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Article

Volatility Spillover in the Turmeric and Chili Market: Linking Futures Activity to Spot Prices

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Abstract: India is the world's largest producer and exporter of major spices such as chili and turmeric, making spice futures markets vital for price discovery and risk management. This study examines the efficiency and price discovery role of chili and turmeric futures traded on the National Commodity and Derivatives Exchange (NCDEX). Using daily spot and futures price data for chili (2010-2020) and turmeric (2010-2020), the study applies Johansen's cointegration test, Vector Error Correction Model (VECM), Granger causality, Wald test, impulse response, variance decomposition, and GARCH (1,1) models. The results reveal a significant long-run cointegrating relationship between spot and futures prices for both commodities, indicating efficient market functioning. Error correction mechanisms operate in both markets, confirming long-run equilibrium adjustments. Short-run causality is found to flow primarily from futures to spot prices, particularly in the chili market, highlighting the price discovery role of futures trading. Volatility analysis shows that unexpected futures trading activity significantly affects spot market volatility in turmeric. Overall, spice futures markets serve as effective hedging instruments for market participants.
Keywords: - Chili, Turmeric, Cointegration, volatility, Price discovery, GARCH

1. Introduction

Chili and turmeric are among the most important spice crops in India, playing a significant role in agricultural production, export earnings, and price risk management. Chili, often referred to as the universal spice of India, belongs to the Solanaceae family and is widely consumed across the country. Andhra Pradesh and Karnataka together contribute nearly 75 per cent of India's total chili production, making India the largest exporter of chili among all spices. Sri Lanka and Mexico are the major importers of Indian chilies. To facilitate price discovery and risk management, chili futures trading was introduced on the National Commodity and Derivatives Exchange (NCDEX) in March 2005.

Agricultural commodity prices in India are characterized by significant volatility, driven by factors such as supply–demand imbalances, weather conditions, storage constraints, and policy interventions. Given that households spend a substantial portion of their income on food, price fluctuations in essential commodities have wide economic and social implications. While several studies attribute commodity price volatility to fundamental factors, others argue that non-fundamental elements such as speculation and market inefficiencies also play a role. Agriculture remains a vital sector in the Indian economy, contributing nearly 23 per cent to the Gross Domestic Product (GDP), and is actively supported by government policies aimed at promotion and protection.

Commodity futures markets serve as an important mechanism for price discovery and risk transfer by enabling arbitrage between spot and futures markets. Although price discovery at local markets may be influenced by region-specific supply and demand conditions, historical basis relationships provide a crucial link between spot and futures prices, enhancing market transparency and efficiency.

Turmeric (Curcuma longa), belonging to the Zingiberaceae family, is another economically significant spice crop grown predominantly in red soils under temperatures ranging from 20°C to 30°C. India is the world's largest producer and exporter of turmeric, accounting for nearly 80–85 per cent of global production, with annual output ranging between 6 to 7 lakh metric tonnes. Andhra Pradesh alone contributes about 55–57 per cent of the country's total turmeric production, followed by Tamil Nadu, Odisha, West Bengal, Karnataka, and Maharashtra. Indian turmeric is highly valued in international markets due to its superior curcumin content and extensive use in food, pharmaceuticals, cosmetics, and traditional medicine. Major export destinations include the UAE, USA, Bangladesh, Sri Lanka, Japan, and Malaysia.

Futures trading in turmeric was introduced on NCDEX in April 2004 and has since witnessed substantial participation from producers, traders, exporters, and speculators. The futures platform enables producers and exporters to hedge against price risks arising from fluctuating domestic and international demand, while high liquidity and adequate stocks create arbitrage opportunities for various market participants. Thus, turmeric futures contracts provide an effective risk management and investment avenue across the supply chain.

2. Review Of literature

Several studies have examined the role of futures markets in price discovery, volatility transmission, hedging effectiveness, and market efficiency using advanced econometric techniques such as GARCH family models, cointegration, Vector Error Correction Models (VECM), and Granger causality tests.

Mishra and Goswami (2016) employed a GARCH model to examine advanced forecasting techniques for sugar futures in the Indian commodity market and found that forecasting accuracy was higher for short-term futures contracts. Srinivasan (2011) investigated the relationship between the National Stock Exchange (NSE) and Bombay Stock Exchange (BSE) using Johansen's cointegration and VECM models and concluded that while markets are inefficient in the short run, they exhibit efficiency in the long run.

Several studies have explored the impact of futures trading activity on spot market volatility. Malhotra and Sharma (2015) used a GARCH model to analyze guar seed markets and reported a positive relationship between unexpected futures trading volume and spot return volatility. Ahmad and Sehgal (2015) examined the destabilizing effects of commodity futures trading using linear and non-linear GARCH-based causality tests and found evidence of volatility spillovers from futures to spot markets for certain agricultural commodities. In contrast, Antoniou and Foster (1992) observed that the introduction of Brent crude oil futures in the UK improved information flow without causing volatility spillovers to spot markets.

Research on volatility forecasting and hedging effectiveness indicates that futures markets enhance risk management. McMillan and Speight (2007) used VAR and GARCH models and demonstrated that improved volatility estimates lead to superior hedge ratios and Value-at-Risk calculations. Bhaduri and Durai (2008) employed VECM and MGARCH models to estimate optimal hedge ratios and found improved hedging performance. Yang (2001) and Kumar and Pandey (2008) further supported these findings by showing that MGARCH models provide greater variance reduction across equity and commodity futures markets.

Studies focusing on Indian agricultural commodities present mixed evidence regarding market efficiency. Chauhan et al. (2013) identified long-run relationships between spot and futures prices of guar seed and chana using cointegration and GARCH models. Tarun Soni (2013), applying GARCH-M and error correction models, reported inefficiencies and bias in guar seed futures markets in both the short and long run, attributing these results to excessive speculation. Sendil and Jha (2014) analyzed commodities such as cumin and cottonseed and concluded that while futures markets reduce spot price volatility in some cases, the effect is not uniform across all commodities.

Evidence from spice markets remains limited. Vasantha and Mallikarjunappa (2015) examined the pepper market using cointegration, VECM, and GARCH (1,1) models and found that the spot market played a more dominant role in price discovery than the futures market. Sharma (2016) reported a significant relationship between spot volatility and unexpected futures trading volume in the pepper market using a GARCH (1,1) framework. Kumar (2015) identified a long-run cointegrating relationship between spot and futures prices of pepper, with unidirectional causality flowing from spot to futures prices.

Studies on information flow and causality also highlight the role of futures markets. Zhong et al. (2004) analyzed the Mexican stock index futures market using VECM and EGARCH models and concluded that futures prices contribute significantly to price discovery while also introducing potential instability. Biswas and Rajib (2011) found evidence supporting the Sequential Information Arrival Hypothesis through Granger causality tests. Naik and Kumar (2001) emphasized that inadequate participation of hedgers is a major reason for the underperformance of Indian commodity futures markets.

Research Gap

The study used daily data of spot and future price of turmeric and chili. The use of intra -day data could be more effective for the analysis.

Data and Methodology

The purpose of the study is to find the reason how trading activity is affecting turmeric and chili price. The two indicators traded volume and open interest of trading activity is taken for the study. Both open interest and traded volume are divided into expected and unexpected values. GARCH (1,1) model has been used for measuring the time series volatility. Stationarity test and decomposition of series Augmented dickey fuller test is applied to check the stationarity of the series. The data has been converted into stationary when they are not stationary in the level. Hodrick Prescott filter was used for decomposing open interest and traded volume into expected and unexpected series. Hodrick Prescott filter is a smoothening method which is widely used among economists to obtain a smooth estimate of the long-term trend component of a series. It is two-sided linear filter that computes the smoothed series s of y by minimizing the variance of y around s, subject to a penalty that constraints the second difference of s ,i.e., the HP filter chooses to minimize s: The expected component is: The parameter is set to control the smoothness of the series. The larger the , the smoother the variance. (1) The Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model was developed in 1982 by economists Robert F. Engle. It is a process which depend on past squared observations and past variances to model for current variance. It is the model to estimate the volatility. Where is the conditional variance of spot returns. (2) ETV refers to Expected traded volume, t refers to time, UTV is unexpected traded volume, EOI is expected open interest and UOI is unexpected open interest. With the help of GARCH model it is easy to interpret the current fitted variance.

Data

The daily closing price of turmeric spot and future prices are being used for the study. The data has been collected from the website NCDEX for the period from 27 July, 2010 to 6 Oct,2020. Trading activities takes place in near monthly contract hence nearly month contract data has been used. The daily continuous compound return is defined as the first logarithmic difference of closing prices on consecutive trading days, i.e., $d\ln S_t = (\ln S_t - \ln S_{t-1})$ and $d\ln F_t = (\ln F_t - \ln F_{t-1})$

3. Results and Discussion

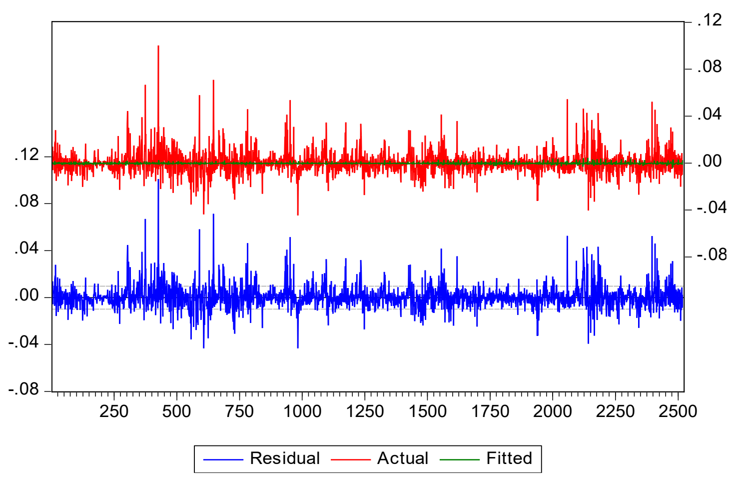
Firstly, ADF test has been applied to test the stationarity of spot price, open interest and traded volume. The stationarity test is also be done for unexpected series. The table 1 reflects the results of unit root test which becomes stationary after first difference.

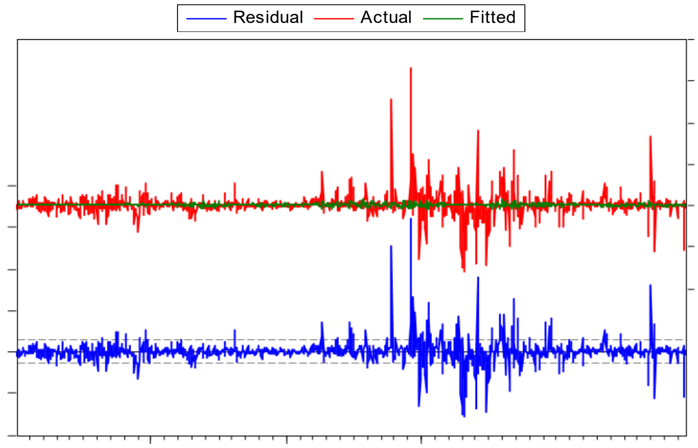
Table 1: Augmented Dickey -Fuller Test Statistic

	Chili		Turmeric	
	t-statistics	Prob.*	t-statistics	Prob.*
Spot Price (First Difference)	-23.64147	0	-27.5251	0
Open Interest (First Difference)	-24.72313	0	-4.83816	0
Traded Volume (First Difference)	-25.02261	0	-5.812453	0
Unexpected Open Interest (First Difference)	-22.03673	0	-11.054	0
Unexpected Traded Volume (First Difference)	-21.73169	0	-12.6182	0
Note:* MacKinnon (1996) one sided p-values at 5% significance level.				

From Figure 1, we can see that there is high volatility from 750 days to 1000 days and low volatility from 250 to 750 days. It is clear that there is small volatility is causing another small volatility for a long term. When the residuals are in this manner, we can represent ARCH and GARCH model.

Figure 1: Residuals of spot price-Chili and Turmeric





It is observed from table 2 , that the null hypothesis has serial correlation. The probability is less than 5% for 36 lags. Hence, the model has serial correlation.

Table 2: Correlogram of standardized squared residuals-chili

	AC	PAC	Q-stat	Prob.
1	0.003	0.003	0.017	0.895
2	0.005	0.005	0.075	0.963
3	-0.016	-0.016	0.7092	0.871
4	-0.016	-0.016	1.374	0.849
5	0.01	0.01	1.616	0.899
6	0.005	0.005	1.6817	0.947
7	-0.017	-0.018	2.4566	0.93
8	-0.025	-0.025	3.9944	0.858
9	-0.019	-0.018	4.9172	0.841
10	-0.015	-0.015	5.5011	0.855
11	-0.028	-0.029	7.4398	0.762
12	0.012	0.012	7.8347	0.798
13	0.003	0.003	7.86	0.852
14	0.016	0.015	8.55	0.859
15	0.017	0.016	9.24	0.864
16	-0.021	-0.021	10.37	0.846
17	-0.008	-0.008	10.52	0.88
18	-0.004	-0.006	10.52	0.912
19	-0.009	-0.011	10.78	0.931
20	-0.014	-0.016	11.277	0.939
21	0.013	0.013	11.713	0.947
22	-0.012	-0.011	12.07	0.956
23	0.007	0.008	12.20	0.967
24	-0.028	-0.028	14.235	0.941
25	-0.001	0.00	14.237	0.957
26	-0.006	-0.007	14.31	0.969
27	-0.006	-0.01	14.40	0.977
28	-0.006	-0.009	14.51	0.983
29	-0.001	-0.002	14.51	0.988
30	-0.016	-0.016	15.16	0.989
31	-0.004	-0.005	15.21	0.992
32	-0.005	-0.005	15.27	0.995
33	0.003	0.001	15.301	0.996
34	-0.006	-0.017	15.94	0.996
35	-0.004	-0.007	15.98	0.998
36	0.072	0.072	29.29	0.778

Table 2: Correlogram of standardized squared residuals-turmeric

	AC	PAC	Q-stat	Prob.
1	0.048	0.048	2.8547	0.091
2	-0.009	-0.011	2.959	0.228
3	-0.027	-0.026	3.8665	0.276
4	0.018	0.02	4.252	0.373

5	-0.024	-0.026	4.949	0.422
6	-0.007	-0.005	5.0123	0.542
7	-0.011	-0.01	5.1552	0.641
8	-0.011	-0.012	5.305	0.725
9	-0.005	-0.004	5.3416	0.804
10	0.016	0.015	5.6632	0.843
11	-0.025	-0.028	6.4679	0.84
12	0.027	0.03	7.4148	0.829
13	-0.013	-0.016	7.6351	0.867
14	-0.009	-0.009	7.7332	0.903
15	-0.003	0.001	7.7423	0.934
16	0.001	-0.002	7.7445	0.956
17	0.023	0.024	8.4062	0.957
18	0.029	0.027	9.4966	0.947
	AC	PAC	Q-stat	Prob.
19	-0.022	-0.025	10.099	0.95
20	0.006	0.01	10.142	0.966
21	-0.013	-0.013	10.34	0.974
22	0.008	0.006	10.42	0.982
23	-0.008	-0.004	10.496	0.988
24	0.024	0.022	11.223	0.987
25	-0.014	-0.014	11.478	0.99
26	0.013	0.015	11.691	0.993
27	-0.001	-0.002	11.691	0.995
28	0.001	0	11.693	0.997
29	-0.013	-0.01	11.92	0.998
30	-0.005	-0.007	11.95	0.999
31	-0.025	-0.021	12.74	0.998
32	0.004	0.004	12.765	0.999
33	-0.002	-0.002	12.77	0.999
34	0.122	0.12	31.662	0.583
35	0.113	0.105	48.074	0.07

36	0.02	0.009	48.573	0.079

To test for heteroskedasticity the null hypothesis is that the residuals have no ARCH effect. The probability is 91.8 which is > 5% in chili and 89.54 which is > 5% in case of turmeric. So. We can say that there is no ARCH effect.

Table 3 : Results of Heteroscedasticity test of residuals -chili and turmeric		
	Chili	Turmeric
F-statistics	0.017273	2.847
Obs. R	0.017287	2.845

Relationship among spot price volatility and future trading activity

Granger causality test is applied to ascertain the relationship between spot price volatility and future trading activity. The table 4 reflects the results of granger causality test. It indicates that the volatility is flowing from open interest to spot price. And causality seems to flow from spot prices to volume . Similarly , UTV and unexpected open interest are causing spot prices. It clearly shows that spot price, expected open interest, expected traded volume ,unexpected open interest ,unexpected traded volume have casual influence on each other.

Table:4 Granger causality test results-chili		
	f-statistics	Prob.
Open interest →spot price(OI →SP) Spot price → open interest(SP →OI)	1.07936 1.62336	0.34 0.19
Traded volume→ spot price(TV→SP) Spot price → traded volume(SP →TV)	1.42577 0.37981	0.24 0.68
Spot price→ Unexpected Traded Volume (SP→UTV) Unexpected Traded Volume →Spot Price (UTV → SP)	0.87223 2.6971	0.41 0.06
Spot Price→ Unexpected Open Interest(SP→UOI) Unexpected Open Interest→ Spot Price(UOI→SP)	0.80725 3.21425	0.44 0.04

Note: the→ denotes the hypothesized direction of granger causality between the two variables ;and * Rejection of null hypothesis of no causality at 5% significance level.

Note: the→ denotes the hypothesized direction of granger causality between the two variables ;and * Rejection

Table:4 Granger causality test results-Turmeric		
	f-statistics	Prob.
Open interest →spot price(OI →SP) Spot price → open interest(SP →OI)	4.19634 0.37814	0.0153 0.6852
Traded volume→ spot price(TV→SP) Spot price → traded volume(SP →TV)	3.48159 8.07925	0.0311 0.0003
Spot price→ Unexpected Traded Volume (SP→UTV) Unexpected Traded Volume →Spot Price (UTV → SP)	3.87528 12.6664	0.021 4.00E-06
Spot Price→ Unexpected Open Interest(SP→UOI) Unexpected Open Interest→ Spot Price(UOI→SP)	0.19903 0.71532	0.8196 0.4892

of null hypothesis of no causality at 5% significance level.

To measure volatility in spot price GARCH(1,1) normal gaussian model has been used . In table 5 ARCH and GRACH terms, OI and UOI all are significant. Positive relationships is found between spot returns volatility and unexpected open interest. This indicates the increase in the level of open interest followed by greater volatility in the underlying spot market of chili causing destabilization in spot prices of chili .

Table 5 : GARCH Estimation Results-Chili					
ARCH term	GARCH term	ETV	UTV	OI	UOI
0.112614 (0.00)	0.873403 (0.00)	0.000997 (0.00)	0.002558 (0.21)	0.000206 (0.46)	0.002792 (0.70)
GARCH Estimation Results-Turmeri					
ARCH term	GARCH term	ETV	UTV	OI	UOI
0.649784 (0.00)	0.556239 (0.00)	3.64E-07 (0.00)	6.88E-08 (0.00)	2.08E-07 (0.00)	6.25E-08 (0.00)

Note: Dependent variable :chili spot return volatility; Methods ML-ARCH (Marquardt):Normal distribution ;and Figures in parenthesis show the probability at 5% significance level.

Hedging activity is found in the futures trading market which has a impact on spot price volatility. Traded volume represents the activity of speculators ,which implies that there is no evidence of increase in spot price due to speculation. Unexpected traded volume does not have impact on spot volatility. The probability is more than 5% ,hence it shows that it is not significant. Table 5 shows that a causality exists among the two variables.

4. Conclusions

Futures trading in chili and turmeric was introduced on the NCDEX in March 2005 and April 2004, respectively. This study examined the impact of futures trading activity on the volatility of spot market prices of chili and turmeric using daily data obtained from the NCDEX website. The study period spans from 2010 to 2020 for chili and from 2010 to 2020 for turmeric.

The empirical analysis employed ARCH and GARCH models to capture the presence of heteroskedasticity in spot price volatility. The diagnostic results indicate that the estimated models are well specified, as they exhibit no serial correlation and no remaining ARCH effects in the residuals. The findings reveal that unexpected traded volume, open interest, and the ARCH and GARCH terms are statistically significant in explaining spot price volatility for both commodities.

However, the Granger causality test results suggest that futures trading activity does not Granger-cause spot prices in either the chili or turmeric markets. This implies that while futures market variables significantly influence volatility dynamics, they do not directly drive spot price movements. Overall, the study concludes that futures trading contributes to volatility transmission without exerting a causal impact on spot prices, highlighting the role of futures markets in information assimilation rather than price manipulation.

References

1. Ahmad, N., & Sehgal, S. (2015). The effect of futures trading on spot price volatility: Evidence from agricultural commodity markets in India. *Journal of Derivatives & Hedge Funds, 21*(2), 98–114.
2. Antoniou, A., & Foster, A. J. (1992). The effect of futures trading on spot price volatility: Evidence for Brent crude oil using GARCH. *Journal of Business Finance & Accounting, 19*(4), 473–484.
3. Bhaduri, S. N., & Durai, S. R. S. (2008). Optimal hedge ratio and hedging effectiveness of stock index futures in India. *Macroeconomics and Finance in Emerging Market Economies, 1*(1), 121–134.
4. Biswas, S., & Rajib, P. (2011). Sequential information arrival hypothesis, volume, and volatility: Evidence from the Indian stock market. *Journal of Quantitative Economics, 9*(2), 67–85.
5. Chauhan, Y., Aggarwal, P., & Kumar, S. (2013). Price discovery and volatility spillover in agricultural commodity markets. *Agricultural Economics Research Review, 26*(2), 273–282.
6. Kumar, V. (2015). Price discovery and volatility spillovers in pepper futures market. *International Journal of Commodity Markets, 7*(1), 45–58.
7. Kumar, B., & Pandey, A. (2008). Hedging effectiveness of constant and time-varying hedge ratio: Evidence from Indian futures markets. *Journal of Risk Finance, 9*(4), 326–344.
8. Malhotra, N., & Sharma, D. (2015). Impact of futures trading volume on spot market volatility: Evidence from guar seed. *International Journal of Economics and Finance, 7*(3), 160–172.

9. McMillan, D. G., & Speight, A. E. (2007). Volatility forecasting and hedge effectiveness with GARCH models. *Journal of Forecasting, 26*(4), 235–252.
10. Mishra, P. K., & Goswami, B. (2016). Forecasting sugar futures price volatility in India using GARCH models. *Journal of Quantitative Economics, 14*(1), 45–60.
11. Naik, G., & Kumar, R. (2001). Performance of Indian commodity futures markets: An empirical analysis. *Economic and Political Weekly, 36*(32), 3161–3169.
12. Sendil, R., & Jha, G. K. (2014). Price volatility and futures trading in agricultural commodities in India. *Agricultural Economics Research Review, 27*(2), 221–231.
13. Sharma, T. (2016). Impact of futures trading on spot price volatility: Evidence from pepper market. *International Journal of Agricultural Economics, 8*(1), 55–66.
14. Soni, T. (2013). Market efficiency and price discovery in guar seed futures market. *Asia-Pacific Journal of Management Research, 2*(4), 78–91.
15. Srinivasan, P. (2011). Price discovery and market efficiency: Evidence from Indian stock markets. *International Journal of Economic Research, 2*(2), 21–32.
16. Zhong, M., Darrat, A. F., & Otero, R. (2004). Price discovery and volatility spillovers in Mexican futures markets. *Journal of Futures Markets, 24*(9), 837–855.