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LINKAGES AMONGST INDIAN AGRICULTURAL COMMODITY FUTURES CONTRACTS

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ABSTRACT

This study examines the interdependence of futures prices of various crops traded on the national commodity exchanges. A finding of significant linkages between the agricultural commodities, would imply the existence of cross speculation and cross hedging opportunities, and would justify the introduction of futures contracts for new crops. Employing daily price data for nine crops for the period 2009-2014, we find that (some) agricultural commodity futures prices have a long term (cointegrating) relationship, but apparently no short term causal relationship. Our results have significant policy implications for stock brokers, traders, mill owners and speculators. The futures prices of agricultural commodities are interdependent. Therefore, the stock brokers, and speculators should rely on the co- movement of agricultural commodity prices.

KEYWORDS: *Futures markets, spot markets, agricultural commodities*

JEL Classification: *Q02, Q18 and G13*

1. INTRODUCTION

Price determination in any market follows two approaches: partial equilibrium approach and general equilibrium approach. In the partial equilibrium approach we determine the price of a specific good or service by emphasising on demand and supply, keeping other factors constant, while in general equilibrium approach we consider the interdependence of all prices. This study examines the interdependence of futures prices of various crops traded on the national commodity exchanges. A finding of significant linkages between the agricultural commodities, would imply the existence of cross speculation and cross hedging opportunities, and would justify the introduction of futures contracts for new crops. A finding of significant linkages between the agricultural commodities, would also imply that the price discovery[1] in the futures market of one commodity will provide valuable information to other commodity markets.

The hypothesis[2] of the study is that the movement of agricultural commodity prices are independent. There are several reasons to expect an interdependence between crop futures prices. One important reason may be substitutability and complementarity on the production and consumption sides. For instance, if two crops are both grown in the same season in a given state, as are wheat and gram in Punjab, their substitutability in production has obvious implications for the prices of both. Similarly, the substitutability of commodities in consumption, as for wheat and rice, implies that their price movements are likely to be related. Complementarity[3] in production may be observed where the growth of a crop aids that of another by supplying nutrients and preventing pest infestation, as is true for pepper intercropped with tomatoes, peas with turnips, and cauliflower with garlic. Similarly, complementarity in consumption, which may result in simultaneous changes in demand for the commodities in question, would lead to related changes in the prices of such commodities (Malliaris and Urrutia 1996).

Second, domestic and international macroeconomic shocks such as changes in aggregate demand, inflation, exchange rates, interest rates, etc. can affect commodity groups in similar ways. Third, speculative behaviour may cause co-movement of commodity prices, partly because of liquidity constraints on speculators and partly because of herd behaviour in financial markets (Pindyck and Rotemberg 1990).

In the Indian context, the previous studies have analysed the price discovery process between the spot and futures prices of a specific commodity only, and did not examine the interdependence of futures prices of various crops (Shihabudheen and Padhi 2010, Jabir and Gupta 2011, Srinivasan 2012, Aggrawal et al. 2014 and Sehgal et al. 2014). The present paper fills this research gap by employing ram, mustard, castorseed, soybean, coriander and cumin. These are some of the important commodities for the Indian economy, as well as those for which data are available. We took the futures and spot price data for these commodities from the National Commodity and Derivative Exchange (NCDEX), Mumbai, and the Multi-Commodity Exchange (MCX), Mumbai. All data are available on a daily basis, i.e. six days a week, from August 2009 to September 2014.

We employ the Johansen co-integration test, the error correction model and the Granger causality test to examine the linkages amongst agricultural commodity futures prices. The results show that there is a long term relationship amongst the agricultural commodity futures prices. However, we could not observe any short term causal relationship even among the related agricultural commodities.

The paper is organized as follows. Section 2 describes the empirical model used in the study. Section 3 discusses the data set. Section 4 discusses the estimation results and their interpretation. Finally, Section 5 provides the important conclusions and policy implications.

2.DEVELOPING THE ECONOMIC MODEL

This paper builds a model that gives some insight that prices play an important role in determining the cropping pattern in Indian agriculture. We modify the model of Chen et al. (2010), who have used the McConnell (1989) crop allocation model[4].

A. Theoretical model[5]

Suppose A is the total agricultural land, which is allocated between ith crop (A_i) and its substitute and competing crops[6] (A_j). A_i refers to the acreage for ith crop and A_j stands for the acreage for jth crop. We denote the inverse demand function for ith crop as $P_i(Q_i)$ where P_i and Q_i refers to the price and quantity of output demanded of crop i. The per hectare cost of agricultural production for ith and jth crops are C_i & C_j respectively.

We define the social benefit to the farmers as a separable function of crop i and its substitute crops (j). Then the total benefits are the sum of benefit from for ith and jth crops (McConnel 1989). The marginal social benefit to land is approximately the value of marginal revenue from a hectare of land. We assume zero external effect.

The modified crop land allocation model can be written as:

$$Max: \sum_{i=1}^{n}[\int P_i(Q_i)\, dQ_i - C_i \cdot A_i] + \sum_{j=1}^{m}[\int P_j(Q_j)\, dQ_j - C_i \cdot A_j] \qquad (1)$$

Subject to

$Q_i \le Y_i \cdot A_i,$ (2)

$Q_j \le Y_j \cdot A_j,$ (3)

$\sum_{i=1}^{n} A_i + \sum_{i=1}^{m} A_j \le A,$ (4)

Where Y_i is the yield for the ith crop and Y_j is the yield from jth crop.

Equation (1) represents the social returns to farmers from agricultural land; and is our objective function. The first term is the area under ith crop demand curve minus total cost of producing ith crop which is referred to as social returns from ith crops. In the same way, the second term is the area under substitute and competing crops (jth crops) minus total cost of producing jth crop which is referred to as social returns from jth crops. The second and third equation indicate that total demand must be less than equal to total supply i.e., demand and supply balance constraints for ith and jth crops respectively. Equation (4) represents the constraints for land.

The optimal quantity of agricultural land under each crop is derived by maximizing:

$$Z = \sum_{i=1}^{n}[\int P_i(Q_i)\, dQ_i - C_i \cdot A_i] + \sum_{j=1}^{m}[\int P_j(Q_j)\, dQ_j - C_i \cdot A_j] + \lambda_i(Y_i \cdot A_i - Q_i) + \lambda_j(Y_j \cdot A_j - Q_j) + \mu(A - \sum_{i=1}^{n} A_i - \sum_{i=1}^{n} A_i)$$

By solving the above equations using first order conditions, we find the following relations:

$$P_i Y_i = P_j Y_j + C_i - C_j. \quad (5)$$

Therefore, one can say that the quantity of ith crop depends on the prices of ith crop, prices of substitute crops and marginal costs of ith and jth crop. The equilibrium conditions show the linkage between the prices of ith crops and the prices of their substitute crops (j).

B. The econometric methodology

We use Johansen Co integration test, Error Correction Model (ECM) and Granger causality analysis to examine the linkages amongst agricultural commodity futures prices.

Johansen Co integration test

Cointegration implies a long-term equilibrium relationship between a set of variables that are individually nonstationary, but linear combination of them is stationary. Although the two non-stationary series may drift apart in the short run but come together systematically in the long run. We employ the Johansen and Juselius (1990,1992) method to examine the cointegrating relationship. If the variables are cointegrated, then we can estimate an error correction model with the lagged value of the residual from cointegrating relationship along with the other variables with lag.

Error correction model

In error correcton model (ECM), the short run dynamics of the variables are controlled by the deviation from long run equilibrium.

$$\Delta Y_t = \beta \Delta X_t + \delta(Y_{t-1} - \gamma X_{t-1}) + u_t \quad (6)$$

where X and Y are prices of crops and $X \ne Y$.

Equation (1) is the error correction model. $\delta(Y_{t-1} - \gamma X_{t-1})$ is the error correction term. X_t and Y_t are co-integrated with γ as co-integrating coefficient. Besides, $(Y_{t-1} - \gamma X_{t-1})$ is stationary and X_t and Y_t are I(1). The equation (6) can be interpreted as: the change in the value of independent variable X, between the time period $t-1$ and t produces the change in Y between the period $t-1$ and t. β is the coefficient of short run dynamics. δ is the speed of adjustment parameter, δ determines the proportion of last period's equilibrium error that is corrected for (Brooks2014, p. 378).

Granger causality test

The Granger causality test tests whether past values of one variable X_t can help explain current values of a second variable Y_t, conditional on past values of the second variable Y_t . We test the Granger causality in the framework of error correction model. We perform the granger causality test by joint test of the error correction term and lags of X_t.

3. THE DATA SET

The present study uses futures price data for wheat, gram, maize, soybean, barley, cumin, coriander, castorseed and mustard. These are some of the important commodities for our economy and for which data are available. We realise that there are many other significant commodities that one can think of; however, data are not necessarily available for them. We collected the futures price data from the websites of the National Commodity and Derivative Exchange (NCDEX), Mumbai, and the Multi-Commodity Exchange (MCX), Mumbai. Several futures contracts are traded simultaneously on daily basis. We chose' nearby contract' for our analysis because nearby contract is the most liquid contract. However nearby contract should be at least one month away (Crain and Lee 1996). In addition, we collected the crop-specific wholesale price indices from the Office of the Economic Advisor, Government of India. All data are available on a daily basis (i.e., six days a week) from May 2009 through August 2014. The number of observations for each crop is 617.

Table 1 presents the descriptive statistics of the log of futures price for the sample commodities. We measure volatility by standard deviation which is highest for coriander (0.17) followed by cumin (0.10) and maize (0.09). The lowest volatility is found in wheat (0.04) and castorseed (0.05). The Jarque-Bera test statistics signifies that the distribution of prices is not normal for all commodities.

4. ESTIMATION RESULTS

We start off by removing the components of inflation from the futures prices of each of our sample commodities. The prices are deflated by the crop-specific wholesale price indices.

We next test for unit root in the prices. We employ[7] the Dickey–Fuller generalized least squares(DF-GLS) test proposed by Elliot et al. (1996) for detecting a unit root in the series. DF-GLS test is a second generation test, and has greater power in detecting a unit root in the series. Since data plots show the deterministic trend and intercept in the series, we assumed deterministic trend and intercept in the DF-GLS test. The optimum lag lengths were selected automatically using the Schwarz Criterion (SC). We found that the futures prices of all crops are nonstationary in levels. Consequently, it is concluded from the DF-GLS statistic that futures prices of all nine crops are integrated of order one (Table 2). To determine if there are structural breaks, we conducted the Elliot and Muller (2006) test. We did not identify any structural break in futures prices for all nine commodities.

We then employ the Johansen cointegration test, the error correction model (ECM) and Granger causality analysis, to examine the linkages amongst the futures prices of the sample commodities.

From Table 3 we find that the trace test statistic of 225.681 and the maximal eigenvalue test statistic of 77.064 are both strongly significant, rejecting the null hypothesis of no cointegration among the commodity prices.

The error correction term in ECM for all crops is negative and significant at 5 percent level of significance (Table 4). Further, the error correction model test results presented in Table 4 do not reveal any short term causal relationship amongst the sample commodities. For soybean futures as dependent variable, the coefficient of wheat futures lag two is -0.171, which is strongly negative significant. This means that the wheat futures lag two lead to negative changes in soybean futures. When we consider the coefficients of the first and third lags of wheat futures, these coefficients are insignificant. Similarly, for coriander futures as dependent variable, the coefficient of wheat futures lag three is 0.272, which is positive significant at the one percent level of significance. This means that the wheat futures lag three lead to positive changes in coriander futures. However, the coefficients of first and third lag of wheat futures are insignificant. This is true for other crops as well. We found that the first lag is significant, while subsequent lags are not. Thus, it is difficult to comment from the ECM results whether one commodity futures leads to changes in the other commodity futures.

We, therefore, conduct Granger causality tests in the framework of error correction model. We perform the granger causality test between the futures prices of the sample crops, but still do not find any clear pattern of causality. Nevertheless, Table 5 shows that wheat futures returns Granger cause coriander and soybean futures returns, implying that wheat futures market dominates the coriander and soybean futures markets. Similarly, gram futures returns Granger causes maize and wheat futures returns, implying that the gram futures market dominated the maize and wheat futures markets.

Unfortunately, we cannot compare our results to other studies for India simply because there aren't any. We, therefore compare our results to those for other countries. This finding differs from the findings of Booth and Ciner (2001). The authors have found that there is a pair wise cointergrating relationship between crops that share strong economic factors, for example, barley and wheat. However, there is no pairwise cointegrating relationship between barley, cocoa, sugar, coffee and wheat. So, Booth and Ciner (2001) concluded that there is no evidence of herding trends among the Tokyo agricultural commodity futures markets. Their conclusion is that the long term co movementis not due to the herd behaviour, but due to common economic factors among the related agricultural commodity prices. Nonetheless, our finding is consistent with the findings of Malliaris and Urruntia (1996). Malliaris and Urruntia (1996) have found the significant pairwise linkages among the agricultural commodities futures pieces traded on the Chicago board of trade (CBOT).

5. CONCLUSIONS AND POLICY IMPLICATIONS

This study examines the interdependence of futures prices of various crops traded on the national commodity exchanges, and finds that (some) primary commodity futures prices have a long term (cointegrating) relationship, but apparently no short term causal relationship. Futures market performs the function of price discovery. The interdependencies amongst the futures prices of the agricultural commodities reveal that the price discovery in the futures market of one commodity signals useful information that is relevant for other linked commodity futures markets. This information might include several factors such as substitutability and complementarity in demand and supply, shocks, weather, herd behaviour (Malliaris and Urrutia 1996).

Our results have significant policy implications for stock brokers, traders, mill owners and speculators. The futures prices of agricultural commodities are interdependent. Therefore, the stock brokers, and speculators should rely on the co- movement of agricultural commodity prices.

Table 1: Descriptive statistics of daily futures prices in some agricultural commodity markets

	Mean	Maximum	Minimum	Standard Deviation	Skewness	Kurtosis	Jarque-Bera statistic	Observations
Barley FP	6.521	6.784	6.368	0.087	0.572	2.284	46.825***	617
Castorseed FP	7.475	7.678	7.314	0.054	0.514	4.543	88.468***	617
Coriander FP	7.701	8.046	7.255	0.172	-0.365	2.512	19.833***	617
Gram FP	7.349	7.751	7.153	0.082	0.137	2.582	6.431**	617
Maize FP	6.336	6.590	6.128	0.096	-0.214	2.040	28.378***	617
Mustard FP	7.581	7.791	7.370	0.083	-0.296	2.764	10.490***	617
Soybean FP	7.412	7.609	7.204	0.081	-0.394	3.066	16.116***	617
Wheat FP	6.586	6.684	6.467	0.048	-0.438	2.458	27.326***	617
Cumin FP	8.913	9.227	8.592	0.107	0.247	22.629	9.816***	617

Notes: FP – futures price.
***, **, and * indicate significance at the 1%, 5% and 10% levels

Table 2: DF-GLS Unit Root test

Variable	Levels (T&I)	First difference	Inference at 5%
Barley FP	-0.581	-8.213***	I(1)
Castorseed FP	-1.449	-34.824***	I(1)
Coriander FP	-1.174	-33.077***	I(1)
Gram FP	-1.326	-35.826***	I(1)
Maize FP	-2.551	-3.948***	I(1)
Mustard FP	-2.099	-3.877***	I(1)
Soybean FP	-1.441	-3.194**	I(1)
Wheat FP	-2.288	-13.402***	I(1)
Cumin FP	-1.914	-3.806***	I(1)

Notes: FP – futures price.
***, **, * denotes significance at 1%, 5%, 10% level implying that the null of unit root is rejected
T&I stand for trend and intercept
I(1) stands for integrated of order one.

Table 3: Johansen's Co-integration tests for daily prices in agricultural futures markets

Rank	Trace test		Maximal Eigen Value		
	Test Value	Critical Value (95%)	Test Value	Critical Value (95%)	Conclusion
H_0: $r = 0$	225.681 **	197.370	77.064 **	58.433	Reject H_0
H_0: $r \leq 1$	148.616	159.529	41.905	52.362	Do not reject H_0

Notes: ** indicates significance at the 5% level
Number of lags – four
r – order of cointegration

Table 4: Error Correction Model statistics for daily returns in some agricultural futures markets

Variable	Barley	Castorseed	Coriander	Gram	Maize	Mustard	Soybean	Wheat	Cumin
Barley lag 1	-0.180***	0.004	-0.094*	-0.101**	0.004	-0.034	0.047	0.004	0
	(0.044)	(0.042)	(0.055)	(0.040)	(0.033)	(0.030)	(0.042)	(0.025)	(0.041)
Barley lag 2	-0.061	0.127	-0.051	-0.033	0.047	0.033	0.046	0.020	-0.003
	(0.044)	(0.043)	(0.056)	(0.041)	(0.034)	(0.031)	(0.043)	(0.025)	(0.042)
Barley lag 3	-0.044	0.041	0.014	-0.059	0.053	0.018	0.065	0.029	0.022
	(0.044)	(0.043)	(0.056)	(0.040)	(0.033)	(0.031)	(0.042)	(0.025)	(0.042)
Castorseed lag 1	0.017	0.031	0.030	0.085**	0.029	0.047	0.041	0.014	0.045
	(0.045)	(0.044)	(0.057)	(0.041)	(0.034)	(0.031)	(0.043)	(0.025)	(0.042)
Castorseed lag 2	-0.022	-0.007	-0.021	0.115***	0.034	0.034	0.015	-0.016	0.036
	(0.044)	(0.043)	(0.056)	(0.041)	(0.034)	(0.031)	(0.042)	(0.025)	(0.042)
Castorseed lag 3	-0.052	-0.016	-0.034	0.111***	0.053	0.085	0.109**	0.005	0.098**
	(0.044)	(0.043)	(0.056)	(0.041)	(0.033)	(0.031)	(0.042)	(0.025)	(0.041)
Coriander lag 1	0.012	-0.014	-0.030	0.041	-0.026	0.002	-0.007	-0.035*	-0.005
	(0.035)	(0.034)	(0.045)	(0.032)	(0.027)	(0.025)	(0.034)	(0.020)	(0.033)
Coriander lag 2	0.038	0.014	-0.031	0	-0.013	-0.010	0.021	-0.005	-0.032
	(0.035)	(0.034)	(0.045)	(0.032)	(0.027)	(0.025)	(0.034)	(0.020)	(0.033)
Coriander lag3	-0.007	0.043	-0.012	-0.006	0.007	0.003	0.062*	-0.011	-0.056*
	(0.035)	(0.034)	(0.045)	(0.032)	(0.027)	(0.024)	(0.034)	(0.020)	(0.033)
Gram lag 1	0.056	0.086*	0.096	-0.055	0.120	0.007	0.067	0.043	-0.021
	(0.051)	(0.049)	(0.064)	(0.046)	(0.038)	(0.035)	0.049	(0.029)	(0.048)
Gram lag 2	-0.029	0.074	-0.064	-0.003	0.025	0.018	0.009	-0.055*	-0.048
	(0.051)	(0.050)	(0.065)	(0.047)	(0.039)	(0.036)	(0.049)	(0.029)	(0.048)
Gram lag 3	-0.026	0.027	-0.067	0.060	-0.043	0.006	-0.033	-0.035	0.093*
	(0.050)	(0.049)	(0.063)	(0.046)	(0.038)	(0.035)	(0.048)	(0.028)	(0.047)

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Maize lag 1	-0.006	-0.054	0.004	0.027	0.027	0.044	-0.032	0.031	0.064
	(0.062)	(0.060)	(0.078)	(0.056)	(0.047)	(0.043)	(0.059)	(0.035)	(0.058)
Maize lag 2	0.018	-0.049	0.088	-0.006	0.029	0.050	-0.064	0.015	0.022
	(0.061)	(0.060)	(0.078)	(0.056)	(0.047)	(0.043)	(0.059)	(0.035)	(0.058)
Maize lag 3	0.075	-0.050	-0.130	-0.055	-0.068	0.017	-0.072	0.046	-0.045
	(0.061)	(0.060)	(0.077)	(0.056)	(0.047)	(0.043)	(0.059)	(0.034)	(0.058)
Mustard lag 1	-0.005	0.022	-0.049	0.111	-0.100	-0.028	0.015	0	-0.044
	(0.072)	(0.071)	(0.092)	(0.067)	(0.055)	(0.051)	(0.070)	(0.041)	(0.069)
Mustard lag 2	0.1152	-0.022	0.101	-0.140	0.014	-0.119**	-0.078	-0.083**	-0.029
	(0.073)	(0.071)	(0.092)	(0.067)	(0.055)	(0.051)	(0.070)	(0.041)	(0.069)
Mustard lag 3	0.191	0.022	-0.002	0.071	-0.008	-0.068	0.013	-0.026	-0.031
	(0.073)	(0.071)	(0.093)	(0.067)	(0.056)	(0.051)	(0.071)	(0.042)	(0.069)
Soybean lag 1	-0.002	-0.057	0.017	0.071	0.080**	0.066**	-0.059	0.015	-0.005
	(0.045)	(0.044)	(0.057)	(0.041)	(0.034)	(0.031)	(0.043)	(0.025)	(0.042)
Soybean lag 2	0.024	-0.053	-0.010	-0.034	0.004	-0.030	-0.146***	0.022	0.053
	(0.044)	(0.043)	(0.056)	(0.041)	(0.034)	(0.031)	(0.043)	(0.025)	(0.042)
Soybean lag 3	-0.061	0.005	-0.040	0.021	-0.003	0.047	-0.024	0.007	-0.043
	(0.044)	(0.043)	(0.056)	(0.041)	(0.034)	(0.031)	(0.042)	(0.025)	(0.042)

Table 4 continued

Variable	Barley	Castorseed	Coriander	Gram	Maize	Mustard	Soybean	Wheat	Cumin
Wheat lag 1	-0.026	0.081	0.153	-0.034	-0.010	-0.042	-0.079	0.009	-0.024
	(0.079)	(0.077)	(0.100)	(0.072)	(0.060)	(0.055)	(0.076)	(0.045)	(0.075)
Wheat lag 2	0.010	0	0.143	0.063	0.014	0.012	-0.171**	-0.021	0.006
	(0.079)	(0.077)	(0.100)	(0.072)	(0.060)	(0.055)	(0.076)	(0.045)	(0.075)
Wheat lag 3	-0.029	0.110	0.272***	-0.057	0.052	0.022	-0.062	-0.049	0.011
	(0.079)	(0.077)	(0.100)	(0.072)	(0.060)	(0.055)	(0.076)	0.045	(0.075)
Cumin lag 1	0.020	0.081	0.063	-0.038	0.029	0.022	0.129***	0.044*	0.022
	(0.046)	(0.045)	(0.058)	(0.043)	(0.035)	(0.032)	(0.044)	(0.026)	(0.044)
Cumin lag 2	0.014	0.035	0.022	-0.034	0.010	0.003	-0.004	0.0147	-0.048
	(0.046)	(0.045)	(0.059)	(0.043)	(0.035)	(0.032)	(0.045)	(0.026)	(0.044)
Cumin lag 3	-0.026	0.057	0.141	0.028	0.084	-0.019	0.016	0.015	-0.025
	(0.046)	(0.045)	(0.059)	(0.043)	(0.035)	(0.032)	(0.045)	(0.026)	(0.044)
δ	-0.001 ***	-0.001 ***	-0.001 ***	-0.001 ***	-0.001 ***	-0.001 ***	-0.001 ***	-0.001 ***	-0.001 ***
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)

Notes: ***, **, and * indicate significance at the 1%, 5% and 10% levels

δ denotes the speed of adjustment parameter.

Error correction model (ECM) based on three lags of 'endogenous' variable. Standard errors are reported in parentheses.

Table 5: Granger causality test from ECM for daily returns in some agricultural futures markets

	Null Hypothesis: Futures price FP_i does not Granger cause futures price FP_j								
	χ^2-Statistic								
	Barley	Castorseed	Coriander	Gram	Maize	Mustard	Soybean	Wheat	Cumin
Barley	NA	8.890**	3.534	8.033**	3.812	3.041	3.813	1.763	0.312
Castorseed	1.912	NA	0.816	16.619***	3.601	9.549**	6.993*	0.867	6.538*
Coriander	1.327	1.938	NA	1.667	1.262	0.201	3.803	3.308	3.703
Gram	1.880	5.165	4.416	NA	11.315**	0.332	2.404	7.332*	5.222
Maize	1.585	2.237	4.082	1.203	NA	2.612	2.965	2.808	1.947
Mustard	8.900**	0.305	1.683	8.698**	3.415	NA	1.353	4.280	0.726
Soybean	2.322	3.049	0.685	4.088	5.630	7.505*	NA	1.116	2.830
Wheat	0.261	3.097	11.806***	1.554	0.856	0.799	6.945*	NA	0.140
Cumin	0.583	5.329	7.108*	1.869	6.494	0.794	8.654**	3.483	NA

Notes: ***, **, and * indicate significance at the 1%, 5% and 10% levels
Granger causality tests based on three lags of 'endogenous' variable

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Notes

[1] *Price discovery implies that futures price is a good forecaster of spot price.*

[2] *We have devised the null hypothesis in the context of partial equilibrium.*

[3] *Complementarity in production is determined by agronomic factors.*

[4] *McConnell (1989) model examined the determinants of optimum quantity of farmland in USA. He has considered three uses of land, namely agricultural, park and urban. By maximising social returns to land in different uses, he calculated the optimum land use. Chen et al. (2010) showed the relationship between oil price and global grain price for corn, soyabean and wheat.*

[5] *We modify the cropland allo-cation model of Chen et al. (2010) by maximising the social returns to land by allocating land use for different crops (substitute and complementary crops) ; and find the optimum land use. We find that the prices of crop and its substitute crops are linked.*

[6] *These crops are other than the main crop grown in the same area.*

[7] *We also employed Augmented Dickey-Fuller Test (Dickey and Fuller 1981), Phillips-Perron Test (Phillips and Perron 1988) for verifying the unit root test results.*

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