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RESEARCH ARTICLE

ANALYSIS OF THE RELATIONSHIP BETWEEN OIL, GOLD AND INFLATION: A CASE STUDY OF PAKISTAN

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ABSTRACT

The dynamic and complex affiliation among price of Gold, Oil and inflation has attracted to the market practitioner and policy makers, from the last few decades. In order to gain the profit, investors consider as a secure form of investment against the unforeseen disasters. This study investigates the relationship between prices of gold, oil and inflation. We use secondary data of gold prices, oil prices and inflation covering the period from August, 2004 to January, 2017 of Pakistan. In order to examine the impact of oil prices and gold prices on inflation we use Vector Error Correction model. It is found that there is long term relation between the oil, gold and inflation via cointegration process. Moreover, empirical analysis shows that fitted VEC model is adequate based on portmanteau autocorrelation and Lagrange Multiplier test. Forecast of gold prices, oil prices and inflation for the next 12 months are computed through VEC model, FMAE is minimum as compared to FRMSE.

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INTRODUCTION

Gold is the most precious metal and oil is the most traded raw material. Both perform a significant role in determining the economy. The first link between oil and gold have initiated when producers of Middle East need gold in exchange of crude oil. Because of these historical events, oil and gold market went through vast development and significant relationship between these two commodities was no longer determined at the level of payment only. Past literature shows Gold and oil are linked positively and almost follow the same pattern. An increase in oil prices will also increases the gold prices. Increase in prices of both commodities is an indication of bad times. Furthermore, important relation between gold and oil is inflation, as the prices of crude oil increases, inflation also increases. Additionally, the value of gold only increases when inflation increases. But on the other side, gold is also used for jewellery and being used as an investment asset. The prices of gold also changes because of change in the demand for jewellery. Similarly, decrease in oil prices is affecting economic hardship. Oil companies are getting out of business when the prices of oil fallen so much. Many areas like North Sea oil, oil extraction from the arctic and other areas are no longer economic, but if there is a small decrease in oil prices then it cannot hit these countries too much. Traditional macroeconomic models suggest that higher oil prices increases the overall price level because of greater production and transportation costs. Because as the prices of oil increases consumers will try to spend more money on petrol but decrease in oil prices diminish the cost of transportation and cause lesser cost for business that can increase the profitability. Inflation is now become a worldwide problem. The main cause of inflation of a country has many reasons for example, bad governance, increase in food prices, utility prices, oil prices, gold prices etc. In this study we consider two major variables that cause inflation, i.e. Gold prices and Oil prices.

The objective of this study has the following perspective.

1. To know the relationship between gold, oil and inflation via co integration.
2. To investigate long term and short term between inflation to oil and gold via VEC model.
3. To forecast inflation using VEC model taking oil and gold as exogenous variables.
4. Forecast Inflation, oil and Gold prices using VEC model.

Framework of this paper is as follows: Review of literature is given in section 2. Section 3 deals with methodology. Section 4 describes detail discussion of the results. Conclusion is given in section 5.

Literature Review

Thai-Ha and chang (2011), discussed the correlation and causation between oil prices and gold prices. They used data spanning the period January, 1986 to April, 2011 and examined the association between prices of gold and oil. Their study classified the hypothesis in three sets. First, they identified that whether an increase in oil price will increases the inflation. Second, an increase in inflation will be increased the gold prices. Last, if the first two hypotheses are correct then it is suggested that there is a direct relationship between gold and oil prices. For this purpose generalized VAR approach was used and the result indicated that oil prices showed a significant contribution to explain the dispersion in gold prices. Their findings revealed that the oil price can be used to forecast the gold price. Moreover, they also explored a trivariate relationship between the variables by adding U.S dollar index and using the generalized forecasting error VDC's. Their finding showed that the variation in the prices of gold was much better explained by the fluctuation in the US dollar as compared to oil prices.

Simakova (2011), examined the association between oil and gold prices. In their study, data from the year 1970 to 2010 were used for inspect and correlation technique. They observed that gold and oil were influenced by some factors and there exists a strongly positive relation between gold prices and oil prices. By using Johnson cointegration test, their study revealed that there was a long term relation among all the studied variables. They also used granger causality test to identify the causal link between the variables.

Bhunia (2012), studied the relation between gold prices, stock market and crude oil. Their study based on secondary data from January 1991 to October 2012. For the purpose of analysis econometric techniques including augmented Dickey fuller test, Johnson cointegration analysis and ganger causality test were used. Result of Johnson cointegration test showed that there is a long term cointegration relationship among these variables. Furthermore, their experimental result also implies that there were two common stochastic trends representing a degree of market integration. Result of Granger causality test represented that there was a bidirectional or no causality is present among the variables.

Ahmed and Rahim (2013), studied the relation between gold, oil and dollar on inflation of Pakistan and used the data from July, 2008 to June, 2013. The purpose of their study was to understand how the change in prices of gold, oil and dollar effected on inflation. They used least square regression to analyse the data and performed ANOVA to explore the significance of these variables. Experimental analysis result showed that these factors played a significant role in the inflation of Pakistan.

Tufail and Batool (2013), explored the relation between inflation and gold prices by applying time series and econometrics techniques such as cointegration and VEC for Pakistan data from 1960 to 2010. Their result depicted that there was a strongly positive relation among gold prices and inflation. Moreover, result suggested that all these assets gold, stock exchange securities and foreign currency run a hedge against inflation and gold is a potential determinant of inflation in Pakistan.

Shahzadi *et al.* (2012), examined the impact of gold prices of Karachi stock data from 2006 to 2010. They examined the impact of gold prices on KSE by using statistical techniques like unit root test of ADF, phillip person test, cointegration test and granger causality test. The result showed that there was no long term existence between these two variables.

Hussain *et al.* (2013), discussed the relation between oil price, gold price and Islamic stock market in Malaysia. The purpose of their study was to analyse the dynamic effects of oil price and gold price changes on Islamic stock market in Malaysia via Vector Autoregressive method. For this purposed they used data from 2007 to 2011.In addition to these, cointegration, granger causality, impulse response and VDC methods were also used. The result represented that Islamic returns were not cointegrated with strategic commodities in the long run. Result of granger causality showed that there is bidirectional causality relationship between stocks with oil. Similarly, gold cannot be used to forecast the changes in Islamic share prices.

Vinayagathasan (2013), used a seven variables structural VAR model by considering the monthly time series data from 1978-2011. They used variance decomposition and impulse response function to determine relationship between these variables. Result of their study suggested that the interest rate shocks play a significant role in determining the movement of economic variables more than exchange rate shocks or monetary aggregate shocks.

Sadeghi *et al.* (2013), determined the long run and short run effects of money on inflation and GDP of Iran by using four variables VECM using quarterly data from 1988-2005. Empirical analysis showed that in case of short, run money had no suitable effect on output and inflation but in case of long run excess supply of money lead to inflation.

Khan (2015), analysed the influence of prices of oil and gold on the GDP growth of Pakistan covering the period 1997 to 2014. The results indicated that oil and gold prices have a significant effect on GDP. Sek *et al.* (2015), studied the impact of prices of oil on inflation, their research divided the countries into two groups, highly vs. low oil dependency groups. They used cointegration test to find the long run relation between the dependent and independent variables. Results showed that oil prices changes had direct effect on inflation in case of low oil dependency groups. But its effect was indirect on effecting the domestic inflation in case of high oil dependency groups. The main determinants are domestic output and exporters for high oil dependency groups.

Lama *et al.* (2015), examined and forecasted ARIMA model, GARCH model and EGARCH for oil and cotton prices. They concluded that for both series, GARCH (1,1)-AR(2) model was better as compared to ARIMA(1,1,0) model in terms of forecasting accuracy. The selection of the GARCH model instead of ARIMA for modelling the series is considered because of the lower AIC values, similarly by considering the low root mean square error.

Guha and Bandyopadhyay (2016), used ARIMA model for forecasting gold prices in India based on monthly data from 2003 to 2015. Analysis of the gold price from preceding 10 years gave ARIMA (1, 1, 1) model as it proved the best model that satisfies all the condition of AIC and BIC values. Similarly it gave less mean square error.

Tang (2017), studied the relations between Euro, gold price, oil price, stock market prices and US dollar using simple

regression. Their result showed that oil had a progressive impact on stock market prices on contrary, an adverse effect on Gold price. Moreover, US dollar and oil influenced emphatically, Gold which was adversely affected by securities exchange costs. Furthermore, US dollar which was affected due to oil in negative direction but Gold price and Stock market prices influence positively. Besides this, Euro played a significant role in monetary and financial position since it had adverse effects on the stock market prices and the gold had a constructive effect on the oil.

METHODOLOGY

Unit Root Test: Numerous financial and economical series display trending behaviour or non-stationary in the mean. In order to check whether the data is stationary and holds a unit root. This process evolves through time that can cause problems in inferential statistics that involved in time series models. If a unit root has a root '1' in the process characteristics equation then it is called a linear stochastic process. Such kind of process is non-stationary. The first difference of the process will be stationary if the other roots lie inside the unit circle.

Null Hypothesis: Null hypothesis is generally defined as the presence of a unit root or the time series is non-stationary.
Alternative hypothesis: Alternative hypothesis is defined as the time series is stationary.

In this study we use ADF test for stationary process.

Cointegration: Basically, traditional method such as ordinary least squares and correlation methods under the assumption of stationary process is supportive to demonstrate the relationship between the oil, gold and inflation. However, when the variables are non-stationary then the error of the process are accumulated resulting the hypothesis test will be biased or misleading. Then the series have to be analysed with different methods. One of these methods is called cointegration. Correlation gives a preview of the statistical relations between two or more variables. On the other hand, cointegration deals with long run equilibrium relationships between two or more variables or it is an econometric technique for finding the relation between non-stationary time series variables. Two or more time series are said to be cointegrated if there is a linear combination of them that is stationary. Economic theory often suggests that certain pairs of economic orfinancial variables should be linked by a long-run economic relationship.

Johansen Cointegration Test: Johansen cointegration test is utilized to discover whether there is co-integrating relationships, that is, regardless of whether there are any long term or short term cointegration relationships between crude oil price, old price and inflation. Test includes in Johnson cointegration test are depend on a vector autoregression (VAR) model. Two test statistics, Trace statistics and the Maximum Eigen Value statistics are computed in this method using the following equations.

$$\gamma_{\text{Trace}}(\rho) = -T\sum_{\ell=\rho+1}^{P}\ln(1-\hat{\gamma}_{\ell}) \quad \text{.....(1)}$$

$$\gamma_{\text{Max}}(\rho,\rho+1) = -T\ln(1-\hat{\gamma}_{\ell+1}) \quad \text{.....(2)}$$

Where ρ the number of cointegrating is vectors and $\hat{\gamma}_{\ell}$ is the ℓ th order eigenvalue.

These tests are utilized to find the number of cointegration vectors. For every series a lag of 1 to 4 with first difference is utilized for each series. The null hypothesis of Trace test is a joint test of the null hypothesis under the assumption that there is no cointegrating equation among the testing variables (H_0: ρ =0). Whereas, the alternate hypothesis that one or more cointegrating variables are present (H_a : ρ>0). The null hypothesis of maximum eigenvalue statistic test is defined as there are 'ρ' cointegrating relations and the alternative hypothesis is there are 'ρ + 1' cointegrating relations. In order to determine the exact number of lag AIC and SBC criterion is used. A significantly non-zero eigenvalue specifies a noteworthy cointegrating vector.

Vector Error Correction model (VECM)

The cointegration test governs which type of the regression either VAR or VECM model is considered. Basically, a VAR model consists of a system of regression models which comprises more than one dependent variable depends on its lagged and the lagged values of other variables. On the other hand, a VEC (Vector error correction) model is basically a restricted VAR that has a restriction of cointegration built into the specification, VEC model is used to manage non stationary time series that must be cointegrated. The detail of Vector Error Correction limits the long-run behaviour of the endogenous variables to meet to their cointegrating relationships while they permit a broad scope of short-run dynamics. The cointegration term is called as the error correction term. The term error correction identifies with the way that last-periods deviation from a long-run balance. In this manner Error Correction demonstrate straight forwardly decide the speed at which a variable comes back to equilibrium after there is a change in other variables. VECM is a proper displaying procedure when the variables are cointegrated. It is suitable when long-run forecast is required. Error correction models are suitable for estimating long as well as short term effects.

Vector error correction model (VEC) is follows as:

$$\Delta z_t = \phi + \sum_{j=1}^{q}\Gamma_j \Delta z_{t-j} + \Phi\psi' \Delta z_{t-j} + \xi_t$$

Where z_t = (m $\times$1) vector of selected series, Γ_j = (m$\times$m) matrix of coefficient, ψ =(m $\times\rho$) matrix of 'ρ' cointegrating vectors (long term relation). Φ = (m$\times\rho$) coefficient matrix of error correction is also recognized as alteration parameter.

Data analysis: In this study we use monthly secondary data of gold prices, oil prices and inflation from august-2004 to January-2017 including total 150 observations, collected from www.opfblog.com. The data of gold prices are in troy ounces, where troy ounce is a unit to measure weight. It is used when dealing with precious metals such as gold, platinum and silver, whereas, one troy ounce is equal to 0.031 kilogram or 31.1035 gram. The data of oil prices are in barrel per dollar, where one barrel equals to 42 US gallons or approximately 159 litters. From the Figure 4.1(a), it is observed that the gold price shows a parabolic increasing from 2000 to 2012 specially it depicts more hikes from the year 2008 to 2012. Furthermore, after 2012 to 2016 price of gold went down. Next, the graph (Figure 4.1(b)) of oil prices during the sample period 2008, shows that there is a significant hike in the oil prices during the year 2008.

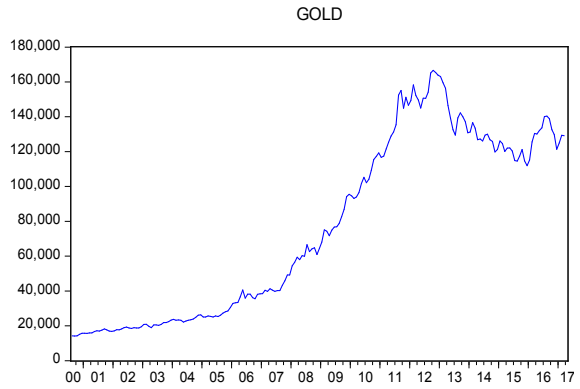

Figure 4.1(a), Graph of Gold price

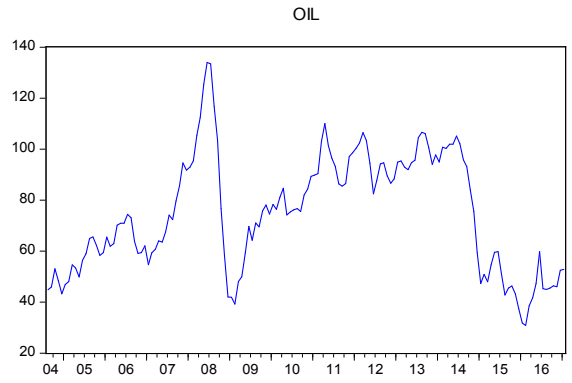

Figure 4.1(b) Graph of oil price

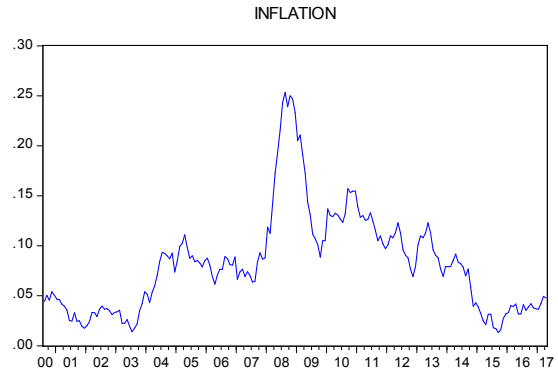

Figure 4.1(c),Graph of inflation

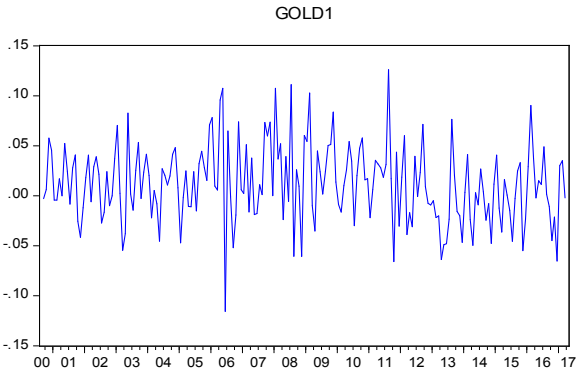

Figure 4.2(a), Return series of Gold price

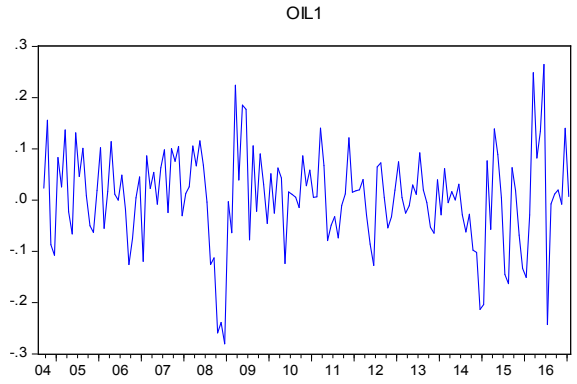

Figure 4.2(b),Return series of oil price

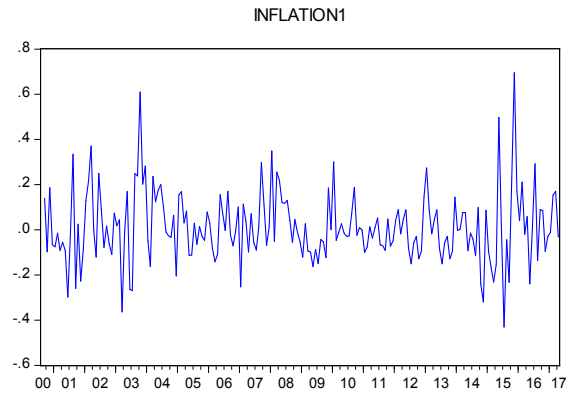

Figure 4.2(c), return series of inflation

Each of these hikes corresponds to an important economic or political event so it suggests that volatility indices are effective measures of the market uncertainty. Moreover, overall movement of oil price is turmoil. Similarly, from the graph of inflation we observe that the inflation was stable till 2003 but after this inflation start increasing from its point up to the year 2005. In addition to this, inflation reaches to almost 11% which was not a good fact in 2005. Another hike was in the year 2008 where inflation reaches up to 25%. The oil prices also reaches at its maximum peak in 2008 and also it can be observed from the graph of gold prices (4.2), the prices of gold start increasing rapidly from the year 2008 to 2012. The graph of gold, oil and inflation which are shown in Figure 4.1(a)-4.1(c), shows the series are non-stationary. A non-stationary financial data produces unreliable results and leads to poor understanding and forecasting. In order to receive consistent, reliable results, there is a need to transform the non-stationary data into stationary data.

A time series is said to be stationary if the mean and variance is constant and independent of time and the covariance's depends upon the distance of two time periods. So, we convert the data into stationary process by finding returns for each series, then the process becomes stationary. Since the mean and variance is constant in all cases gold, oil and inflation, which characterize that the data becomes stationary as shown in Figure 4.2(a)-4.2(c).

Descriptive Statistics: Next we compute descriptive statistics of return series as shown in Table 4.1. We observe that the value of kurtosis is very high in inflation as compared to gold and oil series, inflation has fat tail distribution. On the other hand, gold is to some extant follows normal and oil is little bit higher than normal distribution. Gold has highest mean return while inflation contains lowest mean return. Similarly, all returns are positively skewed except oil designate the values are concentrate towards the left of the mean.

Table: 4.1. Descriptive Statistics of returns series of oil price gold price and inflation

	D(Gold)	D(Oil)	D(Inflation)
Mean	0.1214	0.0055	0.0033
Median	0.0100	0.0111	-0.0143
Max	0.1261	0.2646	0.6956
Min	-0.1159	-0.2803	-0.4303
S.D	0.0415	0.0933	0.1417
SK	0.1586	-0.3494	1.0267
KR	3.1728	3.9623	7.1234
JB	0.8103	8.7881	131.73
Probability	0.6666	0.0123	0.0000

Note: S.D stands standard deviation, SK represent Skewness, KR is Kurtosis and JB represent Jarque-Bera.

Unit Root Test: Next, we apply ADF unit root test to the series under the assumption that the data is stationary at 5% level of significance. Following are null and alternate hypothesis.

H_0 = Data is stationary
H_a = Data is non-stationary

The ADF test reveals gold prices, oil prices and inflation accept the null hypothesis at 5% level as the p-value is greater than 0.05.This suggests the data is non-stationary at level. Therefore, to make the data stationary we apply ADF test at the first difference. Table 4.2, shows that p-value is less than the level of significance (5%) so we reject the null hypothesis and conclude that the data is now stationary at first difference. This indicates that the variable is integrated at order I (1). The result of unit root test for oil, gold and inflation are presented in Table 4.2.

Table: 4.2. The Result of ADF test of oil prices gold prices and inflation

	ADF test at level			ADF test at first difference		
	t -value	CR	PV	t -value	CR	PV
Gold	-1.48	-2.875	0.54	-10.02	-2.875	0
Oil	-2.775	-2.88	0.064	-7.995	-2.88	0
Inflation	-2.881	-2.876	0.142	-9.245	-2.875	0

Note: CR= critical value and PV = p value

Johansen Cointegration Test

Trace and Maximum Eigen values computed from Johnsen cointegration test are presented in Table 4.3. This method determines the number of cointegriting vector. The H_0 defined that the number of cointegrating vectors are less than or equal to 0, 1, 2,…,etc. So, if the null hypothesis is rejected then, we conclude that two variables are cointegrated. This suggests that there is a linear combination exists between the variables that power these indices to have a relationship over the whole time period or there is a long run relationship between these variables. From Table 4.3, the value γ_{Trace} and the value $\gamma_{\text{Max}-\text{Trace}}$ both tests confirm a cointegrating relationship exists.

Table 4.3. Output of Johnsen Cointegration Rank Test of Oil, Gold and Inflation

Hypothesized No. of CE(s)	Eigenvalue	γ_{Trace}	0.05 C- V	P-V**	$\gamma_{Max-Trace}$	0.05 C- V	P-V**
0	0.134	30.331	29.9	0.043	20.997	21.131	0.052
1	0.043	9.333	15.49	0.335	6.410	14.264	0.561
2	0.019	2.923	3.841	0.087	2.923	3.841	0.087

Vector Error Correction model: (VECM)

Next, we establish a cointegrating relationship among the series via linear VECM based on AIC and BIC. Thus, order one of VECM is found suitable. The coefficient of the error correction mechanism which establish long run relation is negative (-0.0025) shows convergence towards the long run relationship between inflation and the considered variables, Equation (1). Similarly, the error correction term is also negative in Equation (2), indicates long term causality from Gold to oil and inflation. Conversely, a positive sign of the error correction coefficient (0.0005) depict a divergence of Oil price from inflation and Gold price Equation (3).

$$\Delta(IN_t) - 1.9\text{E}-6ECt_{t-1} - 8.34\text{E}-07\Delta(G_{t-1}) + 0.0002\Delta(O_{t-1}) + 0.156\Delta(IN) - 0.0003\,. \quad (1)$$

$$\Delta(G_t) = 17.82 - 0.0025ECt_{t-1} + 0.1541\Delta(G_{t-1}) + 0.6587\Delta(O_{t-1}) - 1298.53\Delta(IN_{t-1}) \ldots \quad (2)$$

$$\Delta(O_t) = -0.081 + 0.00051ECt_{t-1} - 0.00041\Delta(G_{t-1}) + 0.4994\Delta(O_{t-1}) - 28.303\Delta(IN_{t-1}) \ldots\ldots\ldots \quad (3)$$

Equation (1), explains that 1% increase in oil causes 0.0002% increase in inflation. However, 1% decrease in gold causes 8.34E-07% increase in inflation. Next, as our main concern is to model inflation. Therefore, Cointegrating equation (Long run method) in which inflation as a dependent variable is given below.

$$ECT_{t-1} = 1.000G_{t-1} - 8.34\text{E}-07O_{t-1} + 0.000159IN_{t-1} - 0.000322$$

We are interested to find the P-value of the coefficient to draw the conclusion about the long run and short term causality about the systems of equation. Therefore, Equation (1) in which Inflation is depended is tested; following is the output of established Inflation Equation.

Table 4.4. Output of VEC Model for Inflation

	Coefficient	Std. Error	t-Statistic	Prob.
C1	-1.87E-06	5.12E-07	-3.649	0.0004
C2	-8.34E-07	7.27E-06	-0.1147	0.909
C3	0.00016	0.00015	1.064	0.289
C4	0.156	0.083	1.875	0.063
C5	-0.0003	0.00092	-0.351	0.726

From this test we obtain following conclusions.

1. From Table 4.4, as the value of C1 which represent error correction term is found negative and significant indicates, i.e. P-value is less than 0.05 (level of significance). Therefore, we can say that there is a long run causality running from gold and oil to inflation.
2. Next, we are interested whether the short run oil and gold Granger causes into inflation. But, the coefficients i.e. C2 and C3 which represent short run is found insignificant at 5% level. Therefore, we apply Wald test to C2 and C3(coefficients), the result are given below in Table 4,5.

Table 4.5. Output of Wald Test for the coefficient

T- Statistic	Value	D. F	P-value
F-Statistic	0.566	(2, 131)	0.5689
Chisquare	1.133	2	0.5675
H_0: C(2)=C(3)=0			
Summary of H_0:			
Normalized Restriction (= 0)		Value	S.E
C(2)		-8.34E-07	7.27E-06
C(3)		0.00016	0.00015

Since, the 'p' values are more than at 5% level of significance, so the null hypothesis is accepted and conclude

that there is no short run causality running from gold to inflation and also oil to inflation. To check adequacy of the fitted VEC model, residual diagnostic test such as Lagrange Multiplier (LM) and Portmanteau Autocorrelation test are used. Result of Portmanteau test result is given in Table 4.6.

Table 4.6. The Result of portmanteau autocorrelation test

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	Df
1	1.037	NA*	1.044	NA*	NA*
2	9.877	0.827	10.006	0.819	15
3	19.537	0.723	19.865	0.704	24
4	27.0367	0.758	27.57	0.734	33
5	38.124	0.642	39.048	0.601	42
6	45.148	0.704	46.368	0.658	51
7	51.938	0.761	53.496	0.711	60
8	63.376	0.668	65.588	0.594	69
9	74.419	0.594	77.345	0.5	78
10	79.122	0.714	82.389	0.62	87
11	87.145	0.729	91.0567	0.62	96
12	104.337	0.5	109.7650	0.36	105

Table (4.6), since all the p-values are greater than at 5% level of significance, therefore, we accept the null hypothesis of "No serial correlation present in the series of residual up to lag h". As the p-values are not less 5% level of significance, therefore we do not reject the null hypothesis that "there is no serial autocorrelation up to lag his existing", Table (4.7).

Table 4.7. The Result of LM test

Lags	LM-Stat	Prob.
1	10.218	0.333
2	10.003	0.350
3	9.766	0.37
4	8.226	0.51
5	11.905	0.219
6	7.7693	0.557
7	7.164	0.620
8	12.416	0.191
9	11.738	0.228
10	5.047	0.83
11	8.396	0.495
12	19.303	0.023

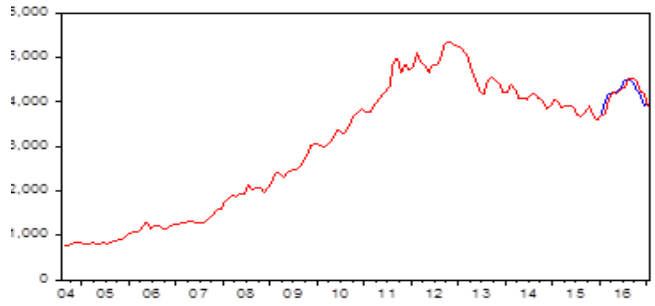

Figure 4.3a. Graph of actual and forecast of values of gold price

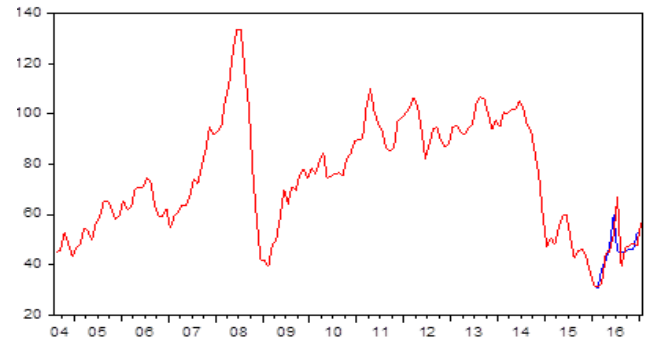

Figure 4.3b. Graph of actual and forecast values of oil price

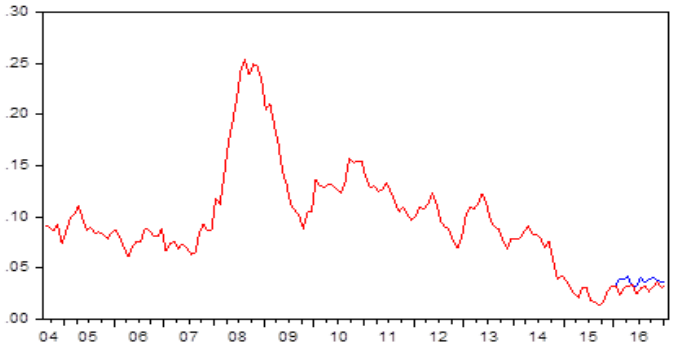

Figure 4.3c. Graph of actual and forecast values of Inflation

In this study, three sets of data were used to assess the forecasting ability of various models. From the total of 150 observations initially, 138 observations are utilized for model building purpose and rest of the (12) observations are kept for validation. The graph of forecast from VEC for gold prices, oil prices and inflation are shown in figure 4.3(a)-4.3(c).

Conclusion

The aim of this paper is to examine the relationship between gold prices, oil prices and inflation by studying the impact of gold and oil prices on inflation for the period August, 2004 to January, 2017. First we determine whether the series is stationary or not by applying ADF test, the result of ADF test statistic shows that the data is stationary at first difference. Furthermore, the relationship between gold prices, oil prices and inflation is investigated by using Johnson cointegration technique. Empirical analysis reveals that there is a cointegration association between the variables. Moreover, Vector Error Correction model is used to find short run and long run causality between these variables. From the consequences of VEC we presume that there is a long run causality running from gold and oil to inflation. Therefore, Equation (1) explains inflation is increased by 1% as the oil increase by 0.0002% but 1% of decrease in inflation because of 8.34E-07% increase in gold. Portmanteau Autocorrelation and Lagrange Multiplier test are used to check the adequacy of the fitted VEC model which reveals the fitted model is suitable.

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