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Future Trading in Soybean - An Econometric Analysis

S.P. Bhardwaj, Ranjit Kumar Paul and Ashok Kumar
ICAR-Indian Agricultural Statistics Research Institute, New Delhi

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SUMMARY

Commodity future has a vital role to play in any economy as the future contracts perform two important functions of price discovery and price risk management. The present study has been undertaken to examine whether the future and cash markets follow the efficiency criterion in trading Soybean for discovering better price. Seven non-overlapping future contracts maturing on March 2008 to September 2010 and secured at NCDEX has been examined. Johansen's cointegration test (1988) between future and spot price at Indore was carried out for each future contract of Soybean. The future and spot markets in NCDEX exchange are cointegrated and sharing a long run relationship. The two statistical tests, Trace Statistics and Eigen Value Statistics confirm the relationship of short and long run between spot and future price of soybean. There is a causality flow from future markets towards spot markets indicating information flow from future to spot markets. At the same time, there is also a reverse information flow happening in some contracts signifying price discovery in both future and spot markets. This finding, to a large extent, answers to the apprehensions of destabilizing impact of commodity future markets in India. The Johansen's vector error correction model (VECM) indicates that the future market leads the spot market in most of the contracts whereas in two contracts spot prices also tends to discover new information more rapidly than future prices.

Keywords: Cointegration, Price discovery, Risk management, Unit Root.

1. INTRODUCTION

The commodities market in India has been governed by short-term policy measures influenced by sociopolitical considerations. As a result, the commodities markets in India observed a restricted growth over the period of time. The need for a long-term national policy on commodities markets can be viewed from the objectives of food security and rapid growth in agricultural production. The policy also needs to serve the purpose of higher returns to the farmers. Commodity future has a vital role to play in any economy as the future contracts perform two important functions of price discovery and price risk management. It also facilitates integrated price structure throughout the country and ensures price stability. Price Discovery is the process of determining the price level for a commodity based on supply and demand conditions in a free market place. The significance of price discovery depends upon a close relationship between future and spot prices. Price discovery may occur in a future or cash market. The buyers and sellers communicate this information through prices at which they intend to take or provide delivery of respective commodities at a future date. These prices indicate the most likely price scenario of respective commodities at a future point in time. The efficiency of the process of price discovery for any commodity can be measured by the trading intensity of the contract on the platform. All physical markets converge to one price bringing in spatial integration, which is facilitated by a national online exchange. There is absence of perfect market conditions in the physical markets and the price discovery on the future exchanges provides right prices

Corresponding author: S.P. Bhardwaj
E-mail address: bhardwaj@iasri.res.in

in advance. This process is more efficient as a large number of buyers and sellers trade with little or virtually no intermediation. In the case of agricultural commodities, price discovery helps efficient resource allocation in the rural economy enabling maximum returns to its growers. Ferretti and Gonzalo (2007) studied modelling and measuring of price discovery in commodity markets using an equilibrium model of commodity spot (S_t) and future (F_t) prices, with finite elasticity of arbitrage services. The theoretical model is able to capture the existence of backwardation in the long-run spot-future equilibrium relationship. In this paper the theoretical possibility of finding a co-integrating vector is considered.

Carlberg *et al*. (2003) developed alternative theories and empirical approaches to price discovery with an application to fed cattle. They found out that, in the Bombay market, future markets prices dominate spot market price in all contracts, but in Ahmedabad, neither the future nor the spot market dominates in price discovery. Across the two markets, even though Bombay has much smaller volumes, there is a clear dominance of the Bombay future prices over the Ahmedabad prices for all contracts, except for the contract maturing at the time of harvest. In this contract, the Ahmedabad future market price dominates over the Bombay future market prices. A further result is that for the contract maturing at harvest, future market prices are dominated by the spot market prices in Ahmedabad. In the harvest period, the spot market reacts to information faster than the future market. Pradhan and Bhat (2009) investigated price discovery, information and forecasting in Nifty future markets. Srivastava *et al*. (2009) studied the commodity future market and its role in Indian economy. Cooke and Robles (2009) investigated the food price movements in the time series frame work. Estrades and Terra (2012) studied commodity prices, trade, and poverty in Uruguay. Zheng *et al*. (2012) studied price discovery in the Chinese soybean future market.

In the present investigation, an attempt has been made to examine whether the future and cash markets follow the efficiency criterion in trading soybean for discovering better price. The main objectives of the study are: (i) to study the order of integration between spot and future price series and (ii) to study the comparative performance of different future contracts in price discovery process.

2. MATERIAL AND METHODS

2.1 Dataset

The secondary data of seven Non-Overlapping future contracts maturing on March 2008 to September 2010 are obtained from National Commodity and Derivatives Exchange (NCDEX) and the spot price of Indore market has been used in the study.

2.2 Testing Stationarity

The stationary condition of the data series needs to be verified before proceeding for analysis. The most widely used tests for stationarity are Augmented Dickey Fuller (ADF) test by Dickey and Fuller (1979) and unit root test by Phillips and Perron (1988). Both would test the null hypothesis that the series has unit root or the series is non-stationary.

2.2.1 Augmented Dickey Fuller (ADF) Tests

The unit root test described by Dickey and Fuller (1979) is valid if the time series y_t is well characterized by an AR(1) with white noise errors. Many financial time series, however, have a more complicated dynamic structure than is captured by a simple AR(1) model. Said and Dickey (1984) augment the basic autoregressive unit root test to accommodate general ARMA(p, q) models with unknown orders and their test is referred to as the augmented Dickey-Fuller (ADF) test. The ADF test tests the null hypothesis that a time series y_t is I(1) against the alternative that it is I(0), assuming that the dynamics in the data have an ARMA structure. The ADF test is based on estimating the test regression

$$\Delta y_t = \boldsymbol{\beta}'\mathbf{D_t} + \pi y_{t-1} + \sum_{j=1}^{p} \psi_j \Delta y_{t-j} + \varepsilon_t \tag{1}$$

where $\mathbf{D_t}$ is a vector of deterministic terms (constant, trend etc.). The p lagged difference terms, Δy_{t-j} are used to approximate the ARMA structure of the errors, and the value of p is set so that the error ε_t is serially uncorrelated. The error term is also assumed to be homoscedastic. Under the null hypothesis, Δy_t is I(0) which implies that $\pi = 0$. The ADF t-statistic is then the usual t-statistic for testing $\pi = 0$.

2.2.2 Phillips-Perron Unit Root Tests

Phillips and Perron (1988) developed a number of unit root tests that have become popular in the analysis of financial time series. The Phillips-Perron (PP) unit root tests differ from the ADF tests mainly in how they deal with serial correlation and heteroscedasticity in the errors. In particular, where the ADF tests use a parametric auto-regression to approximate the ARMA structure of the errors in the test regression, the PP tests ignore any serial correlation in the test regression. The test regression for the PP test is

$$\Delta y_t = \boldsymbol{\beta}'\mathbf{D}_t + \pi y_{t-1} + u_t \qquad (2)$$

where u_t is I(0) and may be heteroscedastic. The PP test corrects for any serial correlation and heteroscedasticity in the errors u_t of the test regression by directly modifying the test statistics. Under the null hypothesis that $\pi = 0$, the PP statistics have the same asymptotic distributions as the ADF t-statistic. One advantage of the PP test over the ADF test is that the PP test are robust to general forms of heteroscedasticity in the error term u_t. Another advantage is that the user does not have to specify a lag length for the test regression.

2.3 Cointegration

Vector autoregressive (VAR) based cointegration test developed by Johansen (1991, 1995) has been used to investigate the long-run relationship between spot and future prices. Consider a VAR of order p:

$$y_t = A_1 y_{t-1} + ... + A_p y_{t-p} + Bx_t + \varepsilon_t \qquad (3)$$

where y_t is a $k \times 1$ vector of non-stationary I(1) spot and future price variables, x_t is a $d \times 1$ vector of deterministic variables, and ε_t is a vector of innovations. We may rewrite this VAR as,

$$\Delta y_t = \prod y_{t-1} + \sum_{i=0}^{p-1} \Gamma \Delta y_{t-i} + Bx_t + \varepsilon_t \qquad (4)$$

where

$$\prod = \sum_{i=1}^{p} A_i - \mathrm{I}, \Gamma_i = \sum_{j=i+1}^{p} A_j \qquad (5)$$

Granger's (1986) representation theorem asserts that, if the coefficient matrix Π has reduced rank $r < k$, then there exist $k \times r$ matrices α and β each with rank r such that $\Pi = \alpha\beta'$ and $\beta' y_t$ is I(0). Where, r is the number of cointegrating relations (the cointegrating rank) and each column of β is the cointegrating vector. The elements of α are known as the adjustment parameters in the VEC model. Johansen's method is used to estimate the Π matrix from an unrestricted VAR model and to test whether we can reject the restrictions implied by the reduced rank of Π.

2.3.1 Number of Cointegrating Relations

Johansen (1988, 1991) derived the distribution of two test statistics for the null of no cointegration referred to as the trace and the maximum eigen value test. The trace statistic tests the null hypothesis of 'r' cointegrating relations against the alternative of 'k' cointegrating relations, where 'k' is the number of endogenous variables, for $r = 0, 1, ... k - 1$. The trace statistic for the null hypothesis of 'r' cointegrating relations is computed as:

$$\mathrm{LR}_{tr}(r \mid k) = -T\sum_{i=r+1}^{k} \log(1-\lambda_i)\binom{n}{k} \qquad (6)$$

where λ_i is the i-th largest eigenvalue of the Π matrix.

The maximum eigen value statistics tests the null hypothesis of r cointegrating relations against the alternative of $r + 1$ cointegrating relations. The test statistic is computed as follows:

$$\begin{aligned} \mathrm{LR}_{\max}(r|r+1) &= -T\log(1-\lambda_{r+1}) \\ &= \mathrm{LR}_{tr}(r|k) - \mathrm{LR}_{tr}(r+1|k) \qquad (7) \\ &\text{for } r = 0, 1, k-1. \end{aligned}$$

The trace statistic (λ trace) tests provide for the number of cointegrating vectors is less than or equal to r. The Eigen value test statistic (λ max) tests the null hypothesis that the number of cointegrating vectors is r against an alternative of $r + 1$. Johansen and Jueselins (1990) provide the critical values of these statistics. The rank of Π may be tested using the λ max and λ trace. If rank (Π) = 1, then there is single cointegrating vector and Π can be factorized as $\Pi = \alpha\beta'$, where α and β are 2×1 vectors. The β represents the vector of cointegrating parameters and α is the vector of error correction coefficients measuring the speed of convergence in the long-run.

3. PRICE DISCOVERY AND SPEED OF PRICE ADJUSTMENT MECHANISM

3.1 Error Correction Model

Johansen's (1988) Vector Error Correction Model (VECM) is employed to investigate the causal relationship between spot and future prices. The null hypothesis is that, price change in future market will bring about price change in the spot market. The general form of linear relationship in the two markets can be seen as follows

$$F_t = \alpha + \beta S_t + \mu_t \quad (8)$$

The long run equilibrium relation between two market prices can be viewed in residual form as

$$F_t - \alpha - \beta S_t = \hat{\mu}_t \quad (9)$$

where F_t and S_t are future and spot price of Soybean in two markets at time t. α and β are intercept and coefficient terms respectively and $\hat{\mu}_t$ is estimated disturbance term. If spot and future prices are cointegrated, then causality must exist at least in one direction (Granger 1986). To test the causality, the following vector error correction model (VECM) is estimated by using ordinary least square (OLS) in each equation. The following form of Error Correction Model can be fitted to examine relationship between two markets over time.

$$\Delta F_t = \delta_f + \alpha_f \hat{\mu}_{t-1} + \beta_f \Delta S_{t-i} + \gamma_f \Delta F_{t-i} + \varepsilon_{fs} \quad (10)$$

$$\Delta S_t = \delta_s + \alpha_s \hat{\mu}_{t-1} + \beta_s \Delta F_{t-i} + \gamma_s \Delta S_{t-i} + \varepsilon_{sf} \quad (11)$$

In the equation (10) and (11), the term $(\hat{\mu}_{t-1})$ is referred as the equilibrium error which explains that how the dependable variables adjust themselves to the previous period's deviation from long run equilibrium. β_f, β_s, γ_f and γ_s are the short run coefficients which represents the short run effect of previous period's change in price on current period's deviation.

In terms of the vector error correction model (VECM) of equation (10) and (11), S_t Granger causes F_t if some of the α_f coefficients are not zero and α_f is significant at the conventional levels. Similarly, F_t Granger Causes S_t if some of the β_s coefficients are not zero and α_s, the error correction coefficient in the equation for spot prices is significant at conventional levels. These hypotheses can be tested by using either t-tests or F-tests on the joint significance of the lagged estimated coefficients. If both F_t and S_t Granger cause each other, then there is a bi-directional relationship between the two markets. The Error Correction Coefficients, α_s and α_f serve two purposes.

(i) To identify the direction of relationship between spot and future prices and

(ii) To measure the speed at which deviations from the long-run equlibrium are corrected by changes in the spot and future prices.

The basic requirement of an ECM is at least one coefficient must be non zero. The coefficient serves the role of identifying the direction of causal relation and shows the speed at which departure from equilibrium is corrected. If α_f is statistically insignificant, the current period's change in future price does not respond to last period's deviation from long run equilibrium. If both α_f and β_f are statistically insignificant, the spot price has no causal relation with future price. Similarly, if both α_s and β_s are statistically insignificant, the future price has no causal relation with spot price. In such cases the process of price discovery may not occur in the trading contract.

4. RESULTS

Seven non-overlapping future contracts maturing on March 2008 to September 2010 and secured at NCDEX has been examined. The detail of each contract is given in Table 1. A perusal of Table 1 showed that the average trading volume of Soybean remained in between 14235 to 31485 metric tons. However the number of trading days remained about 138 days.

Table 1. Future trading in Soybean at NCDEX

Nos.	Contract Expiry Month	No. of Trading days	Volume Soybean Traded (Tonnes)	
			Maximum	Mean
1	March 2008	138	249940	31485.51
2	August 2008	138	62680	14235.58
3	January 2009	136	91140	23515.07
4	June 2009	133	92060	18537.52
5	November 2009	139	141050	29047.70
6	April 2010	135	84180	25952.74
7	September 2010	138	231260	30211.30

Dickey Fuller (DF), Augmented Dickey Fuller (ADF) and Phillips Perron (PP) tests were applied to future and spot prices to test the presence of unit root. The results of these tests for future and spot prices are given in Table 2 and Table 3 respectively. The result shows that, the null hypothesis of unit root in both the

Table 2. Unit root tests of logged future price series of Soybean

Contracts	Unit Root Tests	On Levels		On First Difference	
		Unit Root Statistics	critical value at 1% level	Unit Root Statistics	critical value at 1% level
Mar-08	DF	–2.272	–3.536	–10.917	–3.536
	ADF	–2.005	–4.026	–11.278	–4.026
	PP	–2.118	–4.026	–11.276	–4.026
Aug-08	DF	–1.710	–3.536	–5.488	–3.536
	ADF	–2.060	–4.026	–10.015	–4.026
	PP	–2.051	–4.026	–9.919	–4.026
Jan-09	DF	0.065	–3.536	–12.094	–3.536
	ADF	0.286	–4.026	–12.564	–4.026
	PP	0.667	–4.026	–12.671	–4.026
Jun-09	DF	–1.219	–3.536	–7.717	–3.536
	ADF	–0.563	–4.026	–9.354	–4.026
	PP	–0.661	–4.026	–9.348	–4.026
Nov-09	DF	–1.198	–3.536	–10.155	–3.536
	ADF	–1.038	–4.026	–11.043	–4.026
	PP	–1.102	–4.026	–11.062	–4.026
Apr-10	DF	–1.438	–3.536	–10.027	–3.536
	ADF	–2.432	–4.026	–9.987	–4.026
	PP	–2.632	–4.026	–9.978	–4.026
Sep-10	DF	–1.623	–3.536	–9.844	–3.536
	ADF	–1.475	–4.026	–10.424	–4.026
	PP	–1.758	–4.026	–10.435	–4.026

Table 3. Unit root tests of logged spot price Indore market series of Soybean.

Contracts	Unit Root Tests	On Levels		On First Difference	
		Unit Root Statistics	critical value at 1% level	Unit Root Statistics	critical value at 1% level
Mar-08	DF	–2.177	–3.536	–9.894	–3.536
	ADF	–2.075	–4.026	–11.863	–4.026
	PP	–2.116	–4.026	–11.867	–4.026
Aug-08	DF	–1.514	–3.536	–4.325	–3.536
	ADF	–1.515	–4.026	–10.520	–4.026
	PP	–1.491	–4.026	–10.487	–4.026
Jan-09	DF	–0.257	–3.536	–10.866	–3.536
	ADF	–0.084	–4.026	–11.507	–4.026
	PP	–0.090	–4.026	–11.507	–4.026
Jun-09	DF	–1.545	–3.536	–2.690	–3.536
	ADF	–1.704	–4.026	–10.910	–4.026
	PP	–1.981	–4.026	–10.924	–4.026
Nov-09	DF	–0.840	–3.536	–10.427	–3.536
	ADF	–0.968	–4.026	–10.892	–4.026
	PP	–1.039	–4.026	–10.889	–4.026
Apr-10	DF	–1.577	–3.536	–10.609	–3.536
	ADF	–2.938	–4.026	–10.707	–4.026
	PP	–3.019	–4.026	–10.707	–4.026
Sep-10	DF	–1.603	–3.536	–9.456	–3.536
	ADF	–1.931	–4.026	–10.353	–4.026
	PP	–1.931	–4.026	–10.309	–4.026

series cannot be rejected. Thus data series is subjected to first differencing to make the data stationary. The unit root test on differenced series indicated that, in all the contracts the null hypothesis is rejected. The series became stationary at one differencing and the data is now ready for further econometric analysis.

Johansen's cointegration test (1988) between future and Indore spot price was carried out for each future contract of Soybean and the results are given in Table 4. In the present study, the number of cointegrating vectors (r) can be at most one as there are only two series in each group. In all the contracts, trace statistics show that the null hypothesis of future and spot prices are not cointegrated ($r = 0$) against the alternative of one or more cointegrating vectors ($r > 0$) is rejected. Next, the null hypothesis of $r < 1$ against the alternative of two or more cointegrating vectors cannot be rejected at 5 percent significance level for all the cases. The presence of single cointegrating vector in all cases shows that there exists long run relationship between future and spot prices. Similarly, eigen value statistics rejects the null hypothesis of equal to or less than one cointegrating equation against the alternative hypothesis of one equation. The two statistical tests confirm the relationship of short and long run between spot and future price of Soybean.

Table-4. Cointegration Test Results

Contracts	Null Hypothesis No. of CE(s)	Altern-ative Hypo-thesis	Trace Statistic	5% level Critical Value	Max-Eigen Statistics	5% level Critical Value
March-2008	None	r ≥ 0	68.650	25.872	39.611	19.387
	At most 1	r ≥ 1	9.038	12.517	9.038	12.517
August-2008	None	r ≥ 0	85.622	25.872	53.037	19.387
	At most 1	r ≥ 1	10.585	12.517	11.585	12.517
January-2009	None	r ≥ 0	50.980	25.872	28.994	19.387
	At most 1	r ≥ 1	10.985	12.517	11.985	12.517
June-2009	None	r ≥ 0	54.231	25.872	33.695	19.387
	At most 1	r ≥ 1	10.536	12.517	10.536	12.517
Nov-2009	None	r ≥ 0	61.394	25.872	34.221	19.387
	At most 1	r ≥ 1	9.172	12.517	10.172	12.517
April-2010	None	r ≥ 0	52.628	25.872	35.515	19.387
	At most 1	r ≥ 1	9.113	12.517	10.113	12.517
Sept-2010	None	r ≥ 0	47.996	25.872	25.170	19.387
	At most 1	r ≥ 1	11.825	12.517	9.825	12.517

Accordingly Error Correction Model (ECM) is applied to the series and results are reported in Table 5. The significant results of ECM as given in Table 5 are as follows.

1. The basic requirement of an ECM is at least one coefficient *i.e* α or β must be non zero has been qualified in spot market, as the value of α_s remained positive in all the contracts. The same statement holds valid for future market in all the future contracts.
2. The coefficient α_f is statistically significant in all the contracts, it implies that the current period's change in future price respond to the last period's deviation from the long run equilibrium.
3. The coefficient α_f and β_f are statistically significant, which implied that spot price has causal relation with future price.
4. Similarly both α_s and β_s are statistically significant in some contracts whereas insignificant in others, it implies that the future price has causal relation with spot price only in those contracts. This statement revealed that bi-directional relationship between spot and future market exists only in some contracts. Whereas in remaining contracts the spot market acts as a satellite market.

Table 5. Speed of price adjustment in future and spot market of Soybean using ECM approach

	Future Contracts						
Coefficients	Mar-08	Aug.-08	Jan-09	Jun-09	Nov-09	Aprii-10	Sept.-10
α_f	**0.376**	**0.339**	**0.215**	**0.396**	**0.279**	**0.223**	**0.183**
β_f	--	--	**–0.143**	--	**–0.181**	--	0.065
γ_f	--	0.336	--	0.244	0.279)	--	--
δ_f	4.138	3.340	0.858	1.603	0.823	–3.229	0.477
α_s	0.112	0.138	0.017	0.046	0.002	0.053	0.024
B_s	**–0.361**	--	–0.026	--	--	–0.223	–0.171
γ_s	**0.586**	0.308	0.452	0.364	0.518	0.614	0.520
δ_s	3.565	2.186	–3.368	2.138	–1.342	–1.099	–0.129

5. In terms of price discovery, the coefficients β_s and β_f either both or at least one found to be significant in all the contracts. This statement signifies the facts that better price were discovered in most of the future contracts.
6. In short run adjustment, the comparatively higher value of β_f (ranging from 0.065 to 0.282 in different contracts) indicates that, the spot price adjusts or converges to the future price to the large extent even in the short run as compared to the β_s (future price adjustment).
7. The speed with which deviations from the long-run relationship are corrected by changes in the spot and future prices for each contract revealed that the value of α_f was observed to be significantly higher indicating that the future price series have a greater speed of adjustment to the previous period's deviation from long-run equilibrium than the spot price series. This finding is consistent with the fact that on the delivery date of each contract the future price has to adjust itself to the prevailing spot price.
8. The results reveal that there is causality from future to spot in most of the contracts *i.e*., future market leads the spot market.

5. CONCLUSION

The purpose of this study was to empirically examine whether future markets help in discovering the better price for Soybean in India or not. The results from unit root tests indicate that future and spot prices were not stationary at their levels, but became stationary at their first difference. The future and spot markets in NCDEX exchange are cointegrated and sharing a long run relationship. There is a causality flow from future markets towards spot markets indicating information flow from future to spot markets. At the same time, there is also a reverse information flow happening in case of August 2008 and June 2009 contracts signifying price discovery in both future and spot markets. The Johansen's VECM results indicate that the spot market leads the future market and spot prices tend to discover new information more rapidly than future prices. The results further revealed the importance of the long-run relationship between the future and the spot prices in forecasting future spot prices. This finding, to a large extent, answers to the apprehensions about the destabilizing impact of commodity future markets in India. It has also been reported that the future market leads the spot market in most of the contracts whereas in two contracts spot prices also tends to discover new information more rapidly than future prices.

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