MTH 517

Time Series Analysis

Relationship and Interdependence of Crude Oil and Gold

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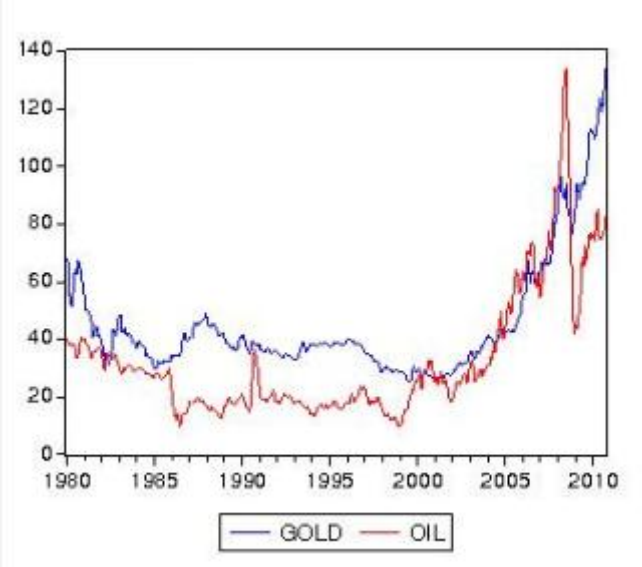
Gold and crude oil have been two of the most important commodities to be traded. Finding correlation between the two quantities, what causes what? These are some of the questions, which many economists in the past had tried and even successfully answered. There have been studies showing, gold inevitably following the trend followed by oil, but that too depends on which data is used to measure such correlations. Some say, there is a weak correlation between the two quantities when the time period under consideration is as small as months or a few a years. But taken over a long period of time, impressive correlation had been visible between the two quantities. In this project we have tried to verify the relationship between the two quantities by checking the presence of cointegration to confirm the presence of a long term relationship.

We have used software Eviews and MATLAB for all the analysis in our project.



To check whether the two quantities are cointegrated, we first have to confirm whether the two time series are non-stationary.

Null Hypothesis: GOLD has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=16)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		3.177143	1.0000
Test critical values:	1% level	-3.447866	
	5% level	-2.869155	
	10% level	-2.570894	

Null Hypothesis: OIL has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=16)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.854348	0.3539
Test critical values:	1% level	-3.447914	
	5% level	-2.869176	
	10% level	-2.570905	

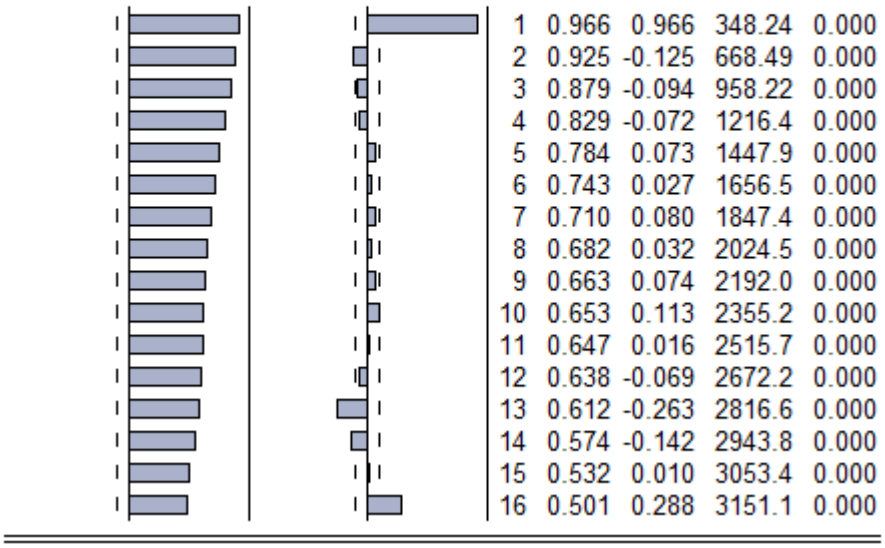
Above tables shows the non stationarity of the given time series through the Augmented Dickey Fuller test since the value of the t-statistics was greater than all 1%, 5% and 10% level.

Also, we confirmed the non stationarity of the given time series by their correlogram, since there is no significant partial correlation after the first lag, suggesting an auto regressive time series of low order.

Sample: 1980M01 2010M10
Included observations: 370

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.920	0.920	315.72	0.000
		2	0.853	0.044	587.92	0.000
		3	0.789	-0.010	821.49	0.000
		4	0.735	0.033	1024.8	0.000
		5	0.682	-0.018	1200.1	0.000
		6	0.626	-0.042	1348.4	0.000
		7	0.583	0.048	1477.1	0.000
		8	0.547	0.037	1591.0	0.000
		9	0.512	-0.014	1690.8	0.000
		10	0.478	0.001	1778.2	0.000
		11	0.445	-0.008	1854.2	0.000
		12	0.420	0.031	1922.1	0.000
		13	0.396	-0.003	1982.4	0.000
		14	0.368	-0.024	2034.8	0.000
		15	0.341	-0.008	2079.9	0.000
		16	0.311	-0.040	2117.5	0.000

Sample: 1980M01 2010M10
Included observations: 370



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.966	0.966	348.24	0.000
		2	0.925	-0.125	668.49	0.000
		3	0.879	-0.094	958.22	0.000
		4	0.829	-0.072	1216.4	0.000
		5	0.784	0.073	1447.9	0.000
		6	0.743	0.027	1656.5	0.000
		7	0.710	0.080	1847.4	0.000
		8	0.682	0.032	2024.5	0.000
		9	0.663	0.074	2192.0	0.000
		10	0.653	0.113	2355.2	0.000
		11	0.647	0.016	2515.7	0.000
		12	0.638	-0.069	2672.2	0.000
		13	0.612	-0.263	2816.6	0.000
		14	0.574	-0.142	2943.8	0.000
		15	0.532	0.010	3053.4	0.000
		16	0.501	0.288	3151.1	0.000

But their first order differences were found to be stationary by the same test as shown by tables below:

Null Hypothesis: D(GOLD) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=16)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-15.89242	0.0000
Test critical values:	1% level	-3.447914	
	5% level	-2.869176	
	10% level	-2.570905	

Null Hypothesis: D(OIL) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=16)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-12.35638	0.0000
Test critical values:	1% level	-3.447914	
	5% level	-2.869176	
	10% level	-2.570905	

To find whether the two quantities are cointegrated, we have to test the residuals of the linear relationship i.e.

$Gold_t = \alpha Oil_t + \varepsilon$

follows a stationary process or not. If it follows a stationary process, we can say that the two series are cointegrated of order zero.

Null Hypothesis: RESIDUAL_Series has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic based on SIC, MAXLAG=16)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.188342	0.0008
Test critical values:	1% level	-3.447963	
	5% level	-2.869198	
	10% level	-2.570917	

Since the residual series follows a stationary process, we can say that the oil and gold prices are cointegrated of order zero. Hence, we can say that there exists a long term relationship between the two quantities.

To check, which of them influence each other, we applied the Granger Causality Test to the stationary time series data, and found that:

Pairwise Granger Causality Tests

Sample: 1980M01 2010M10
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Probability
GOLD_STATS does not Granger Cause OIL_STATS	367	0.48547	0.61581
OIL_STATS does not Granger Cause GOLD_STATS		2.05703	0.12932

We can say that oil prices contains the information about the gold prices with the probability 0.87 according to the above given results.

Hence, we tried to forecast the gold prices using the oil prices. We used the data for the first 20 and 25 years to predict the gold prices for the next 10 and 5 years respectively and compared it with the original prices available with us.

To predict the prices, the used the following regression equation:
$Gold_t = a_o + a_1 Oil_t + u_t$

We calculated the regression coefficients, and variance of the random disturbances under the assumption of normality. Following are the results:

Dependent Variable: GOLD_250
Method: Least Squares

Sample (adjusted): 1980M01 2000M10
Included observations: 250 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	28.56444	1.314822	21.72494	0.0000
OIL_250	0.423014	0.055484	7.624089	0.0000

Mean	**-4.92E-15**
Median	-0.203726
Maximum	24.79043
Minimum	-14.99529
Std. Dev.	**6.769221**
Skewness	0.665711
Kurtosis	4.314685
Jarque-Bera	36.46961
Probability	0.000000
Sum	-1.26E-12
Sum Sq. Dev.	11409.77
Observations	250

We used the MATLAB software to generate the random number from normal distribution and to forecast the gold prices accordingly. Here is the code and the graphs of the predicted and the actual prices.

```
% predict future values of gold based on oil.

pts = 120;

gold = zeros(pts,1);
oil = zeros(pts,1);
for i=1:pts
    gold(i)=log10(data(i+370-pts)/10.0);
    oil(i)=data(370+370-pts+i);
end

pred_gold = zeros(pts,1);
```

```
for i=1:pts
    pred_gold(i) = log10(28.56444 + 0.423014*oil(i) + 6.769221*randn(1,1));
    %pred_gold(i) = log10(29.31802 + 0.339070*oil(i) + 6.907240*randn(1,1));
end

figure(1)
hold on
X = (1:pts);
plot(X,gold,'b')
plot(X,pred_gold,'r:')
hold off
```

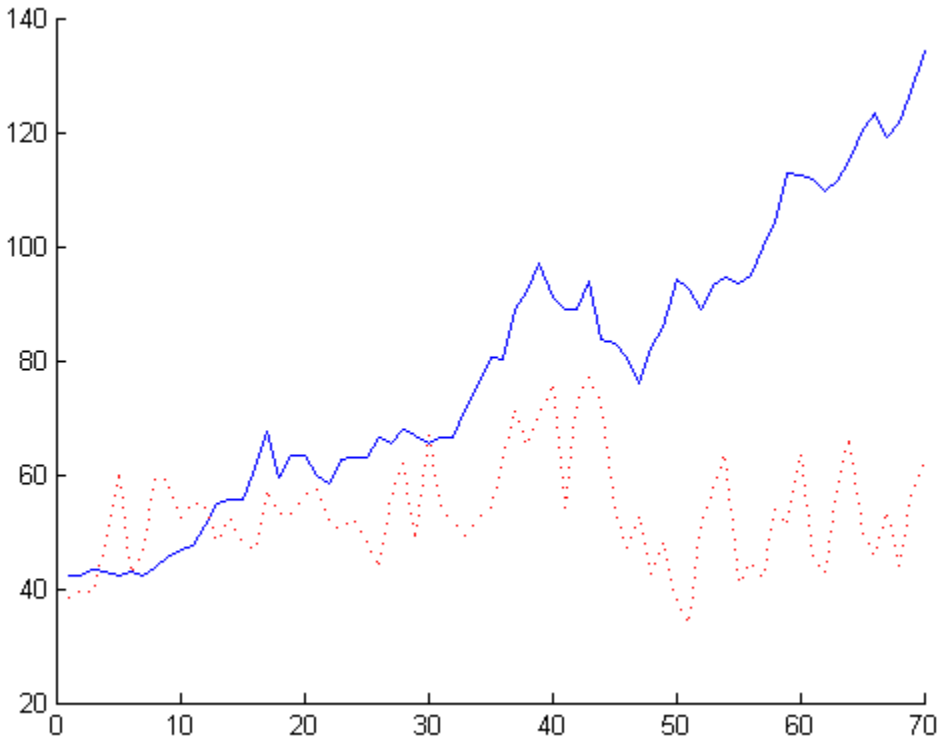


Figure 1: Data used from 1980 to 2004 and predicted from 2005 to Oct, 2010

The red lines indicate the predicted values and the blue line the original. We can see that although there is a difference among the two prices, but the trend or the changes in the both the prices, remains the same. The prices differ since gold prices depend on many factors and we are considering only one of them i.e. the oil prices. The 40th point in the above graph represents the year 2008 during which financial crisis took place and hence explaining the huge gap afterwards.

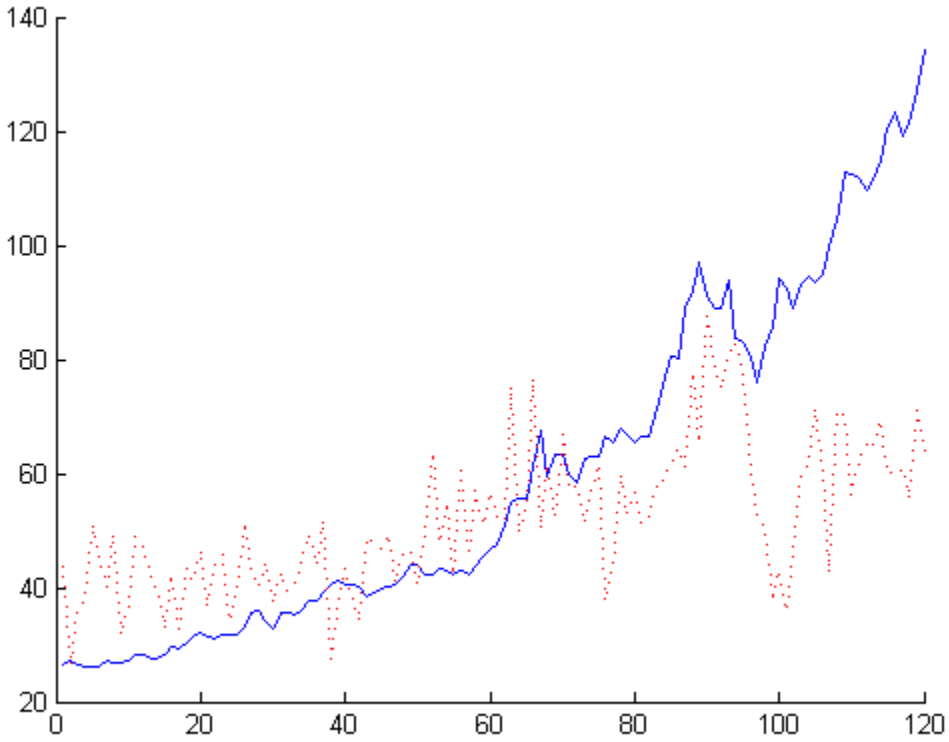


Figure 2: Data used from 1980 to 2000 and predicted from 2001 to Oct, 2010

Conclusion

There always has been a much stronger correlation between the oil and gold prices, with many studies suggesting the gold prices following the oil prices. Our study on that matter partially confirms the historical view of the above fact. We also tried to forecast the prices of the gold with that of oil, and were successful in predicting the trend component to a reasonable accuracy.

References:

http://www.imf.org/

http://www.research.gold.org/