Efficiency of Commodity Markets: A Study of Indian Agricultural Commodities

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Abstract

This paper examines the efficiency in Indian agricultural commodity futures market which has grown phenomenally over last decade. We analysed the long run and short run relationships using cointegration and error correction models. The Results show market efficiency for each commodity in the long run and exhibit inefficiencies in short run.

Keywords:

Agricultural Futures, Cointegration, Error Correction

JEL Classification: G14; C12; C32

Introduction

Efficient futures markets provide a mechanism for managing the risk associated with the uncertainty of future events. The value of futures markets arises from their ability to predict the price of a given asset at a specified future date efficiently and without bias. A market may be defined as efficient in the informational sense if the prices of the assets traded on that market instantaneously reflect all available information. This definition is strong one and in terms of weak definition prices will reflect all available information up to the point where the cost of acquiring additional information is equal to the benefits derived from that information. Efficiency will be achieved through arbitrage between traders.

Market efficiency also implies that futures market prices are equal to expected future spot prices and risk premium which may be constant or time varying. Alternatively, if markets are efficient and if no risk premium is present futures prices will be unbiased predictors of future spot prices only. Under the conditions of market efficiency and risk neutrality, we can frame the hypothesis that futures prices provide unbiased forecasts of spot prices. The concept of market efficiency is to be understood while taking time dimensions into consideration i.e. Markets may be efficient and unbiased in the long run, but may experience short-run inefficiencies and pricing biases. The objective here is to test empirically the two separate hypotheses of market efficiency and unbiasedness in the long-run for four different commodity futures markets, chilli, Jeeera, pepper and turmeric and also determine if any short-run inefficiencies or pricing biases exist in these markets.

Literature Review

Futures market efficiency is one of the most extensively researched topics in the empirical literature but minimal work is done on the efficiency of Indian agricultural commodity futures. Some of the studies are highlighted here; Gosh (1993) investigated the spot and futures index and found cointegration between two in long run. Chowdhary (1991) examined the efficiency of futures for commodities copper, led, tin, and zinc in London Metal Exchange. Beck (1994) tested market efficiency in commodities (cattle, orange juice, corn, copper, and cocoa) futures markets. Beck concluded that all five markets are inefficient at times but efficiency cannot be rejected all the time. Williams et al (1998) studied the development and characteristics of Mung Bean trading at The Zhengzhou Commodity Exchange (CZCE). By examining price differentials in the same crop year between different futures contracts, they concluded arbitrage conditions exist in the CZCE. Kellard et al (1999) analysed the relative efficiency of commodity futures markets. They studied the unbiasedness and efficiency using a cointegration methodology across a range of financial and commodity futures markets, and developed a measure of relative efficiency. The findings suggested spot and futures prices are cointegrated. However, there is evidence of short run inefficiencies and spot price changes are explained by basis and lagged differences in futures and spot prices. Naik and Gopal (2001) used co-integration theory to examine the efficiency and unbiasedness of nine commodities in twenty exchanges of Indian commodity futures market. Their results of efficiency varied across exchanges and commodities. Holly and Ke (2002) investigated the efficiency of Chinese agricultural futures markets and concluded mixed results market is efficient in case of soybean and inefficient in case of wheat. Mckenzie and Holt (2002) examined market efficiency and unbiasedness for four agricultural commodity futures (live cattle, hags, corn and soybean meal) The results indicated that live cattle, hogs, corn and soybean meal futures markets are both efficient and unbiased in long run, however, the results showed some inefficiencies and pricing biases in short run. Sahadevan (2003) investigated the relationship between price return, volume, market depth and volatility in Indian agricultural commodities market. The sample consisted of 12 markets and six commodities. The results suggest that return and volatility of futures as well as spot markets does not significantly influence markets volume and depth. Mazighi (2003) rejected the efficiency of natural gas futures markets on both International Petroleum Exchange (IPE) in London and the New York Mercantile Exchange (NYMEX) in US.

Kenourgios and Samitas (2004) suggested the inefficiency of Copper futures market in London Metal Exchange (LME). Raizada and Sahi (2006) studied about the commodity futures market efficiency in India and analysed its effect on social welfare and inflation in the economy, the results indicate that the commodity futures market is not efficient in short run and growth in commodity futures markets has a significant impact on the inflation in the economy.

Data

The data used in the study is of spices traded on NCDEX Platform. The commodities include; Barley, Channa, Chilli, Guar Gum, Guar Seeds, Jeera, Pepper, Refined Soy Oil, Soy Bean and Turmeric. Depending upon the availability of futures contract different data periods were used for different commodities. For Channa, Chilli, Guar Gum, Guar Seeds, Jeera , Refined Soy Oil, Soy Bean and pepper the data set used is from March 2006 to Dec 2011, Barley from Mach 2007 to Dec 2011 and for turmeric the data used is from March 2009 to Dec 2011. We have used the daily closing spot prices and futures prices (of near month contract). All the data has been collected from NCDEX. To generate the continuous series of futures prices every month roll over was done.

Methodology

If spot and futures prices are both nonstationary and require first differencing to render each series stationary, then in general most linear combinations of the two series will also be nonstationary. A cointegrating vector may, however, exist that makes a specific linear combination of the two series stationary. For example, if u_t in

$$U_t = S_t - \alpha - \delta F_{t-1} \quad (1)$$

is a stationary series, α and δ are the cointegrating terms and the regression $S_t = \alpha + \delta F_{t-1} - u_t$ is the cointegrating or equilibrium regression. The stochastic relationship in Equation 1 implies that in the long run S_t and F_{t-1} cannot move too far apart from each other despite the fact that they are both nonstationary .

When spot and futures prices for a commodity are non-stationary, the existence of a cointegrating relationship between the two is a necessary but not a sufficient condition for short-run market efficiency and unbiasedness. Since Spot and futures prices are determined by the same fundamentals so efficiency means that they cannot move too far apart. However, short-run market inefficiencies and pricing biases are not ruled out by the existence of a cointegrating vector, whereby past information may improve market predictions of future spot prices.

Johansen's methodology takes its starting point in the Vector Autoregression (VAR) of order *p* given by

$$y_t = \mu + A_1 y_{t-1} + \ldots\ldots + A_p y_{t-p} + \varepsilon_t \qquad (2)$$

Where y_t is an nx1 vector of variables that are integrated of order one- commonly denoted I(1) – and $\boldsymbol{\varepsilon}_t$ is an *n*x1 vector of innovations. This VAR can be re-written as

$$\Delta y_t = \mu + \prod y_{t-1} + \sum_{t=1}^{p-1} \Gamma_i \Delta y_{t-1} + \varepsilon_t \qquad (3)$$

Where

$$\Pi = \sum_{i=1}^{p} A_i - I and \Gamma_i = - \sum_{j=i+1}^{p} A_j$$

if the coefficient matrix $\prod$ has reduced rank $r<n$, then there exist *nxr* matrices α and β each with rank *r* such that

$\Pi = \alpha\beta' and \beta' y_t$ is stationary. *r* represents the number of cointegrating relationships, each column of β is a cointegrating vector and the elements of α are known as the adjustment parameters in the vector error correction model. For a given r it can be shown that, the maximum likelihood estimator of β defines the combination of y_{t-1} that yields the r largest canonical correlations of Δy_t and Δy_{t-1} after correcting for lagged differences and deterministic variables when present. Two different likelihood ratio tests proposed by Johansen of the significance of these canonical correlations and thereby the reduced rank of the **Π** matrix are the trace test and maximum eigen value test, shown in equations below;

$$j_{trace} = -T \sum_{i=r+t}^{n} \ln(1 - \hat{\lambda}_i) \qquad (4)$$

$$j_{\max} = -T \ln(1 - \hat{\lambda}_{r+1}) \qquad (5)$$

Where T is the sample size and $\hat{\lambda}_1$ is the i^{th} highest canonical correlation. The trace test of Jhonson tests the null hypothesis that there are *r* cointegrating vectors against the alternative hypothesis of *n* cointegrating vectors. On the other hand the maximum eigen value test, tests the presence of *r* cointegrating vectors (null hypothesis) against the alternative hypothesis of r+1 cointegrating vectors.

A co integrated time series may be rewritten in error correction form (Granger 1986). Such a transformation renders the series stationary, and allows for standard hypothesis testing. A prototypical ECM useful for testing the short-run relationship between spot and futures prices may be specified as

$$\Delta S_t = -\rho u_{t-1} + \beta \Delta F_{t-1} + \sum_{i=2}^{m} \beta_i \Delta F_{t-1} + \sum_{j=1}^{k} \psi_i \Delta S_{t-j} + v_t \qquad (6)$$

Where Δ is a first difference operator such that $\Delta S_t = S_t - S_{t-1}$; u_{t-1} is the error correction term, from equation (1) and v_t is a stationary white-noise residual term.

If ρ> 0, it means existence of cointegration, because spot price changes respond to deviations from long-run equilibrium. Likewise, short-run market efficiency implies the following restrictions on the parameters of Equation (6):

$$\rho = 1, \rho\delta = \beta \# 0 \text{ and } \beta i = \quad j = 0$$

Coefficient β, related with last period's change in the futures price, is either positive or negative but not zero because new information, which also affects the futures price, affects the future spot price change. The logic underlying the additional restrictions that ρ =1, ρδ= β # 0 and $\beta_i = \psi_j = 0$ may be observed by rewriting Equation 6 as

$$S_t = (1-\rho)S_{t-1} + \beta F_{t-1} + (\rho\delta - \beta)F_{t-2} + \rho\alpha + \sum_{i=2}^{m} \beta_i \Delta F_{t-i} + \sum_{j=1}^{k} \psi_j \Delta S_{t-j} + v_t \qquad (7)$$

Where $(S_{t-1} - \alpha - \delta F_{t-2})$ has been substituted for u_{t-1}, the error correction term defined in Equation 6.

If the nonlinear restriction ρ =1, ρδ= β do not hold, then past futures and spot prices would contain relevant information not completely incorporated in the t- 1futures price. Furthermore, this information could be used to predict S_t. The efficient market hypothesis implies that all previous information should already be incorporated in the t-1 futures price, and therefore the past futures price should have no effect on current spot price.

Empirical Results

In the empirical analysis, all subsequent model estimation and empirical results with respect to market efficiency are shown in Tables I to VI. We employed two different unit root tests, the Augmented Dickey Fuller (ADF) Test and the Phillips Perron (PP) Test. For each series all tests indicated the presence of one unit root (Table I and II) at levels and become stationary on first difference. Given that each commodity's spot and futures prices are integrated of the same order, I (1), we can use cointegration techniques to determine if a stable long-run relationship exists between the price pairs. The unit root test for residual obtained in the equation 1 is stationary so it can be concluded that spot and futures are cointegrated in the long run (Engle Granger 1987).

Using Johansen's (1988) procedure, tests for cointegration were performed. Johansen's procedure a multivariate approach is based on maximum likelihood estimates of the cointegrating regression. The VAR (Vector Autoregressive) specification was estimated by using from one to four lags, with the AIC criterion used to choose optimal lag length. From Table V the null hypothesis of no cointegration is rejected at the 10% significance level for each commodity (Maximal eigen value and trace test statistics). On the other hand, the null hypothesis of one cointegrating relationship cannot be rejected. Furthermore, the results were not sensitive to the number of lags used up to the maximum number, four. Only results for the optimal lags are shown in Table VI. Overall , Johansen' s test result s support the hypothesis that spot and futures prices for each commodity are cointegrated and hence we can say the market is efficient in long run for all the commodities.

Although the cointegration test provides evidence for the hypothesis of long-run market efficiency but might still exhibit short-run inefficiencies and pricing biases in the commodity futures market. To test for short-run inefficiencies and pricing biases the standard ECM models consistent with Equation 6 in the methodology section were initially estimated. The results are recorded in Table VI. The models were estimated with zero to four lags of ΔSt_{-1} and ΔF_{t-1}. The significant lagged coefficients whether spot of futures were retained (Engle and Granger 1987). Results of residual diagnostic tests, presented in Table VI, reveal no evidence of serial correlation or heteroscedasticity in the final form equations.

The magnitude of ρ (the estimated coefficient on the error correction term) indicates the speed of adjustment of any disequilibrium towards the long-run equilibrium state. Estimated speed of adjustment parameters is significant in all regressions at 5% level. The speed of adjustment varies from 4% to 17% (Table VI).

Wald test results reported in Table VI show that futures markets fail the test of short-run market efficiency at the 5% level. The reasons behind the inefficiencies, however, vary among the commodities. Some commodities have significant lagged futures coefficient (Chilli, Pepper,) and some have both spot and futures lagged coefficient significant (Jeera, Pepper, Guar Gum, Guar Seeds and refined Soy Oil). Another reason for inefficiency is the slow adjustment to long-run equilibrium in all the commodities.

Conclusion

This study has investigated the efficiency of Indian agricultural commodities futures market through the use of time series methodologies. The markets for all the ten commodities included in the study are efficient in long run. However, short run inefficiencies and pricing biases exist, which can be attributed to dynamic lag structure and slow adjustment to long run equilibrium.

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Table I. Unit Root Analysis (Futures)

Commodity	ADF		PP	
	Level	First Difference	Level	First Difference
Barley	-1.845 (0.358)	-25.384* (0.000)	-1.773 (0.394)	-25.290* (0.000)
Chilli	-20.77 (0.253)	-26.201* (0.000)	-2.054 (0.263)	-26.117* (0.000)
Jeera	-2.302 (0.171)	-36.978* (0.000)	-2.335 (0.160)	-36.968* (0.000)
Pepper	1.359 (0.998)	-39.628* (0.000)	1.212 (0.998)	-39.681* (0.000)
Turmeric	-1.042 (0.739)	-20.070* (0.000)	-1.100 (0717)	-20.061* (0.000)
Channa	-2.017 (0.358)	-33.205* (0.000)	-20182 (0.213)	-33.257* (0.000)
Guar Gum	5.923 (1.000)	-25.384* (0.000)	5.369 (1.000)	-25.290* (0.000)
Guar Seeds	4.225 (1.000)	-31.541* (0.000)	4.492 (1.000)	-31.652* (0.000)
Refined Soya Oil	-1.357 (0.604)	-34.632* (0.000)	-1.410 (0.578)	-34.619* (0.000)
Soya Bean	-2.226 (0.196)	-35.837* (0.000)	-2.246 (0.190)	-35.837* (0.000)

*Significant at 1%

Table II. Unit Root Analysis (Spot)

Commodity	ADF		PP	
	Level	First Difference	Level	First Difference
Barley	-1.485 (0.540)	-31.300* (0.000)	-1.578 (0.493)	-31.144* (0.000)
Chilli	-1.918 (0.323)	-23.869* (0.000)	-1.879 (0.342)	-23.803* (0.000)
Jeera	-1.959 (0.305)	-23.017* (0.000)	-2.028 (0.274)	-33.903* (0.000)
Pepper	1.982 (0.999)	-34.249* (0.000)	1.491 (0.999)	-35.925* (0.000)
Turmeric	-1.176 (0.686)	-18.522* (0.000)	-1.180 (0.684)	-18.562* (0.000)
Channa	-1.599 (0.482)	-29.716* (0.000)	-1.463 (0.551)	-29.631* (0.000)
Guar Gum	7.022 (1.000)	-8.826* (0.000)	5.628 (1.000)	-33.805* (0.000)
Guar Seeds	5.023 (1.000)	-30.968* (0.000)	5.174 (1.000)	-31.144* (0.000)
Refined Soya Oil	-1.240 (0.658)	-31.419* (0.000)	-1.262 (1.000)	-31.411* (0.000)
Soya Bean	-2.145 (0.227)	-32.561* (0.000)	-2.279 (0.179)	-33.059* (0.000)

*Significant at 1%

Table III:Cointegration Equation Results ($U_t = S_t - \alpha - \delta F_{t-1}$)

Parameter	Chilli	Jeera	Pepper	Turmeric	Barley	Channa	Guar Gum	Guar Seeds	Refined SoyOil	Soy Bean
.	0.97	0.95	0.96	1.01	1.02	0.97	1.01	0.99	1.00	0.98
R^2	0.92	0.97	0.99	0.97	0.97	0.95	0.99	0.99	0.99	0.99

Table IV: Unit Root Test for residu al

Test	Chilli	Jeera	Pepper	Turmeric	Barley	Channa	Guar Gum	Guar Seeds	Refined SoyOil	Soy Bean
ADF	-5.456	-7.001	-8.708	-5.027	-7.073	-8.500	-8.424	-9.373	-12.588	-16.460
PP	-7.035	-10.73	-23.73	-9.025	-13.150	-12.184	-31.724	-26.373	-29.683	-28.131

Critical value at 5% level is -2.864

Table V. Johonson Test

Commodity	λ_{trace}		λ_{max}	
	r=0		r=0	r–1
Barley (2)	47.390 (15.494)	2.679 (3.841)	44.710 (14.264)	2.679 (3.841)
Chilli(2)	34.211* (15.494)	3.37 (3.841)	30.837* (14.264)	3.37 (3.841)
Jeera (2)	107.371* (15.494)	4.289 (3.841)	103.081* (14.264)	4.289 (3.841)
Pepper (4)	122.186* (15.494)	1.663 (3.841)	120.523* (14.264)	1.663 (3.841)
Turmeric (2)	20.131* (15.494)	1.063 (3.841)	19.068* (14.264)	1.063 (3.841)
Channa(2)	52.471* (15.494)	3.163 (3.841)	49.308* (14.264)	3.163 (3.841)
Guar Gum(3)	109.866* (15.494)	31.818 (3.841)	78.047* (14.264)	31.818 (3.841)
Guar Seeds(3)	76.242* (15.494)	21.503* (3.841)	54.738* (14.264)	21.503* (3.841)
Refined Soy Oil(3)	86.563* (15.494)	1.986 (3.841)	84.576* (14.264)	1.986 (3.841)
Soya Bean(2)	111.523* (15.494)	4.449* (3.841)	107.074* (14.264)	4.449* (3.841)

The trace test was used to test the null hypothesis that the number of cointegrating vectors is less than or equal to r, where r is 0 or 1.
**Indicates that the null hypothesis is rejected at 5% level*
The critical values at the 5% level are taken at from λ_{trace} and λ_{max} tables, Osterwald-Lenum (1992), and are shown in parentheses below the test statistics.
The lag length chosen by the AIC & SC criteria is shown in parenthesis after the relevant script.

Table VI. Error Correction Model

Parameter	Chilli	Jeera	Pepper	Turmeric	Barley	Channa	Guar Gum	Guar Seeds	Refined SoyOil	Soy Bean
ρ	-0.04 (0.01)	-0.05 (0.007)	-0.10 (0.01)	-0.06 (0.02)	-0.08 (0.02)	-0.06 (0.01)	-0.17 (0.04)	-0.07 (0.02)	-0.14 (0.02)	-0.07 (0.02)
β	0.10 (0.03)	0.211 (0.015)	0.481 (0.01)	0.215 (0.05)	0.195 (0.04)	0.324 (0.03)	0.73 (0.04)	0.59 (0.04)	0.37 (0.04)	0.25 (0.04)
β_1	0.07 (0.031)	-	0.122 (0.01)	-	-	-	0.28 (0.04)	0.12 (0.04)	0.11 (0.04)	-
$\square_1$	-	-0.11 (0.032)	-0.356 (0.03)	-	-0.22 (0.04)	-	-0.38 (0.05)	-0.33 (0.05)	-0.12 (0.04)	-0.14 (0.05)
$\square_2$	-	-	-	-	-	-	-0.25 (0.04)	-	-0.13 (0.05)	-
R^2	0.065	0.15	0.34	0.061	0.070	0.01	0.18	0.15	0.08	0.06
D.W Stat	2.005	2.003	2.005	1.998	1.998	1.998	1.978	1.967	1.996	1.998
Wald Test	2497.378	6502.137	3042.120	646.88	1357.584	1193.12	762.37	971.78	1054.33	338.79
LM Test	0.347	1.415	0.925	0.639	0.275	0.924	5.058	0.294	0.615	0.828

$$\Delta S_t = -\rho u_{t-1} + \beta \Delta F_{t-1} + \sum_{i=2}^{m} \beta_i \Delta F_{t-i} + \sum_{j=1}^{k} \psi \Delta S_{t-j} + v_t$$

Wald and LM Tests are based on F Statistics
Standard errors are shown in parentheses for parametres