# Price Discovery in Commodity Market – An Empirical Study on the Indian Gold Market

**L. S. Sridhar and M. Sathish**

*Abstract*

*This research examines whether precious metal futures serve as a price discovery vehicle for spot market movement. The co-integration test shows that gold futures and spot prices are cointegrated and silver futures and spot prices are cointegrated. The Error Correction model and Granger Causality test show that gold futures serve as a price discovery for gold spot prices. There is an empirical evidence to show that spot prices appear to play a dominant and significant role in the futures market. The Error Correction Estimates, in the case of Gold, shows that spot price (gold) does not cause by itself but it influences the future price (gold) in 2 lags. On the other hand, future price (gold) cause by itself in 2 and 4 lags. The spot price serves as a price discovery tool for Gold.*

## Introduction

Price discovery in futures market commonly refers to the use of futures price to determine the expectations of future cash market prices. Price discovery and hedging are the major economic uses of futures contract. Many theoretical as well as empirical attempts have been made by academicians, practitioners, and regulatory bodies. Many studies first examine this relationship on the basis of price or return. The returns on a variety of futures contracts generally lead spot returns.

Over the years, researchers have focused on different issues in commodities market with particular emphasis on modeling in pricing. Hathway et al (1974) has found that there is a strong relationship between food prices and inflation. Wiese & Lake (1978) studied that Price Discovery refers to the use of futures price for pricing cash market transactions. The significance of their contributions depends upon a close relationship between the prices of futures contract and cash commodities. Cornell and Reinganum (1981) and French (1983) found empirically that the differences between futures and forward prices for metals and foreign exchange were small and were not explained by models of the daily vs. terminal settlement features. In the equities market, Kawaller et al. (1987), and Stoll and Whaley (1990) find that S&P500 futures price lead spot price. Chan et al. (1991) and Pizzi et al. (1999) observe bi-directional causality between S&P 500 futures and stock index, but the futures market has a stronger lead effect. Likewise, commodities futures prices are found to lead spot prices. Garbade and Silber (1983) followed by Engle and Granger (1987), since then most of the price discovery process has identified through co integration test. This process is applicable to equity, debt and forex futures and spot markets. Unlike an equity market, we cannot conclude or generalise the results for all commodity products since each commodity has its own features and various on different factors.

The majority of empirical studies of price

discovery are confined to the analysis of cash and futures market and in relation to equity index futures. Moreover, in the Indian context, though price discovery has been experimented with respect to stock futures and stock options not much evidence on price discovery process. Hence, in this project an attempt is made to examine the price discovery for gold prices in spot and futures market.

Commodity prices, many researchers have used notions of co-integration [Engle and Granger (1987)] to investigate price discovery in futures market. The developments in co-integration theory have provided a new framework to examine the existing relationship between cash and future commodity markets. Price discovery process has been done on agricultural products for storable and non storable commodities in all other international markets.

Schroeder and Goodwin (1991) used co integration procedures to examine that daily cash and futures prices did not share a long-run relationship. They found a short-run relationship between cash and futures prices based on Garbade-Silber (1983) model, but failed to find a long-run relationship using either Granger-causality or co integration procedures. A slightly different approach was adopted by Koontz et al (1990) to study the price discovery in the livestock market. Using weekly US cash and futures prices from 1973 through 1984, they investigated nature of the price discovery process.

In the recent years Praveen and Sudhakara (2006) attempted to study a comparison of price discovery between stock market and the commodity future market. They have taken Nifty future traded on National Stock Exchange (NSE) and gold future on Multi Commodity of India (MCX). The result empirically showed that the one month Nifty future did not have any influence on the spot Nifty, but influenced by future Nifty itself. The casual relationship test in the commodity market showed that gold future price influenced the spot gold price, but not the contrary. So this implies that information is first disseminated in the future market and then later reflected in the spot market

Fu and Qing (2006) examined the price discovery process and volatility spillovers in Chinese spot-futures markets through Johansen cointegration, VECM and bivariate EGARCH model. The empirical results indicated that the models provided evidence to support the long-term equilibrium relationships and significant bidirectional information flows between spot and futures markets in China, with futures being dominant.

Gupta and Belwinder (2006) examined the price discovery mechanism in the NSE spot and future market. The study uses the daily closing values of index future S&P CNX Nifty, from June 2002 to February 2005. By using the techniques like Johansen and VECM, it was empirically found that there was bilateral causality between the Nifty index and futures.

**Objectives of the study**

To examine the Price Discovery in Commodity Market with emphasis on gold

To examine the existing relationship between spot and future price of gold

## Research Methodology

### Data

The data for the study consist of 3 months futures prices and spot prices: Gold - 10th January, 2007 to 31st March, 2009 comprising 581 observations. All the times series are obtained from NCDEX (National Commodities and Derivatives Exchange) database. Most of the investors prefer to invest in Bullion market not only because it is a safe investment but also, because it hedges against inflation and political uncertainties and it is easy to liquidate. In this study, only futures and spot price are considered and the log returns are used.

The research design used here is descriptive in nature, where the study is done based on analyzing the Spot price and future price. We have obtained 27 months daily data series from January 10, 2007 to 31st March 2009 for spot price and future prices. More than 24 months' data were taken for this research, the basic idea being future and spot prices can share long run relationship. The study period selected for spot price of gold during the period April 2002 to June 2005 showed that the Indian gold price volatility is relatively higher than global market (Praveen and Sudhakara, 2006).

### Methodology

Given the time series nature of data, the first step in the analysis is to determine the descriptive statistics and the variables are tested for normality using Jarrque-Bera test. Then, the price linkage between futures market and spot market would be initially investigated using Augmented Dickey Fuller Test and Phillips-Perron Test. Cointegration analysis will be done using Johansen Cointegration Test that measures the extent to which two markets have achieved long run equilibrium. The Causality will be checked using Granger Causality Test. Error Correction dynamics characterize the price discovery process, whereby markets attempt to find equilibrium.

### Testing for Stationarity and Co integration

The first step in the analysis is to determine the descriptive statistics and the variables are tested for normality. Then the stationarity of the time series is tested using the Augmented Dickey-Fuller test and Schmidt-Phillips test. The null hypothesis to be used is that there is a unit root in the series (i.e. series is non-stationarity) while the alternative hypothesis is that there is no unit root. If spot and futures prices are found to be integrated of the same order, co integration test using the Johansen procedure are performed. One of the most widespread unit root test is the Augmented Dickey Fuller (ADF) test. The standard Dickey Fuller test estimates following equation:

$$\Delta x_t = (\alpha - 1)x_{t-1} + \varepsilon_t$$

The case which corresponds to the random walk which is non-stationarity. The Dickey Fuller test tests whether this t-statistic does not converge to the normal distribution but instead to the distribution of a functional of Wiener process.

The Dickey Fuller test is only valid for AR (1) processes. If the time series is correlated at higher lags, the augmented

Dickey Fuller test constructs a parameter correction for higher order correlation, by adding lag differences of the time series:

$$\Delta x_t = (\alpha - 1)x_{t-1} + \sum_{j-1}^{p} \beta_j \Delta x_{t-j} + \varepsilon_t$$

The order of p could be chosen by minimising information criteria such as Akaike or Schwarz.

The basic idea is that futures and cash prices can share a long-run relationship if they are found to be cointegrated, i.e. if there is a linear combination of them which is stationarity. There are several methods available for conducting the co integration test, the most widely used method include the residual based Engle-Granger (1987) test and Johansen-Juselius (1990) tests. Then Engle-Granger co integration test consists of a two stop procedure. In the first step, the residual error is tested for stationarity. Variables Y and X might individually be non-stationarity but if the estimate of their residual error is stationarity, Y and X are said to be cointegrated. It implies that Y and X form a long run relationship and the regression is not spurious. Engle and Granger (1987) have shown that any cointegrated series has an error correction representation. In the second step, if the residual error or the estimation in the first step is stationarity, the error correction mode is estimated, which represents the short run dynamics of the model. If spot and futures prices are found to be integrated of the same order, co integration test using Johansen procedure is performed. The basic idea is that futures and cash priced can share a long-run relationship if they are found to be cointegrated, i.e. if there is a linear combination of them which is stationarity. In this study, Granger causality test and Johansen test is applied for price discovery performance.

**Testing for Stationarity**

The following hypothesis is postulated

Null Hypothesis $H_0$ – Futures price has a unit root in the series (Non- stationary)

Alternate Hypothesis $H_1$ – Futures price has no unit root in the series (stationary)

**Testing for Causality with Error-Correction Models**

The application of Granger causality tests in economics and finance has proliferated. On an intuitive level, the standard Grange causality test examines whether past changes in one variable 'y' help to explain current changes in another variable 'x'. If not, then one concluded that 'y' does not Granger cause 'x'. In order to determine whether causality runs in the direction from 'x' to 'y', the experiment is repeated with 'x' and 'y' interchanged. Four findings are possible: (1) neither variable Granger causes the other; (2) 'y' causes 'x', but not vice versa (3) 'x' causes 'y' but not vice versa, (4) 'x' and 'y' cause each other.

In more formal terms, the standard Granger causality test is based on the following regression:

$$\text{“}x_t = \acute{a}_0 + \text{“}\hat{a}_{xi}\text{”}x_{t-i} + \text{“}\hat{a}_{yi}\text{”}y_{t-i} + \mathring{a}_t \quad (1)$$

$i = 1 \qquad i = 1.$

Where, “ is the first-difference operator and “x and “y are stationary times series. The null hypothesis that ye does not Granger cause x is rejected if the

coefficients, $\hat{a}_{yi}$ in equation (1) are jointly significant based on a Standard F-test The null hypothesis that x does not Granger cause y is rejected if the $\hat{a}_{xi}$ are jointly significant in equation (1) when "x replaces "y as the left side dependent variable.

Granger (1986) and Engle and Granger (1987) provide a more comprehensive test of causality, which specifically allows for a causal linkage between two variables stemming from a common trend or equilibrium relationship. More, specifically, this alternative to the standard test for Granger causality considers the possibility that the lagged level of variable 'y' may help to explain the current change in another variable 'x' even if past changes in 'y' do not. The intuition is that if 'y' and 'x' have a common trend, then the current changes in 'x' partly is the result of 'x' moving into alignment with the trend value of 'y'. Such causality may not be detected by the standard Granger causality test, which only explains whether past changes in a variable help to explain current changes in another variable. As long as 'x' and 'y' have a common trend, however, causality must exist in at least one direction. The finding of no causality in either direction-one of the possibilities with the standard Granger causality test is ruled out when the variables share a common trend. In more formal terms, this alternative test for Granger causality is based on error-correction models that incorporate information from the cointegrated properties of time series variables. Two (or more) variables are cointegrated (have an equilibrium relationship) if they share common trend(s). To test for causality when variables are cointegrated, the following error correction equation is used:

$$\text{"}x_t = \acute{a}_0 + \text{"}\hat{a}_{xi}\text{"}x_{t-i} + \text{"}\hat{a}_{yi}\text{"}y_{t-i} + \acute{a}_1 + \mu_{t-1} + \mathring{a}_t \qquad (2)$$

$i=1$ $i=1$ (p) (p)

Where $x_t$ and $y_t$ have been identified as first differenced stationary, co integrated times series and $\mu_{t-1\,is}$ lagged value of the error term from the following cointegration equation

$$x_t = \tilde{a}y_t + \mu_t \qquad (3)$$

The inclusion of $\mu_{t-1}$, which must be stationary if the, first differentiated stationary 'x' and 'y' series are cointegrate, differentiates the error correction model form the standard Granger causality regression. By including $\mu_{t-1}$, the error correction model introduces an additional channel through which Granger causality can emerge. Based on equation (2), the null hypothesis that 'y' does not Granger cause 'x' is rejected not only if the $\hat{a}_{yi}$ s are jointly significant, but also if the coefficient on $\mu_{t-1}$ is significant. Thus in contrast to the standard Granger causality test, the error-correction approach as discussed by Granger (1987) allows for the finding that 'y' Granger causes 'x', even if the coefficient on lagged changes in 'y' is not jointly significant.

If spot and futures prices are found to be integrated of the same order, cointegration tests using Johansen procedure are performed. Provided the spot and futures prices are cointegrated, they are expected to return to the long

run-equilibrium after possible short run deviations. Using cross correlogram, five lags are identified or both futures and spot price. The cointegrated variables can be represented by an error correction mode, in which the "error" refers to the disequilibrium responses. Since the residual $\{e_{t-1}\}$ from $F_{t-1} = á + â.S_{t-1} + e_{t-1}$, represents an estimation of the deviation from the long run equilibrium in period $_{t-1}$, it can be used in the error correction term in the model.

$$\text{“}F_t = á + ð.e_{t-1} + \text{“}_{i=1}^{q} â_i\text{”}F_{t-i} + \text{“}_{i=1}^{q} ã_j\text{”}S_{t-j} + å_t \quad (5)$$

$$\text{“}S_t = á' + ð'.e_{t-1} + \text{“}_{i=1}^{q} â'_i\text{”}F_{t-i} + \text{“}_{j=1}^{q} ã'_j\text{”}S_{t-j} + å_t \quad (6)$$

, here F and S stand for futures and spot prices, respectively and here q = 5, specifying the lag structure for both futures and spot price has been identified by SBC. The null hypothesis of non-causality is given by

$H_0 = ð = ã_1 = ã_2 = ã3 = \ldots\ldots = ã_q = 0$ in equation (4) and

$H_0 = ð' = â'_1 = â'_2 = â'_3 = \ldots\ldots = â_q = 0$ in equation (5), and

the test statistic follows a chi square distribution with degrees of freedom to the number of restrictions.

**Results and Discussion**

Descriptive statistics and Stationarity Tests

Table -1

**Descriptive Statistics**

| | Gold Future Price | Gold Spot Price |
|---|---|---|
| Mean | 12261.33 | 12788.30 |
| Median | 12241.50 | 12794.18 |
| Maximum | 17988.00 | 17900.00 |
| Minimum | 8675.000 | 8581.250 |
| Std. Dev. | 2464.379 | 2591.420 |
| Skewness | 0.196542 | -0.016599 |
| Kurtosis | 1.855529 | 1.899900 |
| Jarque-Bera | 35.38794 | 29.27360 |
| Probability | 0.000000 | 0.000000 |

Descriptive statistics, using the observations 2007/01/10 - 2009/12/16 for the variable 'Gold Future price' and 'Gold Spot Price' (580 valid observations)

The Descriptive statistics shows that all the variables are not normally distributed. The Skewness and Kurtosis are clearly observed in both the data series, which is a confirmation of the stylized fact, related to fat tails and extreme values with high frequencies data. Skewness measures asymmetry of a distribution. It is also noticed that the gold futures and spot market seems to be more volatile on the considered period regarding standard deviation.

Table -2.1

Augmented Dickey Fuller (ADF) Test - Future Price and Spot Price

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| Gold Future Price (-1) | -0.001080 | 0.003406 | 0.317190 | 0.7512 |
| Constant | 27.60341 | 42.56247 | 0.648539 | 0.5169 |
| Gold Spot Price (1) | -0.002105 | 0.002958 | -0.711694 | 0.4769 |
| Constant | 39.28758 | 38.57137 | 1.018568 | 0.3088 |

The absolute value of ADF and PP test statistic is more than the critical value at 5% level. Therefore, both the series can be taken as non-stationary. The null hypothesis that the Futures price and the Spot Price having a unit root is not rejected. It is further found that the both the gold futures and spot prices are integrated of order 1. Therefore, the necessary condition for testing cointegration is satisfied.

Table - 2.2

**Philip Perron (PP) Test - Future Price and Spot Price**

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| Gold Future Price (-1) | -0.001080 | 0.003406 | -0.317190 | 0.7512 |
| Constant | 27.60341 | 42.56247 | 0.648539 | 0.5169 |
| Gold Spot Price (1) | -0.002105 | 0.002958 | -0.711694 | 0.4769 |
| Constant | 39.28758 | 38.57137 | 1.018568 | 0.3088 |

Table – 3

**Johansen Co integration Test - Futures and Spot Price**

| No. of Cointegration Equation(s) | Eigen value | Statistic | Critical Value | Prob.** |
|---|---|---|---|---|
| None* | 0.023268 | 18.81455 | 15.49471 | 0.0882 |
| At most 1 | 0.000482 | 0.277240 | 3.841466 | 0.5985 |
| Trace test indicates 1 co integrating eqn (s) at the 0.05 level | | | | |
| * denotes rejection of the hypothesis at the 0.05 level | | | | |
| **MacKinnon-Haug-Michelis (1999) p-values | | | | |

Table - 4

Test for Granger-Causality - Futures and Spot Price

| Null Hypothesis | F-Statistic | P-Value |
|---|---|---|
| GSPOTPRICE does not Granger Cause GFUTUREPRICE | 7.84021 | 0.00044 |
| GFUTUREPRICE does not Granger Cause GSPOTPRICE | 0.48108 | 0.61836 |

**Co-integration and Granger Causality Test Results:**

In order to test for cointegration between spot and futures prices, the Johansen (1988) procedure is employed. By using trace statistics and maximum eigen value statistic, it was identified that there exists on cointegration equation between the futures gold and spot gold price and so the ECM for these series was proceeded.

**Error Correction Model**

Then Granger causality test primarily indicated that there is a causal relationship between futures and spot close prices. Granger causality test shows that future price do not Granger cause the spot price but spot price does Granger cause the future price. Therefore, it appears that Granger causality runs one-way from spot price to future price and not the other way in Gold

**Table- 5**

**Vector Error Correction Model - - Futures and Spot Price**

| | D(GFUTUREPRICE) | D(GSPOTPRICE) |
|---|---|---|
| CointEq1 | -0.029299<br>(0.00826)<br>[-3.54605] | 0.002269<br>(0.00767)<br>[ 0.29572] |
| D(GFUTUREPRICE(-1)) | -0.034984<br>(0.04189)<br>[-0.83512] | -0.032466<br>(0.03890)<br>[-0.83465] |
| D(GFUTUREPRICE(-2)) | -0.076448<br>(0.04200)<br>**[-1.82005]** | -0.069209<br>(0.03900)<br>**[-1.77450]** |
| D(GFUTUREPRICE(-3)) | 0.015997<br>(0.04204)<br>[ 0.38055] | 0.026659<br>(0.03903)<br>[ 0.68301] |
| D(GFUTUREPRICE(-4)) | 0.075278<br>(0.04206)<br>**[ 1.78988]** | 0.000408<br>(0.03905)<br>[ 0.01045] |
| D(GFUTUREPRICE(-5)) | 0.023634<br>(0.04259)<br>[ 0.55488] | -0.063063<br>(0.03955)<br>[-1.59452] |
| D(GFUTUREPRICE(-6)) | 0.017236<br>(0.04255)<br>[ 0.40505] | -0.050586<br>(0.03951)<br>[-1.28024] |

| | | |
|---|---|---|
| | 0.043312 | 0.018811 |
| | (0.04620) | (0.04290) |
| D(GSPOTPRICE(-1)) | [ 0.93756] | [ 0.43854] |
| | -0.059648 | -0.012124 |
| | (0.04613) | (0.04283) |
| D(GSPOTPRICE(-2)) | [-1.29312] | [-0.28307] |
| | -0.031855 | -0.024175 |
| | (0.04620) | (0.04290) |
| D(GSPOTPRICE(-3)) | [-0.68946] | [-0.56349] |
| | 0.046047 | 0.008702 |
| | (0.04621) | (0.04290) |
| D(GSPOTPRICE(-4)) | [ 0.99656] | [ 0.20283] |
| | -0.007165 | -0.010372 |
| | (0.04608) | (0.04279) |
| D(GSPOTPRICE(-5)) | [-0.15548] | [-0.24240] |
| | 0.016944 | -0.025132 |
| | (0.04624) | (0.04293) |
| D(GSPOTPRICE(-6)) | [ 0.36646] | [-0.58535] |

tandard errors in () & t-Statistics in [ ].

statistics > 1.76 is significant at 0.10 level of significance

statistics > 1.96 is significant at 0.05 level of significance

statistics > 2.56 is significant at 0.01 level of significance

[aving found that co integration exists nd since the level series are non- :ationary, ECM is the appropriate model ) capture the relationship between ıtures and spot prices. Initially, the rank f the co integration using the Johansen's ıethodology is tested. The Error orrection Estimates, in the case of Gold, ıows that spot price does not cause by self but it influences the future price in lags. Thus spot price influences the ıtures price which is same as the result btained by the Granger Causality Test.

## ONCLUSION

'his study attempts to examine the vidence of price discovery in gold spot ıarket movement. The co integration test ıows that gold futures and spot prices are cointegrated and there exists one co integration equation. The Granger causality test shows that there is no bi-causal relationship between gold futures and spot prices. Spot price significantly influences the Future price. The Error Correction Estimates, in the case of Gold, shows that gold spot price does not cause by itself but it influences the gold future price in 2 lags. On the other hand, gold future price causes by itself in 2 and 4 lags.

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**Authors**

**L. S. Sridhar,** Lecturer, PSG Institute of Management, PSG College of Technology, Coimbatore, e-mail-sonnappansridhar@yahoo.co.in

**M. Sathish,** Lecturer, PSG Institute of Management, PSG College of Technology, Coimbatore, e- mail-mahendran.sathish@gmail.com

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