on export of wheat with exemptions on food security grounds to neighbouring and other developing countries 06.07.2022: Export Policy of wheat flour (atta) remain 'Free', but export subject to recommendation of Inter-Ministerial Committee (IMC) on export of wheat. The Notification came into effect from 12th of July, 2022. 27.08.2022: Wheat or Meslin Flour (HS Code 1101) is no longer exempted from export restrictions/ ban 25.09.2022: Export of wheat flour (atta) allowed under Advance authorization scheme under the notified Standard Input Output Norms (SION)
2023	23.03.2023: Allow export of Multi Grain atta or Fortified Whole Wheat atta under notified SION

Contd.

Table 7.5 contd.

Rice	
2010	03.03.2010: Ban on export of Non-basmati rice not be applicable to export of 20,000 MT of rice (Ponni Samba) to Sri Lanka through PEC, and export of 25,000 MT of Non-basmati rice to Nepal through MMTC. 18.05.2010: Ban on export of Non-basmati rice not be applicable to export of 1,00,000 MT of rice (Parboiled) to Bangladesh through STC, MMTC and PEC 06.08.2010: Ban on export of Non-Basmati rice not be applicable on export of 3 lakh tonnes of parboiled non-Basmati rice to Bangladesh from the Central Pool at prevalent economic cost through FCI 17.08.2010: Nature of Restriction' relating to export of Basmati rice including PUSA Basmati 1121- Grain of rice to be exported should be more than 6.61 mm of length and ratio of length to breadth of the grain should be more than 3.5"
2011	10.02.2011: Certain varieties of rice (Sona Masuri-1,00,000 MT, Ponni Samba-25,000 MT and Matta-25,000 MT) permitted to be exported with a limit on quantity of export for the KMS 2010-11 08.03.2011: Export of Sona Masuri and Ponni Samba varieties of non-Basmati rice subject to a Minimum Export Price (MEP) of USD 850/Mt. No MEP is being prescribed for Matta rice 15.03.2011: Export of 25,000 MT of non-Basmati rice to Nepal through MMTC allowed during the KMS 2010-11 with a maximum of 25% broken 31.03.2011: MEP of USD 850/MT applicable to Matta rice also 19.07.2011: Export of 10 lakh MT of Non-Basmati rice permitted on private account subject to MEP of US$400/MT and other conditions 12.08.2011: MEP) of Sona Masuri, Ponni Samba and Matta varieties of rice reduced to USD 600/MT 09.09.2011: All varieties of non-Basmati rice made free for export out of privately held stocks. Export shall be only through Custom EDI ports. 23.09.2011: Export of non-Basmati rice under Food Aid Programme permitted freely by PSUs or by government organizations also. Export of non-Basmati rice under agreement between India and Maldives permitted. 05.12.2011: Exemption of Bhutan from the application of export bans by India on export of Milk Powder, Wheat, Edible Oils, Pulses and Non-Basmati Rice 12.12.2011: Permitted export of 10,000 Tons of non-Basmati rice to Horn of Africa (Kenya, Somalia & Djibouti)
2012	21.02.2012: Minimum Export Price of Basmati Rice reduced to US$ 700 per MT. Earlier it was US$ 900 23.02.2012: State Trading Enterprises (STEs) permitted to export privately held stocks of non-basmati rice. Export of non-basmati rice also permitted from non-EDI Land Custom Stations on Bangladesh and Nepal border with registration of quantity with DGFT. export of non-Basmati rice (i) under Food Aid Programme and (ii) under bi-lateral trade agreement between Government of India and Government of Maldives shall be permitted
2014	13.06.2014: Exemption to Bhutan from the application of export bans by India on export of Milk Powder, Wheat, Edible Oils, Pulses and Non-Basmati Rice
2015	07.08.2015: Export of rice of seed quality moved from 'Free' to 'Restricted' category

Contd.

Table 7.5 contd.

2016	01.08.2016: Export of basmati rice allowed subject to conditions
2017	19.04.2017: Exemption of application of quantitative ceiling and export bans on export of organic wheat, non-basmati rice, edible oils, sugar, and enhancement of quantitative ceiling on export of pulses & lentils
2022	08.09.2022: Export Policy of broken rice is amended from 'Free' to 'Prohibited'. Transitional arrangement shall not be applicable under this Notification 20.09.2022: Extension of period of export of broken rice from 15.09.2022 to 30.09.2022, further extended till 15.10.2022 on 27.09.2022. 04.10.2022: Rice (5% & 25%) is exempted as it is not broken rice but normal rice with permissible limits of broken rice, carry 20% duty
2023	24.05.2023: Export of broken rice is prohibited, Export allowed on the basis of permission granted by GOI to other countries to meet their food security needs and based on their Govt. request 20.06.2023: Export allowed on the basis of permission granted by GOI to other countries to meet their food security needs and based on their Govt. request. 20.07.2023: Export policy on Non-basmati white rice (Semi-milled or wholly milled rice, whether or not policed or glazed: other) amended from 'Free' to 'Prohibited', However Govt. to Govt. for food security exempted 30.08.2023: Export of Non-basmati white rice to Bhutan (79,000 MT), Mauritius (14,000 MT) and Singapore (50,000 MT) notified. 25.09.2023: Export of 75,000 MT of Non-basmati white rice to UAE is permitted through National Cooperative Exports Limited. 18.10.2023: Export of Non-basmati white rice to Nepal (95,000 MT), Cameroon (1,90,000 MT), Cote D'Ivore (1,42,000 MT), Republic of Guinea (1,42,000 MT), Malaysia (1,70,000 MT), Philippines (1,95,000 MT) and Seychelles (800 MT) is notified.
Maize	
2008	03.07.2008: Ban on export of Maize
2014	29.09.2014: Import policy revised from "State Trading Enterprises" to "Free".
2016	Tariff rate quota of 5,00,000 MT for import of Maize (corn) for the year 2016-17
2019	03.04.2019: Import of 1 Lakh MT of Feed grade maize under TRQ allowed at 15% custom duty through STEs 09.07.2019: Import of 4 Lakh MT of Feed grade maize under TRQ allowed at 15% custom duty through STEs

8 Conclusions and Implications

This study has examined price volatility for 19 food commodities using monthly data from January 2010 to December 2022. Price volatility is the highest for vegetables, followed by spices, pulses, oilseeds, and cereals. Higher price volatility for vegetables is due to weather-induced fluctuations in production. Their short shelf-life and lack of value addition are the main cleadings of price volatility. Low price volatility for cereals is mainly due to the government purchases of wheat and rice at their administered prices. Generally, volatility in prices of most commodities peaks during the pre-harvest period.

The trend in volatility in prices of different commodities is heterogeneous. Over time, price volatility increased for onion and maize and decreased for greengram. Prices of pulses became less volatile because of a significant increase in domestic production. Volatility in prices decreased after the COVID-19 pandemic due to their increasing exports.

The association between market arrivals and prices varies across commodities. A negative relationship exists between market arrivals and prices of vegetables, soybean, and maize. In contrast, turmeric, greengram, sunflower, safflower, and groundnut prices are positively associated with market arrivals. Prices of other commodities are unresponsive to market arrivals. Rainfall affects the prices of several food crops, especially the Kharif crops. Government interventions in food markets, in terms of output price support, stock limits, import tariffs, and export restrictions, also explain price volatility.

Further, there is a significant difference in the speed of adjustment of prices of different commodities. Generally, adjustment to long-run equilibrium is faster in larger markets characterized by higher price volatility.

These findings have some important implications for agri-food price policy. Causes of price volatility differ for different commodities; hence, no size fits all. Managing volatility in prices of different food commodities, thus, requires differential strategies.

First, prices of vegetables are highly volatile due to seasonality in production and high degree of perishability. It has three important implications. One, there is a need to breed varieties that are suited for cultivation under different climatic conditions, resistant to biotic and abiotic stresses, and suitable for processing. Two, investment in refrigerated transportation, cold storage and processing into semi-perishable products, such as powders, pastes, etc., is essential for reducing post-harvest losses and fulfilling consumers' requirements through value-added products. Three, effectively implement market regulations to check hoardings and speculations, especially in larger markets.

Second, the consumption of spices is widespread, but their production has spatial niches. For example, about 67% of the total production of turmeric comes from Maharashtra, Telangana, Karnataka, and Tamil Nadu, and 99% of cumin from Gujarat and Rajasthan. There is a seasonal concentration of their production also, while these are used regularly for culinary and other purposes. A significant proportion of their production finds its way to international markets. These characteristics suggest (i) breeding their varieties for cultivation in non-traditional areas and resistance to climate risks and (ii) strategically regulate their exports depending on domestic demand and supply.

Third, volatility in prices of edible oils and pulses is managed through imports. One of the main reasons for imports is the sluggish growth in their yields. Hence, there is a need for a technological breakthrough to achieve higher yields and climate resilience. There is also a need for a stable trade policy for imports of both edible oils and pulses.

Fourth, institutional arrangements such as contract farming and cooperatives should be promoted to strengthen value chains, especially for perishable commodities.

Finally, effective enforcement of market regulations is essential to discourage hoardings. Simultaneously, a system of market intelligence should be developed for commodity forecasting and tracking trade flows and prices in the domestic and international markets.

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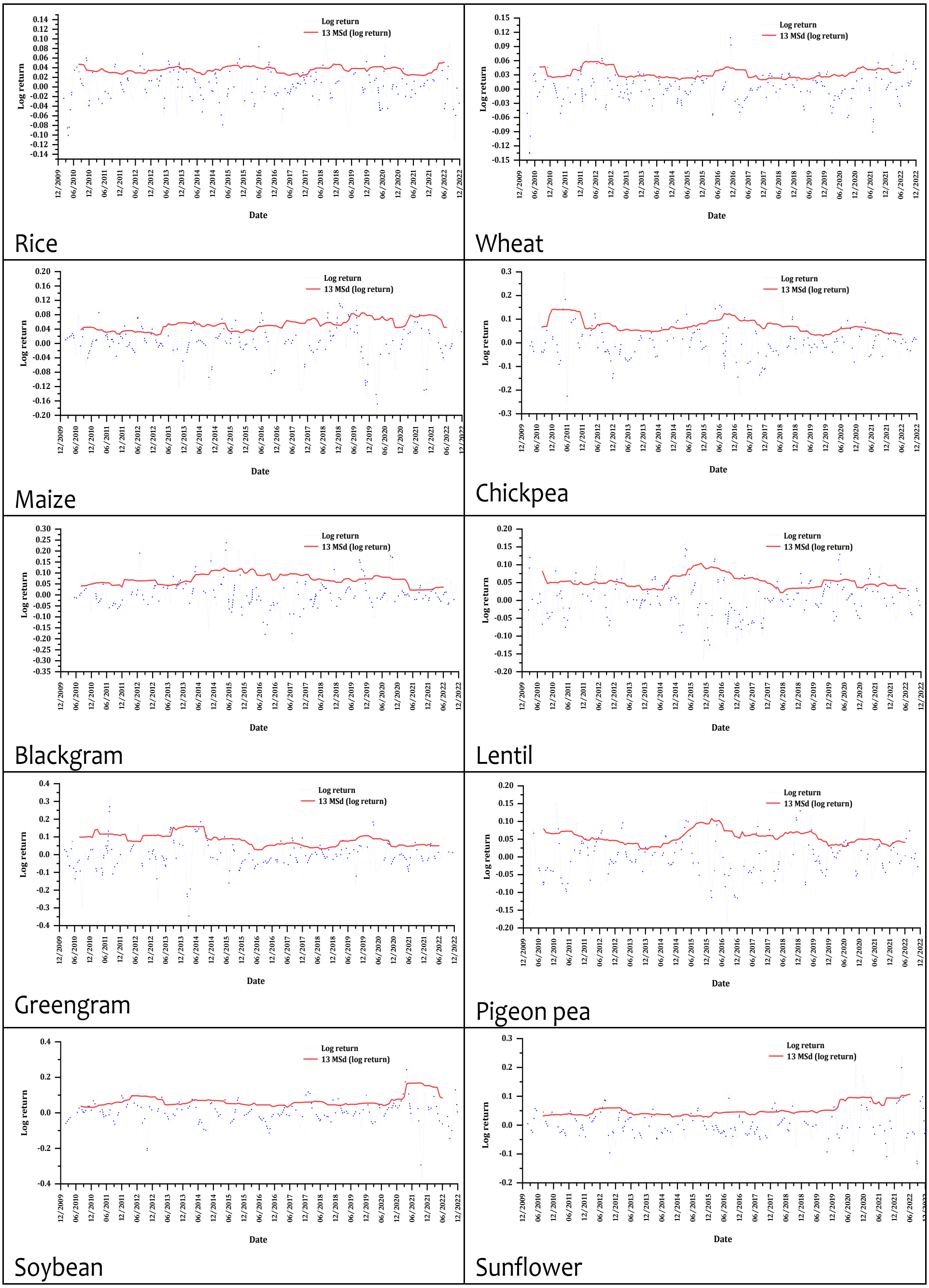
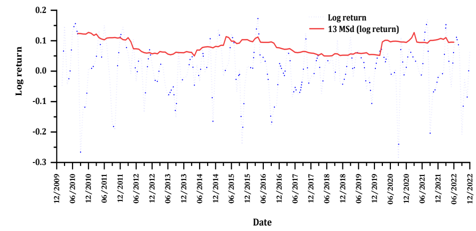
Appendix

Figure A1. Trends in agricultural price volatility





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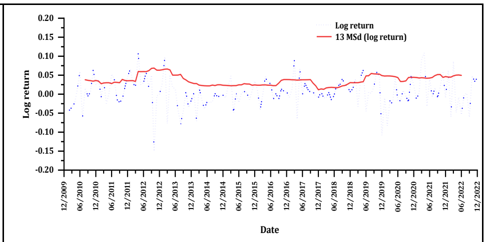

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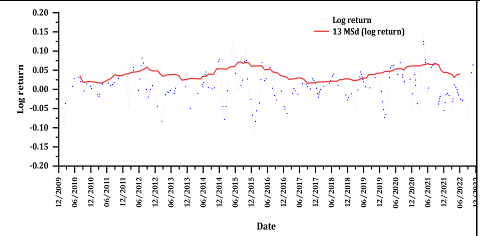

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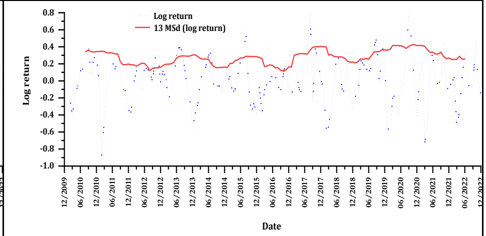

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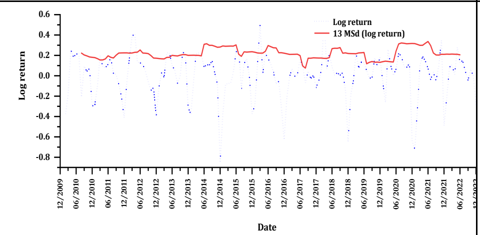

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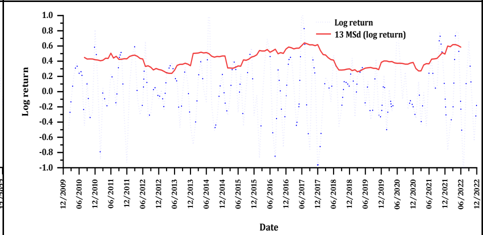

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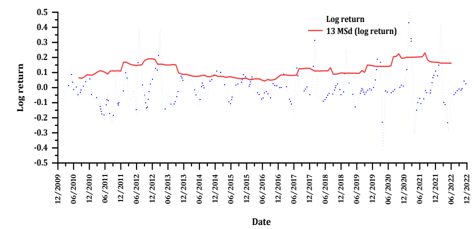

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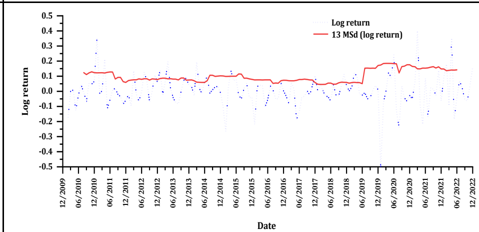
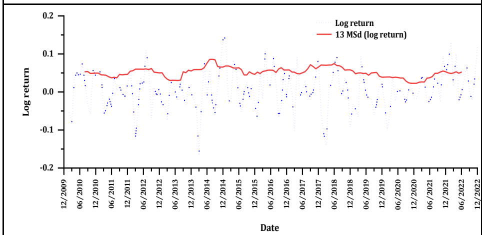


Coriander



Cumin

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ICAR - NATIONAL INSTITUTE OF AGRICULTURAL ECONOMICS AND POLICY RESEARCH

(Indian Council of Agricultural Research)

Dev Prakash Shastri Marg, Pusa, New Delhi - 110 012, INDIA

Ph: +91(11) 2584 7628, 2584 8731 Fax: +91 (11) 2594 2684

Email : director.niap@icar.gov.in, Website : www.niap.icar.gov.in