Price Discovery Process and Volatility Spillover of Chilli spot and Futures Prices Evidence from National Commodity and Derivative Exchange Ltd (NCDEX)

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Abstract

The major population, around 57 per cent, is employed in agriculture which in turn will have to play a major role if we want to achieve 8–10 per cent growth. Hence, it becomes imperative to promote commodity trading in India. India is among the top five producers of most of the commodities besides being the major consumer of agriculture, bullion and energy products. The paper presented chilli production, export and import trends. It also examined the price discovery mechanism and causality between chilli spot and futures markets using Co integration and Vector Error Correction Model (VECM) for the period from 1st April 2006 to 31st March 2013 for the National Commodity and Derivatives Exchange Ltd. India is the largest producer of chilli and contributes 25% to total world production. It is also the largest consumer and exporter of chilli, the production of chilli in India is denominated by Andhra Pradesh which contributes 51% to the total production. Data series were used to determine their stationarity of the series using the ADF, PP and KPSS unit root tests which have shown that the two series are I(1). The findings suggest that there is only one co-integration relationship that exists between futures and spot chilli prices in long run and the causality exists. The causality is not bidirectional and it is unidirectional. The results indicate that futures chilli price leads the spot price. Chilli futures markets provide the direction and farmers' active participation in the futures market certainly improves the efficiency of the futures market. It is inferred that the chilli futures market is efficient. Though the farmers are not highly benefited through the existence of futures market, investors and hedgers prefer futures market than entering into futures market for speculation benefits.

Keywords: Commodity futures market, Turmeric futures, Volatility, price discovery, Co integration, Causality, VECM, and NCDEX.

1. Introduction

India is traditionally an agrarian economy; therefore, instability of commodity prices has always been a major concern of the producers as well as the consumers the major population, around 57 per cent, is employed in agriculture which in turn will have to play a major role if we want to achieve 8–10 per cent growth. Hence, it becomes imperative to promote commodity trading in India. India is among the top five producers of most of the commodities besides being the major consumer of agriculture, bullion and energy products.

Commodity may be defined as an article, a product or material that is bought and sold in the market. Commodities have huge potential to become a separate asset class for market participants namely, investors, arbitrageurs or speculators. Commodity market is a market where a wide range of products viz., base metals (aluminum, copper), agriculture products (soyabean, wheat, and oil), precious metals (gold, silver) and energy products (oil, electricity) are traded. It is pertinent to develop a vibrant, active and liquid commodity market, as it can help in better price discovery for the market. Further, these markets cater to the needs of hedgers who want to mitigate risk arising out of exposure to the underlying asset. From investor's perspective, historically, it has been seen worldwide that volatility in commodities futures market has been less as compared to equities or debt markets, and thus provide an efficient portfolio diversification option. The total value of trade in the commodities market in India increased from 1,19,17,394 crore in 2010-11 to 1,66,11, 851 crore in 2012–13 registering the growth of 40 per cent.

The various challenges that have cropped into Indian agriculture during the post WTO regime are, for instance, technological changes, innovative irrigation techniques, productivity enhancement, and more importantly, the market reforms. Fragmented rural market is a huge challenge in the marketing/trading of agricultural commodities in India. Farmers' direct exposure to price fluctuations makes it too risky for many to invest in otherwise profitable activities. There are various ways to cope with this problem. One of the ways is the introduction of futures market.

Price risk refers to the probability of adverse movements in prices of commodities, services or assets. Agricultural products, unlike others, have an added risk. Many of them being typically seasonal tend to attract lower prices during the harvest season. The forward and futures contracts are considered to be efficient risk minimizing tools which insulate buyers and sellers from unexpected changes in future price movements. These contracts enable them to lock-in the prices of the products well in advance. Moreover, futures prices give necessary indications to producers and consumers about the likely future ready price and the demand and supply conditions of the commodity traded. The cash market or ready delivery market, on the other hand, is a time-tested market system, which is used in all forms of business to transfer title of goods.

Futures market is expected to serve as a price discovery vehicle for investors in spot market. As Fleming, Ostdiek and Whaley (1996) suggested, the trading cost advantage of futures market makes it more responsive to new information than other markets. As a result, prices are first updated in the futures market, which thus serves as a price discovery vehicle for investors. There are other explanations also for one market leading the other (Infrequent trading hypothesis of Tan and Lim, 2001; liquidity factor identified by Daigler, 1990, etc.). In short, a lead-lag relationship would be eventually established between spot and derivatives markets. The success of a specific futures contract in providing price risk protection, however, is dependent on the ability of a potential hedger to accurately anticipate the future relationship between cash and futures prices. Attempts to quantify and forecast futures-cash price relationships have received considerable attention in the futures market literature.

Price discovery and risk transfer are two major contributions of futures market towards the organization of economic activity (Garbade and Silber, 1983). Price discovery refers to the use of future prices for pricing cash market transactions. This implies that future prices represent a market's expectations of the subsequent spot price. Understanding the influence of one market on the other and the role of each market segment in price discovery is the central question in market microstructure design and is very important to academia and regulators. In efficient markets, new information is impounded simultaneously into cash and futures markets In other words, financial market pricing theory states that market efficiency is a function of how fast and how much information is reflected in prices. The rate at which prices exhibit market information is the rate at which this information is disseminated to market participants (Zapata et al. 2005). In reality, institutional factors such as liquidity, transaction costs, and other market restrictions may produce an empirical lead-lag relationship between price changes in the two markets.

Kavussanos and Visvikis (2004) note, market agents can use the volatility transmitting market in order to cover the risk exposure they challenge. A considerable amount of research has been conducted in the field of volatility and its spillover, the results of which are mixed. Therefore, it is necessary, from time to time, to conduct empirical studies to measure the impact of financial derivatives, in our case commodity futures, on volatility spillover to spot market and vice-versa.

Volatility is another area of interest for regulators and market participants who prefer less volatility to more volatility. A meaningful interpretation of volatility gives significant information and acts as a measure of how far the current prices of an asset deviates from its average past prices. At a fundamental level, volatility specifies the strength or the confidence behind a price move. Instinctively, it can be argued that measurement issues of volatility can also be useful to comprehend market assimilation, co-movement and spillover effect. The existence of volatility spillover between two markets specifies that the volatility of returns in one market has an important effect on the volatility of returns in the other market. The paper has six sections. We present dynamics of chilli spot market in section 2. Section 3 provides brief review of the literature review on price discovery. The econometric methodology and results and discussions of data were provided in sections 4 and 5 respectively. Section 6 provides a brief summary of conclusions and policy implications.

2. **Dynamics of Chilli Spot Market**

Chilli is one of the most important commercial crops of India. It is grown almost throughout the country. There are more than 400 different varieties of chillies found all over the world. It is also called as hot pepper, cayenne pepper, sweet pepper, bell pepper, etc. Its botanical name is "**Capsicum annuum**". Chillies are integral and the most important ingredient in many different cuisines around the world as it adds pungency, taste, flavour and color to the dishes. Indian chilli is considered to be world famous for two important commercial qualities—its colour and pungency levels. Chilli occupies an important place in Indian diet. It is an indispensable item in the kitchen, as it is consumed daily as a condiment in one form or the other. Among the spices consumed per head, dried chilli fruits constitute a major share. Currently, chillies are used throughout the world as a spice and also in the making of beverages and medicines. In Indian subcontinent, chillies are produced throughout the year. Two crops are produced in kharif and Rabi seasons in the country. Chilli grows best at 20–30°C. Growth and yields suffer when temperatures exceed 30°C or drops below 15°C for extended periods. The crop can be grown over a wide range of altitudes from sea level upto nearly 2100 meter.

Indian Production ranges between 10-13 lakh MTs per annum which is about 25% to 30% of world production. Other major producers are China (22%), Spain (16%), Mexico (8%), Pakistan (7%). Andhra Pradesh (A.P.) is the leading Chilli producing state and has around 70% - 80% share in total production. Madhya Pradesh (M.P.) contributes around 10%-15% of total production. The total area under chilli cultivation in India is around 8 lakh hectares and the annual production of dry chilli is approximately 10 – 12 lakh tonnes harvested session for chilli starts from February and extends till April. Out of the total spices exported from India, Red Chilli is the second most exported spice with a share of around 25% (volume wise). LCA 334 is the variety traded on exchange platform in the past decade in India while the other popular varieties are Teja, Wonder hot and Bydagi.

Supply characteristics

- India is the world's largest producer, consumer and exporter of chillies in the world. India also has the largest area under chillies in the world. Chillies are the most common spice cultivated in India.
- Almost all the states of India produce the crop. The important chilli growing states of India are Andhra Pradesh (40%), Karnataka (15%), Maharashtra, Madhya Pradesh, Orissa, West Bengal, Rajasthan and Tami Nadu. The major chilli growing districts of Andhra Pradesh are Guntur, Warrangal, Khammam, Krishna and Prakasham.
- Chillies can be grown during the entire year at one of the other part of the country. However, the major arrival season extends from February to April. The crop planting starts from August and extends till October. While, the harvesting begins from December with 5% of the arrivals usually reported in this month. The peaks arrivals are reported in February to March.
- There are several varieties of chilli cultivated in India. The most popular among these are Sannam, LC334, Byadgi, Wonder Hot, Jwala etc.

Demand Characteristics

- India is the largest consumer of chilli in the world. Around 90% of the India's production, is consumed within the country
- It is estimated that around 25 – 30% of the chilly crop is used for powder preparation, with the branded chilly powders manufacturers accounting for around 5% of the total volume.
- India exports around 80,000 – 1 lakh tons of chilli a year
- After India, China is the major producer of chilli in the world.
- Malaysia is now the largest importer of chilli from India which contributes 26% to the total exports from India. Sri Lanka stands second with 19% followed by Bangladesh 17%, USA 14% and other 16%.
- Indian chilli is mainly exported to USA, Sri Lanka, Bangladesh, the Middle East and the Far East

Trade Characteristics

- Well-established spot market at Guntur, Warrangal, and Khammam in Andhra Pradesh, Raichur, and Bellary in Karnataka are the major price reference points, as these are based at the production centers.
- The trade channel involves several members viz., a village level trader, commission agent, wholesaler, retailer, agents and exporters. The commodity changes hands several times, exposing all these members to price risk

- **Guntur is the Asia's largest market for chillies**. Normally, about 80% lakh to one crore bags of chillies, weighing approximately 35 to 50 kgs is traded during the season at Guntur market alone. The marketing season begins in the first week of February, peaks during the month of April and closes by the middle May.
- The market players estimate that trade worth nearly Rs.500 crores takes place in Guntur during season. During the peak arrival period around 0.8 – 1 lakh bags of 35 – 50 kgs is traded here daily.
- Around 35-40% of the crop that arrives at Guntur is estimated to be stored in cold storage present at Guntur and surrounding areas.

India is the largest producer of chilli and contributes 25% to total world production. It is also the largest consumer and exporter of chilli, the production of chilli in India is deominated by Andhra Pradesh which contributes 51% to the total production. Table 1 provides the production trends of chilli in India.

Table 1 - Chilli: Production Trends in India

Year	Area ('000 Hectares)	Production ('000 MT)	Yield (Kg/ Hectares)	% of increase/ (decrease) of production	% of increase /(decrease) of Area of production
1997-98	840.6	870.1	1035	-	-
1998-99	891.2	1043.2	1171	19.89	6.01
1999 – 00	959.20	1052.80	1097.58	0.9	7.63
2000 – 01	836.50	983.70	1175.97	(6.5)	(12.79)
2001-02	880.00	1069.00	1214.77	8.67	5.20
2002-03	827.40	894.60	1081.22	(16.31)	5.97
2003-04	774.30	1235.70	1595.89	38.12	(6.41)
2004-05	737.30	1185.50	1607.46	(4.06)	(4.77)
2005-06	654.00	1014.60	1551.38	(14.41)	(11.29)
2006-07	763.23	1242.11	1627.44	22.42	16.70
2007-08	836.83	1370.853	1610.62	10.36	9.64
2008-09	802.896	1381.531	1629.96	0.77	4.05
2009-10	809.699	1470.352	1579.52	6.42	0.84
2010-11	716.428	1299.191	1532.84	(11.64)	11.51
2011-12	804.792	1276.301	1542.22	(1.76)	12.33

Source: Dept. of Agriculture and Cooperation (Horticulture Division), Ministry of Agriculture, Govt. of India

Table 1 shows the chilli production for the past fifteen years and the average increase in production is more than mean decrease. When the percentage area of production increases the percentage of production of chilli increases except 2010-11 and 2011-12 due to decrease in yield the increase in production of chilli was highest in 2003-04 though the area of production decreased due to increase of yield by 47 per cent in the same year.

Figure 1 Chilli Production Trends

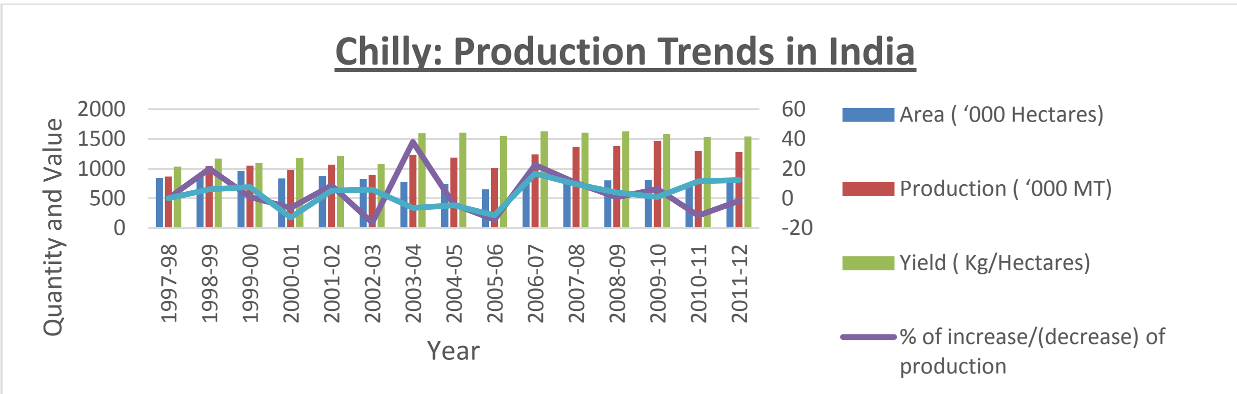


Table 2: State wise area and production of chilli during 2007-08 to 2010-11 (Area in Hectare & Production in '000 tons)

State	2007-08		2008-09		2009-10		2010-11		Total	
	Area	Production	Area	Production	Area	Production	Area	Production	Area (%)	Production (%)
Andhra Pradesh	236.403	809.426	210.792	781.671	206.541	830.990	195.471	638.298	849.207 (26.76)	3060.39 (55.38)
Karnataka	136.704	154.764	125.965	143.481	138.711	144.044	113.849	128.806	515.229 (16.23)	571.095 (10.33)
West Bengal	62.382	93.697	63.249	96.002	63.450	95.765	63.618	96.216	252.699 (7.96)	381.68 (6..90)
Madhya Pradesh	46.218	49.110	47.332	58.455	54.414	90.569	54.414	90.569	202.378 (6.38)	288.783 (6.13)

Orissa	75.140	63.920	75.510	64.300	75.530	64.320	76.010	70.390	302.19 (9.52)	262.93 (5.22)
Maharashtra	99.700	44.200	97.200	45.400	97.200	45.400	34.604	71.749	328.704 (10.36)	206.749 (4.76)
Gujarat	33.510	55.036	31.810	36.215	32.854	42.305	36.570	48.051	134.744 (4.24)	181.607 (3.74)
Tamil Nadu	67.408	34.084	62.617	32.924	58.476	31.230	53.626	21.690	242.127 (7.63)	119.928 (3.29)
Punjab	10.405	16.837	10.414	17.256	10.524	17.492	10.555	17.912	41.898 (1.32)	69.497 (2.17)
Rajasthan	22.059	30.132	15.157	19.976	13.812	13.649	13.381	14.425	64.409 (2.46)	78.182 (1.26)
Assam	16.101	10.134	17.010	10.862	17.111	11.727	18.808	12.237	69.03 (2.18)	44.96 (1.41)
Total including others	836.831	1370.853	802.896	1381.531	809.699	1470.352	724.065	1303.820	3173.49	5526.56

Source: Spices Board of India

Table 2 shows the state-wise production and area under production. Andhra Pradesh has highest area of 26% of the total area which provided 55% of the total production followed by Karnataka which provided 10% of the total production.

Table 3: Export and Import trends in Chilli

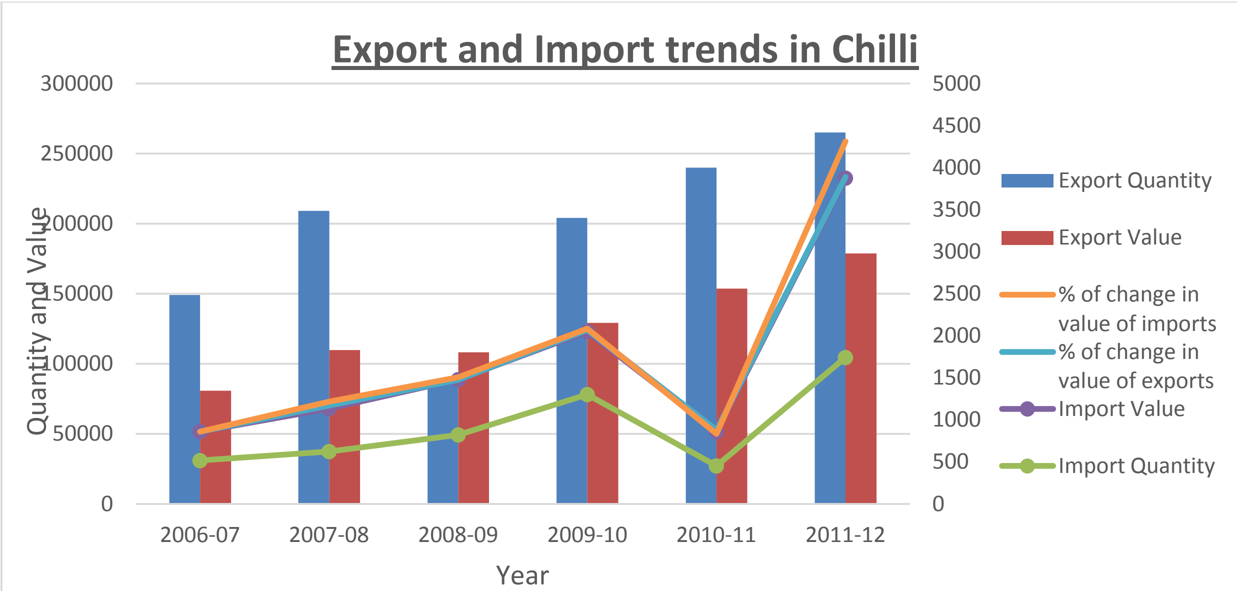
(Quantity in tonnes and values in Rs. lakh)

Year	Export		Import		% of change in value of exports	% of change in value of imports
	Quantity	Value	Quantity	Value		
2006–07	149022	80855.97	514	345		
2007-08	209000	109750.01	622	512	35	48
2008-09	88000	108094.92	820	657.25	(1)	28
2009-10	204000	129172.81	1,300	750.00	19	14
2010-11	240000	153553.96	450	408.25	19	(45)
2011-12	265000	178653.65	1,740	2133.93	16	422

Source: Spices Board of India

Table 3 provides quantity and value of imports and exports of chilli from 2006-07 to 2011-12. There was steady growth in exports of chilli in terms value from 2006-07 to 2011-12 except in 2008-09. There was remarkable growth of chilli exports in 2009-10 and 2010-11. But during the year 2008-09, there was decrease in value of exports due to decrease in value of production. When the value of exports was negative, the imports were increased by 28 per cent in terms of value in 2008-09 to fulfill local demands. The imports were reduced considerably in 2010-11.

Figure 2 Export and Import trends in Chilli



3. Review of Literature

Derivatives trading in the commodity market have been a topic of interest of research in the field of finance. There have been divergent views on the impact of derivatives trading. A number of research studies show the impact of introduction of future trading in commodity markets on the price volatility. There have been two sets of findings, one stating the introduction of derivatives in the stock market has enhanced the volatility and market performance. The other stating the introduction of derivatives has decreased the volatility in stock market thereby increasing steadiness. This study adds to the existing literature in this field using some econometric tools like Co-integration, VECM models and Block Exogeneity Test (Causality Test) to bring conclusiveness to the subject.

Raveendran and Aiyasamy (1982) while analyzing export growth and export prices of turmeric from India observed cyclical pattern of variations in prices. The length of the export price cycle varied from three to seven years. The export prices were studied for their relation with the domestic prices. The coefficient of correlation between the two was 0.9473. The high correlation in export and domestic prices of turmeric explained little variation in value of the variable RT (ratio between price Pe to domestic price Pd in the year t, i.e., (Pe / Pd) t) and consequently its non significant influence on export trade. The very high correlation of export price of turmeric with its domestic prices obviously confirmed the vulnerability of the latter to international price fluctuations.

Koontz et al. (1990) investigate the spatial price discovery mechanism in the livestock market and found that there was high degree of interaction between cash and futures prices using Geweke's causality test (1982). They also find that the price discovery process is dynamic and the structure of the market influences it. Thomas and Karande (2001) analyze price discovery in India's castor seed market and show that markets that trade exactly the same asset in the same time zone, do react differently to information and also a small market may lead a large market. Moosa (2002) with the objective to find out if crude oil performs the function of price discovery and risk transfer re-examine the Garbade and Silber (1983) model. With the daily data he finds that sixty percent of the price discovery function is performed by the futures. It is also discovered in the results that there is a fairly elastic supply of arbitrage system and that Garbade and Silber model is more suitable for intraday behaviour of spot and future prices.

Kumar and Sunil (2004) examine the price discovery for five commodities in six Indian commodities exchanges. Daily futures and comparable ready prices have been used in the study and the ratio of standard deviations of spot and future rates have been taken for empirical testing of ability of futures markets to incorporate information well. Besides, the study empirically analyzes the efficiency of spot and future markets by employing the Johansen co-integration technique. They find the inability of future market to fully incorporate information and confirmed inefficiency of future market. However, the authors conclude that the Indian agricultural commodities future markets are not yet mature and efficient.

Zapata, Fortenbery and Armstrong (2005) examine the observations from January 1990 to January 1995 of 11 future prices traded in New York and the World cash prices for exported sugar. They report that future markets for sugar leads the cash market in price discovery. A unidirectional causality from future price to spot is revealed. Futures and cash prices are found to be co-integrated which suggests the sugar futures contract is a useful vehicle for reducing overall market price risk faced by cash market participants selling at the world price.

In a study conducted by Silvapulle and Moosa (1999) and Karande (2006) a lead is found in the futures prices implying the price is being discovered first in that market and latter in the spot market. It is found that futures prices play a dominant role and the future prices of crude oil and castor seed lead spot prices. Primarily why a lead-lag relationship between the two markets is observed is that it is less costly since transaction cost is lower and the degree of leverage attainable is higher.

Liu and Zhang (2006) have studied the price discovery of spot and futures prices in Chinese copper, aluminum, rubber, soybean and wheat markets. However, the lead lags relationship between spot and futures markets in Indian commodity derivatives are quite limited.

Fu and Qing (2006) study the price discovery process and volatility spillovers in Chinese spot-futures markets through Johansen co-integration, VECM and bivariate EGARCH model. The results show there is a long-term equilibrium relationship and significant bidirectional information flows between spot and futures markets in China, with a dominant role played by futures markets. Although innovations in one market could predict futures volatility in another market, the volatility spillovers from futures to spot are more significant than the other way round.

Dash, Andrews (2010) examine the market behavior and causality effects between spot and futures prices in Indian commodity markets. The pattern is quite different for different commodities. Commodities that suffer from chronic backwardation must be analyzed in more detail, in order to understand the causes, and controls (known as backwardation limits) should be instituted for the same. Causality in commodities markets can be used to either hedge or speculate price movements: if changes in spot prices drive changes in futures prices, efficient hedging strategies can be formulated; whereas if changes in futures prices impel change in spot prices, efficient speculation strategies can be developed. Further, causality can be used in forecasting commodity spot and futures prices.

Phanindra Gayari & Pratap Kumar Jean (2009) examined the market efficiency and forecasted the futures prices of gold, crude oil and guar seed in India. It also examined price variation or fluctuations during the forecast periods. This study found that both in short-run and long-run, the selected commodities futures and spot markets are efficient. Forecasting values indicate that the trends of the average annual forecasted futures prices for gold, crude oil and guar seed are showing upward trends for the ex-ante period from 2009 to 2014. But trend in the ex-ante period is much higher than in the in-sample and out-sample periods. The fluctuations or volatilities in futures prices in the selected three commodities were less during the ex-ante forecast period compared to those during the in-sample and out-sample forecast periods. The increasing trend in price is more prominent in crude oil and gold compared to guar seed. Similarly the results show that volatilities or fluctuations in futures prices during the ex-ante period were more in gold and crude oil as compared to those in the guar seed. Less fluctuation in futures prices in the ex-ante forecast period may be able to attract more traders.

Kato Gogo Kingston (2011) empirically investigates the causal relationship between mineral exploration and environmental pollution in Nigeria with specific focus on natural gas

and crude oil in Niger Delta region. The model of Granger causality tests was used. The ADF unit root tests show that the null hypothesis of unit root is rejected and, the KPSS stationarity test result accepts the null hypothesis of "stationarity" implying that the variables are fit for the purpose of Granger causality analysis. The test for cointegration show that the variables are cointegrated at the trace level; this imply that gas flaring, environmental pollution and foreign direct investment are statistically linked. The regression on the ordinary least square illustrates that the impact of oil and natural gas exploration on the Nigerian environment is persistent in the long-run. The Granger-causality test result shows that there is one-way causality flowing from the flaring of gas by the foreign firms to the environmental pollution in Nigeria. The study finds a long-run uni-directional causal relationship flowing from mineral exploration to air, soil and water pollution.

As mentioned above, empirical literature on price discovery mainly deals with developed markets like US and UK. In India significant and relevant literature on commodity market is thin and has mainly focussed on agricultural commodities (Kabra, (2007; Kolamkar, (2003); Kumar and Pandey, (2009); Naik and Jain, (2002); Ramaswami and Singh, (2007); Raipuria, (2002); Roy, (2008); Sabnavis and Jain, 2007; Thomas, 2003; Nair, 2004, Ghosh (2009a), (2009b), (2010a), Pavaskar (2009) and Pavaskar and Ghosh (2009), Dey, (2009); Dey and Maitra, (2011)).

From the above discussions, we find that there is lot of inconsistency in view about, which market leads the other. Most of the literature supports that there is long run relationship between futures and spot market but there are also a lot literature available which hold an opposite views. There are limited studies available on long run relationship between chilli futures and spot. This study tries to fill up the gap and the present paper attempts to find lead lag and causality between chilli spot and futures market.

4 Methodology

This part of the paper provides data and sample size, objective and tools used for analysis of data.

4.1 Data and Sample Size

The National Commodity and Derivatives Exchange Ltd. (NCDEX) is an online national level commodity exchange established on April 23, 2003 and commenced operations on December 15, 2003. It offers futures trading in 57 commodities in agriculture, energy, metals, plastics and carbon credits and one of the largest agricultural commodity exchanges. The daily closing price for chilli futures and spot contracts are used. Further, the closing prices of spot and futures contacts maturing 180 days were taken for study. The sample period covers seven years data from 1st April 2006 to 31st March 2013. Data pertaining to price series were collected from their website (www.ncdex.com).

4.2 Objectives

The objectives of the paper are

- To provide historic production, export and import pattern of chilli
- To examine the price discovery mechanism in chilli futures market
- To find the causality between chilli spot and futures prices

4.3 Tools of Analysis

Non –stationary is a common property of most of the time series. The classical statistical methods of model building such as OLS are not possible when the series is non- stationary. But the technique of co-integration makes it possible to build models which are both statistically and economically meaningful, using nonstationary stochastic variables. A pre-requisite for co-integration is that the series under consideration must be integrated of the same order. When two series are individually having a stochastic trend, i.e., I (1), and their linear combination is I (0), this implies that the linear combination cancels out the stochastic trends in the two series. In this case two variables are co-integrated. Economically speaking, two variables will be co-integrated if they have a long term or equilibrium relationship between them.

If two series are co-integrated it prevents them from wandering about without bound. Spot price and future price may be expected to be co-integrated since they are obviously prices for the same asset at different points of time, and hence will be affected in very similar ways by given pieces of information. The long run relationship between spot and future prices would be given by the cost of carry. The co-integration between spot and future prices is a necessary condition for market efficiency. The absence of co-integration implies that futures price provide little information about movement in cash price, indicating that the futures market is not very efficient.

Johansen's co-integration test and Vector Error Correction Models (VECM) are among the best tests presently available to test for co-integration. As a pre-test, individual series are subjected to unit root analysis. Augmented Dickey Fuller (1979), Phillips Person and KPSS (1992) tests are used to test the stationarity of spot and futures prices. In ADF test and PP test the hypothesis is that the time series is stationary while in KPSS the hypothesis is that the series is non-stationary.

A Vector Autoregressive (VAR) model with k lags containing these variables could be represented as

$\Delta y_t = \prod y_{t-1} + A_1 \Delta y_{t-1} + A_2 \Delta y_{t-2} + ... A_{k-1} \Delta y_{t-(k-1)} + \eta_t.$ (1)

Where $\mathbf{y}_t$ is an nx1 vector of variables that are integrated of order one – commonly denoted

I(1) – and $\boldsymbol{\varepsilon}_t$is an nx1 vector of innovations. This VAR can be re-written as

$\Delta y_t = \mathbf{\Pi} y_{t-1} + \sum_{i=1}^{p-1} \Gamma i \, \Delta y_{t-1} + \acute{\varepsilon}_t$ (2)

Where $\mathbf{\Pi} = \sum_{i=1}^{p} \mathbf{Ai} - \mathbf{I}$ **and** $\Gamma i = -\sum_{j=i+1}^{p} Aj$

If the coefficient matrix **Π** has reduced rank r<n, then there exist nxr matrices **α** and **β** each with rank r such that $\mathbf{\Pi} = \boldsymbol{\alpha\beta}'$ and $\boldsymbol{\beta}'\mathbf{y}_t$ is stationary where r is the number of cointegrating relationships, the elements of **α** are known as the adjustment parameters in the vector error correction model and each column of **β** is a cointegrating vector. It can be shown that for a given r, the maximum likelihood estimator of **β** defines the combination of $\mathbf{y}_{t-1}$ that yields the r largest canonical correlations of t $\Delta\mathbf{y}_t$ with yt_{-1} after correcting for lagged differences and deterministic variables when present. Johansen proposes two different likelihood ratio tests of the significance of these canonical correlations and thereby the reduced rank of the **Π** matrix: the trace test and maximum eigen value test, shown in equations (3) and (4) respectively.

$\Lambda \text{ trace } (r) = -T \sum_{i=1}^{k} \ln (1 - \hat{\lambda} i)$ (4)

$\lambda \max (r, r+1) = - T \ln(1 - \hat{\lambda}_{r+1})$ (5)

Where$\hat{\lambda}$ is the estimate of i^{th} order Eigen value from Π matrix while r denotes the number of cointegrating vectors? A significantly non- zero Eigen value indicates that the corresponding vectors are significant cointegrating vectors.

If there exists a significant co-integration between two series which are stationary at the same level, it is suggested to check for presence of short term disequilibrium and speed of adjustment of disequilibrium toward the long run equilibrium. This is performed by Vector Error Correction Model (VECM) which is a Vector Autoregressive (VAR) model. The model is as follows

$a_i \Delta y_t = Z_{t-1} + \sum_{i=1}^{k} ai \;\; \Delta y_{t-I} + \sum_{i=1}^{k} bi \Delta x_{t-1} + \epsilon_t$ (6)

Where $Z_{t-1}$is the intercept, a and b are long – run coefficient parameters to be estimated, y_{t-1} indicates the error correction term and ϵ is the random error term. After confirming co-integration it is imperative to test for causality to assess the direction of relationship between spot and futures prices and one lag is given as

$$A^{*} y(t-1) + A^{p-1}(L) \Delta y(t) = \varepsilon(t)$$ (7)

If an autoregressive moving average model (ARMA model) is assumed for the error variance, the model is a generalized autoregressive conditional heteroskedasticity (GARCH, Bollerslev (1986)) model.

In that case, the GARCH (p, q) model (where p is the order of the GARCH terms σ^2 and q is the order of the ARCH terms ϵ^2) is given by

$$\sigma_t^2 = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \cdots + \alpha_q \epsilon_{t-q}^2 + \beta_1 \sigma_{t-1}^2 + \cdots + \beta_p \sigma_{t-p}^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \epsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2 \quad (8)$$

5. Results and Discussion

In this study the price discovery mechanism and volatility spillover between futures and spot price of chilli are examined for seven year period from 2006-07 to 2012-13. The univariate descriptive statistics such as mean, standard deviation and coefficient of variation for spot and futures prices for chilli are presented in Table 4.

Table 4 Descriptive Statistics of Futures and Spot Chilli Prices

Particulars	April 01, 2006 – March 31, 2013	
	Spot Price	Futures Price
Mean (Rs.)	5657.85	5638.41
Median (Rs.)	5299.20	5165.00
Maximum (Rs.)	10177.5	11672.0
Minimum (Rs.)	3180.75	3374.00
Std. Dev.	1390.17	1513.86
Coefficient of variation	0.245705	0.268491
Skewness	1.15438	1.52484
Kurtosis	0.485222	1.91115
Observations	2557	2557

The mean spot price (Rs 5657.85) is more than that of mean futures price (Rs 5638.41). But the maximum futures price was greater than the maximum spot price and at the same the variability, coefficient of variation of chilli futures price was slightly higher than that of chilli spot price. This implies that spot price is more consistent than futures price. Comparing the symmetry of distribution both spot and futures prices have positive skewness which infers that mean price is greater than the most frequently occurring prices. Comparing the coefficient of Kurtosis, both spot and futures have their value less than three implying a platykurtic curve, a curve more flat than normal.

Unit root test

Augmented Dickey Fuller (1979), Phillips Perron and KPSS (1992) tests are used to test the stationarity of spot and futures prices of crude oil. Unit root test is carried out on the log of spot and futures price series. Table 6a and 6b present the results of unit root test results. The optimal lag length of each differenced series is tested specified by Akaike Information Criterion (AIC). According to the criteria of AIC, the lowest AIC value was chosen for this implementation.

Table 6 :ADF, PP and KPSS test results for log of spot and futures price in level

ADF, PP and KPSS test results for log of spot and futures price in level			Augmented Dickey Fuller Test		Philip Perrons Test		KPSS test	
			t statistic	p value	t statistic	p value	LM Statistic value	5% critical value
	Spot price, LnSp3	H_0: the series has unit root	-2.40931	0.498	NA	0.526	6.04609	0.148
	Futures price, LnFp3	H_0: the series has unit root	-2.56956	0.582	NA	0.561	1.18545	0.148

ADF and PP has null hypothesis of rejection of the existence of unit root at 1% of the critical value. The KPSS has null hypothesis of stationarity.

The ADF test results shows that both the series, spot and futures price are non-stationary at level, but attains stationarity at first difference. The stationarity tests conducted for the two pair's sets of time series show that all the series attain stability at the first difference and is now amenable for co-integration analysis. This makes it possible to investigate the existence of long run relation between the variables.

Table 6(a): ADF, PP and KPSS test results for log of spot and futures price in first difference

DF, PP and KPSS test results for log of spot and futures price in first difference			ADF Test		PP Test		KPSS test	
			t statistic	p value	t statistic	p value	LM statistic value	1% critical value
	Spot price,Δ LnSp3	H_0: the series has unit root	-45.4574	0.0000*	NA	0.0000*	0.06082	0.739
	Futures Price,Δ LnFp3	H_0: the series has unit root	-44.9053	0.0000*	NA	0.0000*	0.04359	0.739

ADF and PP has null hypothesis of rejection of the existence of unit root at 1% of the critical value. The KPSS has null hypothesis of stationary.

Co integration Analysis

Johansen's Co integration Test has been carried out to determine the existence of a long-run relationship between the spot and futures prices of turmeric for the pairs of series. The results of Johansen's Trace and Eigen value tests are shown in Table 7.

Table 7 Johansen's Co integration Test Results

Lag order = 1

	Ho	H1	Eigen value	Trace statistic		Max Eigen statistics	
				λ trace	p value	λ max	p value
	r = 0	r ≥ 1	0.018339	50.921	0.0000*	47.310	0.0000*
	r= 1	r ≥ 2	0.001412	3.6115	0.0574NS	3.6115	0.0574NS

* indicates significance at 1% level.
NS- Not significant
The null hypothesis of r=1 is not rejected at 5% level by both the Trace and Max Eigen methods.
There is at least one co integrated equation.

Beta (co integrating vectors)		
Futures Price	-0.0014312	0.00036750
Spot Price	0.0015731	0.00033880

Alpha (adjustment vectors)		
Futures Price	3.1503	-4.4882
Spot Price	-13.365	-1.2021

Renormalized beta			Renormalized alpha	
Futures Price	1.0000	1.0847	-0.0045088	0.0015206
Spot Price	-1.0991	1.0000	0.019128	- 0.00040728

Long-run matrix (alpha * beta')		
	Futures Price	Spot Price
Futures Price	-0.0061583	0.0034352
Spot Price	0.018686	-0.021431

It is important to note that the test of con-integration does not differentiate between a single stationary variable and a stationary linear combination of two or more than two variables constituting co-integrating relationship. The spot and futures price move together closely over time and their difference will be stationary. Hence it is inferred that there is an equilibrium relationship between chilli futures and spot in the long run.

Vector Error Correction Model (VECM)

VECM test is to find the presence of short run relation between spot and futures price which are co-integrated in their long run. An error correction model is a statistical specification of economic dynamics through which the pull and push forces restore the equilibrium relationship whenever a disequilibrium takes place. To apply ECM, the first differences of variables are taken. Both of the two differences are than tested for ECM. The VECM system lag order 1 is given below in Table 8.

Table 8: Vector Error Correction Model

Beta (cointegrating vectors, standard errors in parentheses)	Alpha (adjustment vectors)
Futures_Price 1.0000 (0.00000) Spot_Price -1.0991 (0.072767)	Futures_Price -0.0045088 Spot_Price 0.019128
Log-likelihood = -31348.434 Determinant of covariance matrix = 1.5416543e+008 AIC = 24.5340 BIC = 24.5477 HQC = 24.5390	

Table 8 (a): Equation 1: d_Futures_Price

Particulars	Coefficient	Std. Error	t-ratio	p-value
Const	-1.76977	3.12877	-0.5656	0.57169[NS]
EC1	0.00450885	0.00344506	-1.3088	0.19072 [NS]

NS- not significant

Mean dependent var	0.846244
Sum squared resid	37823141
R-squared	0.000670
Rho	0.120013
S.D. dependent var	121.7107
S.E. of regression	121.6938
Adjusted R-squared	0.000279
Durbin-Watson	1.759973

Table 8 (b): Equation 2: d_Spot_Price

Particulars	Coefficient	Std. Error	t-ratio	p-value
Const	12.2983	2.64608	4.6477	<0.00001
EC1	0.0191277	0.00291358	6.5650	<0.00001

Equation 2 is significant

Mean dependent var	1.200488
Sum squared resid	27053171
R-squared	0.016595
Rho	0.108393
S.D. dependent var	103.7642
S.E. of regression	102.9197
Adjusted R-squared	0.016210
Durbin-Watson	1.783195

Table 8 (c): Cross- Equation of Chilli Futures and Spot Prices

	Futures Price	Spot Price
Futures Price	14798	1567.5
Spot Price	1567.5	10584
Determinant	1.54165e+008	

It is evident from the table that only 0.4 % of disequilibria of futures price are corrected each year by changes in futures price and about 0.01% of disequilibria is corrected by spot price.

Causality Test

Once co-integration is established it is imperative to find the causality to assess the direction of relation between the variables. Grangers' causality test is implemented in this study. Table 9 gives the result of causality test.

Table 9 Causality Test Results

Panel of Data	**Direction of causality**	**F statistic**	**p value**	**Conclusion**	**Causality**
2006 - 2013	Spot does not lead the futures	0.78730	0.3750	Null of no granger cause is not rejected	Future Price leads Spot price
	Futures does not lead the spot	38.577	0.0000**	Rejected SIGNIFICANTLY the null of no granger cause	

Table 9 provides results of causality tests. It is evident from the table that there the null hypothesis of spot does not lead the futures is rejected and futures does not lead the spot is not rejected. Hence Futures price leads the spot price.

GARCH Model

Table 10 provides the GARCH model.

Table 10 GARCH Model

Model 1: GARCH, using observations 1/04/2006 – 31/03/2013 (T = 2557)

Dependent variable: Futures_Price

Standard errors based on Hessian

Particulars	Coefficient	Std. Error	Z	p-value
Const	4830.82	7.87964	613.0765	<0.00001
Alpha (0)	3044.05	606.402	5.0199	<0.00001
Alpha (1)	0.608606	0.0381759	15.9422	<0.00001
Beta (1)	0.391394	0.0332735	11.7629	<0.00001
Mean dependent var	5638.407			
S.D. dependent var	1513.860			
Log-likelihood	-19932.35			
Schwarz criterion	39903.94			
Akaike criterion	39874.70			
Hannan-Quinn	39885.30			
Unconditional error variance	5.69437e+016			

Model 2: GARCH, using observations 1/04/2006 – 31/03/2013 (T = 2557)

Dependent variable: Spot_Price

Standard errors based on Hessian

Particulars	Coefficient	Std. Error	z	p-value
Alpha (0)	78116	1.96746e+06	0.0397	0.96833
Alpha (1)	0.998336	0.412921	2.4177	0.01562
Beta (1)	2.21112e-010	0.409927	0.0000	1.00000
Mean dependent var	5657.855			
S.D. dependent var	1390.166			
Log-likelihood	-25654.92			
Schwarz criterion	51341.23			
Akaike criterion	51317.85			
Hannan-Quinn	51326.33			
Unconditional error variance	4.69504e+007			

6. Conclusion and Policy Implications

The paper presented chilli production, export and import trends. It also examined the price discovery mechanism and causality between chilli spot and futures markets using Cointegration and Vector Error Correction Model (VECM) for the period from 1st April 2006 to 31st March 2013 for the National Commodity and Derivatives Exchange Ltd. Andhra Pradesh has highest area of 26% of the total area which provided 55% of the total production followed by Karnataka which provided 10% of the total production. There was steady growth in exports of chilli in terms value from 2006-07 to 2011-12 except in 2008-09. There was remarkable growth of chilli exports in 2009-10 and 2010-11. But during the year 2008-09, there was decrease in value of exports due to decrease in value of production. Data series were used to determine their stationarity of the series using the ADF, PP and KPSS unit root tests which have shown that the two series are I(1). The findings suggest that there is only one co-integration relationship that exists between futures and spot chilli prices in long run and the causality exists. The causality is not bidirectional and it is unidirectional. The results indicate that futures chilli price leads the spot price. Futures market for agricultural commodities primarily exists for farmers to hedge their price risks. It is found through informal interaction with farmers in Guntur chilli market that farmers' participation in futures markets is very less. Other hedgers such as traders and stockists take the advantage of chilli futures market. Chilli futures markets provide the direction and farmers' active participation in the futures market certainly improves the efficiency of the futures market. It is inferred that the chilli futures market is efficient. The State Government Marketing Committee needs to take appropriate measures to bring awareness about participation in the chilli futures market by the farmers. Though the farmers are not highly benefited through the existence of futures market, investors and hedgers prefer futures market than entering into futures market for speculation benefits. The study has further scope for future collaborative research.

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