Price Discovery and Market Efficiency in Indian Futures Market

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ABSTRACT

Price discovery is one of important economic functions of futures market as it gives competitive reference (futures) price from which spot price can be derived. The study examines price discovery and market efficiency in the Indian futures market using metal and energy futures. Sample data consist of daily futures and spot closing price from 1st September, 2005 to 30th December 30, 2011 for gold, silver, copper, and crude oil, and from 1st November , 2006 to 30th December, 2011 for natural gas based on availability. Using co-integration and error correction mechanism, the study finds the fair price discovery in the futures market. The study also finds that price discovery takes place first in the futures market then transgresses to spot market. Ratio of standard deviation is used to check the market efficiency in the futures market and if is found that gold market is not efficient as it fails to incorporate all the information available in the market.

Keywords

Futures pricing, efficient market
***JEL Classification*:** G13

1. INTRODUCTION

Price discovery is one of the important economic functions of futures market and it is widely accepted that price discovery takes place first in the futures market then transfers to the spot market due to inherent leverage, low transaction cost, and lack of short sell restrictions (Tse, 1999)[1]. The essence of price discovery is to establish a competitive reference (futures) price from which the spot price can be derived. It depends on whether information is reflected first in changed futures price or in changed spot price. Quan (1992)[2] finds that price discovery takes place in spot market and gets transmitted to futures market. In contrast, Garbade and Silber (1983)[3] conclude that futures market plays a major role in the price discovery and spot market has role in price discovery too. The dearth of conclusive statement on price discovery creates scope for the further examination.

Efficient futures market needs to incorporate all the information available in the market during price determination. Day-to-day variations in spot and futures prices are purely a result of new information that is arriving in the market. The extent of variation in both spot and futures markets should be similar for the storable commodities. If the spot market is efficient, the relative magnitude of variation in prices can help assess whether the futures market is able to incorporate information efficiently. The behaviour of investors causes failure to efficient market hypotheses. The study examines market efficiency in the context of Indian market.

2. DATA AND METHODOLOGY

Secondary data are collected from Multi Commodity Exchange (MCX), Mumbai for the analysis. The exchange is chosen on the basis of highest trading volume of metal and energy futures. Daily spot and futures closing prices of gold, silver, copper, crude oil and natural gas are collected from MCX website. Closing price of the commodities is taken into analysis as it is believed that closing price incorporates all the information during the trading day. The commodities are chosen based on MCX's world ranking in terms of number of futures contracts traded in 2011, where silver stood 1st followed by gold, copper, natural gas and crude oil. The future series of the aforesaid commodities are constructed by taking into account the nearby futures contract (i.e. contract with the nearest active trading delivery month to the day of trading). The nearby futures contract is used because it is highly liquid and the most active. Daily futures and spot closing prices are taken from September 1, 2005 to December 30, 2011 for gold, silver, copper, and crude oil. Natural gas futures and spot closing prices are taken from November 1, 2006 to December 30, 2011 based on availability. Data period includes 38 gold futures contracts with 1872 observations, 32 silver futures contracts with 1876 observations, 31 copper futures contracts with 1893 observations, 76 crude oil futures contracts with 1894 observations and 62 natural gas futures contracts with 1554 observations. Futures contracts and observations differ from commodity to commodity as official allocation of contracts differs commodity wise, e.g., gold has six futures contracts per year where crude oil has 12 contracts per annum. The contracts size of commodity is decided by futures exchanges with the consultation of Forward Market Commission. All the observations are reported excluding Sundays and holidays. Furthermore, we have created data series in such a way that both spot and futures data are available in a given date. The data matching has been done for all the series taking into account of availability of the data both for futures and the spot in any given day. The non-availability of data either on spot or futures for any given day has been deleted from both the series.

Generally, price change in one market transgress into the other market. The price change may occur first at futures market and in turn influences the spot market and vice versa. This price change may continue to persist for a longer period of time, which could be due to other fundamental factors associated with the futures and spot market. To capture the long run equilibrium between futures

[1] Tse, Y. (1999): 'Price Discovery and Volatility Spillovers in the DJIA Index and Futures Markets', *The Journal of Futures Markets*, Vol. 19, pp.911–930.

[2] Quan, J. (1992): 'Two-step Testing Procedure for Price Discovery Role of Futures Prices' *The Journal of Futures Markets*, Vol. 12, pp.139-149.

[3] Garbade, K. D. and Silber, W. L. (1983): 'Price Movements and Price Discovery in Futures and Cash Markets', *The Review of Financial and Economic Studies*, Vol.65, pp.421-440.

and spot market the following equation can be written as a regression framework:

$$F_t = \alpha + \beta S_t + \varepsilon_t (1)$$

Where F_t and S_t are spot and futures price at time t. α and β are the intercept and coefficient terms. Equation (3.5.2) can be expressed in the residual as:

$$F_t - \alpha - \beta S_t = \hat{\varepsilon}_t \quad (2)$$

Where $\hat{\varepsilon}_t$ is the estimated white noise disturbance term. Ordinary least squares (OLS) inappropriate if F_t and S_t are non-stationary because standard errors are not consistent. If F_t and S_t are non-stationary but the estimated disturbance term ($\hat{\varepsilon}_t$) is stationary then S_t and F_t are said to be cointegrated. That means they have a long run relationship or price discovery takes place in the market. If each series (F_t and S_t) is non-stationary in the level but the first difference (ΔF_t and ΔS_t) and deviation ($\hat{\varepsilon}_t$) are stationary, the series are said to be cointegrated of the order (1, 1) with β as a cointegrating parameter.

The study mentioned that if each series (S_t and F_t) is non-stationary at the level but the deviation $\hat{\varepsilon}_t$ is stationary then S_t and F_t are said to be cointegrated or they have long run equilibrium. But, in the short run there may be disequilibrium. Therefore, we can treat error term ($\hat{\varepsilon}_t$) as the equilibrium error. The error correction mechanism (ECM) states that if two variables F_t and S_t are cointegrated then the relationship can be expressed as ECM which includes last period's equilibrium error as well as lagged values of first difference of each variable. Therefore, temporal causality can be assessed by examining the statistical significance and relative magnitude of the error correction parameter and parameter of lagged variables. The error correction model is (Pizzi, Economopoulos and O'Neill, 1998; Wahab and Lashgari, 1993):

$$\Delta F_t = \delta_s + \alpha_s \hat{\varepsilon}_{t-1} + \beta_s \Delta S_{t-1} + \gamma_s \Delta F_{t-1} + e_{s,t} (3)$$

$$\Delta S_t = \delta_f + \alpha_f \hat{\varepsilon}_{t-1} + \beta_f \Delta F_{t-1} + \gamma_f \Delta S_{t-1} + \epsilon_{f,t} (4)$$

In the above two equations, the first part ($\hat{\varepsilon}_{t-1}$) is the equilibrium error. This measures how the left hand side variable adjusts to the previous period's deviation from long run equilibrium. The remaining portion of the equation is lagged first difference which represents the short run effect of previous period's change in the price on current period' s deviation. The parameter of the equilibrium error, α_s and α_f, is the speed of the adjustment parameter and have important implication in an error correction model. At least one speed of adjustment parameter must be non-zero for the model to be ECM. The parameter serves the role of identifying the direction of causal relation and shows the speed at which departure is corrected.

3. EMPIRICAL ANALYSIS

All price series are found to be non-stationary with no tendency to revert back to an underlying trend value as they typically exhibit 'random walk' properties, i.e., today's prices cannot be used to predict future prices. However, differencing the data runs the disadvantage of losing information about underlying long run relationships between prices. Thus, the relationship and co-movement between the prices is examined in a co-integration framework in which linear combinations of non stationary variables could be identified.

ADF and PP test results for gold, silver, copper, crude oil and natural gas are reported in the table 1 (see Appendix). The results of both ADF and PP test show that the null hypothesis (that all the series for gold, silver, copper, crude oil and natural gas are non-stationary H_0 : □□□□) cannot be rejected either at 1 percent significance level. Therefore, the spot and futures prices are non-stationary in the levels model. This non-stationarity raises the possibility of spurious regressions in the levels model and requires a test for stationarity at the difference level. The results of applied ADF and PP tests to the first-order difference of the sample spot and futures series of gold, silver, copper, crude oil and natural gas are also reported thereof in the table 1. All the first differences of return series are stationary at 1 percent level of significance. Thus, all the prices are integrated of the first order; *I(1)*. This implies that the levels of all the five spot price and futures prices series show similar temporal properties. However, whether the levels of the spot price and futures prices are statistically linked over the long run has to be examined by the cointegration test.

4. ENGLE-GRANGER COINTEGRATION

Engle-Granger cointegration technique is applied to examine price discovery process in the metal and energy market. Price discovery can be accessed by close relationship between spot and futures in the long run. Cointegration technique is used to check long run equilibrium relationship between spot and futures. Once the long run relationship is established then it can be concluded that price discovery does exist in the respective futures market.

Initially, regression technique is used to calculate residual values. As it is already mentioned that all the variables are non-stationary in the level, therefore regression results are likely to be spurious in nature. However, the major objective of the study is to check stationarity of residual values drawn from the regression so as to know whether futures and spot are cointegrated. ADF and PP tests are applied to the residual values for stationary. These results are reported in the table 2 (see Appendix) and it is observed that residual values for gold, silver, copper, crude oil and natural gas are stationary in the level which indicates futures and spot are cointegrated in all those respective commodities. Whether price discovery takes place first in the futures or spot can be examined from the error correction mechanism.

Error correction results for gold, silver, copper, crude oil and natural gas are reported in the table 3 (see Appendix) where t-statistic values are reported in the parenthesis. For the diagnostic checking, the study has used Ljung Box Q statistics for first order serial correlation. The empirical results say Ljung Box Q statistics are significant at the 5 percent level of significance as it is well below its critical value of 3.84. The results for the error correction model are consistent with and support the results for cointegration. At least one error correction coefficient is significant in all cases where Engle-Granger technique indicates the presence of a cointegration vector. If coefficient α_s is always significant indicating that causality exists from futures to spot for all the commodities. In other words, price discovery occurs first in the futures market than transgress to spot market. Price discovery occurs additionally in the spot market if β_f is significant. The magnitude of β_s is at least twice that of β_f indicating stronger feedback from futures to spot market for all commodities. The error correction results indicate that there is unidirectional causality from futures to spot. Price discovery occurs in the futures market then transgress to spot market for all commodities.

5. MARKET EFFICIENCY

In an efficient market, day- to-day variations in spot and futures prices are purely a result of new information that is arriving in the market. For storable commodities, in the efficient market, the extent of variation in both spot and futures markets should be similar. If the spot market is efficient, the relative magnitude of variation in prices can help assess whether the futures market is able to incorporate information efficiently. The study has analysed the ratio of standard deviations of futures and spot prices on a monthly basis to assess the futures market's performance. Assuming cost of carry in the month is negligible, a ratio of standard deviation of future and spot prices that is closer to one indicates that futures market is efficient, viz., markets are incorporating all the information efficiently, a ratio greater than one close to the maturity period indicates speculative activities. Conversely, a ratio less than one shows that markets are not able to incorporate the information fully and efficiently. For the sake of interpretation, a cut-off has been assumed at 0.7 and 1.3 as the lower and upper levels to provide indication of extent of variability in the spot and futures markets. This assumption is on the same lines as adopted in the previous study (Naik and Jain, 2002).

In case of gold, the ratio were less than 0.7 (see table 4 in Appedix) in most of the cases suggesting that futures price variability is substantially less than the spot price variability. As mentioned earlier, this pattern is an indication of inefficient utilisation of information in the market. However, in 2011, ratio were close to one in all contracts except February indicates the efficient utilisation of information in the gold market.

Ratio of standard deviation of futures price to that of spot price for silver is reported in the table 5 (see Appendix). In most of the cases, ratio for silver were close to one, indicates silver futures prices are able to incorporate information efficiently and silver futures market is efficient. Similarly, In case of copper, the ratio of standard deviation of futures to spot is reported in the table 6(see Appendix). The results show that the ratio of standard deviation of futures to spot were close to one in most of the cases, indicate copper futures prices incorporate information efficiently. Ratio of standard deviation of futures price to that of spot price for crude oil is reported in the table 7(see Appendix) and it is observed that ratio of standard deviation of futures to spot for crude oil were close to one, indicate crude oil futures prices are able to incorporate information efficiently. In case of natural gas, ratio of standard deviation of futures to spot is reported in the table 8(see Appendix). The results show that ratio of standard deviation of futures to spot were close to one in most of the cases, indicate natural gas futures prices incorporate information efficiently.

6. POLICY SUGGESTIONS

Market determined prices in the futures market create confidence among participants for the investment but this is not case always as speculative trading distorts the market fundamentals. Therefore, the role of policymakers in futures market is desirable so as to stabilize the market by ensuring smooth run of price discovery process. Moreover, futures markets need to incorporate all the available information while setting up the prices of futures. The study finds that gold market is not efficient as prices of gold fails to incorporate all the available information. One of the possible reasons may be herd behaviour of investors in the gold market leads to failure of efficient market hypothesis. Policy makers are suggested to apply policy tools to make gold market efficient.

7. CONCLUSION

Using a novel and comprehensive dataset of MCX India daily data, this chapter provides systematic study of price discovery process in the spot and future commodities market of India. This chapter investigated whether spot and futures commodities price are cointegrated or not. The daily closing price series of the commodities under the study are cointegrated and therefore both futures and spot series exhibit a stable long-run equilibrium relationship. The error correction results indicate the futures and spot are cointegrated which support long run relationship. This evidence appears to suggest that more information flows from the futures to the spot market. In other words, price discovery takes place in the futures market first and transgress into the spot market in the commodities under study. In examining price volatility, we find that gold market does not incorporate information efficiently. On the contrary, silver, copper, crude oil and natural gas incorporate information efficiently.

Appendix

Table 1 Stationary Test for Commodities

Variable	ADF		PP	
	Level	1st Difference	Level	1st Difference
Gold Futures	1.354	-11.167*	1.646	-44.684*
Gold Spot	0.572	-43.751*	0.647	-43.78*
Silver Futures	-0.623	-46.98*	-0.688	-46.86*
Silver Spot	-0.785	-44.85*	-0.73	-44.85*
Copper Futures	-2.021	-44.74*	-2.006	-44.74*
Copper Spot	--2.209	-8.916*	-2.329	-10.13*
Crude Oil Futures	-1.168	-43.157*	-1.175	-43.157*
Crude Oil Spot	-1.382	-45.415*	-1.27	-45.454*
Natural Gas Futures	-1.541	-40.09*	-1.514	-40.102*
Natural Gas Spot	-1.571	-43.27*	-1.575	-43.22*

*Note: * indicates 1 percent level of significance*

Table 2 Stationary Test Results for the Residual

Variable	ADF	PP
	Level	**Level**
Gold	-5.864* (0.00)	-7.448* (0.00)
Silver	-12.46* (0.00)	-41.46* (0.00)
Copper	-5.57* (0.00)	-43.33* (0.00)
Crude Oil	-26.167* (0.00)	-38.54* (0.00)
Natural Gas	-39.88* (0.00)	-48.29* (0.00)

Note: indicates 1% level of significance and Probability values in parenthesis*

Table 3 Error Correction Results for the Commodities

Equations	Coefficients	Gold	Silver	Copper	Crude Oil	Natural Gas
Futures	δ_f	11.586* (4.32)	21.73 (1.35)	0.131 (1.05)	1.159 (0.74)	-0.119 (-0.66)
	α_f	0.001 (-0.11)	-0.203* (-5.46)	0.01 (0.86)	0.082** (2.26)	0.057 (0.99)
	β_f	0.004 (0.26)	-0.028 (-1.0)	0.00 (0.01)	0.005 (0.21)	0.015 (0.61
						)
	γ_f	-0.041 (-1.69)	0.026 (0.801)	-0.02 (-0.79)	0.059 (1.67)	0.033 (0.57)
Ljung Box Q	Q(1)	0.003	0.008	0.0002	0.0008	0.001
Spot	δ_s	6.47 (1.75)	17.48 (1.37)	0.11 (0.35)	0.896 (0.73)	-0.111 (-1.27)
	α_s	-0.04* (-5.22)	-0.454* (-15.28)	-0.967* (-30.7)	-0.004* (-21.06)	-0.938* (-33.06)
	β_s	0.52* (15.61)	0.262* (9.71)	-0.061 (-0.906)	0.283* (10.07)	0.051 (1.80)
	γ_s	-0.103* (-4.55)	-0.088* (-3.83)	-0.01 (-0.506)	-0.056* (-2.85)	0.031 (1.09)
Ljung Box Q	Q(1)	0.27	1.001	0.0003	0.78	0.001

*Note: Figure in parenthesis is t-statistic values, and * & ** indicate 1 percent and 5 percent level of significance respectively.*

Table 4 Ratio of Standard Deviation of Futures Price to that of Spot Price for Gold

Year	February	April	June	August	Oct	Dec	the percent times the ratio was	

							<0.7	>1.3
2006	0.73	0.76	0.10	0.06	0.07	0.25	50	0
2007	0.28	0.25	0.13	0.31	0.26	0.35	100	0
2008	0.67	0.12	0.20	0.29	0.17	0.17	100	0
2009	0.59	0.28	0.34	0.82	0.40	0.28	83.33	0
2010	0.29	0.40	0.44	0.45	0.44	0.59	100	0
2011	0.55	0.79	0.89	0.88	1.02	0.91	16.66	0
<0.7(%)	83.33	66.66	83.33	66.66	83.33	83.33		
>1.3(%)	0	0	0		0			

Table 5 Ratio of Standard Deviation of Futures Price to that of Spot Price for Silver

Year	March	May	July	September	December	the percent times the ratio was	
						<0.7	>1.3
2006	0.86	1.08	1.07	0.90	0.91	0	0
2007	1.04	1.29	1.18	1.22	0.80	0	0
2008	1.10	1.58	1.13	1.10	1.05	0	20
2009	0.43	0.99	1.97	0.91	0.88	20	20
2010	1.00	0.99	0.94	1.08	1.01	0	0
2011	1.01	0.95	0.97	0.90	1.08	0	0
<0.7(%)	20	0	0	0			
>1.3(%)	0	20	20	0			

Table 6 Ratio of Standard Deviation of Futures Price to that of Spot Price for copper

Year	February	April	June	August	Nov	the percent times the ratio was	
						<0.7	>1.3
2006	0.14	0.54	1.04	0.96	0.98	20	0
2007	1.018	0.94	1.00	0.90	0.92	0	0
2008	0.97	0.99	0.97	0.90	0.95	0	0
2009	0.87	0.94	0.98	0.97	0.96	0	0
2010	0.95	0.95	0.91	0.91	1.04	0	0
2011	0.94	1.03	0.89	1.01	0.95	0	0
<0.7(%)	20	20	0	0	0		
>1.3(%)	0	0	0	0	0		

Table 7 Ratio of Standard Deviation of Futures Price to that of Spot Price for crude oil

Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Ratio**	
													<0.7	>1.3
2007	1.04	0.77	0.86	0.65	1.23	1.06	0.83	0.83	1.04	0.92	1.08	0.84	8.33	0

2008	0.98	1.09	1.03	1.03	1.06	1.04	0.98	0.94	1.16	1.00	0.91	1.08	0	0
2009	1.02	0.85	0.85	0.85	0.88	0.96	1.01	0.84	0.82	0.87	1.07	0.94	0	0
2010	0.84	1.07	0.81	0.97	1.05	0.88	1.07	1.04	0.90	0.89	0.94	0.84	0	0
2011	0.92	1.13	0.61	0.94	0.98	1.13	0.95	1.01	0.92	0.97	0.95	1.02	8.33	0
<0.7(%)	0	0	20	20	0	0	0	0	0	0	0	0		0
>1.3(%)	0	0	0	0	0	0	0	0	0	0	0	0		

Table 8 Ratio of Standard Deviation of Futures Price to that of Spot Price for Natural Gas

Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Ratio**	
													<0.7	>1.3
2007	0.90	0.91	0.97	0.88	0.68	1.13	0.99	0.97	0.92	0.59	0.75	1.08	16.66	0
2008	0.8	1.14	0.96	0.93	1.00	0.9	1.1	0.92	0.9	0.9	0.95	0.9	0	0
2009	1.02	1.20	0.88	1.01	0.99	0.95	0.99	1.09	1.03	0.85	1.07	0.96	0	0
2010	0.90	1.06	1.04	0.94	1.03	0.86	1.02	1.03	1.09	1.06	0.82	1.14	0	0
2011	0.88	1.04	0.97	0.97	0.98	1.03	0.91	0.84	0.96	0.98	0.95	1.04	0	0
<0.7(%)	0	0	20	20	20	0	0	0	0	20	0	0		0
>1.3(%)	0	0	0	0	0	0	0	0	0	0	0	0		

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