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Price Discovery in Commodity Market – An Empirical Study on the Silver Market

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***Abstract**: This research examines whether precious metals futures serve as a price discovery vehicle for spot market movement. The spot price serves as a price discovery tool for silver. The co-integration test shows that silver, futures and spot prices are co-integrated and there exists one co-integration equation. The Granger causality test shows that there is no bi-causal relationship between futures and spot prices. Spot price significantly influences the future price. The Error Correction Estimates show that spot price does not cause by itself but it influences the future price in one lag. On the other hand, future price does neither cause by itself nor influences the spot price in two lags. Hence, similarly spot price does not Granger causes the future price. It means the dissemination of information is not in a sound form between future and spot price.*

***Key Words:** Price discovery, precious metal market, co-integration, causality, futures, spot*
JEL Classification: G13

I. Introduction

Price discovery and hedging are the major economic uses of futures contract. Many theoretical as well as empirical attempts have been made by the 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.

Commodity futures trading existed in India since 1875. However the commodity futures have been in the state of hibernation for the past few decades owing to a lot of government restrictions. Significant developments took place in 2003-04 in terms of commodity futures market. The government issued a notification on April 1, 2003 withdrawing all previous notifications which prohibited futures trading in a large number of commodities in the country. This was followed by a notification in May 2003 revoking prohibition on non-transferable specific delivery forward contracts. The futures market was opened in anticipation of sound market institutions and market design. In order to set up proper markets, the Government of India (GOI) on recommendation of Forward Market Commission (FMC) granted recognition to National Multi Commodity Exchange, Ahmedabad (NMCE); Multi Commodity Exchange, Mumbai (MCX); National Commodity and Derivative Exchange, Mumbai (NCDEX) as nationwide multi commodity exchanges. Trading commenced at MCX in November 2003 and at NCDEX in December 2003.

Over the years, researchers have focussed on different issues in commodities market with particular emphasis on modelling in pricing. Wiese and Lake (1978) had studied that Price discovery 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 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) have examined the price discovery process and volatility spillovers in Chinese spot-futures markets through Johansen co-integration, 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.

Hoque, Kim and Pyun, (2006) tested the market efficiency of eight different Asian emerging markets (Hong Kong, Indonesia, Malaysia, Korea, Singapore, Philippines, Taiwan and Thailand). They took weekly closing prices from April 1990 to February 2004. They used variance ratio test to find out whether these eight markets prove to be mean reverting or not. The basic findings were that five markets (Indonesia, Malaysia, Philippines, Singapore and Thailand), show specific mean- reverting and predictive behaviour of stock prices while two markets (Taiwan and Korea) show some mean reverting and unpredictable patterns in the time series.

Mukherjee and Mishra (2006), by looking at six months intraday data from April 2004 to September 2004, find that neither Nifty index futures nor Nifty spot index lead and there were found strong contemporaneous and bi-directional relationship among the index and index futures market in India.

Floros and Vougas (2008) was examined efficiency of the Greek stock index futures market from1999 to 2001. The results show that the Greek Futures markets were information more efficient than underlying stock markets.

Zhang et al (2010) tests the random walk hypothesis and weak form market efficiency in the VIX futures market using a variety of tests. A unit root in the aggregated market price series suggests that the VIX futures market is efficient. For the individual VIX futures price series, 51 of 54 futures contracts meet the sufficient condition for an efficient market: the prices are found to follow a random walk either because there is a unit root or because the increments are not correlated. Overall, the market for VIX futures has been efficient since the first day of trading.

Kushankur. D and Debasish. M (2012) inferred that unidirectional causality from futures to spot prices has been observed in the Indian pepper futures market and the adjustment of innovations or shocks in the futures market is relatively faster than that of the spot market.

Srinivasan P (2012) observed that there is a flow of information from spotto futures commodity markets and bi-directional volatility spillover persists between the markets.

Shailesh Rastogi (2011) found that the introduction of gold and silver futures in India has increased the depth of the market and has helped in the price discovery in the spot market but without impacting price volatility

Kapil and Sushil (2013) have investigated the role of price discovery in the Indian stock market by taking into consideration 41 individual securities and Nifty. The present article reports a study based on the daily adjusted closing price of spot and futures for the time period between June 2000 and August 2010 (index) and from November 2001 to August 2010 (individual stocks). To analyses the price discovery role, Engle and Granger's Residual Based approach, Johansen's co-integration test and VECM (Vector Error Correction Model) are used. The results depicted that futures price series leads the spot price series in case of Nifty and 21 stocks, and 20 stocks' future price series is led by spot price series. As far as causality is concerned, 14 stocks show feedback causality, 21 stocks including Nifty show unilateral causality and 7 stocks show absence of causality. This study also finds that both the markets, i.e., futures and spot, play an important price-discovery role, implying that futures (spot) prices may contain useful information about spot (futures) prices.

Samveg and Mallikarjun analysed (2014) the settlement cycle and day of the week anomaly: empirical evidence from Indian stock market. Indian stock market was functioning with Accounting Period settlement cycle till December 31, 2001. But as per the recommendation of G-30 which was a group to determine the best international practices for securities clearing and settlements, Indian stock market has adopted T+2 rolling settlement cycle on April 1, 2003.

II. Objectives Of The Study

1. To examine the Price Discovery in Commodity Market with emphasis on silver
2. To examine the exists relationship between spot and future price of silver

III. Hypothesis

Testing for Stationary:

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)

Granger Causality:

Null Hypothesis H_0 : Spot price does not Granger Cause Future price

Alternate Hypothesis H_1 : Spot price has Granger Cause in Future price

Null Hypothesis H0 : Future price does not Granger Cause Spot price

Alternate Hypothesis H1 : Future price has Granger Cause in Spot price

IV. Data

The data for the study consist of near month (first month contract) futures prices and spot prices from January 1,2011 to December31,2015 comprising 749 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 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.

V. Methodology

This research attempts is a descriptive nature one. Given the time series nature of data, the first step in the analysis is to determine the descriptive statistics and the variable 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. Co-integration analysis will be done using Johansen Co-integration 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 Stationary and Co integration

Given the time series nature of the data, 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 sued is that there is a unit root in the series (i.e. series is non-stationary), 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 where corresponds to the random walk which is non-stationary. 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 co-integrated, i.e. if there is a linear combination of them which is stationary. 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-stationary but if the estimate of their residual error is stationary, Y and X are said to be co-integrated. 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 co-integrated series has an error correction representation. In the second step, if the residual error or the estimation in the first step is stationary, 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 co-integrated, i.e. if there is a linear combination of them which is stationary. In this study, Granger causality test and Johansen test is applied for price discovery performance.

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 regressing:

$$\Delta x_t = \alpha_0 + \sum_{i=1}^{p} \beta_{xi}\Delta x_{t-i} + \sum_{i=1}^{p} \beta_{yi}\Delta y_{t-i} + \varepsilon_t \qquad (1)$$

Where, Δ is the first-difference operator and Δx and Δy are stationary times series. The null hypothesis that ye does not Granger cause x is rejected if the coefficients, β_{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 β_{xi} are jointly significant in equation (1) when Δx replaces Δy 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:

$$\Delta x_t = \alpha_0 + \sum_{i=1}^{p} \beta_{xi}\Delta x_{t-i} + \sum_{i=1}^{p} \beta_{yi}\Delta y_{t-i} + \alpha_1 + \mu_{t-1} + \varepsilon_t \qquad (2)$$

where x_t and y_t have been identified as first differenced stationary, cointegrated times series and μ_{t-1} is lagged value of the error term from the following cointegration equation

$$x_t = \gamma y_t + \mu_t \qquad (3)$$

The inclusion of μ_{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 μ_{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 β_{yi} ‘s are jointly significant, but also if the coefficient on μ_{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 $F_{t-1} = \alpha + \beta.S_{t-1} + e_{t-1}$, 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.

$$\Delta F_t = \alpha + \pi.e_{t-1} + \sum_{i=1}^{q} \beta_i \Delta F_{t-i} + \sum_{i=1}^{q} \gamma_j \Delta S_{t-j} + \varepsilon_t \qquad (5)$$

$$\Delta S_t = \alpha' + \pi'.e_{t-1} + \sum_{i=1}^{q} \beta'_i \Delta F_{t-i} + \sum_{j=1}^{q} \gamma'_j \Delta S_{t-j} + \varepsilon_t \qquad (6)$$

Where 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

$H_0 = \pi = \gamma_1 = \gamma_2 = \gamma 3 = ... = \gamma_q = 0$ in equation (4) and

$H_0 = \pi' = \beta'_1 = \beta'_2 = \beta'_3 = ... = \beta_q = 0$ in equation (5), and

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

VI. Results And Discussions

Descriptive Statistics (Table no.1 about here)

The Descriptive statistics result shows that the Skewness and Kurtosis are clearly observed in both the data series, which is a confirmation of the stylised fact, related to fat tails and extreme values with high frequencies data. Skewness measures asymmetry of a distribution. It is also noticed that the silver, futures and spot market seems to be more volatile on the considered period regarding standard deviation.

Testing for Stationary (Table no2 and Table no.3 about here)

The following hypothesis is postulated

Null Hypothesis H_0 – There is a unit root in the series (Non-Stationary)
Alternate Hypothesis H_1 – There is no unit root in the series (Stationary)

The Augmented Dickey- Fuller Test (ADF) statistic value the observed value both futures and spot price are showing the non-stationary. So transform log is essential to know the movements of values, we applied the log differenced in values, the result observed with the value of - 29.170 and -29.7708 for futures and spot co-efficient respectively. The result of stationary can be seen that the T-test significance at 5% confidence level is less than the significant value (1.96). And hence we will reject the null hypothesis and accept the alternate hypothesis. Thus, it can be concluded that the Spot Price data is stationary.

The Phillips-Perron (PP) statistic value is statistic value the observed value both futures and spot price are showing the non-stationary. So transform log is essential to know the movements of values, we applied the log differenced in values. The value of coefficient -29.223 and -29.653 for futures and spot log differenced results respectively. The critical values at the 1%, 5% and 10% levels are -3.458973, -2.874029 and -2.573502. It can be seen that the statistic value t_α is greater than the critical value at 5% so we do not reject the null at 5% significance level and conclude that Future price has a unit root.

Co-integrating and Error correction results (Table no. 4 and Table no.5 about here)

By using the Trace statistics and maximum Eigen values statistics, it is identified that there exists one co-integrating equation between the futures and spot prices, and so we can proceed with Error Correction Model (ECM) for this series The Error Correction Estimates show that spot price does not cause by itself but it is not influences the future price lags. On the other hand, future price does not cause by itself nor influences the spot price in two lags hence, future price Granger causes the spot price in small level.

Overall, future price influences the spot price which is same as the results obtained by Granger causality test. There seems to be a short-run relationship between silver spot and silver futures prices.

Causality Test results (Table no. 6 about here)

Considering the first hypothesis Spot price does not Granger Cause Future price, the P value is more than the significant value at 5% confidence level, thus the null hypothesis can be accepted and it is concluded that Spot Price Granger does not Cause Future price. Considering the second hypothesis Future price does not Granger Cause Spot price', here the P value is greater that than the significant value at 5% confidence level, therefore the null hypothesis cannot be rejected and thus it can be concluded that Future price does not Granger Cause Spot price. The small level the future price influence towards the spot price, but it does not show the significant impacts. Here, we can conclude the future and spot price of silver does not showing the long run relationship.

VII. Conclusion

This study attempts to examine the evidence of price discovery in silver spot market movement. The co-integration test shows that silver, futures and spot prices are co-integrated and there exists one co-integration equation. The Granger causality test shows that there is no bi-causal relationship between futures and spot prices. Hence the future and spot price does not showing the cause and effect relationship. The Error Correction Estimates show that spot price does not cause by itself but it is not influences the future price lags. On the other hand, future price does not cause by itself nor influences the spot price in two lags hence, future price Granger causes the spot price in small level. The spot price serves as a price discovery tool for silver. Overall, the findings suggest that, spot price movement can be used as price discovery vehicle for futures market transactions.

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Table no. 1
Descriptive Statistics on Future and Spot Prices

Particulars	Future Price	Spot Price
Mean	53613.09	53492.61
Median	54190.50	54108.50
Maximum	71523	73132.50
Minimum	38650	39075.50
Std. Dev.	6399.469	6364.104
Skewness	-0.2369	-0.24430
Kurtosis	2.5629	2.6141
Jarque-Bera	15.9745	11.9358
Probability	0.0003434	0.002560

(Future price' and Spot Price' (739 valid observations))

Testing for Stationary:

Table no.2
Augmented Dickey-Fuller (ADF) Test for Future Price and Spot Price

Augmented Dickey-Fuller Test on Future Price Null Hypothesis : Future price has a unit root		Augmented Dickey-Fuller Test on Spot Price Null Hypothesis : Spot price has a unit root	
T Statistic	**Probability**	**T Statistic**	**Probability**
-2.23677	0.1934	-2.4652	0.1245
Non-stationary		Non-stationary	
Log Differenced Prices			
Augmented Dickey-Fuller Test on Future Price Null Hypothesis : Future price has a unit root		**Augmented Dickey-Fuller Test on Spot Price** Null Hypothesis : Spot price has a unit root	
T Statistic	**Probability**	**T Statistic**	**Probability**
29.170	**0.0000**	**29.7708**	**0.000**
Stationary		**Stationary**	

Test critical values:	1% level		-3.458973
	5% level		-2.874029
	10% level		-2.573502
*MacKinnon (1996) one-sided p-values			

Table no.3
Phillips Perron (PP) Test for Future Price and Spot Price

Phillips Perron (PP) Test on Future Price Null Hypothesis : Future price has a unit root		Phillips Perron (PP) Test on Spot Price Null Hypothesis : Spot price has a unit root	
T Statistic	**Probability**	**T Statistic**	**Probability**
-2.50662	0.1142	-2.5490	0.1044
Non-stationary		Non-stationary	
Log differenced prices			
Phillips Perron (PP) Test on Future Price Null Hypothesis : Future price has a unit root		**Phillips Perron (PP) Test on Spot Price** Null Hypothesis : Spot price has a unit root	
T Statistic	**Probability**	**T Statistic**	**Probability**
-29.223	**0.000**	**-29.653**	**0.0000**
Stationary		**Stationary**	

Test critical values:	1% level		-3.458973
	5% level		-2.874029
	10% level		-2.573502
*MacKinnon (1996) one-sided p-values			

Table no.4
Johansen Co-integration Test for Futures and Spot Price (UnRestricted Co- integration Rank Test (Trace)

No. of Co-integrating Equation(s)	**Eigen value**	**Statistic**	**Critical Value**	**Prob.****
None*	0.008855	6.07027	12.3209	0.4274
At most 1	0.000359	0.23594	4.1299	0.6856
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 no. 5
Vector Error Correction Model

Particulars	**Future Price**			**Spot Price**		
	Co-integration	**StandardError**	**T Statistic**	**Co-integration**	**Standard error**	**T Statistic**
CointEq1	**0.021169**	**0.05814**	**-3.6321****	0.0082	0.0071	1.164
D(Future price (-1))	0.06094	0.0368	1.362	**-0.0794**	**0.0419**	**-1.758***
D(Future price (-2))	0.033794	0.0369	0.9135	-0.0315	0.0045	-0.6960
D(Future price(-3))	**-0.06788**	**0.0368**	**-1.844***	0.00436	0.0450	0.0968
D(Future price (-4))	0.05077	0.0368	1.366	002562	0.0450	0.5684
D(Future price (-5))	0.03341	0.0367	0.09083	0.04545	0.0450	1.008
D(Spot price (-1))	-0.04050	0.0305	1.327	**-0.1026**	**0.0377**	**-2.74*****
D(Spot price (-2))	**-0.07109**	**0.0306**	**-2.318*****	-0.0224	0.3785	-0.5987
D(Spot price (-3))	**-0.08567**	**0.0307**	**-2.783*****	0.0397	0.0375	1.054
D(Spot price (-4))	-0.02344	0.0308	0.7592	0.0616	0.378	1.629
D(Spot price (-5))	0.0333	0.0306	1.0892	0.0629	0.0375	1.67

*T-statistics > 1.76 is significant at 0.10 level of significance

** T-statistics > 1.96 is significant at 0.05 level of significance
*** T-statistics significant lies in less than 0.005 level significance

Table no.6
Test for Granger-Causality on Spot and Future Prices

Null Hypothesis	**F-Statistic**	**P-Value**	**Comments**
H0: Spot price does not Granger Cause Future price	1.78175	0.1691	H0: Accepted
H0: Future price does not Granger Cause Spot price	1.9154	0.1481	H0: Accepted

*MacKinnon (1996) one-sided p-values