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Research Article

Price Discovery In Agricultural Commodity Markets: Empirical Evidence From India

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Abstract

The study examines long run equilibrium relationship between future and spot commodity markets for Channa, Gaur Seed, Soybean and Kapas using Johansen Cointegration. Vector Error Correction Model is used to capture Short Run Adjustment Process between integrated commodity markets. Empirical results show that except for Kapas all commodities are cointegrated and Future market plays a dominant role in the price discovery process.

1. Introduction

The role of derivatives in price discovery process has been extensively researched. Empirical literature studies price discovery of assets in two parts: long run equilibrium between future and spot market and short run adjustment process. The process of information transmission was studied by examining volatility and liquidity spillover between future and spot market. Researchers have examined price equilibrium between the future and spot commodity markets to determine static and dynamic price discovery process (Garbade and Silber, 1983; Bessler and Covey, 1991; Chowdhary, 1991; Yang and Leatham, 1999; Zapata et al. 2005; Bekiros and Diks, 2008). Garbade and Silber, 1983 developed a partial equilibrium model to test risk management and price discovery function[2] of future market. Thereafter, Engle and Granger developed the Theory of Cointegration in 1987, which tested price discovery on the basis of closeness between the current forward prices and future spot prices. Thus, if non stationary future and spot price series did not drift apart, they could be cointegrated. Also, the cointegrating relationship between these markets would imply long run equilibrium. Engle and Granger, 1987 specified an Error-

Correction Model (ECM) which captured short run adjustments for long run equilibrium. Many researchers used the theory of cointegration for identifying the price discovery process in future market (Hakkio and Rush, 1989; Bessler and Covey, 1991; Chowdhary, 1991). Brenner and Kroner, 1995 studied the existence of cointegration in the future and spot markets using noarbitrage, cost of carry asset pricing model. However, the underlying assumption of the ECM model that weakly exogenous variables are same in the long run and short run parameters has been criticized (Urbain, 1992). Also the power of the test gets greatly reduced if there are breaks in the cointegration relationship (Gupta and Guidi, 2012). Johansen's methodology (1988, 1991) is an improved approach to test multivariate cointegration analysis. The method determines the number of cointegrating vectors using trace test and max-eigen value test. A lot of recent research work on market cointegration has been done using Johansen cointegration (Hammoudeh et al., 2003; Deb, 2005; Roy, 2008; Worthington and Higgs, 2010; Gupta and Guidi, 2012). In the international context, it has been found that future trading improves the price discovery function of the US Wheat market (Yang and Leatham, 1999). Whereas empirical investigation on Indian market shows non-existence of long term equilibrium between the Wheat spot and future market prices (Roy, 2008).

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[2] Price discovery function determines whether new information is reflected first in changed futures prices or in changed cash prices.

Research work on the price discovery function performed by futures market primarily concentrates on financial asset and energy markets (Hakkio and Rush, 1989; Silvapulle and Moosa, 1999; Hammoudeh et al., 2003; Bekiros and Diks, 2007; Cheng and Ying, 2009). The empirical literature on agricultural commodity future is comparatively negligible. Therefore, one of the objectives of the current study is to fill this research gap and test Indian agricultural commodity for long term equilibrium and short run adjustment between future and spot market. The present study makes an attempt to throw light on the relationship and fill these important research gaps.

The study seeks to examine the long term equilibrium relationship between future and spot market, short run adjustment process between spot and future market for various commodities such as Channa, Kapas, Soybean and Gaur Seed.

2. Data and Product Profile

In the first phase of the study**,** the data consist of daily closing spot prices and futures prices for eight commodities Channa, Gaur Seed, Kapas and Soybean. 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 have been compiled from National Commodity & Derivative Exchange Limited (NCDEX) website (www.ncdex.com) for the data period from 1st January' 2003 to 31st December' 2013. As the Government of India allowed re-introduction of commodity futures in 2002 the derivative trading picked up after 2002. These commodities are chosen according to the highest trading volumes in the particular agricultural class as on 31st December' 2010. The daily closing spot prices and future prices are transformed to log of spot price series (ln P_{st}) and log of future price series (ln P_{ft}).

Product Profile Channa
It is a premiere pulse crop rich in proteins and is also known as chick pea. The Channa has two popular varieties, Desi and Kabuli. The Desi variety is smaller in size with a thick coat, whereas Kabuli is larger in size with thin seed coat. Around 50% of pulses produced in India by volume are Channa. India is the largest producer and importer of Channa. The crop is grown in rabbi season during winters and the peak arrival period is March-April. The lean arrival period for Channa is October-November. The future contracts for Channa open on 10th of every month and on expiry of the contract, it requires compulsory delivery. The expiry or the due date is on the 20th of the delivery month. The delivery centres for Channa are in Delhi, Bikaner and Indore. The contract note of NCDEX gives other specifications with regard to member position limit, client position limit and the final settlement price.

Gaur Seed
It is a cluster of beans which grows in semi-arid regions and very efficiently absorbs the ground water. A white-yellowish powder is extracted from Gaur Seed. This powder is used as emulsifier, thickener for a wide range of food products, cosmetics and pharmaceuticals. The crop is sown at the end of July and the peak arrival season is November. The country altogether produces 10-11 million tonnes of the crop every year. Rajasthan contributes to 70% of the production of Gaur Seed. Around 75% of the Gaur seed produced is exported every year. The future contract is traded for a minimum lot of 2 metric tons. The delivery centres are in Jodhpur and Bikaner. Other specifications with regard to position limits and product quality specifications are mentioned in the contract note of NCDEX.

Kapas
Kapas is also known as the raw cotton or seed cotton, which is a white fibrous substance. Through the process of ginning, the lint is separated from the seed. It is an important natural fibers and is used in almost half of the world textile industries. India exports around 4.7 million bales of cotton and produces 18% of the world production (about 27 million bales). Kapas is sown in MarchSeptember and is harvested during September-April. The peak arrival marketing season is November-March. The

delivery centre for Kapas is Surendra Nagar, Gujarat. And the contract expiry months are February, March and April. The unit of trading is 4 metric tons and other contract specifications are mentioned in the contract note of NCDEX.

Soybean

Soybean is also known as the golden bean. Whereby, after the crop is processed it is used as vegetable oil and protein feed for animals. Almost 75% of the oil is crushed and a small proportion of the crop is directly consumed. India is the fifth largest producer of Soybean. Soybean is sown in alluvial soil with hot summers. The crop is sown in June-July and harvests from September- December. The delivery centres for trade on NCDEX includes Indore, Nagpur and Kota. The contract launch months include February, March, April, May and June. The delivery unit for trade is 10 metric tons.

Descriptive Statistics

The Descriptive statistics of the Channa, Gaur Seed, Soybean and Kapas future and spot return series are reported in **Table 1**. For Channa, Soybean and Kapas the average prices of all future returns are higher than spot returns. In such a market situation where returns exhibit Contango the market traders are net long and the future prices would fall over the life of the contract. Whereas for Gaur seed, the market traders are net short and are trying to hedge the risk exhibiting Backwardation.

The statistics show that for return volatility most agricultural commodity markets like Channa, Gaur seed, Soybean the futures are more volatile than the spot. Whereas higher return volatility in the spot market has only been observed for Kapas.

Except for Kapas spot return series that exhibits asymmetric distribution and is positively skewed. All other negatively skewed return series have longer left tails and are concentrated on the right.

Except for Channa spot series all return series have a K higher than three indicating thicker tails and Leptokurtic distribution. Only Channa spot is 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.

Table 1: 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

3. Methodology Long Run Equilibrium Relationship between Spot and Future

This section is further sub-divided into two parts: Part 1, examines the order of integration of spot and future price series for all agricultural commodities and Part 2, deals with long-run equilibrium relationship between spot and future market for all agricultural commodities.

Cointegration

To examine cointegration between spot and future market it is necessary that the price series is non-stationary and stationary at return series. The stationarity of the the spot price ($\ln P_{st}$) and future price ($\ln P_{ft}$) series is examined using Augmented Dickey Fuller (ADF) test[3]. It is observed that for all the

[3] 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.

commodities, namely Channa, Gaur seed, Kapas, and Soybean 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, the spot and future series all integrated of order 1, viz. I(1) processes. Also, Johansen test can be applied to examine Cointegrating relationship between spot and future markets. The stationarity test results are given in **Table 2**.

Table 2: 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

Null Hypothesis : variable has a unit root

Johansen (1988) and Johansen & Juselius (1990, 1992) determine the cointegrating relationships between two or more series. If y_t is (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:

$$y_t = M + \Sigma^k{}_i \Pi_i y_{t-1} + e_t, \text{ (t=1, 2 ….T)} \quad (1)$$

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) can be expressed in first difference notation and formulate the error correction representation of y_t as:

$$\Delta yt = \Gamma 1 \Delta yt-1 + \cdots + \Gamma k-1 \Delta yt-k+1 + \Pi yt-1 + ut \quad (5.2)$$

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 matrix Π.

Johansen (1988) had 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:

$$\lambda_{trace} = -T\sum_{i=r+1}^{n} \ln (1 - \hat{\lambda}_i) \quad (3)$$

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:

$$\lambda_{max} = -T\sum_{i=r+1}^{n} \ln (1 - \hat{\lambda}_{r+1}) \quad (4)$$

Where λ_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 four agricultural commodities using the bivariate framework. The results of both the likelihood ratio tests are reported in **Table 3**. Out of all the four commodities only the future and spot market of Kapas is not cointegrated. Since both the statistics λ_{trace} and λ_{max} don't exceed the critical value with a 5% level of significance. The lack of integration between the spot market and the derivatives market shows non-existence of long run equilibrium. Commodities like Chana, Soybean indicate one cointegrating equation implying a single path of convergence towards equilibrium. Whereas Gaur seed 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.

Table 3: 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)	$\lambda trace$	Critical value (5%)	Prob. value	Decision
Channa	None	33.71439	15.49471	0	Indicates one cointegrating equation
	At most one	3.403142	3.841466	0.0651	
Gaur seed	None	1168.421	15.49471	0	Indicates two cointegrating equations
	At most one	23.29346	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	87.08134	15.49471	0	Indicates one cointegrating equation
	At most one	0.679378	3.841466	0.4098	

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	λmax	Critical value (5%)	Prob. value	Decision
Channa	None	30.31125	14.2646	0.0001	Indicates one cointegrating equation
	At most one	3.403142	3.841466	0.0651	
Gaur seed	None	1145.128	14.2646	0	Indicates two cointegrating equations
	At most one	23.29346	3.841466	0	
Kapas	None	6.161514	14.2646	0.5926	Indicates no cointegrating equation
	At most one	1.08837	3.841466	0.2968	
Soybean	None	86.40196	14.2646	0	Indicates one cointegrating equation
	At most one	0.679378	3.841466	0.4098	

Short Run Adjustment Process between Spot and Future Market

The second phase of the analysis involves two parts: Part 1, Vector Error Correction Model (VECM) and Part 2, Block Exogeneity Wald Test for examining the short run adjustment process between spot and future market.

Vector Error Correction Model (VECM)

The Error Correction Model explains the speed with which markets adjust to changes in past disequilibrium as well as changes in independent variables. It captures the magnitude of adjustment and corrected degree of disequilibrium in both the markets from one period to the next 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:

$\Delta y_{st},t = \alpha_1 i c_t - 1 + \beta_1 i \Delta y_{fut},t-1 + \beta_2 i \Delta y_{fut},t-2 + \gamma_1 i \Delta y_{st},t-1 + \gamma_2 i \Delta y_{st},t-2 + \varepsilon_1 i,t$ (5)

$\Delta y fut,t = \alpha 2 j c t-1 + \beta 1 j \Delta y fut,t-1 + \beta 2 j \Delta y fut,t-2 + \gamma 1 j \Delta y st,t-1 + \gamma 2 j \Delta y st,t-2 + \varepsilon 2 j,t$ (6)

In the above equations (5) & (6) c_{t-1} is the error correction term, where $c_{t-1} = (y_{fut,t-1} - \beta y_{st,t-1})$. The long run equilibrium of this error correction term is zero. If y_{st}(ln P_{st}) and y_{fut}(ln P_{ft}) deviate from the equilibrium the term will be non-zero and y_{st} and y_{fut} adjusts to restore the equilibrium relation. The coefficient $\alpha_{1i}$and α_{2j}measures the speed of adjustment of the variable towards equilibrium.

The study analyses Channa, Gaur seed and Soybean as they have significant one or more cointegrating equations. The results of VECM are reported in **Table 4.** 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 1-day lagged spot prices cause change in future market prices. It does not die with 1-day lagged price change and the 2-day lagged spot price change also influences future price change significantly. The 2-day lagged future price exerts shock to the spot market price change at 5% level of significance even though 1-day lagged future price change fails to do so. The significant adjustment in the short term is -0.02% for spot prices and -0.21% for future Gaur seed prices. The overall results indicate that spot prices changes influences future market. 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 Gaurseed future market plays a dominant role in spot price change. In Gaurseed, although both the markets influence each other simultaneously, spot markets have a stronger effect on the future price change.

Table 4 Vector Error Correction Model
Panel A: VECTOR ERROR CORRECTION ESTIMATE RESULTS FOR CHANNA

	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

	D(SP)	D(FP)
CointEq1	-0.02238	-0.21876
	[-2.25706]**	[-25.5280]*
D(FP(-1))	-0.01883	0.063479
	[-0.86201]	[3.36236]*
D(FP(-2))	0.049499	0.016924
	[2.26791]**	[0.89714]
D(SP(-1))	0.079468	-0.18
	[3.32588]*	[-8.71625]*
D(SP(-2))	-0.07915	-0.20984
	[-3.26764]*	[-10.0227]*
C	0.001453	0.001948
	[3.31963]*	[5.14949]*

(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 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 ±2.576 and ± 1.96)

Granger Causality/ Block Exogeneity Wald Test

The Block Exogeneity Test examines bilaterally if the lags of the excluded variable affect endogenous variable. For the given VAR equations (5) & (6) the following hypothesis are tested:

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

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

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 5** at1**%** and 5% level of significance. The table reveals that all commodities except for Gaur Seed, future price change granger causes spot price change. For Gaur Seed, spot price change granger causes future price change. The table also exhibits bilateral causality for Soybean with the causal direction being dominant from future market to spot market.

Table 5: 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	
Soybean	**D(FP)**	134.9092	**2**	**0**	*
	All	134.9092	**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	*
Soybean	D(SP)	23.89432	2	0	*
	All	23.89432	2	0	*

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

4. Summary and Conclusion

Results show that for all commodities except Kapas, future and spot market is cointegrated with one or two cointegrating vectors. 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 for Channa, Gaur seed and Soybean commodities which were examined for short term adjustment process, future market plays a dominant role in spot price change for Channa and Soybean. In the study, Gaur seed spot market causes future price change. 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.

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