EXPLORING THE SHORT-RUN AND LONG-RUN DYNAMICAL LINKS BETWEEN GOLD PRICE, CRUDE OIL PRICE AND NIFTY

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Abstract: The process of globalization of business has increasingly led to the integration of markets around the world. This phenomenon is also found in commodity and financial markets. As a result, there is a tendency for markets to move together and show co-integration in a technical sense. This is a well-researched area and there is plenty of empirical evidence that find support for this phenomenon. In this paper, we study the short-run and long-run relationships between gold, crude oil and one of the major stock indices of India, namely the Nifty. We consider the price of gold in the Indian market and the international crude oil price and the Nifty index in our study. We have used monthly data from February 2005 to August 2012. We have used the Augmented Dickey Fuller tests to establish the non-stationary of the time series processes and the Johansen-Juselius co-integration techniques to establish our results.

Key Words: Co-integration, Augmented Dickey Fuller Test, Market efficiency, Granger causality

The last decade has seen unprecedented movements of investments across countries and across markets. Markets moving up or down in tandem is a phenomenon that is widely observed. In this paper, we attempt to identify links between gold, crude oil and stock markets and try to identify the long-run and short-run linkages between them. The variables identified for our study are the prices of gold and crude oil and the Nifty, which is a major stock index of India. The first section contains the review of literature; the second section contains a brief description of the data and methodology used in our study; in the third section, we present the results of our analysis and the last section contains a discussion of our findings. There are a few studies conducted with respect to India but they do not address the specific issues studied in this paper.

REVIEW OF LITERATURE

An understanding of the relationship between crude oil prices and stock markets is important to investors, financial analysts and policymakers. It is generally believed that high crude oil prices lead to wealth creation in oil producing countries and wealth erosion in oil importing countries. High oil prices lead to increases in the cost of production for non-oil producing firms not only in

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their production processes but also in distribution. Increases in cost of production negatively affect the profitability of enterprises. Thus the expected present value of future cash flows of companies go down and hence their stock prices go down as well. Increases in crude oil prices are also associated with inflationary pressures. In order to moderate inflation, the central bank of a country will tighten money and this leads to an increase in interest rates, which also has an adverse impact on stock markets. This is essentially and empirical issue and there are some studies conducted to analyse the impact of crude oil prices and stock indices.

This empirical issue has been studied by many, however, there has not been any consensus in the literature regarding the exact underlying relationships. For instance, Honarvar (2009), Lardic and Mignon (2008), Anoruo and Mustafa (2007), and Huang, Masulis and Stoll (1996) found significant relationship between high crude oil prices and stock markets. However, Al-Fayoumi (2009), Sari and Soytas (2006) and Maghyereh (2004) found that high crude oil prices have no significant effect on stock markets. Some related works that studied the impact of oil price shocks on stock markets and economic activity are Sadorsky (1999 and 2001), Papetrou (2001 and 2009), Jungwook and Ratti (2008), Miller and Ratti (2009), Basher, Haug and Sadorsky (2012) and Lee, Y-H., Huang, Y-L and Yang, Y (2012).

There has always been a historical link between stock indices and gold prices. Several studies pertaining to developed countries, have shown that gold is a so called 'safe haven' asset and that during stock market down turns, investors tended to favour holding gold.The fact that gold is a safe haven for stocks implies that investors that hold gold in normal times and intimes of stress receive compensation for losses caused by negative stock returns through positive goldreturns.(Upper, 2000, Hartmann, P., S. Straetmans and C.G. de Vries ,2004).

The study by Zang *et al.* (2010) analyzes the co-integration relationship and causality between gold and crude oil prices. They find a significant positive correlation between gold prices and crude oil prices during the sampling period. The study further suggests that the crude oil price Granger causes the volatility of gold price.

Moore (1990) used the leading signals of inflation to test the relationship between the signals and the gold prices of the New York Market since 1970. Empirical results show that, from 1970 to 1988, gold prices and the stock/bond markets had a negative correlation.

Jones and Kaul (1996) noted the adverse impact of oil prices on output and real stock returns in four countries, viz., U.S., Canada, U.K. and Japan. That there

was short-term unidirectional causality from large-cap stock prices to gold mining company stock prices and from the latter to gold prices was shown by Claire G. Gilmore, Ginette M. McManus, Rajneesh Sharma and Ahmed Tezel (2009). Mu-Lan Wang, Ching-Ping Wang and Tzu-Ying Huang (2010) concluded that there was cointegration between variations in prices of oil, gold, exchange rates (USD vis-à-vis other currencies) and stock markets in Germany, Japan, Taiwan and China. There is bi-directional causality between prices of crude oil and the stock/gold prices in Taiwan. The prices of crude oil and gold lead the exchange rate (USD to NT), which leads the Taiwan stock prices. Mutual independence was found between gold prices and stock prices in Taiwan.

Emmanuel Anoruo (2011) finds bi-directional non-linear causality between oil prices and S&P 500 which is a major stock index of the United States using VAR methodology. Rumi Masih, Sanjay Peters and Lurion de Mello (2010) used Vector Error Correction Mechanism (VECM) in their study and concluded that oil price movements had a significant effect on the stock market in South Korea. Ayhan Kapusuzoglu (2011) found the unidirectional causality from three indices; viz., National 100, National 50 and National 30, of the Istanbul (Turkey) stock exchange to oil prices and not the other way around. Shigeki Ono (2011) showed that, barring Brazil, the other three BRIC countries witnessed positive response of real stock returns to oil price changes. Statistically significant asymmetric effects of oil price shocks were observed only in India, among the four BRIC nations.

Amalendu Bhunia and Somnath Mukhuti (2012) found that each of the three stock indices, viz., BSE 500, BSE 200 and BSE 100, exhibit one-way causal relationship towards crude oil price over the period April 2001 to March 2011. Rabi N. Mishra and G. Jagan Mohan of Reserve Bank of India (2012) concluded that there is one-to-one relationship between domestic and international gold prices both in the short-run and long-run. In the post-2003 period, while international commodity prices play a dominating role in influencing global gold prices in the long-run, the U.S. exchange rate (to a significant extent) and international equity prices (to a smaller extent) cast influence in the short-run.

In sum, many studies conducted in the past have found causal relationships between crude oil prices, gold prices and stock movements. They have also found stable long-term relationships between these variables or a subset of them in the long run using error correction methodologies.

This line of enquiry has its origins in the well-known 'Prospect Theory' proposed by Kahneman andTversky (1979) and later refined in Tversky and Kahneman (1992), which describes that people generally evaluate gamblesby thinking about gains and losses and not by the final wealth levels.

However, there are not many studies done with respect to India. Given India's international linkages developed only in the last 20 years or so, the study assumes importance in the post-liberalization era since 1991. India's external trade has always been dominated by POL imports which amounts to almost 70% of total imports and the forex earnings coming from exports have not been sufficient to meet the import bill. With the Indian government removing controls on foreign entities investing in the Indian stock markets, foreign portfolio investments started to flow in and this has led to increased volatility in the domestic stock markets.

Our Paper is aimed at filling this gap in the existing literature. As discussed, the questions we study have not been answered in the context of India. Has the increased openness of the Indian economy led to integration of the Indian stock markets with other global markets such as the gold market and the crude oil market? If there are any linkages, can we determine if there are long-term and short-term linkages between them? Can we also come to some conclusions regarding the efficiency of these markets?

DATA AND METHODOLOGY

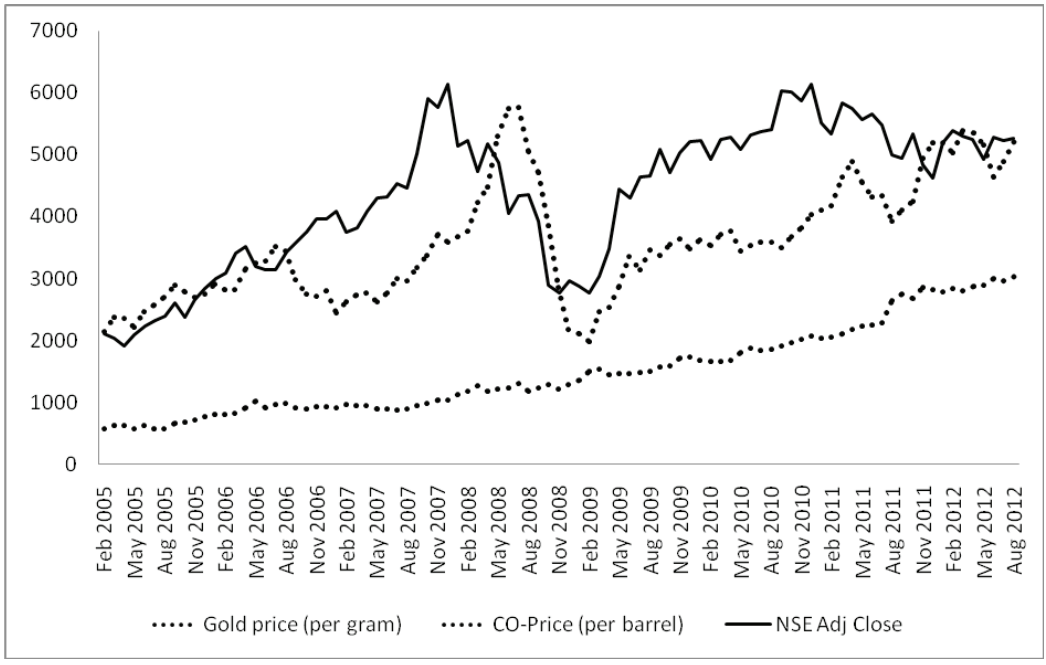
Data pertaining to gold and crude oil prices was sourced from the website of Multi-Commodity Exchange (MCX) and that relating to stock prices (Adjusted close of Nifty Index) from National Stock Exchange. Based on the daily closing, the monthly average was calculated and used in the study. The monthly average crude oil prices and gold prices were computed using the volume and value data available with MCX. We have used monthly data from February 2005 to August 2012 in our study, adding up to a total of 91 observations.

The Augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1979 and 1981) Test was conducted to test for stationary/unit roots. The Akaike Information Criterion (AIC) was used to determine lag length. This was followed by the Johansen-Juselius test (Trace and Maximal Eigenvalue tests) for cointegration. Significance tests were performed to establish the speed of adjustment between variables and their degree of exogeneity. The short-run and long-run relationships between variables were identified by applying the Vector Error Correction Model (VECM). This methodology is necessitated in case the variables are non-stationary

and have unit roots. In the presence of unit roots in the time series processes, Ordinary Least Squares (OLS) Method or even a simple Vector Auto Regressive (VAR) method cannot be used. As discussed, the fact that these variables exhibit co-movements and tend to be co-integrated, is well established in the literature. In the presence of co-integration, the estimated co-efficients need to be adjusted for co-integration. Interpretation of these coefficients is not as straight forward as in the case of other procedures like the OLS etc., but the advantage of using the co-integration approach is that we need not assume any particular functional relationship between the variables. The model lets the data itself suggest the underlying functional behaviors. However, interpretation of results is not very straight forward as in the case of OLS or VAR.

The final step is to test for causal relationships between the variables. In the presence of co-integration, there must be at least one underlying causal relation (Granger, 2004). We have used pair-wise Granger causality test to explore this issue.

Figure 1: Gold Price (GP), Crude oil Price (CP) and Nifty from Feb. 2005 – Aug. 2012



The graph presented above suggests co-movements in the crude oil prices and Nifty, while the Gold price movements appear to be somewhat independent

of the other two variables. Table 1 presented below indicates that the variables considered in the model are positively correlated with one another.

Table 1: Correlation

Prices of variables (in pairs)	Correlation Coefficient
Gold and crude oil	0.712567
Gold and stock	0.660323
Crude oil and stock	0.630762

THE MODEL AND RESULTS

It is standard practice to check the data for stationarity while working with a time-series statistical model. This is the first step and the Augmented Dickey Fuller (ADF) test is the standard test most commonly used for this purpose.

The null and the alternate hypotheses in the ADF test are:

H0: The time series is non-stationary and has unit roots.

H1: The time series is stationary

The test results presented in Table 2 indicate that while gold prices arise from a stationary stochastic process, namely that it is an I(0) process since the computed test statistic is significant at 5% level, the crude oil price and the Nifty index are non-stationary and have unit roots. The crude oil price series was found to be I (1) process since the series was found to be stationary in the first lag of the difference. Nifty was found to be stationary in the second lag of the difference and hence is an I (2) process. The standard Ordinary Least Squares (OLS) or Vector Auto Regression (VAR) techniques cannot be used to study the underlying relationships in non-stationary processes. We therefore, need to explore the presence of co-integration among the variables. The optimal lag length was determined using the Akaike Information Criterion and it was found to be 2.

Table 2: Unit Root Tests (Augmented Dickey-Fuller):

Variables	Test Statistic (without constant and drift)	Type
Gold Price (GP)	3.6988	I(0)
Crude oil Price (CP)	0.598	I(1)
Nifty	1.082	I(2)
5% Significance value	1.95	

Since the ADF results indicate that at least two of the variables included in the model are non-stationary, it is necessary to explore further for possible presence of co-integration. In simplistic terms, co-integration is the phenomenon of two or more time series moving in tandem. To analyze this issue we have used the Johansen-Juselius procedure.

Johansen-Juselius Procedure:

The standard Vector Auto regressive (VAR) model can be written as follows:

$$X(t) = \gamma(1)X(t-1)+ \gamma(2)X(t-2)+ \gamma(3)X(t-3)+\ldots+ \gamma(k)X(t-k)+\mu+\gamma(t),\ t= 1,\ldots,T \quad \text{-------(1)}$$

Where, X(t) is a 3X1 vector containing GP, CP and Nifty. As already mentioned, GP stands for gold price, CP for crude oil price and Nifty is the National Stock Exchange Index. Since we postulate that there is co-integration among the variables and that there are co-movements of these variables towards a long-run equilibrium state, we can hypothesize the following testable relationships that comprise of the Vector Error Correction Model (VECM) of growth.

$$\Delta X(t) = \gamma(1)\Delta X(t-1)+ \gamma(2)\Delta X(t-2)+\ldots+ \gamma(k-1)\Delta X(t-k+1)+\prod X(t-k)+ \mu+\gamma(t),\ t= 1,..,T \quad \ldots (2)$$

We have used the notation Δ to indicate differenced data. ΔX (t) is the vector of the first differences of the variables, γs are estimable parameters and γ(t) is a vector of impulses which represent the unanticipated movements in X (t) with the error term γ(t) following a normal distribution with expected mean equal to zero and expected variance, a constant Σ. In short,γ (t) $\sim$ iid (0, γ). $\prod$ is the long-run parameter matrix with 'r' cointegrating vectors. With only three variables in the system we have, $1 \leq r \leq 3$. $\prod$ has rank r and it can be represented as $\prod = \alpha\beta$, where α and β are 3 x r matrices. It is a composite co-efficient capturing both the long-run and short-run impacts.

The βs capture the long-run cointegrating relationships and the αs capture the short-run adjustment coefficients which measure the speed of adjustment of the cointegrating vectors in the VEC model. In what follows, we separate α and β so as to understand the long-run and short-run impacts clearly by applying co-integration techniques involving a Vector Error Correction Model.

In Table 3 below, we present the results of the trace test and the maximal eigen value test used for estimating the rank of ∏. The results of both indicate that the rank of ∏ = 1. Thus we conclude that there is utmost one co-integrating relationship between the three variables.

The VECM model allows the researcher to resolve the conflict between the long-run and short-run effects as it allows the disequilibrium dynamics by bringing in the adjustment mechanisms in the error correction terms. There is a long-run movement of the variables in the system which converges towards a long-run equilibrium and the adjustment coefficients act as feedback mechanisms, forcing the variables to converge towards that long-run equilibrium. In other words, the adjustment co-efficients represent the speed with which the entire system converges to this long-run equilibrium.

We employed the Vector Error Correction Model of the type suggested by Johansen-Juselius to study the dynamic links between these variables. As already stated, this approach enables us to identify the short-run and long-run relationships between variables, without the researcher having to assume a model *a priori*. The Johansen-Juselius procedure applied to our data with a constant in co-integration indicates that the trace and the maximal Eigen value statistics show the presence of one co-integrating vector with 95% confidence. In Table3, the results of the trace test and the maximal eigen value test are presented.

Table 3: Testing the rank of π without Trend and constant in Cointegration:

Trace Test				**Maximal Eigen value test**			
H_0	**H_1**	**Trace**	**95%**	**H_0**	**H_1**	**Stat**	**95%**
r≤2	r≥3	6.85	9.24	r≤2	r=3	6.85	9.24
r≤1	r≥2	18.5	19.96	r≤1	r=2	11.65	15.67
r=0	r≥1	43.04	34.91	r=0	r=1	24.54	22.00

The β' vector was estimated and it establishes that long run equilibrium exists. The crude oil price and the gold price have a negative long-run relationship. The long run relation between the gold price and Nifty is also negative. The main long-run co-integrating relation is found to be between crude price and Nifty. In the short run, ΔGold Price, i.e., the first difference in gold price has a negative relation with its own lag and also with that of crude price and Nifty, while the speed of adjustment in the crude price is much faster than that of Nifty.

Table 4: Estimated co-efficient

	β'	**α**
Gold price$_{t-1}$	1.00	0.0146 (2.583)
Crude price $_{t-1}$	-3.49	0.0163 (2.776)
Nifty $_{t-1}$	-0.01	0.0359 (0.84)
Constant	22.01	

With the estimation of **β** and **α,** the system is fully identified.

The calculated co-integrating vector **β'** indicates a negative long-run relationship between the three variables indicating the direction in which the long-run equilibrium exists. The calculated **α** vector indicates the speed of adjustment towards this long run equilibrium. The speed of adjustment of Nifty is a little more than twice that of the Crude oil Price. About 1.6% of the adjustment towards the long-run equilibrium is contributed by Crude oil Price while about 3.59% of the same is contributed by Nifty.

This finding is corroborated by historical international experience where the stock indices are found to exhibit strong co-movements vis-à-vis the price of gold. The review of literature in this paper also has presented corroborating evidence from other countries regarding this phenomenon. The emergence of asset classes in recent times has put crude oil in the same basket as gold and investors are known to take positions on commodities. It is interesting to find that, the long-run relationship between gold price and crude oil price is negative and quite significant as well. Test of exogeneity indicates that while Crude oil Price is strongly exogenous, nifty is not. This is concluded based on the significance of α implied by the t-statistics reported within parenthesis in Table 4.

The VECM estimated is reported below in Table 5. Since r = 1 (i.e., the rank of Π =1) the estimated model gives one error correction term.

Table 5: Vector Error Correction Model

	ΔGP	**ΔCP**	**ΔNifty**
Ect1	0.01466	0.0163	0.0359
ΔGP_{t-1}	0.0106	-0.0593	-0.305
ΔCP_{t-1}	-0.0819	0.2885	0.0275
$\Delta Nifty_{t-1}$	0.0197	0.308	-0.0816

Equation 3 presented below summarizes the long-run stable equilibrium process involving the three variables. The long run equilibrium lies in the negative direction for both crude price and Nifty.

$$GP = -3.49\ CP - 0.01\ NIFTY \quad \ldots (3)$$

$$\Delta GP_t = 0.0146\ \Delta GP_{t-1} + 0.0163\ \Delta Cp_{t-1} + 0.0359\ \Delta NIFTY_{t-1} \quad \ldots (4)$$

Equation 4 represents the short-run adjustment process which specifies the first difference in gold price as a linear function of its own lag, the lagged first difference in crude oil price and Nifty respectively. Equation 4 also represents the adjustment process through which these three variables converge to a long-run equilibrium. Nifty is found to be the fastest at 3.6% in one month followed by the crude oil price.

The final step is to find the causal relations underlying the system which is now fully identifies. Given that there is one cointegrating relationship in the system, there exists at least one causal relationship in the short-run, as per econometric theory Granger (1988). To identify this causal relationship we performed the standard pair-wise Granger causality tests and the results are reported in Table 6 below. We find that the strong short-run causality is between Nifty and Crude oil price which exhibit a bi-directional causality. The results also indicate a uni-directional causality going from Gold Price to Crude oil Price. In Table 6 below we present the results of the Granger Causality tests.

Table 6: Causality tests: Lags 4; Degrees of freedom=78

S.No.	Causality among variables	Existence of causality	F statistic (Computed value)	F statistic (Critical value)
1	Gold price **Causes** Crude price	Yes	4.3088	3.15
2	Gold price **Causes** Nifty	No	1.188	3.15
3	Crude price **Causes** Gold price	No	0.8029	3.15
4	Crude price **Causes** Nifty	Yes	3.7433	3.15
5	Nifty **Causes** Gold price	No	0.16	3.15
6	Nifty **Causes** Crude price	Yes	3.49	3.15

DISCUSSION OF RESULTS AND CONCLUSIONS

Our paper finds support for the proposition that Indian stock markets are globally integrated with two major international markets, namely the gold bullion market and the crude oil market. We have also shown that there is a long-run stable equilibrium relationship involving these variables. The short-run adjustment co-efficients have also been estimated. We find that Nifty adjusts twice as fast as crude oil price in getting the system to converge towards a long-run equilibrium. These findings are important from the perspective of investors and possibly the government and the various regulatory bodies.

The Granger causality test throws more light on the short-run movements of the variables. The pair-wise Granger causality tests indicate that gold price Granger causes crude price and not the other way around. This captures the underlying financial flows as well. It shows that when investors buy more gold, thus resulting in the rise in price, they do so at the cost of investing in crude oil. We can therefore conclude that gold and crude oil are regarded as substitutes in this asset class.

There is no causality between gold price and Nifty in either direction. The results indicate that gold is not a safe haven asset vis-à-vis the Nifty. A safe haven asset is essentially a hedge against the stock market volatility, inflation rates and interest rate risks. Our analysis of data does not support this view and finds that these two markets are independent. However, there may be a small spill over coming from the causal relation between gold prices and crude oil prices which can spill over to the stock markets. This finding is useful to investors operating in these markets in devising their investment strategies. Gold is not an obvious alternative to stock market or vice versa. This could also be because in India, the buyers of gold do not always participate in the stock markets. Much of the demand for gold in India comes from the retail, household sector and the stock market penetration in this segment is low. There is a bi-directional causality between crude prices and Nifty. The explanation is presented in the literature review.

An interesting corollary that emerges is that the gold market appears to be efficient, in the sense that the Gold Price movement follows a random walk without drift or constant (refer to ADF results). Efficiency also means that past prices cannot be used to predict the future prices. On the contrary the Indian stock market is not and neither is the international crude oil market. Therefore, in the case of Indian stock market and the Crude oil market, the past prices can be used to predict the future prices. This finding has a powerful application potential from the point of view of investors devising long-term and short-term investment strategies. It can also to an extent be useful for formulating government policy, especially in the area of financial market regulation.

Additional insights can be developed by including other macroeconomic variables like rate of inflation, GDP, exchange rates. However, during the time period following that of our study, we have found that these results are largely borne out.

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