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# THE RELATIONSHIPS AMONG STOCKS, BONDS AND GOLD: SAFE HAVEN, HEDGE OR NEITHER?

**Shu-Mei Chiang**[1]
**Department of Finance, Lunghwa University of Science and Technology, Taiwan**
**Email: shumei@mail.lhu.edu.tw**

**Chi-Tai Lin**[2]
**Marketing & Service Division at ITRI South Campus in Industrial Technology Research Institute**
**Email: itri450235@itri.org.tw**

**Chien-Ming Huang**[3]
**Department of Banking and Finance, Tamkang University, Taiwan**
**Email: snapshop68@yahoo.com.tw**

## ABSTRACT

*This paper applies a multivariate GARCH model to analyze the interdependence among gold, stocks and bonds price. Besides, we also examine the relationship between gold and oil price to see if gold could store value during financial crisis term. The empirical results show that gold is a feedback hedge for stocks for the full sample period. Hence, gold is a good diversification instrument for stock investment. About the correlation between gold and oil price, this paper finds that gold possesses store-value function. During the financial crisis period, gold is a safe haven for bonds only when the innovations flow from gold to bond market. On the relationship between oil price and gold, it is found that gold is no longer a fine product to resist inflation. Although the direction and duration are not identical, the impulse responses among gold, stock and bond markets are short-lived. Briefly, there exists some kind of relatedness between gold and stocks and gold and bonds. Generally, gold is a suitable tool to hedge against the stock market; whilst during financial crisis span, gold is not a safe haven for stocks.*

[1] Shu-Mei Chiang (corresponding author) is a professor at the Department of Finance, Lunghwa University of Science and Technology, Taiwan. Address for correspondence: No. 300 Wanshou Road, Section 1, Gueishan Shiang, Taoyuan County 333, Taiwan. Tel: +886-2-82093211 ext. 6414; Fax: +886-2-82093211 ext. 6408; E-mail: shumei@mail.lhu.edu.tw.
[2] Chi-Tai Lin is a Ph. D. and is in charge of the Marketing & Service Division at ITRI South Campus in Industrial Technology Research Institute. E-mail: itri450235@itri.org.tw.
[3] Chien-Ming Huang is an Assistant Professor at the Department of Banking and Finance, Tamkang University, Taiwan. E-mail: snapshop68@yahoo.com.tw.

**Keywords:** Gold; Stock; Bond; Multivariate GARCH model.

## INTRODUCTION

Owing to the rising oil prices and weak dollar, the quotation of gold rises steadily. In addition to gold's ability to oppose to inflation, the increasing demand for gold from emerging market, the function of gold to serve as reserves in monetary issue and the hedging necessity in the financial market also promote the price of gold. Furthermore, the particular qualities of gold make it different from other commodity, such as gold can be stored eternally and it has negligible impacts from weather changes (Lin, Chiang and Chen, 2008). Accordingly, gold possesses an unquestionable position all the time, no matter in the period of gold standard or in modern times in which gold could be a good store or protection of value along with counter-cyclical investment vehicle under political and economic uncertainty.

Charles de Gaulle has ever said, "There can be no other criterion, no other standard than gold. Gold has no nationality and is externally and universally accepted as the unalterable fiduciary value par excellence". As a consequence, gold has long been a hedge instrument against price fluctuation in other financial products. Especially for some investors, the investment in gold is regarded as a good hedge or safe haven in opposition to the movements in stock or bond markets. However, if the interrelations among stock, bond and gold change, the response to information may not be the same as before. That is, the hedging or safe haven role played by gold might disappear. Therefore, understanding the nature of the interdependence among different classes of assets, such as stock, bond and gold, is important for investors' portfolio choices.

Despite there have been many existing literature associated with gold, they are mainly tended to concentrate on the macroeconomic influences on gold market (Christie-David, Chaudhry and Koch, 2000; Cai, Cheung and Wong, 2001; Tully and Lucey, 2007), the causality relationships between gold and stock market (Smith, 2001; Mishra, Das and Mishra, 2010), the determinants of gold price (Levin and Wright, 2006; Elfakhani, Baalbaki and Rizk, 2009) and the functions of gold as safe havens (Upper, 2000; Kaul and Sapp, 2007). Even though Capie, Mills and Wood (2005) have analyzed the role of gold as a hedge, their research is limited to investigate the condition of gold against the U.S. dollar. That is, they only consider the role of gold as a hedge for exchange rate risk.

It is not until recently that Baru and Lucey (2010) have examined the position of gold as a hedge or a safe haven for stocks and bonds in bull and bear markets, whilst they only check the impacts of stocks and bonds on gold, none the reverse. However, to the best of our knowledge, the fluctuations of financial markets are interactive (Cheung and Mak, 1992; Ibrahim, 2006; Iwatsubo and Inagaki, 2007). Namely, the variations among gold, stocks and bonds might be related (as described in Figure 1). Accordingly, the role of gold could no longer be a hedge or safe haven; that is, gold may be none of them (Sumner, Johnson and Soenen, 2010). But seldom paper has analyzed the interrelation among the previous three financial products so far.
Besides, from Figure 1, we can also see that there seems to have some kind of relatedness between oil price and gold price/stocks/bonds. When global financial crisis in 2008 being

used as a partition point, it shows that the price of oil shows a stable rising trend before 2008, and attains a peak in July 3 2008. But since then, oil price has nosedived and fell to the low band in 19 December 2008. During this six-month period, the oil price plummeted by 77%. At the same time, the prices of stocks and gold also decrease, whilst those of bonds index are the reverse. We therefore suggest that the fluctuations of oil prices have impacts on that of gold, stocks and bonds.

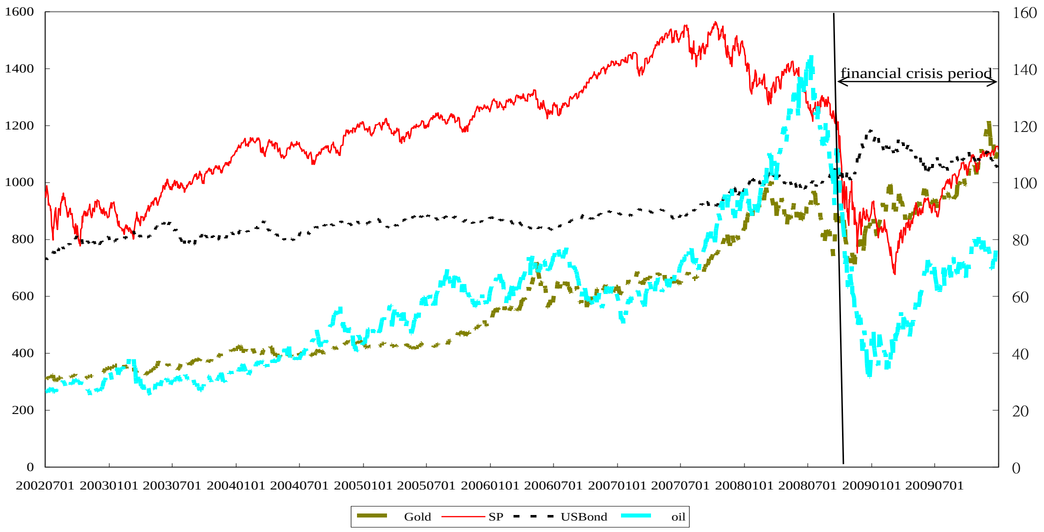


Figure 1 Daily price trend on the stock, bond, gold and oil, July 2002-December, 2009.

Of course, the burst out of subprime mortgage crisis, that is, the bankruptcy of Lehman Brothers Holdings Inc. declared on September 15 2008, may have altered the structure of financial market and have spillover influences on financial products. That is, in addition to stocks, bonds and gold price could also be affected by the subprime mortgage crisis.

Accordingly, the main purpose of this paper is to employ a multivariate GARCH Baba-Engle-Kraft-Kroner (BEKK) model defined in Engle and Kroner (1995) to examine the interrelationship among stocks, bonds and gold along with the role differences played by gold in full sample and subsample period (post-subprime mortgage crisis). In other words, this paper would to analyze whether investors would flee from stocks and bonds investment and get into gold products when stock and bond market exhibits severe losses (Gulko, 2002; Hartmann, Straetmans, and de Vries, 2004; and Baur and Lucey, 2009). In this way, we could learn if gold serves as a good hedge or safe haven instrument when the financial market reverses.

Our empirical results show that gold is a feedback hedge for stocks for the full sample of data. However, the hedge relationship between gold and bonds is unidirectional. Gold can store value only in normal financial market. During the financial crisis period, gold is a good safe haven for bonds, not for stocks. But gold no longer owns the ability to store value. Besides, even if the way, degree and duration are not similar, the impulse responses among gold, stocks and bonds markets are short-term. Generally, gold is a suitable tool to hedge against the stock market; whilst throughtout the financial crisis period, gold is not a safe haven.

The remainder of this paper is organized as follows. Descriptions of the related data and the empirical methodology adopted for this study are provided in Section 2, followed in the penultimate section by presentation of our empirical results. Finally, the conclusions drawn from this study are summarized in the closing section.

## DATA AND METHODOLOGY

### Data

The analyses of interrelation among stock, bond and gold price along with the influences of oil price and subprime mortgage crisis are based upon the daily closing price of S&P 500 stock index, New York gold market (USD/ounce), West Texas intermediate crude oil (USD/barrel) and U.S. bond index. The former three data are obtained from the Taiwan Economic Journal (TEJ), and the last one is obtained for Bloomberg. The sample period for the study covers seven and half years, from July 1, 2002 to December 31, 2009, with a total sample of 1,838 observations. Besides, we define the subprime financial crisis period as the span from September 16, 2008 to December 31, 2009, including 314 observations. All the analysis is conducted on return data.[4]

### Methodology

### 1. Multivariate GARCH Model

As the main purpose of this paper is focused on the dynamic relationship among stock, bond and gold along with the exogenous effects from oil price and subprime mortgage crisis, we apply a multivariate GARCH model to analyze their correlation and related impacts. An important preliminary step in model building is the selection of the lag order. In order to eliminate the autocorrelation of residual, we use some commonly used lag-order selection criteria to choose the lag order, such as AIC (Akaike Information Creteria).

$$AIC = -2\left(\frac{Log L}{T}\right) + \frac{2k}{T} \quad (1)$$

Base on AIC, the lag order we chosen is 2 for the three series in the study. Because the data we used are daily data, the result is reasonable. The empirical model can be constructed as follows.

$$\begin{aligned} G_t = {} & \beta_{G0} + \sum_{k=1}^{2}\beta_{G1k}G_{t-k} + \sum_{k=1}^{2}\beta_{G2k}S_{t-k} + \sum_{k=1}^{2}\beta_{G3k}B_{t-k} + \sum_{k=1}^{2}\beta_{G4k}O_{t-k} + \\ & D\times\left(\gamma_{G0} + \sum_{k=1}^{2}\gamma_{G1k}G_{t-k} + \sum_{k=1}^{2}\gamma_{G2k}S_{t-k} + \sum_{k=1}^{2}\gamma_{G3k}B_{t-k} + \sum_{k=1}^{2}\gamma_{G4k}O_{t-k}\right) + \varepsilon_{G,t} \end{aligned} \quad (2)$$

[4] Unit root tests are conducted for stock, bond, gold and oil series. As the results show that the four series have unit roots, we use first-order difference (return) to implement our empirical study. To save space, related results are not shown here. All results are available on request.

$$S_t = \beta_{S0} + \sum_{k=1}^{2}\beta_{S2k}S_{t-k} + \sum_{k=1}^{2}\beta_{S1k}G_{t-k} + \sum_{k=1}^{2}\beta_{S3k}B_{t-k} + \sum_{k=1}^{2}\beta_{S4k}O_{t-k} + D\times\left(\gamma_{S0} + \sum_{k=1}^{2}\gamma_{S2k}S_{t-k} + \sum_{k=1}^{2}\gamma_{S1k}G_{t-k} + \sum_{k=1}^{2}\gamma_{S3k}B_{t-k} + \sum_{k=1}^{2}\gamma_{S4k}O_{t-k}\right) + \varepsilon_{S,t} \quad (3)$$

$$B_t = \beta_{B0} + \sum_{k=1}^{2}\beta_{B3k}B_{t-k} + \sum_{k=1}^{2}\beta_{B1k}G_{t-k} + \sum_{k=1}^{2}\beta_{B2k}S_{t-k} + \sum_{k=1}^{2}\beta_{B4k}O_{t-k} + D\times\left(\gamma_{B0} + \sum_{k=1}^{2}\gamma_{B3k}B_{t-k} + \sum_{k=1}^{2}\gamma_{B1k}G_{t-k} + \sum_{k=1}^{2}\gamma_{B2k}S_{t-k} + \sum_{k=1}^{2}\gamma_{B4k}O_{t-k}\right) + \varepsilon_{B,t} \quad (4)$$

$$\begin{bmatrix} \varepsilon_{G,t} \\ \varepsilon_{S,t} \\ \varepsilon_{B,t} \end{bmatrix} \Bigg| \Omega_{t-1} \sim N(0, H_t) \quad (5)$$

$$H_t = \begin{bmatrix} h_{GG,t} & h_{GS,t} & h_{GB,t} \\ h_{SG,t} & h_{SS,t} & h_{SB,t} \\ h_{BG,t} & h_{BS,t} & h_{BB,t} \end{bmatrix} \quad (6)$$

where $G_t$, $S_t$, $B_t$ and $O_t$ denote the returns of gold, S&P 500 index, U.S. bond index and West Texas crude oil at time $t$, respectively. $D$ is a dummy variable, representing the occurrence of subprime mortgage crisis. If the date is after September 15, 2008, then $D$ is 1; otherwise zero. $\varepsilon_T$ is the error term, $H_t$ is defined as the covariance matrix, $\Omega_{t-1}$ represents the information set at period $t-1$. The individual factors in the covariance matrix are stated as below.

$$h_{GG,t} = c_{11}^2 + a_{111}^2\varepsilon_{G,t-1}^2 + g_{111}^2 h_{GG,t-1} \quad (7)$$

$$h_{GS,t} = c_{11}c_{12} + a_{111}a_{122}\varepsilon_{G,t-1}\varepsilon_{S,t-1} + g_{111}g_{122}h_{GS,t-1} \quad (8)$$

$$h_{GB,t} = c_{11}c_{13} + a_{111}a_{133}\varepsilon_{G,t-1}\varepsilon_{B,t-1} + g_{111}g_{133}h_{GB,t-1} \quad (9)$$

$$h_{SS,t} = c_{12}^2 + c_{22}^2 + (a_{122}^2 + a_{222}^2)\varepsilon_{S,t-1}^2 + (g_{122}^2 + g_{222}^2)h_{SS,t-1} \quad (10)$$

$$h_{SB,t} = c_{12}c_{23} + c_{22}c_{23} + (a_{122}a_{133} + a_{222}a_{233})\varepsilon_{S,t-1}\varepsilon_{B,t-1} + (g_{122}g_{133} + g_{222}g_{233})h_{SB,t-1} \quad (11)$$

$$h_{BB,t} = c_{13}^2 + c_{23}^2 + c_{33}^2 + (a_{133}^2 + a_{233}^2 + a_{333}^2)\varepsilon_{B,t-1}^2 + (g_{133}^2 + g_{233}^2 + g_{333}^2)\, h_{BB,t-1} \quad (12)$$

In the above equations, equation (2) to (4) are the mean equations, and equation (7) to equation (12) are the variance equations, respectively. When the estimated coefficients $c_{ij}$, $a_{ijk}$ and $g_{ijk}$ are significant, it indicates that taking heteroscedasticity into consideration is well done in this paper.

The advantage of this model is that all of the elements in each covariance matrix are the function of its historical data, so the model can be regarded as a positive definite diagonalized vech type. This study uses normal distribution and maximization likelihood estimation (MLE) to estimate the parameters in the model. The logarithmic likelihood function is defined as follows.

$$L(\theta) = -\frac{1}{2}\sum_{t=1}^{T}\left(\ln|H_t| + \varepsilon_t' H_t^{-1}\varepsilon_t\right) \quad (12)$$

where $\theta$ represents the parameter vectors needed to be estimated; T is the number of observations.

## 2. Impulse Response Function (IRF)

An impulse response refers to the reaction of any dynamic system in response to some external change. This paper uses nonlinear GARCH-IRF equation to analyze the impulse response between variables. This method covers the characteristics of volatility varying with time, which can better correspond to the properties of financial assets. Accordingly, by applying nonlinear GARCH-IRF equation to assay the individual shock from the fluctuations of stock, bond and gold markets**,** we can observe the variation and reaction speed of the impulse response in each series and then make correct investment decision.

## EMPIRICAL RESULTS

### Basic Statistics

The summary descriptive statistics for the daily logarithmic returns of gold, S&P 500 index and bond index over the seven-half-year sample period are presented in Table 1, from which we can see that the mean daily return is found to the highest (lowest) for the gold (S&P 500 index).

Amongst the three indices, the standard deviation of the return is found to be the highest for S&P 500 index. That is, stocks are generally more risky than gold and bonds. Unexpectedly, gold appears relatively risky than bonds in terms of standard deviation, minimum and maximum values. Besides, all of the indices exhibit large kurtosis, and the Jarque-Bera tests for normality revealing that the returns of the three series are non-normal distributed. Therefore, according to the results of the skewness, kurtosis and Jarque-Bera tests, the return distributions of gold, stock index and bond index are more fat-tailed and high-peaked than normal distribution, consistent with the ARCH effect.

Table 1 Summary statistics of the returns of Gold, S&P 500 index and U.S. bond index

| Variables | Mean | Standard deviation | Skewness | Kurtosis | Maximum | Minimum | Jarque-Bera | Q(50) |
|---|---|---|---|---|---|---|---|---|
| Gold | 0.0680 | 1.2676 | -0.2566*** | 3.8332*** | 7.7968 | -7.8934 | 1144.8017*** | 90.199*** |
| S&P 500 | 0.0077 | 1.4186 | -0.2258*** | 8.7617*** | 10.2457 | -9.4695 | 5891.5417*** | 129.591*** |
| U.S. Bond | 0.0200 | 0.5260 | 0.0908 | 3.3546*** | 3.9281 | -2.8228 | 863.8640*** | 69.423*** |

Note: 1. *** represent 1% significant level.
2. The kurtosis examined here is excess kurtosis, which equals to the original kurtosis minus 3.
3. Q (50) is the Q-statistic of the Ljung-Box test.

**ARCH effect**

Many empirical results, such as Bollerslev (1986), Colm and Patton (2000) and Wang and Wang (2001), all documented that, GARCH (1, 1) model can provide a good fit for the time series data. Accordingly, in this study, the returns of S&P 500 index, bond index and gold will be dealt with via GARCH (1, 1) process.

Before estimating the parameters of GARCH (1, 1) model, we need to test if ARCH effect exists in the residuals resulted from fitting for the model. Consequently, we apply LM test (Lagrange Multiplier test) to examine if ARCH effect exists. If ARCH effect indeed is present, then it is appropriate to match the volatility with GARCH model in this paper. The results in Table 2 show that ARCH effect does exist in the three series.

Table 2 ARCH effect test for the S&P 500 index, U.S. bond index and Gold

| Variables | Gold | S&P 500 | U.S. Bond |
|---|---|---|---|
| LM test | 143.6410*** | 533.4720*** | 89.6986*** |

Note: *** represent 1% significant level.

**Empirical analysis of multivariate GARCH model**

This paper employs a multivariate GARCH (1, 1)[5] model to explore the relationship among gold, stocks and bonds along with the role acted by gold. In the following, we abide by the definitions of Baur and Lucey (2010) to investigate if gold could serve as a good hedge or safe haven instrument when the financial market reverses. Accordingly, a hedge is defined as gold return that is uncorrelated or negatively correlated with S&P 500 stock return and U.S. bond return; in contrast, a **s**afe haven is described as gold return that is uncorrelated or negatively correlated with S&P 500 stock return and U.S. bond return in times of market stress or turmoil. In addition, as Harmston (1998) has indicated that gold has maintained its value in terms of real purchasing power worldwide in the very long run. Despite price fluctuations, gold has consistently reverted to its historic purchasing power parity with other commodities and intermediate products. That is, gold has been an effective vehicle to store value. Therefore, this paper defines that gold can be as a store of value when the return of gold is positively correlated with oil return. The related empirical results are presented as follows.

**1. Sum tests**

The empirical results in Panel B of Table 3 show the outcomes of sum test during the whole sample period. It is found that except for the insiginificant impact of gold and bond return on the stock return, others display siginificant causal relationships. Especially, there is a bidirectional causality between gold and bond market, in spite of the marginal significane of

5 When selecting the values for $p$ and $q$, it is typical to set both parameters equal to 1, and uses a GARCH (1,1) model to proceed empirical analysis. While increasing $p$ and $q$ will invariably increase the fit to in-sample data, as the various models are nested, the advantages gained are minimal and can lead to over specification.

gold on bond return. This means that the spillover effects from gold and bond market to the stock market are weak; oppositely, both gold and bond markets have interaction with each other. This is, stock market seems to act a leading role during our sample period. Finally, crude oil price only has significant impact on gold market.

Panel C in Table 3 is the result of sum test for the financial crisis period. Not surprising, the findings are different from those for the whole sample period. In this term, there are no impacts of stock and bond returns on gold return, but the spillover effects from the gold market to stock and bond market are significant and stronger than non-financial crisis period. Thus it can be seen that the character played by gold is more evident than before. Lastly, the impacts of crude oil price on the three markets are insignificant.

Form the sum test results, we believe that gold and stock along with bond returns may be correlated, that is, gold can be helpful in predicting, to some degree, the stock and bond market trend, inconsistent with the result of Sumner, Johnson and Soenen (2010).

**2. The results for total sample period**

Table 3 and Table 4 show the results for the mean equation and variance equation in the multivariate GARCH (1, 1) model. The $\beta_G$ coefficients in the first column of Panel A in Table 3 exhibit the influence of all related variables on the gold return. With regard to the impact of stock return, it is found that $\beta_{G21}$ is insignificant, showing that there is no impact of lag 1 stock return on gold return; however, lag 2 stock return, $\beta_{G22}$ (0.0854), has significantly positive effect on gold return. Therefore, gold could be a hedge for stock only in lag 1 period. As for the influence in terms of bond returns, the significant positive coefficients of $\beta_{G31}$ (0.2770) and $\beta_{G32}$ (0.2126) indicates that when the bond price falls, the gold price also decreases. In other words, gold may not be a good hedge for bond. In addition, the positive coefficient of $\beta_{G41}$ (0.1062) and $\beta_{G42}$ (0.0258) discloses that ascending oil price could also promote the increase in gold price, implying that gold seems to function well in resisting inflation and store value during our sample periods. This finding is consistent with that of Harmston (1998).

The $\beta_S$ coefficients in the second column of Panel A in Table 3 show the impacts of associated variables on the stock return. The effects of $\beta_{S21}$ (-0.0880) is significantly negative, revealing that the stock return could be affected by its own lag return. That is, stock return possesses mean-reversion characteristic. Besides, the influences of gold returns on stock returns are insignificant, consistent with the issue that gold is a good hedge for stock, agreeing with the outcome of Baur and Lucey (2010). Further, both of the bond return and oil return have no significant impacts on stock return. This result corresponds to the sum test that stock market plays a leading part during our whole sample period.

The $\beta_B$ coefficients in the third column of Panel A in Table 3 present the affects of variables on the bond return. Just as the results in the stock return, bond return could also be affected by its own lag return. The significance of $\beta_{B32}$ (-0.0686) shows that mean-revision phenomenon also exists in the bond market. Moreover, $\beta_{B11}$ and $\beta_{B12}$ are both insignificant, showing that there are no impacts of gold returns on the bond return. Hence, gold is a good hedge for bond. Besides, lag stock return, $\beta_{B21}$ and $\beta_{B22}$ has negative impact on the bond return. Hence, bond is also a good hedge for stock market, just like the role of gold. In addition, oil return has no impact on bond return.

Combined with the results of sum test for the whole sample period, this paper finds that gold is a feedback hedge for stock, consistent with the finding of Baur and Lucey (2010); namely, hedge occurs in the bidirection between gold and S&P 500 markets. This result makes gold present diversification benefits for stock investment. However, as to the hedge relationship between gold and bond, it is only unidirectional. That is, when the innovations flow from gold to bond market, the hedge effects just exist; otherwise, the situation reverses. If it the case, because gold and bond price move together, gold is no longer a good hedge for bond. Notably, bond is also a good hedge for stock during our total sample period. As to the relationship between gold and crude oil, the results indicate that gold possesses the function to counter inflation and store value, supporting the finding of Harmston (1998).

Table 3 Estimation results of multivariate GARCH model among Gold, S&P 500 index and U.S. bond index

| Panel A | | | | | |
|---|---|---|---|---|---|
| Parameter | Gold | Parameter | S&P 500 | Parameter | U.S. Bond |
| $\beta_{G0}$ | 0.0354 | $\beta_{S0}$ | 0.0629 *** | $\beta_{B0}$ | 0.0180 * |
| $\gamma_{G0}$ | 0.2174 *** | $\gamma_{S0}$ | -1.1669 *** | $\gamma_{B0}$ | 0.1529 ** |
| $\beta_{G11}$ | -0.0358 | $\beta_{S21}$ | -0.0880 *** | $\beta_{B31}$ | -0.0041 |
| $\gamma_{G11}$ | 0.2378 | $\gamma_{S21}$ | -0.2135 ** | $\gamma_{B31}$ | 0.0801 |
| $\beta_{G12}$ | 0.0236 | $\beta_{S22}$ | -0.0273 | $\beta_{B32}$ | -0.0686 *** |
| $\gamma_{G12}$ | -0.1255 | $\gamma_{S22}$ | -0.1051 | $\gamma_{B32}$ | 0.1083 |
| $\beta_{G21}$ | -0.0085 | $\beta_{S11}$ | -0.0149 | $\beta_{B11}$ | -0.0075 |
| $\gamma_{G21}$ | 0.1312 ** | $\gamma_{S11}$ | 0.1847 * | $\gamma_{B11}$ | -0.0472 |
| $\beta_{G22}$ | 0.0854 *** | $\beta_{S12}$ | 0.0062 | $\beta_{B12}$ | -0.0110 |
| $\gamma_{G22}$ | -0.1124 ** | $\gamma_{S12}$ | 0.2592 *** | $\gamma_{B12}$ | -0.0505 * |
| $\beta_{G31}$ | 0.2700 *** | $\beta_{S31}$ | -0.0605 | $\beta_{B21}$ | -0.0197 ** |
| $\gamma_{G31}$ | 0.3517 * | $\gamma_{S31}$ | 0.3264 | $\gamma_{B21}$ | 0.0760 *** |
| $\beta_{G32}$ | 0.2126 *** | $\beta_{S32}$ | -0.0231 | $\beta_{B22}$ | -0.0140 |
| $\gamma_{G32}$ | -0.4761 *** | $\gamma_{S32}$ | -0.5641 * | $\gamma_{B22}$ | 0.0918 *** |
| $\beta_{G41}$ | 0.1062 *** | $\beta_{S41}$ | -0.0090 | $\beta_{B41}$ | 0.0029 |
| $\gamma_{G41}$ | -0.0684 *** | $\gamma_{S41}$ | 0.0003 | $\gamma_{B41}$ | -0.0202 * |
| $\beta_{G42}$ | 0.0259 *** | $\beta_{S42}$ | -0.0058 | $\beta_{B42}$ | 0.0001 |
| $\gamma_{G42}$ | -0.0343 | $\gamma_{S42}$ | -0.0601 | $\gamma_{B42}$ | 0.0073 |

| Panel B<br>Sum test for the whole sample period | | | | | |
|---|---|---|---|---|---|
| Impact of S&P 500 on Gold | 6.6931*** | Impact of Gold on S&P 500 | 0.1555 | Impact of Gold on Bond | 3.1824* |
| Impact of Bond on Gold | 50.8236*** | Impact of Bond on S&P 500 | 2.0782 | Impact of S&P 500 on Bond | 6.2771** |

| | | | | | |
|---|---|---|---|---|---|
| Impact of oil on Gold | 92.4540*** | Impact of oil on S&P 500 | 1.5034 | Impact of oil on Bond | 0.2746 |
| Panel C<br>Sum test during the financial crisis period | | | | | |
| Impact of S&P 500 on Gold | 1.3938 | Impact of Gold on S&P 500 | 12.5108*** | Impact of Gold on Bond | 9.5651*** |
| Impact of Bond on Gold | 2.0025 | Impact of Bond on S&P 500 | 0.5712 | Impact of S&P 500 on Bond | 15.6758*** |
| Impact of oil on Gold | 0.6023 | Impact of oil on S&P 500 | 1.5024 | Impact of oil on Bond | 0.2958 |

Note: ***, ** and * represent 1%, 5% and 10% significant level individually.

### 3. The results during the financial crisis period

Just as the above mentioned, $\beta_G + \gamma_G$ coefficients in the first column of Panel A in Table 3 show the effects of correlative variables on the gold return. As to the impact of stock return, we find that $\beta_{G21} + \gamma_{G21}$ (0.1227) is significant, whilst $\beta_{G22} + \gamma_{G22}$ (-0.0270) is insignificant, showing that gold is a safe haven for stock only in lag 2. Regarding the effect of bond return, the coefficient estimates is significant in lag 1 ($\beta_{G31} + \gamma_{G31}$=0.6217), while insignificant in lag 2 ($\beta_{G32} + \gamma_{G32}$=-0.2635). This result indicates that gold is also a safe haven for bond in lag 2. That is, gold could be a good safe haven instrument against stock and bond only in lag 2 during financial crisis period. Finally, the insignificance of $\beta_{G41} + \gamma_{G41}$ (0.0378) and $\beta_{G42} + \gamma_{G42}$ (-0.0084) seem to point out that oil return has no crucial impact on gold return during financial crisis period. That is, gold can't work well to store value in this period. Apparently, the effects of stock, bond and oil returns on gold return are different from the whole sample period.

$\beta_S + \gamma_S$ coefficients in the second column of Panel A in Table 3 display the influence of all variables on the stock return. First, as to the impact of gold return, $\beta_{S11} + \gamma_{S11}$ (0.1698) and $\beta_{S12} + \gamma_{S12}$ (0.1987) are both significant positive. Namely, there is a positive relationship between gold and stock index. Hence, gold is not a safe haven for stock, inconsistent with the finding of Baur and Lucey (2010). In term of bond returns, $\beta_{S31} + \gamma_{S31}$ is insignificant; whilst $\beta_{S32} + \gamma_{S32}$ (-0.5872) is significantly negative. These outcomes show that when the financial market suffers drastic danger, the invstors would prefer bonds to stocks, similar to the whole sample period. That is, as there exists tremendous downside risk in the financial market during finanicial crisis period, gold is no longer to be a good safe haven for stocks. Relatively, bonds seems to serve good for stocks. Finally, $\beta_{S41} + \gamma_{S41}$ and $\beta_{S42} + \gamma_{S42}$ are both insignificant, presenting that oil returns have no impacts on the stock return and these results are the same as the whole sample span.

$\beta_B + \gamma_B$ coefficients in the third column of Panel A in Table 3 are the impacts of related variables on the bond return. First, with regard to the impact of gold return, $\beta_{B11} + \gamma_{B11}$(-0.0546) and $\beta_{B12} + \gamma_{B12}$(-0.0615) are significant negative, showing that gold is a good safe haven for bond. Second, as for the influence of stock returns, it is found that $\beta_{B21}+\gamma_{B21}$ (0.0562) and $\beta_{B22}+\gamma_{B22}$ (0.0778) are both significantly positive, indicating that when the stock returns decrease, the bond returns also reduce during financial crisis period. Namely, there is bidirectional causal relationship between stock and bond returns, which is inconsistent with those of the total sample period. Finally, $\beta_{B41}+\gamma_{B41}$ and $\beta_{B42}+\gamma_{B42}$ are both insignificant, again exhibiting that oil return has no effects on the bond return, similar to that of the whole sample term.

Integrated with the outcomes of sum test for the financial crisis period, it shows that gold is a good safe haven for bond, and the influence of gold on bond is even stronger than before, a result disagreeing with that of Baur and Lucey (2010). Similar to the results in whole sample period, gold could be a safe heaven only when the innovations flow from gold to bond market, not the reverse. As to the impact of crude oil price on gold, the results show that gold no longer possesses the effect to resist inflation and store value.

In brief, there exists some kind of relatedness between gold and stocks and gold and bonds, no matter unidirectional or bidirectional. Moreover, it is addressed that the safe haven role played by gold against bond is more evident during financial tsunami. Besides, the move in oil price can only positively impact that of gold price in total sample period; whilst in financial crunch term, oil price is almost unable to influence that of gold. Namely, gold is a good vehicle to store value and oppose to inflation only in normal financial market.

## Conditional variance

Table 4 shows the empirical results of conditional variance in multivariate GARCH (1,1) model. It can be seen that most of $c_{ij}$ 、$a_{ijk}$ and $g_{ijk}$ coefficients in Table 4 are significant, indicating that when studying related issues, time-varying variance must be taken into consideration. Further, due to the insignificance of $Q(5)$ and $Q^2(5)$, showing the adequency of this model.

Table 4 The conditional variance of multivariate GARCH model among Gold, S&P 500 index and U.S. bond index

| | | | | | |
|---|---|---|---|---|---|
| $c_{11}$ | -0.1130 *** | $a_{111}$ | -0.2118 *** | $g_{111}$ | 0.9728 *** |
| $c_{12}$ | 0.0367 | $a_{122}$ | -0.0790 | $g_{122}$ | 0.7363 *** |
| $c_{13}$ | 0.0091 | $a_{123}$ | -0.0145 | $g_{123}$ | 0.7501 *** |
| $c_{22}$ | -0.0963 *** | $a_{222}$ | 0.2544 *** | $g_{222}$ | -0.6139 *** |
| $c_{23}$ | 0.0080 | $a_{233}$ | 0.1787 *** | $g_{233}$ | -0.6342 *** |
| $c_{33}$ | -0.0240 ** | $a_{333}$ | -0.0000 | $g_{333}$ | 0.0000 |
| Q test | Gold | Q test | S&P 500 | Q test | U.S. Bond |
| Q(5) | 0.427 | Q(5) | 0.719 | Q(5) | 2.241 |
| $Q^2(5)$ | 1.107 | $Q^2(5)$ | 5.959 | $Q^2(5)$ | 3.831 |
| log-likelihood function | | | -6506.4562 | | |

Note: 1. *** and * represent 1% and 10% significant level individually.
2. The Q(5) and $Q^2(5)$ statistics denote the Ljung-Box for the residuals and the squared residuals in the model with 5 lags, respectively.

**Impulse response analysis**

Although the causality tests can provide the evidence in direction of causality, it is unfortunately that these results still can't reveal the intertemporal dynamic effects among gold, stocks and bond. However, the intertemporal dynamic information can be displayed via impulse response analysis. Because according to the style of impulse response, we can judge the lasting time, direction and magnitude of innovation.

Figure 2 to 4 present the 24-period responses of, respectively, gold, stock and bond price to shocks in other variables using the full sample span. The results are generally intuitive. First, as to the impulse from the gold market, we note that one unit impulse from gold market on gold return has a maximum positive value (1.2059) in period 0. In period 1, the response turns into negative value (-0.0451). Then the impulse response shows a decay to zero after period 3. Besides, one unit impulse from gold market on stock return attains its highest value (-0.1099) in period 2. After that, the impact gradually decreases. In addition, one unit impulse from gold market on bond return reaches its highest value (0.0250) in period 2. From then, the impact progressively decreases to zero.

Second, with regard to the impulse from the stock market, it is found that one unit impulse from stock market on gold return reached its highest value (0.0820) in period 2. Then the impulse effect is weaker and decays to zero afterward. Moreover, one unit impulse from stock market on stock return attains its highest value (1.3589) in period 0. Since that, the impact also decreases to zero slowly. Further, one unit impulse from stock market on bond return is the highest (-0.1694) in period 0. The impact also diminishs to to zero bit by bit.

Third, regarding the impulse from the bond market, the figure tells that one unit impulse from bond market on gold return has maximum positive reaction (0.1323) in period 2. Then the impulse response shows a decay to zero after period 2. Basides, the impacts of impulse from bond market to stock return are smaller than others. Surpringly, the impulse from bond market on bond return has a maximum value of 0.4901 in period 0. Then the impulse response shows a decay to zero afterward.

Joined the results of impulse response among gold, stocks and bond, this paper finds that the greatest impulse response in period 0 occur in the situation when the innovation arises from themselves market. Second, the impulse responses of individual market return on the other two market returns almost have persistence of at most 2 periods and then decays after the period, although their direction, extent and duration are not similar. Third, the impact of impulse response disappear quickly. Therefore, this paper documents that there are short-term impulse responses among gold, stock and bond markets but no long-term effects.

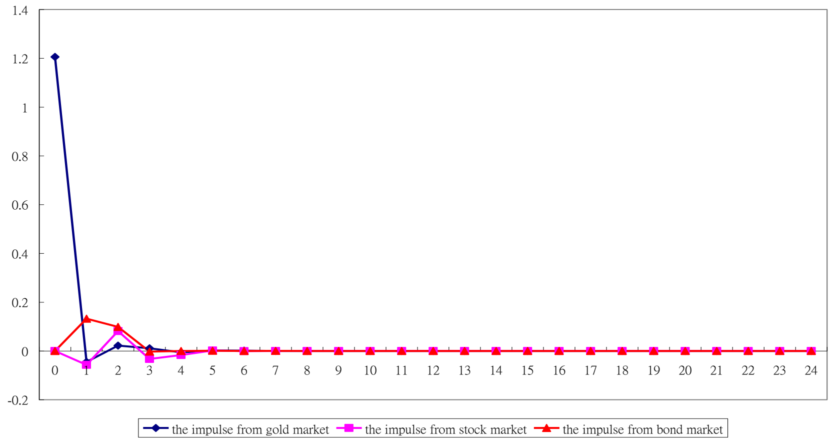


Figure 2. The impulse response of gold return

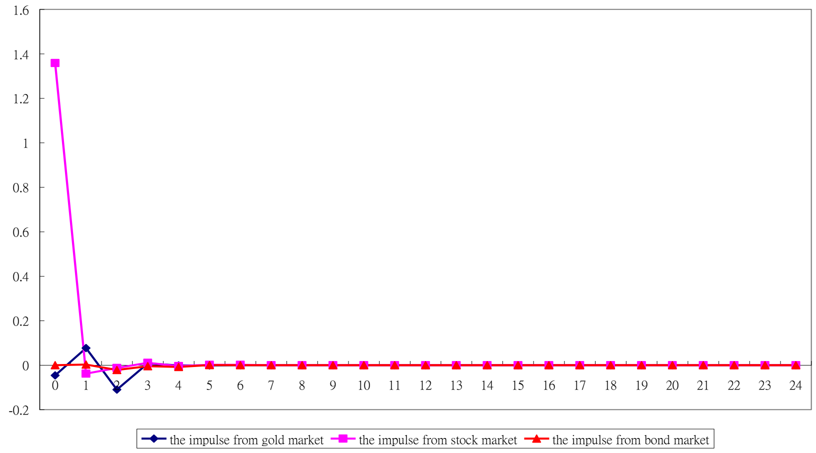


Figure 3. The impulse response of stock return

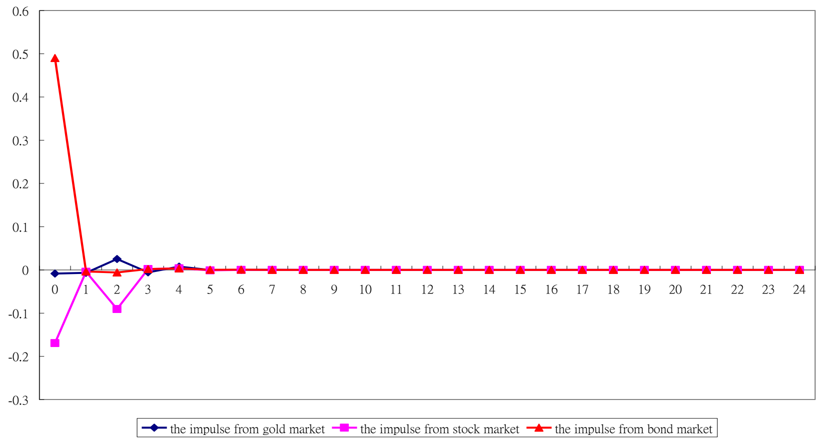


Figure 4. The impulse response of bond return

## CONCLUSION

The bankruptcy of Lehman Brothers Co. in September 2008 leads to a global financial crisis and generates serious impacts on the world economy. For a long time, stocks and bonds in general have been the major assets for investment purposes. Instead, gold has often been regarded as a safe hedge or counter-cyclical investment vehicle. To explore the possible variation in financial market, this paper employs a multivariate GARCH Baba-Engle-Kraft-Kroner (BEKK) model to analyze the interdependence among gold, stock and bond price during whole sample period and financial crisis period. Besides, we further check the relationship between gold and oil price to see if gold could function well to store value in our sample span. In this way, we can not only learn the role that gold acts, a hedge, safe haven or nothing, but also how well that gold operates to preserve value. In addition, by the analysis of impulse response, this paper could also observe the direction, extent and duration of impulse response among gold, stock and bond returns.

The empirical results show several findings among them. For the full sample of data examined, this paper shows that gold is a feedback hedge for stock, hedge occurs in the bidirection between gold and S&P 500 markets. Therefore, gold could present diversification advantage for stock investment. But the hedge relationship between gold and bond is only unidirectional. As to the association between gold and oil price, it is found that gold possesses the function to store value, supporting the finding of Harmston (1998). During the financial crisis period, it is showed that gold is a good safe haven for bond only when the innovations flow from gold to bond market, not the reverse. Besides, whenever there is enormous downside risk in the financial market, such as the financial crisis term, gold is no longer a safe haven for stocks. On the contrary, bonds could function well for stocks. With regard to the impact of oil price on gold, the results propose that gold no longer owns the ability to store value.

In adddition, even though the way, degree and duration are not the same, this paper proposes that the impulse responses of individual market return on the other two market returns have persistence of at most 2 periods and decay quickly. Therefore, it is documented that the impulse responses among gold, stock and bond markets are short-lived, not long-term.

In brief, there exists some kind of relatedness between gold and stocks and gold and bonds, no matter unidirectional or bidirectional. Generally, gold is a suitable tool to hedge against the stock market; whilst when financial crisis occurs, gold and stock price usually shift in the same direction. Hence, gold is not certainly a safe haven. Besides, the move in oil price can only positively effect that of gold price in total sample period; in financial crunch term, oil price is unable to influence that of gold. Namely, gold is a good vehicle to store value and oppose to inflation only in normal financial market.

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