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Case Study

Price Volatility and Transmission: A case study of paddy and redgram markets in Karnataka

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ABSTRACT

Price volatility of major agricultural commodities has attracted major attention in the last few years in India as well as in the world food markets. It is often observed that price changes of major staple food items have negative impact on the welfare of the producer farmers as well as consumers. This study tries to explore the nature and causes of the price changes of paddy and redgram in Karnataka. The secondary data of paddy and redgram prices from major markets were compiled and analysed using volatility index and co-integration techniques. Data from major markets by considering time series data for about two decades from2000-2018 were used to understand the trends, volatility and transmission. It was discovered that, prices were not particularly unpredictable, retail prices were more erratic than farm harvest prices, wholesale prices, and minimum support prices in Paddy whereas in redgram, farm harvest prices were comparatively erratic than other prices. The volatility may be related to agricultural production's intrinsic instability as a result of unexpected and unpredictable exogenous shocks such as weather and poor price and income elasticities. And study on price transmission would help to know, how the prices have transmitted from one market to other market and reveals the relationship between prices over time between the markets considered.

HIGHLIGHTS

- The study revealed that retail prices were more volatile than farm harvest, wholesale and minimum support prices in paddy but in redgram, farm harvest prices were comparatively volatile than retail, wholesale and minimum support prices.
- Gangavathi and Maddur markets are the major markets influencing prices in Bangalore market for Paddy whereas, prices ofredgram in both Bangalore and Hyderabad markets were influenced by prices in Mumbai market.

Keywords: Price Volatility, Price Transmission, Paddy, Red gram, Income Elasticity, Minimum support prices

Human survival depends on a variety of factors, one of which is food. As a result, changes in food costs as a result of changes in the price of foodgrains will affect everyone. Since the implementation of new economic policies in the 1990s, the Karnataka economy has undergone substantial structural changes. Karnataka is often regarded as one of India's most liberalised and industrialised states (Government of India, 2007). Price volatility in agricultural commodities is a persistent worry. Price volatility is perhaps the single most important criterion for assessing futures trading. It provides the basic economic justification for futures trading, which is to provide protection to the hedger against adverse price fluctuations (Treat, 2004). Excessive price fluctuations in food commodities generate a situation of uncertainty that have a significant

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impact on the food supply chain, investments, and social development (OECD, 2010). Studies conducted by Zimmerman & Carter 2003; Barrett and Bellemare, 2011; Dawe *et al.* 2010; Headey, 2014 have looked at the impact of food prices on poverty and discovered that continuous price volatility can contribute to an increase in income disparity, trapping people in poverty. Agricultural price volatility is of importance to policymakers as well as other stakeholders in the food supply chain, and a better understanding of future price behaviour is needed. Food price volatility disrupts the market and puts consumers and governments at risk, in case of food insecurity. Volatility also deters required development investment in agriculture by increasing financial risks and uncertainty for producers and merchants. In the poorest countries, where people spend up to two-thirds of their daily income on food, rising prices are a threat to global growth and social stability (Mittal *et al.* 2018). Food prices in India increased during 2007-08 due to global food crisis,however evidence of price volatility was unclear. Despite the fact that India being self-sufficient in food production, food security remains a major challenge (OECD 2010; Acharya *et al*. 2012; Ahmad and Haseen, 2012; Dasgupta *et al.* 2011; OECD, 2010).

Price transmission research has long piqued the interest of economists looking to better understand market mechanics (Tanaka and Guo, 2020). In a purely descriptive sense, volatility refers to changes in economic variables across time. The current study looks at how agricultural prices have changed throughout time. It's important to remember that not all price changes are harmful, such as when prices follow a smooth and well-defined trend that reflects market fundamentals or when they follow a predictable seasonal pattern. Prices that are volatile and uncertain limit the quality and quantity of investment made by farmers, merchants, processors, and distributors. Farmers are unable to make adequate input investments, obtain loans, or accelerate their supply response due to unstable prices (Poulton *et al.* 2006; Dawe, 2001; Timmer, 1989). Price changes are problematic when they are substantial and unpredictable, resulting in a high level of uncertainty. This in turn would increase risk for producers, traders, consumers including government, making all decisions sub-optimal. Even the variations in prices which do not reflect market fundamentals are also problematic, which may again may lead to incorrect decisions (FAO, 2011).

The extent to which domestic agricultural commodity markets in poor nations adapt to changes in international pricing is a critical consideration when examining trade policy reform in global agricultural markets. Understanding the level of economic agents' integration into the market process hinges on price transmission from global to domestic markets. Price transmission study measures several aspects of the link between the prices in the two markets using price data. Market integration, or the entire transmission of price changes from one market to another, has significant implications for economic welfare. Incomplete price transmission, which can be caused by trade and other restrictions, or transaction costs such as bad transportation and communication infrastructure, reduces the amount of price information available to economic players, which can lead to actions that lead to inefficient outcomes. Food price volatility must be monitored in order to prepare for long-term food security and develop policies and strategies accordingly (OECD 2010).

Methodology

For the present study, paddy and red gram have been selected to assess their price volatility. Here, the importance of these selected crops is analysed through area share in total cropped area and value share in total value of agricultural output (Anonymous, 2013). To know the price volatility in the prices of two selected commodities *viz.*, paddy and redgram, time series data from 2000-2018 were collected from various sources like India. stat., the Directorate of Economics and Statistics, Krishi-Maarata Vahini. To study the volatility index standard deviation of logarithmic prices were estimated (Mittal *et al.* 2018). The study considers not only the retail prices but also wholesale prices, farm harvest prices and minimum Support Prices (MSP) of paddy and red gram to investigate the price volatility.

Volataility index

$$\text{Volatility} = stdev(r) = \left[\Sigma\left(\frac{1}{N-1}\right)\left(r_t - \overline{r}_t\right)^2\right]^{0.5}$$

where,

$r_t = \ln P_t - \ln P_{t-1}$,

stdev(r) is the standard deviation of the logarithmic differences of prices (r_t),

P_t is the price in period '*t*' and P_{t-1} is the price in period '*t*–1'.

Price Transmission using technique of co-integration

In this study, cointegration technique was used to examine the integration among various paddy and redgram markets. The co-integration method of market integration is simple to understand and implement. Prices are decided interdependently in integrated markets. This is commonly interpreted to suggest that price changes in one market are fully transferred to other markets. Markets that aren't connected may send out erroneous price information, which can lead to skewed marketing decisions and inefficient product movement. When two series have a long run equilibrium connection, they are said to be co-integrated. In other words, two series cannot move apart over time. i.e. there is a mechanism in place to bring the two series together. When this notion is applied to any two markets, co integration between their price series suggests long-run reliance. Because price dependency across markets is at the heart of market integration, co-integration of prices in two marketplaces indicates market integration. The following fundamental connection, which is widely used to test for the existence of market integration, can be used to investigate the pricing relationship between two markets.

$$P_{it} = \alpha_0 + \alpha_1 P_{jt} + \varepsilon_t$$

Where, P_i and P_j are price series for a single commodity in two marketplaces *i* and *j*, and $\propto 0$ and $\propto 1$ are residual terms that are believed to be distributed equally and independently.

If p_i and p_j are stationary variables, the test for market integration is simple. Since the economic variables are non-stationary, standard tests are ineffective. The null hypothesis is more likely to be rejected. As a result, before moving on to the next step, it is important to check for the stationarity of the variables (Granger and Newbold, 1974). A stationary series is described as one in which the parameters that describe the series (particularly the mean, variance, and autocorrelation) are time independent or have constant mean and variance, as well as autocorrelation that is invariant across time. After determining the variables' non-stationarity, the next step is to check for the presence of a co-integrating (long run equilibrium) relationship between them by using Unit root test (Augmented Dickey-Fuller test).

Unit root test using augmented Dickey-Fuller (ADF)

The stationarity of a variable was determined using the augmented Dickey Fuller test (ADF test). The test is based on the Dickey Fuller value statistic of ß$_1$, which can be calculated using the equation below:

$$\Delta P_t = \beta o^t\ \beta_1\ P_{t-1} + \sum_{K=1}^{N} \delta k \Delta P_t - k + \eta_t$$

Where, $\Delta P_t = P_t - P_{t-1}$

The t statistic serves as the test statistic. However, it is not distributed as student-t under the null hypothesis, but this ratio can be compared to crucial values in the Dickey Fuller Table. The null hypothesis is H0: Pt is I (1) in estimating Equation (15), which is rejected [in favour of I (0)] if 1 is shown to be negative and statistically significant. The technique described above can also be used to determine the first difference between the variables. To put it another way, we calculate the following regression equation:

$$\Delta_2 P_t = \Theta 0 + \Theta 1\ \Delta P_{t-1} + \sum_{K=1}^{N} \varnothing n\ k_2\ 2P_{t-\mathrm{K}} + \Delta_2 P_{t-\mathrm{k}} + \eta_t$$

If 1 is determined to be negative and significant, the null hypothesis is H0: P_t is I (2), which is rejected [in favour of I (1)]. In general, if a series P_t achieves stationarity after differencing d time, it is said to be integrated of order *d*, denoted P_t I. (d). As a result, we can denote P_t ~ I (1) and P_t I ~(2), if P_t is steady after differencing once. In most cases, however, the process is stopped after the first or second discrepancy. In reality, Nelson and Plosser (1982) found that most macroeconomic variables follow the I (1) process, meaning that they acquire stationarity after the first difference. We can now test for co integration after determining that the variables were non-stationary in level. A hypothetical co-integrating connection can only be formed by variables with the same order of integration. The variables should be non-stationary at the zero order level, but stationary after initial differencing, according to Johansen's co-integration approach. The model was used to check the order of integration using the Augmented Dickey-Fuller test:

$$\Delta Y_t = \alpha + \delta T + \beta_1 Y_{t-1} + \sum_{i=1}^{p} \beta_1 \Delta Y_{t-1} + \varepsilon_t$$

Where, $\Delta Y_t = Yt - Y_{t-1}$, $\Delta Y_{t-1} = Y_{t-1} - Y_{t-2}$, and $\Delta Y_{t-2} = Y_{t-2} - Y_{t-3}$, *etc.*

The pure white noise term is ε_t, the constant term is c, the temporal trend effect is T, and the best lag value is p, which is chosen using the Schwartz information criterion (SIC). The null hypothesis states that 1, the Y_{t-1} coefficient, is zero. 1 0 is an alternate hypothesis. The fact that the null hypothesis is not rejected indicates that the time series under investigation is non-stationary (Gujarati, *et al.* 2012).

Johansen methodology for co-integration analysis

The Johansen approach looks at a Vector Auto Regressive (VAR) model of Y_t and a (n×1) vector of variables that are integrated into a time series of order one-I (1). Equation below can be used to express this VAR:

$$\Delta Y_t = \mu + \sum_{i-1}^{p-1} T_i \, Y_{t-1} \, \Pi \, Y_{t-1} + \varepsilon_t$$

Where, I and Π are parameter matrices, p is the number of lags (determined by the Schwarz Information Criterion), and t is a (n×1) vector of innovations. For the examination of long-run relationships of prices to be viable, at least one co-integrating relationship must exist. Johansen introduced two likelihood ratio tests to discover the number of co-integrating vectors: the trace test and the maximum Eigen value test, which are represented in equations below.

$$J_{trace} = -T \sum_{i=r+1}^{n} ln\,(1-\lambda_i)$$

$$J_{max} = -T\, ln(1 - \lambda_{r+1})$$

The sample size is T, and the i^{th} largest canonical correlation is λ_i. The trace test compares the alternative hypothesis of n cointegrating vectors to the null hypothesis of r cointegrating vectors. On the other hand, the maximum Eigen value test compares the null hypothesis of r cointegrating vectors to the alternative hypothesis of $r + 1$ cointegrating vectors (Hjalmarsson and Osterholm, 2010).

Granger causality test

The Granger causality test was used to determine the existence and direction of a long-run causal price relationship between the markets using the VAR model (Granger, 1969). It's an F-test to see if changes in one price series have an effect on another. The test was based on the following pairs of Ordinary Least Square (OLS) regression equations through bivariate VAR, using the causation link between Bengaluru, Maddur and Gangavathi; Bengaluru, Hyderabad and Mumbai in wholesale, farm harvest and retail markets of paddy and redgram respectively taken places as an example:

$$P\ lnBt = \sum_{i=1}^{m} \propto_i P\ ln\ B_{t-1} + \sum_{i=1}^{m} ß_j PlnD_{t-j} + \sum_{i=1}^{m} \gamma kPln\ E_{t}\text{-}j + e_{1t}$$

$$P\ lnDt = \sum_{i=1}^{m} \gamma_i P\ ln\ D_{t-1} + \sum_{i=1}^{m} \delta_j PlnB_{t-j} + \sum_{i=1}^{m} \gamma\ K\ P\ ln\ E_{\ t-j} + e_{1t}$$

$$P\ lnE_t = \sum_{i=1}^{m} \propto_i P\ ln\ B_{t-1} + \sum_{i=1}^{m} ß_j PlnD_{t-j} + \sum_{i=1}^{m} \gamma kP\ ln\ E_{t}\text{-}j + e_{1t}$$

Where B, D and E denote Bengaluru, Maddurandgangavathi markets for trading Paddy; Bengaluru, Hyderabad and Mumbai trading redgram. *Pln* denotes a logarithmic price series, and t is the time trend variable. The number of lags of both variables in the system is represented by the subscript. The null hypothesis of above equation, i.e. H_0: 1 = 2 =.... = j = 0, is that $P\ ln\ D_t$ does not Granger induce $P\ ln\ B_t$, as opposed to the alternative, i.e. H_1: Not H_0. Similarly, in above Equation checking H_0: 1 = 2 =....= j = 0 against H_1: Not H_0 is a test that $P\ ln\ B_t$ does not Granger induce $P\ ln\ D_t$. A rejection of the null hypothesis in each case implies that the variables have Granger causality (Gujarati *et al.* 2012).

To study the price transmission between the selected markets of paddy and redgram, the modal prices of paddy in Bengaluru, Maddur and Gangavathi and the modal prices of redgram were collected from Bengaluru, Hyderabad and Mumbai for the period 2002-2018, the markets were selected based on the data availability.

RESULTS AND DISCUSSION

The trends in different types of paddy prices are shown in table 1. The retail price of paddy increased rapidly over time, reaching ₹ 9000/qtl. in 2017, which was more than the other three prices, possibly due to the length of the marketing channel, transportation costs, storage, and time required to reach the final consumer which will create the time lag between production and consumption. Between 2000 and 2018, wholesale paddy prices grew, peaking in 2013 (₹ 2635/qtl.) due to a drought that hampered paddy cultivation, resulting in lower yields in the state, and hence a rise in price. Despite the fact that farm harvest prices (FHPs) and minimum support prices (MSPs) were moving upward, they were practically comparable over time, i.e., MSPs stayed almost constant over time. It was Retail prices grew fastest (15%), followed by farm harvest prices (8.41%), MSP (7.30%), and wholesale prices (7.33%) as shown in table 3.

Table 1: Wholesale, Retail, Farm Harvest price and MSP of Paddy (₹/qtl.)

Year	Wholesale Prices	Retail price	Farm harvest price	MSP
2000	978	954	500	510
2001	991	1092	554	530
2002	904	1178	698	530
2003	953	1169	550	550
2004	1005	1245	648	560
2005	1023	1174	642	570
2006	1059	1318	628	580
2007	1184	1445	594	645
2008	1476	1750	587	850
2009	1662	2983	835	950
2010	1873	2100	938	1000
2011	1835	5541	998	1080
2012	2157	6702	1324	1250
2013	2635	6972	1302	1310
2014	2446	7126	1463	1360
2015	2309	8713	1530	1410
2016	2500	6937	2180	1470
2017	2518	7565	—	1550
2018	2650	8321	—	1770
Growth rate (%)	7.93	15.68	8.41	7.30

Table 2: wholesale, retail, Farm harvest prices of Redgram in Karnataka (₹/qtl.)

Year	Wholesale price	Retail price	Farm harvest price	Minimum support price
2001	2451	2950	1539	1320
2002	2553	2751	1616	1320
2003	2735	2890	1710	1370
2004	2993	3450	1789	1390
2005	2833	3102	1597	1400
2006	3481	3221	1950	1410
2007	3565	3665	1950	1550
2008	3540	4255	2979	2000
2009	3542	6600	4358	2300
2010	3686	6716	3567	3000
2011	3600	6560	3031	3200
2012	4158	6690	3469	3850
2013	4368	7450	3679	4300
2014	4657	7676	4797	4350
2015	6980	7800	6134	4425
2016	6818	9870	4722	4625
2017	4371	7571	—	—
Growth rate	7.40	9.62	5.51	10.52

Table 3: price volatility of Paddy in Karnataka (2000-2018)

Particulars	No. of observations	Mean*	Price volatility	S.D. r	Volatility
Paddy					
Wholesale	18	0.046	0.094	0.094	Very low
Retail	18	0.120	0.272	0.279	Low
Farm harvest prices	16	0.086	0.146	0.155	Low
MSP	19	0.064	0.064	0.066	Very low

Note: *Mean*-it is a mean of first difference; r-log of first difference of prices.*

The increase in retail prices was the most evident for redgram, among many different sorts of prices of redgram, as illustrated in table 2. The retail price of redgram dropped dramatically in 2017, owing to increased production. The MSP's for redgram have also been rising in recent years due to fact that cost of cultivation has seen a steep rise in input costs these years. The prices of fertilizers have gone up besides there is a labour shortage which has resulted in rise of daily wages paid to farm labourers. FHPs have also shown an upward tendency, with a substantial increase between 2009 and 2016. Wholesale prices have also been on the rise throughout the years, but have fallen in 2017. The results of annual compound growth rate analysis is presented in table 3, indicating the various redgram prices of which wholesale prices increased the least (5.40 %), retail prices increased at 8.62 percent per year, farm harvest prices increased at 9.51 percent, and the growth rate was found to be the highest (10.52 %) in the case of MSPs of redgram due to above said reasons.

Wholesale prices (WSP) and Minimum support prices (MSP) had the least amount of volatility, as shown in the table 2. Because the government modifies or revises the minimum support prices less regularly, MSP prices are less volatile. The standard deviation of logarithmic values was used to calculate the volatility and this volatility co-efficient ranges from 0 to 1, with values closer to zero indicating less volatility and vice versa. The volatility was found to be substantially higher in the case of retail prices (0.27), followed by farm harvest sprices (0.14), while wholesale prices and MSPs were found to be more stable as indicated by lower values of the volatility coefficients (0.0947 and 0.0974 respectively).

Similarly, the results on volatility in the case of redgram prices are presented in table 4 revealed that, the coefficient of volatility was relatively higher in farm harvest prices (0.17), followed by wholesale (0.159) and retail prices (0.152), indicating less volatile nature of these prices, and there was almost no volatility in MSPs for redgram as indicated by the co-efficient value 0.0916.

Price Transmission

Price signals travel across markets, but imperfect co-integration is common due to higher transaction and transportation costs, asymmetric information, varying contract enforcement, and state government intervention. Evidence in favour of spatial integration of various markets in India includes asymmetric information, varying contract enforcement, and state government intervention. The source of asymmetric information lie in the nature of the commodity supply and demand shocks (Gardner, 1995). The prices across different geographically separated markets show long run spatial linkage, suggesting price integration (Mittal and Virmani, 2007). Though the markets are geographically separated, the price signals are transmitted across markets. However, the law of one price may not prevail (Mittal *et al.* 2018). In this article, we used Johansen's multiple co-integration to know price transmission, and granger causality to determine whether the relationship between markets is unidirectional or bidirectional.

Table 4: Price volatility in Redgram in Karnataka (2000-2017)

Particulars	No. of observations	Mean*	Price volatility	S.D. r	Volatility
Red-gram					
Wholesale	17	0.036	0.159	0.164	Low
Retail	17	0.055	0.152	0.152	Low
Farm harvest prices	16	0.070	0.175	0.175	Low
MSP	16	0.083	0.091	0.092	Very low

Co-integration technique and Granger causality test

The Augmented Dickey-Fuller (ADF), unit root test was used to determine whether the prices of selected crops in major markets were stationary or not. The findings of the ADF unit root test which is presented in Table 5, revealed that prices in all selected markets (Bengaluru, Maddur and Gangavathi) were non-stationary at their base level, but however with the first difference, the price data were found stationary. These markets were selected based on the higher market arrivals along with the reason that these regions are the major paddy producing areas of the state.

Table 5: Modal prices of Paddy in Bengaluru, Maddur and Gangavathi (₹/qtl) (2002-2018)

Year	Bengaluru	Maddur	Gangavathi
2002	628	555	966
2003	775	612	987
2004	775	570	1012
2005	632	570	940
2006	710	597	986
2007	760	590	956
2008	812	654	990
2009	1141	884	1160

2010	1093	954	1690
2011	1130	1000	1330
2012	1260	1014	2157
2013	1700	1335	2390
2014	5150	1410	2318
2015	1475	1390	2204
2016	1525	1400	2414
2017	2805	1608	2557
2018	2450	1628	2449

In the example of Paddy, Johansen's multiple co-integration test was used to assess the long-run relationship between the price series in three selected markets, the results of which is shown in table 6.

Table 6: ADF unit root test for Paddy for selected markets of Karnataka

Sl. No.	Markets	At level/ first difference	T-cal.	(Prob.*)	Remarks
1	Bengaluru	ln Ben	-1.245372	-0.4317	Non-Stationary
		Δ ln Ben	-10.17736**	0	Stationary
2	Maddur	ln Maddur	-0.7159	-0.6923	Non-Stationary
		Δ ln Maddur	-11.0973**	0	Stationary
3	Gangavathi	ln Ganga	-0.8031	-0.712	Non-Stationary
		Δ ln Ganga	-12.8309**	0	Stationary

*Note: ** indicate that unit root at level or in the first difference were rejected at 1 percent as well as at 5 per cent significance. The (Prob.*) denotes Mackinnon (1996) one-side p-values. ln denotes modal price in logarithmic form and Δln denotes the price series in logarithm form after first difference.*

The data found that among three co-integrating equations, one market was co-integrated at a 5 per cent level of significance, meaning that the selected paddy markets had long-run equilibrium relationships and presence of co-integration. The test revealed that out of three co-integrating equations, all three paddy markets had one co-integrating equation, suggesting that they were properly integrated and price signals were passed from one market to the other to ensure efficiency. The test revealed that, despite being geographically separated and spatially segmented, the selected paddy markets in Karnataka were well-connected in terms of paddy prices, suggesting that the selected paddy markets exhibited long-run price linkage due to fact that selected markets are the major paddy producing and consuming areas in the state.

The Granger causality shows the direction of price flow between two markets and related spatial arbitrage, i.e., physical movement of the commodity to adjust the price differences (Ghafoor *et al*. 2009). The findings of a pair-wise co-integration across the marketplaces are depicted in table 7. Granger causality was assessed between the selected pairs of paddy markets in Karnataka after detecting co-integration among three paddy markets. F-statistics for causation analyses of wholesale pricing in Bengaluru market on other markets were found to be statistically significant in all three markets. For the Bengaluru market, the null hypothesis of no Granger causation was thus rejected in each case. The Granger causality test on market co-integration likewise revealed that all markets' integration was unidirectional.

Table 7: Results of multiple co-integration analysis for Paddy

Null Hypothesis	Eigen-value	Trace value	Critical value	Probability**
None *	0.957	52.40	29.79	0.0002
Atmost 1	0.245	4.94	15.49	0.814
Atmost 2	0.047	0.72	3.841	0.394

Note: **denotes rejection of the null hypothesis at 5 per cent level of significance. **Mackinnon Michelis (1999) p-values.*

Gangavathi-Bengaluru, Maddur-Bengaluru, and Gangavathi-Maddur were the unidirectional. This means that a price change in the former market in each pair causes price change in the latter market. However, the price change in the latter market was unable to influence and give feedback by the price change in the former market in each pair.

Efforts were also undertaken to analyse the behaviour of prices in main markets for redgram in greater depth. The results of the ADF unit root test (table 8) for chosen redgram markets revealed that all prices were non-stationary at the base level, however prices were found stationary with the first difference for all three markets (Bengaluru, Hyderabad, and Mumbai). The results of the Johnson multiple co-integration were found to be significant at a 5 per cent level of probability, suggesting that certain markets were co-integrated

Table 8: Pair-wise granger causality in selected Paddy markets in Karnataka

Sl. No.	Null Hypothesis	F-Statistics	Probability**	Granger cause	Direction
1	GANGAVATHI does not Granger Cause BENGALURU	12.04	0.0022*	Yes	Unidirectional
	BENGALURU does not Granger Cause GANGAVATHI	0.48	0.6272	No	
2	MADDUR does not Granger Cause BENGALURU	10.88	0.0031*	Yes	Unidirectional
	BENGALURU does not Granger Cause MADDUR	1.60	0.2477	No	
3	MADDUR does not Granger Cause GANGAVATHI	1.04	0.3880	No	Unidirectional
	GANGAVATHI does not Granger Cause MADDUR	3.53	0.0692**	Yes	

Note: *1. The lags of the dependent variable used to obtain white-noise residuals were determined using the Schwarz Information criterion (SIC); **and *denotes rejection of the null hypothesis at 1 and 5 per cent level of significance.*

in the long run, indicating their long run or short run equilibrium relationship.

The granger causality test (table 10) revealed that there was no relationship between Hyderabad and Bengaluru markets indicating these two markets did not influence each other. While only the Mumbai market influenced pricing in the Bengaluru market but not the other way around, the same was true between Mumbai and Hyderabad, where the Mumbai market influenced redgram prices in the Hyderabad market but not the other way around.

Table 9: Wholesale prices of Red-gram in Bengaluru, Hyderabad and Mumbai (₹/qtl.)

Year	Bangalore	Hyderabad	Mumbai
2002	2553	2633	2504
2003	2735	2825	2762
2004	2993	3031	3027
2005	2833	2884	3065
2006	3481	2808	3130
2007	3565	3679	3912
2008	3883	3993	4518
2009	6320	6450	6701
2010	6204	5933	6406
2011	6025	5510	5913
2012	6063	6179	5656
2013	6329	6471	6571
2014	6904	6846	6929
2015	11283	11483	9763
2016	11300	11058	10121
2017	6217	6083	5846
2018	6119	5942	5683

Table 10: ADF unit root results for Redgram in selected markets of Karnataka

Sl. No.	Markets	At level/ first difference	t-cal.	(Prob.*)	Remarks
1	Bengaluru	ln Ben	-2.3451	-0.3317	Non Stationary
		Δ ln Ben	-12.1321**	0	Stationary
2	Hyderabad	ln Hyderabad	-0.7159	-0.7923	Non-Stationary
		Δln Hyderabad	-10.0973**	0	Stationary
3	Mumbai	ln Mumbai	-0.9121	-0.612	Non-Stationary
		Δ ln Mumbai	-8.8309**	0	Stationary

Note: *** indicate that unit root at level or in the first difference were rejected at 1 percent as well as at 5 per cent significance. The (Prob.*) denotes Mackinnon (1996) one-side p-values. ln denotes modal price in logarithmic form and Δln denotes the price series in logarithm form after first difference.*

Table 11: Johnson multiple co-integration for red-gram

Null Hypothesis	Eigen-value	Trace value	Critical value	Probabiliy**
None *	0.719	35.30	29.79	0.0105
Atmost 1*	0.656	17.48	15.49	0.0247
Atmost 2	0.165	2.53	3.84	0.1116

Note: **denotes rejection of the null hypothesis at 5 per cent level of significance .**Mackinnon Michelis (1999) p-values*

Table 12: Pair-wise granger causality in selected Redgram markets

Sl. No.	Null Hypothesis	F-Statistics	Probability**	Granger cause	Direction
1	HYDERABAD does not Granger Cause BANGALORE	0.25171	0.7822	No	—
	BLORE does not Granger Cause HYDERABAD	0.02619	0.9742	No	
2	MUMBAI does not Granger Cause BANGALORE	2.83458	0.0059	Yes	Unidirectional
	BANGALORE does not Granger Cause MUMBAI	2.36280	0.1444	No	
3	MUMBAI does not Granger Cause HYDERABAD	2.71633	0.0812	Yes	Unidirectional
	HYDERABAD does not Granger Cause MUMBAI	2.17456	0.1174	No	

Note: *1. the lags of the dependent variable used to obtain white-noise residuals were determined using the Schwarz Information criterion (SIC). **and *denotes rejection of the null hypothesis at 1 and 5 per cent level of significance.*

CONCLUSION

Supply shocks are the primary cause of agricultural price volatility. The variances of these shocks, as well as the elasticity coefficients of the supply and demand functions, define the magnitude of the volatility. This study on price volatility shows that retail prices of paddy have a relatively high level of volatility due to the long marketing channel and the presence of a large number of market intermediaries in the paddy market, whereas farm harvest prices of redgram have a high level of volatility because it was observed that crop storage did not improve the price as the late sown crop in other regions started pouring into this market. Those who predict that price volatility would grow over time must assume that either shock variances have increased or demand and supply function elasticity coefficients have decreased.

Despite these complications, several studies suggest that commodity exchanges created at both the national and regional levels should continue to trade commodities with low volatility. The true economic causes for the persistence of volatility must be examined and explained coherently for the rest of the commodity prices that are very erratic. Although price transmission research can help us understand and anticipate price trends by revealing how prices are transmitted from one market to another, it only reveals the link between two prices over time. It doesn't explain why price transmission is rapid or slow, and why it is strong or weak. Despite the knowledge gap in understanding the concept of price volatility and price transmission, advanced econometric tools have been developed to aid in the understanding of agricultural price and price volatility transmissions, which is a study area for the future.

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