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Relationship between Gold and Other Markets: A Cointegration Approach with Structural Breaks

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Abstract

Academic research has focused on gold as an investment, as a hedger for downsizing risk or against inflation, a safe haven or efficiency of market. The current study attempts to explore the relationship of gold with stock market, foreign exchange market, energy (oil and gas) market, commodity futures, agriculture and interest rates through cointegration approach for India. Engle Granger and Johansen cointegration analysis is carried out on the variables after taking into account structural breaks. The results of the study stock market and interest rates are more cointegrated with the gold whereas other markets i.e. foreign exchange, energy, agriculture and commodity futures do not hold a long term cointegrating relation with gold. However, the relationship of gold with these markets keep on varying in the short run as the cointegrating relationship is observed shifting after structural break.

Keywords: Gold, markets, Cointegration, Engle-granger, causality, structural breaks.

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The globalization and commercialization of world has created a space for interconnected markets. The transmission of shocks and disturbances from one market to other markets due to reasons other than shocks is called as 'contagion effect'. It indicates unpredicted transfer of shocks (Park and Song, 2001; Bouber, Jouini and Lahiani, 2015; Samarakoon, 2011), whereas transmission during the normal times is identified as interdependence (Samarakoon, 2011). The travel of a shock from market to the market , even if there is no significant market changes in cross market relationships leads to the transmission of the shocks constituting contagion. The effect of transmission changes the behavior of the markets in times of shocks as compared to normal times.

No consensus on the meaning of contagion has been reached till date (Forbes and Rigobon, 2001). Contagion and interdependence of markets is often discussed parallel. Crisis in the economy creates shocks in the marketplace. The crisis gives rise to the structural shifts in the economy which leads to the propagation of the shocks that were not in existence during the stable period. Many approaches have been suggested for the measurement of shocks like analysis of cross market correlation coefficients (King and Wadhvani, 1990; Baig and Goldfajn, 1998; Forbes and Rigobon, 2001), employment of GARCH frameworks (Forbes and Rigoben, 2001; Aloui,Aissa and Nguyen, 2011; Bondia, Ghosh and Kanjilal, 2016) and cointegration techniques (Agmon, 1972; Blackmann, Holden and Thomas, 1994;Beyer, Haug and Dewald,2009).

Cointegration suggests that while variables are free to move over time but they may be tied together which may be different from cause and effect relationship. Ties between variables act as a mechanism to restore equilibrium conditions and are represented by cointegrating vectors. Cointegration is generally referred to as systematic co-movement of two or more non-stationary series. Two series may share a common stochastic trend among themselves and may not be sharing a dependent-independent variable relationship.

2. Literature Review

Markets have been studied by many researchers for the presence of interdependency (Agmon, 1972; Byers and Peel, 1993; Richards, 1995; Holden and Thomas, 1994; Cheung and Mak, 1992; Choudhary, 1997; Huang, Yang and Hu, 2000; Belke and Keil, 2015; Baumohl,

Kocenda, Lycosa and Vyrost, 2018). Agmon(1972) attributed the interdependency between US,UK, Germany and Japan for the time period 1961 to 1966 on economic relations between the countries. Economic and political integration of stock markets led to the financial integration of markets (Veronkova, 2004). Baumohl, Kocenda, Lycosa and Vyrost (2018) supported the argument that the spatial effects hold an important place in modelling stock market relationships. Belke and Keil (2015) applied cointegrated vector autoregression model using quarterly data for 1980-2009 to analyse the impact of cross border financial transactions, monetary liquidity, output, consumer and commodity prices on short run and long run dynamics.

Aloui, Aissa and Nguyen (2012) employed multivariate copula approach on daily return data from Brazil, Russia, India, China and US during 2004-09 period to investigate the extreme financial interdependencies among the markets. Results of the study indicate that the markets which are more dependent on commodities are more interlinked with US in comparison to the countries which are influenced with exports.

Arfaoui and Rejeb (2017) examined interdependencies between oil, gold, US dollar and stock prices. Results indicated that there was a negative relationship between gold and stock prices but a significant positive relationship between gold and USD. Zhang, Chevallier and Guesmi (2017) introduced Volatility Threshold Dynamic Conditional Correlations (VT-DCC) approach to examine spillover of stock market volatility index on crude oil and natural gas markets from 1995-2015. Ahmadi, Behmiri and Manera (2016) decomposed structural vector autoregressive model for the long term from 1983 to 2014 to investigate the effect of shocks in oil price on volatility of agricultural and metal commodities. The results of variance decomposition indicated that the explanatory power of the oil shocks became much prominent and clear after the crisis of January 2008. Yue, Liu and Xu (2015) employed VAR-DCC-GARCH model to investigate the relationship between Chinese and London commodity markets by considering the nonferrous metals. It was also observed that the co-movement between China and LME lasts for 7-8 trading days. Fractional integration and long memory has been noticed between the spot and futures contracts of non-ferrous metals (aluminium, copper, lead, nickel, zinc and tin) for the term of Jan 2009 to June 2012 (Gil-Alana and Tripathy, 2014).Kumar and Pandey (2013) analysed the long run market efficiency of Indian commodity futures markets(considering four agricultural and seven non-agricultural commodities) employing Johansen cointegration and ECM-GARCH in-Mean framework. Results of the study indicated that commodity market were cointegrated with

spot markets in the short run and the some inefficiency existed for all the commodities in the short run.

Research on gold has mainly focused on exploring the dimensions of gold as a tool for diversification, hedging against inflation or other assets, stocks and buffer against the currency fluctuations.

Many studies (Wang and Chueh, 2013; Zhang and Wei, 2010; Lucey and Tully,2006) have tried to explore the long term relationship between gold and oil in terms of cointegration.

Coronado, Rodriguez and Rojas (2016) found the nonlinear causal relationship between crude oil and gold market. Sofiane, Julien, Rania and Tiwari (2016) found the gold's influence by studying the dynamics between gold, other precious metals and asset markets from 1988 to 2013. Barunik, Kocenda and Vacha (2016) found the increase in the correlations between gold, oil and stocks after the structural break of 2008 crisis. The study employed wavelet approach and dynamic correlations between gold, oil and stocks for the period from 1987 to 2012. Wang and Chueh (2013) showed feedback effects of gold and crude oil prices on the interest rates. Gold prices respond to the movement in oil prices having positive correlation and consistent trends (Zhang and Wei,2010).

Hillier, Draper and Faff (2006) found lower degree of correlations between the returns from the precious metals like gold, platinum and silver and stock market by employing daily data from 1976 to 2004. Lower degree of correlation indicates that metals can act as a better hedging tool. Morales (2008) made an analysis of volatility spillover between precious metal markets i.e. gold, platium, palladium and silver. After analyzing prices of the precious metals from January 1995 to July 2007, the bidirectional existence of volatility spillovers was found from precious metals to stock markets with an exception of Gold. He also found little evidence concluding that precious metals influence the gold. Ciner (2001) analysed future contracts for gold and silver for the period from 1992 to 1998 on the Tokyo Commodity Exchange and found that cointegration between the commodities vanished in 1990s. Whereas, on the other hand, Lucey and Tully (2006) concluded a stable relationship between gold and silver for a period of exceeding 25 years. Pindyck and Rotemberg (1990) used correlation analysis to study excess comovements in the prices of seven unrelated commodities (gold, cotton, crude oil, cocoa, lumber, copper and wheat). Excess co-movement among the unrelated commodities was observed.

The relationship of gold with stock market has been of particular interest to the portfolio managers and financial advisors. Naveed, Ibrahimy, Ali and Ali (2016) suggested that gold has the capacity to act as hedge for stock market fluctuations in the short run. Also, after analyzing gold, stock markets of BRICS from January 1996 to December 2014, results indicated that gold could be safe haven in the short run but not in the long run. Similar results were found by Berdin, Conlon and Poti (2015) indicating that gold can act as short run hedge but upto one year. Baur and Lucey (2010) found that gold has the capacity to act as a safe haven only for a specified time period i.e. 15 trading days approximately. Beyond the given time frame of 15 trading days, the negative shocks in the markets can impact the investments in gold negatively. Results of the study suggested that investors should sell the gold when the volatility gets lower and could buy it on days when the market is generating negative returns. Beckmann, Berger and Czudaj (2014) used monthly data from January 1970 to March 2012 to apply a regime dependent framework for 18 stock markets to suggest that gold serves as a safe haven as well as hedge. Morales (2008) stated that the information travels from stock markets to the precious metals (gold, platinum and silver) markets for the G7 countries. Hillier, Draper and Faff (2006) observed that gold, platinum and silver act as better hedge during the periods of abnormal stock market volatility.

Gold has also been viewed as a hedge against the inflation and exchange rate fluctuations. Many studies have favoured the potential of the gold as hedge against inflation. Haque, Topal and Lilford (2015) employed cointegration analysis and concluded that gold had positive relation with Australian dollar exchange rate for the period from 1996 to 2014. Hood and Malik (2013) favoured gold as a hedge and safe haven. Joy (2011) concluded gold as a poor safe haven by investigating gold against 16 major exchange rates by considering long term data of nearly twenty three years. Gold has also been linked with currency depreciation (Pukthuanthong and Roll, 2011). Sjaastad (2008) examined the gold in relation with dollar, DM and yen for the time period 1991 to 2004 in order to explore the theoretical and empirical foundations. Results of the study suggested gold not to be a store of value against the inflation. A negative and inelastic relationship between gold and the exchange rates (sterling dollar, yen-dollar) was found by employing weekly data of nearly thirty years i.e. from 1971 to 2004 (Capie, Mills and Wood, 2005). Ghosh, Levin and MacMillan (2002) confirmed the presence of cointegration between the gold and inflation rate. Christian (1995) found gold had strong relationship with dollar-yen exchange rate by analyzing the data from 1974 to 1995.

This research would attempt to add to the extant literature regarding the debate on the positioning of the gold as a part of a diversified portfolio by supporting empirical evidence regarding the cointegration and causality between gold prices and the other macro-economic factors like exchange rate, interest rate, stock market, agriculture market and commodity market. Our cointegration approach tries to capture endogenous structural breaks in each series vis a vis gold so as to explore to what extent the co-movement of the variables vary across the time frames before and after time periods focusing structural breaks.

Our evidence on the cointegration has implications for the investors who like to either hedge or manage risk by diversifying across a range of assets in their portfolio. Although macro-economic factors impact the stock market, bond market, commodity market and foreign exchange market but the behavior with gold would provide a better understanding on various aspects relating to investing decisions w.r.t gold.

The remainder of the paper is organized as follows. In Section 3, we describe the methodological approach employed for testing cointegration; in section 4 and 5 we describe the data and discuss the analysis respectively, and in section 6 the conclusions are described.

3. Empirical method

Testing the presence of unit root in a financial time series is an essential part of initial analysis for the avoiding the negative consequences of running a spurious econometric analysis. Augmented Dickey Fuller (ADF) test is one of the best-known and most used test for testing the stationarity of a time series. It is based on the following regression equation

$$\Delta y_t = u_t + \emptyset y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta y_{t-i} + e_t$$

t-statistic is calculated on the $\emptyset$ with null hypothesis $\emptyset = 0$ against the alternative hypothesis that $\emptyset < 0$. While testing the null hypothesis, the series needs to be considered at first differences to conclude absence of unit root or the series is stationary, whereas the alternate hypothesis leads to the conclusion that series is already stationary and contains unit root.

Structural changes may arise due to many reasons like economic and institutional arrangements, sudden policy changes, market shifts etc. Any structural change can trigger a structural break in the market which can change the characteristic of the financial time series. Ignoring structural breaks can make the results obtained from the unit root tests as well as cointegration tests invalid. (Perron, 1989). Structural breaks need adequate adjustment in the

time series otherwise it can lead to distortion in the interpretation of the results (Saikkonen and Lutkepohl, 2000)

Quandt (1960) provided simple ordinary least squares based solution for finding the endogenous structural break between the two series. It states to run the following regression equation

$$Y_t = \beta_0 + \beta_1 X_t + \mu_t$$

Where μ_t is uncorrelated error term, Y_t is dependent variable and β_0, β_1 are regression coefficients. If break date is supposed to be τ then the series would bread into two leading to change in regression coefficients, such as

$$\beta_{1t} = \begin{cases} \beta_1 & if \ \ t < \tau \\ \beta_1 + \delta & if \ \ t > \tau \end{cases}$$

Considering break at τ , null hypothesis taking no break i.e $\delta = 0$ against the alternative $\delta \neq 0$ is tested for suggesting structural break. F-statistic for testing the null hypothesis is calculated and is commonly called as QLR test for finding a structural break (Stock, 2003).

Granger (1981) introduced the concept of cointegration when the series are stationary. Engle and Granger cointegrating regression provides a framework for testing the cointegration between the two time series variables (Granger, 1987) . Under a theoretical base of two variables, Engle Granger provide a bivariate model for testing whether a cointegrating vector exists in the two variables. It refers to evaluation of the situation when two series are integrated of same order. In Engle Granger test, a cointegrating regression is run via ordinary least squares and the residuals are tested for the absence of unit root. In other words, the residuals obtained are tested through ADF test for the null hypothesis to be rejected.

Johansen and Juselius (1990) suggested Johansen methodology for testing cointegration in the framework of multivariate autoregressive models. The Johansen cointegration test follows a maximum likelihood approach and captures the relationship between the rank of the matrix and its characteristic unit roots. The test employs trace test and Lmax test for determining the rank order of the cointegrating vectors existing between the series. The trace test is based on the likelihood ratio for the hypothesis that there exist r distinct cointegrating vectors.

Engle Granger Causality focuses on testing whether there is a causal link between the given two variables or not. It analyses whether a particular variable causes the other one to move or

not. The t-statistic is calculated by finding the f-value for all lags of one variable on the other in a vector autoregressive framework.

3. Data

The study considers the co-movements of gold prices with the interest rates, exchange rate, oil and gas prices, agriculture products prices, stock market and commodity market. Gold prices are the spot prices of the gold commodity taken from the World Gold Council. USD/INR exchange rate is taken as proxy for the foreign exchange market and the data is taken from the RBI database. MCX Energy Index, MCX Agriculture, MCX Comdex are taken as proxy for the energy (Oil and gas) market, agricultural market (cotton, black pepper, crude palm oil, cardamom and mentha oil) and commodity market futures. The data for these indices is taken from the MCX Commodity exchange. The data has been collected for the time period form Jan 2006 to Nov 2017. All values have been taken on weekly basis.

4. Discussion and Analysis

The study focuses on exploring the relationship of gold with other markets by considering proxy for each market. USD/INR, MCX Comdex, MCX Agri, MCX Energy, Interest Rate and Nifty are taken as proxy for foreign exchange market, commodity futures, agriculture, energy, debt and stock market respectively. Descriptive statistics for natural logarithm values of the variables are summarized in table 1. The descriptive statistics indicate the suitability of the data for statistical analysis.

Table 1: Descriptive Statistics for Gold and other variables considered.

Particulars	*Gold*	*USD/INR*	*MCX Comdex*	*MCXAgri*	*MCXEnergy*	*Nifty*	*Interest rate*
Mean	11.001	3.751	8.000	7.685	7.939	8.655	6.899
Standard Error	0.016	0.002	0.009	0.009	0.010	0.013	0.079
Standard Deviation	0.398	0.059	0.216	0.211	0.252	0.318	1.926
Sample Variance	0.158	0.003	0.047	0.045	0.063	0.101	3.711
Kurtosis	-0.781	-1.481	-0.862	-0.406	-0.646	-0.458	2.359
Skewness	-0.810	0.110	-0.349	-0.114	0.157	-0.240	-0.302

Range	1.314	0.179	0.978	0.995	1.180	1.421	15.790
Count	594	594	594	594	594	594	594
JB Test	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
LJ Test	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
ARCH Test	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]

Notes. Weekly data for the period January 2006 to November 2017. The Jarque-Bera (JB) statistic for normality, the Ljung-Box(LJ) statistics for serial correlation in returns computed with 10 lags, and Engle's autoregressive conditional heteroskedasticity(ARCH) Lagrange multiplier test computed using 20 lags are denoted by JB, LB and ARCH, respectively. P values for the tests are in square brackets

Table 2: Correlation Matrix for the Gold and other variables

	Gold	**Interest rate**	**USD/INR**	**MCX Comdex**	**MCX Agri**	**MCX Energy**	**Nifty**
Gold	1	0.1506	0.7581	0.8125	0.7508	0.3082	0.657
Interest rate		1	0.0744	0.2813	0.1065	0.2934	0.023
USD/INR			1	0.4412	0.3361	0.0132	0.7951
MCX Comdex				1	0.7491	0.7716	0.4057
MCX Agri					1	0.3408	0.3418
MCX Energy						1	-0.0463
Nifty							1

Table 2 presents the correlation matrix for gold and other variables considered in the study. It indicates that Gold is highly correlated with exchange rate, MCX Comdex, MCX Energy and Nifty Index. A positive correlation in the variables hints the possibility of significant relationship between the variables.

As part of preliminary analysis, all the variables must be tested for the presence of unit root. Presence of stochastic trends may lead to spurious results in regressions. So, unit root tests are performed to test time series for the condition of stationarity. Before considering cointegration relation, it is necessary to test whether the variables contain unit root i.e. non-stationary or not i.e. stationary. Results of the ADF test are shown in Table 3 and 4. The ADF test has been run for the null hypothesis that 'The series of the variable contains unit root and in not stationary.' For conducting further analysis, the series must be stationary in differences and not in levels. The lag length for the conducting the ADF test is taken on the basis of Akaike Information Criteria (AIC). Results indicate that the series are non-stationary

at levels whereas are the variables were found stationary after first differences. This implies that all the time series are I(1) stationary. Upon fulfillment of this basic condition of initial analysis, we may lead to the application of cointegration test. Financial time series need to be stationary for further econometric analysis, if the series are not I(1) stationary or are not integrated of order 1, then they can be checked for stationarity at order 2. In case the series are not integrated of same order, then ARDL model could be employed for analysis. Table 3 reports the unit root test conducted for the variables at levels. It is clearly evident that the null hypothesis is accepted for all the variables, which means that the series are non-stationary. Whereas, the time series for all variables become stationary after considering the first differences (results in Table 4). It infers that the series for the variables are integrated of same order. However, in the current analysis, the series are found to be integrated of order 1 and are thus, eligible for cointegration analysis involving Engle Granger analysis and Johansen Cointegration analysis.

Table 3: Results of the ADF Test for Gold and other variables (in levels)

	With constant		**with constant and trend**	
	tau statistic	**p-value**	**tau-statistic**	**p-value**
Gold	-1.599	0.7925	-3.026	0.2838
Interest rate	-5.548	0	-5.5857	0
USD/INR	-2.64	0.2621	-0.0164	-2.247
MCXCOmdex	-1.703	0.75	-2.205	0.7269
MCXAgri	-2.108	0.54	-2.277	0.6906
MCXEnergy	-2.7879	0.217	-3.493	0.1146
NIFTY	-2.352	0.4046	-3.162	0.224

Table 4: Results of the ADF Test for first differences of the variables.

	With constant		**with constant and trend**	
	tau statistic	**p-value**	**tau-statistic**	**p-value**
Gold	-12.008	0.000	-12.012	0.000
Interest rate	-10.9825	0.000	-10.973	0.000

USD/INR	-21.961	0.000	-22.0401	0.000
MCXCOmdex	-22.1609	0.000	-22.1421	0.000
MCXAgri	-15.339	0.000	-15.3304	0.000
MCXEnergy	-22.356	0.000	-22.337	0.000
NIFTY	-28.212	0.000	-28.215	0.000

In order to conduct a robust analysis of interdependence of gold and other variables considered, it is very important to incorporate structural breaks in the financial time series. Quandt (1960) suggested the likelihood ratio test (QLR) for identification of the break spot in the time series. He suggested to maximise the value of the likelihood function (which assumes errors terms to be normally distributed at time t) at the time of breaking up the series into two groups (Stock, 2003; Milewski, 2017).

Table 5: Results for the Quandt Likelihood Ratio test for endogenous structural breaks

	Observation point	F-statistic	p-value
Gold-Nifty	131	569.93	[0.000]
Gold-MCXEnergy	205	1205.95	[0.000]
Gold-MCXAgri	270	1103.22	[0.000]
Gold-MCXComdex	129	733.78	[0.000]
Gold-USD/INR	233	1344.4	[0.000]
Gold-Interest	140	2474.9	[0.000]

Results for the QLR test are given in table 5 which indicate the point of structural break for each variable in relation to the variable gold. Structural breaks, thus, discovered are considered are base for forming two windows for set of each variable with gold. Window period 1 would focus on the data before the structural break and window period 2 would focus on the data after the structural break 2.

Engle and Granger (1987) provided for the Engle-Granger cointegration test, which builds itself on the ADF test, for testing cointegration between two series. For the Engle-Granger test, there would be evidence of cointegrating relationship if (a) The unit root test is not rejected for each series and (b) if the unit root hypothesis is rejected for the residuals obtained

after running the cointegrating regression. The foundations of cointegration are closely related to the concept of cointegration. Table 6 report the results of the ADF test on the series for each cointegrating regression run and residuals observed from the Engle Granger Cointegration regression for the window periods split at the structural break point, respectively. Regarding the cointegration relationship between gold and other variables on the basis of Engle Granger cointegration regression, it can be found that gold has a cointegrating relationship with MCX Energy Index, MCX Agriculture Index and USD/INR exchange rate for the first window period. Whereas, in case of post structural break period (referring to window period 2) the null hypothesis for the presence of unit root has been rejected only for MCX Agri Index. The results for the Engle Granger test were not so conclusive in nature.

Table 6 : ADF Unit root tests Results on the Engle Granger Cointegration test of residuals

	Window period 1		Window period 2	
	tau statistic	p-value	tau statistic	p-value
Gold-Nifty	-2.933	0.307	-2.358	0.599
Gold-MCXEnergy	-3.976	0.034	-2.359	0.596
Gold-MCXAgri	-4.6242	0.0045	-3.674	0.069
Gold-MCXComdex	-2.6647	0.4301	-2.58	0.4759
Gold-USD/INR	-4.61503	0.0049	-3.0048	0.266
Gold-Interest	-2.4423	0.5516	-1.2695	0.84

Johansen test is considered better than the Engle Granger test in terms of statistical accuracy. It also provides a greater detailed estimate of the cointegration among the variables. Stemming out of VAR approach to cointegration, Johansen test estimates the number of cointegrating relationships between variables and confirms the presence of multivariate cointegration. Table 7 reports the result for the Johansen trace statistics method used for testing the null hypothesis that there is at most r cointegrating vectors among variables. On observing the p-values obtained from trace test and L-max test, it can be suggested that the gold shared a cointegrating vector with MCXENERGY, MCXAGRI, USD/INR exchange rate and interest rates.

Table 7: Results of the Bivariate Johansen Cointegration Test.

	Window Period 1					Window Period 2				
	Rank	**Trace Test**	**p-value**	**Lmax test**	**p-value**	**Rank**	**Trace Test**	**p-value**	**Lmax test**	**p-value**
Gold-MCXEnergy	0	19.326	[0.0352]	16.862	[0.0525]	0	14.649	[0.1561]	8.4595	[0.5598]
	1	2.4642	[0.1165]	2.4642	[0.1165]	1	6.19	[0.0128]	6.19	[0.0129]
Gold-Nifty	0	13.117	[0.2378]	12.224	[0.2289]	0	24.828	[0.0046]	21.784	[0.0082]
	1	0.8931	[0.3446]	0.8931	[0.3446]	1	3.0443	[0.0810]	3.0443	[0.0810]
Gold-MCXAgri	0	14.893	[0.1455]	11.675	[0.2661]	0	15.484	[0.1222]	13.752	[0.1462]
	1	3.2183	[0.0728]	3.2183	[0.0728]	1	1.7315	[0.1882]	1.7315	[0.1882]
Gold-USD/INR	0	10.935	[0.2191]	10.602	[0.1781]	0	13.447	[0.2178]	12.069	[0.2390]
	1	0.33297	[0.5639]	0.33297	[0.5639]	1	1.3785	[0.2404]	1.3785	[0.2404]
Gold-Interest rate	0	41.573	[0.0000]	31.683	[0.0001]	0	41.573	[0.0000]	33.455	[0.0001]
	1	9.8902	[0.0017]	9.8902	[0.0017]	1	9.8902	[0.0017]	8.444	[0.0001]
Gold-MCXComdex	0	6.3807	[0.6550]	5.6956	[0.6570]	0	16.52	[0.0889]	10.575	[0.3528]
	1	0.68502	[0.4079]	0.68502	[0.4079]	1	5.9451	[0.0148]	5.9451	[0.0148]

Table 8 presents the results for the Granger Causality test among the variables for which the cointegration relationship has been observed. The null hypothesis for the Granger causality test is that variable x does not granger cause the variable y. So, basically the granger causality test provides an estimate for the direction of the causal relationship between the two variables. The results in the table 8 are indicated for only those pairs of variable with gold for which a cointegrating relationship has been observed at previous stages. On rejecting null hypothesis, it can be suggested that stock market fluctuations do cause some fluctuations in gold. Similarly, interest rates also influence gold to move. Possible reasons for this may that

interest rates have impact on the borrowing capacity of the investors and thus, influence the gold prices.

Table 8: Results of the Granger Causality Test

	Window period 1		Window period 2	
Direction of Granger Causality Null Hypothesis	**t-statistic**	**p-value**	**t-statistic**	**p-value**
Gold-Nifty	6.9876	0.009	0.2466	0.6197
Gold-MCXEnergy	0.86613	0.3532	0.6059	0.456
Gold-MCXAgri	0.6971	0.4045	4.5414	0.0338
Gold-USD/INR	1.8469	0.1755	1.497	0.2026
Gold-Interest	0.2591	0.6115	2.479	0.201
Nifty-Gold	7.172	0.0084	8.009	0.0001
MCXEnergy-Nifty	0.2399	0.6248	0.91209	0.3402
MCXAgri-Gold	4.4799	0.0352	0.1595	0.689
USD/INR-Gold	11.045	0.001	0.61621	0.6512
Interest-Gold	7.1	0.01704	7.867	0.015

Conclusion

Gold is not a commodity or a metal, it has been envisaged as an investment, a safe haven, hedging tool, buffer against inflation and other assets. In order to establish gold as an important part of portfolio it is important to study its interaction and relationship with other markets. After carrying out a cointegration analysis of gold with stock market, commodity futures, interest rates, foreign exchange rate, agriculture market, it can be concluded that gold establishes cointegrating relation with other markets but only in short run. After a structural shock, the behavior of gold vis a vis other market may shift. However, in the current study, gold has been observed as cointegrated with interest rates and stock market.

The results of the study would hold implications for the portfolio managers or investors who would like to downsize the risk or put up their investments in safe havens or wish to provide a hedge against the fluctuations of different markets.

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