Price Discovery Via Causality Of Future And Spot Prices In Commodity Market In India

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ABSTRACT

Price discovery is one of the imperative functions of commodity derivative market. Its mechanism is established by long run and causal relationship between two variables. The present treatise is an attempt to examine the price discovery mechanism of commodity market in India. This paper evaluatesthe performance of Multiple Commodity Exchange in price discovery by statistically testing the cointegration and causality between future prices and spot prices of two precious metals i.e. gold and silver. The results of Johansen cointegration test indicate that cointegration exists between spot prices and future prices of gold and silver. Vector error correction mechanism confirms the presence of feedback relationship between spot and future market in case of gold and silver. There is bidirectional causality between future returns and spot returns. However, stronger causal relation from future market to spot market exists as compared to spot market to future market for gold as well as silver.

Key words: Causality, cointegration, price discovery,stationarity and vector error correction mechanism

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INTRODUCTION

Gold and silver are precious metalsthat have been used for thousands of years for ornaments, trade, utensils, etc. These two precious metals have been the basis for many monetary systems. Gold stands first as a precious metal in terms of value followed by silver. Price of gold and silver like any other commodity is driven by supply and demand forces along with speculation. The price of silver is extremely volatile as compared to the price of gold due to lower market liquidity and higher demand fluctuations. Investors protect themselves from the adverse effect of temporal price volatility by adopting hedging trading mechanism in derivative market. Multiple Commodity Exchange is India's biggest commodity exchange that provides a transparent and neutral platform for buyers and sellers to trade with each other under its rules and regulation. Buyer and seller can avail hedging mechanism on Multiple Commodity Exchange to protect themselves from adverse price movements.

OBJECTIVE OF THE STUDY

The present treatise attempts to examine the short run and long run causality of future and spot prices of gold and silver in order to evaluate the performance of Multiple Commodity Exchange (MCX) in price discovery.

REVIEW OF LITERATURE

The main functions of the commodity derivative market are risk management and price discovery. The mechanism of price discovery in commodity derivative market is established by long run and causal relationship between spot prices and future prices. Kawaller et.al. (1987) examined the intraday price relationship between two variable S&P 500 Index and the S&P 500 Index futures. Their results show that both S&P 500 spot and futures markets were simultaneously related with a lead lag relationship. Stoll and Whaley (1990) further extended the study on causal relationships between spot and futures markets using intraday data for both S&P 500 and the major market index (MMI). They concluded that futures lead was stronger than cash index lead. Chan et.al. (1991) also found much stronger bidirectional dependence between stock index and stock index futures price. Wahab and Lashgari (1993) used cointegration analysis to examine the temporal causal linkage between stock index and stock index futures prices for S&P 500 and the FTSE 100 index. They concluded that the spot to futures lead appears to be more pronounced across days relative to the futures to spot lead. Pizzi et.al. (1999) investigated the price discovery in the S&P 500 spot index and its index futures by using intraday minute by minute data. They found bidirectional causality between spot prices and future prices. There was stronger lead effect in futures market. Roope et.al. (2002) make a comparison of the Singapore exchange and the Taiwan futures exchange in term of their information efficiencies. They found that price discovery primarily originates from the Singapore futures market. Zapata, Fortenbery and Armstrong (2005) investigated the relationship between eleven future prices traded in New York and the world cash prices for exported sugar. They concluded that the future market for sugar leads the cash market in price discovery. They found unidirectional causality from future price to spot. Gupta and Belwinder (2006) investigated price discovery mechanism in the NSE spot and future market by considering daily closing values. They applied Johansen test and vector error correction mechanism. They found bilateral causality between the Nifty index and futures. They further confirmed the stronger causal relation from Nifty futures to Nifty index as compared to the vice-versa.Bose, Suchismita (2008) studied the multi-commodity indices of metals and energy products. She found that both contemporaneous futures and spot prices contribute to price discovery. Wagner and et al. (2009) examined the relationship between spot and futures markets in the EU ETS. They concluded that the spot and futures prices are linked by the cost-of-carry approach. They further concluded that the futures markets lead the price discovery process of CO_2 emission certificates. Zhang, Frank (2010) examined the implication of high-frequency trading forstock price volatility and price discovery. He found positive correlation between the high-frequency trading and stock price volatility after controlling firm's fundamental volatility and other exogenous determinants of volatility. However, the high-frequency trading was negatively related to the market's ability to incorporate information about firm fundamentals into asset prices. The stock prices tend to overreact to fundamental news when the high-frequency trading was at high volume. Kumar Narender and Arora Sunita(2011) examined the role of price discovery in case of gold by considering data for spot and futures prices for a period of four and a half years starting from June 2005 to December 2009. They concluded that futures market in India is performing its role of price discovery in case of gold. Arora Srinivasan, P. (2012) examined the price discovery process and volatility spillovers in Indian spot-futures commodity markets. The study confirmed the flow of information from spot to futures commodity markets.

The research work on the price discovery function or mechanism showed mixed results.Some studies confirmed the bidirectional causality and some studies confirmed the unidirectional causality from spot to future price in various markets. But there is lack of exploration of price mechanism in the Multiple Commodity Exchange that started its operations in 2003. The present treatise is an attempt to study the cointegration and causality in MCX between future prices and spot prices of gold as well as silver that will help investors to discover the price of these precious metals for hedging purpose.

RESEARCH METHODOLOGY

The present study is based on the spot and future prices of gold and silver for a period of six years starting from 1 January 2007 and up to 31 December 2012.A series of 1783 spot and future return has been analyzed with the help of EViews 7. The data of spot and future prices of gold and silver was studied for stationarity, cointegration and causality through following statistical tests:

Augmented Dickey–Fuller test : It is a test for a unit root in a time series sample. It examines whether a time series variable is non-stationary using an autoregressive model. It tests the existence of a unit root as the null hypothesis. The testing procedure for the ADF test consists of estimating the following regression:

$$\Delta y_t = \propto + \beta t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \cdots + \delta_{p-1} \Delta y_{t-p+1} + \varepsilon_t$$

The unit root test is carried out under the null hypothes is against the alternative hypothesis of . The calculated test statistic is compared to the relevant critical value. If the test statistic is less than the critical value, then the null hypothesis is rejected implying no unit root is present.

Johansen Cointegration Test : It tests the cointegration of several I (1) time series. It permits more than one cointegrating relationship. This test evaluates the long run or equilibrium relationship. If the residual from the regression equation of the series (which are non stationary in level but are stationary after first differencing) is stationary then it confirms that the series are cointegrated.

Vector Error Correction Mechanism : This mechanism examines the long run causality and short run causality between variables. There may be disequilibrium in the short run in the cointegrated series having long run relationship. The error generated from such cointegratedseries is termed as equilibrium error. The error correction mechanism equation, stating the dependence of Y on X and equlibrium error, is :

$$Y_t \;\propto_0\; \propto_1\; X_t \;(Y_{t\ 1} \quad X_{t\ 1}) \quad {}_t$$

where $Y_t \quad Y_t \; Y_{t\ 1}$

$X_t \quad X_t \; X_{t\ 1}$

${}_t$ *random error term*

Schwartz information criteria have been used to select the lag length in vector error correction mechanism.

BASIC STATISTICS OF SPOT PRICES AND FUTURE PRICES OF GOLD AND SILVER

The spot and future prices of gold and silver for a period of six years starting from 1 January 2007 and up to 31 December 2012 have been taken for the purpose of examining price discovery function of Multiple Commodity Exchange. Prices are taken from the MCX's website (www.mcxindia.com). The series of spot and future prices of gold and silver have been converted into return series by applying the following formula:

$$R_t \quad (In\, P_t \;\; In\, P_{t\ 1}) * 100$$

where R_t is the return for day t, P_t is closing prices forday t, $P_{t\ 1}$ is the closing prices of previous trading day and *In* is natural log.The basic statistics of spot return and future return of gold and silver are portrayed in the exhibit 1:

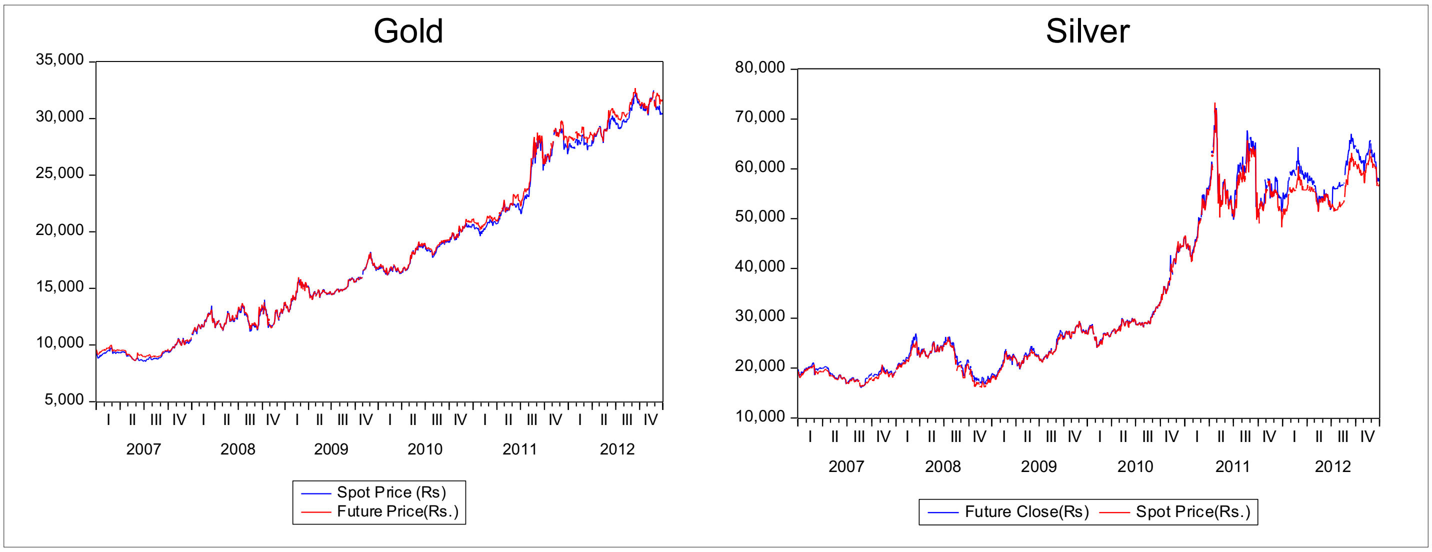
Exhibit 1: Basic statistics of spot return and future return

Descriptive Statistics	Future Return		Spot Return	
	Gold	Silver	Gold	Silver
Mean	0.00067	0.00061	0.00067	0.00061
Median	0.00078	0.00095	0.00054	0.00057
Maximum	0.08112	0.08403	0.0954	0.11246
Minimum	-0.0639	-0.167	-0.0534	-0.1614
Std. Dev.	0.0103	0.01716	0.01029	0.01701
Skewness	-0.0175	-0.7376	0.1503	-0.8026
Kurtosis	10.1016	11.6935	10.4012	13.6172
Jarque-Bera	3746.77	5776.39	4076.23	8565.9
Probability	0.000000	0.000000	0.000000	0.000000
Observations	1783	1783	1783	1783

The basic statistics of gold and silver return series have similar values and features in terms of average, skewness and peakedness. However, the variability in prices are more in silver as compared to gold as indicated by higher standard deviation of silver returnsas compared to gold returns. The value of kurtosis statistics is more than 3 indicating that the data is leptokurtic i.e. more peaked as compared to the normal curve. The value of probability is zero in all series indicating the rejection of null hypothesis of normal distribution by the Jarque-Bera test.

The time series of spot prices and future prices of gold as well as of silver are first tested for stationarity by graphical method and then by applying Augmented Dickey–Fuller test. The graphical presentation in exhibit 2 for spot prices and future prices of gold and silver indicates that time series are non stationary.

Exhibit 2



The augmented Dickey–Fuller test is further applied to test the null hypothesis of unit root. Exhibit 3 indicates the results of augmented Dickey–Fuller test for future and spot prices of gold:

Exhibit 3: Results of augmented Dickey–Fuller test on future and spot prices of gold

Null Hypothesis: FUTURE PRICE has a unit root			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.352673	0.9809
Test critical values:	1% level	-3.433815	
	5% level	-2.862957	
	10% level	-2.567572	
Durbin-Watson stat		2.022818	

Null Hypothesis: SPOT PRICE has a unit root			
		t-Statistic	Prob.*
AugmentedDickey-Fullerteststatistic		0.139422	0.9686
Test critical values:	1% level	-3.433815	
	5% level	-2.862957	
	10% level	-2.567572	
Durbin-Watson stat		2.002665	

The null hypothesis that spot prices and future prices of gold have unit root cannot be rejected as the probability value is greater than 0.05. A peculiar point to note here is that value of Durbin–Watson statistic i.e.d is almost equal to 2 indicating no autocorrelation.

Augmented Dickey–Fuller test is further applied to test the null hypothesis of unit root for spot prices and future prices of silver. Exhibit 4 indicates the results of augmented Dickey–Fuller test for future prices and spot prices of silver:

Exhibit 4: Results of augmented Dickey–Fuller test on future and spot prices of silver

Null Hypothesis: FUTURE PRICE has a unit root			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.623931	0.8628
Test critical values:	1% level	-3.433815	
	5% level	-2.862957	
	10% level	-2.567572	
Durbin-Watson stat		1.931803	
Null Hypothesis: SPOT PRICE has a unit root			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.659885	0.8545
Test critical values:	1% level	-3.433815	
	5% level	-2.862957	
	10% level	-2.567572	
Durbin-Watson stat		2.002665	

The null hypothesis that spot prices and future prices have unit root cannot be rejected as the probability value is greater than 0.05. Again, the value of Durbin–Watson statistic i.e.d is almost equal to 2 indicates no autocorrelation.

TRANSFORMATION OF NON-STATIONARY TIME SERIES TO STATIONARY TIME SERIES

The series of future prices and spot prices of gold and silver are non-stationary time series as confirmed by the results of augmented Dickey–Fuller test. These non-stationary time series are transformed to stationary time series by estimating differentiated log of future prices and by estimating differentiated log of spot prices. Again the augmented Dickey–Fuller test is applied on differentiated log of spot price{dlog(spot)} and on differentiated log of future price {dlog(future)} to test the null hypothesis of unit root.Exhibit 5indicates the results of augmented Dickey–Fuller test for differentiated log of future returns and for differentiated log of spot returns of gold:

Exhibit 5: Results of augmented Dickey–Fuller test on future and spot returns of gold

Null Hypothesis: FUTURE RETURN has a unit root		
	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-41.50236	0.0000
Null Hypothesis: SPOT PRICE has a unit root		
	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-42.51342	0.0000

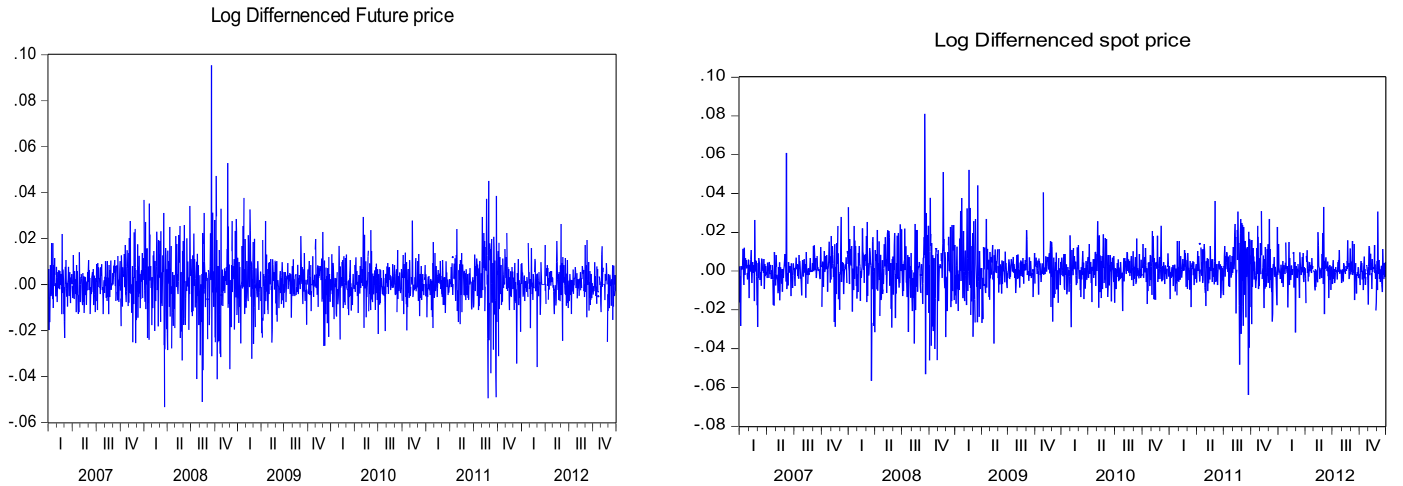
Exhibit 6indicates the results of augmented Dickey–Fuller test for differentiated log of future prices and for differentiated log of spot prices of silver:

Exhibit 6: Results of augmented Dickey–Fuller test on future and spot returns of silver

Null Hypothesis: FUTURE RETURN has a unit root		
	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-41.76515	0.0000
Null Hypothesis: SPOT PRICE has a unit root		
	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-44.24043	0.0001

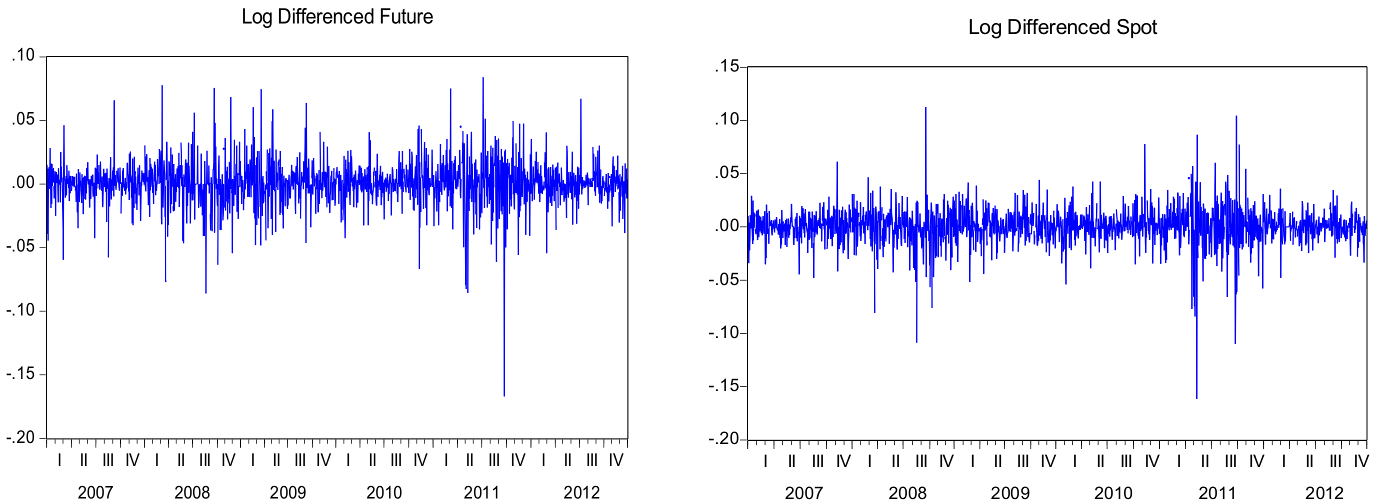
The null hypothesis that spot returns and future returns have unit root is rejected as the probability value is 0 i.e less than 0.05. The results for future and spot returns of silver are also same. The null hypothesis that spot returns and future returns of silver have unit root is also rejected. The graphical presentation of spot returns and future returns of gold in exhibit 7indicates transformation of non-stationary time series to stationary time series:

Exhibit 7 Spot and Future returns of Gold



Similarly, the graphical presentation of spot return and future returns of silver in exhibit 8 indicates transformation of non-stationary time series to stationary time series

Exhibit 8 Spot and Future returns of Silver



The time series of spot prices and future prices are non-stationary at level form and stationary at the first difference for gold as well as silver. So it can be concluded that both series are I(1) series and these series may be cointegrated. Johansen cointegration test is first applied to determine either the future and spot series of gold are cointegrated or not. Exhibit 9 portrays the result of Johansen cointegration test on future prices and spot prices of gold:

Exhibit 9: Result of Johansen cointegration test on gold prices

Included observations: 1779 after adjustments
Trend assumption: Linear deterministic trend
Series: FUTURE SPOT
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.020493	36.88997	15.49471	0.0000
At most 1	3.02E-05	0.053689	3.841466	0.8167

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The time series of gold spot prices and future prices are cointegrated as confirmed by the result of Johansen cointegration test. The same test is further applied to determine either the future and spot series of silver are cointegrated or not. Exhibit 10 portrays the result of Johansen cointegration test on future prices and spot prices of silver:

Exhibit 10: Result of Johansen cointegration test on silver price

Included observations: 1779 after adjustments
Trend assumption: Linear deterministic trend
Series: FUTURE SPOT
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.018754	34.09571	15.49471	0.0000
At most 1	0.000234	0.415495	3.841466	0.5192

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The time series of silver spot prices and future prices are also cointegrated as confirmed by the result of Johansen cointegration test. But this test does not show any long term and short term causal relationship between two time series. Vector error correction mechanism is applied to explore the dynamism of equilibrium process in short term as well as long term. Exhibit 11 portrays the result of vector error correction model for gold return series. The lag of three years (please make sure that it is a lag of three years and not three days!) for future and spot return series of gold was selected on the basis of Schwartz information criteria.

Vector Error Correction Estimates
Date: 08/10/13 Time: 07:15
Sample (adjusted): 1/08/2007 12/31/2012
Included observations: 1778 after adjustments
Standard errors in ( ) & t-statistics in [ ]
SR=Spot Returns
FR=Future Returns

Error Correction:	SR	FR
Vector Error Correction Long Run Granger Causality		
CointEq1	-1.627230	0.782668
	(0.07577)	(0.11119)
	[-21.4746]	7.03930]
Vector Error Correction Short Run Granger Causality	Dependent variable SR	Dependent variable FR
Independent variable		
SR(-1)	0.130879	-0.657816
	(0.06112)	(0.08968)
	[2.14138]	[-7.33508]
SR(-2)	-0.046796	-0.492315
	(0.04041)	(0.05929)
	[-1.15816]	[-8.30377]
SR(-3)	-0.060877	-0.209061
	(0.01904)	(0.02794)
	[-3.19742]	[-7.48338]
FR(-1)	-0.759326	-0.016666
	(0.06979)	(0.10241)
	[-10.8799]	[-0.16274]
FR(-2)	-0.290759	0.035999
	(0.05170)	(0.07586)
	[-5.62380]	[0.47453]
FR(-3)	-0.106080	0.013895
	(0.02855)	(0.04189)
	[-3.71545]	[0.33168]
C	0.000711	0.002432
	(0.01832)	(0.02688)
	[0.03879]	[0.09047]

Vector error correction estimates on gold returns indicatethat there is autocorrelation in spot returns for lag one and three whereas there is no autocorrelation in future returns. The three lag terms of gold future returns are significant with gold spot returns as dependent variable. The results are same for gold spot returns with gold future returns as dependent variable. Further, the error correction terms are significant for spot returns as well as future returns. So, the feedback relationship exists between gold spot returns and gold future returns. However, the error correction termsof spot return series is more than the future return series, as depicted by the three times higher t value of spot returns as dependent variable, indicating a stronger feedback from future market to spot market.

Vector error correction mechanism is further applied to explore the dynamism of equilibrium process in short term as well as long term in silver series. The lag of four years (?) for future and spot return series of silver was selected on the basis of Schwartz information criteria.

Exhibit 12: Results of vector error correction model on silver returns

Vector Error Correction Estimates
Date: 08/10/13 Time: 07:15
Sample (adjusted): 1/08/2007 12/31/2012
Included observations: 1778 after adjustments
Standard errors in ( ) & t-statistics in [ ]
SR=Spot Returns
FR=Future Returns

Error Correction:	**SR**	**FR**
Vector Error Correction Long Run Granger Causality		
CointEq1	-1.805105	1.088852
	(0.09457)	(0.12580)
	[-19.0884]	[8.65571]
Vector Error Correction Short Run Granger Causality	Dependent variable SR	Dependent variable FR
Independent variable		
SR(-1)	0.367499	-0.877291
	(0.08101)	(0.10776)
	[4.53655]	[-8.14105]
SR(-2)	0.097139	-0.668278
	(0.06301)	(0.08382)
	[1.54167]	[-7.97302]
SR(-3)	-0.040184	-0.417197
	(0.04268)	(0.05677)
	[-0.94162]	[-7.34903]
SR(-4)	-0.083361	-0.196979
	(0.02130)	(0.02833)
	[-3.91376]	[-6.95210]
FR(-1)	-0.947777	0.141774
	(0.08306)	(0.11049)
	[-11.4105]	1.28311]
FR(-2)	-0.559940	0.138783
	(0.06703)	(0.08917)
	[-8.35358]	[1.55645]
FR(-3)	-0.307066	0.055978
	(0.04853)	(0.06456)
	[-6.32702]	[0.86707]
FR(-4)	-0.110015	-0.001729
	(0.02748)	(0.03656)
	[-4.00323]	[-0.04730]
C	0.003948	0.000497
	(0.03270)	(0.04350)
	[0.12073]	[0.01143]

The results are same for silver return series. There is autocorrelation in spot returns for lag one and four whereas there is no autocorrelation in future returns. The four lag terms of silver future returns are significant with silver spot returns as dependent variable. All the four lag terms for silver spot returns are also significant with silver future returns as dependent variable. So, the feedback relationship exists between silver spot returns and silver future returns. The error correction terms are significant for spot returns as well as future returns. The error correction terms of spot return series of silver is more than the future return series indicating a stronger feedback from future market to spot market.

DISCUSSION

The present treatise confirms the results of earlier studies of Kawaller et.al. (1987), Chan et.al.(1991), Stoll and Whaley (1990), Wahab and Lashgari (1993), Pizzi et.al. (1999) on stock exchange data and the results of recent studies of Bose, Suchismita (2008), Kumar Narender and Arora Sunita (2011), Arora Srinivasan, P. (2012) on commodity exchange data regarding the feedback relationship between spot and future market. This relationship exists between spot and future market in case of gold and silver in MCX also. Some studies found the bidirectional causality and some studies found the unidirectional causality from spot to future price in various markets. The present work confirms the bidirectional causality between the future returns and spot returns for gold and silver in MCX. The present study further confirmed the stronger causal relation from future market to spot market as compared to spot market to future market for gold and silver.

CONCLUSION

Gold and silver as a precious metals are popular investment avenue for investors. Their price is driven by supply and demand forces along with speculation. Silver returns are more volatile as compared to gold returns. The volatility in gold returns and silver returns attracts investors to enter in derivative market in order to hedge against price risk. The present treatise attempts to evaluate the performance of MCX in the price discovery of these precious metals. The presence of cointegrationbetween spot prices and future prices of gold and silver indicates long run relationship between these two prices.The bidirectional causality in case of gold and silver indicates the contribution of both future as well as spot returns in the price discovery mechanism.So,investors in gold and silver by analysing the information of futures market for current spot prices as well as future prices can effectively hedge the price risk. The results of present treatise indicate virtuous performance of futures market in the price discovery of gold and silver. The efficient price discovery may be attributed to low transaction cost, convenience in taking leverage position and availability of various futures contracts in futures market. The hedging efficiency of MCX can be further studied to guide traders that may help them in reducing portfolio variance.

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