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AN EMPIRICAL EXAMINATION OF THE PROCESS OF INFORMATION TRANSMISSION IN INDIA'S AGRICULTURE FUTURES MARKETS

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Abstract

This study examines the process of information transmission in India's agriculture commodity futures market by investigating the price discovery and directional volatility spillovers between futures and spot prices of nine agricultural commodities viz., Barley, Cardamom, Castor seed, Chana (Chickpea), Chili, Mentha oil, Pepper, Soybean and Refined Soya, traded on Multi-Commodity Exchange (MCX) and National Commodity & Derivatives Exchange (NCDEX). The study uses the daily data from January 01, 2009 to May 31, 2013. The empirical results confirm the price discovery between futures and spot prices, indicating strong information transmission. The volatility spillover results indicate that in the short-run, there is strong volatility spillover from spot to futures market whereas in the long-run it is exactly opposite. Further, the study applies the directional spillover method pioneered by Diebold and Yilmaz (2012) to analyze the direction of informational spillover. The estimated results suggest that the magnitude of volatility based information spillover is low in agri-futures market. With the exception of Soybean and Refined Soya, the spillovers are basically intra-commodity and not inter-commodity .Finally, the study concludes that India's agriculture commodity derivatives market is evolving in the right direction as futures market has started playing pivotal role in the information transmission process.

Keywords: Commodity futures market; Price discovery; Volatility spillovers, Spillover index, Information transmission

JEL Classification: C32, G12, G13

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1. Introduction

In this paper, an empirical attempt has been made to examine the process of information transmission in India's agriculture futures market. More particularly, we attempt to answer two fundamental questions. First, what is the channel of transmission of new information in prices? Second, is the process of information transmission inter-commodity or intra-commodity only? By answering these two questions, the study promises to investigate following issues related with the development of agriculture commodity futures market in India. First, the introduction of futures contracts in agricultural commodities has long been a hotly debated topic among academia, regulators and researchers. As it is believed that futures contracts in agricultural products have aggravated the problem of rising inflation due to their speculative nature. In particular, the role of speculators and traders has been the subject of considerable disagreements. The main focus of entire debate appears to be whether the introduction of commodity futures has improved the fair price discovery process or whether the presence of different types of commodity traders has made the process less effective and more unsteady. In 2012, the United Nation (UN) appealed all its member nations to curb on speculative trading of agricultural commodities (see UN, 2012). Consequently, concerns have been raised against the constructive role of commodity futures market in price stabilization and market efficiency. Second, agricultural futures contracts are often linked with increase in volatility of traded assets and the cross market spillover of unexpected shocks, leading to sudden jump and crash in commodity prices. More technically, in the process of fair-price discovery, examination of volatility spillover also plays crucial role as it helps regulators and investors in gauging the risk associated with inter-and intra-commodity volatility spillovers. The detection of volatility spillover across assets or markets is important because it explains about how one large shock increases the volatility not only in its own asset or market but also in other assets or markets as well (Hong, 2001). Therefore, examination of directional spillover in the context of India's commodity derivatives market may further provide important direction for various stakeholders in the formulation of risk management strategies.

In the existing literature, price discovery and volatility spillovers have been dealt in great length. A large number of studies provide sufficient theoretical and empirical evidence about how these two concepts are important for the commodity-futures market literature (see Ross, 1989; Tse, 1998; Thomas and Karande, 2001; Chan *et al*. 2004; Hua and Chen, 2007; Lee *et al*. 2009; Mahalik et al., 2009; Fung *et al*. 2010; Dey and Maitra, 2011; Du *et al*. 2011; Liu and An, 2011;Kumar and Pandey, 2011; Jabir and Gupta, 2011; Chevallier andLelpo, 2013, Sehgal*,* Ahmad and Deisting, 2014). Studies have defined the price discovery a process that deals with flow of information from one market to another. In other way, price discovery takes into account the speed at which price of an asset reacts to new information. Under cointegration framework, price discovery implies the existence of long-run equilibrium relationship between futures and cash prices. And in the event of any departures from equilibrium, prices in one of these markets adjust to correct the disparity (see Zhong *et al*. 2004). As above discussed, apart from price discovery, volatility is also an important source of information that helps the investors in examining the process through which volatility in one market affects that of another market (see Chan *et al*. 1991). According to Anderson (1996) information flows from one market to another drive an asset's volatility process which further helps in formulating the risk management strategies. The volatility spillovers are usually attributed to the cross-market hedging and changes in commonly available information, which may simultaneously impact the expectations of various participants across markets (Engle *et al*. 1990).

Considering the case of India and its buoyant financial sector, the introduction of commodity futures in agri-products (both food and non-food) is often regarded as paradigm shift in India's financial sector development. The process of financialization of commodity markets started in 2003. In the first five years, it has achieved the spectacular growth of more than 119%and it's still in its expansionary phase. At present, there are 22 commodity exchanges in India (6 national and 16 regional) which carry out futures trading in as many as 110 commodity items (see Forward Market Commission (FMC), 2013). The six national level commodity exchanges are Multi Commodity Exchange (MCX) of India Ltd., Mumbai; NCDEX, Mumbai; National Multi Commodity Exchange (NMCE) of India Limited., Ahmedabad; Indian Commodity Exchange Limited, New Delhi; Ace Derivatives and Commodity Exchange Limited, Mumbai; Universal Commodity Exchange Ltd., Navi Mumbai. Since inception, MCX predominantly specializes in metals, bullion and hydro-carbon products, whereas, NCDEX is considered as the leading exchange in agricultural commodity trading.[4]NMCE is also often named as one of the leading trading floors of agriculture and non-agriculture commodities. According to Section 15 of Forward Market Commission Act (FRCA) 1952, commodities are divided into seven broad categories viz., Fibers, Spices, Edible oil, Oil cakes and Oil seeds, Pulses, Energy products, metals, bullions, vegetables and grains. According to FMC, during 2011, there were 66 commodities in which commodity futures trading was allowed (see FMC, 2012). During January 2013 to March 2013 quarter, the total value of trade in all traded commodities at the recognized commodity exchanges were $812 billion less than the previous quarter (October 2012 to December 2012) of $834 billion (see FMC, 2013).[5]During the same quarter of 2013, among all national level commodity exchanges, the total value of trade in agricultural commodities is reported as $88 billion. One of the most difficult challenges faced by agricultural commodity market is suspension of trading of major agricultural commodities. In 2011 and 2012, the futures trading of Tur, Urad, Rice, Guar gum and Guar seed have been suspended for speculative reasons.[6] This often poses great difficulty in analyzing suspended commodities due to discontinuity in the data. In this background, the present study sets to examine the following objectives.

a. To examine the process of price discovery between futures and spot prices of sample agricultural commodities.
b. To investigate if there are any short- and long-term volatility spillovers between futures and spot prices of sample commodities.
c. To develop a spillover index in order to gauge the level of volatility spillover between spot and futures components of agricultural commodity markets.

This study is comprised of six sections, including the present one. A brief review of literature is provided in Section 2. Section 3 covers data and their sources, while methodology

4 Bose (2008) provides excellent overview on the development of commodity market in India.

5 The actual figures in Indian rupees have been converted in US dollar by taking the average exchange rate during January, 2013 to March 2013 as 1 USD = INR 50.296.

6 For further details of suspension of agricultural commodities. Please refer http://www.ncdex.com/MarketData/FuturePrices.aspx

and estimation procedures are described in Section 4. In Section 5, we provide empirical results, followed by a summary and conclusion in the last section.

2. Review of Literature

In the literature, numerous studies have empirically investigated the price discovery and volatility spillover covering developed as well as emerging markets. Garbade and Silber (1979) examine the price discovery for agricultural commodities and report the dominance of futures market over spot. The study's results substantiated the role of commodity futures in fair price discovery of agricultural products especially the inflationary agricultural food items. Seemingly, Brockman and Tse (1995) empirically investigate the process of price discovery in agricultural products for Canada. Similar to the findings of Garbade and Silber (1979), they also report strong role of futures market in price discovery of examined agricultural products and conclude that the price discovery is mainly driven by the futures market. Yang *et al*. (2001) examine the role of futures markets in the price discovery process of storable and non-storable agricultural products. Using the conventional test of cointegration and vector error correction model (VECM), the study reports the dominance of futures markets over spot markets in case of both storable and non-storable commodities. In the context of emerging markets, Mattos and Garcia (2004) test the price discovery potential of Brazilian agricultural commodity markets. By analyzing the lead-lag relationship, the study finds mixed results with respect to price discovery of sample commodities. Zapata *et al*. (2005) examine price discovery of eleven futures prices traded in New York and the world cash prices for exported sugar. Based on the empirical results, the study reports strong evidence of strong role played by futures market than spot in the price discovery process. Trujillo-Barrera *et al*. (2011) examine the volatility spillovers from energy to agricultural markets in the USA. Using multivariate GARCH model, the emprical results confirm the bilateral spillover between two biofuel products viz., corn and ethanol. Liu and An (2011) examine information transmission and price discovery in informationally linked markets. Using data on both synchronous and non-synchronous trading from Chinese futures/spot markets, the New York Mercantile Exchange (NYMEX), Chicago Board of Trade (CBOT), and CME Globex futures markets for copper and soybeans, their study finds evidence of bidirectional volatility spillovers between U.S. and Chinese markets moving strongly from U.S. to China. Hua and Chen (2007) investigate the international linkages of Chinese commodity futures markets in case of aluminium, copper, soybean, and wheat. Considering Chicago Board of Trade (CBOT) and London Metal Exchange (LME) as counterpart markets for agricultural and non-agricultural commodities, they report that aluminium, copper, and soybean futures prices are integrated with spot prices, but they do not find such cointegration in case of wheat spot and futures prices. Ge *et al*. (2008) examine the dynamic linkages between the cotton futures markets of China and the United States. Their study report both markets as strongly linked market. Du *et al*. (2011) examine the important factors that impact crude oil volatility, and investigated the possible linkages between crude oil volatility and agricultural commodities. Their study finds sufficient evidence of volatility spillovers for sample commodities.

More recently, some studies have also analyzed the direction of volatility spillovers by constructing the volatility spillover index as suggested by Diebold and Yilmaz (2009). In this regard, the study of Summer *et al*. (2010) examine the interdependence among stocks, bonds and gold for US economy. The study finds some evidence of volatility spillovers from innovations in stocks to bond return volatility. Awartani and Maghyereh (2013) investigate the dynamic spillover between oil and stock market for Gulf Co-operation Council countries. Applying the model of Diebold and Yilmaz (2012), the study reports strong bi-directional spillovers with stronger volatility spillover moving from oil to equity market of GCC countries. The study also reports that the process of volatility spillovers has intesified following the global financial crisis (2008). Chevallier andLelpo (2013) examines the volatility spillovers in commodity markets on a large group of dataset that includes commodities, equities, currencies, interest rates for the period 1995 to 2012. Applying Diebold and Yilmaz (2012), the study reports that the agricultural commodities exhibit the lowest informational spillovers in examined baskets while precious metals and energy are the largest contributors.

As regards to the research concerning India, Thomas and Karande (2001) study the price discovery process in the castor seed futures market traded on Ahmedabad and Mumbai regional exchanges. Based the empirical results, their study suggests that Ahmedabad and Mumbai markets react differently to information in the price discovery of castor seed. In the Bombay market, futures prices dominate over spot prices. Kumar and Sunil (2004) empirically examine the price discovery potential of India's commodity futures markets. Analyzing agricultural commodity futures, the study reports very limited information transmission between spot and futures markets. Karande (2006) investigates the lead-lag relationship between spot and futures prices of castor seed. Based on the empirical results, the study reports unidirectional causality from futures to spot market. Roy and Kumar (2007) investigate the lead-lag relationship between spot and futures prices of wheat spot markets in India and reports strong evidence of price discovery. Iyer and Pillai (2010) attempt to examine the role of futures market in price discovery process. Using the two-regime threshold vector autoregression (TVAR) for six commodities, the study reports that futures markets play dominant role in price discovery as well as volatility spillovers. Shihabudheen and Padhi (2010) examine the price discovery mechanism and volatility spillovers effect for six Indian commodity markets, viz., Gold, Silver, Crude oil, Castor seed, Jeera and Sugar. The finding of the study suggests that futures price acts as an efficient price discovery vehicle in the case of Gold, Silver, Crude oil, Castor seed, Jeera. Further, with respect to volatility spillover, the study finds strong evidence of information transmission from futures to spot market in all cases except sugar. Jabir and Gupta (2011) examine the efficiency of twelve agricultural commodities by analyzing the relationship between spot and futures prices. Using cointegration and causality tests, the study reports that all the examined commodities' futures and spot markets are efficient except wheat and rice. In cross market framework, Kumar and Pandey (2011) empirically investigate the international linkages of the Indian commodity futures market with its offshore counterpart's markets viz., CBOT, LME and NYMEX. Their study reports that world markets have a bigger (unidirectional) impact on Indian markets. In a comprehensive study, Sehgal *et al*. (2012) examine the price discovery in India's agricultural commodity market. The study uses the data of ten agricultural commodities viz., Guarseed, Turmeric, Soybean, Pepper, Barley, Maize, Castor seed, Chana, Kapas and Potato Agra, and reports lead-lag relationship between futures and spot prices with the exception of Turmeric. Srinivasan (2012) examines the price discovery process and volatility spillovers in Indian spot-futures commodity markets. Using four commodity indices, the study suggests that spot market serves as effective price discovery vehicle. Further, the study also reports same inference with respect to volatility spillovers in case of all MCX commodity markets.

To summarize, it is apparent from the existing literature that in commodity derivatives market even though futures and spot markets assimilate the same information in their prices, the major question is which market reacts first and from which market volatility spills over to other markets. The empirical research on the role of price discovery and volatility spillover is limited especially with regards to the level and direction of informational spillover in agri-futures market. In the light of recent upheavals in India’s commodity derivatives market, there is an immediate need to confirm whether the futures market plays constructive role in the fair price discovery of traded commodities and whether the direction of spillover is inter or intra-commodity. So far, to the best of our knowledge, none of the study has analyzed the directional spillover as well as magnitude of overall volatility spillover in case of Indian agricultural commodity market. In this regard, the present study attempts to add value to the existing literature.

3. Methodology

3.1. Process of price discovery

At first stage, stationarity condition using conventional methods of unit root tests viz., Augmented Dickey Fuller (ADF), Phillips and Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests have been used to check for stationarity for all sample series. Following Zhong*et al*. (2004), we apply Johansen and Juselius (1992) test to exhibit the long-run relationship followed by vector error correction model (VECM) as mentioned in equations (1) and (2). The bivariate co-integrated series $P_t = (F_t, S_t)'$, :

$$\Delta F_t = \alpha_1 + \beta_1 EC_{t-1} + \sum_{i=1}^{k} d_{1i}\Delta F_{t-i} + \sum_{i=1}^{k} g_{1i}\Delta S_{t-i} + \varepsilon_{1t} \quad \text{... (1)}$$

$$\Delta S_t = \alpha_2 + \beta_2 EC_{t-1} + \sum_{i=1}^{k} d_{2i}\Delta F_{t-i} + \sum_{i=1}^{k} g_{2i}\Delta S_{t-i} + \varepsilon_{2t} \quad \text{... (2)}$$

Note that $EC_{t-1} = F_{t-1} - a - bS_{t-1}$ is the lagged error correction (EC) term.

Given the large number of parameters that would have to be estimated in the volatility spillover model (as discussed in subsection 3.2), a two-step procedure similar to that implemented by Bekaert and Harvey (1997), Ng (2000) and Baele (2005) has been considered in this study. In the first step, the vector error correction model is estimated to obtain estimates of the shock vector for futures prices. In the second step, the first-stage residuals are used as data to check for volatility spillover between the futures prices of both markets.

3.2. Process of volatility spillovers

The BEKK model is the most natural way to deal with the multivariate matrix operations. In this study, the model is implemented on the residuals of the series under following specification.

Mean equation:

$$\upsilon_{it} = \mu_{i0} + \sum_{j=1}^{2} \mu_{ij}\upsilon_{j,t-1} + \varepsilon_{it} \quad \text{... (3)}$$

where $\varepsilon_{it} \mid I_{it-1} \sim N(0, h_{it}), i = 1,2$

In equation 5, u_{it} is the estimated residual of the sample series. ε_{it} is a random error term with conditional variance h_{it}. I_{it-1} denotes the market information at time t-1. Equation (4) specifies the variance equation. i=1, 2 denotes the bivariate model. The BEKK parameterization of multivariate GARCH model is written in the following manner:

$$H_{t+1} = C'C + A'\varepsilon_t \varepsilon_t' A + B' H_t B \qquad \text{... (4)}$$

where the individual elements of C, A and B matrices for equation (4) are mentioned below:

$$A = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}, \quad B = \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} \quad \text{and } C = \begin{bmatrix} c_{11} & 0 \\ c_{21} & c_{22} \end{bmatrix}$$

The off-diagonal elements of matrix A (a_{12} and a_{21}) represent the short-term volatility spillover (ARCH effect) from market 1 to another market 2. The off-diagonal elements of matrix B (b_{12} and b_{21}) represent the long-term volatility spillover (GARCH effect) in the same manner as mentioned above. The MGARCH models are estimated by Quasi-Maximum Likelihood Estimation (QMLE) using the BFGS algorithm. t statistics are calculated using a robust estimate of the covariance matrix.

4. Data Description

In order to select the adequate number of commodities, we have used following procedure to select the sample commodities. At first stage, we review the number of sample commodities traded on three prominent exchanges in agricultural commodity trading viz., MCX, NCDEX and NMCE. A close appraisal of list of commodities traded indicate that despite visible trading volume, there are frequent and long period of trading breaks. Some commodities are even not traded on all exchanges like for example, Chili is not traded on NMCE. Furthermore, commodities like Pepper traded on NMCE and there is trading break from the period from June to December 2011 and May to December 2012. While for the same period, the trading data of pepper are still available on NCDEX. We found the similar evidence in cases of Refined Soya oil, Soybean, Guargum and Guarseed. On MCX, there are trading breaks in Guargum and Guarseed from 19 June 2009 to 20 June 2013 and same is the case on NCDEX and NMCE. Second, owing to these difficulties in the data compilation, we have considered only those commodities which have continuous data with less frequent breaks of at least not more than three months. At last, we have selected commodities only from MCX and NCDEX trading platforms. It may here be relevant to note that in order to arrive at convincing empirical evidence, it is important that one should have large number of datasets. The sample data for the daily futures and spot prices are retrieved from the NCDEX's and MCX's website. All closing prices of futures series are taken for the nearest contract to maturity. The sample period of each commodity is as follows: Barley, Chana, Cardamom, Coriander, Mentha oil and Refined Soya (January 01, 2009, to May 31, 2013;1283, 1353, 1311, 1217,1288and1295observations, respectively); Soybean (January 01, 2009, to May 27, 2013; 1291 observations);Castor seed (August 25, 2009 to May 31, 2013;925 observations); Chili (January 01, 2009, to May 10, 2013;1327 observations);Pepper (January 01, 2009 to May 20, 2013; 1158 observations).[7] For estimation purpose, all price series are further converted into natural logarithms.

5. Empirical Results

We begin by analyzing the descriptive statistics of sample commodity returns shown in Table (1), exhibits that the mean returns of sample commodities are positive. The highest mean daily return is observed in case of spot price of Soybean (0.055%) followed by futures of Soybean (0.053%) and Mentha oil (0.048%) and spot prices of Chana and Mentha oil (0.042%), respectively. The lowest average return is found in case of Pepper (0.001%) followed by spots of Chili (0.012%) and Castor seed (0.015%). The standard deviation as a measure of volatility is highest for futures of Cardamom (3.59) followed by futures of Mentha oil (3.39) and futures (2.35) prices of Chili. The lowest volatility is observed in case of futures and spot prices of Pepper as (0.014 and 0.013), respectively. The skewness coefficients of all commodities series are more or less positive, except futures returns of Barley, Refined Soya and Pepper and spot returns of Castor seed. All returns series are leptokurtic and violate normality, as exhibited by significant values of Jarque-Bera (JB) statistics.

Table 1. Descriptive statistics

Descriptive	*Mean*	*Max.*	*Min.*	*Std. Dev.*	*Skew.*	*Kurt.*	*JB*	*Obs.*
fbarley	0.028	7.180	-11.811	1.528	-0.235	7.806	0.000*	1282
sbarley	0.030	9.628	-11.073	1.187	0.383	19.999	0.000*	1282
fcastor	0.022	14.687	-12.547	1.761	0.276	13.789	0.000*	924
scastor	0.015	8.086	-6.927	1.684	-0.151	5.335	0.000*	924
fchana	0.038	7.889	-7.547	1.496	0.102	5.891	0.000*	1207
schana	0.042	5.701	-5.680	1.402	0.223	4.380	0.000*	1207
fchilli	0.025	17.998	-16.888	2.350	0.213	10.930	0.000*	913
schilli	0.012	18.951	-7.218	1.415	4.529	54.880	0.000*	913
frefsoya	0.035	4.142	-7.473	1.076	-0.369	5.908	0.000*	1292
srefsoya	0.030	4.586	-6.104	0.806	0.101	8.560	0.000*	1292
fsoya	0.053	4.986	-12.654	1.423	-0.445	8.234	0.000*	1290
ssoya	0.055	5.017	-17.063	1.254	-2.458	33.205	0.000*	1290
fpepper	0.001	0.050	-0.127	0.014	-0.445	8.234	0.000*	1290
spepper	0.001	0.050	-0.171	0.013	-2.458	33.205	0.000*	1290
fmoil	0.048	17.314	-21.369	3.392	0.107	11.924	0.000*	1287
smoil	0.042	11.769	-10.359	1.677	-0.171	11.405	0.000*	1287
fcard	0.023	35.768	-30.781	3.593	1.800	26.923	0.000*	1308
scard	0.026	11.459	-12.133	2.044	-0.127	7.675	0.000*	1308

Note: * denotes the level of significance at 1% and better. Commodities are fbarley (futures of barley), sbarley (spot of barley), fcastor (futures of castor seed), scastor (spot of castor seed), fchana (futures of chana), schana (spot of chana), fchilli (futures of chilli), schilli(spot of chilli), frefsoya (futures of refined soya oil), srefsoya (spot of refined soya oil), fsoya (futures of soybean), ssoya (spot of soybean), fpepper(futures of pepper), spepper(spot of pepper), fmoil(futures of mentha oil), smoil(spot of mentha oil), fcard (futures of cardamom), scard (spot of cardamom).

[7] As the reviewer suggested, we have added Cardamom and Mentha oil traded on MCX. Due to lack of continuous historical time-series data, we not have included commodities like Guarseed, Guargum, Cotton and Turmeric.

5.1. Tests of stationarity and price discovery process

Stationarity conditions of sample futures-spot price series expressed in logarithmic form are tested by conventional ADF, PP and KPSS tests.[8] All unit root tests clearly confirm the existence of unit root at level and exhibit stationarity at first difference for all sample price series. The results of Johansen and Juselius (1992) test of cointegration indicate that all sample commodities series exhibit the long-run relationship between futures and spot prices, confirming the strong informational linkages between spot and futures.[9]

Table 2. Estimated co-efficient of VEC model

Commodity	*Co-efficient*	*Commodity*	*Co-efficient*	*Commodity*	*Co-efficient*
$\beta_{1fbarley/sbarley}$	0.0001 [0.017]	$\beta_{1fchilli/schilli}$	-0.010 [-1.175]	$\beta_{1frefsoya/srefsoya}$	-0.006 [-0.436]
$\beta_{2sbarley/fbarley}$	0.029 [4.832]**	$\beta_{2schilli/fchilli}$	0.021 [4.069]**	$\beta_{2srefsoya/frefsoya}$	0.039 [4.448]**
$\beta_{1fcastor/scastor}$	-0.056 [-3.411]**	$\beta_{1fpepper/spepper}$	-0.007 [-0.507]	$\beta_{1fsoya/ssoya}$	-0.0005 [-0.037]
$\beta_{2scastor/fcastor}$	0.013 [0.733]	$\beta_{2spepper/fpepper}$	0.030 [4.049]**	$\beta_{2ssoya/fsoya}$	0.067 [5.779]**
$\beta_{1fchana/schana}$	-0.069 [-4.078]**	$\beta_{1fcard/scard}$	-0.0314 [-2.411]**	$\beta_{1fmoil/smoil}$	-0.146 [-6.008]**
$\beta_{2schana(fchana)}$	0.037 [2.793]**	$\beta_{2scard/fcard}$	-0.039 [-5.693]**	$\beta_{2smoil/fmoil}$	0.010 [0.852]

Note: ** denotes the level of significance at 1% and better.

Table (2) exhibits the VECM results. The EC which is also called as speed of adjustment co-efficient β_i is shown in the table. The results indicate that in case of between spot and futures prices of all sample markets, the speed of adjustment co-efficient (β_2) appears to be greater in spot than the futures market with the exception of Castor seed, Chana and Mentha oil, indicating that when the co-integrated series is in disequilibrium in the short-run, it is the spot price (cash market) that makes greater adjustment than the futures price (futures market) in order to restore the equilibrium. In other words, futures price leads the spot price in price discovery process. However, in cases of Castor seed, Chana and Mentha oil, it is the spot price that leads the futures price. From investment strategy perspective, the significantly negative EC terms in cases of spot price of Cardamom and futures price of Castor seed, Chana, Chili, Cardamom, Soybean and Mentha oil imply that these series are over-valued in the short-term. In contrast, significantly positive EC terms as reported in casesof spot prices of Barley, Chana, Chili, Pepper, Refined Soya and Soybean indicate that the spot prices of these commodities are relatively undervalued in the short-run. This information provides market traders' incentive to sell/short-sell in spot/futures in case of overvalued asset and buy futures/spot in case of undervalued commodities to make arbitrage profits. Such arbitrage process is probably ensuring a long-run equilibrium relationship between spot and futures prices in these markets as confirmed by cointegration results.

8 Unit root results are available upon request.

9 Results are available to the Authors' upon request.

5.2. Volatility spillovers

The estimated results of GARCH-BEKK model to examine the volatility spillovers among sample commodities are shown in Table (3). The volatility spillover results between futures and spot indicate that there is ARCH effect in case of spot and futures in cases of Barley, Cardamom, Chana, Chili, Mentha oil while rest exhibits ARCH effect only in spot prices. Turning to cross volatility spillover effects in the short-run, the results indicate that there are bilateral volatility spillovers between futures and spot prices of Cardamom, Pepper and Refined Soya with stronger volatility moving from futures to spot prices. Barley, Castor seed, Chana and Soybean exhibit unilateral volatility spillover moving from spot to futures prices. In case of Chili, there is no short-term volatility spillover. Analyzing long-term volatility spillovers, there appears to be strong GARCH effect in case of all agricultural commodities. With respect to long-term cross market volatility spillovers, the results indicate that among sample commodities, Castor seed, Cardamom, Chana, Refined soya, Mentha oil and Soybean exhibit bidirectional volatility spillovers moving strongly from futures to spot. In case of Barley and Pepper, the direction of volatility spillover appears to be unilateral, moving strongly from spot to futures. Like for short-term, there is no volatility spillover in case of Chili in the long-term.

In sum, we can say that in India's agricultural commodity market, in the short-term, it is the spot price volatility that impacts the futures market volatility more strongly. While, in the long-term, it is the futures market volatility which has greater impact on spot market volatility. It may here be noted that the long-term volatility spillovers are in agreement with price discovery results. From information transmission point of view, it appears that in case of Indian agricultural commodity market, it is the futures market that assimilates new information quickly than the spot market in the long-term while opposite is true in the short-term. Surprisingly, in case of Chili, the empirical results indicate no evidence of volatility spillover in the short as well as long term.

5.3 Directional spillover and spillover index

In order to confirm the volatility spillover results, we also construct spillover index pioneeredby Diebold and Yilmaz (2009, 2012) for futures and spot markets volatility of respective sample commodities. According to Diebold and Yilmaz (2012) a spillover index is calculated using forecast error variance decomposition under vector autoregression model (VAR) framework. The forecast error variance decomposition shows the portion of the variance to variable *i* that is the result of innovations (shocks) to variable *j* represented as a percentage. In this study, we have implemented this model only on the variance of the VECM residuals. We apply generalized VAR framework of Koop et al. (1996) and Pesaran and Shin (1998) to compute the variance decompositions which is insensitive to the order of variables. It further helps in calculating the net spillover between variables. The model is specified as follows:

Let volatility of futures and spot series of sample commodities is modelled as a vector autoregressive process. A VAR (p) model of N variables (in generalized form) can be written as

$$x_t = \sum_{t=1}^{p} \psi_i x_{t-i} + \varepsilon_t \qquad \text{... (5)}$$

Table 3. MGARCH-BEKK results

		μ_1	μ_2	$c_{(1,1)}$	$c_{(2,1)}$	$c_{(2,2)}$
Barley	***Coeff.***	-0.015	0.009	0.223	-0.246	0.000
		[-0.823]	[0.377]	[4.812]*	[-1.442]	[0.000]
Castor seed	***Coeff***	-0.003	0.029	0.632	0.414	0.000
		[-0.136]	[1.017]	[9.495]*	[7.977] *	[0.000]
Chana	***Coeff***	-0.018	-0.040	0.560	0.184	0.000
		[-0.739]	[-1.480]	[11.42] *	[5.377] *	[0.010]
Pepper	***Coeff***	0.002	0.000	0.174	0.824	0.000
		[0.073]	[-0.021]	[1.139] *	[4.866] *	[0.000]
Refined soya	***Coeff***	-0.001	-0.018	0.138	-0.027	0.000
		[-0.025]	[-0.711]	[3.936] *	[-0.771]	[0.000]
Soybean	***Coeff***	0.032	0.030	0.158	-0.049	0.000
		[1.215]	[1.619]	[3.344] *	[-0.867]	[0.000]
Chilli	***Coeff***	-0.041	-0.026	0.176	0.655	0.101
		[-0.942]	[-0.795]	[4.525] *	[0.501]	[0.014]
Moil	***Coeff***	0.008	-0.017	0.822	0.027	0.000
		[0.514]	[-1.107]	[22.03] *	[1.275]	[0.000]
Cardamom	***Coeff***	0.011	0.014	0.620	0.080	0.000
		[0.282]	[0.560]	[19.74] *	[2.883] *	[0.000]

		$\alpha_{(1,1)}$	$\alpha_{(1,2)}$	$\alpha_{(2,1)}$	$\alpha_{(2,2)}$	$\beta_{(1,1)}$	$\beta_{(1,2)}$	$\beta_{(2,1)}$	$\beta_{(2,2)}$
Barley	***Coeff.***	0.590	-0.011	-0.087	0.161	0.763	0.042	0.119	0.939
		[9.950] *	[-0.153]	[-2.064] *	[3.81] *	[12.92] *	[0.554]	[2.172] *	[13.568] *
Castor seed	***Coeff***	0.105	0.090	0.470	0.080	0.303	-0.426	0.158	1.070
		[1.134]	[1.487]	[6.688] *	[1.583]	[3.57] *	[-7.427]*	[5.041] *	[73.734] *
Chana	***Coeff***	0.328	0.049	0.412	0.122	0.469	-0.226	0.164	1.058
		[7.403] *	[1.562]	[7.403] *	[2.87] *	[6.30] *	[-4.362] *	[4.110] *	[63.400] *
Pepper	***Coeff***	-0.007	-0.281	-0.374	0.296	0.539	-0.061	0.562	0.490
		[-0.125]	[-2.947] *	[-2.741] *	[3.07] *	[3.47] *	[-0.725]	[3.839] *	[2.488] *
Refined soya	***Coeff***	-0.091	-0.363	0.220	0.373	1.083	0.217	-0.241	0.794
		[-1.078]	[-9.017] *	[4.799] *	[8.01] *	[77.20] *	[17.592] *	[-9.581] *	[45.781] *
Soybean	***Coeff***	-0.166	0.167	0.261	0.300	1.049	0.198	-0.172	0.774
		[-1.564]	[1.695]	[3.097] *	[1.948]	[53.90] *	[4.267] *	[-2.998] *	[7.298] *
Chilli	***Coeff***	0.161	0.103	-0.020	0.595	0.984	0.090	-0.031	0.378
		[2.276] *	[1.802]	[-0.561]	[3.53] *	[62.01] *	[0.394]	[-0.580]	[2.860] *
Moil	***Coeff***	0.421	0.184	-0.032	0.307	-0.199	-0.133	0.432	0.964
		[9.034] *	[9.046] *	[-1.259]	[9.60] *	[-2.74] *	[-2.960] *	[7.863] *	[59.78] *
Cardamom	***Coeff***	0.945	0.128	-0.658	0.113	-0.121	-0.262	0.337	1.045
		[9.232] *	[2.930] *	[-4.200] *	[2.18] *	[-1.25]	[-4.671] *	[16.62] *	[149.72] *

Note: * denotes the level of significance at 5% and better.Values in parentheses are t-values.

where ε error vector which is i.i.d and $\sum$ is the variance-covariance matrix. The moving average representation of VAR (p) model can be written as $x_t = \sum_{t=1}^{\infty} A_i \varepsilon_{t-i}$, where the N×N coefficient matrices observe the recursion $A_i = \psi_1 A_{i-1} + \psi_2 A_{i-2} + ... + \psi_p A_{i-p}$ with A_0 an N×N matrix and $A_i = 0$ for i< 0. The variance decompositions further allow the fraction of the H-step-ahead residual variance in forecasting y_i to shocks to $x_j, \forall j \neq i$, for each i to be measured. Under Koop et al. (1996) and Pesaran and Shin (1998) frameworks, the formula to calculate the H-step-ahead generalized forecast error decompositions therefore is given by

$$\theta_{ij}(H) = \frac{\sigma_{ii}^{-1} \sum_{h=0}^{H-1} \left(e_i^{'} h_h \sum e_j \right)^2}{\sum_{h=0}^{H-1} \left(e_i^{'} h_h \sum e_j \right)} \quad ... (6)$$

where σ_{ii} is the i element on the principle diagonal of $\sum$. Since each row of $\theta_{ij}(H)$ does not sum to one, therefore, we normalize each element of the matrix by the summing the row as $\tilde{\theta}_{ij}(H) = \frac{\theta_{ij}(H)}{\sum_{j=1}^{N} \left(\theta_{ij}(H) \right)}$ so that decomposition including shocks in each market sums to 1, i.e., $\sum_{j=1}^{N} \left(\theta_{ij}(H) \right) = 1$ and total decomposition over all markets sums to N i.e., $\sum_{j=1}^{N} \left(\theta_{ij}(H) \right) = N$. Following Diebold and Yilmaz (2012), the total spillover index is calculated as

$$S(H) = \frac{\sum_{\substack{j=1 \\ i \neq j}}^{N} \tilde{\theta}_{ij}(H)}{N} \times 100 \quad ... (7)$$

In this study, we measure the directional spillover between futures and spot of nine sample commodities. It is the sum of the proportions of the forecast error variance of i series due to shocks to $j \forall i \neq j$. The directional spillover from futures to spot is calculated as

$$S_{i^{\circ}}(H) = \frac{\sum_{\substack{j=1 \\ i \neq j}}^{N} \tilde{\theta}_{ij}(H)}{\sum_{j=1}^{N} \tilde{\theta}_{ij}(H)} \times 100 \quad ... (8)$$

It is noteworthy that directional spillover measure are not ordering sensitive. In similar vein, directional spillover received from spot to futures is obtained as

$$S_{\circ i}(H) = \frac{\sum_{\substack{j=1 \\ i \neq j}}^{N} \tilde{\theta}_{ij}(H)}{\sum_{j=1}^{N} \tilde{\theta}_{ij}(H)} \times 100 \quad ... (9)$$

Lastly, we calculate the net spillovers from futures to spot in case all 9 commodities by offsetting the (8) and (9) as

$$S_i(H) = S_{i^{\circ}}(H) - S_{\circ i}(H) \quad ... (10)$$

The net spillover shows whether the futures market is a net transmitter or net receiver in a system of volatility spillovers (see Awartani and Maghyereh, 2013; Cronin, 2013; Sehgal *et al.* 2014).

Table 4. Directional spillovers estimated for sample commodities

	fbarley	sbarley	fcastor	scastor	fchana	schana
1	2	3	4	5	6	7
fbarley	83.8	3.8	2.1	1.9	0.5	0
sbarley	11.2	84.4	0.1	0.2	0.2	0.1
fcastor	0.1	0	75.1	20.2	0.6	0.2
scastor	0.5	0.1	10.2	83.4	0.2	0.1
fchana	0.2	0.6	0.2	1	81.7	9.5
schana	0.2	0.6	0.1	0.1	10.6	84.8
fchilli	0	0	1.7	0.2	1	0.1
schilli	0	0.4	0.1	0.1	0	0
fpepper	0.2	0.1	0.3	0	0.1	2.8
spepper	0	0.1	0.1	0.3	0.1	3.5
frefsoya	0.1	0.4	0.3	1.2	0.5	3.3
srefsoya	0.5	0	0.6	0.3	0.1	0.7
fsoya	0.2	0.1	0	0.3	0.1	1.4
ssoya	0.9	0.4	0.1	0	0.8	0.4
fmoil	0.4	0	0	0.3	0.4	0.2
smoil	0.3	0.3	0.1	0.9	0.8	0.1
fcard	0.9	0.6	0.2	0.2	0.3	0.1
scard	0.1	0.4	1.2	1.7	0.4	0.4
Contribution to others	16	8	17	29	17	23
Contribution including own	99	92	92	112	98	108

	fchilli	schilli	fpepper	spepper	frefsoya	srefsoya	fsoya
1	8	9	10	11	12	13	14
fbarley	0.5	0	0.1	0.2	1.1	0.6	0.8
sbarley	0.1	0	0	0.1	0.8	0.2	0
fcastor	0.6	0.5	0.1	0	0.1	1.1	0.6
scastor	0.1	1.3	0.1	0.1	0.6	1.1	0.9
fchana	0.5	0	0.9	0.8	0.8	0.1	1.9
schana	0.3	0.1	0.5	0.1	0	0.4	0.6
fchilli	91.5	0.4	0	0.1	0.2	0.3	0.4
schilli	1.4	93.9	0.3	0.1	0.4	0.1	0.6
fpepper	0.7	0.2	54.2	38.8	0.1	0.1	0.1
spepper	0.7	0.2	42.1	50.4	0.1	0.1	0.1
frefsoya	1.8	0.7	0.2	0.1	50.5	12.7	18.3
srefsoya	0.2	1.2	0.2	0	2.1	72.4	5.1
fsoya	0.1	0.1	0.1	0.1	17.2	8.8	58
ssoya	0.2	0.2	0.1	0.4	7.1	22.4	14.6
fmoil	3	0.1	0.1	0.3	0.1	0.6	0.1
smoil	0.3	0.5	0.2	0.1	0	0.7	0.3
fcard	0.1	0.7	0.4	0.9	0.5	0.3	0.4
scard	0.5	1.6	0.1	0.2	0	0.3	0.3
Contribution to others	11	8	45	42	31	50	45
Contribution including own	102	102	100	93	82	122	103

	ssoya	fmoil	smoil	fcard	scard	From others	Net Spillover
1	15	16	17	18	19	20	21
fbarley	0.2	0.5	0.6	2.4	0.9	16	0
sbarley	0.3	1.4	0.1	0.7	0.2	16	-8
fcastor	0.1	0.4	0.1	0.3	0	25	-8
scastor	0	0.4	0.1	0.5	0.3	17	12
fchana	0.6	0.1	0.2	0.9	0	18	-1
schana	0	0.2	0.1	1.1	0.2	15	8
fchilli	0	1.8	1.8	0.1	0.4	9	2
schilli	0.5	0	1	0.8	0.3	6	2
fpepper	0.2	0.7	0.1	0.7	0.7	46	-1
spepper	0.1	1	0	0.9	0.2	50	-8
frefsoya	9.1	0.3	0.5	0	0	50	-19
srefsoya	15.3	0.9	0.1	0.2	0.1	28	22
fsoya	12.8	0.7	0.2	0	0	42	3
ssoya	51.2	0.5	0.4	0	0.4	49	-5
fmoil	0.2	92.6	1	0	0.4	7	12
smoil	4.1	7.1	84	0.1	0.2	16	-7
fcard	0.3	0	0.1	92	2.2	8	2
scard	0.6	2.8	2.3	1.6	85.4	15	-8
Contribution to others	44	19	9	10	7	431	
Contribution including own	96	112	93	102	92		**Total spillover index 23.9%**

Note: The (i,j) entry in the above table indicates the estimated contribution to the forecast error variance of futures market *i* coming from innovations to spot market *j*. Contribution to others, shows the directional spillovers from a market to all other markets. Contribution from including own exhibits the directional spillovers from all markets to a particular market.

Now, we turn to examine the estimated results shown in Table (4). The results indicate that there are visible patterns of bi-directional spills between futures and spot of all the sample commodities. The gross directional volatility spillover from futures of Barley to and from all is same 16%. This indicates that on the net, futures of Barley spills its volatility to all other commodities as 0%. Similarly in case of spot of castor seed, the gross directional spillover to all appears to be 29% compared to from all (17%). This implies that on the net, the spot of castor seed is the net (12%) transmitter of volatility spillover to all commodities. This further suggests that the commodity market of castor seed is relatively well developed due to large number of market players. Analyzing the Table 4 carefully, it appears that the commodity with highest gross directional volatility spillover to all is spot of Refined Soya (50%) followed by futures of Pepper and Soybean (45%), spot of Soybean (44%) and Pepper (42%). On the net, the spot of Refined Soya seems to be the largest transmitter of volatility spillover to all sample commodities. Overall results suggest that instead of being a volatility transmitter, many important commodities are still net recipient of volatility related information spillover. The futures of Refined Soya is the highest net receiver of spillover (19%) followed by spot of Barley, Cardamom, Pepper (8%), Mentha oil (7%), implying that the markets of these commodities are either not well developed or there are frequent trading breaks in these commodities, discouraging the participation of large number of players. Analyzing the information spillover between Soybean and Refined Soya, the results indicate that unlike other commodities, there are observable level of volatility interdependence between futures and spot. Like for example in case of Soybean, futures explain the forecast error variance of about 18% of futures Refined Soya. Similarly, spot of Soybean explains about 15% of forecast error variance of spot of Refined Soya. Such interdependence could be examined in terms of input-output relationship, the usage, geographical nature and coincidence of market arrival timings. Such interdependence may also be analyzed separately, therefore, it is left for the future research. However, the value of the total spillover index is 23.9%. This indicates that on average, across all sample commodities, about 24% of the volatility forecast error variance in all nine commodities markets comes from transmission. Analyzing the time-varying nature of volatility transmission, we now estimate the model by using 75 and 200 days rolling windows and assess the time-varying spillover. Fig. (1) shows the total volatility spillover index. The plot displays the more or less same level of spillover. We repeated this exercise by using 10-days and 5-days forecast horizon and the results are by and large same (see Fig. (2), panels A & B). Lastly, we have applied the Diebold and Yilmaz (2012) on bivariate futures and spot series of all the sample commodities and plotted the directional and net spillovers. Fig. (3), panels (A to I), starting with Barley (Panel A), the plot indicates that during 2011-2012, there was sudden jump in the spillover level from futures to spot. The magnitude of spillover appears to be high from futures to spot. This is depicted in net spills which suggests that there is spillover in volatility from futures to spot and the feedback effect is weaker. The result further suggests that there is a strong information transmission from futures to spot which is in contrast with the findings of GARCH-BEKK (long-term results). Similar inferences can be drawn from the plots of Chana, Chili and Cardamom which also exhibits the bi-directional volatility spillover moving strongly from futures to spot. It may here be noted that unlike GARCH-BEKK results which exhibited no short and long terms significant volatility spillovers in case of Chili, the directional spillover results solve the asymmetry. And based on this, it can be concluded that in case of Chili, information transmission moves from futures to spot markets. The other five commodities viz. Castor seed, Mentha oil, Pepper, Soybean and Refined Soya (see Fig. 3, Panels B & E to I) exhibit the strong bidirectional spillovers. On the net, it appears that the spot market plays more dominant role in information transmission than futures markets. This further suggests that the spot market of all these commodities are well developed with large number of players compared to futures market. Surprisingly, in case of Pepper, spot market dominance is strongly visible than other three commodities. Comparing the spillover findings of GARCH based model, there results seem to be in contrast in cases of Castor seed, Mentha oil, Soybean and Refined Soya while finding of Pepperis in agreement.

To summarize, it is apparent from the directional spillover results that there is strong evidence of information transmission between futures and spot markets of examined commodities. With the exception of Soybean and Refined Soya, there is no evidence of cross commodity (inter-commodity) spillover, implying that the nature of volatility spillover in case of India's agriculture derivatives is only intra-commodity. The movement of spillover is bi-directional in nature and on the net it appears that the findings are by and large in contrast with the spillovers estimates of GARCH-BEKK model. It further makes the application of Diebold and Yilmaz (2012) approach more appealing in spillover analysis than conventional GARCH models. This may also be considered as one of the major contributions of this study. In Table (5), which shows the diagnostic tests for the standardized residuals.We find no evidence of serial correlation and non-linearity in any of the examined series.

Table 5. Diagnostic statistics of residuals

Statistics	fbarley	sbarley	fcastor	scastor
Q(20)	0.516	0.102	0.341	0.186
McLeod- Li(20)	0.982	0.993	0.042	0.351
	frefined	**srefined**	**fsoybean**	**ssoybean**
Q(20)	0.622	0.381	0.909	0.756
McLeod-Li(20)	0.449	0.257	0.018	0.987
	fchana	**schana**	**fchili**	**schili**
Q(20)	0.536	0.593	0.842	0.562
McLeod- Li(20)	0.629	0.956	0.712	0.965
	fpepper	**spepper**	**fmoil**	**smoil**
Q(20)	0.338	0.945	0.787	0.246
McLeod- Li(20)	0.999	0.988	0.588	0.406
	fcard	**scard**	-	-
Q(20)	0.813	0.420	-	-
McLeod-Li(20)	1.000	0.695	-	-

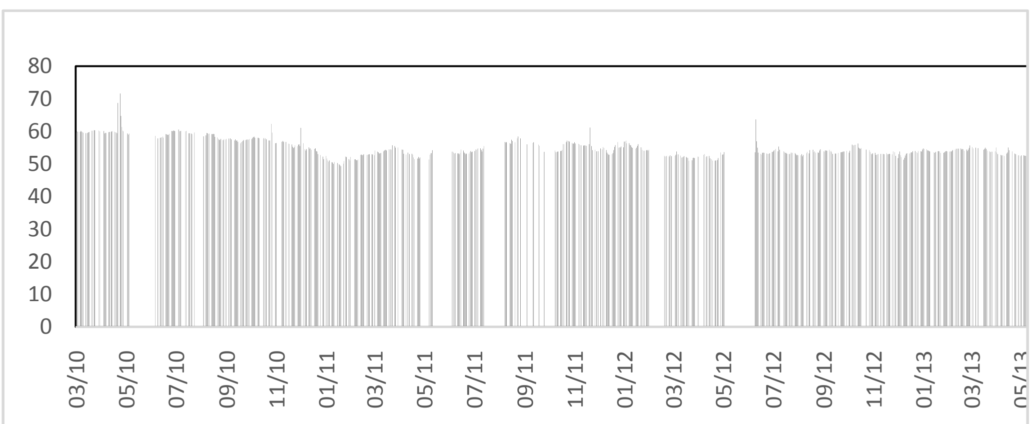
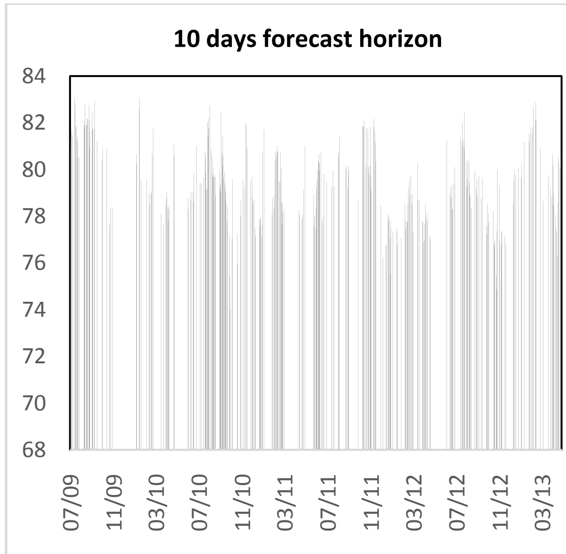


Figure 1. Total volatility spillover index (in %), 200 days rolling windows

Panel A



Panel B

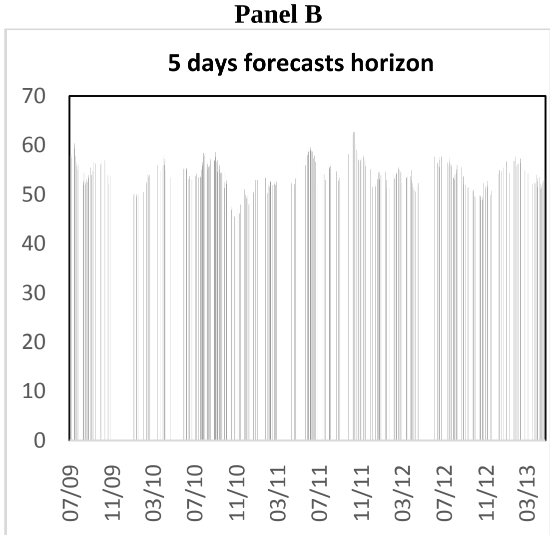
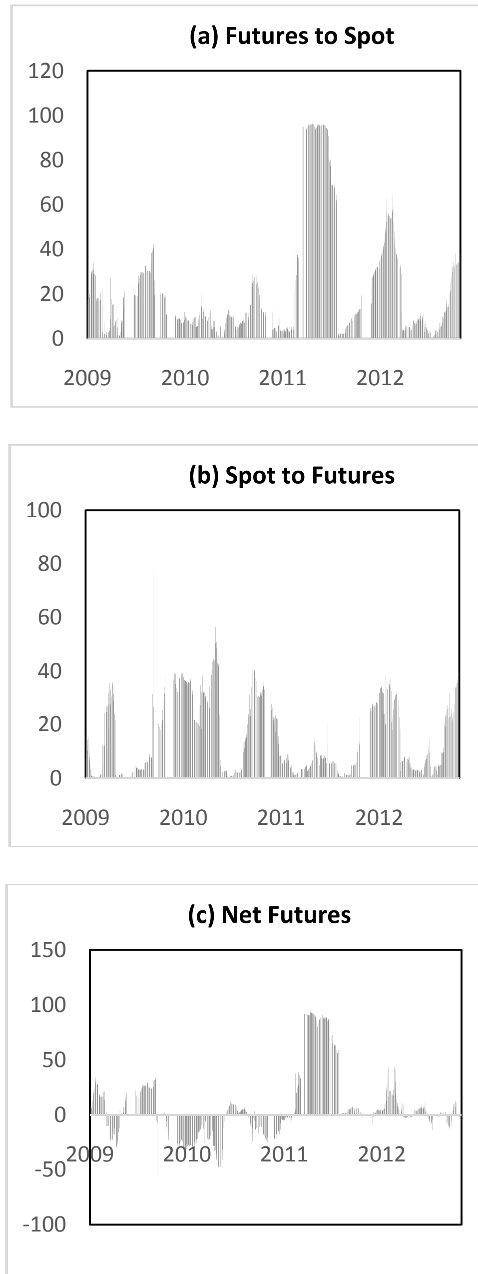
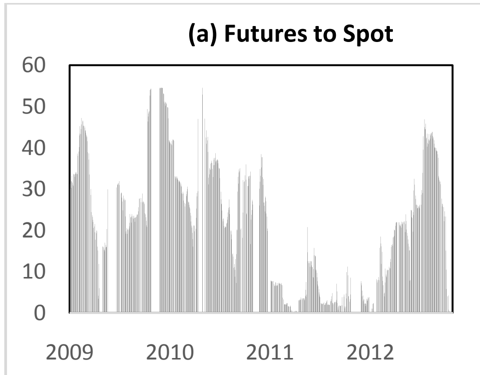


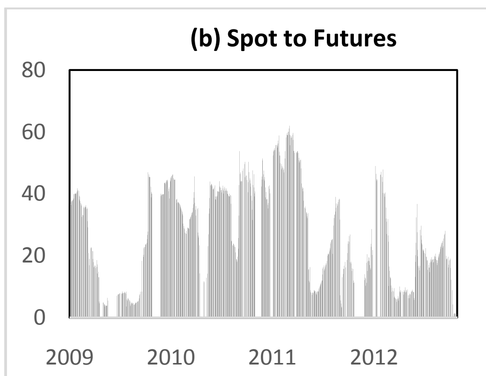
Fig. 2. Total spillover index (%), 75 days rolling windows

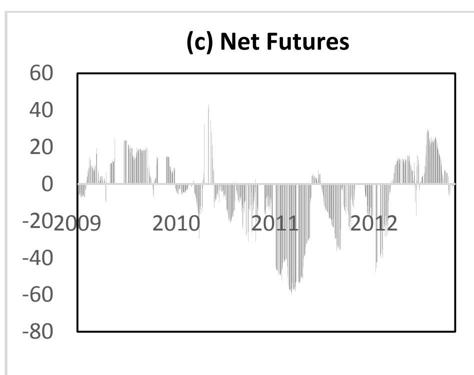
Panel A. Barley



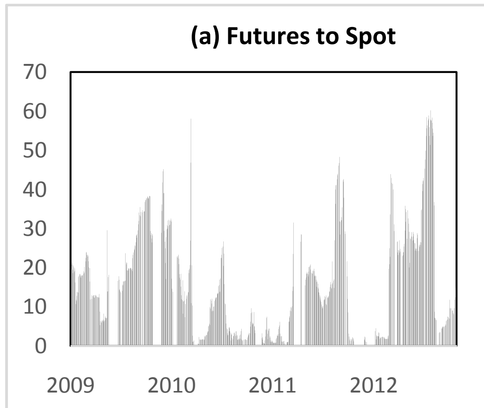
Panel B. Castor seed

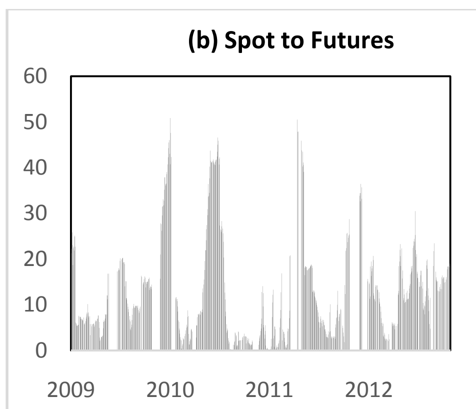


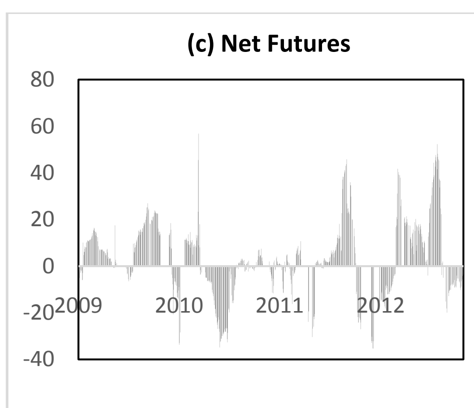




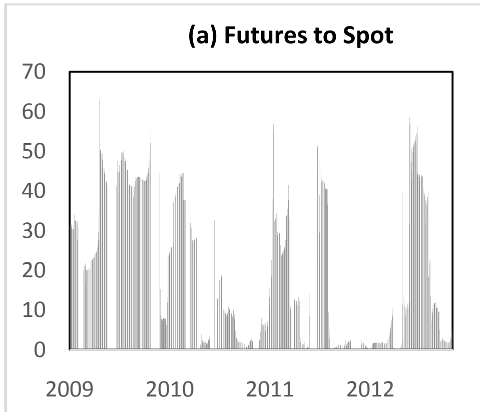
Panel C. Chana

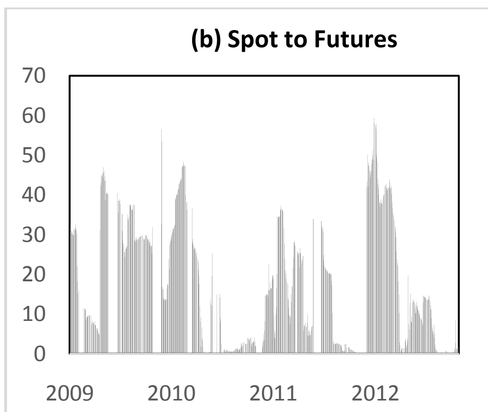


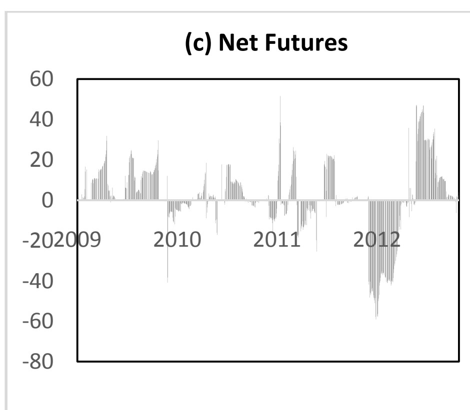




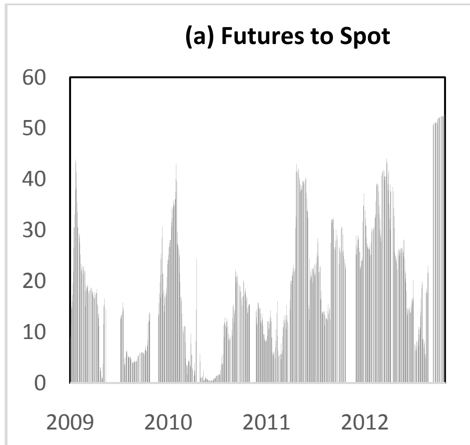
Panel D. Chili

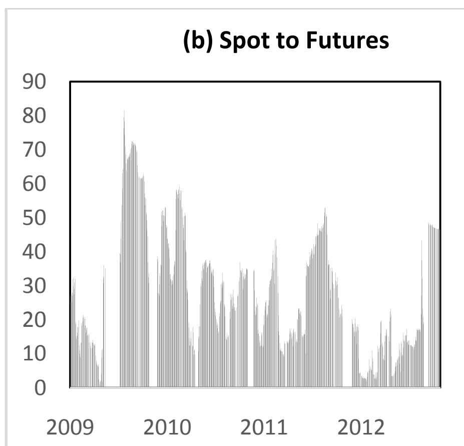


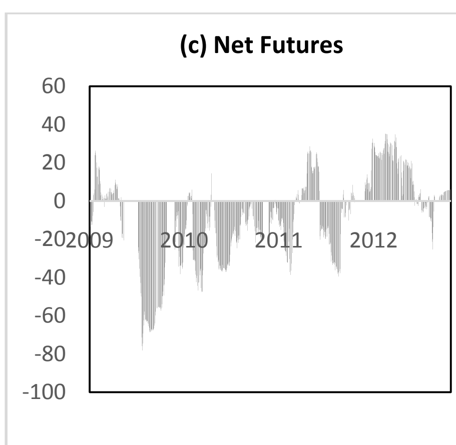




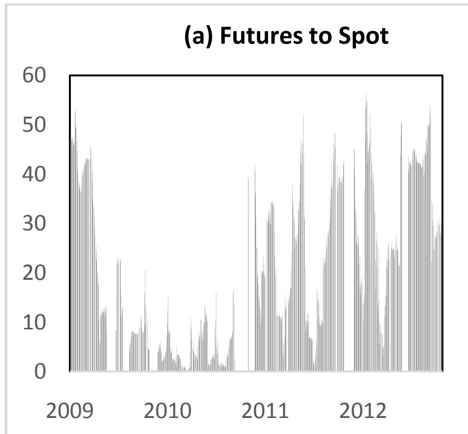
Panel E. Pepper

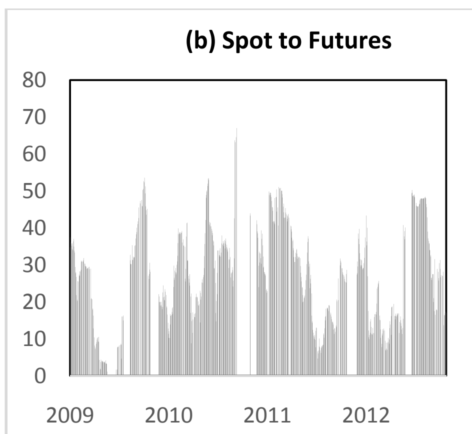


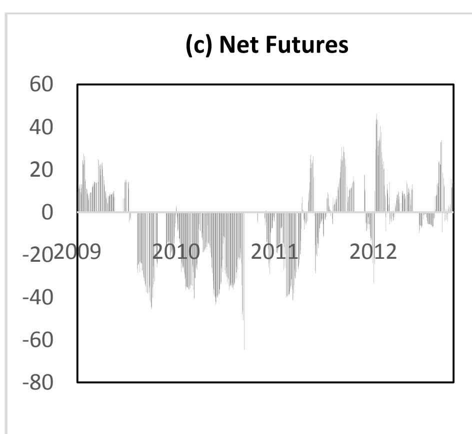




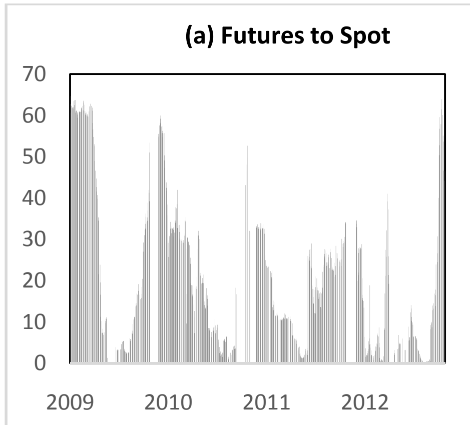
Panel F. Refined Soya oil

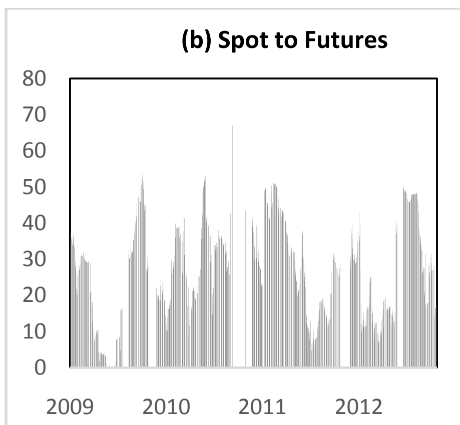


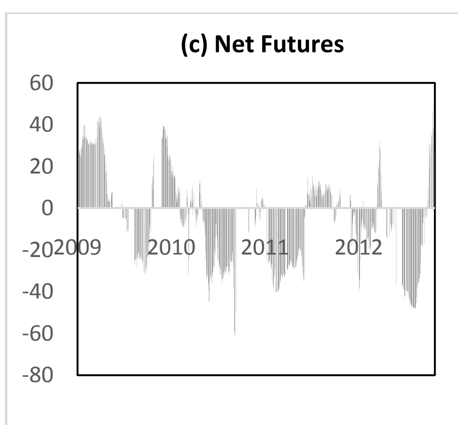




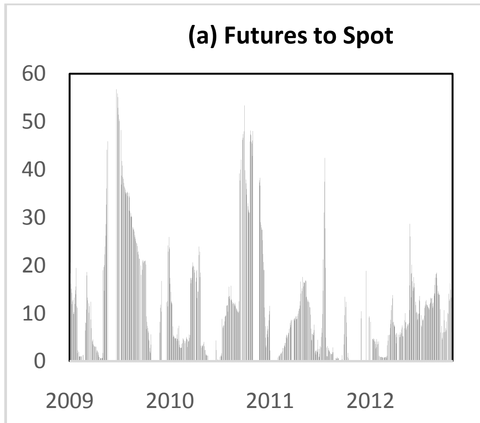
Panel G. Soybean

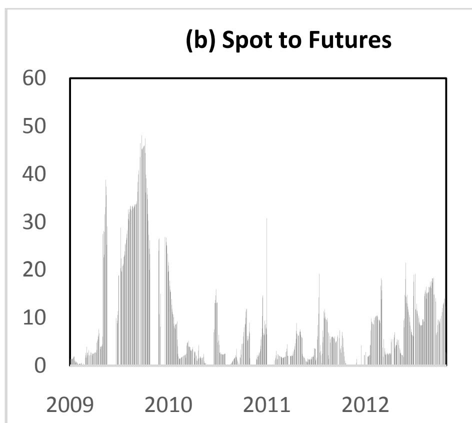


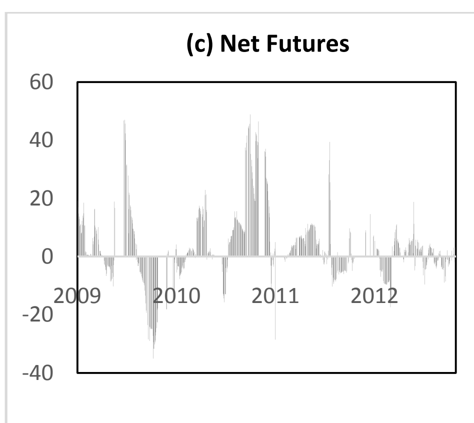




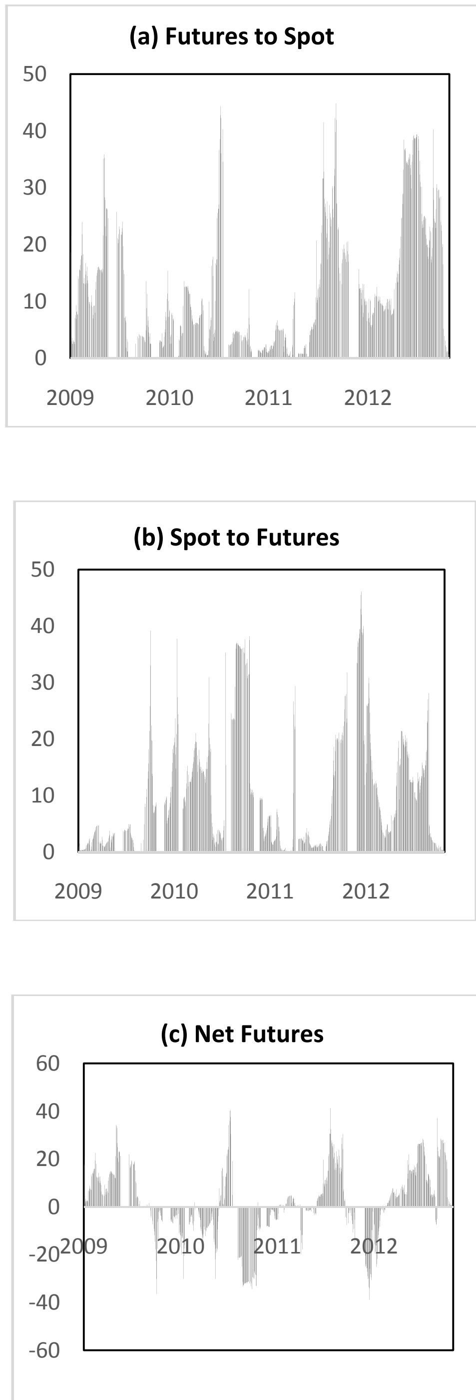
Panel H. Mentha oil







Panel I. Cardamom



6. Summary and Conclusion

In this study, the information transmission in case of India's commodity futures markets has been examined in three ways. First, the study investigates the process of price discovery between spot and futures price series of sample commodities. The empirical results confirm the price discovery between spot and futures. Between futures and spot, futures price leads the spot price in price discovery process, implying that futures prices assimilate new market information quickly than spot in all sample markets with the exceptionsof Castor seed, Chana and Mentha oil.These results appear to be in agreement with Sehgal*et al*. (2012).Second, the study examines the volatility spillover using GARCH-BEKK model. The results suggest that in the short-run, there is a strong volatility spillover from spot to futures market. While, in the long-run, volatility related information transmits from futures to spot markets. Third and last, the study applies directional spillover approach given by Diebold and Yilmaz (2012) to reconfirm the spillover findings. The results indicate that there is significant difference between directional spillovers between GARCH based volatility spillover and directional spillover methods. As in case of commodities like Barley, Castor seed, Cardamom, Chili, Mentha oil, Soybean and Refined Soya, the long-term directional spillover results are in contrast with the GARCH based findings. The overall findings of this study is that there is observable level of information transmission in case of Indian agricultural commodity derivatives market. The magnitude of information transmission is at satisfactory level (24%), implying that the commodity derivatives market is in evolving stage and futures market has started playing important role in the process of fair price discovery and volatility spillovers. This finding is in agreement with ChevallierandLelpo (2013) with regard to the low level of information transmission in case of agricultural products. The most striking outcome of this study is that the nature of information transmisison is of intra-commodity and not inter-commodity. As the results indicate, with the exception of Soybean and Refined Soya, none of the commodities exhibit inter-commodity directional spillover, implying that the information tranmission is by and large commodity specific and symmetric. Another important feature of this study is that the role of spot market is strongly visible, indicating that the spot market plays equally important role vis-à-vis futures market in price discovery and volatility spillover process. The finding of this study has strong implications on India's agri-futures market development as it provides new directions for further policy research. The study contributes to both market efficiency as well as commodity derivatives market literature from the perspective of emerging markets.

References

Anderson, T. (1996),"Return volatility and trading volume: an information flow interpretation of stochastic volatility",*Journal of Finance, 51*(1), 169-204.

Awartani, B., and Maghyereh, A. I. (2013),"Dynamic spillovers between oil and stock markets in the Gulf Cooperation Council Countries",*Energy Economics, 36*, 28–42.

Baele, L. (2005),"Volatility spillover effects in European equity markets: Evidence from a regime switching model",*Journal of Financial and Quantitative Analysis, 40*(2), 373–401.

Bekaert, G., and Harvey, C. R. (1997),"Emerging equity market volatility",*Journal of Financial Economics, 43*(1), 29–77.

Bose, S. (2008),"Commodity futures market in India: A study of trends in the National Multi-Commodity indices",*ICRA Bulletins Money and Finance*, 125-158. Retrieved from http://www.icra.in/Files/MoneyFinance/CommodityFutureMarket.pdf

Brockman, P., and Tse, Y. (1995),"Information shares in Canadian agricultural cash and futures markets",*Applied Economics Letters, 2*, 335-338.

Chan, K. C., Fung, H. G., and Leung, W. K. (2004),"Daily volatility behavior in the Chinese futures markets",*Journal of International Financial Markets, Institutions and Money, 14*(5), 491–505.

Chan, K., Chan, K. C., and Karolyi, G. A. (1991),"Intraday volatility in the stock index and stock index futures markets",*Review of Financial Studies, 4*(4), 657-684.

Chevallier, J., and Lelpo, F. (2013),"Volatility spillovers in commodity markets",*Applied Economics Letters, 20*(13), 1211-1227.

Cronin, D. (2013),"The interaction between money and asset markets: A spillover index approach",*Journal of Macroeconomics*, 39(A), 185-202.

Dey, K., and Maitra, D. (2011),"Price discovery and market efficiency revisited: Anecdotes from the Indian commodity futures markets",*Commodity Vision, 4*(4), 22-34.

Diebold, F. X., and Yilmaz, K. (2009),"Measuring financial asset return and volatility spillovers, with application to global equity markets",*The Economic Journal, 119*, 158-171.

Diebold, F. X., and Yilmaz, K. (2012),"Better to give than receive: predictive directional measurement of volatility spillovers",*International Journal of Forecasting, 28*, 57-66.

Du, X., Yu, L. C., and Hayes, D. J. (2011),"Speculation and volatility spillover in the crude oil and agricultural commodity markets: A Bayesian analysis",*Energy Economics, 33*(3), 497–503.

Engle, R., Ito, T., and Lin, W. (1990),"Meteor showers or heat waves? Heteroscedastic intraday volatility in the foreign exchange market",*Econometrica, 58*(3), 525–542.

FMC. (2012),*Annual Report 2011-2012,* Mumbai: Forward Market Commission, Govt. of India.

FMC. (2013),*FMC Bulletin, January 2013 - March 2013,* Mumbai: Forward Market Commission, Govt. of India.

Fung, G. H., Liu, Q., and Tse, Y. M. (2010),"The information flow and market efficiency between the US and Chinese copper and aluminum futures markets",*Journal of Futures Markets, 30*(12), 1192–1209.

Garbade, K. D., and Silber, W. L. (1979),"Dominant and satellite: A study of dually-traded securities",*Review of Economics and Statistics, 61*(3), 455–460.

Ge, Y., Wang, H. H., and Ahn, S. K. (2008),"Implication of Cotton price behavior on market integration",*Proceedings of the NCCC-134 Conference on applied commodity price analysis, forecasting, and market risk management, St. Louis.*

Hong, Y. (2001),"A test for volatility spillover with application to exchange rates",*Journal of Econometrics, 103*(1-2), 183-224.

Hua, R., and Chen, B. (2007),"International linkages of the Chinese futures markets",*Applied Financial Economics, 17*(6), 1275–1287.

IMF. (2012),*World Economic Outlook April 2012,* New York: International Monetary Fund.

Iyer, V., and Pillai, A. (2010),“Price discovery and convergence in the Indian commodities market”,*Indian Growth and Development Review*, 53-61.

Johansen, S., and Juselius, K. (1992),“Testing structural hypotheses in a multivariate cointegration analysis of the PPP and the UIP for UK”,*Journal of Econometrics, 53*(1-3), 211–244.

Karande, K. (2006),*A study of Castorseed futures market in India,* Mumbai: Indira Gandhi Development Research.

Koop, G., Pesaran, M. H., and Potter, S. M. (1996),“Impulse response analysis in nonlinear multivariate models”,*Journal of Econometrics,74*, 119-147.

Kumar, B., and Pandey, A. (2011),“International linkages of the Indian commodity futures markets”,*Modern Economy, 2*(3), 213–227.

Kumar, S., and Sunil, B. (2004),“Price discovery and market efficiency: Evidence from agricultural commodities futures markets”, *South Asian Journal of Management,, 11*(2), 32–47.

Lee, K. C., Fung, H. G., and Liao, T. L. (2009),“Day-of-the-week effects in the US and Chinese commodity futures markets”,*Review of Futures Markets, 18*(1), 27-53.

Liu, Q., and An, Y. (2011),“Information transmission in informationally linked markets: Evidence from US and Chinese commodity futures markets”,*Journal of International Money and Finance, 30*(5), 778–795.

Mahalik, K. M., Acharya, D. and Babu, S. M. (2010),“Price Discovery and Volatility Spillovers in Futures and Spot Commodity Markets: Some Empirical Evidence from India”,IGIDR Working Paper, Proceedings/Project Reports Series PP-062-10

Mattos, F., and Garcia, P. (2004),“Price discovery in thinly traded markets: Cash and futures relationship in Brazilian agricultural futures market”, *Proceedings of the NCR -134 Conference on Applied Commodity Price Analysis, Forecasting and Risk Management, available at http://www.farmdoc.uiuc.edu/nccc134*.

Ng, A. (2000),“Volatility spillover effects from Japan and the US to the Pacific-Basin”,*Journal of International Money and Finance, 19*(2), 207–233.

Pesaran, M. H., and Shin, Y. (1998),“Generalized impulse response analysis in linear multivariate models”,*Economics Letters, 58*, 17-29.

Ross, S. A. (1989),“Information and volatility: The no-arbitrage martingale approach to timing and resolution irrelevancy”,*Journal of Finance, 44*(1), 1-17.

Roy, A., and Kumar, B. (2007),“A comprehensive assessment of Wheat futures market: Myths and reality”,*Paper presented at International Conference on Agri-business and Food Industry in Developing Countries: Opportunities and Challenges held at IIM Lucknow.* Lucknow.

Sehgal, S., Ahmad, W., and Deisting, F. (2014),“An investigation of price discovery and volatility spillovers in India's foreign exchange market”,Forthcoming in *Journal of Economic Studies*.

Sehgal, S., Rajput, N., and Dua, K. R. (2012),“Price discovery in Indian agricultural commodity markets”,*International Journal of Accounting and Financial Reporting, 2*(2), 34-54.

Shihabudheen, M. T., and Padhi, P. (2010),“Price discovery and volatility spillover effect in Indian commodity market”,*Indian Journal of Agricultural Economics, 65*, 46-59.

Srinivasan, P. (2012),“Price discovery and volatility spillovers in Indian spot-futures commodity markets”,*The IUP Journal of Behvaioural Finance, 9*(1), 70-85.

Sumner, S., Johnson, R., and Soenen, L. (2010),“Spillover effects between gold, stocks, and bonds”,*Journal of Centrum Cathedra,, 3*, 106-120.

Thomas, S., and Karande, K. (2001),“Price discovery across multiple spot and futures markets”,*IGIDR Working Paper, Mumbai*.

Trujillo-Barrera, A., Mallory, M., and Garcia, P. (2011),“Volatility Spillovers in the U.S. Crude Oil, Corn, and Ethanol Markets”,*Proceedings of the NCCC-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management. .* St. Louis, MO.

Tse, Y. (1998),“International linkages in Euro mark futures markets: Information transmission and market integration”,*Journal of Futures Markets, 18*(2), 129–149.

UN. (2012),*Addressing Excessive Price Volatility in Food and Related Financial and Commodity Markets (A Concept Note),* New York: United Nations Organizations.

Yang, J., Bessler, D. A., and Leatham, D. J. (2001),“Asset storability and price discovery in commodity futures markets: a new look”,*The Journal of Futures Markets, 21*, 279-300.

Zapata, H., Fortenbery, T. R., and Armstrong, D. (2005),“Price discovery in the world sugar futures and cash markets: Implications for the Dominican Republic”, *Staff Paper No. 469, Department of Agricultural and Applied Economics, University of Wisconsin-Madison*.

Zhong, M., Darrat, F. A., and Otero, R. (2004),“Price discovery and volatility spillovers in index futures markets: Some evidence from Mexico”,*Journal of Banking and Finance, 28*(12), 3037–3054.

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