AN EMPIRICAL ANALYSIS OF FACTORS AFFECTING GOLD PRICES

-Dr. Rahul Bishnoi
-Jia Lan

ABSTRACT

This paper analyses the critical factors affecting the price of gold using ordinary least square, white-test and weighted least squares. Yearly data from 1994 to 2013 were carefully collected and statistically tested. The results show that Gold prices, US dollar to Indian Rupee exchange rate, and Crude oil prices are positively correlated albeit a negative relationship clearly emerges with the Rate of Inflation, long run interest rates in the US and their Real GDP.

KEYWORDS:

GDP, INFLATION

1. INTRODUCTION

2014 saw a decline in gold prices, plus the Modi government is widely expected to allow more imports of gold over time. This directly affects the Indian consumers who happen to be among the top buyers of this precious metal. Our paper addresses the issue of gold pricing in relation to its most important variables to help the readers make educated decisions about their future purchases.

Gold, one of the most used investment and hedging tools in the market, has seen a price increase from 1994 to 2013 on the whole as well as fluctuations in the short run. Its price increased from an average of US$385.42 per ounce in 1994 to an average of $1700 per ounce in 2012. Even taking the inflation into consideration, the gold price still jumped dramatically but it fell to $1598 per ounce from 2012 to 2013 and is continuing its downward spiral. (please see the figure below)

Gold price is determined by many factors, such as the US dollar to Indian Rupee exchange rate, Inflation Rate, Crude oil prices, US dollar short term and long term interest rates, and US real GDP. This paper empirically analyses these factors affecting the price of gold by using Ordinary Least Square, Weighted Least Square and White-test etc. to help explain this correlation and give guidance to investors regarding any future investment that they may have in mind.
2. LITERATURE REVIEW

Many scholars have shown their interest in gold pricing. A comprehensive list of 25 scholarly papers can be found in the references to feed the interest of an avid researcher. Capie et al., F. Capie, T.C. Mills, G. Wood (2005) show that although gold has served as a hedge against fluctuations in the foreign exchange rate of the dollar, it has only done so to a degree that seems highly dependent on unpredictable political attitudes and events.

Muhammad Shahbaza, Mohammad Iqbal Tahirb, Imran Alia, Ijaz Ur Rehmand (2014) have applied the ARDL bounds testing approach to co-integration for the long run, and innovative accounting approach (IAA) to examine the direction of causality in variables to reveal that “investment in gold is a good hedge against inflation” not only in the long-run but also in the short-run.

Roger C. Van Tassel (1981) found that the use of gold as a major commodity explains the long-term real price increase and restrains purely panic-speculative deviations from a trend.

Shahriar Shafiee and Erkan Topalb (2010) estimate gold prices for the next 10 years, based on monthly historical data of nominal gold price quotations.

Mark Joy (2011) has three key findings: (i) During the past 23 years gold has behaved as a hedge against the US dollar. (ii) Gold has been a poor safe haven and (iii) In recent years, gold has increasingly acted as an effective hedge against currency risk associated with the US dollar.

Joscha Beckmanna and Robert Czudaj (2013) ponder over the question of gold providing the ability of hedging against inflation from a new perspective, using data for four major economies, namely the USA, the UK, the Euro Area, and Japan.
Christian Pierdzioch, Marian Risse and Sebastian Rohloff (2014) find that the gold market is informationally efficient with respect to international business-cycle fluctuations.

Li Lili and Diao Chengmei (2013) show the dynamics of gold pricing in the New York Gold Exchang using a dataset that includes global macroeconomic indicators, financial market indices, quantities and prices of energy products. They find a negative correlation with financial market indices and macroeconomic indicators whereas the effect of gold reserve and prices of energy product to gold is positive.

Chia-Lin Changa, Jui-Chuan Della Changb and Yi-Wei Huanc (2013) examine the inter-relationships among gold prices in five global gold markets, namely London, New York, Japan, Hong Kong (which became a Special Administrative Region of China on July 1, 2007), and Taiwan.

Yu Long (2013) finds the logarithmic gold price time series to appear as a multifractal Brownian series, the return series of log-gold price appears as a multifractal Gaussian noise series, the visibility graphs of price series and return series are both small world networks and the price series is a hierarchy structure in agreement with Elliot’s Wave Theory.


3. DATA AND METHODOLOGY

This paper uses yearly data from 1994 to 2013 coming mainly from the MeasuringWorth and OANDA database.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Gold price</th>
</tr>
</thead>
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<tr>
<td></td>
<td>US dollar to Indian Rupee exchange rate</td>
</tr>
<tr>
<td></td>
<td>Inflation Rate</td>
</tr>
<tr>
<td></td>
<td>Crude oil price</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>US dollar short term interest rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>US dollar long term interest rate</td>
</tr>
<tr>
<td></td>
<td>US real GDP SP 500 Index</td>
</tr>
</tbody>
</table>

The data for all the variables are presented in table 1. Table 2 shows the descriptive statistics for all the variables.

(1) Multivariate regression model - If we define gold price as Y, US dollar to Indian Rupee exchange rate as X_1, Inflation Rate as X_2, crude oil price as X_3, US dollar short and long term interest rate as X_4 and X_5, US real GDP as X_6, SP 500 Index as X_7 then the regression model is:

\[ Y = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + b_7 X_7 \]
Using Eviews Ordinary Least Square Method, the regression equation is
\[ Y = 4354.772 + 14.46697X_1 - 11054.93X_2 + 21.50028X_3 - 0.121358X_4 - 161.0319X_5 - 0.00029798X_6 + 106.2007X_7 \]
(Regression results are shown in Table 3)

(2) Statistical Test - \( R^2 \) is a statistical measure of how well the regression line approximates the real data points. A larger \( R^2 \) shows a better fit of the regression model to the sample observations.

Adjusted \( R^2 \) is a modification of \( R^2 \) that adjusts for the number of explanatory terms in a model. Unlike \( R^2 \), the adjusted \( R^2 \) increases only if the new term improves the model more than would be expected by chance. The adjusted \( R^2 \) can be negative, and will always be less than or equal to \( R^2 \). The larger the adjusted \( R^2 \), the better the fit of the regression model to the sample observations.

In our regression model, \( R \)-squared = 0.966970, adjusted \( R \)-squared= 0.947703 which exemplifies a good fit to the sample observations. We can also see from Table 4, depicting the actual sample, regression model and residual, that the regression model and the sample observations are quite a match.

(3) F-test - The null hypothesis is:
\[ H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = 0 \]
The alternative hypothesis is that at least one \( b_i \) does not equal zero (i=1,2,3,4,5,6,7)

We get F-statistic = 50.18677 for a significance level of \( a = 0.05 \). The critical value for a 7-numerator freedom and 22-denominator freedom is 2.464 which is less than 50.18677 so we reject \( H_0 \) showing that the regression model is indeed significant.

(4) White-test - The auxiliary regression result is
\[ Y = 77571.36 - 24.23448X_1 + 5399095 + 8.033133X_3 - 1175.637X_4 + 477.7411X_5 - 0.000000000178X_6 - 4661.099X_7 \]
\( R^2 = 0.825367 \) (Regression results are shown in Table 5)

The white \( nR^2 = 20\times0.825367 = 16.20734 \). From \( c^2 \) distribution table, we get that for a significance level of \( a = 0.05 \), and freedom level=7, this \( c^2 \) critical value \( ic^2_{a=0.05} = 14.067 \). Because \( nR^2 > c^2_{a=0.05} \) it rejects the null hypothesis of homoscedasticity in this model. Thus to eliminate heteroscedasticity, we use the

Weighted Least Squares method) The WLS equation output is \( Y = 3848.471 - 13.70254X_1 + 9301.900X_2 + 21.87139X_3 - 16.53885X_4 + 111.7561X_5 - 0.000278X_6 - 121.6887X_7R_2 = 0.388622 \). From \( c^2 \) distribution table, we get that for a significance level of \( a = 0.05 \), and freedom level=7, the \( c^2 \) critical value \( ic^2_{a=0.05} = 14.067 \). Because \( nR^2 < c^2_{a=0.05} \) we accept the null hypothesis of Homoscedasticity. So
the heteroscedasticity is eliminated.

4. RESULTS AND CONCLUSIONS

From the above regression equation and correlation coefficient tests, we can arrive at the conclusion that at a significance level of 0.05, US dollar to Indian Rupee exchange rate, US Inflation Rate, Crude oil price, US dollar long term interest rate and US real GDP do have an influence on gold price since the p-value is less than 0.05 for these factors. Furthermore, gold prices to US dollar to Indian Rupee exchange rate, and Crude oil prices have positive relationship whereas there is negative relationship with Inflation, US long term interest rate, and US real GDP.

5. SOME REFLECTIONS ARE IN ORDER HERE

1. As the Rupee exchange rate increases, India will have more demand for gold in order to keep the value of their money that will result in an increase in gold price.

2. From a historical perspective, for each unit increase in US dollar to Indian Rupee exchange rate, the price of gold decreases by 9.301900 units. The higher the inflation rate, the higher the price will and purchasing power of money will decline, resulting in the gold price to rise significantly.

3. Gold price and crude oil price have positive relationships, the world’s major oil spot and futures prices are priced in dollars. Fluctuations in oil prices relate to the dollar, thus oil prices and gold prices indirectly influence each other.

4. Gold prices and US dollar long term interest rate have negative relations since for each unit US dollar to Indian Rupee exchange rate increase, the price of gold decreases by 16.53885 units. A possible explanation is that when the interest rate is low, the investment in gold will have certain benefits, and as the demand for gold increases, the price of gold will increase consequentially.

5. Gold prices and US real GDP have negative relationship since historically, for each unit of US dollar to Indian Rupee exchange rate increase, the price of gold decreases by -0.000278 units. The higher the GDP, the better the economic conditions, and it will enhance people’s desire to buy gold. As a result, the high demand increases gold price. From the correlation coefficient matrix (Table 8), we can see the existence of multicollinearity for US real GDP as a factor (correlation coefficients between US real GDP and Gold prices, and US dollar to Indian Rupee exchange rate are 0.7299 and 0.80567 respectively). Therefore, the regression coefficients of the interest rate variable and the dollar index may be somewhat compromised.

Further studies can try to overcome multicollinearity by using inflation adjusted data or by using monthly or daily data instead.

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REFERENCES:

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♦ Moore, G.H. Mooreb, Gold prices and a leading index of inflation Challenge, 33 (4) 1990, pp. 52–56


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Hofstra University,
New York, USA
## APPENDIX

### TABLE 1

**DATA FOR ALL VARIABLES**

<table>
<thead>
<tr>
<th>Year</th>
<th>Gold Price</th>
<th>US Exchange Rate</th>
<th>Inflation Rate</th>
<th>Crude Oil Price</th>
<th>Dollar Short-term Interest Rate</th>
<th>Dollar Long-term Interest Rate</th>
<th>US Real GDP</th>
<th>S&amp;P 500</th>
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</thead>
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<td>1994</td>
<td>385.42</td>
<td>31.39</td>
<td>2.61%</td>
<td>16.53</td>
<td>4.25</td>
<td>7.97</td>
<td>9,894,700</td>
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<td>2.81%</td>
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<td>6.53</td>
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<tr>
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<td>65.61</td>
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<td>5.59</td>
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<td>2.85%</td>
<td>72.39</td>
<td>4.36</td>
<td>5.56</td>
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<td>0.15</td>
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<td>1.47%</td>
<td>103.27</td>
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### TABLE 2

**DESCRIPTIVE STATISTICS**

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<th></th>
<th>Gold Price</th>
<th>US Exchange Rate</th>
<th>US Inflation Rate</th>
<th>Crude Oil Price</th>
<th>Short-term Interest Rate</th>
<th>Long-term Interest Rate</th>
<th>US Real GDP</th>
<th>S&amp;P 500</th>
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<td>Mean</td>
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<td>31.39</td>
<td>2.61%</td>
<td>16.53</td>
<td>4.25</td>
<td>7.97</td>
<td>9,894,700</td>
<td>2.79</td>
</tr>
<tr>
<td>Median</td>
<td>385.50</td>
<td>32.42</td>
<td>2.81%</td>
<td>17.73</td>
<td>5.48</td>
<td>7.59</td>
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<td>2.86</td>
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<tr>
<td>Minimum</td>
<td>295.24</td>
<td>41.36</td>
<td>1.55%</td>
<td>13.59</td>
<td>4.78</td>
<td>6.53</td>
<td>11,513,400</td>
<td>1.68</td>
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<tr>
<td>Maximum</td>
<td>279.91</td>
<td>43.13</td>
<td>2.19%</td>
<td>18.62</td>
<td>4.64</td>
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<td>2.27%</td>
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<td>1.94</td>
</tr>
<tr>
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<td>272.22</td>
<td>47.22</td>
<td>2.83%</td>
<td>25.22</td>
<td>3.40</td>
<td>7.08</td>
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<td>48.63</td>
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<td>-0.34%</td>
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<td>53.37</td>
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<td>58.51</td>
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<td>4.23</td>
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### TABLE 3

**ORDINARY LEAST SQUARE TEST**

Dependent Variable: GOLD_PRICE  
Method: Least Squares  
Date: 04/9/14   Time: 14:13  
Sample: 1994-2013  
Included observations: 20

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<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
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<td>0.0446</td>
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<td>101.6723</td>
<td>-1.044539</td>
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R-squared: 0.966970  
Adjusted R-squared: 0.947703  
S.E. of regression: 111.0767  
Sum squared resid: 148056.3  
Log likelihood: -117.4749  
F-statistic: 50.18677  
Prob(F-statistic): 0.000000

AN EMPIRICAL ANALYSIS OF FACTORS AFFECTING GOLD PRICES
TABLE 4
THE ACTUAL SAMPLE, REGRESSION MODEL AND RESIDUAL
TABLE 5

HETEROSKEDASTICITY TEST: WHITE

<table>
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<th></th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>77571.36</td>
<td>64335.95</td>
<td>1.205723</td>
<td>0.2512</td>
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<td>-2.207499</td>
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<td>0.462789</td>
<td>0.6518</td>
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<tr>
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<td>8.033133</td>
<td>1.793736</td>
<td>4.478437</td>
<td>0.0008</td>
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<tr>
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<td>-1175.637</td>
<td>409.6542</td>
<td>-2.869828</td>
<td>0.0141</td>
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<tr>
<td>LONG_TERM_INTEREST_RATE^2</td>
<td>477.7411</td>
<td>709.5150</td>
<td>0.673335</td>
<td>0.5135</td>
</tr>
<tr>
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<td>2.60E-10</td>
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<td>-2.279066</td>
<td>0.0417</td>
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</tbody>
</table>

R-squared             | 0.825367    | Mean dependent var | 14282.34 |
Adjusted R-squared    | 0.723498    | S.D. dependent var  | 24316.82 |
S.E. of regression    | 12786.62    | Akaike info criterion | 22.03936 |
Sum squared resid      | 1.96E+09    | Schwarz criterion   | 22.43765 |
Log likelihood         | -212.3936   | Hannan-Quinn criter. | 22.11711 |
F-statistic            | 8.102246    | Durbin-Watson stat  | 2.117940 |
Prob(F-statistic)      | 0.000944    |                    |         |

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 04/9/14  Time: 14:39
Sample: 1994 2013
Included observations: 20

AN EMPIRICAL ANALYSIS OF FACTORS AFFECTING GOLD PRICES
TABLE 6
WEIGHTED LEAST SQUARE TEST

Dependent Variable: GOLD_PRICE
Method: Least Squares
Date: 04/11/14   Time: 20:23
Sample: 1994 2013
Included observations: 20
Weighting series: (ABS(RESID))^(-0.5)
Weight type: Inverse standard deviation (EViews default scaling)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
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<tbody>
<tr>
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<td>3848.471</td>
<td>826.4504</td>
<td>4.656627</td>
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<tr>
<td>US_EXCHANGE_RATE^2</td>
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<td>INFLATION_RATE^2</td>
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<td>1.544376</td>
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<td>15.30461</td>
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<tr>
<td>LONG_TERM_INTEREST_RATE^2</td>
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<td>46.27543</td>
<td>-2.415020</td>
<td>0.0326</td>
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<tr>
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<td>SP500^2</td>
<td>-121.6887</td>
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**Weighted Statistics**

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<th>Coefficient</th>
<th>Mean dependent var</th>
<th>S.D. dependent var</th>
<th>Akaike info criterion</th>
<th>Schwarz criterion</th>
<th>Hannan-Quinn criter.</th>
<th>Durbin-Watson stat</th>
<th>Weighted mean dop.</th>
<th>Prob.</th>
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<tbody>
<tr>
<td>R-squared</td>
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<td>794.9256</td>
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<tr>
<td>Adjusted R-squared</td>
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<td></td>
<td>597.4675</td>
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<tr>
<td>S.E. of regression</td>
<td>56.67788</td>
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<td>11.20182</td>
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<tr>
<td>Sum squared resid</td>
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<td>Log likelihood</td>
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<tr>
<td>F-statistic</td>
<td>156.4602</td>
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<td>1.886012</td>
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<tr>
<td>Prob(F-statistic)</td>
<td>0.000000</td>
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**Unweighted Statistics**

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<th>Durbin-Watson stat</th>
<th>Prob.</th>
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<tbody>
<tr>
<td>R-squared</td>
<td>0.962084</td>
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<td>670.1760</td>
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<tr>
<td>Adjusted R-squared</td>
<td>0.939966</td>
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<td>485.7168</td>
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<tr>
<td>S.E. of regression</td>
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<td>169960.2</td>
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<td>Durbin-Watson stat</td>
<td>1.950747</td>
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</table>
TABLE 7
HETEROSKEDASTICITY TEST: WHITE FOR WLS

<table>
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<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
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<tbody>
<tr>
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<td>INFLATION_RATE^2</td>
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<tr>
<td>CRUDE_OIL_PRICE^2</td>
<td>1765003.</td>
<td>1757060.</td>
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<td>SHORT_TERM_INTEREST_RATE^2</td>
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</tr>
<tr>
<td>LONG_TERM_INTEREST_RATE^2</td>
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<td>538.3493</td>
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</table>

R-squared       | 0.388622    | Mean dependent var | 1112.593|
Adjusted R-squared | -0.056016   | S.D. dependent var  | 1424.216|
S.E. of regression | 1463.563    | Akaike info criterion | 17.71730|
Sum squared resid | 23562174    | Schwarz criterion   | 18.16538|
Log likelihood   | -168.1730   | Hannan-Quinn criter. | 17.80477|
F-statistic      | 0.874018    | Durbin-Watson stat  | 2.046375|
Prob(F-statistic)| 0.565023    |                        |       |

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 04/11/14  Time: 21:32
Sample: 1994 2013
Included observations: 20

AN EMPIRICAL ANALYSIS OF FACTORS AFFECTING GOLD PRICES
TABLE 8
MULTICOLLINEARITY

<table>
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<th>INFLATION_RATE</th>
<th>CRUDE_OIL_PRICE</th>
<th>SHORT_TERM_INTEREST_RATE</th>
<th>LONG_TERM_INTEREST_RATE</th>
<th>REAL_GDP</th>
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<tbody>
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