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Is Gold a ‘Safe-Haven’? - An Econometric Analysis

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Abstract

Gold has been considered a resplendent and highly coveted precious metal since the genesis of humankind. Gold standards have been the most common basis for monetary policies throughout history. Recently, gold price volatility has garnered the attention of many researchers, academicians and analysts. This paper is hence an attempt to analyze the correlation and causality relation that may run between gold prices and stock market returns across six countries. The study based on data related to six renowned stock exchanges, investigates the Granger causality in the Vector Error Correction Model for the period January 2002 to December 2011 and aims to analyze the reasons behind contrasting results observed across countries. The analysis provides the evidence of feedback causality between the variables. Thus, it concludes whether one variable can be used to predict the other, or not.

Keywords: Granger Causality Test; Karl Pearson’s correlation coefficient; ‘Safe-Haven’ effect

1. Introduction

The study of the capital market of a country in terms of a wide range of macro-economic and financial variables has been the subject matter of many researches since last few decades. Empirical studies reveal that once financial deregulation takes place, the stock markets of a country become more sensitive to both domestic and external factors. They thus get influenced by various macro-economic factors such as foreign exchange rates, gold prices, broad money supply, industrial production index, consumer price index etc.

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One important factor, which we will analyze in the course of this paper, is the price of gold with respect to the stock market. When talking about macro economy including economic prosperity and recession, the stock market up and down, and consumer price index high or low, one cannot help but think of the investment “Gold” which maintains its value well and can also hedge against inflation. Historical experience shows that in countries during periods of stock market slump, the gold always trends higher. In some countries the observed trend is strong while in some there is a meek or no trend observed. The stability of any trend observed has also been spoken of, further in the paper. With this backdrop, our paper would like to explore the impact of gold price fluctuations on stock indices in six major and contrasting economies namely: USA, United Kingdom, Germany, Japan, India and China.

2. Data Collection:

This paper aims at investigating the dynamic relationship between gold prices and stock market returns in six different countries namely: India, China, USA, United Kingdom, Germany and Japan for the period January 2002 to December 2011. The secondary data for gold prices in this period for all the six countries has been collected from YCharts, a leading provider of investment research tools. The secondary data for the stock prices have been taken from the countries’ respective stock exchanges for a renowned stock index listed on that exchange. In particular we have used the following:

Table 1. List of Countries along with the Stock Indices used

| Country | Stock Index | Stock Exchange |
|---------|-------------|----------------|
| USA     | S&P 500     | NYSE and NASDAQ |
| UK      | FTSE 100    | London Stock Exchange |
| Germany | GDAX (Germany DeutscherAktien Index) | Frankfurt Stock Exchange |
| Japan   | Nikkei 225  | Tokyo Stock Exchange |
| India   | S&P CNX Nifty | NSE |
| China   | SSE 180     | Shanghai Stock Exchange |

3. Methodology

The daily stock price and gold price returns (Rt) have been calculated using the formula: \( R_t = \frac{(P_t - P_{t-1})}{P_{t-1}} \) where \( P_t \) and \( P_{t-1} \) are the daily closing prices for the stock or simply the prices for gold at time ‘t’ and ‘t-1’ respectively. To measure the lead-lag effects, we take a lag of 1 day. This is a limitation in our paper, as although the gold and stock prices change every single moment, the smallest period for which we could find the data was 1 day and since smaller the lag, the better it is, we have taken the smallest available value of lag i.e. 1 day. The Karl Pearson’s correlation coefficient between the stock prices and gold prices has been calculated for the simple series (i.e. for a 0 time lag) \( r_0 \) and for series of gold prices lagged by 1 day \( r_1 \) and its significance has been tested by the t-test. The correlation coefficient has been calculated by using the following formula:

\[
r = \frac{N \sum xy - (\sum x)(\sum y)}{\sqrt{[N \sum x^2 - (\sum x)^2][N \sum y^2 - (\sum y)^2]}}
\]

(1)

Where: \( N \) = number of pairs of scores, \( \sum xy \) = sum of the products of paired scores, \( \sum x \) = sum of x scores, \( \sum y \) = sum of y scores, \( \sum x^2 \) = sum of squared x scores, \( \sum y^2 \) = sum of squared y scores
The significance of this correlation coefficient has been tested by the t-test using the t-statistic (n-2) given by:

$$ t_{n-2} = \frac{\sqrt{n-2}}{\sqrt{1-r^2}} $$

(2)

under the null hypothesis $H_0: \rho = 0$ against the alternative hypothesis of $H_1: \rho \neq 0$ with n-2 degrees of freedom. If the calculated value of t exceeds the critical value of t, then the null hypothesis will be rejected; otherwise accepted.

Then the Granger causality between the variables has been investigated in the Vector Error Correction framework. And, as the essential steps of Granger Causality test, the stationarity and co-integration between variables have been found out. The Augmented Dickey-Fuller unit root test has been used to examine the stationarity of the time series of the study and to find the order of integration between them. The ADF unit root test has been performed by estimating the regression:

$$ \Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \sum_{j=1}^{p} y_j \Delta Y_{t-j} + \varepsilon_t $$

(3)

The ADF unit root test is based on the null hypothesis $H_0: Y_t$ is not I(0). If the calculated ADF statistic is less than the critical value, then the null hypothesis is rejected; otherwise accepted. If the variable is stationary at level, the variable is said to be integrated of order zero, I(0). If the variable is non-stationary at level, the ADF test can be utilised and the first difference of the variable can be used for testing a unit root. In this case, the variable is said to be co-integrated of order one, I(1).

In the second step, the Johansen’s co-integration test has been applied to check whether the long run equilibrium relation exists between the variables. The Johansen approach to co-integration test is based on two test statistics, viz., the trace test statistic, and the maximum eigen value test statistic. The trace test statistic can be specified as:

$$ \tau_{trace} = -T \sum_{t=r+1}^{K} \log(1 - \lambda_t) $$

(4)

Where $\lambda_i$ is the $ith$ largest eigen value of matrix $\Pi$, and $T$ is the number of observations. In the trace test, the null hypothesis is that the number of distinct co-integrating vector(s) is less than or equal to the number of co-integrating relations (r). The maximum eigen value test examines the null hypothesis of exactly r co-integrating relations against the alternative of $r + 1$ co-integrating relations with the test statistic:

$$ \tau_{max} = -T\log (1 - \lambda_{r+1}) $$

(5)

Where $\lambda_{r+1}$ is the $(r+1)th$ largest squared eigen value. In the trace test, the null hypothesis of $r = 0$ is tested against the alternative of $r + 1$ co-integrating vectors.

At the end, the Granger Causality test has been used to determine whether one time series is useful in forecasting another thereby finding out the direction of relationship between the variables of the study.

In the Granger Causality test, the vector of endogenous variables is divided in two sub-vectors, $Y_1t$ and $Y_2t$ with dimensions $K_1$ and $K_2$ respectively, so that $K = K_1 + K_2$. The sub-vector $Y_1t$ is said to be Granger-causal for $Y_2t$ if it contains useful information for predicting the latter set of variables. For testing this property, the levels VAR following form without exogenous variables of the model is considered.

$$ A_0 Y_t = A_1 Y_{t-1} + \cdots + A_{p+1} Y_{t-p-1} + B_0 X_t + \cdots + B_q X_{t-q} + C^* D_t^* + u_t $$

(6)
If that model contains \( p+1 \) lags of the endogenous variables as in the above model, the test is based on a model with \( p+2 \) lags of the endogenous variables,

\[
\begin{bmatrix}
Y_{1t} \\
Y_{2t}
\end{bmatrix} = \sum_{i=1}^{p+2} \begin{bmatrix}
\alpha_{11,i} & \alpha_{12,i} \\
\alpha_{21,i} & \alpha_{22,i}
\end{bmatrix} \begin{bmatrix}
Y_{1,t-i} \\
Y_{2,t-i}
\end{bmatrix} + CD_t + \begin{bmatrix}
\epsilon_{1t} \\
\epsilon_{2t}
\end{bmatrix}
\]

(7)

as proposed by Dolado and Lutkepohl (1996). The null hypothesis that \( Y_{1t} \) is not Granger-causal for \( Y_{2t} \) is tested by checking the null hypothesis \( \alpha_{21,i} = 0, \ i=1,2,\ldots,p+1 \).

A Wald test statistic, divided by the number of restrictions \( pK_1K_2 \), is used in conjunction with an \( F(pK_1K_2, KT - n^* ) \) distribution for testing the restrictions. Here \( n^* \) is the total number of parameters in the system (Lutkepohl, 1991), including the parameters of the deterministic term. Of course, the role of \( Y_{1t} \) and \( Y_{2t} \) can be reversed to test Granger-causality from \( Y_{2t} \) to \( Y_{1t} \).

4. Empirical Analysis

Part 1

This section contains the results and interpretation of these results, analytically and graphically for each of the six countries. We have divided these six countries into two categories for a structured analysis, namely:

- Developing nations: India and China
- Developed nations: USA, UK, Germany, Japan

We have been able to do this categorization based on the similarity in the trends observed for those countries that are grouped together. These trends are strikingly evident from the analysis done further in this section.

For each country, we have analyzed the results, first, for a 0 time lag using the correlation coefficient (r0), and second, for a 1-day time lag using two measures namely the correlation coefficient for a 1day lag (r1) and the results of the Granger Causality test.

The null hypothesis for the Granger Causality Test is taken as:

Stock prices don’t Granger cause Gold prices and Gold prices don’t Granger cause Stock prices.

For all the six countries we have tested whether this hypothesis is valid or not.

For each country, we have the made graphs of:

- Gold prices and Stock prices on Y-axis vs Time on the X-axis.
- Gold price and Stock price returns on Y-axis vs Time on the X-axis. (This graph has been drawn only for a 1 month period, to show the results in a magnified form)

I) Developing nations:

a) India:

0 time lag:

In India, the Karl Pearson’s correlation coefficient observed between gold prices and stock prices for the 10 year data from 2002 to 2012 is \( r_0 = 0.040291483 \).

1-day time lag:

The observed correlation coefficient r1 is -0.002267452.

According to the t statistic calculated using the formula mentioned above, we infer that since this is greater than the critical \( t \) at 95% confidence level (\( t_{crit}=1.96 \) for \( \infty \) degrees of freedom since our number of observations is greater than 3000), we accept the alternate hypothesis \( H_1: \rho \neq 0 \) i.e. both the correlation coefficients are significant.
Results of the Granger Causality test: (Here, Y refers to gold prices and X to the Stock prices)

Table 2. Results of Granger Causality Test for India

| Granger Causality Test: Y = f(X) | Model | Res.DF | Diff. DF | F        | p-value     |
|----------------------------------|-------|--------|----------|----------|-------------|
| Complete model                   | 2208  |        |          |          |             |
| Reduced model                    | 2209  | -1     |          | 9.89164074101347 | 0.00168240760177403 |

| Granger Causality Test: X = f(Y) | Model | Res.DF | Diff. DF | F        | p-value     |
|----------------------------------|-------|--------|----------|----------|-------------|
| Complete model                   | 2208  |        |          |          |             |
| Reduced model                    | 2209  | -1     |          | 0.0424591828808496 | 0.83676596067373 |

We see that for Y = f(X), the observed F is higher than the critical value at 95% confidence (F critical=1.03 for df1 and df2 > 1000 at 5% significance) and the p-value is less than 0.005. Hence we reject the null hypothesis and infer that in India the **Stock prices granger cause Gold prices**.

For X= f(Y), the observed F is less than the critical F and p-value is greater than 0.05, therefore the null hypothesis is accepted implying the **gold prices don't granger cause stock prices**.

We observe that in India, the r0 is positive whereas the r1 is negative. This implies that the change in stock prices doesn’t immediately turn the gold prices in the opposite direction, but the effect is observed a little later as reflected by r1. The main reason for this is that the Indian people don’t consider Gold as just a mere asset to earn returns on. The period of holding gold is, to a large extent, guided by the individual sentiments. The gold investing habits of Indians are strongly ingrained in the Indian Social Psyche. In India gold has been held by individuals for years and have passed hands of many generations. In addition, the equity culture in India is not as developed as in some other parts of the world. Therefore the change in stock returns doesn’t immediately change the investment of Indians in Gold but this takes a while to happen. This primarily explains the observed results.

Also, Gold has not yet lost its prime importance as a hedge against loss of wealth in times of crises, in India. Indians consider gold the **safe haven** investment as a financial asset and as jewellery. World Gold Council Report says that India stands today as the world’s largest single market for gold consumption. Traditionally, gold has been more attractive than bank deposits, stocks and bonds. In India, gold remains an integral part of various social and religious customs, besides being the basic form of savings.

Recently many innovative financial products have been launched relating to gold. In March 2003, the first Gold Exchange Traded Fund, i.e., Gold Bullion Securities was launched on the Australian Stock Exchange. Now, gold exchange traded funds are being traded like shares on the major stock exchanges including London, New York and Sydney. In India the first gold ETF was launched in March 2007 by Benchmark Mutual Fund. And, the UTI gold ETF has emerged as the best performer since May 2009. The number of new accounts created by Gold ETFs in India surged 57% between March and September 2009. It shows that Indian investors are gradually moving into gold ETFs for investment instead of physical form.

Recently derivatives such as gold forwards, futures and options have become very popular and have been traded on various exchanges around the world and over-the-counter directly in the private market. In the USA, gold futures are primarily traded on the New York Commodities Exchange. In India, the National Commodity
and Derivatives Exchange introduced 100 gram gold futures in November 2006. The volume of Gold futures traded in this exchange during January to August 2007 was 4,479,114 which have been increased to 9,038,795 in January to August 2008. It is thus inferred that Indians have started considering gold more than jewellery and as good as investments on bonds and equities. Perhaps, this explains the co-movement of gold prices and stock prices in the aftermath of global financial crisis as reflected by our value of r0.

![Fig. 1. The plot of gold prices and stock prices vs time for India](image)

Gold prices have been on an uptick since 2000, while the stock market declined from 2000 to 2003 and then again in 2008 (Fig.3). In 2008 when the market was suffering from bearish phase worldwide, gold prices spiked as panic spread across global markets. So far since March 2009 in India signs of recovery in the stock markets have emerged. At the same time gold continues to forge ahead, albeit at a slower pace. In 2008, the two assets prices – equity and gold, were moving in opposite directions, displaying the ability of the yellow metal to protect one's portfolios at the time of a dip. In fact, during each of the two prolonged bear phases (lasting at least a year) over the past decade, gold has provided an effective hedge.

b) China:

0 time lag:
In China, the Karl Pearson’s correlation coefficient observed between gold prices and stock prices for the 10 year data from 2002 to 2012 is $r_0 = 0.00663903$.

1-day time lag:
The observed correlation coefficient $r_1$ is -0.008212115
According to the t statistic calculated using the formula mentioned above, we infer that since this is greater than the critical t at 95% confidence level ($t_{crit}=1.96$ for $\infty$ degrees of freedom since our number of observations is greater than 3000), we accept the alternate hypothesis ($H_1: \rho \neq 0$) i.e. both the correlation coefficients are significant.

Results of the Granger Causality test: (Here, Y refers to gold prices and X to the Stock prices)

| Model           | Res.DF | Diff. DF | F          | p-value     |
|-----------------|--------|----------|------------|-------------|
| Complete model  | 2320   |          |            |             |
| Reduced model   | 2321   | -1       | 5.72022276228034 | 0.0168497980481653 |
Granger Causality Test: $X = f(Y)$

| Model           | Res.DF | Diff. DF | F         | p-value      |
|-----------------|--------|----------|-----------|--------------|
| Complete model  | 2320   |          |           |              |
| Reduced model   | 2321   | -1       | 1.00628929396626 | 0.200963276337357 |

We see that for $Y = f(X)$, the observed $F$ is higher than the critical value at 95% confidence ($F_{critical}=1.03$ for $df_1$ and $df_2 > 1000$ at 5% significance) and the $p$-value is less than 0.005. Hence we reject the null hypothesis and infer that **in China the Stock prices granger cause Gold prices.**

For $X = f(Y)$, the observed $F$ is less than the critical $F$ and $p$-value is greater than 0.05, therefore the null hypothesis is accepted implying the **gold prices don’t granger cause stock prices.**

We observe that in China, again, the $r_0$ is positive whereas the $r_1$ is negative. This implies that the change in stock prices doesn’t immediately turn the gold prices in the opposite direction, but the effect is observed a little later as reflected by $r_1$, just as we saw for India.

The reasons for this are very similar to those described for India above. Traditionally, gold has been more attractive than bank deposits, stocks and bonds in developing nations. People in these countries have often trusted gold as a better investment. Also, for them gold remains an integral part of various social and religious customs, besides being the basic form of savings. In addition, the equity culture in developing nations is not as developed as in some other parts of the world. The people in these nations are highly guided by their sentiments and hence don’t change their present investment in gold immediately, but it takes a while for this to happen. Further, Gold behaves as a safe haven investment in developing nations especially during the time of a crisis.

**II) Developed nations:**

**a) USA:**

**0 time lag:**

In USA, the Karl Pearson’s correlation coefficient observed between gold prices and stock prices for the 10 year data from 2002 to 2012 is $r_0 = -0.040738294$.

**1-day time lag:**

The observed correlation coefficient $r_1$ is $0.077544366$.

According to the $t$ statistic calculated using the formula mentioned above, we infer that since this is greater than the critical $t$ at 95% confidence level ($t_{crit}=1.96$ for $\infty$ degrees of freedom since our number of observations is greater than 3000), we accept the alternate hypothesis ($H_1: \rho \neq 0$), i.e. both the correlation coefficients are significant.

Results of the Granger Causality test: (Here, $Y$ refers to gold prices and $X$ to the Stock prices)
Table 4. Results of the Granger Causality test for USA

| Granger Causality Test: Y = f(X) | Model                  | Res.DF | Diff. DF | F          | p-value       |
|---------------------------------|------------------------|--------|----------|------------|---------------|
| Complete model                  | 2464                   |        |          |            |               |
| Reduced model                   | 2465                   | -1     |          | 0.00653435202631782 | 0.935579468486139 |

| Granger Causality Test: X = f(Y) | Model                  | Res.DF | Diff. DF | F          | p-value       |
|---------------------------------|------------------------|--------|----------|------------|---------------|
| Complete model                  | 2464                   |        |          |            |               |
| Reduced model                   | 2465                   | -1     |          | 13.4292962843018 | 0.000252953700369967 |

We see that for Y = f(X), the observed F is lower than the critical value at 95% confidence (F critical=1.03 for df1 and df2 > 1000 at 5% significance) and the p-value is greater than 0.005. Hence we accept the null hypothesis and infer that in USA the Stock prices don't granger cause Gold prices.

For X= f(Y), the observed F is greater than the critical F and p-value is smaller than 0.05, therefore the null hypothesis is rejected implying the gold prices granger cause stock prices.

We observe that in USA, the r0 is negative whereas the r1 is positive. This implies that, in developed nations since people are very practical and are not guided by sentiments, emotions, customs and traditions, there is an instantaneous opposite reaction observed in their gold and stock investments.

Also, after a while the gold prices start positively affecting the stock prices as shown by r1 and the granger test results. This is because as the prices of gold in the developed nations increase, their already stronger currency becomes even more powerful. This increases the spending power of the people who are thus able to invest more in any asset of their interest including stocks and gold etc.

![Fig. 3. The plot of gold prices and stock prices vs time for USA](image)

b) UK:

0 time lag:
In UK, the Karl Pearson’s correlation coefficient observed between gold prices and stock prices for the 10 year data from 2002 to 2012 is r0= -0.07158169.

1-day time lag:
The observed correlation coefficient r1 is 0.046775529.
According to the t statistic calculated using the formula mentioned above, we infer that since this is greater than the critical t at 95% confidence level (t crit=1.96 for ∞ degrees of freedom since our number of observations is greater than 3000), we accept the alternate hypothesis (H1: ρ ≠ 0 ) i.e. both the correlation
coefficients are significant.

Results of the Granger Causality test: (Here, Y refers to gold prices and X to the Stock prices)

Table 5. Results of the Granger Causality test for UK

| Model            | Res.DF | Diff. DF | F          | p-value        |
|------------------|--------|----------|------------|----------------|
| Complete model   | 2269   |          |            |                |
| Reduced model    | 2270   | -1       | 8.66340267620722e-05 | 0.992574423313105 |

Granger Causality Test: X = f(Y)

| Model            | Res.DF | Diff. DF | F          | p-value        |
|------------------|--------|----------|------------|----------------|
| Complete model   | 2269   |          |            |                |
| Reduced model    | 2270   | -1       | 4.17607941745 | 0.0411137093854121 |

We see that for Y = f(X), the observed F is lower than the critical value at 95% confidence (F critical=1.03 for df1 and df2 > 1000 at 5% significance) and the p-value is greater than 0.005. Hence we accept the null hypothesis and infer that in UK the Stock prices don't granger cause Gold prices. For X= f(Y), the observed F is greater than the critical F and p-value is smaller than 0.05, therefore the null hypothesis is rejected implying the gold prices granger cause stock prices. We observe that in UK, the r0 is negative whereas the r1 is positive. We observe a similar trend in UK as observed in USA, hence the reasons for the results are same as the ones explained above for USA. This provides the basis for categorizing them into the category of Developed nations.

Fig. 4. The plot of gold prices and stock prices vs time for UK

Results similar to those of the developed nations were observed for Japan and Germany. The detailed analysis of these two countries has not been included in the paper due to space constraints.

Part 2:

We now move further and analyze the graph of gold and stock returns with time. The following is the graph observed for one of the countries: (This is drawn only for a month, to provide a magnified view)

Fig. 5. Plot of the stock and the gold price returns for 1 month
We see that the peaks of gold returns and stock returns are totally in totally opposite directions at several points. This thus proves evidence of the fact that the gold returns and stock returns are interdependent and move in opposite directions on a day to day or short term basis. Further, to see the stability of the results we plot a graph of the 12 day rollover correlation for the stock and the gold price returns. We get the following graph for one of the countries plotted for 6 months:

Fig. 6. 12 day rollover correlation for the stock and the gold price returns for 6 months

The correlation ranges from -1 to +1 from time to time which shows that the magnitude and the direction of correlation keep changing continuously. Hence, the change in the intensity of correlation is very high, i.e. there are times when gold and stock move together and times when they move opposite. Hence, although at several times gold and stock move opposite, these results are not very stable over time.

5. Conclusion

We have observed different trends for Developed and Developing nations. In the Developing nations the Stock prices granger cause the Gold prices whereas in Developed nations the Gold prices granger cause the Stock prices. However, the values of correlation are very small and hence we cannot generalize this result. Also, these results are not very stable as depicted by the 12 day rollover correlation graph which shows that the correlation between gold and stock ranges from positive to negative on a day to day basis and hence no strong conclusion can be gathered to prove this intuitive notion held by people. But at the same time, in the situations of dire economic distress, people always prefer investing in Gold as opposed to stocks, thus giving light to the ‘safe haven’ effect of Gold.

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