Convergence of Futures and Spot Prices: A Cointegration Analysis

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National online future exchanges were allowed to be set up in the late 2003 by the government with the purpose of helping efficient price discovery and providing them with an effective mechanism to hedge their price risk. This would not have been possible if the prices discovered by the futures market participants were not relevant to the spot market situation. This pioneering effort taken to analyze the convergence of future prices with the spot market prices using cointegration analysis proved that the future and the spot prices have effectively converged, asserting that futures markets offer the perfect mechanism for hedging their price risk in selected crops.

Introduction

India is traditionally an agrarian economy; therefore, instability of commodity prices has always been a major concern of the producers as well as the consumers. Various challenges have cropped into Indian agriculture during the post WTO regime, for instance, technological changes, innovative irrigation techniques, productivity enhancement, and more importantly, the market reforms. Fragmented rural market is a huge challenge in the marketing/trading of agricultural commodities in India. Farmers' direct exposure to price fluctuations makes it too risky for many to invest in otherwise profitable activities. There are various ways to cope with this problem. Market-based risk management tools for commodities have assumed special significance in the liberalization era (Sahadevan, 2002). Apart from increasing the stability of the market, various factors in the farm sector can better manage their activities in an environment of unstable prices through futures markets. These markets serve as a risk-shifting function, and can be used to lock-in prices instead of relying on uncertain price developments (Raipuria, 2002).

Price risk refers to the probability of adverse movements in prices of commodities, services or assets. Agricultural products, unlike others, have an added risk. Many of them being typically seasonal tend to attract lower prices during the harvest season. The forward and futures contracts are considered to be efficient risk minimizing tools which insulate buyers and sellers from unexpected changes in future price movements. These contracts enable them to lock-in the prices of the products well in advance. Moreover, future prices

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give necessary indications to producers and consumers about the likely future ready price and the demand and supply conditions of the commodity traded. The cash market or ready delivery market, on the other hand, is a time-tested market system, which is used in all forms of business to transfer title of goods.

Model

The cointegration test[1] suggested by Engle and Granger (1987) was employed (Gujarati, 2004) in the present study to analyze the long run relationship between spot price and future price. In addition, the Augmented Dickey Fuller (ADF) test was applied to test for stationarity. This test is used for controlling higher order serial correlations in a series.

The regression for the ADF test is the AR (1) process:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-i} + \varepsilon_t$$

where,

Y_t = a vector to be tested for cointegration,
$\Delta Y_t = Y_t - Y_{t-1}$ = t is time or trend variable,
β_1, β_2 and α_i = parameters, and
ε_t = Random error term (white noise).

After getting the stationarity in the time series, the next step is the Engle-Granger two-step procedure to test for cointegration. The first step involves cointegration of two series, which are of the same order of integration.

The cointegration regression model used is:

$$S_t = \alpha + \beta f_t + u_t$$

where,

S_t = Spot prices of crop at time t,
f_t = Future price at time t,
α and β = Cointegration parameters, and
μ_t = Residual is the cointegration vector/equilibrium error.

Residual μ_t, shows the deviation from equilibrium. This equilibrium error, which in the long run tends to zero, has to be made stationary for finding the cointegration between two integrated variables. The stationarity of the error can be verified through the following equation:

$$\Delta u_t = a_0 u_{t-1}$$

The test implies that errors adjust to the long run equilibrium.

[1] The necessary condition for cointegration is the stationarity of time series data. For the stationary time series data, the mean value and variance/covariance does not vary systematically. To test stationarity, unit root test is employed.

In the second step, the Error Correction Model[2] (ECM) developed by Engle and Granger is used for correcting the disequilibrium. The model for ECM is represented as:

$$\Delta S_t = \alpha_0 + \alpha_1 \Delta f_t + \alpha_2 u_{t-1} + \varepsilon_t$$

The ECM equation states that ΔS_t depends on Δf_t and the equilibrium error term. If the error term is non zero, then the model is in disequilibrium. The speed at which the price approaches equilibrium depends on the magnitude of α_2. Hence, α_2 is expected to be negative. Then, $\alpha_2 u_{t-1}$ is also negative and ΔS_t will be negative to restore the equilibrium in the long run.

Results and Discussion

In order to have an empirical resonance of the mechanism of the futures market in the country, a detailed analysis relating to stationarity, cointegration and price adjustment mechanism between spot and futures prices of important cereals, pulses, oilseeds and cash crops was undertaken.

The descriptive statistics of spot and futures prices of these crops have been illustrated in Table 1. The table shows that futures in the *masoor*, potato, *jeera* and *kapas* commodities were relatively more instable than the spot prices of their counterparts, While for

Table 1: Descriptive Statistics of Spot and Future Prices

Commodity	Prices	N	Mean	Coeff. of Variation	Skewness	Kurtosis
Wheat	Spot	339	816.60	10.86	0.88	–0.42
	Future	339	814.25	9.54	0.76	–0.10
Chana	Spot	474	1741.91	13.54	0.12	–1.41
	Future	474	1755.67	13.33	0.49	–0.60
Urad	Spot	474	2117.69	30.24	0.66	–1.07
	Future	474	2102.76	27.90	0.75	–0.76
Masoor	Spot	272	1876.86	7.78	–0.48	–0.97
	Future	272	1905.21	8.31	–0.48	–0.75
Refined Soya Oil	Spot	476	374.62	6.02	0.52	–0.33
	Future	476	376.76	5.35	0.20	–0.73
Potato	Spot	46	612.36	6.67	0.13	–1.62
	Future	46	669.14	7.66	–0.13	–1.79
Jeera	Spot	388	6802.49	10.47	–0.15	–1.32
	Future	388	6826.60	11.59	0.20	–1.21
Kapas	Spot	351	333.26	6.46	0.25	–0.81
	Future	351	337.36	6.82	0.47	–0.72

[2] The Engle and Granger theorem states that if a set of variables are cointegrated of order (1, 1), then there exits a valid error correction representation of the data. The converse of this theorem also holds good, i.e., if an Error Correction Model (ECM) provides an adequate representation of the variables, then they must be cointegrated. Two integrated variables can be cointegrated, when they converge in the long run, despite short run divergences. ECM is also known as Granger representation theorem, which states that if two variables X and Y are cointegrated, then the relationship between the two can be expressed as ECM.

commodities like wheat, *chana*, *urad*, and Refined Soya oil, the spot prices were more instable than futures.

The ADF test was conducted to examine the stationarity of the spot and future prices of wheat, *chana*, *urad*, *masoor*, refined Soya oil, potato, *jeera* and *kapas,* and results are presented in Table 2.

Table 2: ADF Test—Removal of Non-Stationarity of Spot and Futures Price Series of Different Commodities

Commodity	Prices	Level		First Difference	
		Intercept	Intercept and Trend	Intercept	Intercept and Trend
Wheat	Spot	–1.75	–2.07	–11.15*	–11.14*
	Future	–1.86	–2.55	–12.23*	–12.21*
Chana	Spot	–0.23	–3.08	–15.14*	–15.18*
	Future	–0.03	–2.32	–14.40*	–14.46*
Urad	Spot	–0.10	–2.28	–14.36*	–14.40*
	Future	0.07	–2.20	–13.49*	–13.54*
Masoor	Spot	–1.11	–0.88	–12.50*	–12.52*
	Future	–1.23	–0.97	–10.81*	–10.83*
Refined Soya Oil	Spot	–1.74	–0.20	–15.15*	–15.48*
	Future	–1.24	–0.26	–15.85*	–16.04*
Potato	Spot	–1.23	–1.55	–4.09*	–4.14*
	Future	–0.88	–2.18	–6.83*	–6.66*
Jeera	Spot	–0.07	–3.10	–13.16*	–13.24*
	Future	–0.72	–3.96	–14.36*	–14.36*
Kapas	Spot	–2.27	–2.41	–12.32*	–12.36*
	Future	–2.19	–2.46	–12.55*	–12.57*

Note: * Reveal significance at 1% of probability level.

The ADF test at the series levels (integrated of order 0, I(0)) accepted the null hypothesis of unit root (non-stationary) at 95% level of significance for the spot and futures price series of the all crops. The ADF test statistics of spot and future price series have fallen within the confidence interval, indicating all price series exhibited random walk or levels of series were non-stationary. The first difference of all the non-stationary time series of spot and futures price of each crop was then tested. The first difference or integrated of order 1 denoted as I(1) of all these price series was found to be stationary.

After having established the requirements of unit root, the Augmented Engle-Granger (AEG) cointegration analysis was carried out (Table 3). The spot price series was regressed with the futures price for each crop and the residual—white noise residual, was obtained. This indicates that there was a cointegrating relationship between pairs of spot and futures

price series of the crops. Furthermore, one of the prices in the pair could be predicted from the other price series. Hence, it is suggested that, there is long run equilibrium/ co-movement among the spot and future price series of each crop.

Table 3: Augmented Engle-Granger Cointegration Test			
Commodity	**Intercept**	**Coefficient**	***t*–statistic**
Wheat	–0.003	–0.74	–14.04*
Chana	0.022	–1.06	–22.90*
Urad	0.026	–1.07	–23.30*
Masoor	0.002	–1.14	–18.96*
Refined Soya Oil	–0.002	–1.08	–23.62*
Potato	0.092	–0.63	–4.29*
Jeera	0.180	–1.06	–20.92*
Kapas	0.011	–1.11	–21.00*
Note: * Reveal significance at 1% of probability level.			

Price Transmission Mechanism

Long run equilibrium relationships between these prices were also observed, even though there can be disequilibrium in the short run. For this, the error term can be treated as equilibrium error, and also the intertwined relationship in the short run, giving way to a long run relationship. The ECM was used to estimate the acceleration speed of the short run deviation towards long run equilibrium (Table 4). The advantage of ECM is that it allows for the short run dynamics as well as an assessment for the degree towards the long run relation as shown by cointegration.

Table 4 : Error Correction Mechanism (Speed-of-Adjustment) for Prices					
Commodity	**Intercept**	**First Diff. of FP**	***t*-statistic**	**Error Correction Term**	***t*-statistic**
Wheat	0.20	0.18	5.09	0.26	4.95
Chana	0.91	0.39	10.42	–0.06	–1.23
Urad	1.53	0.56	16.18	–0.07	–1.59
Masoor	0.01	0.55	12.71	–0.14	–2.42
Refined Soya Oil	–0.03	0.34	10.32	–0.08	–1.85
Potato	–2.00	0.10	2.21	0.38	2.45
Jeera	–2.35	0.26	9.16	–0.06	–1.24
Kapas	–0.05	0.67	22.56	–0.11	–2.15

The lagged values and the lag residual of the long run model, and the difference of the spot and future price series were used to estimate the error correction to determine the short run deviation from the equilibrium. The coefficients of the error correction estimate indicated the speed of adjustment at which the price series returns to equilibrium. All the error correction coefficients were significant and their signs were negative, which implied that the series converges to the long run equilibrium for each of the crops considered in the analysis.

The coefficients of the error term are expected to be negative. These coefficients are referred to as the speed-of-adjustment factors, and measure the short run deviation from the long run equilibrium. As the coefficient values approach zero, the paths are slow to adjust back to the long run deviation. This indicates that the spot price series adjusts to changes in the futures price series in the same period. The error correction terms for all crops are presented in Table 4. It is evident from the table that the error correction term for *chana, urad, masoor,* refined Soya oil, *jeera* and *kapas* exhibit not only the desired negative signs with varied degree—from –0.06 to –0.14, but also the convergence in spot and futures prices.

Thus, short run changes in the futures price series have a positive impact on the short run changes in the spot price for *chana*, *urad*, *masoor*, refined Soyabean oil, *jeera*, and *kapas*. This phenomenon of price convergence for all the above crops clearly depicts that the farmers are mitigating price risk as spot prices and future prices converge. This is a good option for hedging in the Indian futures market for the farmers growing these crops.

Conclusion

Instability of commodity prices has always been a major concern for producers as well as consumers in an agriculture-dominated country like India. Farmers, in a bid to avert the price risk, often tend to go for distress sale and thereby, reduce the potential returns. In order to cope up with this problem, futures trading has emerged as a viable option. Apart from increasing the stability of the market, this mechanism also provides a greater degree of assurance on the price front. Hence, the futures markets serve as a risk-shifting function, and can be used to lock-in prices instead of relying on uncertain price developments.

In the present study, an attempt has been made to look into the mechanism of movement of spot and futures prices for various cereals, pulses, oilseeds and major cash crops in the Indian agriculture. The ADF test was used to check the stationarity of the time series data for each of the crops. Most of the series have been found to be stationary at first difference. The cointegration test was used to find out whether there exists a long run relationship between spot and futures prices of various contract months for these crops. However, in the short run there may be disequilibrium between these two. Short run changes in the future price series have a positive impact on the short run

changes in the spot price for *chana, urad, masoor,* refined Soya oil, *jeera* and *kapas*. Hence, it has been observed that the futures contract behaves in an expected manner, and there exists a mechanism for long run equilibrium in these purposively selected crops. This phenomenon of price convergence for all the above crops clearly indicates that the farmers are mitigating price risk as spot prices and future prices converge.

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