



# Linkage between Gold and Crude Oil Spot Markets in India-A Cointegration and Causality Analysis

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## ABSTRACT

India is among the largest importers of gold and crude oil. As rise in crude oil prices is expected to further increase inflation in the economy while gold is used to hedge against inflation, we expect some nexus between gold and crude oil prices. The present study aims to investigate the linkage between gold and crude oil spot prices using cointegration and causality approach from 1<sup>st</sup> January 2012 to 31<sup>st</sup> December 2016. The results show that there is a low positive correlation (+0.31) between crude oil and gold. Johansen's cointegration results indicate that there is no long run equilibrium between the two price series. However, gold prices are found to Granger cause crude oil spot prices. In other words, gold prices lead the crude oil prices and bear a long term causality. The findings of this research are important to the investors, portfolio managers, corporate houses, crude oil traders, the government and policy makers.

**Keywords:** Cointegration, Casuality, Gold, Crude Oil, Spot Price

## 1. INTRODUCTION

Gold and crude oil are among the most traded commodities over the globe. India is among the largest importers of gold and crude oil. Out of the total imports, crude oil accounts for about 34 % and gold (and silver) accounts for 12 %. Crude oil and its products are used in different industries for different purposes. Where gold is used as hedging tool against inflation, in India gold is primarily used in making jewellery for religious and personal purposes. India is second largest gold jewellery market in the world and among the largest importers of Gold. When there is an increase in the price of crude oil, it is expected to affect all its products and by-products' prices. Diesel being the main fuel used in transport industry, it is the key factor in deciding the prices of food (vegetables and fruits) and other commodities, and hence may result in higher inflation. To hedge against inflation, investors start buying gold that further results in increase in gold demand and hence the price of gold.

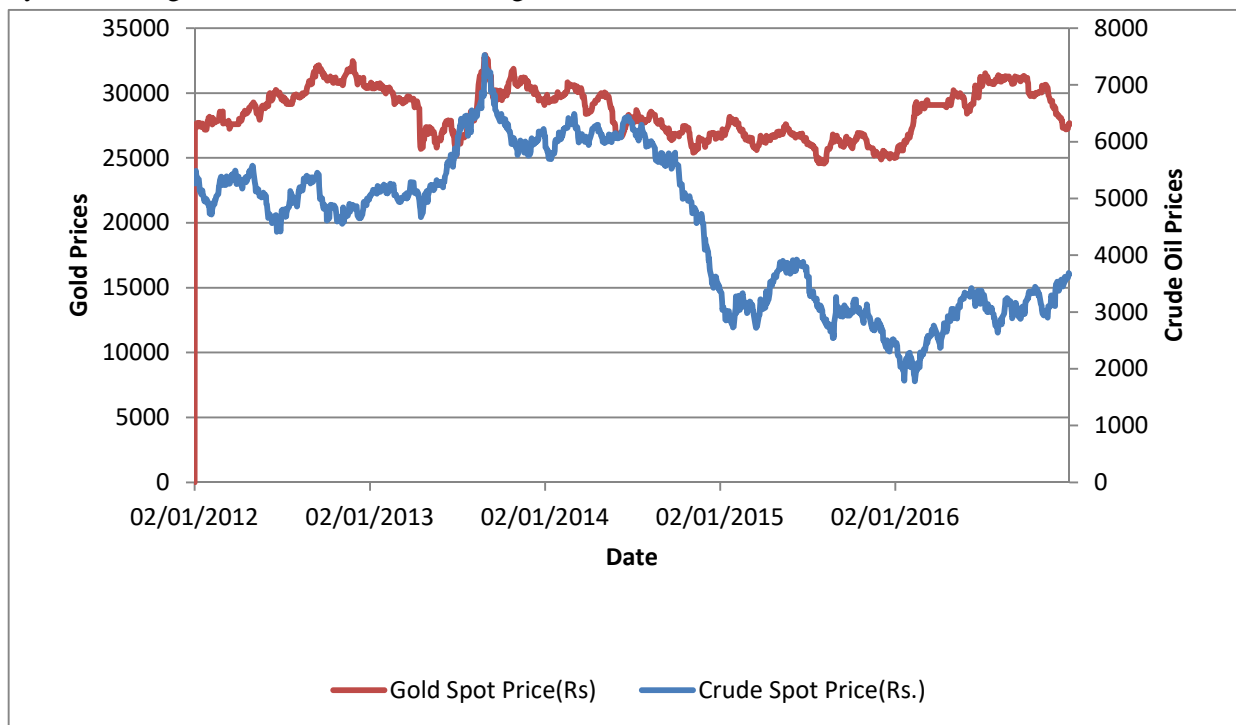
Volatility in crude oil prices in international market impacts economies all over the globe. Any factor that is expected to influence supply and demand of crude oil viz. OPEC's decision to cut down production, weak global oil demand due economic slowdown etc. is going to affect the crude oil price also (Singh and Singh, 2017). For instance, during the recent global financial crisis, the spot price of crude oil slipped down by more than 73% slipping all the way down from Rs 6299/bbl to Rs 1695/bbl. A recent example would be the effect of Brexit announcement on crude oil prices. In India, crude oil is main source energy as one third of the total energy is drawn from crude oil. Also, around 80% of the total demand of crude oil in India is met through imports. Thus, it is important for various stakeholders in oil trading to understand the crude oil price movements to reduce price risk.

According to World Gold Council report 2017, the three main factors which influence gold demand in short run are gold prices, inflation, monsoon and tax regime. The report finds that for a 1% fall in the gold price, demand will increase by 0.9% and for a 1% increase in inflation, gold demand increases by 2.6%. As rise in crude oil prices is expected to further increase inflation in the economy while gold is used to hedge against



inflation, we expect some nexus between gold and crude oil prices. Thus, this study aims to examine the relationship between gold and crude oil spot markets.

Figure 1 shows the price movement of gold and crude oil prices over the select period of five years. It is difficult to conclude the nature of relationship between the two. For some periods like 27<sup>th</sup> June, 2013 to 28<sup>th</sup> August, 2013, their movements almost overlap each other. However, the other periods like 2<sup>nd</sup> November, 2012 to 19<sup>th</sup> June, 2013 they are seen to move apart in opposite directions. This calls for a further robust analysis of linkage between the crude oil and gold.



**Figure 1: Gold and Crude Oil Prices Movement**

## 2. LITERATURE REVIEW

In literature there are a few studies on the relationship between gold and crude oil prices. Some of the important studies have been tabulated in the Table 1. From literature, it is evident that there is a further scope to analyze the nexus between the two variables. Given the findings of studies in literature and importance of gold and crude oil for a country like India, we are motivated to investigate the relationship between gold and crude oil spot prices.

## 3. DATA

This study uses secondary data on daily closing spot prices gold and crude oil for a period of five years from 1<sup>st</sup> January 2012 to 31<sup>st</sup> December 2016. The data is collected from the websites of Multi commodity exchange (MCX), India. This study has used software like Eviews 8.0 and MS Excel for analysis and presentation of data. Logarithmic (log) series have been used here. The missing values have been replaced by the average values of immediate preceding and succeeding values.



**Table 1: Summary of Literature**

S. No.	Author	Year	Objective	Research Methodology	Findings
1	Chhatwal and Puri	2013	To explore the long term and causal effect between spot and future prices of crude oil from May 2005 to December 2012.	Augmented Dickey–Fuller, Johansen’s Cointegration, and Granger Causality	They report unidirectional causality from spot return to futures return for before crisis period while during crisis period, there is bi-directional causality between futures return and spot return. In post-crisis period, there is unidirectional relationship between spot returns and futures return.
2	Jain and Ghosh	2012	To examine the cointegration and causality among global crude oil, Platinum, Silver prices and Indian Rupee–US Dollar exchange rate using daily data.	ARDL bounds tests and Toda–Yamamoto version of Granger causality	The cointegration among various variables exists only when there is relationship between gold and exchange rate. There is no correlation between oil silver and platinum. Toda–Yamamoto version of Granger causality indicates that exchange rates cause all the variables and relationship exist between oil an precious metals.
3	Sindhu	2013	To examine the factors (Exchange rate, crude oil, repo rate and inflation) that impact the price of gold	Trend Analysis, Regression Analysis and ANOVA	There exists inverse relationship between gold and US\$. Crude oil has an impact on the gold prices while the Gold prices and repo rates are interdependent on each other. Gold prices and inflation rates are also dependent and a positive correlation exists between them.
4	Yuwei Wang	2013	To identify the relationship between Gold prices and Crude Oil Futures.	Granger Causality, GARCH and TGARCH Models	The prices of gold and Crude oil are highly correlated but not their returns. The volatility of crude oil return has an effect on volatility of gold prices returns.
5	Sujit and Kumar	2011	To examine the relationship between Gold price, stock returns, exchange rates and oil price.	ADF and Granger Causality	It clearly states that the fluctuations in the gold prices are dependent on gold and not on any other variables. The results of the tests reveal a weak long term relationship between these variables.
6	Nirmala and Deepthy	2015	To identify the relationship between gold and Crude oil	Trend Line Evaluation	Gold and Crude oil prices are positively correlated and the reason for the correlation is stated due to valuation in US \$ for both these commodities.
7	Subhashini, and Poornima	2014	To identify the relationship between gold, exchange Rate and crude oil.	ADF and Regression Analysis	Crude Oil affects exchange rates. There is positive correlation between gold price and crude oil.
8	Narang and Singh	2012	To study the causal relationship between gold and sensenx.	ADF and Johansen Cointegration	There is no causality between gold price and sensenx.
9	Sahu and Banopadhyay	2013	To examine the relationships between oil price shocks and Indian Stock market.	VECM, Johansen Cointegration Test, Granger Causality, IRF and VDC	There exists a long term relationship and long term causality from stock market to oil but there is no short term causality between the variables.
10	Tomar and Singh	2016	To analyse the causal relationship between stock market, gold, crude oil and exchange rates.	Johansen Cointegration Test , Granger Causality	There is a bidirectional causality for exchange rate-stock market and gold prices - crude oil prices. Also, there exists a unidirectional causality between gold and exchange rate.



#### 4. RESEARCH METHODOLOGY

##### 4.1. Descriptive Statistics and Test for Normality (Jarque Bera)

It gives basic information on the averages and distribution of the sample series. It gives series statistics like mean, median, mode, kurtosis and skewness etc. Positive or negative value of skewness shows that the data is positively skewed or negatively skewed respectively. Similarly positive or negative value of kurtosis shows that the data is leptokurtic or platykurtic respectively

Jarque Bera is a test of normality based on the ordinary least square residuals. This test calculates the following test statistics

$$JB = n \left[ \frac{S^2}{6} + \frac{(K - 3)^2}{24} \right] \dots \dots \dots (1)$$

Where n is the sample size, S represents skewness coefficient and K represents kurtosis coefficient. If p-value is less than the level of significance (usually 5% or 0.05) then the null hypothesis of normal distribution is rejected.

**4.2. Augmented Dickey Fuller (ADF) Test:** It is most widely used stationarity test. The ADF test consists of estimating the following regression.

$$\Delta Y_t = \alpha + \beta_1 t + \beta_2 Y_{t-1} + \beta_3 \sum_{i=1}^m \Delta Y_{t-i} + \epsilon_t \dots \dots (2)$$

where  $\epsilon_t$  is a pure white noise error term and  $Y_{t-1}$ ,  $Y_{t-2}$  etc. are lagged difference terms. The number of lagged difference terms to include is determined by Akaike Information Criterion (AIC). If p-value is less than the level of significance (5%), the null hypothesis of unit root (non-stationary) is rejected and the series is said to be stationary.

##### 4.3. Johansen’s Cointegration Approach

Johansen’s Co-integration methodology has been extensively used for testing the long run equilibrium relationship between different financial and economic variables. Two variables are said to be cointegrated if there combination is a stationary variable. For *Johansen’s cointegration* test, a VAR model with k lags containing the given two variables is represented as follows:

$$\Delta Y_t = \mu + \Pi Y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-1} + \epsilon_t \dots \dots (3)$$

where

$Y_t$  : vector to be tested for cointegration

and  $\Pi$  : Coefficients matrices;

$\mu$ : the deterministic term and

k: represents lags of differenced dependent variable.

$\lambda_{t_i}$  : trace statistics and

$\lambda_m$  : max eigen value statistics

##### 4.4. Granger Causality Test

The lead lag relationship between two times series variables can be studied using Granger causality approach. A causality test seeks to answer the question, “Do changes in one time series cause changes in other?” If y Granger causes x then the lags of y should be significant in the equation of x. In this case, it would be said that there is unidirectional causality running from y to x. If x Granger causes y then the lags of x should be significant in the equation of y. In this case, it would be said that there is unidirectional causality running from x to y. Granger causality test to can be represented as a bi-variate of k<sup>th</sup> order VAR as given below:



$$Y_t = \alpha_0 + \sum_{i=1}^k \alpha_i Y_{t-i} + \sum_{j=1}^k \beta_j X_{t-j} + \epsilon_t \tag{4}$$

$$X_t = \gamma_0 + \sum_{i=1}^k \gamma_i X_{t-i} + \sum_{j=1}^k \delta_j Y_{t-j} + \epsilon'_t \tag{5}$$

Where  $X_t$  and  $Y_t$  are gold and crude oil spot price series variables,  $\alpha_0$  and  $\gamma_0$  are constant drift terms, and  $\epsilon_t$  and  $\epsilon'_t$  are error terms. Using F-test, we test the null hypothesis that  $X_t$  does not granger cause  $Y_t$ . Similarly, we test the null hypothesis that  $Y_t$  does not granger cause  $X_t$ .

## 5. EMPIRICAL FINDINGS

### 5.1. Descriptive and Jarque Bera Statistics

Table 2 shows the descriptive statistics of logarithmic returns on gold and crude oil spot prices. Returns have been calculated by the formula  $r = \ln \left( \frac{P_t}{P_{t-1}} \right) * 100$ . The table depicts that the return distributions are not normal as the values of skewness and kurtosis are non-zero. The returns on crude oil prices are positively skewed while that of gold prices are negatively skewed. Returns distributions of both gold and crude oil are of highly leptokurtic nature, gold being on the higher side. The non-normal distribution is confirmed by Jarque Bera test results. As the  $p$ -value is zero, the null hypothesis of normality is rejected even at 1% level of significance. The results also show that the gold spot market is more volatile than crude oil spot market. Also, the correlation between the prices of two commodities is found to be +0.31 i.e. there is low positive correlation between them. This finding is supported by their price movements shown in the Figure 1.

**Table 2: Descriptive and Jarque Bera (JB) Statistics**

	Log Return on Crude Oil Prices (RCP)	Log Return on Gold Prices (RGP)
Mean	-0.030318	0.002111
Median	0.000000	0.000000
Std. Deviation	2.337945	0.868647
Skewness	0.390609	-0.674810
Kurtosis	6.243748	12.85030
J B Probability	0.000000	0.000000

### 5.2. Unit Root Test - ADF

To test stationarity of given series, we have employed Augmented Dickey Fuller (ADF) test in *intercept, trend & intercept* and *none* form. The series are found to be non-stationary on levels in logarithmic forms. However on first differencing, these series (i.e. return series) become stationary. Table 3 shows the results of log returns series of gold and crude oil spot prices. As  $p$ -value is less than the level of significance (5%), the null hypothesis of unit root (non-stationary) is rejected and hence the series are stationary i.e. integrated series of first order  $I(1)$ . Thus, we may proceed to test cointegration relationship between the given log price series.



**Table 3: ADF Test results for First Difference of log Series of Crude Oil Spot and Futures Price Series**

Series	Model Form	Test Statistics	Critical Values @ 5% level of significance	p-value
log(SP <sub>t</sub> )	Intercept	-8.984946	-2.863750	0.000*
	Trend and Intercept	-8.960332	-3.450436	0.000*
log(FP <sub>t</sub> )	Intercept	-7.846667	-2.887425	0.000*
	Trend and Intercept	-3.490243	-3.450436	0.000*

Significant at 5% level of significance

### 5.3. Johansen Cointegration Test

Figure 1 does not reflect any sign of cointegration between the two variables. To analytically examine cointegration, we run Johansen’s cointegration test. The results are shown in Table 4. We have used different criterions like AIC and Lutkepohl in order to determine optimal lag length (k). Both of these criterions give different value of k. AIC reports k=3 while we get k=6 using Lutkepohl criterion. As Johansen’s method is sensitive to lag length selection, so we run this test for different lags. In is evident from the results that there is no cointegration between gold and crude oil spot prices log series as the p-values are greater than 5% level of significance. The results are robust as the result does not change on changing the lag length from 3 to 6. Thus, we conclude that crude oil and gold prices are not cointegrated and they don’t possess long run equilibrium.

### 5.4. Granger Causality Test

The results of Granger causality test have been reported in Table 5. As discussed above, we have used different criterions like AIC and Lutkepohl in order to determine optimal lag length (k). As Granger causality test is also sensitive to lag length selection, so we have reported results for different lags. From Table 4, we cannot reject the null hypothesis of no causality from log series of crude oil prices (LCP) to log series of gold prices (LGP) at 5% level of significance for both k=3 and k = 6. It means crude oil prices do not Granger cause gold. However, we reject the null hypothesis of no causality from log series of gold prices (LGP) to log series of crude oil prices (LCP) at 5% level of significance in case of k=3 and 10% level of significance for k = 6. Thus the results are robust. Hence, we conclude that gold prices Granger cause crude oil i.e. there is unidirectional causality running from gold prices to crude oil.

**Table 4: Johansen’s Cointegration Test Results**

Max lag length	Hypothesised No of CE(s)	Eigen Value	trace Statistics	Prob. For Trace Test	max Statistics	Prob for Max eigen value Test
3	r=0 (None)	0.0099	13.78599 (15.4947)	0.0890	11.9115 (14.2646)	0.1140
	r 1 (at most 1)	0.0015	1.874459 (3.8414)	0.1710	1.87445 (3.84147)	0.1710
6	r=0 (None)	0.0092	13.00638 (15.4947)	0.1146	11.07237 (14.2646)	0.1506
	r 1 (at most 1)	0.0016	1.934007 (3.8414)	0.1643	1.934007 (3.84147)	0.1643

Note: The critical values have been shown in parentheses.





Table 5: Granger Causality Test Results

Max lag length	Null Hypothesis	F-Statistic	Prob.
k = 3	LGP does not Granger Cause LCP	3.16070	0.0239#
	LCP does not Granger Cause LGP	0.57714	0.6301
k = 6	LGP does not Granger Cause LCP	1.78013	0.0998*
	LCP does not Granger Cause LGP	0.39519	0.8824

Note: # and \* represents significant results at 5% and 10% level of significance.

Thus, it is evident from the results that gold and crude oil prices are cointegrated but there runs unidirectional feedback from gold spot prices to crude oil spot prices. In other words, gold prices lead the crude oil prices and bear a long term causality.

## 6. POLICY IMPLICATIONS

The findings of this research are important to the investors and portfolio managers who invest in gold and crude oil and switch their positions from one to other commodity. The results of this study are also useful to corporate houses as crude oil is one of the important inputs and factors that affect product prices. This study also finds a key space in book shelves of gold and crude oil traders. Crude oil is main source energy in India because one third of the total energy is drawn from crude oil and, around 80% of the total demand is met through imports. As far as gold is concerned, India is second largest gold jewellery market in the world and among the largest importers of Gold as well. Thus, the results are imperative to the government and policy makers.

## 7. CONCLUDING REMARKS

Gold and crude oil are among the most traded commodities over the globe. India is among the largest importers of Gold and crude oil. When there is increase in price of crude oil, it is expected to affect all its products and by-products' prices. Diesel being the main fuel used in transport industry, it is the key factor in deciding the prices of food (vegetables and fruits) and other commodities, and hence results in inflation. To hedge against inflation, investors start buying gold that further results in increase in demand and hence the price of gold. The present study aims to investigate the linkage between gold and crude oil spot prices using cointegration and causality approach from 1<sup>st</sup> January 2012 to 31<sup>st</sup> December 2016. The results show that there is a low positive correlation (+0.31) between crude oil and gold. Johansen's cointegration results indicate that there is no long run equilibrium between the two price series. However, gold prices are found to Granger cause crude oil spot prices. In other words, gold prices lead the crude oil prices and bear a long term causality. The findings of this research are important to the investors, portfolio managers, corporate houses, crude oil traders, the government and policy makers. The study can be extended for a longer period and tested for structural breaks. Further, the relationship between gold and crude oil futures markets can be studied.

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