Price Behaviour of Spot and Futures Markets for Commodities in India : Case of Soy Oil

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Abstract

The purpose of this paper was to study the relationship between the spot and futures prices of soy oil - the most actively traded commodity in the futures market in India. It aimed to test whether the futures market is fulfilling the price discovery function, which is important for providing an effective hedging platform. Data related to daily prices of spot and futures markets were used to analyze the long-run and short-run relationship. Cointegration, vector error correction model , and bivariate BEKK-GARCH model were applied to examine the relationship between the returns and volatilities of both the markets. The study found existence of a long-run equilibrium relationship between the spot and futures markets. We also observed that the futures market played a lead role in the price discovery function. In the short-run, the volatility spillover from the spot market to futures was found to be strong. The findings of this study are of significance to hedgers who can design appropriate hedging strategies based on the volatility behaviour.

Keywords: **price discovery, volatility spillover, cointegration, VECM, BEKK-GARCH**

JEL Classification: C32, C58, G13, Q02

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The beginning of this century witnessed increased integration of various markets across the globe, which resulted in more frequent flow of information between the markets. The impact of this was more explicitly seen in commodity markets in developing countries like India. Moreover, with the commodities emerging as investment class of assets, the prices of commodities became more volatile across the globe, and such volatility was transmitted from one market to another without any delay. The increased volatility was observed in almost all types of commodities, including the precious metals, base metals, and agricultural commodities. High levels of price volatility created risks for both buyers as well as sellers of commodities. As a result, the derivative contracts emerged as innovative tools for managing price risk. Though, derivative contracts, per se, are not new to commodity markets, they assumed greater significance in developing countries like India during recent times. Futures contract is the only market-traded derivative available in India for hedging commodity price risk. Though the market for commodity futures in India is much older than the one for financial derivatives, it remained subdued for a long time due to government interventions and excessive regulation. The commodity markets became active in 2002, when the government permitted setting up of national level electronic exchanges like Multi Commodity Exchange (MCX) and National Commodity and Derivatives Exchange (NCDEX) for trading in futures contracts. Since then, the commodity futures market in India exhibited phenomenal growth, both in terms of volume and value of trade.

Futures market is expected to perform two significant functions of price discovery and risk transfer. Price

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Table 1. Trade in Commodity Futures in India

Year	Value of Trade (All Commodities)	Growth (%)	Value of Trade (Agri Commodities)	Growth (%)	Agri Commodities to Total (%)
2009-10	77,647	--	12,179	--	15.69
2010-11	119,489	53.89	14,564	19.58	12.19
2011-12	181,261	51.70	21,962	50.79	12.12
2012-13	170,468	-5.95	21,557	-1.84	12.65
2013-14	101,447	-40.49	16,024	-25.66	15.80

Note: The value of trade is in INR billions.

Source: Forward Markets Commission, Ministry of Finance, Government of India. (2010 - 2014)

discovery is the process of assimilation of new information into the prices of commodities. An efficient market is one, where every piece of new information is quickly reflected in the price. Theoretically, both the spot and futures markets should react to new information simultaneously. But, due to various practical considerations, this does not happen. Tse (1999) argued that the market that provides greater liquidity, lower transaction costs, and fewer restrictions is likely to play an important role in price discovery. Hence, the futures market, which satisfies the above conditions, is expected to play a lead role in the price discovery process. In other words, the new information is expected to be reflected first in the futures market, which is then transmitted to the spot market later. One of the ways of understanding the influence of information on prices is by analyzing the behaviour of volatility of prices in both the markets. The futures market is said to be providing an efficient platform for hedging the price risk, when the futures and spot prices exhibit a close relationship. The nature of this relationship in the long-run as well as short-run assumes significance in terms of hedging efficiency. It is also important to understand the direction of volatility spillover from one market to the other.

NCDEX is the leading futures trading platform for agricultural commodities in India. Soy oil constitutes the largest share of futures trading among the agricultural commodities traded on NCDEX. Hence, this study attempts to model the relationship between the rates of returns as well as the volatility of futures and spot prices of soy oil.

Commodity Futures Market in India

➯ **Growth of the Market :** Trading in commodity derivatives started in India in 1875, with trade in cotton derivatives in Mumbai. The market expanded to include various agricultural commodities over the years. Post-independence, the market witnessed a series of excessive regulations, trade restrictions, as well as suspension of trade for long durations. With the setting up of national level markets like MCX and NCDEX in 2002, the market emerged out of prolonged suppression. The ensuing years witnessed huge capital flow, introduction of latest technology, and innovations in the commodity futures market. Although agricultural commodities led the initial surge by constituting the largest proportion of the value of trade till 2005-06 (55.32%), this place was later taken over by bullion and metals in 2006-07 (Sen, 2008). This trend continues even now, with gold and silver together constituting about 42% of the trade. The share of agricultural commodities averaged 13.69% of the total trade during 2009-14 (Table 1).

The commodity futures markets witnessed huge growth rates till 2011-12, after which the value of trade fell for the next 2 consecutive years. Various government measures aimed at combating inflation - like restrictions on gold imports, higher import duty, and introduction of Commodity Transaction Tax (CTT) affected the trading activity in the markets adversely during this period. However, the fall in value of trade in agricultural commodities was comparatively smaller than the fall in trade of all commodities put together.

The commodity futures market in India was mired in many controversies over the years. Futures trading was

Table 2. Share of Value of Trade in NCDEX (%)

Commodity	2009-10	2010-11	2011-12	2012-13
Soy Oil	14.89	18.46	22.97	34.88
Soy Bean	10.78	7.21	6.77	13.64
Mustard Seed	9.24	6.18	9.14	11.27
Chana	11.58	7.99	15.17	9.98
Guar Seed	28.12	17.46	17.85	0.00
Total of first four	46.50	39.83	54.05	69.77

Source: Forward Market Commission (FMC) Annual Reports 2010, 2011,2012, & 2013

held responsible for increased inflation in agricultural commodities during 2006-07. The government responded by suspending futures trading in most of the agricultural commodities during this period. It appointed an expert committee under the chairmanship of Dr. Abhijit Sen to study the impact of futures trading on the wholesale as well as retail prices of agricultural commodities. The committee submitted its report in 2008. It could not find any conclusive evidence to suggest a causal relationship between the futures trading and inflation in agricultural commodities. Subsequently, the ban on futures trading on most of the commodities was lifted except for few sensitive commodities like tur, urad, and rice. The ban on these three commodities continues even today.

➢ **Market Structure :** The government has permitted futures trading in more than 100 commodities across various categories like metals, agricultural commodities, energy, and so forth. The commodity futures market in India consists of six national level exchanges and 11 commodity specific regional exchanges. However, MCX (78.25%) and NCDEX (15.70%) together contributed 93.95% share of total value of trade of all exchanges put together (Forward Markets Commission, Ministry of Finance, Government of India, 2010-2014). The commodity specific regional exchanges account for only 0.56% of the trade. While MCX specializes in metals with gold and silver as the major commodities, NCDEX focuses on agricultural commodities with soy oil and soya bean as the major commodities.

It can be seen from the Table 2 that the share of soy oil in the futures trading at NCDEX has risen gradually over the years. Even though trading is carried out in many agricultural commodities in NCDEX, four commodities, soy oil, soy bean, mustard seed, and chana accounted for close to 70% of the trade in NCDEX in 2012-13. Among these commodities, soy oil constituted the major share. Hence, this study intends to analyze the price behaviour of soy oil, the largest traded agricultural commodity in the Indian market.

➢ **Soy Oil :** Soy oil is one among the most traded edible oils globally, next only to palm oil. China is the largest producer of soy oil followed by USA, Argentina, and Brazil. Though, USA is the second largest producer, it exports only a small percentage, owing to the huge domestic consumption. Argentina and Brazil are the leading exporters of soy oil. Due to large domestic demand, China remains the largest importer. India is the second largest importer, with 1.25 million metric tons of imports during 2012-13. At the same time, India is also the sixth largest producer, with 1.78 million metric tons of production of soy oil. This is due to the fact that soy oil is one among the most widely used edible oils in India. The price of soy oil is influenced largely by international factors like: (a) production of soy oil in countries like Argentina, Brazil, USA, etc; (b) the price fluctuations in Chicago Board of Trade (CBOT), which is the major international reference rate; (c) domestic demand; (d) domestic production, and so forth. The government banned futures trading in soy oil, along with other commodities, for a period of 8 months in 2012. After the ban, the trading in soy oil picked up steadily and touched INR 7,083 billion in 2012-13.

Review of Literature

The relationship between the spot and futures markets is an area where extensive empirical work has already been carried out on financial markets as well as commodity markets. But most of these studies are done on more mature and developed markets like USA. Over the years, the methodology and econometric tools used for analysis have moved from simple tools like correlation and covariance to more complex models based on time-varying volatility. Some of the earlier studies like the ones conducted by Garbade and Silber (1982), Hasbrouck (1995), Koutmos and Tucker (1996), Fortenbery and Zapata (1997), Tse (1999), and Yang and Leatham (1999) tried to study the impact of futures markets on the spot prices.

Garbade and Silber (1982) suggested a model for studying the price discovery mechanism and the lead-lag relationship between the cash and futures markets. They found that the futures markets incorporated about 75% of the new information first and then transmitted the same to the spot markets. Hasbrouck (1995) proposed a new model called the information share (IS) model for attributing the source of variation in the random walk component to the innovations in the various markets. Information share of a market was defined as the proportion of the innovation variance that could be attributed to that market.

Koutmos and Tucker (1996) studied the relationship between the spot and futures prices of S&P 500 index using a bi-variate ECM-EGARCH model. They found that the volatility of returns was an asymmetric function of past innovations. They also found that the volatility of futures market spilled over to the spot market, but there was no spillover in the reverse direction. Fortenbery and Zapata (1997) analyzed the cheddar cheese market and concluded that there was no long run relationship between the futures and cash markets. Tse (1999) used high frequency minute by minute data on Dow Jones Industrial Average (DJIA) Index and applied VECM-EGARCH (1,1) model to study price discovery and volatility spillover between spot and futures markets. Apart from establishing the dominance of the futures market over the spot market, he also concluded that bad news - rather than good news - in either market increased the volatility in both the markets. Yang and Leatham (1999) studied the price discovery function of wheat futures and cash markets separately in USA using cointegration and error correction models. They concluded that the futures markets provided informed prices as compared to the cash markets.

Recent studies like Lin, Chen, Hwang, and Lin (2002), Mattos and Garcia (2004), and Rahman, Nawi, and Naziman (2012) tried to capture the market dynamics in emerging economies like Brazil, Taiwan, China, and Malaysia. Lin et al. (2002) studied the price discovery mechanism between index futures and index spot of Taiwan market. They found that even though both the futures and spot markets shared a long term cointegrating relationship, the spot market was leading the futures market in price discovery. This is quite opposite to what is found in developed markets. Mattos and Garcia (2004) examined the efficiency of commodity markets in Brazil and found that there was a long-run equilibrium relationship between the futures and spot markets of actively traded commodities like coffee and live cattle. This was not true in case of thinly traded commodities, and the results of price discovery are mixed. Similar results were reported by Rahman et al. (2012), who studied the palm oil market in Kuala Lumpur. From the above literature, we can conclude that the futures market is playing a lead role in price discovery in most of the emerging economies. However, there is limited literature available on the role of futures markets in the emerging economies.

Research on Indian commodity derivatives markets is at a nascent stage. Some of the earlier studies like the ones conducted by Sahadevan (2002), Naik and Jain (2002), and Kumar (2004) presented mixed results on the leading role of the futures market. Sahadevan (2002) analyzed the futures markets of six commodities and found that futures exchanges failed to provide an efficient hedge against the risk emerging from volatile prices of farm products. Whereas, Naik and Jain (2002) reported that the liquidity in the futures markets was low and hence, many markets were not efficient in assimilating new information. Only few markets provided hedging effectiveness in commodities. Kumar (2004) examined the relationship between the spot and futures markets and concluded that the futures markets did not contribute towards price discovery and hence, did not provide hedging efficiency. However, some of the recent studies like the ones conducted by Elumalai, Rangaswamy, and Sharma

(2009) ; Kumar and Pandey (2011) ; and Srinivasan and Ibrahim (2012) found that the futures markets were leading the spot market in price discovery. Elumalai et al. (2009) studied the impact of the futures market on production and prices of three agricultural commodities and found a strong co-integrating relationship between the spot and futures prices. Kumar and Pandey (2011) examined the price relationship between spot and futures of gold and silver, along with other commodities. They concluded that in case of gold and silver, there was a clear dominance of futures markets in both return and volatility spillovers in the recent period. In case of silver, the significant role of spot markets in the price discovery process was observed. Srinivasan and Ibrahim (2012) studied the relationship between the spot and futures prices and the volatility spillovers of gold market in India. Contrary to the general expectation, this study found that the spot market was leading the futures market in price discovery in case of gold in India.

From the above discussion, we can conclude that the research on the role of commodity futures markets in emerging economies is limited in nature, and the results of the existing studies are mixed, with some reporting dominance of the futures market on spot, while some others reporting prominence of spot market in the price discovery process. With this background, the present study aims at analyzing the role of the futures market in the price discovery process for soy oil in India.

Objectives of the Study

The study aims at comparing the behaviour of spot and futures prices of soy oil in order to check the dominance of one market over the other in terms of information assimilation. Hence, the following objectives are set for the study :

(1) To study the long-term equilibrium relationship between the returns of spot and futures markets of soy oil.

(2) To analyze the extent and direction of short-term causality between the spot and futures returns of soy oil.

(3) To examine the nature of volatility spill over between the spot and futures markets of soy oil.

Methodology

➯ **Data Description :** The trading in soy oil futures contracts was temporarily suspended by the government for a period of eight months in 2008. As discussed earlier, the trading in soy futures picked up after the ban was lifted. Hence, the current study covers a period of 5 years after the ban was lifted. The daily data relating to spot prices and closing prices of futures contracts were collected from the website of National Commodity and Derivatives Exchange (NCDEX) for 5 years - from 01-01-2009 to 31-12-2013. The prices of near month contracts were used in case of futures contracts. As and when a contract matured, prices were rolled over to the next near month futures contract. The data set contains 1462 observations after adjusting for date mismatches and non-availability of data for certain days. In order to facilitate analysis, the base data of spot and futures prices was transformed to log of prices by taking the natural logarithm of each data point. The daily rates of returns are arrived at by taking the first difference of the data series.

Econometric Models

➯ **Test for Stationarity:** Since the study deals with time series data, it is important to test for stationarity of data. Generally, the asset prices are expected to be non-stationary in nature. However, the rates of returns on assets, defined as the first difference of log of prices is expected to be stationary in nature. Hence, the unit root property of the daily prices as well as the daily rates of returns is tested here. Augmented Dickey Fuller (ADF) test and Phillips-Perron (PP) test are the two commonly used tests for stationarity and the same are used in this study.

➯ **Test for Cointegration:** Cointegration is a tool used to examine the long-run equilibrium relationship between two or more trending variables. It is quite possible for spot and futures prices of commodities to move together. Even when the price series are non-stationary, if there is a linear combination of these series, which is stationary in nature, the data series are said to be cointegrated. The Johansen-Jesulius Test is applied here to examine the long-run relationship between the spot and futures markets of soy oil through the cointegrating equation. The lag length for the cointegration test is decided based on Schwarz Information Criteria (SIC).

➯ **Vector Error Correction Model (VECM):** Cointegration confirms the existence of long-run relationship between two data series. However, it is quite possible for two cointegrated variables to diverge from the equilibrium in the short run. Such short-run divergences are brought back to the equilibrium through an error-correction mechanism. Granger (1986) argued that if two variables are $I(1)$ and cointegrated, there must be Granger causality in at least one direction, which means at least one variable takes the initiative to converge with the other in case of short-run divergence from the equilibrium. At times, both the variables contribute towards convergence. Vector error correction model (VECM), a restricted form of vector autoregression (VAR), is a tool that examines the nature and direction of error correction mechanism between two cointegrated variables. The behaviour of short-run causality can be analyzed using the VECM. The VECM applied in the present study is represented in equations (1) and (2).

$$\Delta S_t = \alpha_s + \lambda_s e_{t-1} + (\Sigma^{r}_{\mathrm{i}=1} \gamma_{s,\mathrm{i}} \Delta S_{t-\mathrm{i}}) + (\Sigma^{r}_{i=1} \omega_{f,i} \Delta F_{t-\mathrm{i}}) + \varepsilon_{st} \qquad (1)$$

$$\Delta F_t = \alpha_f + \lambda_f e_{t-1} + (\Sigma^{r}_{\mathrm{i}=1} \gamma_{f,\mathrm{i}} \Delta F_{t-\mathrm{i}}) + (\Sigma^{r}_{i=1} \omega_{s,i} \Delta S_{t-\mathrm{i}}) + \varepsilon_{ft} \qquad (2)$$

Equation (1) models the rates of returns of spot market with the lags of spot returns as well as the lags of futures returns as dependent variables. Equation (2) defines the futures returns as a function of its own lags and lags of spot market returns. The first term in both the equations, λ_s and λ_f represent the coefficients of long term error correction terms based on the cointegrating relationship. The terms $\omega_{s,i}$ and $\omega_{f,i}$ represent the short-run influence of the returns of one market on the other.

➯ **Volatility Modeling Using the BEKK-GARCH Model:** Understanding the behaviour of volatility of futures markets & spot markets and their interrelationship is crucial in analyzing the volatility spillover between the markets. In order to understand the impact of volatility of one market on the other, the volatilities of the daily rates of returns of both markets are modeled in this study. Since the rates of returns of assets markets exhibit time varying volatility, traditional ordinary least square (OLS) regression fails to capture the complete behaviour of volatility. Hence, the generalized autoregressive conditional heteroskedasticity model (GARCH) proposed by Bollerslev (1986) and its subsequent variants are used by researchers to model volatility of asset prices. Even though many variants of the basic GARCH model have been proposed by researchers over the years, the model proposed by Baba, Engle, Kraft, and Kroner (1991), known as the BEKK-GARCH model, is found to be suitable for modeling bi-directional volatility spillover across markets and hence, the same is applied in this study. The variance equation for the BEKK bivariate GARCH model is given in equation 3, which is further expanded in equation 4.

$$H_t = \acute{C}_0 C_0 + \acute{A}_{11}\, \varepsilon_{s,t-1}\, \varepsilon'_{f,t-1} A_{11} + B'_{11} H_{\mathrm{t-1}} B_{11} \qquad (3)$$

$$H_t = C_0 C_0 + \begin{bmatrix} a_{11} & ' \; a_{12} \\ a_{12} & a_{22} \end{bmatrix} \begin{bmatrix} \varepsilon^2_{s,t-1} & \varepsilon_{s,t-1}\varepsilon_{f,t-1} \\ \varepsilon_{s,t-1}\varepsilon_{f,t-1} & \varepsilon^2_{s,t-1} \end{bmatrix} \begin{bmatrix} a_{11} & ' \; a_{12} \\ a_{21} & a_{22} \end{bmatrix} + \begin{bmatrix} b_{11} & ' \; b_{12} \\ b_{21} & b_{22} \end{bmatrix} H_{t-1} \begin{bmatrix} b_{11} & ' \; b_{12} \\ b_{21} & b_{22} \end{bmatrix} \qquad (4)$$

In equations 3 and 4, a_{11} and a_{22} explain if the volatility of spot and futures markets are influenced by their own lagged values. The diagonal elements of matrix A (a_{12} and a_{21}) capture the short-run volatility spillover between

Table 3. Summary Statistics of Spot and Futures Daily Returns

	Spot	Futures
No of observations	1461	1461
Mean (%)	0.0243	0.0268
Maximum (%)	4.5859	5.3374
Minimum (%)	-6.1042	-10.4482
Standard Deviation (%)	0.7948	1.0641
Skewness	0.1708	-0.7734
Kurtosis	8.2157	11.7477
Jarque-Bera	1663.15*	4803.95*
ARCH-LM	11.3478*	7.1131*

Note:* denotes significance at 5%. The lag length for ARCH-LM Test is 12.

Table 4. Test for Stationarity

Price Series	ADF Test Statistics		PP Test Statistics	
	Level	First Difference	Level	First Difference
Spot	-1.0992 (0.7182)	-29.5974* (0.0000)	-1.1193 (0.7102)	-30.0074* (0.0000)
Futures	-1.2093 (0.6725)	-36.6598* (0.0000)	-1.2925 (0.6351)	-36.7896* (0.0000)

Note: Null hypothesis of ADF and PP Tests is that the series has unit root. * denotes significance at 5% level and hence rejection of the null hypothesis. The critical value at the 5% level is -2.86331

the spot and futures market (ARCH effect). The diagonal elements of matrix B (b_{12} and b_{21}) represent the long-run volatility spillover between the markets (GARCH effect). The terms b_{11} and b_{22} measure if there is volatility clustering in the markets. This study has adopted a two-stage approach proposed by Tse (1999), where first the VECM is estimated and the residuals generated from VECM, $\varepsilon_{s,t}$ and $\varepsilon_{f,t}$ are used in estimating the BEKK bivariate GARCH model.

Data Analysis

- **Summary Statistics:** The summary statistics of daily rates of returns of spot and futures prices are given in the Table 3. It can be observed that the rates of returns offered by spot and futures are very close to each other, but the variance in returns is comparatively higher in the futures market. The standard deviation of returns in the futures market is more than what it is in the spot market. The difference between the maximum and minimum returns during the period is also wider in case of the futures market. While the spot returns exhibit positive skewness, the futures returns are negatively skewed with a greater value. Both the markets show leptokurtic behaviour with the kurtosis measure lying above 3. This indicates that the return series have peaked distribution with fat tails. Jarque-Bera (JB) statistics suggest that neither of the series is normally distributed. The ARCH Lagrange multiplier (ARCH-LM) test is carried out to test the presence of heteroskedasticity or ARCH effect in the data, and the test results suggest that both the spot and futures returns exhibit ARCH effect. The presence of the ARCH effect in the data series justifies the use of GARCH based time varying volatility model for analyzing the behaviour of volatility.

- **Test for Stationarity :** The spot and futures price series are subjected to stationarity tests at level as well as at the first difference. Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test were applied to the data, and the results are summarized in the Table 4. Based on the results of ADF and PP tests, we can conclude that both

Table 5. Johansen-Jesulius Cointegration Test - Spot and Futures Prices

Hypothesised	Trace Test		Max Eigen Value Test	
No. of CE(s)	Test Statistic	*p*- value	Test Statistic	*p*- value
None	86.5722*	0.0000	85.1462*	0.0000
At most 1	1.4261	0.2324	1.4261	0.2324

Note: CE - Cointegrating Equations
*denotes rejection of hypothesis at the 5% level of significance.
Trace Test indicates 1 cointegrating equation
Lag interval selected: 2

Table 6. Estimates of Vector Error Correction Model

Coefficient	Spot Returns			Coefficient	Futures Returns		
	Value	SE	*t*- statistic		Value	SE	*t*- statistic
λ_s	-0.0832*	0.0142	0.0000	λ_f	-0.0588*	0.0232	0.0113
γ_{s1}	-0.0575	0.0316	0.0686	γ_{f1}	0.0397	0.0356	0.2647
γ_{s2}	-0.0004	0.0249	0.9863	γ_{f2}	-0.0231	0.0371	0.5339
ω_{f1}	0.3724*	0.0221	0.0000	ω_{s1}	0.0875	0.0507	0.0848
ω_{f2}	0.0519*	0.0231	0.0249	ω_{s2}	0.0837*	0.0401	0.0369
ε_{st}	0.0002	0.0002	0.3857	ε_{ft}	0.0002	0.0003	0.4289

Note: * denotes significance at 5% level. SE - Standard Error.

the spot and futures prices are not stationary at level. On the other hand, both the series are stationary at first difference. This means that when the series of prices show unit root property, the daily rates of returns, defined as the first difference of log series of prices, do not show unit root property. Since the stationarity is achieved at the first difference, both the data series are integrated at order 1 [$I(1)$]. Hence, we now proceed to examine the presence of cointegrating relationship between the spot and futures prices of soy oil.

➯ **Johansen's Test for Cointegration:** The Johansen's cointegration test reports test statistics for two tests, the Trace test and Max eigen value test. The results of Johansen's test are summarized in the Table 5. We can observe that the test rejects the hypothesis that there is no cointegrating relationship between the variables. Moreover, it confirms the presence of one cointegrating equation. Both the Trace test and Max eigen value test confirm the existence of cointegrating relationship between the spot and futures prices.

The cointegrating relationship between the two markets proves that the markets share a long-run equilibrium relationship. We can also conclude that there is information share between spot and futures markets of soy oil in the long-run. Since the markets are cointegrated, an error correction mechanism would always bring them back to equilibrium, whenever there is a deviation from the equilibrium in the short-run. The convergence to equilibrium may be caused by one market or both the markets. In order to examine which market plays the lead role in price discovery in the short-run, the VECM model was applied to the data.

➯ **Vector Error Correction Model (VECM) :** While cointegration establishes the long-run relationship, it does not throw light on which variable is playing a dominant role in convergence to equilibrium, once there is a deviation. However, VECM identifies the significance and direction of long-run causality as well as the influence of each variable on the other in the short-run. The parameter estimates of VECM applied to the spot and futures prices of soy oil are given in the Table 6. A lag length of 2, based on SIC, is used for estimation of VECM. The first panel of Table 6 shows the coefficients of VECM with spot returns as dependent variable and futures

Table 7. BEKK-GARCH Model Results

Variable	Coefficient	*t*-statistics	Probability
c_{11}	0.0002	0.4875	0.6259
c_{21}	0.0077*	11.3111	0.0000
c_{22}	0.0000	0.0003	0.9997
a_{11}	-0.1920*	-7.3654	0.0000
a_{12}	-0.2514*	-2.3088	0.0210
a_{21}	-0.1497*	-8.0648	0.0000
a_{22}	0.1301*	2.9602	0.0031
b_{11}	0.8706*	24.9871	0.0000
b_{12}	0.5722*	4.7755	0.0000
b_{21}	0.0552	1.9495	0.0512
b_{22}	0.3949*	2.7321	0.0063

Note: * denotes significance at the 5% level.

returns as explanatory variable (Equation 1). The second panel shows the results, when futures return is the dependent variable and spot return is the explanatory variable (Equation 2). We can observe that both the error correction coefficients λ_s and λ_f are negative and significant, indicating that both the futures and spot markets respond to new information and contribute towards the long-run equilibrium. However, the spot market (0.0832) is contributing more towards the equilibrium than the futures market (0.0588). In other words, even when both the markets are contributing towards the long-run relationship, the spot market moves by a greater magnitude, which indicates the leading role played by the futures market.

VECM captures the short-run dynamics through the lagged values of spot and futures returns. The influence of futures market on spot market is captured by $\omega_{f,i}$, and $\omega_{s,i}$ captures the impact of futures market on the spot. We can observe from the Table 6 that the first and second lags of futures returns have a significant influence on the spot returns at the 5% level. On the other hand, the first lag of spot returns has significance only at the 10% level, but the second lag has significant influence at the 5% level. When we consider the absolute values of the coefficients of the first lag, we can conclude that the influence of futures on spot (0.3724) is greater than the influence of spot on futures (0.0875). Hence, we can conclude that the futures market is playing a lead role in the short-run. The new information, which is captured in the futures market, is causing the spot market to react to the information and revert to the equilibrium relationship. Though the spot market exhibits a small impact on the futures market, it is clear that the price discovery happens at the futures market, which is then transmitted to the spot market. This means that though there are signs of bi-directional causality, the causality flowing from futures to spot is found to be stronger than the causality in the opposite direction. Once the relationship between the returns of spot and futures is represented by VECM, we proceed to analyze the relationship between the volatilities of the markets. For this purpose, the bivariate BEKK-GARCH model is applied.

➪ **The BEKK-GARCH Model:** As the first step towards applying the BEKK-GARCH model, the residuals of VECM from equations 1 and 3 are generated. The bi-variate BEKK-GARCH model is applied on the residuals of spot and futures market returns. The results of the model are given in the Table 7.

It can be observed that both a_{11} and a_{22} are statistically significant, which indicates that the volatility of spot and futures markets are considerably influenced by their own lagged values in the short-run. The statistical significance of a_{12} and a_{21} indicate that the volatility spillover is happening in both the directions. That is, the volatility of futures markets influences the volatility of the spot market, and the volatility of the spot market, in turn, also influences the volatility of the futures market. However, even when there is bi-directional volatility spillover between the markets, we can see that the influence of spot market on futures market is greater in absolute terms with a_{12} (0.2514) being greater in size than a_{21} (0.1497). This indicates the dominant role of spot markets in the volatility spillover process in the short-run. It is interesting to note that while the futures market plays the lead role in the price discovery process, the short-run volatility spillover from the spot market to futures market is seen to be stronger. Hence,it can be concluded that the spot market for soy oil is assimilating new information faster, and the same is transmitted to the futures market later. This finding is contrary to the theoretical assumption that the futures market, due to its inherent advantages like lower transaction costs and greater transparency, are expected to capture the new information faster.

The long-run coefficients, b_{11} and b_{22} are statistically significant, indicating volatility clustering in the spot and futures markets of soy oil. This shows that the volatility of both the markets behave in clusters of high volatility followed by low volatility. This has significance in volatility forecasting, because in case of markets with clustering, the volatility depends more on the volatility of the immediate past and less on the long-run volatility. When we look at the absolute values of the coefficients, we find that the clustering is more prominent in the spot market (b_{11} = 0.8706) than in the futures market (b_{22} = 0.3949). The significance of b_{12} shows that there is long-run volatility spillover from spot market to the futures market. However b_{21} is not significant, which shows that the volatility of futures market does not have any impact on the spot markets in the long-run. Hence, we can conclude that the long-run spillover is unidirectional, flowing from the spot market to the futures market.

The findings of this study are consistent with the findings of Yang and Leetham (1999), Rahman et al. (2012), Elumalai et al. (2009), and Kumar and Pandey (2011). All these studies confirmed the lead role played by the futures market in the price discovery process. These studies also found that the volatility spillover from the futures market was stronger than the spillover in the opposite direction. However, the findings of the current study are contradicting the findings of other studies in case of short-run volatility transmission. However, the findings of the study are in line with Srinivasan and Ibrahim (2012), who reported dominance of spot markets over the futures market in precious metals.

Implications of the Study

This study has implications for hedgers interested in covering the price risks arising from price volatility. The hedgers have to consider the fact that the volatility of spot market has significant spillover effect on the futures markets in the short-run. This study also has implications for policy makers and regulators interested in growth and development of the commodity markets in India. Finally, since the commodity derivatives markets in India are at the nascent stage of development, we can expect better patterns of price relationships emerging as the markets become more mature in the future.

Conclusion

The agricultural commodity futures market in India is on a long-term growth trajectory. Soy oil futures account for the maximum value of trade among the various commodities traded. The relationship between the spot and futures prices plays a crucial role in hedging the price risk. In light of this, the current study is carried out to analyze the long-term as well as short term relationship between the spot and futures prices of soy oil and to draw conclusions on how the volatilities of both the markets behave.

We found that there is long-term equilibrium relationship between the spot and futures prices of soy oil. Both the spot and futures markets are contributing towards the long-run equilibrium. In the short-run, there is bi-directional causality resulting in both the markets contributing towards the process of price discovery. However, the futures market is found to play the lead role in price discovery. As far as volatility spillover between the markets is concerned, it is found that the volatility spillover is bi-directional. But the spillover from spot to futures is found to be stronger. We also found that both the spot and future markets exhibit volatility clustering, indicating the importance of short-run volatility in volatility forecasting. Finally, it can be concluded that the prices of spot and futures contracts of soy oil in India share a long-run equilibrium relationship, and the price discovery process is happening efficiently in the market.

Limitations of the Study and Scope for Future Research

Research related to price discovery and volatility spillover can be conducted using high-frequency data, which provides more insights into the short-run behaviour of the markets. However, this study is based on daily price data due to the fact that it is not possible to get minute-by-minute high frequency data for the Indian markets. The study focused on the relationship between the movements of spot and futures markets and did not consider other variables like trading volumes, open interest, and so forth as part of the model.

Research on Indian commodities markets is at a nascent stage. Hence, there is scope for lot of future research. Future studies on price discovery and volatility behaviour can be conducted by considering a large sample of commodities across various categories. Similarly, studies related to the market microstructure, impact of speculative activity on the markets, awareness of futures trading among various stakeholders, and so forth have a great significance in the Indian context.

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