Price Discovery and Spillovers in Indian Agricultural Commodity Markets

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Paper prepared for the 34th IARIW General Conference

Dresden, Germany, August 21-27, 2016

PS1.4: Financial Activity

Time: Monday, August 22, 2016 [Late Afternoon]

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Introduction

Commodities traded in the spot markets are susceptible to price fluctuations. As these commodities can have adverse price changes in the future, the producers and traders dealing with these commodities are exposed to risk. Derivative markets have been set up to provide a hedge against adverse price risk and investment opportunity for speculators to assume risk for possible returns. However, for agricultural commodities which have dispersed spot markets throughout the country, electronic derivative markets are also a linking tool and acts as a price barometer. Hence, the role of agricultural derivative market is not only risk management and price stabilization but also price discovery. These markets are meant to give price signals, provide a level playing field and hedging facilities to the farmers in India. However, over decades future trading has been accused of encouraging speculative trading and destabilizing spot markets. As these form part of the basket of commodities for calculating the Consumer Price Index (CPI) & Wholesale Price Index (WPI) government has exercised rigorous controls over these markets.

In the year 1952, the Government enacted Forward Contract (Regulation) Act to regulate trading in future and forward contracts. The enactment was followed by the formation of the Forward Markets Commission (FMC) to have a regulatory oversight. However, the pre-liberalization economic policies were overly regulated and the derivative market could not flourish. Trading in essential commodities was altogether banned in the 1960's following a war, severe draught and farmer suicides as they defaulted on their forward contracts. Later, in 1980's Khusroo committee was formed which recommended trading in a few essential commodities. After which the Kabra committee further advocated trading in 17 commodities. But the real breakthrough happened in the year 2002-03, after the National Agricultural Policy (NAP), 2000 which advocated price control removal and trading in futures contracts. The change in policy was also due to pressure from international organizations like UNCTAD and WTO, which encourage the development of well-organized commodities market to bring about stabilization in commodity prices and move away from a system of price control and support by governments of various states. The trade negotiations under WTO required the government to sign the Agreement on Agriculture, whereby commitments were made for market access, domestic support and export subsidies. After Agriculture Policy Statement of the year 2000, the government shifted its stand from protectionist to liberalization and privatization in agriculture. The period after 2003, saw a magnanimous upsurge in trade volumes at agricultural derivative markets. However, in 2007-08 there was a ban on many essential commodities and the stated reason given for the ban was rising inflation due to futures trading. It has been argued that the government had put a ban due to political pressure (Srinivasan, 2008) and the Sen Committee Report, 2008 was inconclusive about the effect of futures trading on unexpected spurt in prices of agricultural commodities. The committee gave policy recommendations for developing electronic spot markets for better linkages between mandis, improvement in infrastructure facilities, transport and warehousing receipt system and encouraging participation of farmers to take benefit of the futures market. The report also highlighted that although the volume of trading had grown phenomenally in the future market it was greatly dominated by speculators and it had failed to provide instrument of risk management (Sen, 2008).

Research studies are generally disputed about the effect of futures trading on spot prices. Some research findings have documented that trading on futures market increases market depth for the commodity, leads to rapid dissemination of information and better price discovery[1] (Fligewski, 1981, Bessembinder and Seguin, 1992). The design of future market is such that, the electronic system provides rapid dissemination of floor information to traders and market makers help improve market liquidity (Schrieber and Schwartz, 1986). Without electronic derivative markets, price determination for agricultural commodities would be dependent upon scattered mandis all over the country. Future markets improve the process of price discovery of commodities. The Price Discovery process starts with the arrival of new information that generates trades and price movements as traders absorb the news while market reaches new equilibrium. The process is barred by impediments like noise in the information content of assets, returns on the assets over a short period are not serially independent, increased variance of short period returns and biased beta of short period data. The derivative markets are expected to reduce the information distortions, because of low transaction cost involved in future trading which pushes the traders to search for better information. Thereby, the future markets are considered more efficient[2] than the spot markets. They give signals about future cash price and are important for production and consumption decision made by the producers, manufacturers and investors (Yang and Leatham, 1999). The price risk is spread amongst a large number of investors and transferred from those hedging spot positions to professional speculators who could bear it. Thereby, reducing the risk premium attached to spot market transactions (Fligewski, 1981). However, for dispersion of information among markets, it is necessary that the spot and future markets are integrated. Market integration is a situation where prices of commodities in different markets move together that is they exhibit co-movements and the price of one market has a smooth reflection on prices in the other integrated markets (Roy,

[1] According to Yang and Leatham, 1999, "In a static sense, Price Discovery implies the existence of equilibrium prices. In a dynamic sense, the price discovery process describes how information is produced and transmitted across the markets."

[2] Efficient market implies price change happens only due to new unanticipated information.

2008). Different studies, (Hammoudeh, Li and Jeon 2002, Roy 2008 and Worthington and Higgs 2010) have investigated the integration using Johansen Cointegration Lambda and Trace Test. The Johansen cointegration test examines long term equilibrium relationship between two series. Series which are cointegrated in the long run are then examined for short run adjustment process using Vector Error Correction Model (VECM). A large body of literature is available dealing with the Price Discovery among financial assets. Even in Indian context, several studies have dealt with the subject. However, there is very limited work on the Price Discovery in agricultural commodities. In Indian context, empirical work on the price discovery in agricultural commodities is almost negligible. In this study, the objective is to fill this gap in the literature.

According to the literature, price discovery function[3] can be determined by examining return[4] and volatility[5] spillover[6] between spot and future market of the underlying asset. Researchers have pointed out that new information is reflected more in volatility than in returns (Kyle, 1985). Hence, the study tries to determine information spillovers by examining volatility spillovers. The literature on volatility spillovers for financial and commodity markets has been quite diverse, with some researchers focusing on first and second moments, (Nath and Lingareddy, 2008; Roy, 2008 and Bekiros and Diks, 2007) to examine return and volatility spillovers across markets. Volatility spillovers are also estimated among multiple financial markets using the multivariate GARCH model, (Yang and Awokuse, 2002; Bala and Premaratne, 2004; Worthington et al., 2005). Multivariate approach models volatility of all the markets simultaneously. Others have applied VAR Model, Chng, (2008) to see economic linkages among unrelated commodities in a common industry. A large body of literature is available dealing with volatility spillovers between financial markets. However, limited work has been done on volatility spillover between future and spot market for agricultural commodities. This study uses EGARCH to model volatility and then examines volatility spillovers between spot and future market using granger causality test. It also fills the gap in the present stream of literature on volatility spillover for agricultural commodities in Indian context.

The study adds another dimension to the analysis of information inter-linkages by examining liquidity[7] spillover between spot and future market. Liquidity commonality[8] in markets plays a

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[3] In the dynamic sense, the price discovery process describes how information is processed and transmitted across the markets.

[4] Return for the purpose of this study is ln P_t/P_{t-1}

[5] Volatility is conditional variance of return

[6] According to Gallo and Otranto (2007), spillover refers to a situation where change in the order of a dominating market leads to a change in the order of dominated market with a lag.

[7] Liquidity is the quantity of contracts bought and sold

[8] Liquidity commonality is defined as liquidity co-movements across markets.

key role in inventory risk management and inter-temporal changes in liquidity. Thereby, trading activity in one commodity market has inter-temporal response in the other market. Any unanticipated change in trading volume in one market affects the trading volume of the other market. So, it becomes important to study the change in liquidity in one market brought about by change in liquidity in the other market.

Empirical work on liquidity has been more on market commonalities. Chordia et al., (2005) explored cross market liquidity (bid-ask spread, depth, and order flow in the markets) between stock and bond market using a Vector Autoregressive model. Researchers have also examined liquidity shock spillover across financial and real estate market by employing a VAR methodology (Ambrose and Park, 2012). Whereas Marshall et al., (2013) examine liquidity commonalities in sixteen commodity futures markets using market model[9] and component analysis. Brockman et al., (2009) studies commonality in liquidity across 47 stock exchanges using the market model. Different studies have examined liquidity characteristics across different markets or for different assets of the same market. However, research work on liquidity spillover between future and spot market for agricultural commodity has been almost negligent. The present study attempts to fulfill this research gap by using data from Indian markets. An important contribution of this work is for the market participants who take marketing and production decisions amid risk and uncertainty. The study gives an overall understanding of market behavior, transmission of risk and shocks across spot and future market.

The study is organized into five sections, including the present one. Section 2 describes the data, its sources and descriptive statistics, Section 3 deals with Cointegration between spot and future market in the long run and the short run adjustment process between spot and future market. While Section 4 covers volatility and liquidity spillover between spot and future market The last section discusses summary and conclusions.

2. Data

2.1. Data Source

The data consists of daily closing spot prices and futures prices for eight commodities Channa, Gaur Seed, Kapas, Soybean, Pepper, Potato, Refined Soya Oil and Wheat. The future price series has been constructed using daily closing future prices of middle month contracts for all commodities. Both the spot and future price series has been compiled from National Commodity & Derivative Exchange Limited (NCDEX) for the data period from 1st January'

[9] The market model regresses percentage change in liquidity measure for a commodity on percentage change in liquidity measure of a market.

2003 to 31st December' 2013.As the Government of India allowed re-introduction of commodity futures in 2002, the trading picked up and data was available only after the year 2002. These commodities were chosen according to the highest trading volumes in the particular agricultural class. Location of the spot market and the quality of agricultural products is given in **Table 2.1**.

2.2. Descriptive Statistics

Descriptive statistics of the future and spot return series are reported in **Table 2.2**. The average prices of all future returns are higher than spot returns except for Gaur seed and Pepper. The pattern exhibits a market situation known as the Contango, whereby for almost all the commodities the market traders are net long and the future prices would fall over the life of the contract. Whereas for Gaur seed and Pepper, returns exhibit Backwardation a situation when market traders are net short and are trying to hedge the risk.

An analysis of return volatility as shown by standard deviation reveals that for most agricultural commodity markets like Channa, Gaur seed, Pepper, Refined soya oil, Soybean, Potato and Wheat the future markets are more volatile than the spot market. Whereas higher return volatility has been observed for Kapas in the spot market.

All the return series exhibit asymmetric distribution with Kapas spot returns, Pepper spot returns, Refined soya oil spot return, Potato future and spot returns series being positively skewed implying that the return series has a longer right tail and most of the distribution is concentrated on the left. Whereas, for other than those mentioned above most of the returns series are negatively skewed with longer left tail and mostly concentrated on the right.

The statistical Kurtosis which measures thickness of the tails reveals that all the distributions have a K higher than three indicating thicker tails and leptokurtic distribution. Channa spot returns, Pepper future and spot returns being the only series closer to normal distribution. The return series exhibits the pattern of small changes that would happen less frequently as there is clustering around the mean and a more likely large variation with fat tails.

3. Cointegration and short run adjustment process between spot and future market

This section is further sub-divided into two parts: Part 1, examines long-run equilibrium relationship between spot and future market for all agricultural commodities and Part 2, deals with Short Run Adjustment Process between Spot and Future Market

3.1. Long Run Equilibrium between Spot and Future Market

To run the Johansen Cointegration test, is necessary that the first form difference is integrated of order 1 or higher. The order of integration of the spot price (ln P_{st}) and future price (ln P_{ft}) series is examined using Augmented Dickey Fuller (ADF) test[10]. It is observed that for all the eight commodities, namely Channa, Gaur seed, Kapas, Pepper, Potato, Refined soya oil, Soybean and Wheat, both spot and future price series are non-stationary at the level form, whereas it is stationary at first form difference, i.e. future series (ln P_{ft}/P_{ft-1}) and spot series (ln P_{st}/P_{st-1}). Hence, it can be concluded that the series are all integrated of order 1, viz. I(1) processes and Johansen test for long run equilibrium relationship can be applied. The result of the stationarity test is given in **Table 3.1**.

Earlier researches have estimated market integration based on the Engle-Granger (1987) technique of bivariate cointegration. It involved two or more series, which were non stationary, but a linear combination of them was stationary. The more recent techniques are Johansen (1988) and Johansen & Juselius (1990, 1992) to determine the cointegrating relationships. If y_t is considered to be (n×1) vector of non-stationary I(1) variable, then the Vector Auto Regression (VAR) of $y_t$upto k lags can be specified as:

$$y_t = M + \Sigma_i^k \Pi_i y_{t-1} + e_t, \text{(t=1, 2 ....T)} \qquad (3.1)$$

Where each of π_i is an (n×n) matrix of parameters, e_t is an identically and independently distributed n-dimensional vector of residuals and M is an (n×1) vector of constants.

The above equation (1.1) can be expressed in first difference notation and formulate the error correction representation of y_t as:

$$\Delta y_t = \Gamma_1 \Delta y_{t-1} + \cdots + \Gamma_{k-1} \Delta y_{t-k+1} + \Pi y_{t-1} + u_t \qquad (3.2)$$

Where, $\Gamma_i = -(I - \Pi - \cdots - \Pi_i); i = 1,2, \cdots k-1, \Pi = -(1 - \Pi_1 - \cdots \Pi_k)$

Γ_i 'S are (n×) coefficient matrix for, Δy_{t-1},i=1,2,…k-1

$\Pi$is an (n×n) coefficient matrix for the variables in y_{t-1},

$u_t$is an (n×1) column vector of disturbance terms.

The above equation gives information about both the short and long run adjustments to changes in y_t through Γ_i and Π respectively. The information of the long run relationship is gathered from the cointegration analysis, which basically involves examining the impact matrixΠ.

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10 ADF testis applied on the following regression model;
$\Delta Yt = \beta 1 + \beta 2t + \delta Yt-1 + \sum_{i=1}^{m} \alpha i \Delta Yt-i + \varepsilon t$, where εt is a pure white noise error term.
It is a unit root test for the time series with the null hypothesis δ=0.

Johansen (1988) derived two likelihood ratio test statistics to test for the number of cointegrating vectors. The null hypothesis of r cointegrating vectors against alternative of more than r cointegrating vectors is tested by using the lambda-trace statistics which is given by:

$$\lambda_{trace} = -T\sum_{i=r+1}^{n}\ln(1 - \hat{\lambda}_i) \qquad (3.3)$$

On the other hand, the null hypothesis of r cointegrating vectors against the alternative of (r+1) cointegrating vectors is tested by using the lambda-max. Statistics, which is computed as:

$$\lambda_{max} = -T\sum_{i=r+1}^{n}\ln(1 - \hat{\lambda}_{r+1}) \qquad (3.4)$$

Whereλ_i's are the estimated Eigen values (characteristic roots) and T is the number of usable information.

The lambda-trace test and maximum eigenvalue test has been applied on two non-stationary variables spot price (ln P_{st}) and future price (ln P_{ft})of eight agricultural commodities using the bivariate framework. The results of Johansen trace test and maximum eigenvalue are reported in **Table 3.2**. Out of the eight commodities only one commodity, namely Kapas accept the null hypothesis that spot and futures market are not cointegrated since both the statistics λ_{trace} and λ_{max} don't exceed the critical value with a 5% level of significance.The absence of any long run relationship reveals lack of integration of the spot market with the derivatives market. Also five other commodities like Chana, Soybean, Pepper, Refined Soya Oil and Wheat indicate one cointegrating equation implying a single path of convergence towards equilibrium. The remaining two commodities Gaur seed and Potato indicate two cointegrating equations in its cash and futures market, implying that they have tight comovements and if they move on their own because of non-stationarity they don't go far from each other.

3.2. Short Run Adjustment Process between Spot and Future Market

The second part of the analysis involves Vector Error Correction Model (VECM) and Block Exogeneity Wald Test for examining the short run adjustment process between spot and future market.

VECM consists of lags of the dependent and explanatory variables and it captures the speed with which independent variable adjusts to changes in past disequilibrium as well as changes in the explanatory variables. It not only shows the corrected degree of disequilibrium from one period to the next, but also the relative magnitude of adjustment that takes place in both the markets to achieve equilibrium in the long run.

In the present situation the two series, futures price series and spot price series are set up in VEC framework as follows:

$$\Delta y_{spot,t} = \alpha_1 c_{t-1} + \sum_{i=1}^{k} \beta_{1i} \, \Delta y_{futures,t-i} + \sum_{i=1}^{k} \gamma_{1i} \, \Delta y_{spot,t-i} + \varepsilon_{1,t} \qquad (3.5)$$

$$\Delta y_{futures,t} = \alpha_2 c_{t-1} + \sum_{i=1}^{k} \beta_{2i} \, \Delta y_{futures,t-i} + \sum_{i=1}^{k} \gamma_{2i} \, \Delta y_{spot,t-i} + \varepsilon_{2t} \qquad (3.6)$$

In the above equations (3.5) & (3.6) c_{t-1} is the error correction term, where c_{t-1} $=\left(y_{futures,t-1} - \beta y_{spot,t-1}\right)$. The long run equilibrium of this error correction term is zero.If y_{spot}(ln P_{st}) and $y_{futures}$(ln P_{ft}) deviate from the equilibrium the term will be non-zero and y_{spot} and $y_{futures}$adjusts to restore the equilibrium relation. The coefficient $\alpha_1$and $\alpha_2$measures the speed of adjustment of the variable towards equilibrium.

The study uses VECM to analyze for seven agricultural commodities with significant one or more cointegrating equations. The lag terms are chosen in accordance to the SIC (Schwarz Information Criterion). The results of VECM analysis are reported in **Table 3.3.** The result for Channa shows that at 1% level, the influence of 1-day lagged future price change on the spot price change is significant, but the 1-day lagged spot price change does not wield significant shock to the Channa future price change. According to the EC term the adjusting extent of the Channa spot price change is -0.025 and statistically significant, whereas for the future market, it is insignificant. The empirical results show that the explanatory power of future prices is more than the spot prices. The VECM results of Gaur seed at 1% level of significance show that all 8 days spot prices cause change in future market prices. Whereas lagged future prices don’t have any significant change on the spot prices. The significant adjustment in the short term is -0.14% for future Gaur seed prices. The results show that the information transmission takes place over a long period of time. The future markets take a long time to adjust its prices to new information. The table for short term interactions between spot and futures market for Pepper exhibit that the error correction term is significant for both the markets and has opposite sign suggesting that 1% rise in the difference between prices of two markets leads to a rise in the spot market prices by 0.02% and fall in future markets prices by 0.04%. The 1-day, 2-day and 3-day lagged price change of futures market affects the spot price change by 0.4%, 0.09% and 0.04% respectively. Whereas only the 2-day lagged price of spot market significantly affect price changes in the futures market. The table for short term adjustments of Potato reveals that the market prices do not change with the change in 1-day or 2-day lagged prices of the other market. Only the error correction term is significant at 1% level for adjustments in spot prices, i.e. the spot market prices fall by 0.04% with 1% rise in the difference between the two markets. The results indicate that the integration of the two markets is due to variables other than spot and future price change. For Refined soy oil, the 1-day lagged future price changes significantly affect spot price change. Whereas, the spot market price change has a non-significant impact on the future price change. On the other hand, there is a 0.27% price change in spot markets with 1% 1-day lagged future price change. The error correction term and short term deviation are only significant for spot price change at 0.036%. The results show that the future market has a significant impact on the spot markets and not vice-versa. VECM results of Wheat are very similar to Refined soy oil with a 1-day and 2-day lagged future price change of Wheat significantly causing 0.13% and 0.06% price change in spot markets respectively. The influence of future price change lasts for a longer time, whereas spot price changes affect future price changes at 5% level of significance with 1-day lagged period. Soybean results reveal that the the1-day and 2-day lagged price change of spot markets and has a significant impact on the future market price change. The influence of future price change on spot markets dies down within 1-day. However, percentage change in spot markets is 0.23% almost double the change in the future markets i.e. 0.12%. For almost all commodities except Gaur seed future market plays a dominant role in spot price change. In Gaur seed spot markets have a stronger effect on the future price change.

The Block Exogeneity Test examines bilaterally if the lags of the excluded variable affect endogenous variable. For the given VAR equations (3.5) & (3.6) the following hypothesis are tested:

Firstly, H_0 :β_{1i}= β_{2i}= 0 for Dependent spot price change (endogenous variable), against H_a: at least one of them ≠ 0

Secondly, H_0:γ_{1j}= γ_{2j}= 0 forDependent future price change (endogenous variable), against H_a: at least one of them ≠ 0

In case the first null hypothesis is rejected, it means that future price change granger causes spot price change. And the rejection of the second null hypothesis implies that spot price change granger causes future price change.

The results of the Block Exogeneity tests are exhibited in **Table 3.4** at1**%** and 5% level of significance. The table reveals that all commodities except for Gaur Seed and Potato, future price change granger causes spot price change. For Gaur Seed, spot price change granger causes future price change and there is no particular lead lag relationship in case of the Potato. The table also exhibits bilateral causality for Refined soy oil and Soybean with the causal direction being dominant from future market to spot market.

4. Spillover between Spot and Future Market

Empirical analysis is performed in two parts: Part 1 deals with volatility modeled on EGARCH and volatility spillover between spot and future market and Part 2 involves liquidity modeled on unexpected trading volume and liquidity spillover between spot and future market.

4.1. Volatility spillover between spot and future market

Volatility spillover is the change in the conditional variance of return in one market led by a change in the conditional variance of return of another.

Previous literature has modeled volatility as conditional on time due to presence of heteroscedastic error terms. The error terms of asset returns exhibit varying variances and these unequal variances may be autoregressive over a period of time. Engle (1982) introduced Autoregressive Conditional Heteroscedastic (ARCH) model for time varying pattern of variances, the error terms in this model are conditioned on information available at lagged square error terms and the disturbance term is distributed as:

$$\varepsilon_t \sim N[0, (\gamma_0 + \sum_{i=1}^{p} \gamma_i \, \varepsilon_{t-i}^2)] \tag{4.1}$$

ε_t being normally distributed with zero mean and variance of error terms being:

$$\sigma_t^2 = \gamma_0 + \sum_{i=1}^{p} \gamma_i \, \varepsilon_{t-i}^2 \tag{4.2}$$

The ARCH model portrays volatility as the clustering of large shocks to the dependent variable. The model was further extended by Bollerslev (1986) to Generalized Autoregressive Conditional Heteroscedasticity (GARCH). The GARCH models not only on the past squared error terms but also on the past conditional variances. The model can be represented as:

$$\sigma_t^2 = \gamma_0 + \sum_{i=1}^{p} \gamma_i \, \varepsilon_{t-i}^2 + \sum_{i=1}^{q} \omega_i \sigma_{t-i}^2 \tag{4.3}$$

Where σ_t^2, variance of error terms is a function of lagged values of ε_t^2 and itself. $\{\gamma_i\}$ i= 1,2,…..,p and $\{\omega_i\}$ $i =$ 1,2,….,q are non negative constants. However the study does not use the GARCH model due to its inherent assumptions that positive and negative error terms have symmetric effect on volatility. The assumption implies that arise and fall in the market will have the same outcome. The second problem of the GARCH model is that it imposes a restriction of positive coefficients. It has been documented that volatility transmission are asymmetric and spillovers are more pronounced for bad than good news (Booth, Martikeinan and Tse, 1997).To overcome these shortcomings the study examines time varying pattern of spot and future volatility on Exponential Generalized Autoregressive Conditional Heteroscedasticity (EGARCH) introduced by Nelson (1991). The model captures asymmetric impact of shocks and does not impose non negativity restrictions on GARCH parameters. It also envisages fall in prices as more influential for predicting volatility than the rise. It is represented as follows:

$$\log \sigma_t^2 = \gamma_0 + \sum_{i=1}^{p} \gamma_i \frac{|\varepsilon_{t-i}|}{\sigma_{t-i}} + \sum_{i=1}^{p} \theta_i \frac{\varepsilon_{t-i}}{\sigma_{t-i}} + \sum_{i=1}^{q} \omega_i log\, \sigma_{t-i}^2 \qquad (4.4)$$

The above equation allows $\varepsilon_t$to have positive and negative values and impact volatility differently.

The study models EGARCH (p,q) for the following spot and future mean equation:

$$\Delta y_{spot,t} = \alpha_{1i} + \beta_{1i} \Delta y_{spot,t-1} + e_{ti} \qquad (4.5)$$

$$\Delta y_{futures,t} = \alpha_{2j} + \beta_{2j} \Delta y_{futures,t-1} + e_{tj} \qquad (4.6)$$

Where $\Delta y_{spot,t}$and $\Delta y_{futures,t}$ is the spot and future return series with 1-day lag term as the autoregressive variable and e_{ti}, e_{tj} are the error terms for spot return and future return equation respectively. The terms p and q i.e. ARCH and GARCH order is chosen in accordance with the minimization rule of SIC (Schwarz Information Criterion). The results of the selected EGARCH model are exhibited in **Table 4.1.**

For the purpose of determining volatility spillovers between the spot and futures market for all the agricultural commodities, the study applies granger causality test. Granger (1969) examines if the past values of dependent variable (y) and the lagged values of independent variable (x) can improve the explanation for the current (y). When the test examines the statement 'x granger causes y' it only implies the precedence of information content and not the effect or result. It determines the lead lag relationship using the following specifications:

$$\sigma_{f,t} = \alpha_1 + \sum_{i=1}^{p} \beta_{1i} \sigma_{f,t-i} + \sum_{j=1}^{q} \gamma_{1j}\, \sigma_{s,t-j} + \varepsilon_{1,t} \qquad (4.7)$$

$$\sigma_{s,t} = \alpha_2 + \sum_{i=1}^{p} \beta_{2i} \sigma_{s,t-i} + \sum_{j=1}^{q} \gamma_{2j}\, \sigma_{f,t-j} + \varepsilon_{2,t} \qquad (4.8)$$

Where σ_f is the futures volatility, σ_s spot volatility and $\varepsilon_{1t}$and $\varepsilon_{2t}$are white noise residuals. The granger causality test involves testing the following null hypothesis using the F-Statistic:

$$\gamma_{11} = \gamma_{12} = \ldots = \gamma_{1q} = 0 \qquad (4.9)$$

$$\gamma_{21} = \gamma_{22} = \ldots = \gamma_{2q} = 0 \qquad (4.10)$$

The granger causality test is applied for lag (p,q) in accordance with the minimization criteria of SIC. The test examines if spot volatility granger causes future volatility and vice versa if future volatility granger causes spot volatility. The results of the granger test between spot and future returns are exhibited in **Table 4.2.**

The results of volatility spillover between spot and future markets show significant bivariate causality in atleast six out of eight commodities including Channa, Pepper, Potato, Kapas, Refined soy oil and Wheat. For all the six commodities except Refined soy oil, future markets granger cause volatility in the spot market. The parameter estimates of Channa, Pepper, Refined soy oil, Kapas and Wheat show that 1-day lagged future volatility leads to a rise in spot volatility. Whereas 2-day lagged future volatility leads to a fall in spot volatility for Channa and Pepper. Gaurseed shows univariate causal relationship with spot volatility leading volatility in the future market. For Potato and Soybean, 2-day lagged future volatility significantly causes an increase in spot volatility. Result of Refined soy oil shows that although both the markets influence each other, spot volatility has a stronger influence over the volatility in the future market. It has been generally documented in research studies that price discovery happens from future to spot due to structural advantages of trading in futures market (Mahalik, Acharya and Babu, 2009). For the two commodities Refined soy oil and Gaurseed which does not back this theory, the results shows that the nature of commodity markets is backward where the commodity producers do not participate in the derivative trading. They don't take risks and are only interested in subsistence exchange.

4.2. Liquidity Spillover between Spot and Future Market

According to Bollerslev and Jubinski (1999) unexpected good and bad news results in a price increase and price decrease respectively. Both the news types are followed by an above average trading activity as it adjusts to a new equilibrium. The unexpected trading shocks lead to a volatile asset market, (Bessembinder and Seguin 1993). The study examines the interaction of unexpected trading shocks between spot and future markets. Following the literature (Bessembinder and Seguin, 1992 and 1993 and Yang et al., 2005) the study uses 21 day moving average of trading volume as the expected trading volume and the difference between expected and actual as the unexpected trading volume. The test examines bidirectional causality between spot and future unexpected trading volume. It inspects if spot unexpected trading volume granger causes future unexpected trading volume and vice-versa. To determine liquidity spillovers across spot and future markets the study uses Granger causality test with the following equation:

$$y_{fv,t} = \alpha_1 + \sum_{i=1}^{p} \beta_{1i} y_{fv,t-i} + \sum_{j=1}^{q} \gamma_{1j}\, y_{sv,t-j} + \varepsilon_{1,t} \qquad (4.11)$$

$$y_{sv,t} = \alpha_2 + \sum_{i=1}^{p} \beta_{2i} y_{fv,t-i} + \sum_{j=1}^{q} \gamma_{2j}\, y_{sv,t-j} + \varepsilon_{2,t} \qquad (4.12)$$

Where y_{fv} is the unexpected future trading activity, y_{sv} unexpected spot trading activity and $\varepsilon_{1,t}$ and $\varepsilon_{2,t}$ are white noise error residuals. The granger causality test is applied of appropriate lag (p,q) using SIC. The results for the granger causality test are reported in **Table 4.3.**

Table 4.3 shows significant bidirectional causality in three out of eight commodities including Potato, Soybean and Refined soy oil. For Potato, although bidirectional causal feedback exists between spot liquidity and future liquidity it is stronger from future market to spot market. Whereas Soybean and Refined soy oil exhibit future trading activity leads spot trading activity. The unexpected spot trading volume has strong influence on the trading activity in futures market for almost all commodities including Channa, Gaur seed, Soybean, Pepper and Refined Soy Oil. The parameter estimates show that a rise in the 1-day lagged unexpected trading volume in the spot market leads to a fall in the unexpected trading volume in the future market. Kapas and Wheat indicates unidirectional causality from Futures market liquidity to Spot market liquidity.

5. Summary and Conclusion

There is very limited research work on the role of future markets in price discovery of agricultural commodities. Empirical literature deals with price discovery in two parts: long term equilibrium and short term adjustment process between future and spot market. Long term equilibrium relationship between the two markets is examined by Johansen cointegration test (1988). Short term adjustment process, on the other hand, is studied by VECM which explains the speed of adjustment of the future and spot market for any price change in the other market. Also, the causal relationship is identified using block exogeneity wald test. Data employed consists of daily returns of future and spot market for eight commodities where the derivative of these agricultural commodities is traded on NCDEX. The study period is from January 2003 to December 2013.

Results show that for all commodities except Kapas, future and spot market is cointegrated with one or two cointegrating vectors. Long term equilibrium for Wheat spot and future market is in contrast to the earlier empirical work in this commodity, which shows no cointegrating relation, Roy (2008). For Kapas, there is no equilibrium between spot and future market in the long term. Indicating, spot and future markets do not move together on common asset information, thereby defeating the process of price discovery. Result of other commodities is in conformity with existing literature on cointegrated future and spot market (Kumar and Pandey, 2011).

Further, it is discovered that out of the seven commodities which were examined for short term adjustment process, future market plays a dominant role in spot price change for five commodities. In the study, Gaur seed spot market causes future price change and there is no causal behavior between spot and future market for Potato. Although, the Potato spot market adjusts to a change in error correction term. The results are in conformity with the theory, as future market has a structural advantage over the spot market, information processing and price change first happens in the future market and is then transmitted to the spot market. Therefore, future market plays a leading role in the price discovery process. The study contributes to the existing literature on price discovery in agricultural commodities, especially for an emerging market like India.

Volatility spillover in agricultural commodities has received less focus in financial literature. And until recently liquidity spillover between asset markets had not been researched. This study examines price discovery function in agricultural commodity markets by analyzing volatility and liquidity spillover between spot and future market. The volatility is modeled on time varying pattern using EGARCH and spillover is analyzed by granger causality test. The liquidity spillover measures granger causality test between unexpected spot trading volume and unexpected future trading volume.

It is found that for two commodities Refined soy oil and Gaurseed spot volatility drives future volatility whereas for the other six commodities Channa, Kapas, Pepper, Potato, Soybean and Wheat it is the future volatility which leads volatility in the spot markets. Although the results are mixed but they are in conformity to the studies which believe that future market leads in transmitting new information to the spot market (Zapata et al., 2005 and Fu and Qing, 2006). However they are in contradiction with Mahalik et al., (2009), for metal and energy commodities volatility in future market leads spot market but for agricultural commodities the spot leads future in India.

Further the result of liquidity spillover are in contradiction with the volatility spillover and for five commodities including Channa, Gaur seed, Soybean, Pepper and Refined soy oil that the unexpected spot trading volume leads the unexpected future trading volume. However, the parameter results also show that there is a fall in liquidity of future market if the liquidity of spot market rises. The burst of trading activity in spot market leads the future market. The results show that with new information trading activity picks up in spot market. But price formation and volatility is led by future markets due to presence of speculators, hedgers in the future market.

Policy makers and government agencies can use the results of this study to analyze the role of future market. Future market can perform the function of Price discovery for agricultural commodities only if future and spot markets are cointegrated in the long run. The future and spot market of Kapas does not have a long run equilibrium relationship. Thereby, future trading of Kapas requires structural policy changes. Government can initiate steps for substantial involvement of producers of Kapas in the derivative exchange.

To deepen the markets the government needs to encourage participation of hedgers in the future market. The hedging activity can be promoted with better infrastructure facilities like low storage costs, warehouse receipts and electronic spot exchange for better information symmetry. The farmers can be encouraged to participate in the derivative trading by introduction of commodity options. Commodity options provide direct benefit farmers.

The findings are relevant for investors to analyse volatility and liquidity transmission across spot and future markets to estimate risk associated with the agricultural commodities and develop various hedging techniques. From academic point of view, the study documents spillover of volatility and liquidity between spot and future market as arrival and transmission of new information in Indian agricultural commodity markets. The study contributes to the literature on information transmission for Indian market.

References

Ambrose, B. W. and Park, S. Y. (2012), "The Spillover Impact of Liquidity Shocks in the Commercial Real Estate Market", Working paper, available at: *http://www.reri.org/research/article_pdf/ wp183.pdf.*

Antoniou, A. and Holmes, P. (1995), "Futures trading, information and spot price volatility: evidence for the FTSE-100 Stock Index Futures contract using GARCH", *Journal of Banking and Finance Vol. 19*, pp. 117-129.

Avramov, D., Chordia, T. and Goyal, A. (2006), "The Impact of Trades on Daily Volatility", *The Review of Financial Studies*, Vol. 19, No. 4, pp. 1241-1277.

Bala, L. and Premaratne, G. (2003), "Stock Market Volatility: Examining North America, Europe and Asia", *National University of Singapore, Economics Working Paper,* Available at SSRN: *http://ssrn.com/abstract=375380.*

Bekiros, D. and Diks, H. (2008), "The Relationship between Crude Oil Spot and Futures Prices: Cointegration", *Energy Economics*, Vol. 30, No. 5, pp. 2673–2685.

Bessembinder, H. and Seguin, P. J. (1993), “Price Volatility, Trading Volume, and Market Depth: Evidence from Futures Markets” *The Journal of Financial and Quantitative Analysis*, Vol. 28, No. 1, pp. 21-39.

Bessler, D. A. and Covey, T. (1991), “ Cointegration: Some Results on U.S. Cattle Prices”, *The Journal of Futures Markets,* Vol. 11, No. 4, pp. 461-474.

Bilson, J. F.O. (1981), “The Speculative Efficiency Hypothesis”, *Journal of Business*, Vol. 54, No. 3, pp. 435-451.

Bollerslev, T. and Jubinski, D. (1999), “Equity Trading Volume and Volatility: Latent Information Arrivals and Common Long-Run Dependencies”, *Journal of Business & Economic Statistics*, Vol. 17, No. 1, pp. 9-21

Booth, G. G., Martikainen, T. and Tse, Y., (1997),“Price and volatility spillovers in Scandinavian stock markets*”, Journal of Banking & Finance,* Vol. 21, No. 6, pp. 811–823.

Brenner, R. and Kroner, K. F. (1995), “Arbitrage, Cointegration, and Testing the Unbiasedness Hypothesis in Financial Markets”, *The Journal of Financial and Quantitative Analysis,* Vol. 30, No. 1, pp. 23-42.

Brockman P., Chung D.Y. and Pérignon C. (2009), “Commonality in Liquidity: A Global Perspective”, *The Journal of Financial and Quantitative Analysis,* Vol. 44, No. 4, pp. 851-882.

Calice G., Chen J. and Williams J.(2013), “Liquidity spillovers in sovereign bond and CDS markets: An analysis of the Eurozone sovereign debt crisis”, *Journal of Economic Behavior & Organization,* Vol. 85, No. C, pp. 122–143.

Cespa G. and Foucault T.(2011), “Learning from Prices, Liquidity Spillovers, and Market Segmentation”,availableat:http://www.cepr.org/active/publications/discussion_papers/dp.php?dpno=8350

Chang, Eric C., Cheng J. W. and Pinegar J. M. (1999), “Does futures trading increase stock market volatility? The case of the Nikkei stock index futures market”, *The Journal of Banking & finance,* Vol.23, No. 5, pp. 727-753.

Chng, M. T. (2009), “Econimic linkages across commodity futures: Hedging and trading implications”, *Journal of Banking & Finance,* Vol. 33, No. 5, pp. 958–970.

Chopra A. and Besslern D.A. (2005)., "Price Discovery in the Black Pepper Market in Kerala", *Indian Economic Review, New Series,* Vol. 40, No. 1, pp. 1-21.

Chordia, T., Sarkar and,A. and Subrahmanyam, A. (2005), "An Empirical Analysis of Stock and Bond Market Liquidity", *The Review of Financial Studies,* Vol. 18, No. 1, pp. 85-129.

Chordia,T., Roll, R.,and Subrahmanyam, A. (2011), "Market Liquidity and Trading Activity", *The Journal of Finance,* Vol. 56, No. 2 , pp. 501-530.

Chordia,T., Roll,R.and Subrahmanyam,A.(2000), "Commonality in liquidity", *Journal of Financial Economics,* Vol. 56, No. 1, pp. 3-28

Chowdhry, B. and Nanda, V. (1991), "Multimarket Trading and Market Liquidity", *Review of Financial Studies,* Vol. 4, No. 3, pp. 483-511.

Chowdhury, A. R. (1991), " Futures Market Efficiency : Evidence from Cointegration Tests", *The Journal of Futures Markets,* Vol.11, No. 5, pp. 577-589.

Cornell, B. (2000), "The Relationship between Volume and Price Variability in Futures Markets", *The Journal of Futures Markets,* Vol. 20, No. 1, pp. 5–18.

Craig, S. Hakkio and Mark, R. (2002), "Market efficiency and cointegration : an application to the sterling and deutschemark exchange markets", *Journal of International Money and Finance,* Vol. 8, No. 1, pp. 75–88.

Dahl, C. M. and Iglesias, E. M. (2009), " Volatility spill-overs in Commodity Spot Prices: New Empirical Results", *Economic Modelling,* Vol. 26, No.3, pp. 601–607.

Darrat, A. F. and Rahman, S. (1995), "Has Future trading Activity caused stock Price volatility", *The Journal of Futures Markets,* Vol. 15, No. 5, pp. 537-557.

Deb, S. (2005), "Terms of Trade and Supply Response of Indian Agriculture: Analysis in Cointegration Framework", *The Indian Economic Review,* Vol. 40, No. 1, pp. 65-92.

Diebold, F.X. and Yilmaz, K. (2008), "Measuring Financial Asset Return And Volatility Spillovers, With application To Global Equity Markets", *http://hdl.handle.net/ 10419/43200.*

Engle, R. F., and Granger, C.W.J., (1987), "Co-Integration and Error Correction: Representation, Estimation, and Testing", *Econometrica,* Vol. 55, No. 2, pp. 251-276.

Engle, R. F., Ito, T. and Lin, W. (1990), “Meteor Showers or Heat Waves ? Heteroskedastic Intra-Daily Volatility In The Foreign Exchange Market”, *Econometrica,* Vol. 58, No. 3, pp. 525-542.

Fama, E. F. (1970), “Efficient Capital Markets: A Review of Theory and Empirical Work”, *The Journal of Finance,* Vol. 25, No. 2, pp. 383-417.

Forbes, K. J. and Rigobon, R. (2002), “No Contagion, Only Interdependence: Measuring Stock Market Co-Movements”, *Journal of Finance,* Vol. 57, No.5, pp. 2223-2261.

Gallo, G. M. and Otranto, E. (2008), “Volatility Spillovers, Interdependence and Comovements: A Markov Switching Approach”, *Computational Statistics and Data Analysis,* Vol. 52, No. 6, pp. 3011-3026.

Garbade, K. D. and Silber, W. L. (1983), “Price Movements and Price Discovery in Futures and Cash Markets”, *The Review of Economics and Statistics,* Vol. 65, No. 2, 289-297.

Goyenko,Y. & Ukhov, A. (2009), “ Stock and Bond Market Liquidity: A Long-Run Empirical Analysis”, *The Journal of Financial and Quantitative Analysis,* Vol. 44, No. 1, pp.189-212.

Granger, C.W.J. (1981), “Some Properties of Time Series Data and their Use in Econometric Model Specification”, *Journal of Econometrics,* Vol. 16, No.1, pp. 121-130.

Gupta R., and Guidi F. (2012), “Cointegration relationship and time varying co-movements among Indian and Asian developed stock markets”, *International Review of Financial Analysis*, Vol. 21, pp. 10-22.

Hamao, Y., Masulis, R. W. and Ng, V. (1990), “Correlations in Price Changes and Volatility across International Stock Markets” *The Review of Financial Studies,* Vol.3, No.2, pp. 281-307

Hammoudeh, S., Li, H. and Jeon, B.(2003), “Causality and volatility spillovers among petroleum prices of WTI, gasoline and heating oil in different locations”, *North American Journal of Economics and Finance,* Vol. 14, No. 1, pp. 89-114.

Harry G. Johnson 1976), “Destabilizing Speculation: A General Equilibrium Approach”, *Journal of Political Economy,* Vol. 84, No. 1,pp. 101-108.

Huand B., Yang, C. J., and Hu, W.S. (2000), “Causality and cointegration of stick markets among the United States, Japan and the South China Growth Triangle”. *International Review of Financial Analysis*, Vol. 9, No.3, pp. 281-297.

Huang, R. (1984), “Some Alternative Tests of Forward Exchange Rates As Predictors of Future Spot Rate” *Journal of International Money and Finance.* Vol. 3, No. 2, pp. 153–167.

Miao, H. and Ying, K. (2009), “The causality of hourly price-volume relationship: An empirical study of mini Taiwan exchange futures”, *Expert Systems with Applications* Vol. 36, No. 3, pp. 4896-4899.

Funga, H. and Patterson, G. (1999), “The dynamic relationship of volatility, volume and market depth in currency futures markets”, *The Journal of International Financial Markets, Institute and Money,* Vol. 9, No. 1, pp. 33-59.

Yang, J. and Awokuse, T. (2003), “Asset Storability and Hedging Effectiveness in Commodity Futures Markets”, *Applied Econometric letters,* Vol. 10, No. 8, pp. 487-491.

Johansen, (1998), “Statistical Analysis of CointegratingVectors”, *Journal of Economic Dynamics and Control,* Vol. 12, No. 2-3, pp. 231-254.

Johansen, S. and Juselius, K.(1990), “Maximum Likelihood Estimation and Inference on Cointegration – With Applications to the Demand For Money” *Oxford Bulletin Of Economics And Statistics,* Vol. 52, No. 2, pp. 169-210.

Kasman, A. and Kasman, S. (2008), “The impact of futures trading on volatility of the underlying asset in the Turkish stock market”, *Physica A: Statistical mechanics and its application,* Vol. 386, No. 12, pp. 2837-2845.

Kavli, H. and Kotzé, K. (2014), “Spillovers in Exchange Rates and The Effects Of Global Shocks On Emerging Market Currencies”, *South African Journal of Economics,* Vol. 82, No. 2, pp. 209-238.

Kohlhagen, S. (1977), “The Identification of Destabilizing Foreign Exchange Speculation”, *Journal of International Economics*, Vol.9, No. 3, pp. 321-340.

Kumar, B. and Pandey, A. (2011), “International Linkages of the Indian Commodity Futures Markets”, available at: http://file.scirp.org/pdf/ME20110300018_29008742.pdf

Kyle, A. S. (1985), “Continuous Auctions and Insider Trading”, *Econometrica*, Vol. 53, No. 6, pp. 1315-1335.

Lombardi, M. J. and Robays, I.V. (2011), " Do Financial Investors Destabilize The Oil Price?", Working Paper Series No 1346, Europe Central Bank, Germany, June 2011.

Maggio, M. D. (2014), "Market Turmoil and Destabilizing Speculation", Columbia Business School Research Paper No. 13-80, available at: http://ssrn.com/abstract=2353133

Mahalik, M. K., Acharya, D. and Babu, M. S.(2014), "Price Discovery And Volatility Spillovers in Futures and Spot Commodity Markets: Some Empirical Evidence From India", *Journal of Advances in management research,*Vol. 11, No. 2, pp. 211-226.

Malkie, B. G. (2003), "The Efficient Market Hypothesis and Its Critics", *The Journal of Economic Perspectives,* Vol. 17, No. 1, pp. 59-82.

Mallikarjunappa, T. and Afsal, E.M., (2008), "Effect of Futures Trading on Spot Market Volatility: A study of CNX Bank Nifty Index", *Decision,* Vol. 35, No.1, pp. 31-45.

Marshall, B. R., Nguyen, N. H. and Visaltanachoti, N. (2011), "Liquidity commonality in commodities", *Journal of Banking and Finance,* Vol. 37, No. 1, pp. 11-20.

Matar, W., et. al., (2012), "An introduction to oil market volatility analysis", *USAEE Working Paper No. 12-152,* available at :http://ssrn.com/abstract=2194214

Mukherjee, K. and Mishra, R. K. (2008), "Stock Market Integration and Volatility Spillover: India and its Major Asian Counterparts", *Research in International Business and Finance,* Vol. 24, No. 2, pp. 235-251.

Murray, M. P. (1994), "A Drunk and Her Dog: An Illustration of Cointegration and Error Correction", *The American Statistician,* Vol. 48, No. 1, pp. 37-39.

Nath, G. C & Lingareddy, T. (2008), "Commodity derivatives contributing for rise or fall in risk", available at: *http://www.igidr.ac.in/money/mfc_10/Golaka%20C%20Nath_submission_57.pdf*

Nazliglu, S. & Soytas, U. (2012), "Oil price, agricultural commodity prices, and the dollar: A panel cointegration and causality analysis", *Energy Economics*, Vol. 34, No. 4, pp. 1098-1104.

Netz, J. (2005), "The Effect of Futures Markets and Corners on Storage and Spot Price Variability", *American Journal of Agricultural Economics,* Vol. 77, No. 1, pp. 182-193.

Quan J. (1992), "Two-step Testing Procedure for Price Discovery Role of Futures Prices", *The Journal of Futures Markets,* Vol. 12, No. 2, pp. 139-149.

Righi, M. B. and Vieira, K. M. (2014), “Liquidity Spillover in International Stock Markets through Distinct Time Scales”, *Plos one,* available at: http://dx.doi.org/10.1371/journal.pone.0086134.

Roll R., Schwartz E., and Subrahmanyam, A.(2007), “Liquidity and the Law of One Price: The Case of the Futures-Cash Basis”, *The Journal of Finance,* Vol. 62, No. 5, pp. 2201-2234.

Ross, S. (1989), “Information and Volatility: The No-Arbitrage Martingale Approach to Timing and Resolution Irrelevancy”, *The Journal of Finance,* Vol. 44, No. 1, pp. 1-17.

Roy, A. (2008), “Dynamics of spot and future markets in Indian Wheat Market: Issues and Implications”, available at *SSRN: http://ssrn.com/abstract=1178762*

Schreiber, P. S. and Schwartz, R.A. (1986), “Price discovery in securities markets”, *The Journal of Portfolio Management,* Vol. 12, No. 4, pp. 43-48.

Schwarz, T. and Szakmary, A. (1994), “Priced Discovery in Petroleum Markets: Arbitrage, Cointegration, and The Time Interval of Analysis”, *The Journal of Futures Markets,* Vol. 14, No. 2, pp. 147-167 .

Sehgal, S., Ahmad, W. and Deisting, F., “An investigation of price discovery and volatility spillovers in India’s currency futures market”, Forthcoming in Journal of Economic Studies.

Sieczka, P. and Hołyst, J. A. (2009), “Correlations in commodity markets”, *Physica A,* Vol. 388, No. 8, pp. 1621-1630.

Silvapulle, P. and Moosa, I. A. (1999), “The Relationship between Spot and Futures Prices: Evidence from the Crude Oil Market”, *The Journal of Futures Markets*, Vol. 19, No. 2, pp. 175-193.

Slade, M. E. and Thille, H. (2006), “Commodity Spot Prices: An Exploratory Assessment of Merket Structure and Forward Trading Effects”, *Economica,* Vol. 73, No. 290 , pp. 229-256.

Urbain, J. (2005), “On Weak Exogeneity in Error Correction Models”. *Journal of Business Finance & Accounting,* Vol. 32, No. 1, pp. 297-323.

Worthington, A. C. and Higgs, H. (2010), “Assessing financial Integration in the European Union Equity Markets: Panel Unit Root and Multivariate Cointegration and Causality Evidence”, *The Journal of Economics Integration*, Vol. 25, No. 3, pp. 457-479.

Worthington, A., Spartley, A. K. and Higgs, H. (2005), "Transmission of prices and price volatility in Australian electricity spot markets: A multivariate GARCH analysis", *Energy Economics,* Vol. 27, No. 2, pp. 337-350.

Yang, J. and Leatham, D. J. (1999), "Price Discovery in Wheat Futures Markets*". Journal of Agricultural and Applied Economics,* Vol. 31, No. 2, 2359–2370 .

Yang, J. and Awokuse T. O. (2002), "Asset Storability and Hedging Effectiveness in Commodity Futures Markets", *Staff Papers from University of Delaware, Department of Food and Resource Economics, No 15826,* available at: *http://www1.udel.edu/FREC/PUBS/SP02-03.pdf*

Yang, J., Balyeat, R. B. and Leatham, D. J.(2005), "Futures Trading Activity and Commodity Cash Price Volatility", *The Journal of Business Finance & Accounting,* Vol. 32, No. 1-2, pp. 297-323.

Zapata, H., Fortenbery, T. R. and Armstrong, D. (2005), "Price Discovery in the World Sugar Futures and Cash Markets: Implications for the Dominican Republic", *Agricultural & Applied Economics, Staff Paper Series, No. 469,* available at: http://purl.umn.edu/12657.

Zhao, J. and Goodwin, B. K. (2011), "Volatility Spillovers in Agricultural Commodity Markets: An Application Involving Implied Volatilities from Options Markets", paper presented at Agricultural & Applied Economics Association's 2011 AAEA & NAREA Joint Annual Meeting, 2011, Pittsburgh, Pennsylvania, available at: http://ageconsearch.umn.edu/bitstream/103636/2/AAEA%20Paper%202011,%20Zhao%20J_2.pdf

Tables

Table 2.1: Data Source

Commodities	**Spot market**	**Future market**
Channa	Channa in Delhi	NCDEX Channa futures
Gaur Seed	Gaurseed 2 MT in Jodhpur	NCDEX Gaurseed 2 MT futures
Kapas	Kapas in Surendra Nagar	NCDEX Kapas futures
Soybean	Soybean in Indore	NCDEX Soybean futures
Pepper	Pepper in Kochi	NCDEX Pepper futures
Potato	Potato in Agra	NCDEX Potato futures
Refined Soya Oil	Refined Soya Oil in Indore	NCDEX Refined Soya Oil futures
Wheat	Wheat in Delhi	NCDEX Wheat futures

Table 2.2: Descriptive Statistics

Return series	**Mean**	**Std. dev.**	**Skewness**	**Kurtosis**
Channa futures returns	0.000262	0.015324	-1.27592	16.20248
Channa spot returns	0.00025	0.013517	-0.04511	5.811579
Gaur seed future returns	0.000616	0.029257	-16.1136	533.7049
Gaur seed spot returns	0.001395	0.019552	-0.52882	13.29458
Kapas future returns	0.001871	0.029975	-1.65581	65.79809
Kapas spot returns	0.000978	0.032324	13.86836	290.1442
Soybean future returns	0.000328	0.014645	-0.93351	19.98
Soybean spot returns	0.000316	0.012692	-4.15578	66.08046
Pepper future returns	0.000567	0.016727	-0.03731	4.928924
Pepper spot returns	0.000668	0.010221	0.185033	7.962562
Potato future returns	0.000343	0.044453	0.619753	161.9819
Potato spot returns	0.000152	0.042651	5.701955	306.5665
Refined soya oil future returns	0.000155	0.011521	-4.01153	126.7824

Refined soya oil spot returns	0.000141	0.008036	0.100544	12.0076
Wheat future returns	0.000414	0.010958	-1.50971	21.90146
Wheat spot returns	0.000338	0.010776	-1.22503	17.67057

Table 3.1: ADF Test Results for Spot and Future Series in Level Form and First Form Difference

	Level form		First form difference	
	t-statistic	**p-value**	**t-statistic**	**p-value**
Channa future	-1.70431	0.429	-49.6214	0.0001
Channa spot	-1.64281	0.4604	-48.3915	0.0001
Gaur seed future	-3.51434	0.0077	-20.5365	0
Gaur seed spot	7.024081	1	-43.4227	0
Kapas future	-1.19854	0.6764	-20.0453	0
Kapas spot	-1.45183	0.5575	-22.4825	0
Soybean future	-0.32505	0.9188	-51.0733	0.0001
Soybean spot	-0.691	0.8471	-42.8653	0
Pepper future	-0.18105	0.9384	-48.9609	0.0001
Pepper spot	1.353456	0.9989	-18.7443	0
Potato future	-1.65223	0.4553	-28.3314	0
Potato spot	-2.39317	0.1438	-35.6705	0
Refined soya oil future	-1.00593	0.7532	-50.974	0.0001
Refined soya oil spot	-1.0275	0.7455	-39.5026	0
Wheat future	-1.03258	0.7435	-39.5627	0
Wheat spot	-1.81971	0.3711	-14.2009	0

Null Hypothesis: Variable has a unit root

Table 3.2: Johansen Cointegration Test

Panel A: Cointegration Rank (Trace) Test;with 1st hypothesis H_0: No. of Cointegrating equations = 0 against H_1: No. of Cointegrating equations is more than 0 and 2nd hypothesis H_0: No. of Cointegrating equations at most 1 against H_1: No. of Cointegrating equations is more than 1

Commodity	Hypothesized no. of CE(s)	λ_{trace}	Critical value (5%)	Prob. value	Decision

Channa	None	38.29290	15.49471	0	Indicates one cointegrating equation
	At most one	3.285213	3.841466	0.0699	
Gaur seed	None	114.6385	15.49471	0	Indicates two cointegrating equations
	At most one	19.50304	3.841466	0	
Kapas	None	7.249884	15.49471	0.5488	Indicates no cointegrating equation
	At most one	1.08837	3.841466	0.2968	
Soybean	None	88.24936	15.49471	0.0000	Indicates one cointegrating equation
	At most one	0.523649	3.841466	0.4693	
Pepper	None	59.24405	15.49471	0.0000	Indicates one cointegrating equation
	At most one	0.143257	3.841466	0.7051	
Potato	None	24.72956	15.49471	0.0015	Indicates two cointegrating equations
	At most one	5.060907	3.841466	0.0245	
Refined soya oil	None	54.02861	15.49471	0	Indicates one cointegrating equation
	At most one	1.093681	3.841466	0.2957	
Wheat	None	35.95096	15.49471	0	Indicates one cointegrating equation
	At most one	2.682034	3.841466	0.1015	

Panel B: Cointegration Rank (Maximum Eigenvalue) Test; with 1st hypothesis H_0: No. of Cointegrating equations =0 against H_1:No. of Cointegrating equations =1 and 2nd hypothesis H_0: No. of Cointegrating equations at most 1 against H_1:No. of Cointegrating equations =2

Commodity	Hypothesis	λ_{max}	Critical value (5%)	Prob. value	Decision
Channa	None	35.00768	14.2646	0.0001	Indicates one cointegrating equation
	At most one	3.285213	3.841466	0.0699	
Gaur seed	None	95.13547	14.2646	0	Indicates two cointegrating equations
	At most one	19.50304	3.841466	0	
Kapas	None	9.419570	14.2646	0.3280	Indicates no cointegrating equation
	At most one	1.481991	3.841466	0.2235	
Soybean	None	87.72571	14.2646	0.0000	Indicates one cointegrating equation
	At most one	0.523649	3.841466	0.4693	
Pepper	None	59.10079	14.2646	0	Indicates one cointegrating equation
	At most one	0.143257	3.841466	0.7051	
Potato	None	19.66866	14.2646	0.0063	Indicates two cointegrating equations
	At most one	5.060907	3.841466	0.0245	
Refined soya oil	None	52.93492	14.2646	0	Indicates one cointegrating equation
	At most one	1.093681	3.841466	0.2957	
Wheat	None	33.26892	14.2646	0	Indicates one cointegrating equation
	At most one	2.682034	3.841466	0.1015	

Table 3.3: Vector Error Correction Model

Panel A: Vector Error Correction Estimate Results for Channa

Error Correction	**D(SP)**	**D(FP)**
CointEq1	-0.02576	0.006894
	[-3.73221]*	[0.82416]
D(SP(-1))	-0.23185	-0.0381
	[-8.17913]*	[-1.10885]
D(SP(-2))	0.053462	0.050063
	[2.01838]**	[1.55929]
D(FP(-1))	0.364612	0.053622
	[15.3227]*	[1.85906]
D(FP(-2))	-0.0078	-0.01856
	[-0.31440]	[-0.61687]
C	0.000249	0.000274
	[0.89929]	[0.81672]

(at 1% and 5% level of significance critical value for two tailed t-distribution is ±2.576 and ±1.96)

Panel B: Vector Error Correction Estimate Results for Gaur Seed

Error Correction	D(SP)	D(FP)
CointEq1	0.008241	-0.139028
	[0.34468]	[-9.82088]*
D(FP(-1))	-0.008472	-0.352107
	[-0.22158]	[-15.5536]*
D(FP(-2))	0.009870	-0.159897
	[0.26178]	[-7.16225]*
D(FP(-3))	0.033267	-0.050882
	[1.31788]	[-3.40428]*
D(FP(-4))	0.012051	0.031251
	[0.54246]	[2.37572]**
D(FP(-5))	0.031227	0.029757
	[1.40543]	[2.26178]**
D(FP(-6))	-0.000265	0.003366
	[-0.01191]	[0.25570]
D(FP(-7))	0.022929	-0.006636
	[1.03134]	[-0.50411]
D(FP(-8))	0.019370	0.027542
	[0.87294]	[2.09620]**
D(SP(-1))	0.105982	-0.139957
	[3.32545]*	[-7.41660]*
D(SP(-2))	-0.049349	-0.138665
	[-1.54619]	[-7.33736]*
D(SP(-3))	0.018862	-0.102028
	[0.58811]	[-5.37271]*
D(SP(-4))	0.027482	-0.121475

	[0.86056]	[-6.42399]*
D(SP(-5))	0.059151	0.215559
	[1.83916]	[11.3193]*
D(SP(-6))	-0.004361	0.688348
	[-0.13457]	[35.8740]*
D(SP(-7))	-0.017377	0.285119
	[-0.44379]	[12.2976]*
D(SP(-8))	0.057346	0.169883
	[1.56644]	[7.83701]*
C	0.001039	0.000824
	[2.18999]**	[2.93570]*

(at 1% and 5% level of significance critical value for two tailed t-distribution is ±2.576 and ±1.96)

Panel C: Vector Error Correction Estimate Results for Pepper

Error Correction	D(SP)	D(FP)
CointEq1	0.025343	-0.039974
	[3.72549]*	[-2.89912]*
D(SP(-1))	-0.254834	0.016398
	[-10.0836]*	[0.32013]
D(SP(-2))	-0.010496	0.112320
	[-0.40477]	[2.13706]**
D(SP(-3))	0.013218	0.084512
	[0.51375]	[1.62059]
D(SP(-4))	0.050716	0.023716
	[1.99727]**	[0.46078]
D(SP(-5))	0.077634	0.038505
	[3.14522]*	[0.76963]
D(SP(-6))	0.009572	0.007972
	[0.50397]	[0.20707]
D(FP(-1))	0.402845	0.063514
	[29.9993]*	[2.33352]**
D(FP(-2))	0.096192	-0.037273
	[5.82130]*	[-1.11289]
D(FP(-3))	0.042295	-0.075374
	[2.54943]**	[-2.24154]**
D(FP(-4))	0.027802	0.042897
	[1.68981]	[1.28636]
D(FP(-5))	-0.019097	-0.030805
	[-1.19088]	[-0.94773]
D(FP(-6))	0.007742	0.052216
	[0.53099]	[1.76683]
C	0.000343	0.000398
	[2.06656]**	[1.18177]

(at 1% and 5% level of significance critical value for two tailed t-distribution is +2.576 and +1.96)

Panel D: Vector Error Correction Estimate Results for Potato

Error Correction	**D(SP)**	**D(FP)**
CointEq1	0.040364	0.017849
	[2.81466]*	[0.90245]
D(SP(-1))	0.084845	0.081103
	[1.02625]	[0.71129]
D(FP(-1))	-0.042295	-0.019189
	[-0.69815]	[-0.22966]
C	0.000304	0.000291
	[0.19224]	[0.13369]

(at 1% and 5% level of significance critical value for two tailed t-distribution is +2.576 and +1.96)

Panel E: Vector Error Correction Estimate Results for Refined Soy Oil

Error Correction	**D(SP)**	**D(FP)**
CointEq1	-0.03485	0.001959
	[-4.35115]*	[-0.18531]
D(SP(-1))	-0.10488	0.096739
	[-3.36023]*	[2.34839]**
D(SP(-2))	-0.02825	-0.01788
	[-0.99036]	[-0.47488]
D(FP(-1))	0.276839	-0.019
	[11.4222]*	[-0.59401]
D(FP(-2))	0.047626	-0.00422
	[1.96005]**	[-0.13147]
C	0.000134	0.000158
	[0.78009]	[0.69525]

(at 1% and 5% level of significance critical value for two tailed t-distribution is ±2.576 and ±1.96)

Panel F: Vector Error Correction Estimate Results for Soybean

Error Correction	**D(SP)**	**D(FP)**
CointEq1	-0.06216	-0.01041
	[-8.64126]*	[-1.23435]
D(SP(-1))	0.004921	0.12246
	[0.21572]	[4.57812]*
D(SP(-2))	0.001539	0.0495
	[0.07188]	[1.97221]**
D(FP(-1))	0.234835	-0.04419
	[11.4870]*	[-1.84349]
D(FP(-2))	0.020009	-0.02898
	[0.96650]	[-1.19363]
C	0.000272	0.00031
	[1.08349]	[1.05056]

(at 1% and 5% level of significance critical value for two tailed t-distribution is $\pm$2.576 and $\pm$1.96)

Panel G: Vector Error Correction Estimate Results for Wheat

Error Correction	**D(SP)**	**D(FP)**
CointEq1	-0.02727	-0.00419
	[-5.66976]*	[-0.71852]
D(SP(-1))	0.1408	0.064326
	[5.47300]*	[2.06166]**
D(SP(-2))	-0.02214	-0.02422
	[-0.88123]	[-0.79462]
D(FP(-1))	0.133414	0.050438
	[6.10339]*	[1.90257]
D(FP(-2))	0.069313	0.005762
	[3.13835]*	[0.21510]
C	0.000306	0.000306
	[1.36165]	[1.30984]

(at 1% and 5% level of significance critical value for two tailed t-distribution is ±2.576 and ±1.96)

Table 3.4: VEC Granger Causality/Block Exogeneity Wald Tests

The first row shows if lagged variables of future price change are significantly different than 0, the second row shows if lagged variables of all variables other than spot price change are zero (in this study both tests are identical as there are only two variables).

Panel A: Dependent variable is D (SP)

Commodity	**Exogenous**	**Chi-square**	**Degree of freedom**	**Prob.**	**Significance**
Channa	D(FP)	254.9217	2	0	*
	All	254.9217	2	0	*
Gaur seed	D(FP)	5.585665	2	0.0612	
	All	5.585665	2	0.0612	
Pepper	D(FP)	898.6343	2	0	*
	All	898.6343	2	0	*
Potato	D(FP)	0.559843	2	0.7558	
	All	0.559843	2	0.7558	
Refined soy oil	D(FP)	133.36	2	0	*
	All	133.36	2	0	*
Soybean	D(FP)	134.9092	2	0	*
	All	134.9092	2	0	*
Wheat	D(FP)	45.93876	2	0	*
	All	45.93876	2	0	*

(Significance Level At 1% and ** Significance level at 5%)*

Panel B: Dependent variable is D(FP)

The first row shows if lagged variables of spot price change are significantly different than 0, the second row shows if lagged variables of all variables other than future price change are zero (in this study both tests are identical as there are only two variables).

Commodity	Exogenous	Chi-square	Degree of freedom	Prob.	Significance
Channa	D(SP)	4.722621	2	0.0943	
	All	4.722621	2	0.0943	
Gaur seed	D(SP)	157.0616	2	0	*
	All	157.0616	2	0	*
Pepper	D(SP)	2.346851	2	0.3093	
	All	2.346851	2	0.3093	
Potato	D(SP)	2.796012	2	0.2471	
	All	2.796012	2	0.2471	
Refined soy oil	D(SP)	6.208874	2	0.0448	**
	All	6.208874	2	0.0448	**
Soybean	D(SP)	23.89432	2	0	*
	All	23.89432	2	0	*
Wheat	D(SP)	4.510971	2	0.1048	
	All	4.510971	2	0.1048	

(Significance Level At 1% and ** Significance level at 5%)*

Table 4.1: EGARCH (p,q) modeled for mean equation; $\Delta y_{spot,t} = \alpha_{1i} + \beta_{1i}\Delta y_{spot,t-1}$ + e_{ti} and $\Delta y_{futures,t} = \alpha_{2j} + \beta_{2j}\Delta y_{futures,t-1}$+ $e_{tj}$of spot and future return series

Commodity	**EGARCH (future return series)**	**EGARCH (spot return series)**
Channa	EGARCH(1,4)	EGARCH(2,3)
Guar Seed	EGARCH(4,4)	EGARCH(1,1)
Kapas	EGARCH(2,4)	EGARCH(1,0)
Soybean	EGARCH(4,4)	EGARCH(3,3)
Pepper	EGARCH(1,1)	EGARCH(1,1)
Refined soya oil	EGARCH(1,4)	EGARCH(1,1)
Wheat	EGARCH(3,3)	EGARCH(3,3)
Potato	EGARCH(0,4)	EGARCH(4,4)

Table 4.2

Panel A: Granger Causality Test; H_0: Spot volatility does not granger cause future volatility, against H_a: spot volatility granger causes future volatility

Agricultural commodity	Lag	f-statistic	Prob. value	Significance
Channa	8	5.0079	4.E-06	*
Gaur seed	5	60.6383	3.E-59	*
Kapas	4	4.43777	0.0018	*
Soybean	6	0.90748	0.4883	
Pepper	2	17.4303	3.00E-08	*
Potato	5	2.94072	0.0123	**
Refined soya oil	8	46.8489	6.E-71	*
Wheat	6	3.87246	0.0008	*

**Significance Level At 1% and ** Significance level at 5%*

Panel B: Granger Causality Test; H_0: future volatility does not granger cause Spot volatility, against H_a: future volatility granger causes spot volatility

Agricultural commodity	Lag	f-statistic	Prob. value	Significance
Channa	8	5.52809	6.E-07	*
Gaur seed	5	1.50028	0.1864	
Kapas	4	6.31489	7.E-05	*
Soybean	6	3.86711	0.0008	*
Pepper	2	121.872	3.00E-51	*
Potato	5	3.17096	0.0077	*
Refined soya oil	8	7.74765	3.E-10	*
Wheat	6	4.04133	0.0005	*

**Significance Level at 1% and **Significance level at 5%*

Panel C: Parameter estimate γ_{2j} for Granger causality test; Direction: FV ⟶ SV

Parameter estimate									
	FV(t-1)	**FV(t-2)**	**FV(t-3)**	**FV(t-4)**	**FV(t-5)**	**FV(t-6)**	**FV(t-7)**	**FV(t-8)**	**R^2**
Channa	0.1581	-0.2165	0.1384	-0.0264	-0.0223	0.0134	-0.0389	-0.0201	0.7773
	(0.000)*	(0.000)*	(0.0020)*	(0.5509)	(0.6137)	(0.7647)	(0.3595)	(0.4362)	
Gaur seed	-0.0066	0.0163	-0.0062	0.0053	-0.0119				0.9660
	(0.3930)	(0.0346)**	(0.3590)	(0.4912)	(0.1211)				
Kapas	0.1011	0.0571	0.0091	-0.1174					0.1248
	(0.0005)*	(0.0222)**	0.7158	(0.0001)*					
Soybean	-0.4022	0.9479	-0.2610	0.0095	-0.0608	0.0927			0.1037
	(0.2077)	(0.0037)*	(0.5190)	(0.9811)	(0.8525)	(0.7704)			
Pepper	0.3236	-0.3017							0.8939
	(0.0000)*	(0.0000)*							
Potato	-3.6604	54.1937	-29.6772	13.5668	-6.8135				0.0442
	(0.8013)	(0.0004)*	(0.0661)	(0.3816)	(0.6398)				
Refined soya oil	0.0220	0.0166	0.0238	-0.0144	0.0160	-0.0331	-0.0138	-0.0049	0.9100
	0.0011)*	(0.0222)**	(0.0010)*	(0.0242)**	(0.0112)**	(0.0000)*	(0.0548)	(0.4564)	
Wheat	0.1991	0.1932	0.0944	-0.1419	-0.1239	1.37E-05			0.5803
	(0.0142)**	(0.0169)**	(0.2499)	(0.0832)	(0.1253)	(0.9999)			

**Significance Level at 1% and ** Significance level at 5%*

Panel D: Parameter estimateγ_{1j} for Granger causality test; Direction: SV ⟶ FV

Parameter estimate									
	SV(t-1)	**SV(t-2)**	**SV(t-3)**	**SV(t-4)**	**SV(t-5)**	**SV(t-6)**	**SV(t-7)**	**SV(t-8)**	R^2
Channa	0.0263	0.0314	0.0070	0.0061	0.0024	0.0139	-0.0189	-0.0078	0.9163
	(0.1145)	(0.1346)	(0.7409)	(0.7781)	(0.9118)	(0.5139)	(0.3669)	(0.6414)	
Gaur seed	0.9415	-0.4985	-0.2959	-0.2603	0.2744				0.6112
	(0.0000)*	(0.0000)*	(0.0043)*	(0.0122)**	(0.0001)*				
Kapas	-0.5561	-0.0377	0.1177	-0.0572					0.6868
	(0.0001)	(0.7782)	(0.3800)	(0.6629)					
Soybean	0.0002	-0.0007	0.0002	-2.34E-05	0.0019	0.0013			0.9144
	(0.8497)	(0.5440)	(0.8467)	(0.9847)	(0.1109)	(0.2576)			
Pepper	0.0592	-0.0081							0.9663
	(0.0020)*	(0.6738)							
Potato	-1.48E-05	0.0002	-0.0001	-1.34-05	2.44E-05				0.5451
	(0.8639)	(0.0008)*	(0.0543)	(0.8468)	(0.7186)				
Refined soya oil	0.8797	-0.3082	-0.5754	0.2735	-0.1902	0.1039	-0.2052	0.177925	0.8862
	(0.0000)*	(0.0001)*	(0.0000)*	(0.0007)*	(0.0184)**	(0.1976)	(0.0106)**	(0.0014)*	
Wheat	0.0100	0.0244	-0.0208	-0.0163	0.0008	0.0169			0.7551
	(0.1830)	(0.0031)*	(0.0106)**	(0.0453)**	(0.9138)	(0.0256)**			

**Significance Level At 1% and ** Significance level at 5%*

Table 4.3

Panel A: Granger Causality Test; H_0: Spot (unexpected) trading volume does not granger cause future (unexpected) trading volume, against H_a: Spot (unexpected) trading volume does granger cause future (unexpected) trading volume

Agricultural commodity	Lag	f-statistic	Prob. value	Significance
Channa	8	25.2821	7.E-38	*
Gaurseed	7	38.1241	9.E-51	*
Kapas	1	1.50906	0.2202	
Soybean	8	8.28175	4.E-11	*
Pepper	7	14.2488	3.E-18	*
Potato	2	3.68897	0.0254	**
Refined soya oil	8	17.4802	1.E-25	*
Wheat	2	2.01601	0.1335	

**Significance Level at 1% and ** Significance level at 5%*

Panel B: Granger Causality Test; H_0: Futures (unexpected) trading volume does not granger cause spot(unexpected) trading volume, against H_a: Futures (unexpected) trading volume does granger cause spot (unexpected) trading volume

Agricultural commodity	Lag	f-statistic	Prob. value	Significance
Channa	8	1.05982	0.3885	
Gaur seed	7	1.78623	0.0858	
Kapas	1	13.2794	0.0003	*
Soybean	8	2.36884	0.0154	**
Pepper	7	1.02426	0.4117	
Potato	2	5.09384	0.0063	*
Refined soya oil	8	2.60125	0.0078	*
Wheat	2	3.81762	0.0222	**

**Significance Level at 1% and ** Significance level at 5%*

Panel C: Parameter estimate γ_j for Granger causality test; Direction: FUTV ⟶ SUTV

Parameter estimate									
	FV(t-1)	**FV(t-2)**	**FV(t-3)**	**FV(t-4)**	**FV(t-5)**	**FV(t-6)**	**FV(t-7)**	**FV(t-8)**	**R^2**

Channa	-0 0019	0.0199	-0.0334	0.0451	-0.0819	0.0430	-0.0384	-0.0125	0.3026
	(0.9636)	(0.7160)	(0.5411)	(0.4099)	(0.1348)	(0.4321)	(0.4823)	(0.7663)	
Gaur seed	0.0118	0.0401	-0.0269	0.0167	0.0052	-0.0771	0.0903		0.2921
	(0.7072)	(0.3308)	(0.5138)	(0.6837)	(0.8993)	(0.0612)	(0.0040)*		
Kapas	-0.0360								0.2579
	(0.2327)								
Soybean	0.0435	-0.0048	-0.0047	-0.1198	0.1013	0.0597	-0.1511	0.0713	0.2839
	(0.2836)	(0.9183)	(0.9217)	(0.0122)**	(0.0344)**	(0.2123)	(0.0015)*	(0.0792)	
Pepper	-0.0342	-0.0447	0.0586	0.0371	-0.0159	0.0348	-0.0663		0.2769
	(0.3680)	(0.3448)	(0.2174)	(0.4339)	(0.7364)	(0.4607)	(0.0802)		
Potato	-0.1204	-0.0153							0.3518
	(0.0237)**	(0.7735)							
Refined soya oil	0.0525	0.0480	-0.0751	-0.1037	0.0032	0.1527	-0.1323	0.0239	0.2286
	(0.2462)	(0.3574)	(0.1567)	(0.0504)	(0.9513)	(0.0039)*	(0.0110)**	(0.5951)	
Wheat	-0.0200	-0.0596							0.3668
	(0.5900)	(0.1100)							

**Significance Level at 1% and ** Significance level at 5%*

Panel D: Parameter estimate γ_j for Granger causality test; Direction: SUTV ⟶ FUTV

Parameter estimate									
	SV(t-1)	**SV(t-2)**	**SV(t-3)**	**SV(t-4)**	**SV(t-5)**	**SV(t-6)**	**SV(t-7)**	**SV(t-8)**	**R^2**
Channa	-0.4347	0.0643	0.0717	0.0195	0.0889	0.1905	-0.0787	0.1012	0.4444
	(0.0000)*	(0.2954)	(0.2433)	(0.7506)	(0.1480)	(0.0019)*	(0.2001)	(0.0295)**	
Gaur seed	-0.5394	0.0383	0.0853	0.0845	0.0876	0.2389	-0.0422		0.5282
	(0.0000)*	(0.5043)	(0.1368)	(0.1422)	(0.1291)	(0.0000)*	(0.3698)		
Kapas	-0.7807								0.0385
	(0.0201)**								
Soybean	-0.2761	-0.0034	0.0504	0.1039	-0.0903	0.1403	-0.0087	0.0554	0.3583
	(0.0000)*	(0.9472)	(0.3347)	(0.0470)**	(0.0846)	(0.0075)*	(0.8666)	(0.2222)	
Pepper	-0.2536	-0.0275	-0.0029	0.0011	0.0518	0.1978	0.0106		0.4453
	(0.0000)*	(0.6216)	(0.9587)	(0.9843)	(0.3557)	(0.0004)*	(0.8175)		
Potato	0.1649	-0.1661							0.3300
	(0.0141)**	(0.0132)**							
Refined soya oil	-0.2957	-0.1700	0.0922	0.1350	0.0951	0.0724	0.1154	0.0236	0.3566
	(0.0236)**	(0.0026)*	(0.1073)	(0.0182)**	(0.0964)	(0.2049)	(0.0402)**	(0.6349)	
Wheat	-0.0648	0.0883							0.4016
	(0.1439)	(0.0459)**							

**Significance Level at 1% and ** Significance level at 5%*