

Impact of Global Financial Crisis on Precious Metals Returns: An Application of ARCH and GARCH Methods

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Abstract. This paper is focusing on seeing the resilient of precious metals returns in facing the global financial crisis and provide a new guide for the investors before making investment decisions on precious metals. Four types of precious metals returns which are the variables selected in this study. The precious metals are gold, silver, bronze and platinum. All the variables are transferred to natural logarithm (ln). Daily data over the period 2 January 1995 to 30 December 2011 is used. Unit root tests that involve Augmented Dickey- Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests have been employed in determining the stationarity of the variables. Autoregressive Conditional Heteroscedasticity (ARCH) and Generalized Autoregressive Conditional Heteroscedasticity (GARCH) methods have been applied in measuring the impact of global financial crisis on precious metals returns. The result shows that investing in platinum is less risky compared to the other precious metals because it is not influence by the crisis period.

Keywords: Precious metals; ARCH; GARCH.

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INTRODUCTION

A precious metal is a rare, naturally occurring metallic chemical element of high economic value. The best-known precious metals are the coinage metals consist of gold and silver. Generally, both have industrial uses and commonly used in art, jewelry and coinage. Historically, precious metals have much higher prices than industrial metals and many people use them as investment commodity. Precious metals not limited only to gold and silver but also include other precious metals such as platinum, bronze and palladium. The higher relative values of these metals are driven by various factors including their rarity, either it is used in industrial processes or as an investment commodity.

From the previous studies, most of the research that has been done until now has been mainly focused on the analysis of the gold market as a main area of interest [1, 2, 3]. Several studies have also analyzed variables that could be affecting the behavior of gold prices [4, 5], but there is less focus on other precious metals such as silver, bronze or platinum. Besides, there is also lack of studies analyzing the impact of global financial crisis on precious metals prices. In addition, most of the studies focus more on stock market return [6, 7, 8].

Therefore, the purpose of this study is to see either the global financial crisis phenomenon will have an effect on the price of precious metals returns. The finding from this paper could help the investors to develop effective investment portfolio before making decision prior investing in precious metals especially during the crisis period.

In this study, four types of precious metals prices will be used to compare their resilient during crisis period including gold, silver, bronze and platinum by using ARCH and GARCH methods. There are two periods of global financial crisis that have been created for this study which is from July 1997 to September 1998 and from August 2007 until October 2008.

The structure of this paper is organized as follows. In Section 2, it explains the methodology that is used in this study. Meanwhile, Section 3 describes the data, presents the research findings and discussions of the empirical results. Finally, Section 4 discusses the summary of the main conclusion.

DESCRIPTION OF THE METHOD

GARCH model is now considerably more popular than ARCH model, therefore it is more common to estimate a GARCH model [9]. The equations of a GARCH model are as follows:

$$y_t = \mu + \delta\sigma_{t-1} + \mu_t, \quad \mu_t \sim N(0, \sigma_t^2) \quad (1)$$

$$\sigma_t^2 = \alpha_0 + \alpha_1\mu_{t-1}^2 + \beta\sigma_{t-1}^2 \quad (2)$$

If δ is positive and statistically significant, then increased risk, given by an increase in the conditional variance, it will lead to a rise in the mean return. Hence, δ can be interpreted as a risk premium. Equation (1) above represent the conditional mean equation which is modelled as an autoregressive process which the residuals, μ_t are not serially correlated. While equation (2) refers to the conditional variance equation. The σ_t^2 , conditional variance depends on lagged squared errors and lagged conditional variances.

The GARCH model has been proposed by Bollerslev [10] where he generalized the ARCH model by modelling the conditional variance to depend on its lagged values as well as squared lagged values of disturbance. According to Brooks [9], the GARCH model allows the conditional variance to be dependent upon previous own lags, so that the conditional variance equation in the simplest case is now

$$\sigma_t^2 = \alpha_0 + \alpha_1\mu_{t-1}^2 + \beta\sigma_{t-1}^2 \quad (3)$$

where this is a GARCH(1,1) model.

Brooks [9] also has noted that σ_t^2 is known as the conditional variance since it is a one-period ahead estimate for the variance calculated based on any past information thought relevant. It is possible to use the GARCH model to interpret the current fitted variance, h_t , as a weighted function of a long-term average value (dependent on α_0), information about volatility during the previous period ($\alpha_1\mu_{t-1}^2$) and the fitted variance from the model during the previous period ($\beta\sigma_{t-1}^2$).

Notice that the GARCH model can be expressed in a form that shows that it is effectively an ARMA model for the conditional variance. To illustrate this, Brooks [9] considers that the squared return at time t relative to the conditional variance is given by

$$\sigma_t^2 = u_t^2 - \varepsilon_t \quad (4)$$

Using (4) expression to substitute in for the conditional variance in (3), so that it will be

$$u_t^2 - \varepsilon_t = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta(u_{t-1}^2 - \varepsilon_{t-1}). \quad (5)$$

Rearranging

$$u_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta u_{t-1}^2 - \beta \varepsilon_{t-1} + \varepsilon_t. \quad (6)$$

so that

$$u_t^2 = \alpha_0 + (\alpha_1 + \beta)u_{t-1}^2 - \beta\varepsilon_{t-1} + \varepsilon_t. \quad (7)$$

This last expression is an ARMA(1,1) process for the squared errors.

In addition, the GARCH(1,1) model can be extended to a GARCH(p,q) formulation, where the current conditional variance is parameterized to depend upon q lags of the squared error and p lags of the conditional variance

$$\sigma_t^2 = \alpha_0 + \alpha_1\mu_{t-1}^2 + \alpha_2\mu_{t-2}^2 + \dots + \alpha_q\mu_{t-q}^2 + \beta_1\sigma_{t-1}^2 + \beta_2\sigma_{t-2}^2 + \dots + \beta_p\sigma_{t-p}^2 \quad (8)$$

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^q \alpha_i \mu_{t-i}^2 + \sum_{j=1}^p \beta_j \sigma_{t-j}^2. \quad (9)$$

However, in general Brooks [9] mentioned that, a GARCH(1,1) model will be sufficient to capture the volatility clustering in the data, and rarely is any higher order model estimated or even entertained in the academic finance literature.

EMPIRICAL RESULTS

This section will discuss on the results and analyses that being employed in this study. It consists of summary of descriptive statistics, stationarity and unit root testing for precious metals prices and returns, testing of ARCH effect for precious metals returns and end with results of GARCH method using precious metals returns.

Description of The Data

The data set used in this study consists of daily closing prices of precious metals data which is the US\$/Troy ounce for gold, the Zurich silver price in SW. Francs/kilogram, the Bronze CR UK 101 4% Ex Works in £/MT and London Free Market Platinum price in US\$/Troy ounce over the period 2 January 1995 to 30 December 2011. All data are taken from DataStream International, giving a total of 4435 observations for each series. Furthermore, all data are analyzed as precious metals return which is calculated as the first differences of natural logarithmic daily closing prices, $\ln(P) - \ln(P_{t-1})$ where P is precious metals daily closing prices.

Since this study is focus to examine the impact of financial crisis, therefore dummy variable will be formed taking 0 and 1 values (1=crisis period and 0=none crisis period). The decision to create dummy variable which represents the crisis period is subjective and this study is setting the crisis divided into two periods. The first period is on July 1997 to September 1998 and the second period is from August 2007 until October 2008.

The period is chosen according to the reason that on the period from July 1997 to September 1998, the Asian financial crisis happened. The issues involved are: i) shortage of foreign exchange that has caused the value of currencies and equities in Asian countries to fall dramatically, ii) inadequately developed financial sectors and mechanisms for allocating capital in the troubled Asian economies, and iii) effects of the crisis on both the United States and the world [11].

On the other hand, Singh [12] has noted that the 2007-2008 crisis started off in August 2007 as the financial market could not solve the subprime mortgage crisis. This phenomenon is primarily concentrated in the United States but quickly spread beyond the United State's borders where most of financial institutions face to the bankruptcy in many countries. A global economic crisis followed in which nonfinancial firms around the world appear to spiral downward as well. However, the crisis slowly down and end by October 2008.

TABLE (1). Descriptive Statistics of Precious Metals Returns

| | Gold | Silver | Bronze | Platinum |
|-------------------------------|-------------|---------------|---------------|-----------------|
| Mean | 0.031892 | 0.031555 | 0.020666 | 0.026581 |
| Median | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Minimum | -7.1434 | -17.1580 | -25.2580 | -17.2770 |
| Maximum | 7.3820 | 12.2960 | 23.1030 | 11.7280 |
| Standard Deviation | 1.0408 | 1.9237 | 1.5565 | 1.4710 |
| Coefficient of Variation (CV) | 32.635 | 60.963 | 75.314 | 55.342 |
| Skewness | -0.14404 | -1.08920 | -0.36906 | -0.70290 |
| Kurtosis | 6.2214 | 10.0740 | 30.7610 | 10.6310 |
| Observations | 4435 | 4435 | 4435 | 4435 |

Descriptive statistics of the variables are given in Table 1. Based on the table, from the observations of mean indicates that mean of 0.031892 gold return is the highest value and mean of 0.020666 bronze return is the lowest. Next, median provides the same value which is 0.0000 for all the variables. The coefficient of variation (CV) for gold return is the lowest which has the value of 32.635 and bronze return is the highest that has the value of 75.314. The CV values indicate that gold return has better risk-return trade off compared to the others.

In addition, based on the skewness of the variables, all of them have the value of -0.14404, -1.08920, -0.36906 and -0.70290 respectively. This negative skewness values indicate that the distribution has a long left tail. Meanwhile, the kurtosis of the variables shows the value of 6.2214, 10.0740, 30.7610 and 10.6310 respectively. These positive values of kurtosis reveal that all distribution are relatively peaked distribution.

To test the stationarity of precious metals time series, Augmented Dickey Fuller (ADF) test and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test are applied. The results are presented in Table 2. For ADF test, the hypotheses to be tested are H_0 : The time series has a unit root versus H_1 : The time series is stationary while for KPSS test, the hypotheses to be tested are H_0 : The time series is stationary versus H_1 : The time series is not stationary

TABLE (2). ADF and KPSS Tests

| | Test Statistic | | | |
|----------|-----------------------|------------------|-----------|------------------|
| | ADF Test | | KPSS Test | |
| | Level | First Difference | Level | First Difference |
| Gold | -1.60582 | -38.1327* | 33.8450* | 0.647597 |
| Silver | -2.50192 | -38.2631* | 22.9365* | 0.0777683 |
| Bronze | -2.16451 | -42.0709* | 26.5488* | 0.347205 |
| Platinum | -2.63897 | -39.5592* | 9.11802* | 0.0709415 |

* Test is significant at 1% significance level

From Table 2, it shows the values of test statistics for each test. For ADF test, the values indicate that we can accept the null hypothesis of the existence of a unit root in levels for all variables. The tests are also show that they are not significant at 1% significance level. However, the values in first difference indicate that the null hypothesis can be rejected at 1% significance level which indicate the existence of a unit root for all variables which means that the time series is stationary.

Different with ADF test, KPSS test in level for each variable indicates that there is significant at 1% significance level. It means that the null hypothesis is rejected and therefore, the time series is not stationary. Whereas, KPSS test in first difference indicates that there are not significant at 1% significance level which means that the null hypothesis is accepted and therefore, the time series is stationary. In short, it means all precious metals return time series are stationary.

Next, to test for ARCH effects, the null hypothesis is no ARCH effect is present while the alternative hypothesis is ARCH effect is present. The important part to confirm the existence of heteroskedasticity is on ARCH test. The results for ARCH effects testing of order 1 were summarized in Table 3 as below:

TABLE (3). Testing ARCH(1) Effects for Precious Metals Returns

| | Gold | Silver | Bronze | Platinum |
|----------------|-------------|---------------|---------------|-----------------|
| Test Statistic | 149.347 | 134.755 | 624.235 | 156.054 |
| p-value | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

From Table 3, all testing for ARCH(1) effects for all variables indicate p-value is 0.0000 for each of the test which is less than 0.01. This clearly suggests that null hypothesis is rejected in 1% significance level. Therefore, it can be conclude that the ARCH effects are present for all the variables. With regard to the ARCH effect, it is clear that the variance is not constant and GARCH method needed to model changing volatility and to identify whether volatility returns on the variables is affected by the crisis. The GARCH method is used because it can explain the characteristics or behaviour of the variance that are not constant.

Volatility Measures

The GARCH method used to identify whether crisis affects the samples of the variables. This study examines the estimation of the generalized mode to the case where both p and q are set to 1 since several studies indicate the adequacy of this specification in fitting time series [13]. Dummy variables in this analysis represent for crisis whether its influence to precious metals returns or not where 0 represent as no crisis and 1 represent as crisis happens for each of the series in precious metals returns.

In the analysis, DUMMY1 and DUMMY2 are created based on crisis period from 1 July 1997 to 30 September 1998 and from 1 August 2007 to 30 October 2008 respectively, while DUMMY3 is created based on both period.

The date is considered as referred from the economic situation as mentioned above. The date is chosen not on exact date because it is not mentioned when the event is actually happened. Therefore for the first analysis, DUMMY1 represents for July 1997 to September 1998 crisis period is analyze and the results shown in Table 4.4 until Table 4.7 for each of the variables.

TABLE (4). Maximum likelihood estimation for GARCH (1,1) with DUMMY1

| | Variance Equation | | | | Mean Equation | | |
|-----------------|--------------------|--------------------|--------------------|---------------------|--------------------|---------------------|---------------------|
| | α_0 | α_1 | β_1 | DUMMY1 | μ | δ | DUMMY1 |
| Precious Metals | | | | | | | |
| Gold | 0.0023 (0.0000) | 0.0549 (0.0000) | 0.9464 (0.0000) | 0.0031 (0.0633) | 0.0056 (0.6107) | 0.0086 (0.5789) | -0.0593 (0.1771) |
| Silver | 0.1451 (0.0000) | 0.1281 (0.0000) | 0.8376 (0.0000) | 0.1147 (0.0004) | 0.0504 (0.0213) | -0.0646 (0.0000) | -0.0515 (0.6641) |
| Bronze | 0.0169 (0.0000) | 0.0239 (0.0000) | 0.9691 (0.0000) | -0.0104 (0.0000) | 0.0407 (0.0643) | -0.0969 (0.0000) | -0.1552 (0.0154) |
| Platinum | 0.0218 (0.0000) | 0.1006 (0.0000) | 0.8945 (0.0000) | 0.0306 (0.0291) | 0.0275 (0.0868) | 0.0147 (0.3444) | -0.0851 (0.3172) |

From the Table 4, the probabilities (values in parenthesis) of the DUMMY1 in the mean equation for all variables show that the existence of crisis is not significant in influencing the variables which the value is greater than 0.01 or 1%. This is shown by the probability of 0.1771, 0.6641, 0.0154 and 0.3172 for gold, silver, bronze and platinum returns respectively. Meanwhile, from the variance equation in the same tables, it suggests that the existence of crisis is significant in influencing silver and bronze returns. This is shown by the probability of 0.0004 and 0.0000 while gold and platinum returns are not significant according to the probability of 0.0633 and 0.0291 in 1%. Comparing the result of variance equation in terms of significances in their model, it suggests that investing in silver and bronze returns will be facing more risk as compare to gold and platinum returns.

TABLE (5). Maximum likelihood estimation for GARCH (1,1) with DUMMY2

| | Variance Equation | | | | Mean Equation | | |
|-----------------|--------------------|--------------------|--------------------|--------------------|--------------------|---------------------|---------------------|
| | α_0 | α_1 | β_1 | DUMMY2 | μ | δ | DUMMY2 |
| Precious Metals | | | | | | | |
| Gold | 0.0026 (0.0000) | 0.0523 (0.0000) | 0.9474 (0.0000) | 0.0233 (0.0000) | 0.0006 (0.9554) | 0.0082 (0.5952) | 0.0992 (0.2092) |
| Silver | 0.1458 (0.0000) | 0.1268 (0.0000) | 0.8381 (0.0000) | 0.1393 (0.0000) | 0.0442 (0.0433) | -0.0647 (0.0000) | 0.0539 (0.6766) |
| Bronze | 0.0162 (0.0000) | 0.0229 (0.0000) | 0.9694 (0.0000) | 0.0184 (0.0164) | 0.0291 (0.1747) | -0.0952 (0.0000) | -0.0750 (0.4273) |
| Platinum | 0.0193 (0.0000) | 0.0988 (0.0000) | 0.8984 (0.0000) | 0.0107 (0.2313) | 0.0185 (0.2483) | 0.0140 (0.3694) | 0.1093 (0.1924) |

From the Table 5, the probabilities (values in parenthesis) of the DUMMY2 in the mean equation for all variables show that the existence of crisis is not significant in influencing the variables which the value is greater than 0.01 or 1%. This is shown by the probability of 0.2092, 0.6766, 0.4273 and 0.1924 for gold, silver, bronze and platinum returns respectively. Whereas, from the variance equation in the tables, it suggests that the existence of crisis is significant in influencing gold and silver returns. This is shown by the probability of 0.0004 and 0.0000 while bronze and platinum returns are not significant according to the probability of 0.0164 and 0.2313 in 1%. Comparing the result of variance equation in terms of significances in their model, it suggests that investing in gold and silver returns will be facing more risk as compare to bronze and platinum returns.

From the Table 6, the probabilities (values in parenthesis) of the DUMMY3 in the mean equation for all variables show that the existence of crisis is not significant in influencing the variables which the value is greater than 0.01 or 1%. This is shown by the probability of 0.4678, 0.9948, 0.0116 and 0.7924 for gold, silver, bronze and platinum returns respectively. However, from the variance equation in the same tables, it suggests that the existence of crisis is significant in influencing gold and silver returns. This is shown by the probability of 0.0017 and 0.0000 while bronze and platinum returns are not significant according to the probability of 0.0242 and 0.0113 in 1%. Comparing the result of variance equation in terms of significances in their model, it suggests that investing in gold and silver returns will be facing more risk as compare to bronze and platinum returns.

TABLE (6). Maximum likelihood estimation for GARCH (1,1) with DUMMY3

| | Variance Equation | | | | Mean Equation | | |
|-----------------|---------------------|--------------------|--------------------|---------------------|--------------------|---------------------|---------------------|
| | α_0 | α_1 | β_1 | DUMMY3 | μ | δ | DUMMY3 |
| Precious Metals | | | | | | | |
| Gold | 0.0023 (0.0000) | 0.0550 (0.0000) | 0.9456 (0.0000) | 0.0057 (0.0017) | 0.0040 (0.7184) | 0.0089 (0.5665) | -0.0268 (0.4678) |
| Silver | 0.1490 (0.0000) | 0.1291 (0.0000) | 0.8322 (0.0000) | 0.1406 (0.0000) | 0.0478 (0.0306) | -0.0651 (0.0000) | -0.0005 (0.9948) |
| Bronze | -0.1381 (0.0000) | 0.0246 (0.0000) | 0.9686 (0.0000) | -0.0050 (0.0242) | 0.0457 (0.0457) | -0.0963 (0.0000) | -0.1381 (0.0116) |
| Platinum | 0.0201 (0.0000) | 0.0980 (0.0000) | 0.8974 (0.0000) | 0.0205 (0.0113) | 0.0216 (0.1843) | 0.0144 (0.3558) | 0.0161 (0.7924) |

Overall, the GARCH model has significant variance equation indicating the importance of modeling changing variance while the mean equation is not significant, indicating inadequacy of fitting the return series. However, in this study it only considering on variance equation rather than mean equation because of GARCH model deals with variance equation which this study attempts to see the impact of financial crisis on precious metal returns.

CONCLUSION

Financial crisis could affect the returns of four precious metals. An empirical study is conducted with applying ARCH and GARCH method to analyze the data of precious metal returns. The focus on this study is to see the impact of precious metals returns in facing the global financial crisis and to provide new guidance for the investors prior making investment decisions on precious metals. The significant of dummies variables for the variance equation in previous Table 4, 5 and 6 is summarized in the Table 7. From the results, the resilient of precious metals returns will be clarified.

TABLE (7). The Significant of DUMMY Variables for Variance Equation

| | Gold | Silver | Bronze | Platinum |
|--------|-----------------|-------------|-----------------|-----------------|
| DUMMY1 | Not significant | significant | significant | Not significant |
| DUMMY2 | significant | significant | Not significant | Not significant |
| DUMMY3 | significant | significant | Not significant | Not significant |

Table 7 above showing that for the crisis period of July 1997 to September 1998 which is represent by DUMMY1, it suggests that investing in silver and bronze returns will be facing more risk as compare to gold and platinum returns. This finding shows that gold and platinum returns are more resilience towards crisis compared to silver and bronze returns. With these results, gold and platinum returns are better alternative for the investor especially during crisis time.

However, for the crisis period of August 2007 to October 2008 which is represent by DUMMY2, it suggests that investing in gold and silver returns will be facing more risk as compared to bronze and platinum returns. This finding shows that bronze and platinum returns are more resilience towards crisis compared to gold and silver. With these results, bronze and platinum returns are better alternative for the investor especially during the crisis time.

Meanwhile, for the both crisis period of July 1997 to September 1998 and August 2007 to October 2008 which is represent by DUMMY3, suggested that investing in gold and silver returns will be facing more risk as compared to bronze and platinum returns. This finding shows that bronze and platinum returns are more resilience towards crisis compared to gold and silver returns for the both period. With these results, bronze and platinum returns are better alternative for the investor especially during crisis time.

From all the findings, it can be concluded that investing in platinum return is the most secure compared to the other precious metals returns because it is not influence by the crisis period. However, some of risk seeker investors usually like to take the risk during crisis period because it will give higher return. But, for the investor which is afraid to take the risks, it will be better to invest in platinum return.

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