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Modeling Nonlinear Granger Causality and Co-Integration Between Gold Price Returns and Crude Oil Price Returns

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ABSTRACT
To model the nonlinear analysis of commodities, Gold market and crude oil market have importance to test their lead and lag price mechanism between the two. For this purpose, the log transformation has been done to calculate easier multiplicative effects. However, to record the dynamic effects of long run cointegreation model applied and tested to find the significance of the problem statement issues. Furthermore, granger causality approach also uses to examine the fundamental linkages between Gold Prices and Crude Oil prices. Meanwhile, the study of Gold markets and oil markets gained popularity among development economists during in last some decades. And try to find out stochastic relationship between the two nonlinear markets. The academic practitioners paved their efforts to run casual time series models in order to find out the robust results which help the economists and financial experts to drive the industry indicator in positive way. This study confirmed that there is cointegration between the two important indicators of large market commodities i.e Gold and crude oil and also casual interactions. Pairwise Granger Causality Tests concluded that Gold Prices return has Granger Cause on Oil Prices return in the long run and if the βeta change in the prices of gold may effect on the prices of crude oil in the long run.

Keywords: *Crude Oil Prices, Gold Oil Prices, Cointegration, Nonlinear modeling, log returns*

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INTRODUCTION

In recent years, the prices of crude oil and gold are the two main indicators of large commodity markets, which were largely driven by the market supply and demand. Meanwhile, a great amount of evidence suggests that the two markets, Gold and crude oil have close interaction as well maintaining neighboring trend(Zhang & Wei, 2010).

The purpose of this study is to investigate the causality and co-integration of gold prices return and crude oil price return; as it is distinguished from traditional economic equilibrium which pulls the balance of forces to produce stable long term. The co-integrated indicators are generally unstable in their nature, but demonstrate mean-reverting and force the indicators to move around the common stochastic trends.

Moreover, for scholars finding causality is a deep convoluted question and investigated empirically which may have many possible answers that may not satisfy everyone. But, still holds significant importance to find "cause" deep fundamental relationship between the stationary models. Granger causality provides linear information of Gold price returns and Oil price returns and as well assumes that the analyzed indicators are covariance stationary. Granger causality is entirely dependent on right selection of variables and also its implementation. Additionally, the Gold prices are taken in per ounce and crude oil in per barrel, and the returns of the same have been calculated by taking log returns.

Background of the Study

During the year 2002 gold and oil prices simultaneously boomed which was caused by US (United States) dollar depreciation, global inflation oil supply manipulation by the Organization of Petroleum Exporting Countries (OPEC) and also due to some momentous geopolitical events. In addition to that, these particular facts have caused a surging momentum in prices till the mid of 2008.

After the mid of 2008, large commodity markets faced severe situation due to global financial and economic crisis; which resulting a continuous decline in the prices of crude oil per barrel from $147 to 30 by the end of year 2008. And during the same period a sharp decline saw in Gold prices per ounce from $1000 to 700. However, in a year 2009 the expectation of global economic recovery has changed the staggering and tumble trends of crude oil prices and gold prices into positive level and also caused rise in large commodity market demand.

a- Crude Oil Prices (Per Barrel) **b-** Gold Prices (Per Ounce)

Figure.1: Crude Oil Prices& Gold Prices - 10 Year Daily Chart

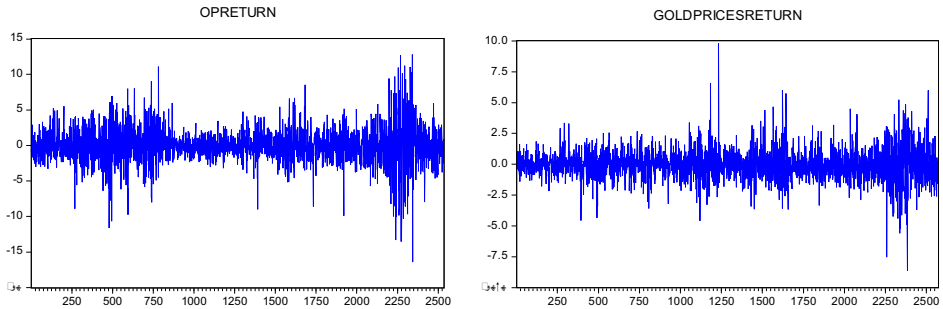


Figure.2: Price returns of Crude oil (Per Barrel) and Gold (Per Ounce)

The last 10 years daily chart of Crude and Gold prices have shown mixed trend and at some point similarities between the two. Currently Crude oil per barrel is trading at $57.67 and Gold per ounce trading at $1258.20. After Mid of August, 2017 the trend of gold prices saw continuous decline whereas sharp increase has been observed in the prices of crude oil since the starting of October 2017.

Furthermore, Geopolitics, with respect to oil, could continue to generate volatility, but it is implausible to have an immediate supplementary impact. However, a small number of active hotspots that monitor is more likely to impede oil supply that stimulates prices.

Hypotheses

The following hypotheses of study are formulated on the basis of critical literature review:
Ho: There is no co-integrating vector between Gold Prices return and Oil Prices return
H_a: There is co-integrating vector between Gold Prices and Oil Prices return
Ho: Oil Prices return does not Granger Cause Gold Prices return
H_a Oil Prices return has Granger Cause Gold Prices return
Ho Gold Prices return does not Granger Cause Oil Prices return
H_a Gold Prices return has Granger Cause Oil Prices return

Problem Statement

Prices of crude oil and gold are the two main indicators of large commodity markets, which were largely driven by the market supply and demand. For Finance Managers and regulators there are some important implications if the trend of Gold and Crude oil prices are linearly co-integrated or not in the long run. The implausible causes of deepening fundamental relationship between the two main large commodities has also significant impact on large commodity markets and may help the regulator to set the prices level. And this study is effort to investigate which indicator causes the most between Gold prices return and Oil prices return.

Objectives of Study

To find out the causality and co-integration between Gold prices return and Oil prices return of the modeled nonlinear indicators.

Scope of the Study

This study will cover the preliminary questions related to the trend of the two large markets commodities Gold Prices return and Oil prices return in context to their causality and co-integration. And on the basis of empirical evidences practitioners and analysts of the field will be able to answer the deep convoluted questions related to the fundamental relationship and their stochastic nature.

LITERATURE REVIEW

Gold has been predominant valuable metal for many centuries and plays a significant role as a store of value, especially in periods of political and economic uncertainty (Aggarwal & Lucey, 2007). While comparing with other metals gold has dominant position in the large commodity market. In recent years, gold is a good profit making commodity and having remarkable risk-avoidance feature which makes distinctive then other large market commodities and due to this Gold has received increasing attention of academia scholars and industrial practitioners. Whereas, research concerned also become apparent and conducted a lot of research in relation to the volatility of gold market. For instance, two academic researchers (Xu & Fung, 2005) used a bivariate asymmetric GARCH model to analyze the information flow for the gold, platinum, and silver future contracts and founded strong volatility and spillover effects in two international markets including Japan and leading role of US market.

Moreover, on the basis of historical data the gold prices and crude oil prices of world has shown relatable trend but the studies on the two markets interaction appears to be an inadequate and even some important aspects have not been widely studied. For instance, whether there is robust impact between the crude oil and gold markets and what are their robustness and relative ranks in the large commodity markets. And what are the important features holds these commodities in forecasting the price volatility (Zhang, Fan, Tsai &Wei, 2008). However, to discuss the important interaction between the two markets into two perspectives: price cointegration and price causality. Meanwhile, with respect to the price cointegration, the cointegration theory and error correction model discovered by(Engle & Granger, 1987) is applied in this study. Several researchers have investigated the correlation between oil prices and gold prices and various market indexes using different econometric tools on the sample of many countries. And in this respect sample of South Africa used to measure volatility of oil prices caused by political unrest showed the significant gold spot price forecast errors(Melvin & Sultan, 1990). Cashin, McDermott and Scott (1999) analyze the sample period from April 1960 to November 1985 in order to test the relation between seven commodities and data results explain that there is significant association between oil and gold. To test the impact of international stock markets on variability of oil prices and its significance to the future changes in expected returns of real cash flows are noted that Canadian and US stock market prices to the oil prices cause shocks in real cash flows (Jones & Kaul, 1996). Another study conducted while using VAR approach to test the correlation between daily oil returns and daily US stock returns; it is empirically revealed that oil returns has effect on few individual companies stock returns whereas oil companies impact recorded at some extent to the market indices of S&P 500 (Huang, Masulis, & Stoll, 1996). Oil prices and its volatility both have significant effect on the stock returns(Sadorsky, 1999). Meanwhile, it is founded that there is nonlinear relationship between oil prices and stock market. And this study provides the evidence that oil shocks has effect on S&P 500 index returns while using nonlinear causality tests(Ciner, 2001).

The gold is good hedge both against the inflation and also other valuable assets. When general prices are high the utility of gold against inflation helped in increase the prices of gold which resulting assets can be sold in order to finance the overall costs. However, this study explored that usefulness of gold as a hedge against other assets may help to diversify portfolio. For instance, if prices of stocks, bonds, foreign currency fall then the prices of gold rises which confirms that diversification helped firm to sustain the hedge advantage. For this many studies conducted to see the pattern of gold prices and what are the factors that affect the most to the gold prices (Capie, Mills, & Wood, 2005; Worthington & Pahlavani, 2007; Baur& Lucey, 2010) and the few factors studied are i.e inflation, exchange rate, bond prices, market performance, seasonality, income, business cycles and most important oil prices which have influence on gold prices. However, one of the study conducted on developed countries reveled the empirical results that Oil price has a negative association with gold price and it is implied that gold is good hedge against the oil investments (Reboredo, 2013). The gold price has also a

cointegrating association with the US bonds rates, Consumer Price Index, exchange rate, stock market index and oil price(Baur & McDermott, 2010).

In contrast, it is observed that only a few researches have been carried out to investigate the fundamental relationship between gold price, oil price and stock markets. Meanwhile oil has significant place in US economy, and the price changes may have serious implications on stock prices(Hamilton, 1983).Furthermore, the casual relationship tested between gold prices and crude oil prices before and after the great depression. And the statistical results predict that before the financial crisis period the causality is linear and unidirectional between oil and gold. But during the post financial crisis period the trend is bidirectional and shown nonlinear causality relationship. Whereas the volatility spillover was emerging as a root of nonlinearity between the two during the same post financial crisis era. In addition, the time path and casual interactions of both gold prices return and oil prices return analyzed through dynamic bootstrap causality analysis and same is coingrated. Empirical result shows a significant casual relation between gold and oil that gold has granger cause on oil in the short run by an increase of 30% during the Euro financial crisis (Bampinas & Panagiotidis, 2015).

To test the short-run dynamics and the long run effects in terms of shocks, monthly data of effective dollar exchange rate, oil and gold prices from 1976 to 2011 have been collected and carefully analyzed the same by applying cointegrated VAR model to explore the stochastic relationships. And through results it is concluded that gold and oil are significant commodities and their effect in terms of shocks differs. Whereas, in the long-run both commodities were seemingly positive and the shocks of gold determined the system. Meanwhile, the gold and oil prices spread has pragmatic relationship with the U.S consumer prices, and also have implication of stronger association of consumer prices to the old(Beckmann & Czudaj, 2013).

Research Model

The following econometric model has developed to run the cointegration and granger causality of log transferred variables:

$PO_t=\beta_o+ \beta_1 PG_t+\mu$

PO_t = log daily Prices of Oil
PG_t= log daily Prices of Gold
μ = Error term

METHODOLOGY

To model the nonlinear analysis commodities, Gold market and crude oil market have importance to test their lead and lag price mechanism between the two. For this purpose, the log transformation has been done to calculate easier multiplicative effects. However, to record the dynamic effects of long run cointegreation model applied and tested to find the significance of the problem statement issues. Furthermore, granger causality approach also uses to examine the fundamental linkages between Gold Prices and Crude Oil prices.

Source of Data

This study purely was a quantitative in nature; therefore, the secondary source for the data collection had been used.

Sample Size

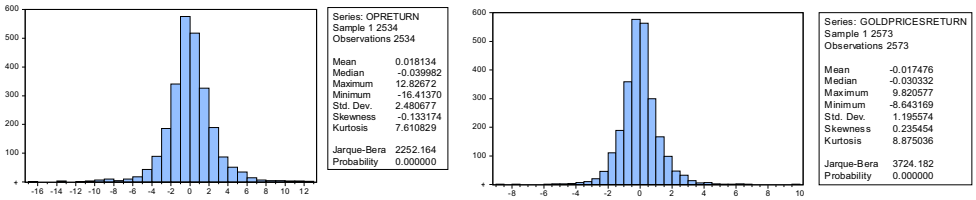
The study has been conducted on the sample data for the period of 10 years. And the data has been collected for the extensive period from 2008 to 2017 mid-December. This includes daily prices of Gold in (per ounce) and Crude Oil (in per barrel).

Variables

The following to log transformed variables have been chosen to complete the study:
PO_t = log daily Prices of Oil
PG_t= log daily Prices of Gold

RESULTS & DISCUSSION

Empirical results of study revealed that after the log transformation the returns of Gold prices and Oil Prices showed normally distributed pattern as the Jarque-Bera p-value is less than 0.05 which indicates that the desired population have zero skew and zero Kutosis refer fig.4.1.



(a) **(b)**

Figure.3: Histogram of a. Oil Prices Return (Per barrel) b. Gold Prices Return (Per Ounce)

Furthermore, Augmented Dickey-Filler test is applied to determine the stationary of the nonlinear time series model and the results are:

Variables	T Static	p-value	Stationary At
PO_t	-51.84267	0.0001	Same Order *I*(0)
PG_t	-50.18254	0.0001	Same Order *I*(0)

Table.1: ADF Unit Root Test

Table.2 mentioned above is the summary of ADF test. The results indicate that variables were non-stationary at I(0), as prob. value for all the variables are less than 0.05 (i.e. PO_t =(0.0001), PG_t =(0.0001). Therefore, the study is accepted the null hypothesis that data is non-stationary. At this instant, when variables became stationary at I(0*)*, Johansen Co-integrationtest is applied to know whether there exist long run correlation.

Gold markets and oil markets gained popularity among development economists since many centuries. And try to find out stochastic relationship between the two nonlinear markets. The academic practitioners paved their efforts to run casual time series models in order to find out the robust results which help the economists and financial experts to drive the industry indicator in positive way. This study confirmed that there is cointegration between the two important indicators of large market commodities i.e. Gold and crude oil and also casual interactions.

Maximum Eigen Value		
	None	**At Most 1**
Eigen value	0.178383	0.157216
Statistic	496.7047	432.3993
Critical Value	14.26460	3.841466
p-value	0.0001	0.0000
Trace Statistic		
	None	**At Most 1**
Eigenvalue	0.178383	0.157216
Statistic	929.1040	432.3993
Critical Value	15.49471	3.841466
p-value	0.0001	0.0000

Table. 2: Johansen Co-integration test

Table 4.2 presented above shows the results of Co integration test. Both the tests criterion (i.e. Trace Statistic and Maximum Eigen value) indicate at none and most 1are Co integrating equation at 5% level because the prob. Values for both criterion at most 1 are less than 0.05 (i.e. Trace Statistic=0.1671 and Maximum Eigen value= 0.3679). Hence, the null hypothesis rejected and concluded that; There is co-integrating vector between Gold Prices and Oil Prices return and suggests that in the long run their Gold prices may affect the oil prices. This study confirmed that there is cointegration between the two important indicators of large market commodities i.e. Gold and crude oil and also casual interactions. In addition to that, the time path and casual interactions of both gold prices return and oil prices return analyzed through dynamic bootstrap causality analysis and same is coingrated. Empirical result shows a significant casual relation between gold and oil that gold has granger cause on oil in the short run by an increase of 30% during the Euro financial crisis confirmed significance of this study (Bampinas & Panagiotidis, 2015). Moreover, on the basis of critical literature this study can also be the extension of previous studies conducted on other important financials and commodities. Regarding this further revelation is that the gold price has also a cointegrating association with the US bonds rates, Consumer Price Index, exchange rate, stock market index and oil price(Baur & McDermott, 2010) .

Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**
OPRETURN does not Granger Cause GOLDPRICESRETURN	2528	0.43068	0.8275
GOLDPRICESRETURN does not Granger Cause OPRETURN		2.15763	0.0561

Table.3: Pairwise Granger Causality Tests

Table.3 presented above shows the results of Pairwise Granger Causality Tests. And it is concluded that Gold Prices return has Granger Cause on Oil Prices return in the long run and if the βeta change in the prices of gold may effect on the prices of crude oil in the long run.

Furthermore, on the basis of results it is also confirmed and other study conducted in US. To test the short-run dynamics and the long run effects in terms of shocks, monthly data of effective dollar exchange rate, oil and gold prices from 1976 to 2011 have been collected and carefully analyzed the same by applying cointegrated VAR model to explore the stochastic relationships. And through results it is concluded that gold and oil are significant commodities and their effect in terms of shocks differs. Whereas, in the long-run both commodities were seemingly positive and the shocks of gold determined the system. Meanwhile, the gold and oil prices spread has pragmatic relationship with the U.S consumer prices, and also have implication of stronger association of consumer prices to the old (Beckmann & Czudaj, 2013).

Hypotheses Assessment Summary

Hypotheses	P-value ⩽ 0.05	Accept /Reject
Ho: There is no co-integrating vector between Gold Prices return and Oil Prices return	0.0001	Reject
Ho: Oil Prices return does not Granger Cause Gold Prices return	0.8275	Accept
Ho: Gold Prices return does not Granger Cause Oil Prices return	0.0561	Reject

CONCLUSION

This nonlinear modeled study confirms that there is cointegration vector between Gold Prices and Oil Prices return. As the results suggest that both the tests criterion (i.e. Trace Statistic and Maximum Eigen value) indicate at none and most 1are Co integrating equation at 5% level because the prob. Values for both criterion at most 1 are less than 0.05 (i.e. Trace Statistic=0.1671 and Maximum Eigen value= 0.3679). Hence, the null hypothesis rejected and concluded that; There is co-integrating vector between Gold Prices and Oil Prices return and suggests that in the long run their Gold prices may affect the oil prices. Furthermore, Pairwise Granger Causality Tests concluded that Gold Prices return has Granger Cause on Oil Prices return in the long run and if the βeta change in the prices of gold may effect on the prices of crude oil in the long run.

Limitations of the study

The limitations of this study that there must be some other indicators should be included from large commodities and as well comparison of dollar rate.

Recommendation

Government and financial institutions should invest in Gold market as it has lesser shocks then the crude oil and the returns are safer than the other one.

Policy Implications

This study will help to diversify the portfolio investments which help in long run to make investments in those commodities that are lesser riskier and returns are safe in the long run.

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APPENDIX

Unit Root Test

Null Hypothesis: OPRETURN has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=26)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-51.84267	0.0001
Test critical values:	1% level	-3.432738	
	5% level	-2.862481	
	10% level	-2.567316	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(OPRETURN)
Method: Least Squares
Date: 12/13/17 Time: 18:21
Sample (adjusted): 2 2534
Included observations: 2533 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
OPRETURN(-1)	-1.030005	0.019868	-51.84267	0.0000
C	0.019042	0.049286	0.386358	0.6993

R-squared	0.515010	Mean dependent var	0.000633
Adjusted R-squared	0.514818	S.D. dependent var	3.561079
S.E. of regression	2.480469	Akaike info criterion	4.655562
Sum squared resid	15572.55	Schwarz criterion	4.660171
Log likelihood	-5894.269	Hannan-Quinn criter.	4.657234
F-statistic	2687.663	Durbin-Watson stat	2.000214
Prob(F-statistic)	0.000000		

Date: 12/13/17 Time: 18:44
Sample (adjusted): 6 2533
Included observations: 2528 after adjustments
Trend assumption: Linear deterministic trend
Series: GOLDPRICESRETURN OPRETURN
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 *	0.178383	929.1040	15.49471	0.0001
At most 1 *	0.157216	432.3993	3.841466	0.0000

Trace test indicates 2 cointegratingeqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.178383	496.7047	14.26460	0.0001
At most 1 *	0.157216	432.3993	3.841466	0.0000

Max-eigenvalue test indicates 2 cointegratingeqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

GOLDPRICESRETURN	OPRETURN
0.734736	0.849256
1.736274	-0.328177

Unrestricted Adjustment Coefficients (alpha):

Pairwise Granger Causality Tests
Date: 12/13/17 Time: 18:45
Sample: 1 2573
Lags: 5

Null Hypothesis:	Obs	F-Statistic	Prob.
OPRETURN does not Granger Cause GOLDPRICESRETURN	2528	0.43068	0.8275
GOLDPRICESRETURN does not Granger Cause OPRETURN		2.15763	0.0561