TITLE: THE WEAK FORM EFFICIENCY OF INDIAN-COMMODITY FUTURES

NAME: JATINDER BIR SINGH

DESIGNATION: SENIOR LECTURER IN ECONOMICS
INSTITUTIONAL-AFFILIATION S.G.G.S. COLLEGE OF COMMERCE
(UNIVERSITY OF DELHI)
PITAM PURA, DELHI- 110 034

ADDRESS: E-202, SECTOR-18, BLOCK-E, ROHINI, DELHI-110085
E-mail: jbsingh75@hotmail.com

PHONE NO. 011-7851365

# THE WEAK FORM EFFICIENCY OF INDIAN COMMODITY FUTURES

## ABSTRACT

*This paper examines the hypothesis that Indian agricultural futures markets are weak form efficient. The concept of weak form efficiency in futures markets is outlined and hypothesis is tested with respect to Indian Castorseed, Pepper, Gur, Hessian, Potato and Turmeric futures markets, using cointegration technique. Evidence for market efficiency is mixed and varies across the commodities. The results indicate evidence of efficiency and unbiasedness in relation to Gur and Potato. For other commodities, efficiency and unbiasedness varies according to maturity and months left to maturity.*

## The Weak-Form Efficiency of Indian Commodity Futures

A futures market is efficient relative to an information such that only new unanticipated information leads to a price change i.e. at any moment in time, futures prices fully reflect publicly available information. The traditional versions of the efficient market hypothesis are known as the weak, semi-strong and strong versions. The weak-form efficient market hypothesis claim that prices in a market fully reflects all information contained in time series of prices. The Semi- strong version states that market prices fully reflect all publicly available information. The strong version states that market prices reflect all information, public or private. Private information includes information possessed only by corporate insiders and governmental officials.

The view of market efficiency employed in this study is weak form efficiency. If the Futures market is weakly efficient, there will be no opportunities to earn abnormal profits using the trading rule based upon the historical sequence of prices. In the past many studies have used weak form efficiency (e.g. Aulton, Ennew and Rayner, 1997; Cargill and Rausser, 1975; Goss, 1981; Kofi, 1973; Solt and Swanson, 1981; Sheldon, 1987; Tomek and Gray, 1970). The efficiency of futures market can be explained through distributed lag specification of futures price-

$$S_t = a + bF_d + cF_{d-1} + dS_{t-1} + \varepsilon_t \qquad \dots(1)$$

Where $S_t$ is the delivery date spot price, $F_d$ is the futures price on the first trading day of contract maturing in period t, $\varepsilon_t$ ~ IID (0, $\sigma$2) and |d| <1 and S an F series are integrated of order one i.e. I (1)

The long run cointegrating relation between the spot and futures prices can be labeled as-

$$S_t = \alpha + \beta^e F_d + u_t \qquad \dots(2)$$

which is obtained by applying Bewley transformation to equation (1).
Here $\alpha$ = a/1-d and $\beta^e$ = b + c/1-d

For cash and futures prices to be cointegrated, $u_t$ (residual) should be stationary. For market to be unbiased it is necessary that $\beta^e = 1$.Efficiency implies that the futures price is an unbiased predictor of a subsequent spot price. If unbiasedness exists then spot and future prices are cointegrated with unit parameter.

Testing the relationship (1), for efficiency requires two steps:

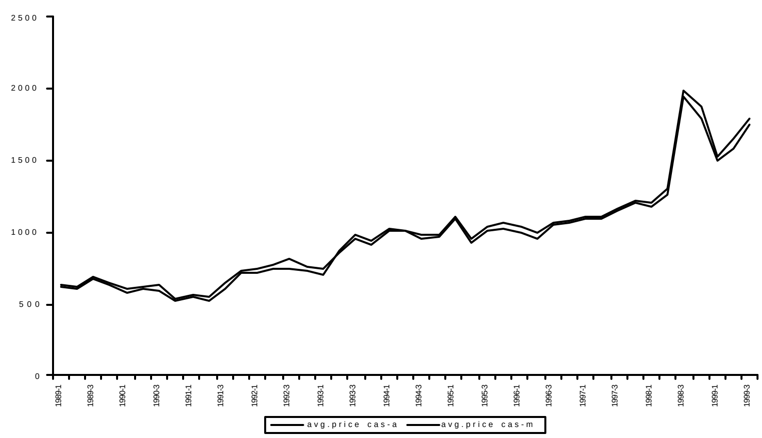
- Test for cointegration. This entails estimating the long-run relationship between $S_t$ and $F_d$ in equation (2) and testing the residuals for non-stationary.

- If cointegration is accepted, then proceed to test the parameter values consistent with efficiency. This entails testing the joint null-hypothesis that c = d = 0 in equation(1), which ensures that the lagged futures and lagged spot prices don't contain any useful information which could be used to forecast $S_t$.

If null hypothesis of no cointegration is rejected and the null hypothesis that lagged spot and futures prices do not influence the spot price is not rejected, then it is appropriate to test for unbiasedness, namely that b = 1. There is no direct way to test it if F and S are I (1); however, the restriction b = 1 can be imposed and residual series $u_t = s_t - f_{t,\, t-1}$ tested for stationary.

Six agricultural commodities, in which Futures Markets are operating, have been investigated for efficiency. These commodities are Potatoes, Pepper, Hessian, Turmeric, Gur & Castorseed. Because of the inherent price instability in the agricultural commodities, Futures market has been favored for performing its risk reduction and forward pricing role. This price instability in case of above agricultural crops has been shown in Figures 1-6, which present the quarterly average prices for the period 1989-99.

Figure1 Average prices of Castorseed 1988-99 (quarterly)




The first impression that we get from the time series plotted here is that they all seem to be trending upwards, although the trend is not smooth, especially in the Potato, Gur and Turmeric. There is substantial price decline in case of Turmeric during 1991-95. Virtually all the commodities signify the variability with Potato, Turmeric and Gur showing sharp peaks and troughs, which characterize the agricultural commodities.

Looking at the commodities time series in figures 1-6, we get the feeling that these series are not stationary because their mean, variance and autocovariance do not seem to be time-invariant. The first difference in the logarithm of price series (which approximates to annual growth rate) is stationary. Table 1 and table 2 present the descriptive statistics of these nominal growth rates and the absolute values of growth rates. These values indicate that the prices are rising at the rate of 16.1% in case of Pepper, 6.7% per annum in case of Turmeric, 4.3% in case of Castorseed and 3.6% in case of Gur, Hessian and Potato. Variability is highest in case of Potato spot prices followed by Turmeric, Pepper, Gur, Castorseed and Hessian. For Hessian being manufactured product, low variability is to be expected. The skewness is negative in case of Hessian, Potato and turmeric and positive in case Pepper, Castorseed and Gur, indicating that the distribution is more concentrated to the left of the mean in the former case and right of the mean in latter case. There is excess kurtosis in case of Gur showing that the curve is leptokurtic i.e. distribution is more peaked than normal distribution. Table 1 represents descriptive statistics of growth rates for the commodities.

| Table 1 | | | Growth Rate | | | |
|---|---|---|---|---|---|---|
| Commodity | Mean | Medi-an | Stadard Deviation | Skewne-ss | Kurto-sis | JB |
| Pepper | 0.161 | 0.0539 | 0.141 | 0.196 | 2.224 | 0.314 (0.85) |
| Castorseed (Ahmedabad) | 0.043 | 0.0473 | 0.0522 | 0.1104 | 2.4243 | 0.1426 (0.93) |
| Castorseed (Mumbai) | 0.043 | 0.0413 | 0.0522 | 0.4528 | 2.7664 | 0.328 (0.84) |
| Gur (Hapur) | 0.036 | 0.0123 | 0.0799 | 1.0100 | 3.236 | 1.5512 (0.46) |
| Gur (Muzaff) | 0.036 | 0.0132 | 0.0748 | 1.1240 | 3.404 | 1.957 (0.37) |
| Hessian | 0.036 | 0.0470 | 0.048 | -0.2884 | 2.207 | 0.3206 (0.85) |
| Potato | 0.036 | 0.1159 | 0.2609 | -0.1823 | 2.2521 | 0.2884 (0.86) |
| Turmeric | 0.067 | 0.1028 | 0.1444 | -0.2597 | 2.0677 | 03998 (0.81) |

| **Table 2 Absolute value of Growth Rate** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Pepp-er | Cas (A) | Cas (M) | Gur (H) | Gur (M) | Hessi-an | Pota-to | Turm-eric |
| Mean | 0.118 | 0.052 | 0.051 | 0.057 | 0.053 | 0.051 | 0.217 | 0.132 |
| Median | 0.104 | 0.048 | 0.041 | 0.032 | 0.400 | 0.048 | 0.183 | 0.106 |

**Figure 2 Average Prices of Hessian 1989-97 (quarterly)**

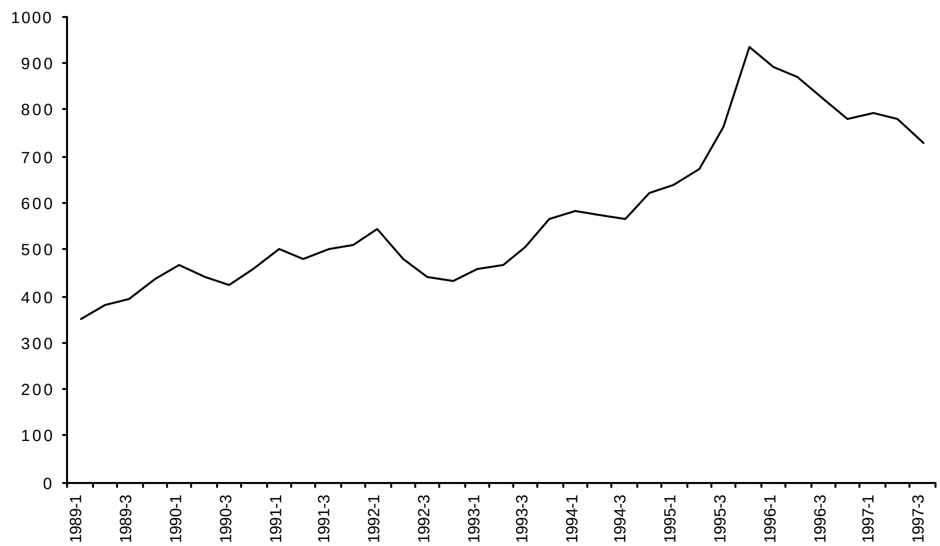



**Figure3 Average Price of Gur1989-99 (quarterly)**

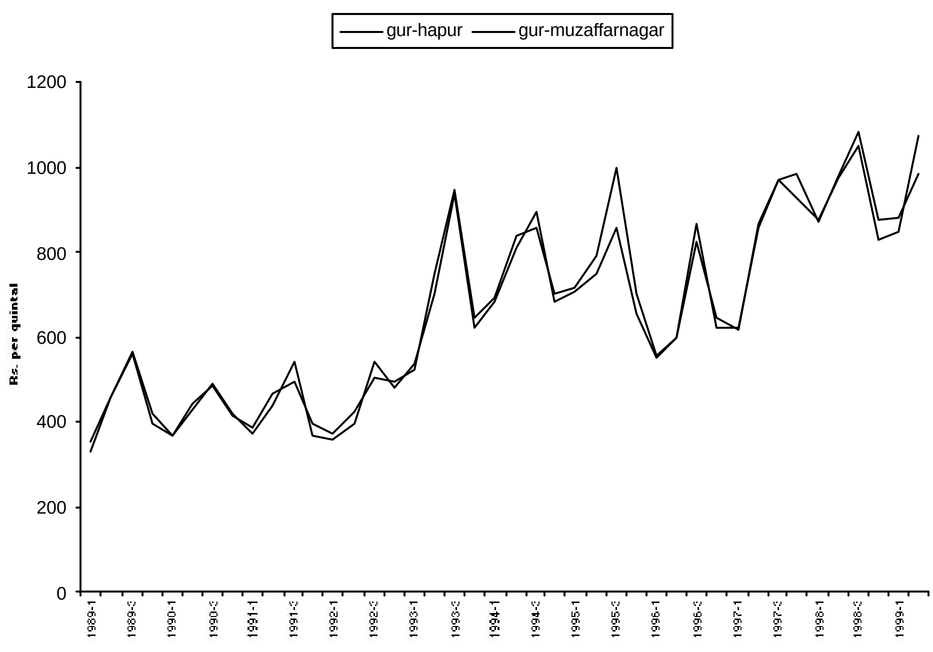


Figure 4 average price of potato 1989-99 (quarterly)

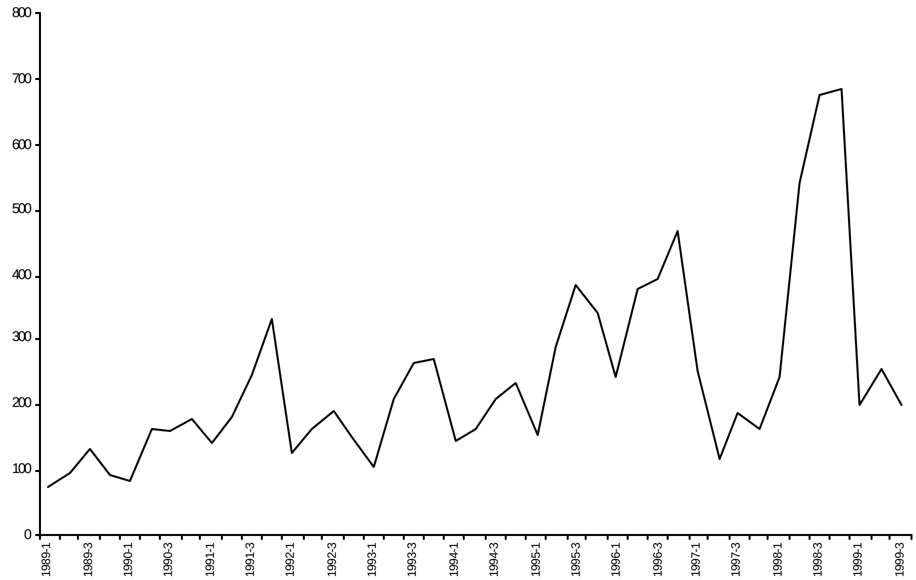



Figure 5 average price of pepper 1989-99 (quarterly)

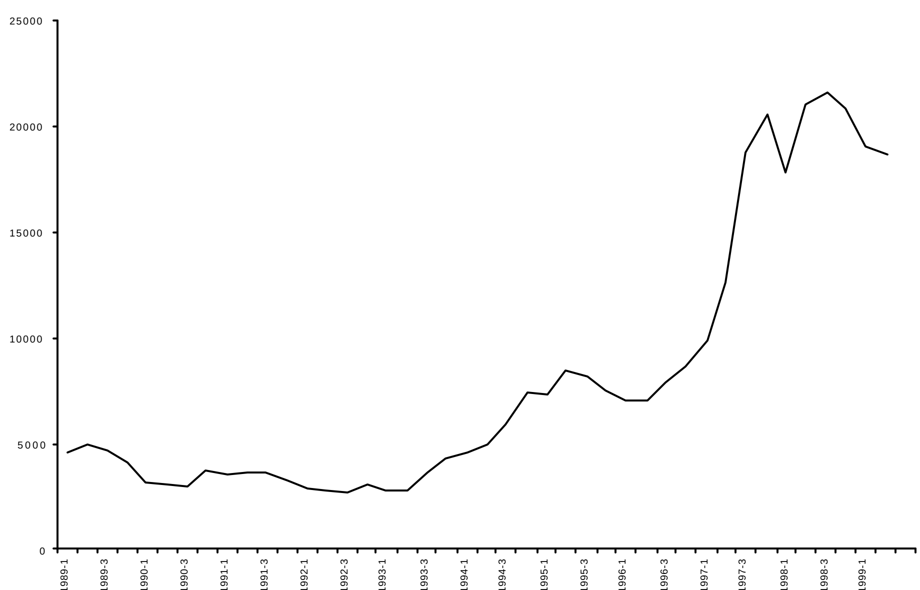
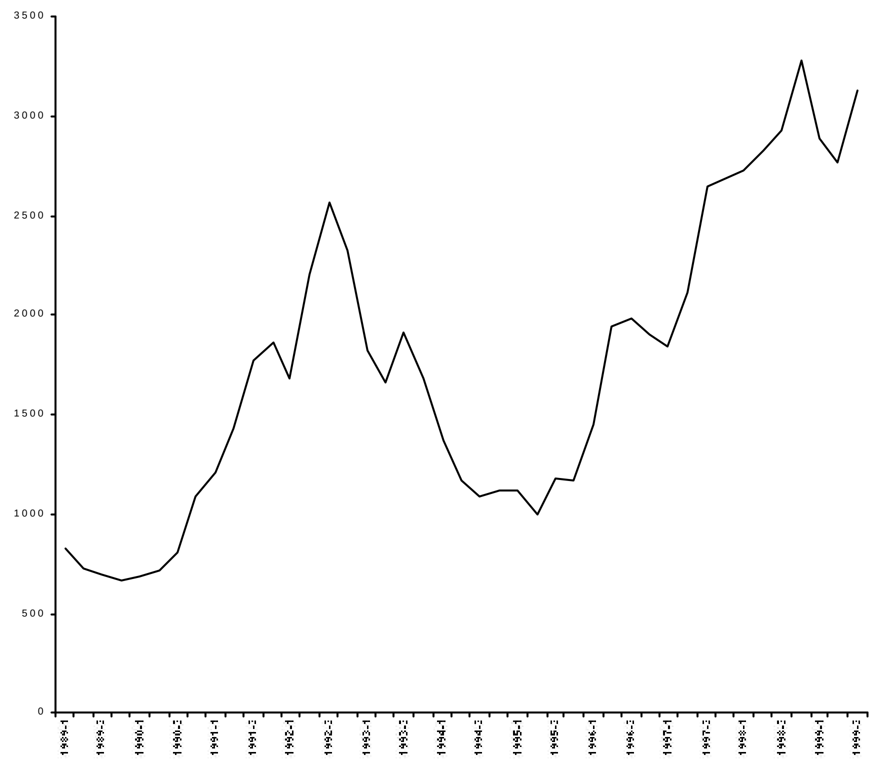


**Figure 6 Average Prices of turmeric 1989-99 (quarterly)**




However in case of other commodities the distribution is Platykurtic indicating that the distribution is flatter than the normal distribution. The Jacque –Bera test show that for all commodities the null hypothesis of normality is rejected. The mean of the absolute value of growth rate avoids the problem that the large positive changes can be neutralized by large negative changes and thus can be used as an indicator of volatility. The order of ranking according to this measure is Potato, Turmeric, Pepper, Gur, Castorseed and Hessian. The same ordering is obtained when nominal growth rate is used.

To formally test the series for stationarity Augmented Dickey-Fullner and non-parametric Phillips-Perron unit root tests have been employed. The results of these tests have been presented in table 3 and table 4. Since the null hypothesis of unit root in the series is accepted at level, they are non-stationary. However they are stationary in the first difference i.e. original price series are integrated of first order I (1).

| Table 3 Augmented Dicky-Fullner and Phillips-Perron unit root tests for stationarity | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Price Series | Potato | Pepper | Turmeric | hessian | Gur (H) | Gur (M) | Castor (A) | Castor (M) |
| ADF test for unit root | | | | | | | | |
| Z(∝) statistics | | | | | | | | |
| $S_t$ | -13.19 | -0.06 | -2.39 | -4.59 | - | - | -2.08 | -1.179 |
| $F_d$ | -7.59 | - | -2.53 | -4.11 | -1.61 | -1.76 | - | -0.38 |
| $F_1$ | - | -0.23 | -1.76 | -4.17 | -1.33 | -1.34 | 0.65 | -0.61 |
| $F_2$ | - | 0.08 | - | -4.20 | - | - | -1.76 | - |
| Z(t) statistics | | | | | | | | |
| $S_t$ | -2.81 | -0.03 | -1.02 | -1.76 | -0.57 | -1.42 | -0.74 | -0.48 |
| $F_d$ | -2.02 | -0.27 | -1.08 | -1.71 | -0.66 | -0.79 | -0.13 | -0.17 |
| $F_1$ | -0.80 | -0.14 | -0.85 | -1.73 | -0.57 | -0.65 | -0.31 | -0.27 |
| $F_2$ | -0.70 | 0.05 | -1.98 | -1.80 | -0.48 | -0.26 | -0.73 | 0.83 |
| P-P test for unit root | | | | | | | | |
| Z (∝) statistics | | | | | | | | |
| $S_t$ | -12.8 | -0.06 | -2.84 | -4.81 | -5.01 | -6.30 | -1.24 | -0.67 |
| $F_d$ | -7.30 | -0.14 | -2.43 | -4.42 | -1.09 | -1.45 | -0.81 | 0.10 |
| $F_1$ | -7.31 | -0.27 | -1.86 | -4.59 | -1.02 | -1.15 | -0.39 | -0.20 |
| $F_2$ | -7.46 | -0.13 | -2.10 | -4.80 | -1.45 | -1.60 | -1.23 | -0.42 |
| Z (t) statistics | | | | | | | | |
| $S_t$ | -2.78 | -0.04 | -1.13 | -1.78 | -1.62 | -1.96 | -0.52 | -0.29 |
| $F_d$ | -1.98 | -0.09 | -1.06 | -1.75 | -0.49 | -0.70 | -0.35 | 0.56 |
| $F_1$ | -2.05 | -0.16 | -0.88 | -1.78 | -0.47 | -0.59 | -0.19 | -0.09 |
| $F_2$ | -2.13 | -0.08 | -0.96 | -1.86 | -0.63 | -0.75 | -0.57 | -0.20 |

*St, Fd, F1 & F2 are spot prices on delivery date, futures prices on the first day of delivery month & Futures prices of one, two months before delivery date respectively.Gur (H), Gur (M), Castor (A) & Castor (M) are Gur prices at Hapur & Muzaffarnagar, Castor seeds prices at Ahmedabad & Mumbai respectively. The critical values for DF & P-P Tests at 5% significance level are:* Z (∝) = -14.1; Z (t) = -2.86

Table 4 Phillips-Perron test for stationarity of first difference of logarithm of price series.

| commodity | Price series | Z(α)statistics | Z(t)statistics |
|---|---|---|---|
| Potatoes | $S_t$ | -35.10 | -6.00 |
| | $F_d$ | -32.31 | -5.12 |
| | $F_1$ | -33.70 | -5.66 |
| | $F_2$ | -37.47 | -7.47 |
| Pepper | $S_t$ | -60.43 | -7.62 |
| | $F_d$ | -56.41 | -7.10 |
| | $F_1$ | -60.84 | -7.64 |
| | $F_2$ | -55.75 | -7.04 |
| Turmeric | $S_t$ | -22.91 | -4.33 |
| | $F_d$ | -29.12 | -5.45 |
| | $F_1$ | -25.88 | -4.90 |
| | $F_2$ | -26.59 | -4.94 |
| Hessian | $S_t$ | -19.98 | -4.24 |
| | $F_d$ | -18.29 | -3.96 |
| | $F_1$ | -17.26 | -3.74 |
| | $F_2$ | -16.31 | -3.50 |
| Gur(H) | $S_t$ | -41.57 | -6.98 |
| | $F_d$ | -43.73 | -7.35 |
| | $F_1$ | -41.04 | -6.85 |
| | $F_2$ | -37.81 | -6.15 |
| Gur(M) | $S_t$ | -45.08 | -7.74 |
| | $F_d$ | -42.51 | -7.03 |
| | $F_1$ | -41.01 | -6.62 |
| | $F_2$ | -45.08 | -7.74 |
| Castorseed (A) | $S_t$ | -48.22 | -8.03 |
| | $F_d$ | -51.55 | -8.78 |
| | $F_1$ | -45.22 | -7.00 |
| | $F_2$ | -48.22 | -8.03 |
| Castorseed (M) | $S_t$ | -41.52 | -7.05 |
| | $F_d$ | -41.82 | -6.78 |
| | $F_1$ | -42.14 | -6.91 |
| | $F_2$ | -45.77 | -8.29 |

*$S_t$ is the spot price on the delivery date. $F_2$, $F_1$ & $F_d$ are futures pries two, one month prior to maturity date and on the 1st trading day of delivery month respectively. Critical values for Z ($\alpha$)= -14.1; Z (t) =-2.86; at 5% significance level. Gur (H) & Gur (M) denotes commodity at Hapur & Muzaffarnagar exchanges.*

Futures markets provide a platform for management of price variability and risks associated with production and trading of commodities. A precondition for managing risks is that the futures market is able to predict the future spot price at maturity with accuracy i.e. basis tends to narrow as contract nears maturity. This is described as price discovery role of futures market. The price discovery role depends on the quality of information flows between the spot and futures market. If futures market is performing its price discovery function in an efficient way, then any changes in spot and futures prices should be closely associated with information flows. If the market is efficient then the futures prices are the unbiased predictor of subsequent spot prices.

The performance of futures prices to predict the subsequent spot prices is judged mostly by regression of the observed spot prices at maturity on previous period futures quotation for the maturity time. For the regression doesn't report spurious result, the price series for spot and futures contracts have been investigated for stationarity. The spot prices have been observed at maturity of contract ($S_t$); $F_d$ is the futures price on the first trading day of delivery month; $F_1$ is futures price lagged one month behind spot price and $F_2$ is two months lagged futures price behind spot price. The sample period is from September 1988 to August 1999 for Castorseed, Pepper, Gur, Turmeric and Potato and September 1992 to September 1997 for Hessian. These price series were deseasonalized by regression on seasonal dummy variables. Table 3 reveals the details of stationarity of the price series. Augmented Dickey-Fullner and Phillips-Perron tests applied to logarithms of price series determine the unit root in them. The null hypothesis is unit root ($\alpha$=1) against the alternative hypothesis of $|\alpha|<1$(one sided). The Phillips-Perron test uses a non-parametric correction for serial correlation. The Phillips-Perron test statistics are obtained by non-parametric correction to standard statistics- Standardized-bias,

$$T(\hat{\alpha}-1), \text{ and standard t-ratio, } t_{\alpha} = (\hat{\alpha}-1)/s.e.\hat{\alpha}$$

The corresponding relevant Phillips-Perron test statistics are Z ($\alpha$) and Z (t) respectively. The results show that for Potatoes, Pepper, Turmeric, Gur traded at Hapur and Muzaffarnagar, Castorseed traded at Ahmedabad and Mumbai and Hessian, the unit root hypothesis is not rejected; all series are I (1) or nonstationary. The Phillips-Perron unit root test applied to the $1^{st}$ difference of logarithm price series shows that the hypothesis of unit root is rejected in all cases i.e. $1^{st}$ difference of the series is stationary. This means that the series in level form are I (1) time series; essentially, they are random walk (table 4). The standard hypothesis tests are inapplicable in case of non-stationary series. This problem could be overcome by testing the series for cointegration. The efficiency criterion embodies a long-run stable relationship between the spot prices and futures prices. If the price series are non-stationary i.e. I (1), then the residuals from cointegration regression ($S_t - F_{t,\ t-1}=u_t$) will be stationary or I (0), otherwise the spot price and futures price series will drift away from each other without bound. In fact, the cointegration between the spot and futures price series is a necessary but not a sufficient condition for efficiency. Given cointegration, efficiency requires that the long run slope parameter (cointegrating parameter) be equal to unity.

Table 1.5 reports the Phillips-Perron tests on the hypothesis that the spot and futures prices are cointegrated. The null of no cointegration implies that the residual series from cointegrating regression for all futures traded commodities are non-stationary i.e. I (1). As the null hypothesis of no cointegration is rejected for almost all commodities (except Turmeric in one month lagged futures market), it shows evidence of cointegration between the spot and futures prices, which is consistent with market efficiency.

**Table 5 Z( a ) and Z(t) Statistics for Phillips-Perron tests for stationarity of residuals from cointegration- regression**

| Commodities | Price-Series | Z(α)-Statistics | Z(t)-Statistics |
|---|---|---|---|
| Potatoes | $S_t, F_d$ | -36.43 | -6.32 |
| | $S_t, F_1$ | -38.71 | -6.92 |
| | $S_t, F_2$ | -38.18 | -6.96 |
| Pepper | $S_t, F_d$ | -70.84 | -9.2 |
| | $S_t, F_1$ | -69.00 | -9.32 |
| | $S_t, F_2$ | -65.37 | -8.4 |
| Turmeric | $S_t, F_d$ | -17.21 | -3.65 |
| | $S_t, F_1$ | -13.40* | -2.98* |
| | $S_t, F_2$ | -18.68 | -3.77 |
| Hessian | $S_t, F_d$ | -23.97 | -4.89 |
| | $S_t, F_1$ | -23.28 | -4.71 |
| | $S_t, F_2$ | -22.20 | -4.50 |
| Gur(H) | $S_t, F_d$ | -20.56 | -3.79 |
| | $S_t, F_1$ | -22.63 | -4.03 |
| | $S_t, F_2$ | -30.66 | -5.03 |
| Gur(M) | $S_t, F_d$ | -32.45 | -5.05 |
| | $S_t, F_1$ | -30.58 | -4.89 |
| | $S_t, F_2$ | -28.80 | -4.63 |
| Castorseed(A) | $S_t, F_d$ | -44.37 | -7.25 |
| | $S_t, F_1$ | -46.35 | -7.42 |
| | $S_t, F_2$ | -47.35 | -7.32 |
| Castorseed(M) | $S_t, F_d$ | -36.25 | -5.73 |
| | $S_t, F_1$ | -43.60 | -7.13 |
| | $S_t, F_2$ | -43.03 | -7.00 |

Z (α)-statistics and Z (t)-statistics are Phillips-Perron test statistics for determining stationarity in the residuals from the cointegrating regression. $S_t$ is the spot price on maturity date. $F_2$, $F_1$ & $F_d$ are futures prices two, one month before maturity period and on the first trading day of maturity month respectively. Critical values for Z (α) = -20.6; Z (t) =-3.34 at 5% significance level. Gur (H), Gur (M) stand for commodities being traded at Hapur & Muzaffarnagar exchanges. Castorseed (A), Castorseed (M) denotes commodities being traded at Ahmedabad and Mumbai exchanges.

| Table 6 Bivariate cointegration result: Spot prices and Futures prices | | | | |
|---|---|---|---|---|
| Commodity | Cointegrating Regression | t-value | DW | $R^2$ |
| Potatoes | $S_t$ = -0.47 + 1.07 $F_d$ (0.15) (17.97) | (0.77) p0.59 | 2.28 | 0.91 |
| | $S_t$ = -0.30 + 1.04 $F_1$ (-0.48) (14.90) | (0.68) p0.49 | 2.24 | 0.90 |
| | $S_t$ = -0.74 + 1.00 $F_2$ (-0.16) (11.96) | (0.86) p0.93 | 2.22 | 0.83 |
| Pepper | $S_t$ = -0.84 + 1.00 $F_d$ (-0.97) (102.67) | (0.85) p0.39 | 2.14 | 0.99 |
| | $S_t$ = -0.13 + 1.01 $F_1$ (-0.94) (61.65) | (0.91) p0.36 | 2.15 | 0.98 |
| | $S_t$ = -0.38 + 1.00 $F_2$ (-0.22) (50.72) | (0.23) p0.81 | 2.10 | 0.97 |
| Turmeric | $S_t$ = -0.55 + 1.08 $F_d$ (-1.84) (26.01) | (1.96)* p0.06 | 1.29* | 0.96 |
| | $S_t$ = -0.79 + 1.11 $F_1$ (-1.86) (18.87) | (1.99)* p0.06 | 0.99* | 0.92 |
| | $S_t$ = -0.55 + 1.08 $F_2$ (-1.32) (18.74) | (1.44) p0.16 | 1.35 | 0.92 |
| Hessian | $S_t$ = 0.27 + 0.99 $F_d$ (0.82) (18.96) | (-0.33) p0.97 | 2.08 | 0.94 |
| | $S_t$ = 0.52 + 0.99 $F_1$ (0.14) (17.29) | (-0.86) p0.93 | 2.00 | 0.93 |
| | $S_t$ = 0.23 + 0.96 $F_2$ (0.58) (15.44) | (-0.54) p0.58 | 1.90 | 0.91 |
| Gur (Hapur) | $S_t$ = 0.14 + 1.00 $F_d$ (0.37) (16.91) | (-0.59) p0.95 | 1.06* | 0.88 |
| | $S_t$ = 0.25 + 0.98 $F_1$ (0.65) (15.80) | (-0.23) p0.81 | 1.16* | 0.87 |
| | $S_t$ = 0.18 + 0.99 $F_2$ (0.44) (15.33) | (-0.37) p0.97 | 1.50 | 0.86 |
| Gur (Muzaffarnagar) | $S_t$ = 0.64 + 1.00 $F_d$ (0.86) (17.25) | (-0.11) p0.90 | 1.52 | 0.88 |
| | $S_t$ = 0.29 + 0.97 $F_1$ (0.74) (15.74) | (-0.45) p0.65 | 1.47 | 0.86 |
| | $S_t$ = 0.39 + 0.95 $F_2$ (0.99) (15.26) | (-0.66) p0.63 | 1.40 | 0.85 |
| Castorseed (Ahmedabad) | $S_t$ = -0.41 + 1.00 $F_d$ (-0.27) (45.24) | (0.26) p0.79 | 2.17 | 0.98 |
| | $S_t$ = -0.34 + 1.05 $F_1$ (-1.52) (31.37) | (1.56) p0.12 | 2.26 | 0.96 |
| | $S_t$ = -0.27 + 1.04 $F_2$ (-0.89) (22.88) | (0.90) p0.37 | 2.28 | 0.92 |
| Castorseed (Mumbai) | $S_t$ = -0.49 + 1.07 $F_d$ (-2.48) (36.89) | (2.47)* p0.01 | 1.87 | 0.97 |
| | $S_t$ = -0.70 + 1.10 $F_1$ (-2.87) (30.83) | (2.89)* p0.00 | 2.29 | 0.96 |
| | $S_t$ = -0.95 + 1.14 $F_2$ (-2.73) (22.30) | (2.77)* p0.00 | 2.27 | 0.93 |

$F_2$, $F_1$, $F_d$ are futures prices two, one month before maturity period (delivery month) & first trading day of maturity period respectively. $S_t$ is the spot price at maturity time. The figures in the parentheses in the column 2 are asymptotic t-statistics for hypothesis that estimates are equal to zero. The t-value in column 3 is asymptotic t-statistics of the coefficients for the hypothesis that estimated coefficients are equal to one. The p-value in column 3 denotes the lowest significance level at which the null hypothesis of coefficient being equal to one can be rejected.

Table 6 presents the results testing that the cointegrating slope parameter is unity.

In case of Potatoes, Pepper, Hessian, Gur (Hapur & Muzaffarnagar) and Castorseed (Ahmedabad), the coefficients of futures prices two, one month prior to maturity and that of maturity period are equal to one indicating unbiasedness of their prices. The coefficients of futures prices prevailing two months and one month prior to maturity and in the maturity period are different from one in case of Turmeric and Castorseed traded at Mumbai indicating biases in their prices. The estimates of intercept of regression are equal to zero in most of the cases except for Turmeric and Castorseed (Mumbai), where they are significantly different from zero for two and one months prior to maturity and in the maturity month indicating biases. There is evidence of first order autocorrelation in the case of Turmeric indicating inefficiency of futures market. First order autocorrelation is also present in maturity period and one month prior to maturity in case of Gur traded at Hapur.

We have also employed several diagnostic tests to the residuals of cointegrating regression to know about other properties of the residuals. The results of diagnostic tests of the residuals from cointegrating regression are given in Table 7. Three tests namely Jarque-Bera (JB), Beusch-Pagan-Godfrey (BPG) and Lagrange- Multiplier (LM) have been employed to test for normality, Hetroscedasticity and Serial Correlation in the residuals. Jarque-Bera is distributed as $\chi$ (2). BPG test for hetroscedasticity is distributed as $\chi^2$ (1) and LM is distributed as $\chi^2(9)$ for Potatoes (Critical value- 16.91), $\chi^2(20)$ for Pepper (Critical value for Pepper-31.41), $\chi^2(9)$ for Turmeric (Critical value-16.91), $\chi^2(7)$ for Hessian (Critical value-14.07), $\chi^2(12)$ for Gur (Critical value-21.02) and $\chi^2(13)$ for Csatorseed (Critical value-22.36) at 5% level.

The LM test indicates that there is evidence of serial correlation in the maturity month and one month prior to maturity in case of Gur (Hapur). The JB test reveals that in case of Pepper and Hessian, the residuals are not normally distributed in the maturity month. For Pepper, Hessian and Castorseed (Ahmedabad), they are non-normal in one month prior to maturity. In the two months lagged trading period, residuals are not normally distributed for Castorseed (Ahmedabad and Mumbai). There is evidence of hetroscedasticity in the residuals in one month prior to maturity for Hessian and Pepper and in the maturity month for Hessian. For Castorseed (Ahmedabad & Mumbai), hetroscedasticity is present in residuals in two months prior to maturity. Overall results indicate that futures market is efficient in case of Gur (Muzaffarnagar) and Potato. Also the futures market of Castorseed (Ahmedabad and Mumbai) is efficient in maturity month.

Overall results indicate that there is an efficient price discovery between the futures price and spot price for Gur (Muzaffarnagar) and Potato: there is long run cointegrating relationship and residuals are both stationary and white noise. For Gur traded at Hapur, there is cointegration between the spot and futures price series, which is necessary, but not a sufficient condition for efficiency. For one month prior to maturity and in the maturity month itself, there is evidence of serial correlation in the residuals from these cointegrating relationship; the residuals may be stationary but not white noise. Although the residuals from cointegrating relationship between the pair of price series in case of Castorseed (Ahmedabad) is both stationary and white noise in the maturity month but this relationship deteriorates as the futures prices are lagged away from contract maturity. The long term cointegrating relationship in maturity month and one lagged

**Table 7 Diagnostics tests on the residuals from cointegrating regression**

| Commodity | Price series | BPG | JB | LM |
|---|---|---|---|---|
| Potatoes | $S_t$, $F_d$ | 0.74 (0.39) | 6.76(0.03) | 13.51(16.91) |
| | $S_t$, $F_1$ | 0.11(0.73) | 3.13(0.20) | 6.11(16.91) |
| | $S_t$, $F_2$ | 0.007(0.93) | 1.48(0.47) | 7.18(16.91) |
| Pepper | $S_t$, $F_d$ | 2.76(0.09) | 60.72(0.00)* | 12.32(31.41) |
| | $S_t$, $F_1$ | 9.74(0.00)* | 18.71(0.00)* | 14.63(31.41) |
| | $S_t$, $F_2$ | 3.13(0.37) | 0.81(0.66) | 20.66(31.41) |
| Turmeric | $S_t$, $F_d$ | 1.87(0.17) | 3.56(0.16) | 14.72(16.91) |
| | $S_t$, $F_1$ | 1.71(0.18) | 3.28(0.19) | 7.76(16.91) |
| | $S_t$, $F_2$ | 0.29(0.59) | 1.54(0.46) | 14.44(16.91) |
| Hessian | $S_t$, $F_d$ | 6.19(0.01)* | 18.67(0.00)* | 4.98(14.07) |
| | $S_t$, $F_1$ | 4.80(0.02) | 8.45(0.01)* | 5.95(14.07) |
| | $S_t$, $F_2$ | 3.16(0.07) | 8.59(0.01)* | 3.04(14.07) |
| Gur(H) | $S_t$, $F_d$ | 0.40(0.52) | 2.48(0.28) | 42.18(21.02)* |
| | $S_t$, $F_1$ | 0.65(0.41) | 1.96(0.37) | 31.10(21.02)* |
| | $S_t$, $F_2$ | 0.51(0.47) | 1.31(0.51) | 13.45(21.02) |
| Gur(M) | $S_t$, $F_d$ | 0.07(0.78) | 1.36(0.50) | 12.33(21.02) |
| | $S_t$, $F_1$ | 0.09(0.76) | 2.82(0.24) | 11.15(21.02) |
| | $S_t$, $F_2$ | 0.05(0.81) | 1.55(0.46) | 14.83(21.02) |
| Castorseed(A) | $S_t$, $F_d$ | 2.48(0.11) | 0.62(0.73) | 9.84(22.36) |
| | $S_t$, $F_1$ | 4.61(0.03)* | 15.30(0.00)* | 6.68(22.36) |
| | $S_t$, $F_2$ | 5.17(0.02)* | 7.00(0.03)* | 7.19(22.36) |
| Castorseed(M) | $S_t$, $F_d$ | 0.30(0.58) | 4.82(0.09) | 7.41(21.02) |
| | $S_t$, $F_1$ | 0.056(0.81) | 14.60(0.10) | 8.05(21.02) |
| | $S_t$, $F_2$ | 3.93(0.05)* | 17.96(0.00)* | 8.60(21.02) |

*JB is Jarque-Bera test for normality of residuals and is distributed as $\chi^2(2)$.*
*BPG is Breusch-Pagan-Godfrey test for hetroscedasticity and is distributed as $\chi^2(1)$. The p-value given in the parenthesis in columns 3 & 4 represents the lowest significance level at which the null hypothesis of JB and BPG tests can be rejected. LM represents LaGrange Multiplier test for serial correlation. This test is distributed as $\chi^2(9)$ for Potato,*
*$\chi^2(20)$ for Pepper, $\chi^2(9)$ for Turmeric, $\chi^2(7)$ for Hessian, $\chi^2(12)$ for Gur, $\chi^2(13)$ for Castorseed. The critical level of LM statistics for different commodities is given in parentheses in column 5.*

month in case of Castorseed (Mumbai), is stationary and white noise but is biased. For Pepper, the residuals from the relationship between the spot price and futures price in the delivery month and lagged one month are not normal and also hetroscedastic. It shows the residuals are stationary but not white noise. However they are white–noise two months before maturity. In case of Turmeric, the residuals from cointegrating regression are stationary but non- white noise, as there is evidence of autocorrelation. For Potato, residuals are stationary and white noise in case of lagged one and two months period

**Table 8 OLS Estimation**

| Ind.Var | Potatoes | Pepper | Turmeric | Hessian | Gur (H) | Gur (M) | Cast (A) | Cast (M) |
|---|---|---|---|---|---|---|---|---|
| $F_t$ | 1.15 (0.00) | 0.99 (0.00) | 1.06 (0.00) | 1.09 (0.00) | 1.05 (0.00) | 0.81 (0.00) | 1.01 (0.00) | 1.06 (0.00) |
| $S_t$ (-1) | -0.99 (0.58) | -0.10 (0.39) | 0.35 (0.09) | -0.12 (0.61) | 0.45 (0.00) | 0.26 (0.06) | -0.12 (0.47) | 0.053 (0.76) |
| $F_t$ (-1) | -0.34 (0.87) | 0.12 (0.32) | -0.37 (0.08) | 0.24 (0.91) | -0.54 (0.02) | -0.14 (0.51) | -0.10 (1.51) | -0.055 (0.77) |
| Constant | -0.11 (0.73) | -0.12 (0.15) | -0.32 (0.35) | 0.46 (0.90) | 0.27 (0.46) | 0.41 (0.22) | -0.16 (0.91) | -0.46 (0.06) |
| $R^2$ | 0.94 | 0.99 | 0.96 | 0.93 | 0.90 | 0.92 | 0.98 | 0.97 |
| Diagnostic Tests | | | | | | | | |
| JB | 3.44 (0.17) | 68.49 (0.00) | 4.30 (0.11) | 45.08 (0.00) | 1.28 (0.52) | 0.93 (0.62) | 1.63 (0.44) | 6.16 (0.04) |
| BPG | 7.62 (0.10) | 4.29 (0.23) | 4.59 (0.20) | 7.6 (0.05) | 2.17 (0.53) | 1.80 (0.87) | 3.65 (0.30) | 1.21 (0.74) |
| LM | 18.12 (16.91) | 10.69 (31.34) | 7.56 (15.50) | 2.24 (12.59) | 9.62 (19.67) | 8.44 (21.02) | 8.74 (21.02) | 6.85 (19.67) |
| Ind.Var. | | | | | | | | |
| $F_1$ | 1.15 (0.00) | 1.02 (0.00) | 1.18 (0.00) | 1.09 (0.00) | 0.89 (0.00) | 0.75 (0.00) | 1.31 (0.00) | 1.10 (0.00) |
| $S_t$ (-1) | -0.88 (-0.63) | -0.13 (0.43) | 0.46 (0.02) | -0.97 (0.71) | 0.47 (0.00) | 0.27 (0.06) | -0.31 (0.06) | -0.15 (0.41) |
| $F_1$(-1) | -0.36 (0.87) | 0.13 (0.30) | -0.61 (0.00) | -0.60 (0.98) | -0.40 (0.07) | -0.12 (0.60) | 0.56 (0.73) | 0.18 (0.35) |
| Constant | -0.15 (0.68) | -0.21 (0.14) | -0.25 (0.59) | 0.79 (0.85) | 0.33 (0.38) | 0.59 (0.12) | -0.32 (0.16) | -0.88 (0.00) |
| $R^2$ | 0.91 | 0.98 | 0.94 | 0.92 | 0.89 | 0.90 | 0.96 | 0.96 |
| Diagnostic Tests | | | | | | | | |
| JB | 0.28 (0.86) | 24.93 (0.00) | 3.28 (0.19) | 26.14 (0.00) | 0.91 (0.92) | 0.59 (0.74) | 6.69 (0.03) | 6.23 (0.04) |
| BPG | 3.96 (0.41) | 16.35 (0.00) | 6.63 (0.08) | 7.85 (0.04) | 1.44 (0.48) | 2.27 (0.80) | 2.24 (0.52) | 0.80 (0.84) |
| LM | 8.95 (16.91) | 11.48 (31.34) | 7.76 (15.50) | 2.74 (12.59) | 7.39 (19.67) | 5.75 (21.02) | 3.59 (21.02) | 5.91 (19.67) |
| Ind.Var. | | | | | | | | |
| $F_2$ | 1.08 (0.00) | 0.90 (0.00) | 1.18 (0.00) | 1.10 (0.00) | 0.77 (0.00) | 0.76 (0.00) | 1.15 (0.00) | 1.04 (0.00) |
| $S_t$ (-1) | -0.23 (0.21) | 0.10 (0.57) | 0.24 (0.30) | -0.75 (0.77) | 0.29 (0.29) | 0.32 (0.04) | -0.24 (0.27) | -0.73 (0.73) |
| $F_2$(-1) | 0.19 (0.32) | 0.45 (0.97) | -0.38 (0.08) | -0.61 (0.79) | -0.10 (0.64) | -0.19 (0.42) | 0.14 (0.40) | 0.20 (0.32) |
| Constant | -0.27 (0.57) | -0.12 (0.45) | -0.29 (0.55) | 0.22 (0.63) | 0.27 (0.51) | 0.65 (0.11) | -0.39 (0.24) | -1.18 (0.011) |
| $R^2$ | 0.86 | 0.98 | 0.93 | 0.91 | 0.87 | 0.98 | 0.92 | 0.93 |
| Diagnostic Tests | | | | | | | | |
| JB | 1.27 (0.53) | 6.39 (0.04) | 2.29 (0.31) | 25.03 (0.00) | 0.17 (0.91) | 0.25 (0.87) | 6.52 (0.03) | 32.86 (0.06) |
| BPG | 6.28 (0.09) | 4.74 (0.44) | 4.42 (0.21) | 5.64 (0.13) | 0.43 (0.97) | 3.10 (0.68) | 9.00 (0.02) | 5.99 (0.11) |
| LM | 5.32 (16.91) | 17.98 (31.34) | 5.24 (15.50) | 2.61 (12.59) | 6.81 (19.67) | 5.58 (21.02) | 5.69 (21.02) | 6.87 (19.67) |

The figures in the parentheses are the p-values to test the null-hypothesis of non-significance of coefficients in regression. The p-values also test the null hypothesis of normality, homoscedasticity & no serial correlation for JB, BPG & LM tests. $S_t$ is the dependent variable. $S_t$ (-1), $F_1$ (-1) & $F_2$ (-1) are the lagged spot and futures prices. JB= Jarque-Bera Test; BPG = Breusch- Pagan- Godfrey Test; LM = LaGrange- Multiplier Test. Castorseed (A) and Castorseed (M) are Castorseed traded at Ahmedabad and Mumbai respectively.
Gur (H) and Gur (M) are Gur traded at Hapur and Muzaffarnagar respectively.

before maturity and in maturity period itself. The residuals from spot and futures prices relationship are stationary but non-normal.

For efficiency of futures market, it is essential that the current futures prices contain all available information to predict the future spot price. In other words neither the lagged futures prices nor lagged spot prices would provide any additional information to improve the price discovery process. To appraise this hypothesis we regress the contract maturity spot price on lagged futures and spot prices apart from current futures prices. The results for three different time series (futures price two months and one month prior to maturity month and futures price at the start of maturity month) for six commodities are presented in table 8. For the efficiency of the market, the coefficients of both lagged futures and spot prices in the distributed lag regression should be equal to zero (c = d = 0). The joint significance of both lagged prices is determined using F-test (table 9).

**Table 9 F-Statistics for OLS Regression**

| Variab-les | Potat-oes | Pepp-er | Turme-ric | Hessi-an | Gur (H) | Gur (M) | Cast (A) | Cast (M) |
|---|---|---|---|---|---|---|---|---|
| St (-1) Fd (-1) | 1.69 p-0.20 | 0.50 p-0.60 | 1.65 p-0.21 | 0.39 p-0.67 | 4.68* p-0.01 | 2.22 p-0.12 | 0.26 p-0.77 | 0.46 p-0.95 |
| St (-1) F1(-1) | 0.11 p-0.34 | 0.54 p-0.58 | 4.38* p-0.02 | 0.30 p-0.74 | 4.96* p-0.01 | 1.96 p-0.15 | 3.17 p-0.05 | 0.44 p-0.64 |
| St (-1) F2(-1) | 0.90 p-0.41 | 0.24 p-0.78 | 1.65 p-0.21 | 0.40 p-0.67 | 1.60 p-0.21 | 1.96 p-0.15 | 0.64 0.53 | 0.59 p-0.55 |

*St (-1), F1 (-1) & F2 (-1) are the lagged values of spot prices at maturity and futures prices one and two months prior to maturity period. F-statistics tests the joint significance of lagged variables in the distributed model. The p-value represents the lowest significance level at which null hypothesis can be rejected.*
*Gur- (H) and Gur (M) indicate futures contract of Gur traded at Hapur and Muzaffarnagar respectively. Cast- (A) and Cast (M) indicate futures contracts of Castorseed traded at Ahmedabad and Mumbai respectively.*

The null hypothesis of joint significance of lagged futures and spot prices (c = d =0) in three Ols regressions involving three different price series namely, maturity month and lagged (two and one month) futures prices, is not rejected for the majority of the commodities. Thus for Pepper, Potato, Hessian, Gur (Muzaffarnagar) and Castorseed (Mumbai), there is no trace of lagged spot and futures prices providing any information that is helpful in prediction of future spot price. However in case of Turmeric (one month lagged) and Gur, Hapur (maturity and one month lagged), markets are not fully efficient as lagged futures and spot prices do contain some information, which could be used for forecasting future spot price. In case of Gur (Hapur) and Turmeric, the earlier study showed evidence of autocorrelation in the maturity month. For Gur (Hapur), there is also presence of autocorrelation between spot and futures prices one month prior to maturity. So there is possibility that the results of these commodities not being efficient in those months may not be due to significance of lagged prices but due to serial correlation. In order to test that the results of Gur (Hapur) and Turmeric are not a reflection of impact of lagged values of spot and futures prices but of autocorrelation, we employ further set of regressions to incorporate the effect of autocorrelation. As shown in Table 1.10, DW statistics of first specification doesn't reject the null hypothesis of autocorrelation.

| **Table 10 Verification of autocorrelation** | | | |
|---|---|---|---|
| | Gur (Hapur) | Gur (Hapur) | Turmeric |
| | $S_t$, $F_d$ | $S_t$, $F_1$ | $S_t$, $F_1$ |
| **1.$S_t$=C+$F_t$+$F_t$(-1)+$S_t$(-1)+$U_t$** | | | |
| dw | 2.07 | 2.02 | 2.27 |
| B-G Serial Correlation LM Test | | | |
| (a)F-statistics | 0.29 (0.59) | 0.07(0.79) | 2.765(0.11) |
| (b)$nR^2$ | 0.33 (0.56) | 0.08(0.77) | 2.996(0.08) |
| Wald-Test: Null Hypothesis C(3)+C(2)*C(4)=0 | | | |
| (a)F-statistics | 5.81 (0.021) | 3.95(0.05) | 8.287(0.01) |
| (b)chi-square | 5.81 (0.015) | 3.95(0.04) | 8.827(0.00) |
| **2.$S_t$=C+$F_t$+$U_t$** | | | |
| dw | 1.06 | 1.16 | 0.99 |

*d-w denote Durbin-Watson test. B-G is Breusch-Godfrey test figures in parenthesis in column 2, 3 & 4 are the respective probabilities of the tests.*
*$S_t$, $F_d$ and $F_1$ stand for contract maturity spot prices, futures prices in the beginning of maturity month and one month lagged futures prices.*

However this test is not reliable because of the presence of lagged spot prices among the regressors. The F-Statistics and Breusch-Godfrey Serial Correlation LM test statistics test for the first order autocorrelation of the disturbance term. None of these statistics reject the hypothesis of zero first-order autocorrelation of disturbance term. Wald test for the restriction on the parameters of the relationship among $S_t$, $F_t$ (-1) and $S_t$ (-1) i.e. C (3) +C (2)*C (4) = 0 were also decisively rejected indicating that the results of these commodities for their particular delivery were not indicative of serial correlation. Hence it is concluded that the lagged (one-period) spot and futures prices for these commodities did contain some useful information for forecasting the future spot prices.

Though the above results provide evidence of efficiency of futures markets of different commodities they do not throw any light on the unbiasedness of the markets i.e. Intercept=0 and Slope Coefficient=1. In a situation where the time series are non-stationary or are I (1), the ols method for judging the unbiasedness of the markets can't be applied. In such a case an indirect method has to be used. This test puts the restrictions of unbiasedness on the intercept and slope coefficients i.e. constant term=0 and coefficient =1 (since the hypothesis to be tested is the joint one) and test the residuals of the regression for stationarity. To be precise, because the series are I (1), the inspection of the results of regression from table 6 are inappropriate. The results showed the acceptance of null hypothesis that relationship between the contract maturity spot price and futures prices are unbiased (except for Gur (Hapur) and Turmeric). To prove it conclusively an informal indirect method has been used. The results from this test are given in table 11. This table shows that residuals are stationary for all commodities for all periods except for delivery period and one month before delivery for Turmeric. Although this test is not a formal method of testing for bias in the price relationship, these results provide additional support that the relationship is unbiased.

**Table 11 Phillips-Perron Tests for bias**

| Commodity | Variables | Z(α)-statistics | Z(t)-statistics |
|---|---|---|---|
| Potatoes | $S_t$, $F_d$ | -37.31 | -6.48 |
| | $S_t$, $F_1$ | -38.81 | -6.83 |
| | $S_t$, $F_2$ | -38.03 | -6.81 |
| Pepper | $S_t$, $F_d$ | -69.40 | -8.94 |
| | St, $F_1$ | -66.90 | -8.85 |
| | $S_t$, $F_2$ | -65.04 | -8.31 |
| Turmeric | $S_t$, $F_d$ | -13.84* | -3.03 |
| | $S_t$, $F_1$ | -11.48* | -2.62* |
| | $S_t$, $F_2$ | -16.43 | -3.35 |
| Hessian | $S_t$, $F_d$ | -23.98 | -4.78 |
| | $S_t$, $F_1$ | -23.32 | -4.61 |
| | $S_t$, $F_2$ | -22.35 | -4.45 |
| Gur(Hapur) | $S_t$, $F_d$ | -20.61 | -3.75 |
| | $S_t$, $F_1$ | -22.52 | -3.94 |
| | $S_t$, $F_2$ | -30.69 | -4.96 |
| Gur (Muzaffarnagar) | $S_t$, $F_d$ | -32.48 | -5.00 |
| | $S_t$, $F_1$ | -30.33 | -4.76 |
| | $S_t$, $F_2$ | -28.39 | -4.47 |
| Castorseed (Ahd) | $S_t$, $F_d$ | -44.09 | -7.12 |
| | $S_t$, $F_1$ | -44.01 | -6.84 |
| | $S_t$, $F_2$ | -45.40 | -6.83 |
| Castorseed (Mum) | $S_t$, $F_d$ | -29.87 | -4.84 |
| | $S_t$, $F_1$ | -33.62 | -5.33 |
| | $S_t$, $F_2$ | -32.37 | -5.11 |

*Z ( α)-Statistics and Z (t)- statistics are Phillips-Perron test statistics for determining the stationarity in the residuals of regression. St, F2, F1 & Fd are contract maturity spot prices, futures prices lagged two, one month before maturity and of maturity month resp. The Critical value for Z ( α) and Z (t) are –14.1 and –2.86 respectively at 5% level.*

There appears to be strong evidence that the relationship between the maturity month and one month lagged futures prices and contract maturity spot prices are biased for Turmeric. The estimates of the parameters of the relationship in table 6 and evidence of stationarity in the residuals in table 11 (where the condition intercept = 0 and slope coefficient = 1 has been imposed) are corroboration of the result that null hypothesis stand rejected in case of Turmeric.

In order for futures market to play the risk management and price discovery role, it must be efficient and preferably unbiased. The results presented here are varied across the commodities. Gur (Muzaffarnagar) and Potato futures markets are the efficient and unbiased. Gur futures market shows backwardation revealing the utility of convenience yields to traders. Both Gur and Potato are semi-storable commodities. So efficient price discovery here signifies the importance of futures markets to semi-storable goods. Gur, Hapur (St & F1, F2) and Turmeric (St & F1) are inefficient and biased. The different conclusion for Gur (Hapur) could be due to difference in variety traded of Gur in ready and futures market. The price quotations in two markets correspond to different varieties. For other commodities, the efficiency and unbiasedness varied according to maturity and months left to maturity. Castorseed (Ahmedabad and Mumbai) are efficient and unbiased in the maturity month but this relationship deteriorates as we move away from delivery period. Forward pricing efficiency is weak in case of Pepper and Hessian in the maturity month, which may be due to low level of trading in the maturity month. Inefficiency is more common in thin markets. A further study is required to explore the relationship between price discovery and volume of futures trading in each month of different contracts.

Policy makers should focus on optimizing the contribution of futures markets to discover the prices and minimize risk. Exchanges should regulate the manipulations by speculators. The Government on its part should liberalize the price-fixing exercise to allow market to determine the right price, relax restrictions on free movement of commodities and initiate private participation in warehousing facilities.

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