Performance and Relevance of Wheat Futures Market in India
– An Exploratory Analysis

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Selected Paper Prepared for Presentation at the Agricultural & Applied Economics Association's 2014 AAEA Annual Meeting, Minneapolis, MN, July 27-29, 2014

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Abstract

The present study highlights the context of wheat futures trading in India and examines its performance in terms of price transmission between Indian and US futures, domestic futures and spot markets, and, extent of integration between those markets. Role of wheat futures in price stabilisation/volatility reduction and its relevance to the small scale production system in the country have also been examined. Evidence of unit root in price series and a strong integration between spot and futures markets in India were found through Johansen's test. Despite the integration of domestic markets, US and Indian futures are not integrated in the long-run. Application of Generalized auto-regressive conditional heteroscedasticity (GARCH) model indicated a high degree of volatility in spot prices right from inception of trading and revival of trading, however it was low during the ban period. This showed that the function of price stabilisation of futures trading has not been fulfilled. Despite futures market serving as a platform for price discovery and hedging, low marketed surplus and the complexity in trading avoids farmers' participation. On the whole, the study concludes that wheat futures are efficient in price transmission but inefficient in price stabilisation and warrants for awareness, margin money discount and aggregating farmers produce so that farmers can participate and take advantage of hedging in an uncertain situation of the farm business.

Keywords: *wheat futures; cointegration; GARCH; volatility; NCDEX.*

Introduction

Volatility in agricultural commodities is a priority policy question in the ongoing debate on commodity markets vis-à-vis food inflation. It is a major concern for the policy makers since volatility in commodities have determined the economic prospects of nations for eons and would continue to do so in the future (Dasgupta and Chakrabarty, 2009). Fundamentally, it originates from the supply shocks and with the short-run demand and supply elasticity coefficients cause fluctuations in prices. These variations particularly at good crop harvest reduce the potential gains of the producers (Singh et al., 2005) and it can threaten agriculture performance and negatively impact the livelihood security (World Bank, 1997).

The uncertain movement of prices over time can be managed by an individual and/or group initiative. Among alternatives, futures trading is considered to be one of the effective strategies in price stabilisation. Several developing countries have established and promoted commodity futures hitherto. In India, the futures trading which was dormant and unorganised for a long time, interest has revived only in the recent past. In the context of changing economic scenario, efforts were made to promote organised agricultural commodity futures in India (FMC, 2000).

Futures contract made under organised commodity exchanges perform the twin functions *viz.,* price discovery and risk management (Velmurugan et al*.,* 2010) and expected to help in the process of price stabilisation safeguarding the interests of farmers, exporters and others stakeholders. Price discovery which is a continuous process of arriving at a future price for a contract made in commodity exchange depends on the information reflected in futures and/or spot market. Infact both the markets contribute to the price discovery function, however, a unique and common unobservable price is expected and it is the efficient price (Velmurugan et al*.,* 2010). Various hedging performance measure are often employed to test this process (Lien, 2012).

Analysing the performance of agricultural commodity futures has garnered much attention among economists and policy makers (Garbade and Silber, 1982; Singh et al., 2005; Easwaran and Ramasundaram, 2008; Sen, 2008; Brosig et al*.,* 2011; Sendhil et al., 2013 and Zelda, 2013). Despite this, only limited research has been carried out in India in general and wheat in particular, an important commodity next to rice. Though Minimum Support Price (MSP) offered by the government plays a major role in wheat procurement and trade, liberalisation of 1990s witnessed cessation of state supports leading to vulnerable prices in many food commodities owing to the domestic and international market forces (UNCTAD, 1997 and World Bank, 1997). Consequent to this, the government took several contingent policy measures including wheat and wheat flour imports at zero duty, ban on exports and futures trade, imposing stock limits on traders, consistent hike in the support price to encourage production and subsequent storage as buffer stock and raise in norms of buffer and food security stocks. Increase in the overall price of food commodities during mid-2009 blamed the operation of futures trading and the panic state reaction resulted in delisting of sensitive commodities including wheat. Listing, delisting and relisting the commodities on exchanges questioned the utility of the futures market, efficiency of public management in containing volatility as well as the sustainability of current economic growth process. The Sen (2008) committee, constituted to examine the impact of futures trading on food inflation could not establish any relationship between the futures and spot prices, which is still under debate (Srinivasan, 2008).

Futures price and the speed of information flow play a major role in facilitating the acreage under wheat, currently India holding the maximum share across world. Volatile prices are unpleasant to consumers and traders as well. In this context, the present study was carried out to test the market integration, to examine the extent of volatility in spot market due to futures trading, and to analyse its relevance for the small scale production system prevailing in the country.

Data

The study sourced data from various official publications, portals of National Commodity Derivatives Exchange (NCDEX)-Mumbai, India and Directorate of Economics and Statistics, Ministry of Agriculture, Government of India.

Methodology

Growth and instability

Compound annual growth rates were estimated using ordinary least squares (OLS) and the instability index as a source of risk was computed by coefficient of variation (CV) and Cuddy-Della Valle index (Cuddy and Della Valle, 1978).

Market integration and price transmission

Several studies have tested integration between markets with subsequent improvement in the methodology (Hendry and Anderson, 1977; Engle and Granger, 1987; Johansen, 1988, 1991, 1994 and 1995; and Goodwin and Schroeder, 1991). The present study has utilised the Johansen's cointegration approach to explore the cointegration possibility of futures with that of spot market. The test relies heavily on the relationship between the rank of a matrix and its characteristic roots. Kumar and Sharma (2003) recognized the superiority of Johansen's technique owing to its computational ease, robustness *sans apriori* assumptions on endogenity or exogenity of variables and simultaneity in test and number of cointegration relationships unimposed beforehand. The formulation is as follows:

$$\Delta Y_t = \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \alpha\beta' Y_{t-k} + \varepsilon_t$$

where, Y_t is the price time series, Δ is the first difference operator (Y_t - Y_{t-1}) and matrix $\Pi = \alpha\beta'$ is (n x n) with rank r ($0 \le r \le n$), which is the number of linear independent cointegration relations in the vector space of matrix. Here, α represents the speed of adjustment to disequilibrium and β is a matrix of long-run coefficients. The Johansen's method of cointegrated system is a restricted maximum likelihood method with rank restriction on matrix $\Pi = \alpha\beta'$. The rank of Π can be determined by λ_{trace} test statistic and is given by,

$$\lambda_{trace} = -T\sum_{i=r+1}^{n}\ln(1-\hat{\lambda}_i)\text{, for r = 0, 1,…, n-1}$$

where, $\hat{\lambda}_i$'s are the Eigen values (estimated values of the characteristic roots obtained from the estimated Π matrix) representing the strength of the correlation between the first difference part and the error-correction part, and T is the number of usable observations. The following hypotheses can be tested, H_0: rank of $\Pi = r$ (null hypothesis), and H_1: rank of $\Pi > r$ (alternate hypothesis), where 'r' is the number of cointegration equations.

Prior to testing for cointegration, the presence and the order of stationarity were checked by performing the Augmented Dickey-Fuller (ADF) test, Philips Perron (PP) test and Levin-Lin-Chu (LLC) test. In our study, ADF and PP were used for pair variables and LLC was used for group variables. These tests were conducted on the variables in level (original price series) and their first differences (Dickey and Fuller, 1979). Since the test is sensitive to lag length, the appropriate lag distribution was decided by choosing a specification minimising the Schwarz Information Criterion (SIC), derived from the principles of information.

Granger causality test

If the price series doesn't conclude cointegration then simply Granger causality test can be done to know the cause variable. This method is based on multiple regression analysis and investigates whether one time series can correctly forecast another (Granger, 1969). Basically for a pair time series, the hypothesis whether series X does not Granger cause series Y was tested by a simple F-test. The paired model is given as:

$$Y_t = \sum_{n=1}^{p} A_n X_{(t-p)} + \sum_{n=1}^{p} B_n Y_{(t-p)} + CZ_t + E_t$$

$$X_t = \sum_{n=1}^{p} A'_n Y'_{(t-p)} + \sum_{n=1}^{p} B'_n X'_{(t-p)} + C'Z_t + E'_t$$

where, X_t and Y_t represent the two time series at time *t*, $X_{(t-p)}$ and $Y_{(t-p)}$ represent the time series at time *t-p, p* is the number of lagged time points (order), A_n and $A_n^{'}$ are signed path coefficients, B_n and $B_n^{'}$ are auto-regression coefficients, and, E_t and $E_t^{'}$ are residual terms.

Price volatility

Usually, commodity markets exhibit volatile prices based on the flow of market information, hedging and speculation, and physical transaction of commodities. These features justify the use of information based process to model the pattern of volatility (Vasisht and Bhardwaj, 2010). The present study has employed the Generalised Autoregressive Conditional Heteroscedasticity (GARCH) model to measure the extent of volatility in wheat spot prices due to futures trading. Besides distinguishing predictable and unpredictable components of prices, GARCH allows the variance of unpredictable element to be time varying (Bollerslev, 1986). Auto Regressive Integrated Moving Average (ARIMA) filtration analysis was first done to identify the best fit ARCH term and then proceeded with fitting the best order GARCH model (Vasisht and Bhardwaj, 2010). Higher order GARCH models, denoted as GARCH (*p, q*), were estimated by choosing either *p* or *q,* or both greater than one (Jordaan et al., 2004) and represented as:

$$Y_{it} = a_0 + b_1 Y_{it-1} + b_2 Y_{it-2} + \varepsilon_{it}$$

$$\sigma_{i,t}^2 = \omega + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2$$

where, Y_{it} is the spot price in t^{th} period of i^{th} commodity, *p* is the order of the GARCH and *q* is the order of the ARCH. $\alpha_i + \beta_i$ indicate the degree of persistence in volatility – closer to one, volatility to persist for long time and >1 indicate an explosive series meandering away from mean. After fitting the model, it was tested for ARCH-LM (test for identifying the serial correlation in residuals) to check for any ARCH effect. The best fit model with no ARCH effect was presented and discussed for three periods (before ban, during ban and trading revival).

Empirical Findings

Profile of wheat futures

Wheat futures trading in India had its inception on June 10, 2005 at the National Commodity and Derivatives Exchange Limited (NCDEX), Mumbai and Multi Commodity Exchange of India (MCX), Mumbai (Table 1). Forward Markets Commission (FMC) under the Ministry of Consumer Affairs is the chief regulator that decides the commodity to be included for trading in futures market and contract size (10 tonnes in the case of wheat). From the table it is evident that the commodity registered a volume of 2.24 million tonnes and a turnover of INR (Indian rupees) 26.61 billion during 2011-12 (Table 1).

Table 1. Profile of wheat futures.

Commodity (Scientific name)	**Code (Exchange)**	**Inception (DD.MM.YY)**	**Exchange (lot size in tonnes)**	**Trade (April 2011- March 2012)**	
				Value in INR million	**Volume in million tonnes**
Wheat* (*Triticum aestivum*)	WHTSMQDELI (NCDEX) WHEAT (MCX)	10.06.2005 (NCDEX)	NCDEX (10) MCX (10)	26.61 (0.18) [0.12]	2.24 (0.61) [0.45]

Note: Figures in parentheses and square brackets in last column are percentages to total trade of food items and agricultural commodities, respectively. * Trading suspended from February 28, 2007 to May 21, 2009.

Perusal of Table 2 indicated that the volume traded and its value from inception till 2010-11 crop year experienced an initial increase and declined later. The number of contract days ranged from as low as 26 days (June 2009) to as high as 217 days (December 2006). It is explicitly evident that trade volume and value was very low before trade suspension (Table 2). While the mean price of wheat contracts witnessed a rising trend, the price range had its peak in November 2009 (INR 296.80/100kg) vis-à-vis INR 63.60/100kg in November 2005 (Table 3). It is clear from Table 4 that the instability in wheat prices was highest (7.05%) in December 2009 ending contract compared to February 2011 contract (1.65%). There was a highly significant and positive relationship between trade volume and value (correlation coefficient = 0.99), which together sported an inverse relationship with number of trading days.

Table 2. Details of wheat futures contracts from NCDEX.

Year	Number of contracts (ending month)	Contract period	Number of days	Trade value (INR million)	Trade volume (tonnes)
2005-06	October 2005	10.06.05 to 20.10.05	111	8256.46	1032090
	November 2005	11.07.05 to 18.11.05	114	9773.57	1197850
	December 2005	10.08.05 to 20.12.05	116	10572.68	1273610
	January 2006	10.09.05 to 20.01.06	120	17375.95	2025540
	February 2006	10.10.05 to 20.02.06	120	30380.19	3475050
	March 2006	10.11.05 to 20.03.06	115	24512.86	2905600
	April 2006	10.12.05 to 20.04.06	114	16166.11	2059610
	May 2006	10.01.06 to 19.05.06	111	23669.34	2806920
	June 2006	10.02.06 to 20.06.06	112	35825.21	3950840
2006-07	July 2006	10.03.06 to 20.07.06	114	38687.84	4202990
	August 2006	10.04.06 to 18.08.06	112	21555.66	2373060
	September 2006	10.04.06 to 20.09.06	140	14459.72	1546040
	October 2006	10.04.06 to 17.10.06	162	12595.74	1294600
	November 2006	10.04.06 to 20.11.06	191	10581.60	1049350
	December 2006	10.04.06 to 20.12.06	217	32587.20	3152130
	January 2007	10.08.06 to 19.01.07	137	12853.39	1199700
	February 2007	10.08.06 to 20.02.07	163	8839.52	858360
	March 2007	11.09.06 to 20.03.07	161	4964.16	516730
	April 2007	10.10.06 to 20.04.07	164	2132.62	235870
	May 2007	10.12.06 to 18.05.07	161	1328.32	146840
	June 2007	11.12.06 to 20.06.07	163	450.87	49260
2007-08	July 2007	10.01.07 to 20.07.07	164	53.00	5720
	August 2007	10.02.07 to 20.08.07	163	26.11	2770
2008-09	June 2009	21.05.09 to 19.06.09	26	871.29	78530
2009-10	July 2009	21.05.09 to 20.07.09	52	1094.78	98760
	August 2009	21.05.09 to 20.08.09	78	1681.98	147600
	September 2009	21.05.09 to 18.09.09	103	1670.15	142170
	October 2009	21.05.09 to 20.10.09	129	977.68	80750
	November 2009	21.05.09 to 20.11.09	156	2704.19	198610
	December 2009	11.06.09 to 18.12.09	161	5355.97	382860
	January 2010	10.09.09 to 20.01.10	111	5996.96	434840
	February 2010	10.09.09 to 19.02.10	136	3157.77	234710
	March 2010	10.09.09 to 19.03.10	160	2540.85	198500
	April 2010	10.10.09 to 20.04.10	161	1806.02	154940
	May 2010	10.11.09 to 20.05.10	160	3172.29	275290
	June 2010	10.12.09 to 18.06.10	160	4986.22	415140
2010-11	July 2010	11.01.10 to 20.07.10	161	4855.42	391830
	August 2010	10.02.10 to 20.08.10	163	3645.09	291200
	September 2010	10.03.10 to 20.09.10	164	3662.19	292680
	October 2010	10.04.10 to 20.10.10	163	2467.64	196770
	November 2010	10.05.10 to 19.11.10	165	2041.15	160730
	December 2010	10.06.10 to 20.12.10	164	1820.49	141110
	January 2011	10.08.10 to 20.01.11	138	1336.65	99190
	February 2011	10.08.10 to 18.02.11	162	869.17	64040
	March 2011	13.09.10 to 18.03.11	158	953.14	75160
	April 2011	11.10.10 to 20.04.11	162	1890.95	158470
	May 2011	10.11.10 to 20.05.11	161	4348.93	360940
	June 2011	10.12.10 to 20.06.11	161	2671.27	221960

Table 3. Descriptive statistics of wheat futures prices from NCDEX.

Year	Number of contracts (ending month)	Mean (INR/100kg)	Maximum (INR/100kg)	Minimum (INR/100kg)	CV (%)
2005-06	October 2005	803.91	841.80	769.00	2.78
	November 2005	815.54	849.80	786.20	2.22
	December 2005	824.61	867.80	781.60	2.38
	January 2006	837.62	907.00	799.40	3.21
	February 2006	851.37	928.40	819.00	3.16
	March 2006	816.91	964.60	770.20	4.37
	April 2006	758.00	825.20	712.60	3.99
	May 2006	807.22	897.60	746.00	5.78
	June 2006	857.48	952.80	780.20	5.68
2006-07	July 2006	885.78	993.00	816.60	5.75
	August 2006	912.43	1016.80	844.00	5.63
	September 2006	937.75	1034.60	866.60	4.84
	October 2006	961.00	1057.00	881.20	4.57
	November 2006	994.88	1140.20	895.00	5.98
	December 2006	1015.33	1151.00	910.00	6.09
	January 2007	1060.79	1152.80	994.00	4.48
	February 2007	1044.43	1129.80	996.60	3.80
	March 2007	975.23	1105.00	913.60	3.64
	April 2007	922.87	1024.80	874.40	4.63
	May 2007	927.09	980.00	866.40	3.55
	June 2007	929.82	974.00	867.20	2.64
2007-08	July 2007	959.50	1085.00	874.00	3.86
	August 2007	989.42	1041.40	881.00	3.50
2008-09	June 2009	1094.65	1136.00	1057.60	1.76
2009-10	July 2009	1104.82	1153.20	1076.40	1.65
	August 2009	1128.82	1182.80	1096.20	1.69
	September 2009	1154.71	1231.40	1115.20	1.91
	October 2009	1185.76	1331.20	1130.00	3.06
	November 2009	1235.16	1443.40	1146.60	6.61
	December 2009	1277.68	1448.80	1163.20	7.05
	January 2010	1349.41	1447.00	1234.00	4.82
	February 2010	1331.53	1410.80	1234.80	3.75
	March 2010	1284.54	1378.40	1190.00	4.11
	April 2010	1207.33	1301.80	1115.60	4.81
	May 2010	1193.52	1310.00	1108.00	4.81
	June 2010	1200.90	1286.40	1120.00	3.93
2010-11	July 2010	1209.88	1298.00	1134.40	3.40
	August 2010	1227.22	1310.40	1147.00	3.35
	September 2010	1245.36	1329.60	1160.60	3.37
	October 2010	1269.10	1349.20	1185.60	2.69
	November 2010	1287.46	1367.80	1241.00	2.47
	December 2010	1298.27	1390.00	1257.20	1.94
	January 2011	1316.58	1418.20	1273.40	2.12
	February 2011	1328.17	1379.00	1289.60	1.65
	March 2011	1283.74	1342.20	1145.20	2.54
	April 2011	1194.71	1254.00	1133.80	2.22
	May 2011	1200.36	1263.40	1148.80	2.10
	June 2011	1214.44	1288.40	1138.60	2.45

Table 4. Correlation matrix of trading days with trade value and trade volume.			
Variables	**Trading days**	**Trade value**	**Trade volume**
Trading days	1.00	-0.14	-0.18
Trade value	-0.14	1.00	0.99*
Trade volume	-0.18	0.99*	1.00

Note: * indicates the significance of Pearson's correlation coefficient at one per cent level of probability (2 tailed).

Cointegration test for market integration and price transmission

India and US: It is imperative to know the price trend in order to know the behavior of the variable in different markets. Figure 1 shows the behaviour of wheat futures prices in India (NCDEX price) and US (Chicago Board of Trade - CBOT price). A comparison between those prices indicated that the Indian wheat futures exhibit a rising trend whereas, mixed trend coupled with high instability (15.69 %) prevailed in US wheat futures. Unit root testing by augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) confirmed non-stationarity at level data (original price time series) and stationarity at the first difference, indicating an integration of order one (Table 5). This confirmation allowed testing the cointegration relationship.

Table 5. Estimated unit root test statistic.

Wheat futures	Level series		1st differenced series		Order	Instability (%)
	ADF statistic	Phillips-Perron	ADF statistic	Phillips-Perron		
India	-2.83	-3.03	-4.47*	-4.82*	I(1)	5.38
US	-1.66	-1.71	-5.91*	-5.91*	I(1)	15.69

Note: * indicates significance at one per cent level of MacKinnon (1996) one-sided p-values.

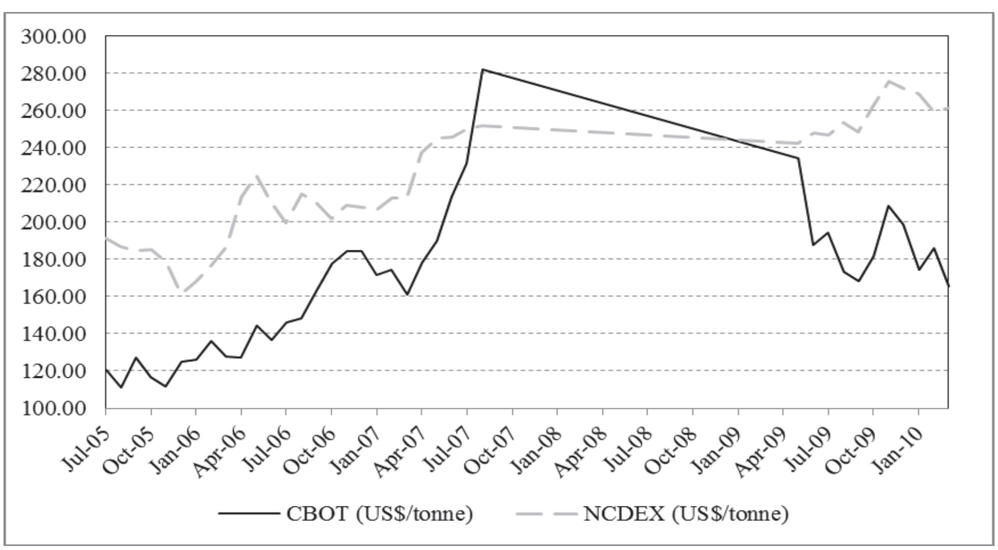

Figure 1. Price behaviour of wheat in Indian (NCDEX) and US (CBOT) futures market.

The estimates of the Johansen's test are presented in Table 6 along with the coefficient of correlation between India and US futures. Correlation analysis revealed a significant positive price relationship in the short-run. The cointegration test exposed the Eigen value and the trace statistic for the selected variables. The test has not rejected the null hypothesis of no cointegration relationship (r=0) and less than or equal to one cointegration relationship ($r \leq 1$) indicating the non-existence of cointegration relationship between the two markets in the long-run. Following this, Granger pairwise causality test was done to know the cause variable and surprisingly, none of the futures price series helped to forecast the other (Table 7). This is a clear indication that wheat futures in India doesn't react to changes in US futures price.

Table 6. Estimates of correlation and Johansen's bivariate cointegration analysis.

Wheat futures	**Correlation**	**Lag length (SIC Value)**	**H_0: rank= r**	**Max Eigen statistic**	**Trace statistic**
India and US	0.74*	1	r = 0	6.13	8.47
		(-4.67)	$r \leq 1$	2.33	2.33

Note: * indicates the significance of Pearson's correlation coefficient at one per cent level of probability (2 tailed).

Table 7. Estimates of pairwise Granger causality tests.

Null hypothesis	**Observations**	**F statistic**	**Probability**
INDIA's wheat futures does not Granger cause US futures	35	1.12	0.33
US wheat futures does not Granger cause INDIA's futures		0.73	0.49

India (futures and spot): The results of unit root and cointegration test for two periods *viz.,* pre-ban and post trade resumption is furnished in Table 8. Spot market prices from Bareilly, Delhi, Kanpur, Karnal and Khanna covering major wheat producing states were collected and tested for short-run and long-run relationship with futures prices. LLC (Levin, Lin and Chu) test indicated the presence of unit root in original price series and found to be stationary at their first differences. Cointegration test indicated synchronous oscillation (Figure 2 and 3) of spot and futures prices confirming price transmission and long-run equilibrium (Table 8). This supports the findings of Singh et al., (2005), Sendhil et al., (2013) and Zelda (2013).

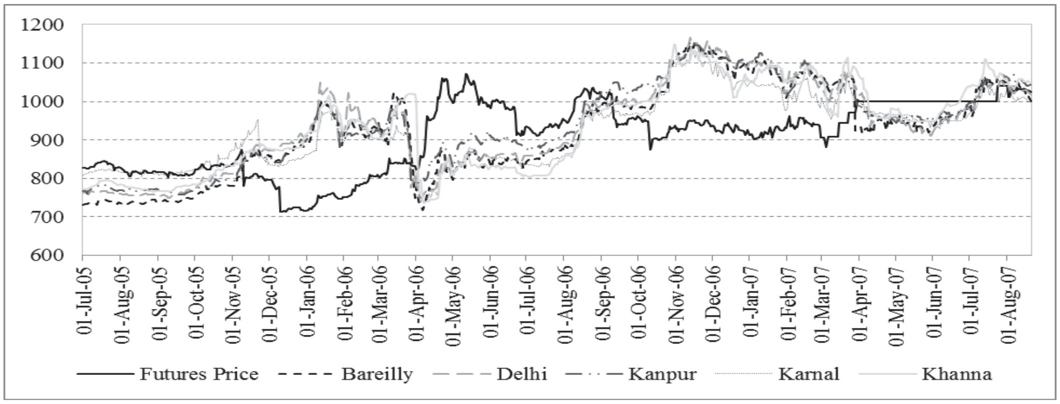

Figure 2. Price behaviour of wheat in Indian futures and spot market (pre ban).

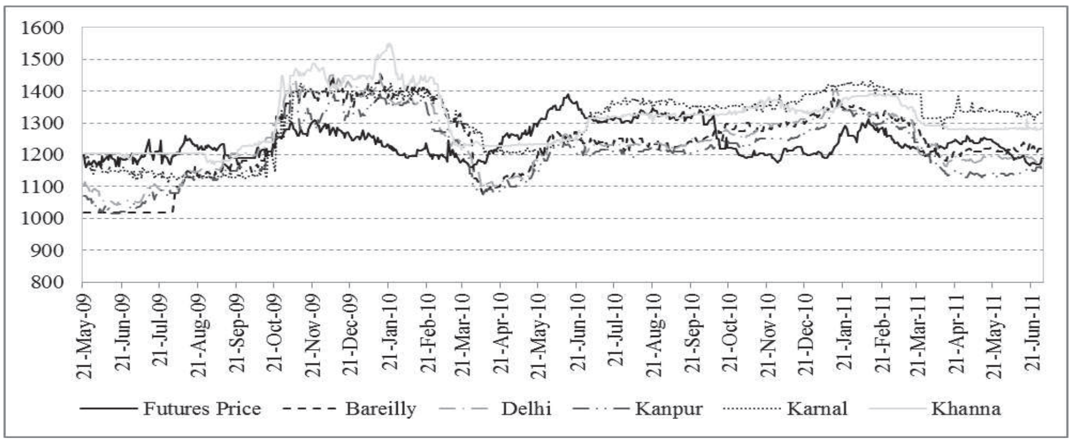

Figure 3. Price behaviour of wheat in Indian futures and spot market (post revival).

Table 8. Estimates of unit root and cointegration test.

Selected markets	LLC statistic		Lag length (SIC Value)	H_0: rank= r	Max Eigen statistic	Trace statistic
	Level	1st differenced				
Before ban						
Futures and Spot (Bareilly, Delhi, Kanpur, Karnal and Khanna)	0.12	-51.95*	1 (-37.38)	r = 0^	96.17	257.44
				r ≤1^	85.08	161.28
				r ≤2^	52.99	76.19
				r ≤3	16.83	23.21
				r ≤4	4.52	6.38
				r ≤5	1.85	1.85
After revival						
Futures and Spot (Bareilly, Delhi, Kanpur, Karnal and Khanna)	0.52	-75.50*	1 (-39.85)	r = 0^	71.87	175.89
				r ≤1^	43.08	104.03
				r ≤2^	33.60	60.95
				r ≤3	16.63	27.35
				r ≤4	5.89	10.72
				r ≤5	4.83	4.83

Note: LLC (Levin, Lin and Chu) is the unit root test for a group of variables that assumes a common root.
* indicate the significance at one per cent level of MacKinnon (1996) one-sided probability value.
^ denotes rejection of the null hypothesis at one per cent level of MacKinnon-Haug-Michelis (1999) probability.

Extent of price volatility

The extent of volatility captured by the GARCH model (Table 9 to 11) that models of various order fit the price time series for different periods under study (Guida and Matringe, 2004). A comparison of the price behaviour indicated that the price range across spot markets was generally lower during the ban period. The selected market prices were skewed in general barring Indore showing only positive skewedness, and irrespective of markets, all price series exhibited platykurtic distribution. The selected market prices were flatter than a normal distribution with a wider peak and the values are wide spread around the mean. Interestingly, the estimates of standard deviation and instability were lowest during the ban period indicating that futures trading failed to stabilise the spot market prices while under operation.

Table 9. Descriptive statistics of prices and estimates of GARCH model (pre-ban).

Particulars	**Bareilly**	**Delhi**	**Indore**	**Kanpur**	**Karnal**	**Khanna**
Mean (INR/100kg)	922.17	932.91	1027.64	939.66	924.01	931.73
Maximum(INR/100kg)	1152.00	1165.65	1192.40	1157.50	1140.00	1148.90
Minimum(INR/100kg)	718.30	749.05	852.30	745.15	739.30	736.65
Standard deviation	119.42	114.80	93.12	112.08	90.76	112.72
Skewness	-0.03	-0.01	0.01	-0.04	0.18	-0.02
Kurtosis	1.94	1.91	1.65	1.93	1.98	1.67
Instability (%)	8.34	8.27	7.24	6.58	7.77	7.84
GARCH estimates						
Mean equation	0.0004**	0.0008***	-0.0005*	0.0005**	0.0002	0.0009***
	(2.35)	(3.04)	(-1.68)	(2.20)	(0.55)	(8.45)
Constant	6.77E-06***	2.01E-06***	-8.01E-07*	2.38E-06***	1.13E-05***	1.96E-05***
	(9.23)	(5.55)	(-1.78)	(6.52)	(11.85)	(24.03)
Estimates of ARCH term (α_i)						
ε^2_{t-1}	0.4165***	0.2685***	0.4225***	0.1568***	0.0668***	0.5362***
	(27.06)	(11.32)	(4.86)	(7.70)	(4.00)	(17.71)
ε^2_{t-2}	--	--	--	--	0.2129***	1.5877***
					(10.70)	(39.94)
Estimates of GARCH term (β_i)						
σ^2_{t-1}	0.2960***	0.0289**	0.8121***	0.5213***	0.3136*	0.2260***
	(5.03)	(2.36)	(23.70)	(3.60)	(1.66)	(16.52)
σ^2_{t-2}	0.3108***	0.740555***	--	0.2890**	0.3765**	--
	(6.05)	(38.34)		(2.23)	(2.19)	
Log likelihood	4047.59	2710.75	1475.92	2858.99	2558.70	2563.40
GARCH fit	(2,1)	(2,1)	(1,1)	(2,1)	(2,2)	(1,2)
$\alpha_i + \beta_i$	1.02	1.04	1.23	0.97	0.97	2.35
Volatility	High	High	Very high	High	High	Explosive

Note: Figures in parenthesis indicate calculated z statistic.
*** Significant at one per cent level of probability (z statistic).
** Significant at five per cent level of probability (z statistic).
* Significant at 10 per cent level of probability (z statistic).

Table 10. Descriptive statistics of prices and estimates of GARCH model (ban period).						
Particulars	**Bareilly**	**Delhi**	**Indore**	**Kanpur**	**Karnal**	**Khanna**
Mean (INR/100kg)	1036.24	1109.51	1106.39	1034.79	1090.68	1112.42
Maximum(INR/100kg)	1105.40	1224.05	1215.00	1117.35	1205.00	1204.20
Minimum(INR/100kg)	972.50	1005.50	1022.50	969.30	981.25	1003.50
Standard deviation	28.68	50.52	44.79	37.72	48.64	48.32
Skewness	0.24	0.28	0.29	0.28	-0.11	-0.15
Kurtosis	2.07	2.47	2.23	2.05	3.11	2.65
Instability (%)	2.50	3.47	3.59	2.88	1.76	3.34
GARCH estimates						
Mean equation	-0.0004 (-1.14)	-1.96E-05 (-0.05)	9.52E-05 (0.54)	-0.0001 (-0.57)	0.0002 (0.4104)	-8.38E-06 (-0.24)
Constant	2.96E-05** (9.10)	2.63E-06* (2.02)	3.23E-07** (2.84)	3.90E-06** (5.28)	3.32E-05** (4.30)	1.67E-09 (1.19)
Estimates of ARCH term (α_i)						
ε^2_{t-1}	0.3353** (5.27)	0.0540** (3.87)	0.0217** (3.46)	0.1142** (6.09)	0.1449** (5.20)	0.2480** (5.03)
ε^2_{t-2}	--	--	--	--	--	0.4339** (7.84)
Estimates of GARCH term (β_i)						
σ^2_{t-1}	0.4184** (8.46)	0.9269** (44.23)	0.9665** (122.72)	0.8131** (29.15)	0.5701** (7.35)	0.1945** (1.77)
σ^2_{t-2}	--	--	--	--	--	0.4353** (5.08)
Log likelihood	1795.45	2000.61	3384.13	2290.62	2008.68	2771.60
GARCH fit	(1,1)	(1,1)	(1,1)	(1,1)	(1,1)	(2,2)
$\alpha_i + \beta_i$	0.75	0.98	0.99	0.93	0.71	1.31
Volatility	Medium	High	High	High	Medium	Very high

Note: Figures in parenthesis indicate calculated z statistic.
** Significant at one per cent level of probability (z statistic).
* Significant at five per cent level of probability (z statistic).

The $\alpha_i + \beta_i$ coefficients irrespective of the study period were either closer to 'one' or more than 'one" respectively indicating the persistence of volatility and explosiveness in wheat prices. The result also showed that the volatility for the current day depends on its preceding day for most of the markets as evident from the significant ARCH term. While comparing the periods under study, only a miniscule change was noticed in the ($\alpha_i + \beta_i$) coefficients. Again, the estimates of GARCH indicated that volatility was low during the ban period barring Khanna market prices, indicating the failure of futures trading. However, the reason behind persisting volatility during futures trading has to be addressed in a coherent way even though it is a characteristic feature of agricultural commodities.

Table 11. Descriptive statistics of prices and estimates of GARCH model (trading revival).

Particulars	**Bareilly**	**Delhi**	**Indore**	**Kanpur**	**Karnal**	**Khanna**
Mean (INR/100kg)	1265.99	1242.57	1262.45	1209.92	1304.00	1310.36
Maximum(INR/100kg)	1455.00	1454.70	1467.00	1390.00	1433.05	1551.70
Minimum(INR/100kg)	1065.00	1042.50	1106.75	1015.00	1110.00	1171.00
Standard deviation	86.86	98.99	91.41	93.76	97.10	84.65
Skewness	0.01	0.04	0.35	-0.06	-0.70	0.45
Kurtosis	2.26	2.32	2.19	2.19	2.03	2.47
Instability (%)	6.86	7.81	7.55	5.85	6.30	7.24
GARCH estimates						
Mean equation	7.99E-05 (0.34)	8.88E-05 (0.61)	6.99E-05 (0.42)	0.0002 (0.70)	-1.78E-05 (-0.06)	-7.57E-05 (-0.78)
Constant	4.17E-06* (5.47)	1.07E-06* (5.62)	1.27E-05* (8.00)	1.73E-06* (4.79)	9.67E-06* (8.57)	6.71E-07* (17.69)
Estimates of ARCH term (α_i)						
ε^2_{t-1}	0.1490* (11.74)	0.2619* (7.54)	0.1498* (4.58)	0.1601* (9.48)	0.1602* (7.78)	0.1268* (4.48)
ε^2_{t-2}		0.0813* (2.05)	0.1659* (3.81)			0.2510* (8.27)
Estimates of GARCH term (β_i)						
σ^2_{t-1}	0.8164* (51.79)	0.7345* (43.86)	0.3790* (5.56)	0.3801* (4.43)	0.7463* (28.70)	0.7340* (67.24)
σ^2_{t-2}	--	--	--	0.4483* (5.88)	--	--
Log likelihood	3404.42	2909.47	3988.94	2727.49	2546.40	3048.57
GARCH fit	(1,1)	(1,2)	(1,2)	(2,1)	(1,1)	(1,2)
$\alpha_i + \beta_i$	0.97	1.08	0.69	0.99	0.91	1.11
Volatility	High	High	Medium	High	High	High

Note: Figures in parenthesis indicate calculated z statistic.
* Significant at one per cent level of probability (z statistic).

Futures trading vis-à-vis Indian wheat farming

Agricultural commodity futures in a developed and stable economy having symmetry in information benefit the producers. But a developing and agrarian economy with a small scale production system like India has its own limitations. The awareness level among producers is below one per cent vis-à-vis 100 per cent (traders) and traders in general speculate rather than hedging (Sen, 2008). This stressed the importance of awareness creation among farmers who should be the ultimate beneficiary by taking advantage of hedging. Currently, futures trading in India is limited by the cumbersome trading procedures, conceptual difficulties due to high illiteracy rate of farmers, poor data base of commodity exchanges regarding producers' participation, contract size beyond the marketed surplus quantity and to a large extent absence of physical delivery (Velmurugan et al., 2010).

It is evident from Table 12 that barring Punjab with larger operational holdings and farm output, coupled with a huge marketed surplus per farmer (mean productivity x mean operational holdings x marketed surplus ratio) estimated at 14.68 tonnes, the rest of the country possesses marketed surplus much less than the contract size. The deficits across the states are furnished in Table 12. It was highest in Bihar (9.43 tonnes) followed by Himachal Pradesh (9.40 tonnes) and Uttar Pradesh (8.44 tonnes). This warrants an intervention from the market regulator to reduce the contract size or need for emergence of institutions like banks and co-operative societies to act as aggregators in pooling the farmers produce to meet the fixed contract size. State-wise level of aggregation required ranged from two farmers in Haryana and Gujarat to as high as18 in Bihar.

Table 12. Relevance of futures trading to Indian wheat producers.

State/Country	Marketed surplus ratio (2010-11)	Average productivity in tonnes/ha (2010-11)	Average operational holding* (ha)	Estimated marketed surplus (tonnes)	Contract quantity (tonnes)	Deficit or surplus (tonnes)	Aggregati on level of farmers
Bihar	74.58	1.95	0.39	0.57	10	-9.43	18
Gujarat	87.77	3.16	2.11	5.85	10	-4.15	2
Haryana	83.54	4.62	2.25	8.68	10	-1.32	2
Himachal Pradesh	39.48	1.53	0.99	0.60	10	-9.40	17
Madhya Pradesh	73.77	1.76	1.78	2.31	10	-7.69	4
Punjab	86.74	4.49	3.77	14.68	10	4.68	-
Rajasthan	44.41	2.91	3.07	3.97	10	-6.03	3
Uttar Pradesh	66.99	3.11	0.75	1.56	10	-8.44	6
India	**73.20**	**2.99**	**1.16**	**2.54**	**10**	**-7.46**	**4**

Note: This table shows the data compiled from NCDEX, indiastat and agmarknet portals for exhibiting the relevance of wheat futures to farmers in India. The * denotes the average operational holding of a farmer and is taken from the 2005-06 Agricultural Census for the above calculation. Monocropping is assumed for giving a meaningful inference.

Conclusions

In the ongoing debate on futures market vis-à-vis food inflation, the study examined the integration and transmission of wheat prices from the US futures to the domestic markets and between domestic futures and spot markets. Despite integration and price transmission between futures and spot prices in India, Indian wheat futures and US futures failed in Johansen's test.

Several inferences have been drawn from the market integration: Price transmission occurs due to the flow of market information which is a consequence of development in information technologies, the speed of convergence depends on the market regulations and policy changes, and market integration itself is one of the indicators for efficient functioning of markets. The analysis on extent of volatility in spot prices due to futures trading and in its absence indicated the persistence of volatility for all periods. However, the magnitude of the GARCH coefficients were low during the period in which ban was imposed. Yet, the probable reasons behind the persistence of volatility in wheat prices have to be enlightened in a logical manner. The present study though indicated the efficiency in price transmission pointed the inefficiency in price stabilisation. The study has drawn some policies for a more focused and pragmatic approach to increase the system's efficiency. Producers have to understand the principles and philosophies of futures trade to participate and reap the benefits of hedging. Further, market regulators should invest on propagating the concept by exploratory training programmes and exposure visits to commodity exchanges, and educating the producers since they are the ultimate beneficiaries. They should also consider downsizing the contract quantity and margin money to suit the small scale production system in India. At the same time, institutions like banks, co-operative societies and producers' union should be empowered to aggregate the marketed surplus to meet the desired contract quantity.

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