

GDE ASE Project 2020

Relationship between gold and US stock market returns during financial crises

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Gold is widely used as a hedge against volatility in investment portfolios and a financial safe haven in times of market turmoil, suggesting that gold is negatively correlated or uncorrelated with market performance. This project uses data on daily returns to construct a linear time series regression model to study the relationship between gold and US market returns in the short-run. The recent COVID-19 pandemic and the 2008 financial crisis are used to evaluate how gold prices have behaved during recent episodes of financial market instability and whether these changes coincide with its popular denomination as a safe haven and its use as a diversification instrument.

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Program(s): EViews

1. Background

Gold is widely believed to be negatively correlated with stock market performance. This belief has fuelled its status as a hedge against volatility and a financial safe haven in times of market turmoil.

Baur and Lucey (2010) define a safe haven “as an asset that is uncorrelated or negatively correlated with another asset or portfolio in times of market stress or turmoil” and a hedge as “a diversifier is defined as an asset that is positively (but not perfectly correlated) with another asset or portfolio on average”. Combined with economic theory, which suggests that prices rise with an increase in demand, we would expect the price of gold to rise during period of market turmoil and thereby be negatively correlated with market performance.

Historical relationship...

Financial crisis...

Covid-19 crisis...

This project will use data on daily gold and S&P 500 returns to evaluate the relationship between the price of gold and the US stock market during recent episodes of market turmoil, namely the 2008 financial crisis and the recent COVID-19 pandemic. My aim is to determine whether the attribute of gold as a safe haven holds in financial crises in the short-run.

In section 2, information on the data used in my analysis is provided. Section 3 presents an overview of the historical relationship between gold and US stock market prices. Section 4 evaluates the statistical correlation between daily gold and stock market returns in two periods of market turmoil. The results of this correlation analysis are then used to construct a linear regression model in section 5. This project concludes with section 6, in which I summarize my findings.

An appendix is provided at the end with statistical details in the form of graphs and tables not included in the main text.

2. Data

The daily prices of gold and the S&P 500 were used to create graphs and the corresponding daily returns (%) were used for statistical analysis:

Gold

For the gold prices, I used the Gold Fixing Price 3:00 P.M. (London time) from the Federal Reserve Economic Data database (<https://fred.stlouisfed.org/>) (reference: GOLDPMGBD228NLBM) in U.S. Dollars per Troy Ounce.

S&P 500 index

For the S&P 500 prices, I used the closing price of the S&P 500 from the Yahoo! Finance database (<https://finance.yahoo.com/>) (reference: ^GSPC) in U.S. Dollars.

3. Relationship between gold and S&P 500 index

Historical relationship

Figure 1 shows the prices of gold and S&P from 1968 to 2020. Prices in both markets appear to

have steadily increased over time, and are clearly higher at the end of the sample than in the beginning.

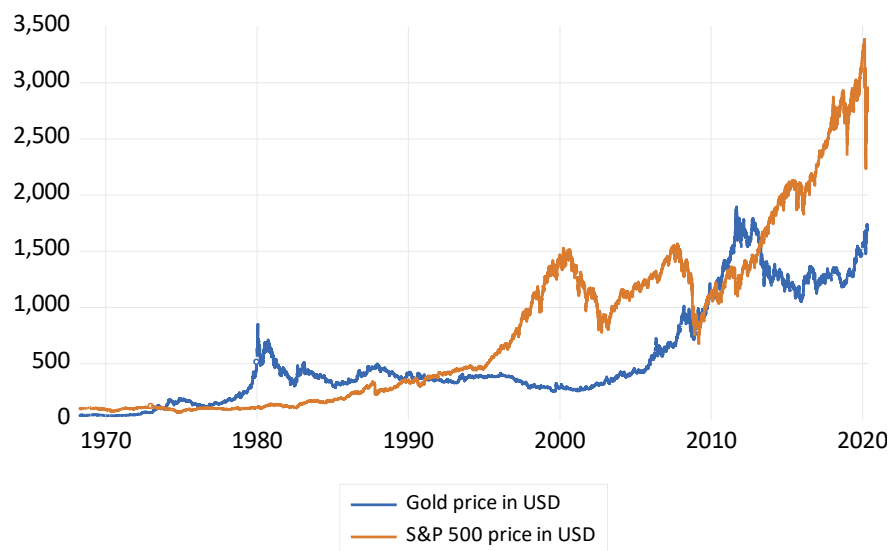


Figure 1. Historical prices of gold and S&P 500 (1968-2020).

The prices appear to overlap at four years: 1973, 1991, 2008, and 2013, coinciding with historical financial phenomena, namely the 1973 oil crisis, the run-up to the dotcom bubble in the 1990s, the 2008 financial crisis, and the European debt crisis. These overlaps at more or less consistent intervals throughout history suggest that the US stock market and gold prices are closely related.

Moreover, the fact that these overlaps coincide with periods of economic, political, or financial instability supports the view that gold and stock markets are correlated during times of market turmoil. Furthermore, these overlaps support the idea that these two indices are negatively correlated – in other words, as one rises, the other falls and vice versa.

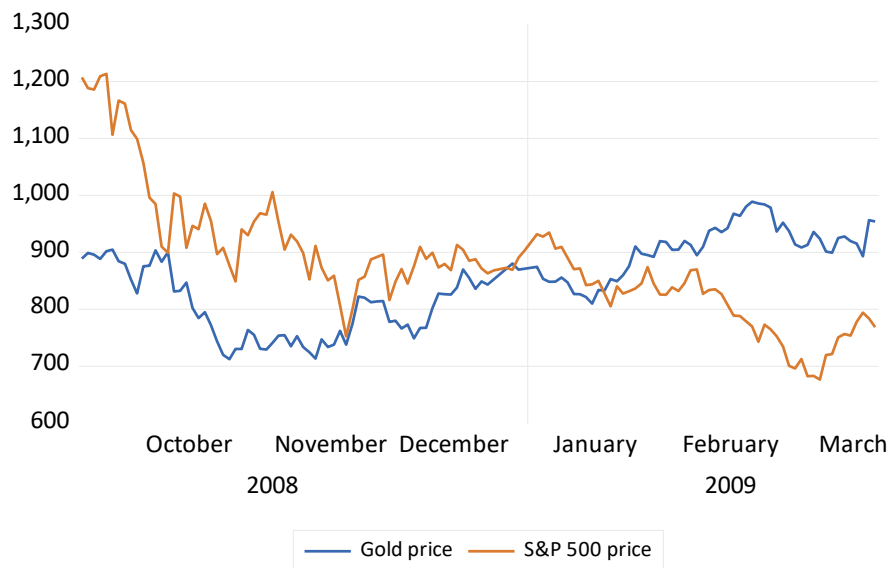
In Figure 1, gold and stocks also appear to experience periods of positive correlation and other when they do not appear to correlated at all: examples? Therefore, I hypothesized that there is no long-run correlation between gold and the S&P 500, but a significant negative correlation in the short-run during times of market turmoil.

H1: No long-run correlation.

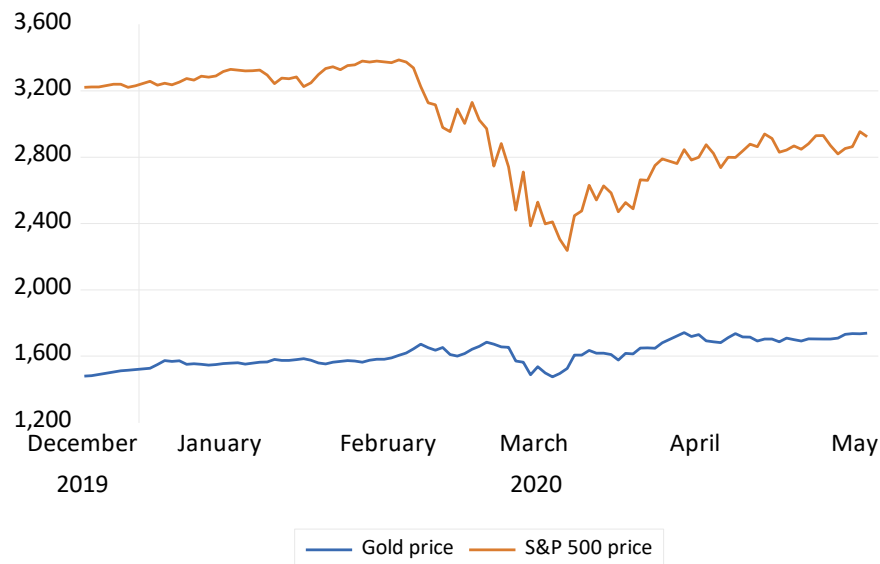
H2: Short-run negative correlation.

Relationship during financial crises

A closer look at two recent periods of market turmoil is shown in **Figure 2A** (2008 financial crisis) and **Figure 2B** (COVID-19 pandemic).



(A)



(B)

Figure 2. Prices of gold and S&P 500 during (A) financial crisis in 2008 and (B) COVID-19 pandemic in 2020.

Figure 2A shows the relationship between gold and the S&P during the end of the 2008 financial crisis. There appears to initially be a positive correlation between the two variables, both losing 26% and 17% in value during October 2008, respectively (**Table 1**). However, this correlation appears to be negative from November 2008 onwards as the price of gold appears to rise while the S&P 500 continues to fall.

Figure 2B shows the relationship between gold and the S&P during the beginning of the ongoing COVID-19 pandemic. Prior to the pandemic, the prices of gold and the S&P 500 were both rising. However, both the S&P 500 and gold prices fell sharply in late February and early March, losing 33% and 5% of their value in one month, respectively (**Table 1**).

Table 1. Worst monthly returns for gold and S&P 500 during financial crisis and COVID-19 pandemic.

| | Index | Overall return |
|--|---------|----------------|
| COVID-19 pandemic (February 2020[*]) | S&P 500 | -33.7% |
| | Gold | -5.8% |
| Financial crisis (October 2008[†]) | S&P 500 | -26.8% |
| | Gold | -16.9% |

* February 20 to March 23, 2020. †October 1 to October 27, 2008.

4. Correlation analysis

To determine whether gold and US stock market returns are statistically correlated over the short-run during financial crises, I used two short-run subsamples for correlation analysis: (1) a 6-month interval of the financial crisis (2008-2009) and (2) a 6-month interval of the COVID-19 pandemic (2019-2020) (**Table 2**).

A 6-month period was chosen as the duration of both samples because this is the duration of the COVID-19 pandemic at the time of writing. The same sample size was used for the 2008 financial crisis for comparison.

Table 2. Short-run subsamples for correlation analysis.

| | Sample | Size | No. of observations |
|--------------------------|---------------------|----------|---------------------|
| Financial crisis | Sep 2008 – Mar 2009 | 6 months | 130 |
| COVID-19 pandemic | Dec 2019 – May 2020 | 6 months | 109 |

Plotting gold returns against S&P returns showed contrasting results for the two subsamples (**Figure 4**): a weakly negative correlation during the financial crisis and a strongly positive correlation during the COVID-19 pandemic. However, covariance analysis confirmed that only the correlation during the COVID-19 pandemic was significant ($p=0.000$) at the 5% level (**Table 3**).



Figure 4. Scatterplots of gold returns against S&P500 returns during the 2008 financial crisis (left) and the COVID-19 pandemic (right).

Table 3. Correlation between gold and market returns in short-run subsamples.

| | Correlation (<i>r</i>) | P-value | No. of observations |
|--------------------------|--------------------------|---------------|---------------------|
| Financial crisis | -0.068 | 0.465 | 117 |
| COVID-19 pandemic | 0.515 | 0.000* | 89 |

* Significant at 5% level ($p < 0.05$)

The lack of a significant correlation between gold and stock market returns during the 2008 financial crisis confirms what is implied in the graph in **Figure 2**, where the relationship appears to be positive during the first month, before becoming negative.

Similarly, the significantly positive correlation between gold and stock market returns during the COVID-19 pandemic seems to confirm what is implied in the graph in **Figure 3**, whereby gold and S&P 500 returns appear to be positively correlated both before and after the fall in the S&P 500 index in February, 2020.

5. Regression analysis

Model

To quantify the correlation between gold and stock market returns, I used the following univariate linear regression model:

$$d\log(\text{gold}) = \alpha + \beta d\log(\text{sp500}) + u_t$$

where $d\log(\text{gold})$ denotes the change in the log of the gold price and $d\log(\text{sp500})$ denotes the change in the log of the S&P 500 index. A regression was run for each of the short-run subsamples, and a summary of the regression output is provided in **Table 4**.

Table 4. Summary of regression analysis results of short-run subsamples.

| | Financial crisis (Sep 2008 – Mar 2009) | | COVID-19 pandemic (Dec 2019 – May 2020) | |
|---------|---|---------|--|---------------|
| | Coefficient | P-value | Coefficient | P-value |
| β | -0.045 | 0.465 | 0.225 | 0.000* |

* Significant at 5% level ($p < 0.05$).

Analysis of financial crisis subsample

As shown above in **Table 4**, there appears to be a no correlation between gold and S&P returns during the financial crisis, as expected (Table S3).

However, a breakpoint test (Quandt-Andrews unknown breakpoint) detects a statistically significant breakpoint in late October 2008 (10/20/2008) at the 5% level ($p = 0.0439$) (Table S4), as suspected from the graphs (**Figure 2**) and correlation analysis (**Figure 4**).

After running a set of regression models, one before and one after the confirmed breakpoint, the relationship appears to be the opposite of what was initially expected (**Table 5**):

- The regression before the breakpoint (i.e. late September to late October 2008) indicates a significant negative relationship between daily gold returns on S&P returns in the first month of the financial crisis subsample, with a 1% change in the S&P index causing a -0.30% change in the gold price ($p = 0.0212$), at the 5% level (Table S5).
- The regression after the breakpoint (i.e. late October 2008 to late March 2009) indicates a significant positive relationship, with a 1% change in the S&P index causing a 0.16% change in the gold price ($p = 0.0576$), at the 10% level (Table S6).

The “pre-breakpoint” regression model has <30 observations. However, both variables appear to be normally distributed (Figure S2).

Table 5. Regression results of financial crisis subsample before and after 10/20/2008 breakpoint.

| | Financial crisis pre-breakpoint (late Sep 2008 – late Oct 2008) | | Financial crisis post-breakpoint (late Oct 2008 – late Mar 2009) | |
|---------|--|---------------|---|----------------|
| | Coefficient | P-value | Coefficient | P-value |
| β | -0.303 | 0.021* | 0.167 | 0.057** |

* Significant at 5% level ($p < 0.05$). ** Significant at 10% level ($p < 0.10$).

Neither model shows evidence of serial correlation ($DW = 2.0-2.5$) and both appear to have small standard errors of regression (2.1-2.6%) (Table S5 and S6).

This change in the relationship between gold and S&P returns mid-sample explains the lack of correlation found in the initial correlation analysis, and indicates that what initially appeared to be a positive correlation followed by a negative correlation is in fact the inverse.

Analysis of COVID-19 pandemic subsample

As shown above in **Table 4**, there appears to be a significant positive relationship between gold and S&P returns during the COVID-19 pandemic.

In a regression of daily gold returns on S&P returns over the final month of 2019 and the first half of 2020, a 1% change in the S&P index caused a 0.23% change in the gold price (significant at $p=0.00$), with a small standard error of regression (1.23%) and no evidence of serial correlation ($DW=2.53$) (Table S6).

5. Model fit

Despite providing statistically significant, serially uncorrelated, homoscedastic results, in this section I analyse the fit of my model and discuss how it may be improved.

Correlation analysis

Despite being statistically significant, the regression line on the scatterplots is not closely fitted to the data in Figure 4. Although there is, particularly for 2020. In fact, this regression line seems to be distorted by several outliers.

Outliers

The large number of outliers seems to suggest that this analysis is particularly sensitive

Residuals

6. Discussion

Although gold is widely believed to be negatively correlated with stock market indices in times of market turmoil, my analysis suggests that this relationship does not hold in the US stock market during the 2008 financial crisis or the current COVID-19 pandemic. In fact, gold was found to behave counterintuitively to its status of a safe haven, either becoming positively correlated with an ailing US stock market or remaining positively correlated before and after a sustained run of negative returns in a major US stock index.

Although my findings seem to initially discredit the widely held belief that gold is inversely correlated or uncorrelated with the stock market, in the following sub-sections, I provide some intuition for these counterintuitive results.

A dash for cash

In times of financial turmoil, cash is king. As markets lose value, investors rush to obtain cash by selling any available assets, such as gold, which is one of the most liquid assets after cash. This is evident in both the financial crisis in 2008 and the COVID-19 pandemic, where the price of an oz. of gold appears to drop with the stock index, as investors sell off their gold holdings in exchange for increased liquidity.

The regression model for gold returns on S&P returns during both the COVID-19 pandemic and financial crisis initial positive relationship of gold and stock during financial crises.

During the 2008 financial crisis gold was found to be negatively correlated to stock market returns initial, there is clearly a downward trend in the price of gold during the first month of my sample (Figure 2A)

Gold as a store of value

Here, I provide some intuition for the negative relationship of gold and stock during financial crises.

Intuition for negative relationship between gold and stock indices: As markets lose value, asset are moved to safer investment that will hold value, e.g. gold. After an initial sell-out, it is expected for gold to grow and obtain upward momentum as the market shifts into a risk-off attitude.

Duration of market volatility

Intuition for positive relationship during COVID-19 pandemic: Unlike the change in correlation observed during the 2008 financial crisis, gold appears to have remained positively correlated with markets throughout 6-month sample period, i.e. the current duration of the ongoing pandemic. This may be partly due to the nature of the market response to the COVID-19 pandemic – a sharp fall in the stock index was followed by an equally a sharp rise.

7. Conclusion

Due to the ongoing nature of the COVID-19 pandemic, my analysis of the COVID-19 pandemic has been restricted to the beginning of this crisis. It will be worth monitoring the changes in the prices of gold and S&P 500 index in the coming months to see how the relationship between these two variables changes as this crisis develops further.

Furthermore, with regards to the 2008 financial crisis, there is much more data available for this episode than the current COVID-19 pandemic. The results of my analysis reflect only one period during the financial crisis, which started in 2007 and had an effect on financial markets from 2007 until 2009. My analysis draws on data obtained near the end of this crisis, and it may be worth looking at other samples from this crises, whether a 6-month sample in the earlier stages of the financial crises or the full 3-year sample.

Lastly, this analysis focused solely on the short-run relationship between the price of gold and the S&P index in times of ailing stock markets using samples comprising 6 months of data. More insights could be gained by using larger sample sizes and more variables, including analysing periods of stable markets and using volatility as a measure of correlation.

6. Bibliography

Baur and Lucey (2010). Is Gold a Hedge or a Safe Haven? An Analysis of Stocks, Bonds and Gold. *The Financial Review* 45 (2010) 217–229.

Appendix

Supplementary tables and figures to support my analysis can be found in this Appendix, where “S” in the figure and table numbering denotes “supplementary”. The files included herein are as follows: (i) tables of covariance analysis; (ii) regression output results; (iii) graphs of fitted residual; (iv) histograms to verify normality.

1. Correlation analysis

Table S1. Covariance analysis for gold and S&P 500 daily returns in financial crisis subsample: September 2008 to March 2009.

| | | |
|---|--|-----------------------------------|
| Covariance Analysis: Ordinary Date: 05/24/20 Time: 22:47 Sample: 9/22/2008 3/20/2009 Included observations: 117 Balanced sample (listwise missing value deletion) | | |
| Correlation t-Statistic Probability | | |
| Observations | SP500_DLOG | GOLD_DLOG |
| SP500_DLOG | 1.000000 ----- ----- 117 | |
| GOLD_DLOG | -0.068167 -0.732719 0.4652* 117 | 1.000000 ----- ----- 117 |

* Not significant at 1%, 5%, or 10% level.

Table S2. Covariance analysis of gold and S&P 500 daily returns in COVID-19 subsample: December 2019 to May 2020.

| | | |
|---|---|--|
| Covariance Analysis: Ordinary Date: 05/21/20 Time: 12:39 Sample: 12/23/2019 5/19/2020 Included observations: 89 Balanced sample (listwise missing value deletion) | | |
| Correlation t-Statistic Probability | | |
| Observations | GOLD_DLOG | SP500_DLOG |
| GOLD_DLOG | 0.000207 1.000000 ----- ----- 89 | |
| SP500_DLOG | 0.000244 0.515097 5.605325 0.0000* 89 | 0.001084 1.000000 ----- ----- 89 |

* Significant at 5% level (p<0.05).

2. Regression output

2.1. Financial crisis: September 2008 to March 2009

Table S3. Regression output of financial crisis subsample: September 2008 to March 2009.

| Dependent Variable: GOLD_DLOG | | | | |
|-------------------------------|-------------|-----------------------|-------------|-----------|
| Method: Least Squares | | | | |
| Date: 05/24/20 Time: 22:31 | | | | |
| Sample: 9/22/2008 3/20/2009 | | | | |
| Included observations: 117 | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| C | -0.000299 | 0.002257 | -0.132359 | 0.8949 |
| SP500_DLOG | -0.045307 | 0.061834 | -0.732719 | 0.4652* |
| R-squared | 0.004647 | Mean dependent var | | -0.000124 |
| Adjusted R-squared | -0.004008 | S.D. dependent var | | 0.024233 |
| S.E. of regression | 0.024282 | Akaike info criterion | | -4.581241 |
| Sum squared resid | 0.067804 | Schwarz criterion | | -4.534025 |
| Log likelihood | 270.0026 | Hannan-Quinn criter. | | -4.562072 |
| F-statistic | 0.536877 | Durbin-Watson stat | | 2.117752 |
| Prob(F-statistic) | 0.465221 | | | |

* Not significant at 1%, 5%, or 10% level.

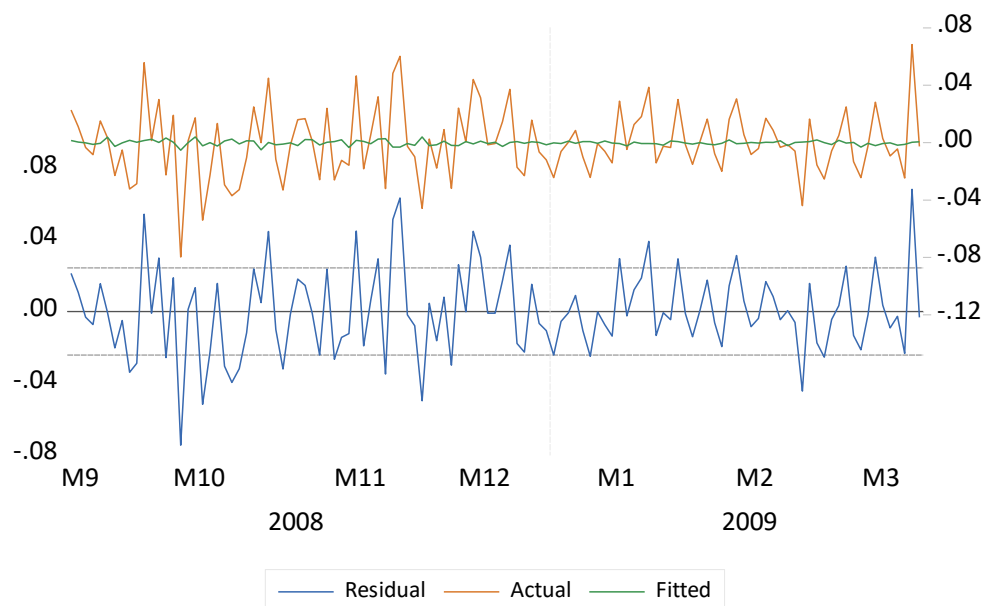


Figure S1. Plotted fitted residuals of regression analysis for financial crisis subsample: September 2008 to March 2009.

Table S4. Quandt-Andrews unknown breakpoint test: significant breakpoint at 10/20/2008.

| Quandt-Andrews unknown breakpoint test Null Hypothesis: No breakpoints within 15% trimmed data Varying regressors: All equation variables Equation Sample: 9/22/2008 3/20/2009 Test Sample: 10/16/2008 2/25/2009 Number of breaks compared: 82 | | |
|---|----------|----------------|
| Statistic | Value | Prob. |
| Maximum LR F-statistic (10/20/2008) | 5.935979 | 0.0439* |
| Maximum Wald F-statistic (10/20/2008) | 11.87196 | 0.0439 |
| Exp LR F-statistic | 1.287964 | 0.0969 |
| Exp Wald F-statistic | 3.406127 | 0.0404 |
| Ave LR F-statistic | 1.522421 | 0.1708 |
| Ave Wald F-statistic | 3.044842 | 0.1708 |
| Note: probabilities calculated using Hansen's (1997) method WARNING: estimation sample is non-continuous (probabilities calculated assuming a continuous sample) | | |

* Significant at 5% level ($p < 0.05$).

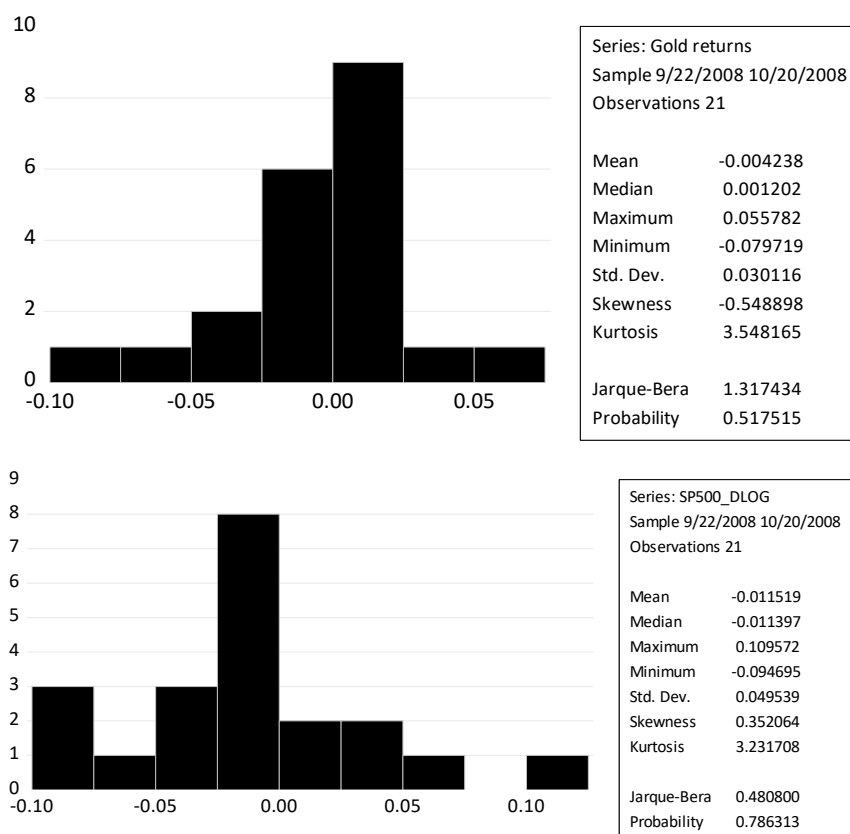


Figure S2. Histograms confirming the normality of gold and S&P 500 returns in reduced financial crisis subsample (<30 observations): September to October 2008.

Table S5. Regression output of pre-breakpoint financial crisis subsample: September to October 2008.

| Dependent Variable: GOLD_DLOG | | | | |
|-------------------------------|-------------|-----------------------|-------------|----------------|
| Method: Least Squares | | | | |
| Date: 05/24/20 Time: 22:36 | | | | |
| Sample: 9/22/2008 10/20/2008 | | | | |
| Included observations: 21 | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| C | -0.007735 | 0.006005 | -1.288120 | 0.2132 |
| SP500_DLOG | -0.303586 | 0.120831 | -2.512485 | 0.0212* |
| R-squared | 0.249385 | Mean dependent var | | -0.004238 |
| Adjusted R-squared | 0.209879 | S.D. dependent var | | 0.030116 |
| S.E. of regression | 0.026769 | Akaike info criterion | | -4.312727 |
| Sum squared resid | 0.013615 | Schwarz criterion | | -4.213249 |
| Log likelihood | 47.28363 | Hannan-Quinn criter. | | -4.291138 |
| F-statistic | 6.312579 | Durbin-Watson stat | | 2.537897 |
| Prob(F-statistic) | 0.021175 | | | |

* Significant at 5% level ($p < 0.05$).

Table S6. Regression output of post-breakpoint financial crisis subsample: October 2008 to March 2009.

| Dependent Variable: GOLD_DLOG | | | | |
|-------------------------------|-------------|-----------------------|-------------|----------------|
| Method: Least Squares | | | | |
| Date: 05/24/20 Time: 23:44 | | | | |
| Sample: 11/20/2008 3/20/2009 | | | | |
| Included observations: 74 | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| C | 0.001601 | 0.002526 | 0.633754 | 0.5282 |
| SP500_DLOG | 0.167556 | 0.086824 | 1.929831 | 0.0576* |
| R-squared | 0.049182 | Mean dependent var | | 0.001580 |
| Adjusted R-squared | 0.035976 | S.D. dependent var | | 0.022133 |
| S.E. of regression | 0.021731 | Akaike info criterion | | -4.793479 |
| Sum squared resid | 0.034002 | Schwarz criterion | | -4.731207 |
| Log likelihood | 179.3587 | Hannan-Quinn criter. | | -4.768638 |
| F-statistic | 3.724248 | Durbin-Watson stat | | 2.041141 |
| Prob(F-statistic) | 0.057568 | | | |

* Significant at 10% level ($p < 0.10$).

2.2. COVID-19 pandemic: December 2019 to May 2020

Table S7. Regression output of COVID-19 pandemic subsample.

| Dependent Variable: GOLD_DLOG | | | | |
|---|-------------|-----------------------|-------------|----------------|
| Method: Least Squares | | | | |
| Date: 05/24/20 Time: 22:52 | | | | |
| Sample (adjusted): 12/23/2019 5/19/2020 | | | | |
| Included observations: 89 after adjustments | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| C | 0.001393 | 0.001325 | 1.051184 | 0.2961 |
| SP500_DLOG | 0.225371 | 0.040207 | 5.605325 | 0.0000* |
| R-squared | 0.265325 | Mean dependent var | | 0.001022 |
| Adjusted R-squared | 0.256880 | S.D. dependent var | | 0.014485 |
| S.E. of regression | 0.012486 | Akaike info criterion | | -5.906133 |
| Sum squared resid | 0.013564 | Schwarz criterion | | -5.850209 |
| Log likelihood | 264.8229 | Hannan-Quinn criter. | | -5.883592 |
| F-statistic | 31.41967 | Durbin-Watson stat | | 1.860022 |
| Prob(F-statistic) | 0.000000 | | | |

* Significant at 5% level ($p < 0.05$).

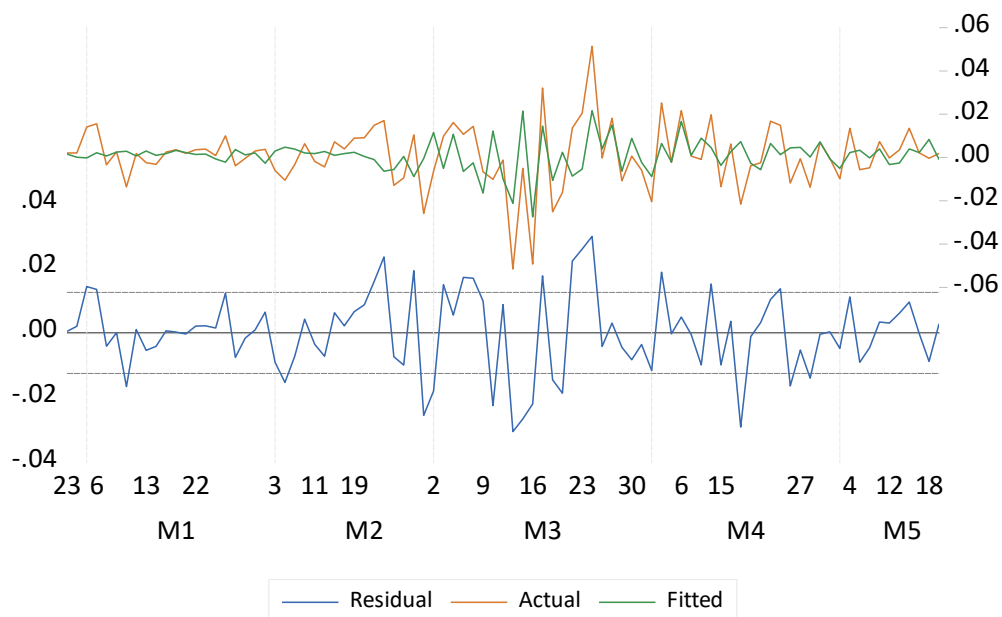


Figure S3. Fitted residuals of COVID-19 subsample (2019-2020) regression analysis.