Empirical analysis of flight-to-quality from stocks into gold in the US during economic recessions (1969-2020)

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ABSTRACT

Background: Gold is widely viewed as a safe haven in times of market turmoil, a period that is characterized by investor flight-to-quality, a financial market phenomenon wherein investors sell higher-risk investments and purchase safer assets. However, research on this claim in relation to gold has reported inconsistent results both within and across different economies. This project seeks to evaluate the behaviour of gold prices within the world's largest economy, the United States, during periods of economic recession to provide empirical evidence for this claim.

Methods: Returns for gold were compared to returns for the S&P 500 stock index during eight recessionary periods: 1969, 1973, 1980, 1981, 1990, 2001, 2007, and 2020. A time series econometric analysis using a regression of gold returns on stock index returns at different frequencies (daily, weekly, and monthly) was used to evaluate the relationship between gold and S&P 500 during these periods. Additional analyses using descriptive statistics were used to gain further insights into a potential relationship between the two assets.

Results: Gold returns were only significantly correlated with S&P 500 returns in three of the eight recessions studied when using daily returns: 1981, 1990, and 2020. Paradoxically, within these periods, gold returns were only negatively correlated with S&P 500 returns in 1990 alone, and positively correlated otherwise. Furthemore, the use of longer frequencies (weekly and monthly data) in the regression model resulted in fewer significant relationships and one new relationship, casting doubt on the reliability of using returns to model relationships between assets in financial markets.

Conclusion: Evidence was observed both for and against the generalized belief that gold and stocks are negatively correlated during economic recessions, providing evidence against the commonly held belief that investors widely divest from stocks and invest in gold during financial markets crises. Further analysis could explore whether these findings hold in other countries, including large emerging markets and developing economies, to shed light on investor behaviour during financial crises. The use of additional variables (US bonds) in the regression model could improve the statistical power of the model and provide further insights into the role of gold in times of market turmoil.

1. INTRODUCTION

The belief that gold is an inherently valuable commodity has persisted for centuries, dating from its use in coins in 600 BC to its role backing the US dollar up until the 1970s through the Bretton Woods agreement (Metcalf 2012). Although gold no longer holds weight in monetary terms, it continues to carry both financial and economic importance today, best represented by the present size of its holdings on the balance sheets of many central banks (WGC 2021).

The holding of gold by governments and large public institutions is strategy used to weather financial crisis partly due to the fact that fiat currencies are subject to value erosion through inflation and foreign exchange volatility. As gold is not subject to exchange rates, it is widely ascribed the role of a hedge against inflation and as a store for value during times of financial crisis, when investments in other financial instruments tend to yield negative returns. In this way, gold is also commonly viewed as a barometer for economic sentiment, with demand for gold rising during periods of financial crisis. Similarly, the opposite is true for stock markets, which are typically used as barometers for the economic health of a country, gaining in value during expansionary periods and losing value during financial crises.

At any given time the economy fluctuates between peaks and troughs of activity, based on the growth of real GDP over time, known as the business cycle (NBER 2020). These different phases are reflected in financial markets, with asset allocation varying according to investor sentiment. This manifests in the paradigm of “risk-on” and “risk-off” asset allocation under which asset prices are dictated by changes in investors’ risk tolerance. During the latter, a phenomenon known as flight-to-quality is often observed, wherein investors move their money from risky assets into safe assets. High-yielding instruments, including equity stocks, are among the former, while the latter includes lower-yield instruments, among which US bonds and gold are popular choices.

The intuition underlying “risk-on” and “risk-off” investing indicates that risky and safe assets should be either negatively correlated or uncorrelated, which may partly explain the widely held belief that gold and stocks are negatively correlated. Figure 1 plots the prices of gold and S&P 500 from 1968 to 2020 in an attempt to visualize this potential relationship.

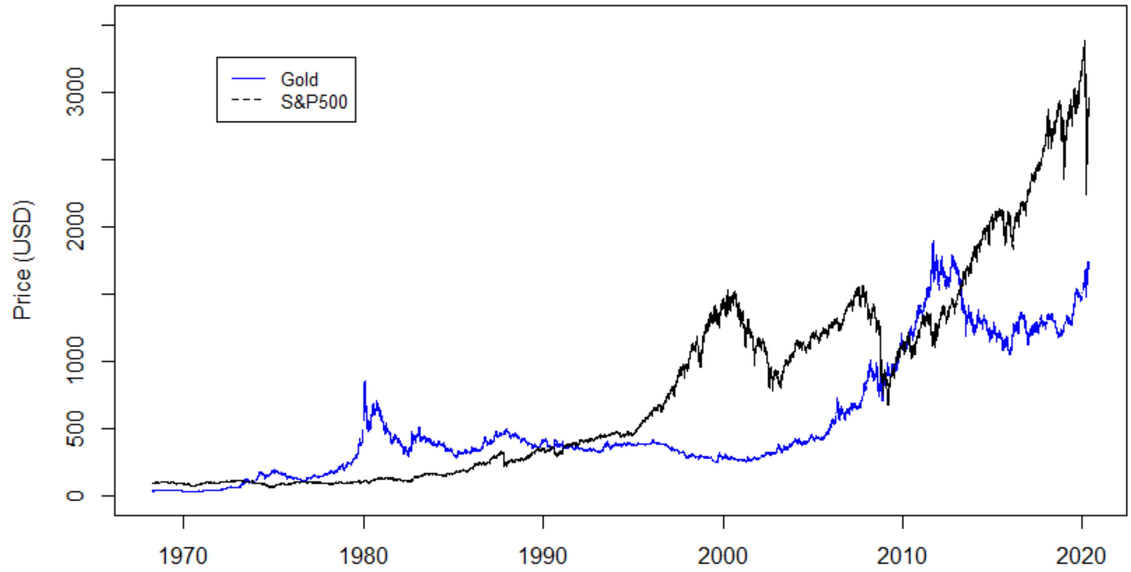

Figure 1. Gold and S&P 500 prices (1968-2020). Evolution of the prices of gold (blue) and S&P 500 (black) over the last 50 years. Gold price is expressed in USD/oz. Data were obtained from Federal Reserve Economic Data database for gold and Yahoo! Finance database for S&P 500.

The prices of gold and S&P 500 clearly overlap four times, in 1973, 1991, 2008, and 2013. These years coincide with historical financial crises, including the 1973 oil crisis, the run-up to the dotcom bubble in the 1990s, the 2008 financial crisis, and the European debt crisis. That these overlaps at more or less consistent intervals throughout history suggest that the US stock market and gold prices move in opposite directions, at least during periods of economic instability.

To empirically evaluate the relationship between the price of gold and stocks during period of financial crises, this project will analyze the movements in gold and S&P 500 prices during eight episodes of market turmoil in the 20th century, including the recent COVID-19 pandemic and the 2008 financial crisis.

The remainder of this report is organised as follows. Section 2 provides an overview of the literature on the topic of gold and highlights some of the shortcomings of current research. Sections 3 and 4 present the data and research design used in my analysis, respectively. Section 5 presents the results, the implications of which are discussed in-depth in Section 6. Section 7 concludes by summarizing my findings and discussing potential future perspectives. Appendices providing detailed statistical output are included at the end.

2. LITERATURE REVIEW

Flight-to-quality is a phenomenon observed in financial markets in which investors experience a pronounced and rapid increase in their appetite for risk. This shift in investor sentiment is generally manifested as a wide divestment from high-return ("risky") assets to low-return ("safe") alternatives in an attempt to manage out exposure to risk in portfolios (Caballero 2008).

The relationship between these two types of assets has important implications on the wider economy, as expressed by Hartmann et al. (2004), who explored the effects of linkages between the returns of different assets during periods of stress in an attempt to evaluate the inherent stability of financial markets and determine the amount of systemic risk within these markets on an international level.

This shift in investor behaviour is often observed in a move of investments from the stock market to US Treasury bonds (Gulko 2002, Connolly et al. 2005, Baur and Lucey 2006). The same pattern is also widely believed to hold true for gold. The yellow metal has long being considered as an alternative to high-return assets in times of financial turmoil. In fact, many have studied the relationship between gold and indicators of economic activity in an attempt to identify a pattern in investor behaviour during periods of financial stress. However, despite the narrative widely portrayed in the financial media (Hume 2022), empirical evidence for a simple way relationship between the stock market and gold is lacking.

One example of the lack of a clear relationship between gold and other assets is given by Baur and Lucey (2010), who used a regression model of gold on stocks and bonds to determine whether gold acts as a safe haven in the US, UK, and Germany. Although they found that gold acted as a safe haven for stocks in the short-run, this relationship varied between that observed in the US and Germany and that in the UK. This highlights the fact that gold may behave differently in different countries and cannot be assigned a strictly negative correlation with stocks on a global level.

In this context of variable findings, particular attention should be paid to the phenomenon of the random walk, famously applied to stocks and financial markets by Robert Malkiel (Malkiel, 1973). This theory claims daily return rates are inherently random and cannot be predicted. However, in research on financial assets, particularly in the study of stocks and other asset returns, high-frequency returns data is often used. In research of gold price movements specifically, a range of different data frequencies have been used to model the relationship between gold and other assets, whether daily (Baur and Lucey 2010, Wang 2013), weekly (Capie 2005, Joy 2011, Reboredo 2013), or monthly (Akbar 2019, Iqbal 2017). This raises the question as to whether the use of different frequencies plays a role in the different (at times contradictory) findings on gold price behaviour in financial markets.

This project will evaluate the safe haven status of gold according to Baur and Lucey's definition, namely "an asset that is uncorrelated or negatively correlated with another asset or portfolio in times of market stress or turmoil" (Baur and Lucey 2010). To this end, three different types of data (daily, weekly, and monthly) will be used to test the hypothesis that gold acts as a safe haven during financial crises in the US.

3. DATA

3.1. US recessions

This project analyses financial data within recessionary periods only. Eight recessionary periods, as defined by the National Bureau of Economic Research (NBER), in the US throughout the 20th century were chosen for the analysis of gold and S&P 500 price behaviour:

(1) 2020: COVID-19 pandemic from 3 February 2020 to 1 April 2020 ~~[42]~~

(2) 2007: The Great Recession from 3 December 2007 to 1 June 2009 ~~[390]~~

(3) 2001: Early 2000s recession from 1 March 2001 to 1 November 2001 ~~[175]~~

(4) 1990: Early 1990s recession from 2 July 1990 to 1 March 1991 ~~[174]~~

(5) 1981: Early 1980s recession II from 1 July 1981 to 1 November 1982 ~~[348]~~

(6) 1980: Early 1980s recession I from 2 January 1980 to 1 July 1980 ~~[129]~~

(7) 1973: End of Bretton Woods and oil crisis from 1 November 1973 to 3 March 1975 ~~[347]~~

(8) 1969: Recession of 1969–1970 from 1 December 1969 to 2 November 1970 ~~[240]~~

Throughout this report, these periods are denoted by their start year.

A graphic representation of these periods is shown in **Figure 2**, with the eight periods studied in this project indicated by asterisks.

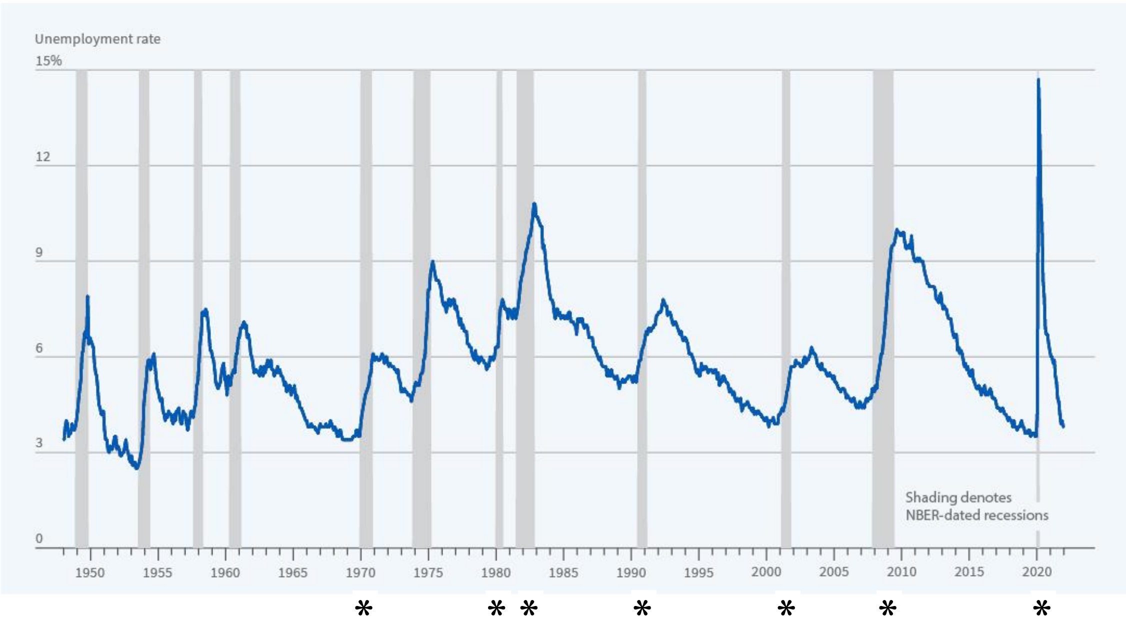

Figure 2. US business cycle (1950-2020). The unemployment rate in the US is plotted to show the relationship between rising and falling rates of unemployment during and between economic recessions (shaded in gray). Asterisks denote the recessionary periods evaluated in this project. Source: Bureau of Labor Statistics via the Federal Reserve Bank of St. Louis.

The average duration of the recessions was 231 ± 115 working days (mean ± SD). The most recent recession, corresponding to the COVID-19 pandemic, was the shortest (42 days). The NBER addresses this anomaly by stating that, despite the short duration, the drop in economic activity was large and diffuse enough to be classified as a recession (NBER 2020).

3.2. Gold price

The data series for gold was comprised of daily observations on the price of gold, quoted in US dollars per troy ounce. The gold price represents the Gold Fixing Price 3:00 PM (London time) as quoted by the Federal Reserve Economic Data database. Daily prices from 1 December 1969 to March 31 2020 were used, with a total of 1835 observations.

3.3. S&P 500 price

The data series for the S&P 500 stock index was comprised of daily observations on the price of the index, quoted in US dollars. The stock price represents the closing price of the S&P 500 quoted by the Yahoo! Finance database. Daily prices from 1 December 1969 to March 31 2020 were used, with a total of 1835 observations.

3.4. Data pre-processing

3.4.1. Missing data

Due to the continuous nature of the data and the long time series of the datasets included in this project (n = 3670 daily data points), some data points were missing (right-most column in **Table 1**).

Missing data can be addressed either by excluding or interpolating the missing data points. This involves an inherent trade-off between accuracy and having enough data for statistical analysis, since estimating missing data can lead to inaccuracies but may be impossible if too much data is missing.

In the case of my dataset, the rate of missing data was low (~5%, i.e. 5 missing values for every 100 data points). However, because my analysis involved the use different frequencies (e.g. daily, weekly, and monthly returns) for which the number of data points decreased exponentially, every data point was significant. For this reason, any missing data points were interpolating using the averaging method.

Most often, one data point would be missing between two days. In this case, the average of the values above and below the missing data point was used to obtain a value. In cases with more than missing data point in consecutive days, the same method was used:

This is worth mentioning because at least 5% of the data points in my dataset were interpolated, and thus not true. However, because of the low rate of missing data, my interpolation is unlikely to affect my results.

3.4.2. Detrending

Finally, as the statistical modeling of time series variables using regression requires stationary time series, the daily price data was used to compute daily, weekly, and monthly returns using the following formulas (Eq. 1-3):

$$Daily\ returns = \frac{P(t)-P(t-1)}{P(t-1)} \tag{1}$$

$$Weekly\ returns = \frac{P(t)-P(t-5)}{P(t-5)} \tag{2}$$

$$Monthly\ returns = \frac{P(t)-P(t-20)}{P(t-20)} \tag{3}$$

The calculated returns were used for all subsequent statistical analyses.

All of the time periods studied were sufficiently long for the purposes of statistical modeling using regression analysis when using daily (n = 231 ± 114 observations) and weekly (n = 42 ± 22 observations) returns, with a minimum of 30 data points per period, as per the Central Limit Theorem.

However, the number of observations for monthly returns were well below the necessary threshold for all of the periods studied (n = 11 ± 5 observations).

To address any potential violations of the assumptions required for regression analysis, the returns in all data sets were subjected to the appropriate diagnostic tests, described in in the Research Design section below (section 4.1 , “Regression analysis”).

3.5. Summary of data sets

A summary of the data sets used, including the number of data points corresponding to each recessionary period evaluated, is given in **Table 1**.

Table 1. Summary of eight data series for the prices and returns of gold and S&P 500.

Period	Number of data points				Missing data points	
	Daily prices	Daily returns	Weekly returns	Monthly returns	Gold	S&P 500
2020	44	43	8	2	1	2
2007	391	390	72	18	30	30
2001	176	175	32	8	9	13
1990	175	174	32	8	9	12
1981	350	349	64	16	22	20
1980	132	131	24	6	8	7
1973	349	348	64	16	19	24
1969	242	241	44	11	13	12

4. RESEARCH DESIGN

4.1. Regression analysis

To evaluate the relationship between gold and stock market returns over time, three univariate linear regression models were constructed (Eq. 4-6). The models differed in their use of daily, weekly, and monthly data:

$$Daily\ gold\ returns\ =\ \alpha\ +\ \beta\ (S\&P500\ daily\ returns)\ +\ u_t \tag{4}$$

$$Weekly\ gold\ returns\ =\ \alpha\ +\ \beta\ (S\&P500\ weekly\ returns)\ +\ u_t \tag{5}$$

$$Monthly\ gold\ returns\ =\ \alpha\ +\ \beta\ (S\&P500\ monthly\ returns)\ +\ u_t \tag{6}$$

Gold was used as the dependent variable and S&P 500 as the independent variable because of the nature of the flight-to-flight phenomenon, wherein a fall in a stock index precedes a rise in the price of gold due to increase demand in periods of higher risk.

The regression models were run in R (RStudio, version 2021.09.1) for each recessionary period studied (1968, 1973, 1980, 1981, 1990, 2001, 2007, and 2020). A summary of the regression output is provided in the Results section (**Table 2**). Full regression outputs are provided in **Appendix I**.

4.2. Diagnostic tests

The diagnostic tests used to evaluate the assumptions required for the use of regression analysis are described in the following sections, including normality, linearity, homoscedasticity, and serial correlation.

4.2.1. Normality

Normality was tested using the Shapiro-Wilk's test in the "stats" package in R. Data was considered to follow a normal distribution when $p > 0.05$.

4.2.2. Linearity

Linearity was tested using the Harvey-Collier test in the "lmtest" package in R. The models were considered to be linear when $p > 0.05$.

4.2.3. Homoscedasticity

Homoscedasticity was tested using the Breusch-Pagan test in the "lmtest" package in R. The models were considered to exhibit homoscedasticity when $p > 0.05$.

4.2.4. Serial correlation

The presence of serial correlation was tested using the Durbin-Watson test in the "lmtest" package in R. This test is particularly important to discard the notion that the returns data follow a random walk. Data were considered to exhibit no serial correlation when $p > 0.05$.

4.3. Other statistical analyses

Additional analyses were used for comparison with the regression results in the case that the regression model is not a good fit for the data. The results of each robustness test were used to gain either supporting evidence or evidence against the results of the regression model.

4.3.1. Period returns

The overall returns for S&P 500 and gold over each period were calculated to identify potential patterns:

$$Period\ return = \frac{P(k) - P(1)}{P(1)} \qquad (7)$$

where *k* denotes the final price in a given period's data series and "1" denotes the first price given for the period. The results of the calculations are presented in **Table 3**. The results were expected to match the regression data and show an inverse relationship, with negative S&P 500 returns and positive gold returns overall.

4.3.2. Correlation analysis

Pearson's correlation analysis was used to gain insights into the relationship between S&P 500 and gold returns rather than their casual dependence, as in the regression model. The resulting scatterplots were used to observe both the trends and significance of relationship between the assets. The results of the analysis in R presented in **Table 4**. Based on the initial hypothesis, a significant ($p < 0.05$) negative correlation ($r < 0$) was expected between the two assets.

5. RESULTS

5.1. Regression analysis

5.1.1. Results

The results of the regression analysis are presented in **Table 2**. A summary of the significant results is provided in the following subsections.

Daily data

A significant relationship between daily gold returns and daily S&P 500 returns was observed in 1981, 1990, and 2020 ($p < 0.01$). Interestingly, gold returns were only found to be negatively correlated with S&P 500 returns in 1990, in agreement with my hypothesis: a 1% rise in S&P 500 returns resulted in a 0.29% fall in gold returns. By contrast, in 1981 and 2020, gold returns were positively correlated with S&P 500 returns, yielding a 0.41% and 1.3% rise in gold returns for every 1% rise in S&P 500 returns, respectively. The 1981, 1990, and 2020 regression models exhibited poor to moderate coefficients of determination ($R^2 = 0.05$, 0.07, and 0.3, respectively), indicative of the weak statistical power of these models.

Weekly data

A significant relationship between daily gold returns and daily S&P 500 returns was observed in 1981 and 1990 only ($p < 0.01$), and the significant relationship between returns in 2020 was lost ($p > 0.05$). In 1990, weekly gold returns retained the negative relationship observed using daily data, wherein a 1% rise in S&P 500 returns resulted in 0.45% fall in gold returns. The contradictory finding that gold returns were positively correlated with S&P 500 returns in 1981 was also sustained, with a 1% rise in S&P 500 returns resulting in a 0.99% rise in gold returns. These models exhibited higher coefficients of determination ($R^2 = 0.26$ and 0.24 for 1981 and 1990, respectively) compared to the same models using daily data.

Monthly data

A new significant relationship between gold returns and S&P 500 returns was observed when using monthly returns in 1980 ($p < 0.01$), and the significant relationship between returns in both 1981 and 1990 was lost ($p > 0.05$). In 1980, a 1% rise in S&P 500 returns resulted in a 2.24% rise in gold returns. This model exhibited the highest R^2 values among all of the models tested ($R^2 = 0.86$).

Table 2. Results of regression analysis using daily, weekly, and monthly returns. Bold is used to indicate models with statistically significant results.

Period	Returns frequency	*β*		Goodness-of-fit (R^2)
		Coefficient	***P*-value**	
2020	Daily	**1.3041**	**0.0001341***	**0.3023**
	Weekly	0.281169	0.2466	0.2154
	Monthly	0.22594	NA	1
2007	Daily	-0.0636025	0.09788	0.007046
	Weekly	-0.088094	0.4692	0.007509
	Monthly	0.08865	0.7239	0.008017
2001	Daily	-0.0808190	0.1664	0.01104
	Weekly	0.12368	0.3509	0.02906
	Monthly	-0.114155	0.6744	0.03145
1990	Daily	**-0.2940646**	**0.0002746***	**0.07427**
	Weekly	**-0.450518**	**0.004405***	**0.2402**
	Monthly	-0.369821	0.2102	0.247
1981	Daily	**0.4196712**	**5.519e-05***	**0.04585**
	Weekly	**0.981338**	**1.178e-05***	**0.2681**
	Monthly	0.665983	0.11	0.1722
1980	Daily	0.048791	0.8911	0.0001459
	Weekly	0.66790	0.3023	0.04827
	Monthly	**2.24407**	**0.007715***	**0.8601**
1973	Daily	0.031707	0.6908	0.0004578

	Weekly	-0.016687	0.9085	0.0002148
	Monthly	0.23932	0.4456	0.04216
1969	Daily	-0.0107409	0.6311	0.0009665
	Weekly	-0.004851	0.1167	0.05758
	Monthly	-0.007148	0.5438	0.04236

*Significant at 1% level (p < 0.01).

5.1.2. Reliability of the regression results

Although few violations of the assumptions required for regression analysis were observed overall, the data showed significant deviations from normality, homoscedasticity, and serial correlation for several periods at given data frequencies, providing evidence against the reliability of my results.

First, significant ($p < 0.01$) deviations from normality were observed for several daily and weekly data sets (**Appendix II, Table 1**). In the daily data sets, a significant deviation from normality was observed for all data sets except 2020. This may be due to the sensitivity of the Durbin-Watson statistic to large data sets. This line of thinking is supported by the fact that the smallest daily data set (2020, n= 43 observations) was normally distributed. Furthemore, because of the large number of observations for each daily data set, normality could be assumed. Thus, the results for the daily data were discarded, and the data was considered to hold true for normality.

For the weekly data, no evidence of deviation from normality, except in 2001 and 1981 weekly data. This has potentially important implications for the reliability of outcome of the weekly regression model for both periods, since 2001 did not show a significant relationship wile 1981 showed a significant positive relationship. Finally, no evidence of deviation from normality for all monthly data sets.

Second, evidence for heteroscedasticity was observed in the daily data for the periods of 1981 and 1990 (**Appendix II, Table 2**). This calls into question the significant relationships observed for these periods, since heteroscedasticity tends to produce p-values that are smaller than they should be, and very small p-values were exhibited by both models. However, it is worth noting that the significant relationships observed in the regression using daily data were sustained in the regression using weekly data, in which no heteroscedasticity was observed. This suggests that the results of the model for 1981 and 1990 are in fact reliable.

Third, evidence for first-order autoregression was observed in the monthly data for 1973 and the daily data for 1969 (**Appendix II, Table 3**). Similar to heteroscedasticity, this error tends to produce p-values that are smaller than they should be. However, no significant relationships were observed for either regression model, which suggests that this error did not impact my findings.

Lastly, no evidence for deviation from linearity was observed for any of the models at different data frequencies (**Appendix II, Table 4**), which provided support for the use of a regression model.

It is worth noting that no test statistics were generated for the monthly data set of 2020 due to the small sample size (n = 2).

5.2. Robustness analysis

5.2.1. Period returns

Positive versus negative returns

In five out of the eight recessionary periods, a negative relationship appeared to hold between gold and S&P 500 returns: gold returns were positive and S&P 500 returns were negative in 1969, 1973, 2001, 2007, and 2020 (**Table 3**). However, this relationship was violated in the three remaining periods – 1980, 1981, and 1990 – during which both gold and S&P 500 experienced positive returns overall.

Trends

The size of the returns was highly variable between periods, ranging from positive returns of +1% and +87% for gold to returns of -38% to +9% for S&P 500. Gold returns were positive during all periods. In periods when both variables experience positive returns, gold returns tended be higher, except for during two successive recessionary periods (1981 and 1990), during which S&P 500 experienced higher returns than gold.

Table 3. Returns for S&P 500 index and gold price for entire eight recessionary periods.

Period	Variable	Return (%)
COVID-19 pandemic (2020)	Gold	+2%
	S&P 500	-20%
The Great Recession (2007-2008)	Gold	+24%
	S&P 500	–38%
Early 2000s recession (2001)	Gold	+5%
	S&P 500	–15%
Early 1990s recession (1990)	Gold	+1%
	S&P 500	+3%
Early 1980s recession II (1981)	Gold	+1%
	S&P 500	+4%
Early 1980s recession I (1980)	Gold	+18%
	S&P 500	+9%
End of Bretton Woods and oil crisis (1973)	Gold	+87%
	S&P 500	–23%
Recession of 1969–1970 (1969-1970)	Gold	+6%
	S&P 500	–10%

5.2.2. Pearson's correlation analysis

Daily data

A significant correlation was observed in three periods: 1981, 1990, and 2020. In 2020 and 1981, gold returns were positively correlated with S&P 500 returns ($r = 0.55$ in 2020, r = 0.22 in 1981, $p < 0.01$) (**Appendix III, Figure 1a,e**). By contrast, in 1990, gold returns using Pearson's correlation analysis were negatively correlated with S&P 500 returns ($r = -0.25$ in 2020, $p < 0.01$) (**Appendix III, Figure 1d**).

Weekly data

A significant correlation was observed in two periods: 1981 and 1990. The significance between gold and S&P 500 returns in the 2020 period that was observed when using daily returns was lost.

In 1981, gold returns using Pearson's correlation analysis remained positively correlated with S&P 500 returns (r = 0.52, $p < 0.01$) (**Appendix III, Figure 2e**). Similarly, in 1990, gold returns using Pearson's correlation analysis remained negatively correlated with S&P 500 returns ($r = -0.49$, $p < 0.01$) (**Appendix III, Figure 2d**).

Both relationships became stronger (r = -0.25 vs. -0.49 in 1990 and r = 0.22 vs. 0.52 in 1981) in their respective directions when using weekly data.

Monthly data

The significance between gold and S&P 500 returns that held in both 1981 and 1990 when using weekly data was lost when monthly data was used in the model. By contrast, a new significant positive relationship was observed between gold and S&P 500 returns for 1980 (r = 0.93, p < 0.01) (**Appendix III, Figure 3f**).

Table 4. Results for Pearson's correlation analysis using (a) daily, (b) weekly, and (c) monthly returns. Bold is used to indicate models with statistically significant results.

(a) Daily returns

Period	**R**	***P*-value**
2020	**0.55**	**0.00024***
2007	-0.081	0.13
2001	-0.067	0.4
1990	**-0.25**	**0.0016***
1981	**0.22**	**7.6e-05***
1980	0.036	0.69
1973	0.029	0.6
1969	-0.036	0.59

*Significant at 1% level (p < 0.01)

(b) Weekly returns

Period	**R**	***P*-value**
2020	0.46	0.25
2007	-0.087	0.47
2001	0.17	0.35
1990	**-0.49**	**0.0044***
1981	**0.52**	**1.2e-05***
1980	0.22	0.3
1973	-0.015	0.91
1969	-0.24	0.12

*Significant at 1% level ($p < 0.01$)

(c) Monthly returns

Period	**R**	***P*-value**
2020	NA	NA
2007	0.09	0.72
2001	-0.18	0.67
1990	-0.5	0.21
1981	0.41	0.11
1980	**0.93**	**0.0077***
1973	0.21	0.45
1969	-0.21	0.54

*Significant at 1% level ($p < 0.01$)

6. DISCUSSION

The literature on the role of gold in financial markets is rich and varied. While several studies claim that gold is an inflation hedge, acts as a safe haven in times of stress, and serves as a currency hedge, other studies that have found no significant relationship between gold and other financial assets.

This project focused specifically on the claim that gold acts as a safe haven during times of market stress. To address both the inconsistency in the frequency of data used in the literature on this topic and the bias imposed by the theory of random walk, three different frequencies were used when modeling gold and stock returns, namely daily, weekly, and monthly.

Despite the widely held belief that gold is negatively correlated with stocks in times of market turmoil, my analysis suggests that this relationship does not hold in the US. A lack of a significant relationship between gold and S&P 500 returns was observed in the majority of the recessionary periods studied under regression analysis, with only three out of the eight periods studied showing significant relationships between these two assets. This lack of significance was also reflected in the correlation analysis, casting doubt on the theory that gold and S&P 500 prices move together, at least during financial crises.

Furthermore, in the three models that showed significant relationships, two showed a positive relationship between S&P 500 and gold returns, providing evidence against the belief that stocks and gold are negatively correlated. An additional key result was the fact that the regression results were sensitive to the choice of data frequency. The number of significant relationships decreased as the frequency of the data increased, casting doubt on the reliability of using returns to model relationships between assets in financial markets.

Although the reliability of the regression results was found to hold through the use of diagnostic tests, the models exhibited a poor fit overall. The reasons for this could be attributed to the choice of periods studied and to the simplicity of the regression models used.

Firstly, the use of recessionary periods (NBER) in my time series analysis could account for the lack of significant relationships, as these periods are typically longer and do not necessarily align with financial markets crises. It is widely understood that the prospect of recession usually, but not always, brings about a major stock price downturn. Further analyses could seek to use breakpoint analysis in the time series models presented here to identify where within the recessionary period financial markets crash, focusing a subsequent regression within these specific periods.

Lastly, the weakness of the statistical model could be due to the large number of potential confounders in this simple linear regression. To address the weak statistical power of the models used in this project, multilinear regression analysis could used to determine whether investors move their money into other assets aside from gold, including gold mining stocks, bonds, and other low-risk assets.

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APPENDICES

Appendix I: Regression output

Table 1. Output for regression of daily gold returns on daily S&P 500 returns in R. (a) 2020, (b) 2007, (c) 2001, (d) 1990, (e) 1981, (f) 1980, (g) 1973, and (h) 1969.

(a) 2020

```
Residuals:
    Min      1Q  Median      3Q     Max 
-6.1974 -2.4498 -0.1705  2.1819 10.4790 

Coefficients:
                          Estimate Std. Error t value Pr(>|t|)    
(Intercept)                -0.5360     0.5580  -0.960 0.342450    
X2020$`Daily SP500 returns`   1.3041     0.3094   4.214 0.000134 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 3.659 on 41 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.3023,	Adjusted R-squared:  0.2852 
F-statistic: 17.76 on 1 and 41 DF,  p-value: 0.0001341
```

(b) 2007

```
Residuals:
      Min        1Q    Median        3Q       Max 
-0.069926 -0.008405  0.000214  0.009546  0.069316 

Coefficients:
                            Estimate Std. Error t value Pr(>|t|)  
(Intercept)                0.0006668  0.0009175   0.727   0.4678  
X2007$`Daily SP500 returns` -0.0636025  0.0383325  -1.659   0.0979 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.01811 on 388 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.007046,	Adjusted R-squared:  0.004486 
F-statistic: 2.753 on 1 and 388 DF,  p-value: 0.09788
```

(c) 2001

```
Residuals:
      Min        1Q    Median        3Q       Max 
-0.035456 -0.004091 -0.000368  0.003264  0.067914 

Coefficients:
                            Estimate Std. Error t value Pr(>|t|)
(Intercept)                0.0002414  0.0007918   0.305    0.761
X2001$`Daily SP500 returns` -0.0808190  0.0581518  -1.390    0.166

Residual standard error: 0.01046 on 173 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.01104,	Adjusted R-squared:  0.005325 
F-statistic: 1.932 on 1 and 173 DF,  p-value: 0.1664
```

(d) 1990

```
Residuals:
      Min        1Q    Median        3Q       Max
-0.048883 -0.005897  0.000403  0.006919  0.041002

Coefficients:
                            Estimate Std. Error t value Pr(>|t|)
(Intercept)                0.0003050  0.0008964   0.340 0.734084
X1990$`Daily SP500 returns` -0.2940646  0.0791592  -3.715 0.000275 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.01182 on 172 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.07427,	Adjusted R-squared:  0.06889
F-statistic:  13.8 on 1 and 172 DF,  p-value: 0.0002746
```

(e) 1981

```
Residuals:
      Min        1Q    Median        3Q       Max
-0.074786 -0.011701 -0.001901  0.010223  0.101953

Coefficients:
                           Estimate Std. Error t value Pr(>|t|)
(Intercept)               0.0001421  0.0010365   0.137    0.891
X1981$`Daily SP500 returns` 0.4196712  0.1027797   4.083 5.52e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.01936 on 347 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.04585,	Adjusted R-squared:  0.0431
F-statistic: 16.67 on 1 and 347 DF,  p-value: 5.519e-05
```

(f) 1980

```
Residuals:
      Min        1Q    Median        3Q       Max
-0.134507 -0.021369 -0.003378  0.023077  0.130993

Coefficients:
                           Estimate Std. Error t value Pr(>|t|)
(Intercept)                0.002411   0.003631   0.664    0.508
X1980$`Daily SP500 returns` 0.048791   0.355664   0.137    0.891

Residual standard error: 0.0415 on 129 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.0001459,	Adjusted R-squared:  -0.007605
F-statistic: 0.01882 on 1 and 129 DF,  p-value: 0.8911
```

(g) 1973

```
Residuals:
      Min        1Q    Median        3Q       Max
-0.072624 -0.010960 -0.002171  0.010717  0.100618

Coefficients:
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)               0.001997   0.001073   1.861   0.0636 .
X1973$`Daily SP500 returns` 0.031707   0.079647   0.398   0.6908
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.01999 on 346 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.0004578,    Adjusted R-squared:  -0.002431
F-statistic: 0.1585 on 1 and 346 DF,  p-value: 0.6908
```

(h) 1969

```
Residuals:
      Min        1Q    Median        3Q       Max
-0.024478 -0.001350 -0.000192  0.001013  0.011659

Coefficients:
                            Estimate Std. Error t value Pr(>|t|)
(Intercept)                0.0002332  0.0002160   1.080    0.281
X1969$`Daily SP500 returns` -0.0107409  0.0223369  -0.481    0.631

Residual standard error: 0.00335 on 239 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.0009665,    Adjusted R-squared:  -0.003214
F-statistic: 0.2312 on 1 and 239 DF,  p-value: 0.6311
```

Table 2. Output for regression of weekly gold returns on weekly S&P 500 returns in R. (a) 2020, (b) 2007, (c) 2001, (d) 1990, (e) 1981, (f) 1980, (g) 1973, and (h) 1969.

(a) 2020

```
Residuals:
      Min        1Q    Median        3Q       Max
-0.067924 -0.017505  0.001028  0.015247  0.057263

Coefficients:
                           Estimate Std. Error t value Pr(>|t|)
(Intercept)                0.005972   0.014434   0.414    0.693
X2020$`Weekly SP500 returns` 0.281169   0.219053   1.284    0.247

Residual standard error: 0.04082 on 6 degrees of freedom
  (36 observations deleted due to missingness)
Multiple R-squared:  0.2154,         Adjusted R-squared:  0.08467
F-statistic: 1.648 on 1 and 6 DF,  p-value: 0.2466
```

(b) 2007

```
Residuals:
     Min        1Q    Median        3Q       Max
-0.086249 -0.027432  0.000522  0.029113  0.123616

Coefficients:
                           Estimate Std. Error t value Pr(>|t|)
(Intercept)                 0.002282   0.004752   0.480    0.633
X2007$`Weekly SP500 returns` -0.088094   0.121054  -0.728    0.469

Residual standard error: 0.04026 on 70 degrees of freedom
  (319 observations deleted due to missingness)
Multiple R-squared:  0.007509,      Adjusted R-squared:  -0.00667
F-statistic: 0.5296 on 1 and 70 DF,  p-value: 0.4692
```

(c) 2001

```
Residuals:
     Min        1Q    Median        3Q       Max
-0.057197 -0.010757 -0.000870  0.007194  0.082526

Coefficients:
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)                 0.00366    0.00443   0.826    0.415
X2001$`Weekly SP500 returns`  0.12368    0.13052   0.948    0.351

Residual standard error: 0.02488 on 30 degrees of freedom
  (144 observations deleted due to missingness)
Multiple R-squared:  0.02906,        Adjusted R-squared:  -0.003302
F-statistic: 0.898 on 1 and 30 DF,  p-value: 0.3509
```

(d) 1990

```
Residuals:
     Min        1Q    Median        3Q       Max
-0.046652 -0.014351  0.000611  0.012876  0.067081

Coefficients:
                           Estimate Std. Error t value Pr(>|t|)
(Intercept)                 0.003829   0.003979   0.962   0.3435
X1990$`Weekly SP500 returns` -0.450518   0.146279  -3.080   0.0044 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.02251 on 30 degrees of freedom
  (143 observations deleted due to missingness)
Multiple R-squared:  0.2402,          Adjusted R-squared:  0.2149
F-statistic: 9.485 on 1 and 30 DF,  p-value: 0.004405
```

(e) 1981

```
Residuals:
     Min       1Q   Median       3Q      Max 
-0.081999 -0.025814 -0.002542  0.024205  0.156127 

Coefficients:
                             Estimate Std. Error t value Pr(>|t|)    
(Intercept)                  0.004902   0.005087   0.964    0.339    
X1981$`Weekly SP500 returns` 0.981338   0.205922   4.766 1.18e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.04068 on 62 degrees of freedom
  (286 observations deleted due to missingness)
Multiple R-squared:  0.2681,	Adjusted R-squared:  0.2563 
F-statistic: 22.71 on 1 and 62 DF,  p-value: 1.178e-05
```

(f) 1980

```
Residuals:
     Min       1Q   Median       3Q      Max 
-0.144969 -0.020332  0.004395  0.038040  0.101813 

Coefficients:
                             Estimate Std. Error t value Pr(>|t|)
(Intercept)                   0.01187    0.01235   0.961    0.347
X1980$`Weekly SP500 returns`  0.66790    0.63228   1.056    0.302

Residual standard error: 0.05954 on 22 degrees of freedom
  (108 observations deleted due to missingness)
Multiple R-squared:  0.04827,	Adjusted R-squared:  0.005012 
F-statistic: 1.116 on 1 and 22 DF,  p-value: 0.3023
```

(g) 1973

```
Residuals:
     Min       1Q   Median       3Q      Max 
-0.088647 -0.028237 -0.007587  0.020995  0.114065 

Coefficients:
                              Estimate Std. Error t value Pr(>|t|)
(Intercept)                   0.006302   0.005109   1.234    0.222
X1973$`Weekly SP500 returns` -0.016687   0.144602  -0.115    0.908

Residual standard error: 0.04086 on 62 degrees of freedom
  (285 observations deleted due to missingness)
Multiple R-squared:  0.0002148,	Adjusted R-squared:  -0.01591 
F-statistic: 0.01332 on 1 and 62 DF,  p-value: 0.9085
```

(h) 1969

```
Residuals:
      Min         1Q     Median        3Q        Max
-0.0132492 -0.0030322 -0.0005348  0.0034081  0.0129178

Coefficients:
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)                 0.001278   0.000838   1.525    0.135
X1969$`Weekly SP500 returns` -0.004851   0.003028  -1.602    0.117

Residual standard error: 0.005557 on 42 degrees of freedom
  (198 observations deleted due to missingness)
Multiple R-squared:  0.05758,        Adjusted R-squared:  0.03514
F-statistic: 2.566 on 1 and 42 DF,  p-value: 0.1167
```

Table 3. Output for regression of weekly gold returns on weekly S&P 500 returns in R. (a) 2020, (b) 2007, (c) 2001, (d) 1990, (e) 1981, (f) 1980, (g) 1973, and (h) 1969.

(a) 2020

```
Residuals:
ALL 2 residuals are 0: no residual degrees of freedom!

Coefficients:
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)                  0.04278        NaN     NaN      NaN
X2020$`Monthly SP500 returns`  0.22594        NaN     NaN      NaN

Residual standard error: NaN on 0 degrees of freedom
  (42 observations deleted due to missingness)
Multiple R-squared:      1, Adjusted R-squared:    NaN
F-statistic:   NaN on 1 and 0 DF,  p-value: NA
```

(b) 2007

```
Residuals:
     Min       1Q   Median       3Q      Max
-0.17887 -0.05473  0.02630  0.05665  0.09899

Coefficients:
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)                  0.02395    0.01951   1.228    0.237
X2007$`Monthly SP500 returns`  0.08865    0.24652   0.360    0.724

Residual standard error: 0.08033 on 16 degrees of freedom
  (373 observations deleted due to missingness)
Multiple R-squared:  0.008017,       Adjusted R-squared:  -0.05398
F-statistic: 0.1293 on 1 and 16 DF,  p-value: 0.7239
```

(c) 2001

```
Residuals:
     Min        1Q    Median        3Q       Max
-0.046612 -0.024919  0.006155  0.015147  0.056256

Coefficients:
                            Estimate Std. Error t value Pr(>|t|)
(Intercept)                  0.006696   0.014569   0.460    0.662
X2001$`Monthly SP500 returns` -0.114155   0.258627  -0.441    0.674

Residual standard error: 0.03848 on 6 degrees of freedom
  (168 observations deleted due to missingness)
Multiple R-squared:  0.03145,        Adjusted R-squared:  -0.13
F-statistic: 0.1948 on 1 and 6 DF,  p-value: 0.6744
```

(d) 1990

```
Residuals:
    Min       1Q   Median       3Q      Max
-0.06362 -0.01027  0.01590  0.02332  0.02983

Coefficients:
                            Estimate Std. Error t value Pr(>|t|)
(Intercept)                  0.008377   0.013997   0.598    0.571
X1990$`Monthly SP500 returns` -0.369821   0.263591  -1.403    0.210

Residual standard error: 0.03959 on 6 degrees of freedom
  (167 observations deleted due to missingness)
Multiple R-squared:  0.247,           Adjusted R-squared:  0.1215
F-statistic: 1.968 on 1 and 6 DF,  p-value: 0.2102
```

(e) 1981

```
Residuals:
    Min       1Q   Median       3Q      Max
-0.11379 -0.05229 -0.01799  0.05544  0.11006

Coefficients:
                           Estimate Std. Error t value Pr(>|t|)
(Intercept)                 0.007536   0.017829   0.423    0.679
X1981$`Monthly SP500 returns` 0.665983   0.390247   1.707    0.110

Residual standard error: 0.0713 on 14 degrees of freedom
  (334 observations deleted due to missingness)
Multiple R-squared:  0.1722,          Adjusted R-squared:  0.1131
F-statistic: 2.912 on 1 and 14 DF,  p-value: 0.11
```

(f) 1980

```
Residuals:
        1         2         3         4         5         6 
-0.000539 -0.019345 -0.001489 -0.062997 -0.019552  0.103923 

Coefficients:
                           Estimate Std. Error t value Pr(>|t|)
(Intercept)                -0.01058    0.02654  -0.399  0.71049
X1980$`Monthly SP500 returns`  2.24407    0.45258   4.958  0.00772 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.06231 on 4 degrees of freedom
  (126 observations deleted due to missingness)
Multiple R-squared:  0.8601,	Adjusted R-squared:  0.8251 
F-statistic: 24.59 on 1 and 4 DF,  p-value: 0.007715
```

(g) 1973

```
Residuals:
     Min       1Q   Median       3Q      Max 
-0.10596 -0.06171 -0.01586  0.06761  0.20101 

Coefficients:
                           Estimate Std. Error t value Pr(>|t|)
(Intercept)                 0.04194    0.02269   1.849   0.0858 .
X1973$`Monthly SP500 returns`  0.23932    0.30488   0.785   0.4456  
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.08944 on 14 degrees of freedom
  (333 observations deleted due to missingness)
Multiple R-squared:  0.04216,	Adjusted R-squared:  -0.02626 
F-statistic: 0.6162 on 1 and 14 DF,  p-value: 0.4456
```

(h) 1969

```
Residuals:
       Min         1Q     Median         3Q        Max 
-0.0241051 -0.0086866 -0.0004109  0.0067690  0.0286153 

Coefficients:
                            Estimate Std. Error t value Pr(>|t|)
(Intercept)                 0.006368   0.004953   1.286    0.231
X1969$`Monthly SP500 returns` -0.007148   0.011330  -0.631    0.544

Residual standard error: 0.01568 on 9 degrees of freedom
  (231 observations deleted due to missingness)
Multiple R-squared:  0.04236,	Adjusted R-squared:  -0.06405 
F-statistic: 0.3981 on 1 and 9 DF,  p-value: 0.5438
```

Appendix II: Diagnostic tests

Table 1. Results of Shapiro-Wilk's test (test for normality).

	Frequency	**Statistic (W)**	**p-value**
2020	Daily	0.96546	0.2188
	Weekly	0.92918	0.5087
	Monthly	NA	NA
2007	Daily	**0.97125**	**5.78e-07***
	Weekly	0.99087	0.8861
	Monthly	0.93035	0.1969
2001	Daily	**0.80372**	**4.579e-14***
	Weekly	**0.84967**	**0.0004081***
	Monthly	0.94748	0.6858
1990	Daily	**0.94413**	**2.458e-06***
	Weekly	0.95669	0.2225
	Monthly	0.92136	0.441
1981	Daily	**0.96229**	**7.829e-08***
	Weekly	**0.92035**	**0.0005143***
	Monthly	0.94258	0.3818
1980	Daily	**0.97738**	**0.02756****
	Weekly	0.97758	0.8475
	Monthly	0.91034	0.4386
1973	Daily	**0.96033**	**4.225e-08***
	Weekly	0.96973	0.1171
	Monthly	0.94625	0.4328
1969	Daily	**0.81226**	**2.367e-16***
	Weekly	0.98346	0.7712
	Monthly	0.9765	0.9436

*Significant at 1% level ($p < 0.01$). **Significant at 5% level ($p < 0.05$)

Table 2. Results of Harvey-Collier test (test for linearity).

	Frequency	**Statistic (HC)**	**p-value**
2020	Daily	0.64862	0.5203
	Weekly	0.31356	0.7665
	Monthly	NA	NA
2007	Daily	0.55421	0.5798
	Weekly	0.032713	0.974
	Monthly	0.88448	0.3904
2001	Daily	0.4337	0.6651
	Weekly	0.97042	0.3399
	Monthly	0.82234	0.4483
1990	Daily	0.98469	0.3262
	Weekly	0.64576	0.5235
	Monthly	0.90727	0.4059
1981	Daily	0.52272	0.6015
	Weekly	0.43444	0.6655
	Monthly	0.071191	0.9443
1980	Daily	1.267	0.2075
	Weekly	0.59373	0.559
	Monthly	0.66759	0.5522
1973	Daily	1.2182	0.224
	Weekly	1.041	0.302
	Monthly	1.5927	0.1352
1969	Daily	1.3529	0.1774
	Weekly	1.1489	0.2573
	Monthly	1.6672	0.134

Table 3. Results of Breusch-Pagan test (test for homoscedasticity).

	Frequency	**Statistic (BP)**	**p-value**
2020	Daily	0.035228	0.8511
	Weekly	0.57076	0.45
	Monthly	NA	NA
2007	Daily	2.7183	0.0992
	Weekly	1.6085	0.2047
	Monthly	1.4842	0.2231
2001	Daily	0.031596	0.8589
	Weekly	0.62927	0.4276
	Monthly	0.35773	0.5498
1990	Daily	**5.1269**	**0.02356****
	Weekly	0.54306	0.4612
	Monthly	0.011314	0.9153
1981	Daily	**12.689**	**0.0003679***
	Weekly	1.2787	0.2581
	Monthly	0.0021128	0.9633
1980	Daily	1.7687	0.1835
	Weekly	1.5741	0.2096
	Monthly	0.22167	0.6378
1973	Daily	0.063721	0.8007
	Weekly	1.6623	0.1973
	Monthly	0.035481	0.8506
1969	Daily	0.58852	0.443
	Weekly	0.15429	0.6945
	Monthly	0.74248	0.3889

*Significant at 1% level ($p < 0.01$). **Significant at 5% level ($p < 0.05$)

Table 4. Results of Durbin-Watson test (test for serial correlation).

	Frequency	Statistic (DW)	p-value
2020	Daily	2.5189	0.9603
	Weekly	3.2228	0.9681
	Monthly	NA	NA
2007	Daily	1.9624	0.3575
	Weekly	2.1834	0.7828
	Monthly	2.205	0.655
2001	Daily	2.3067	0.9791
	Weekly	2.3232	0.8185
	Monthly	2.3607	0.7181
1990	Daily	2	0.4953
	Weekly	2.0893	0.5991
	Monthly	2.7823	0.8306
1981	Daily	2.3152	0.9984
	Weekly	1.8493	0.2687
	Monthly	2.0501	0.5092
1980	Daily	2.2109	0.887
	Weekly	2.4095	0.8444
	Monthly	1.3904	0.2059
1973	Daily	1.9239	0.2341
	Weekly	1.8195	0.2358
	Monthly	**1.1612**	**0.03175****
1969	Daily	**1.301**	**2.396e-08***
	Weekly	1.5335	0.0571
	Monthly	1.4173	0.1553

*Significant at 1% level ($p < 0.01$). **Significant at 5% level ($p < 0.05$)

Appendix III: Pearson's correlation scatterplots

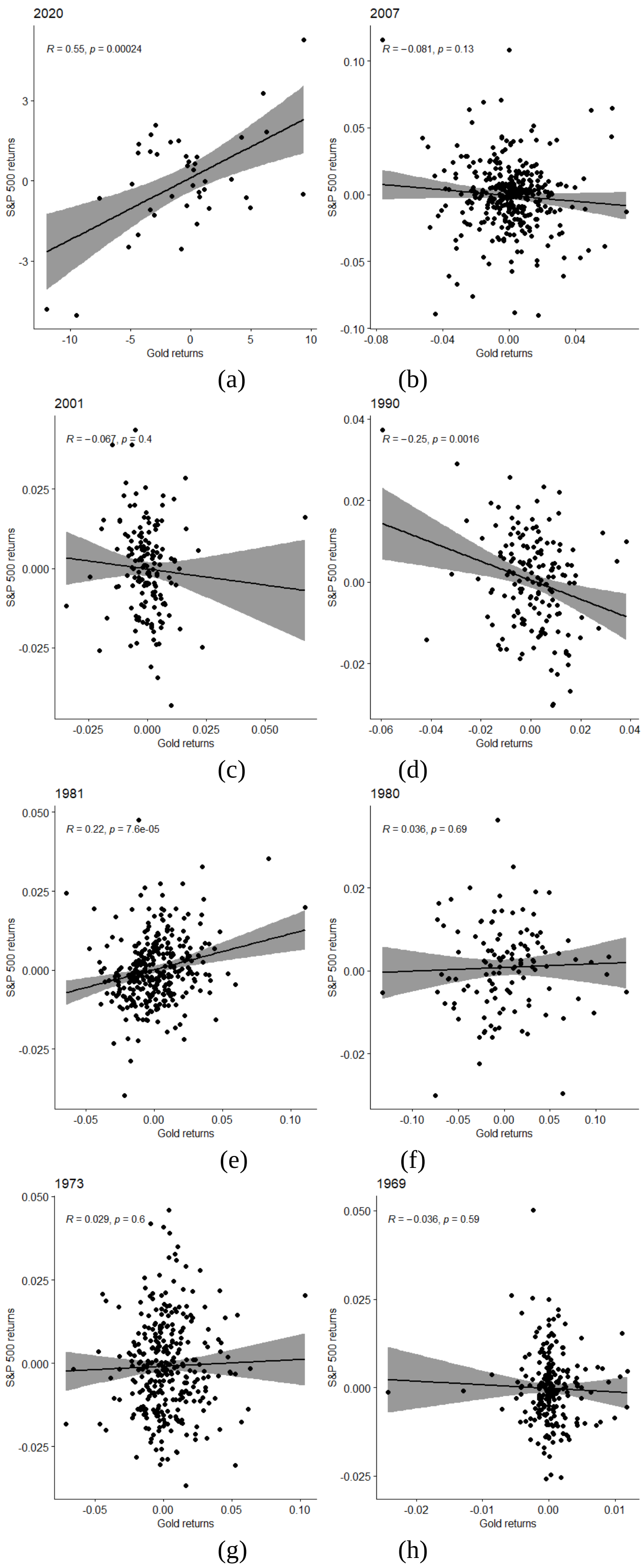

Figure 1. Scatterplots for Pearson's correlation analysis of daily data. (a) 2020, (b) 2007, (c) 2001, (d) 1990, (e) 1981, (f) 1980, (g) 1973, and (h) 1969.

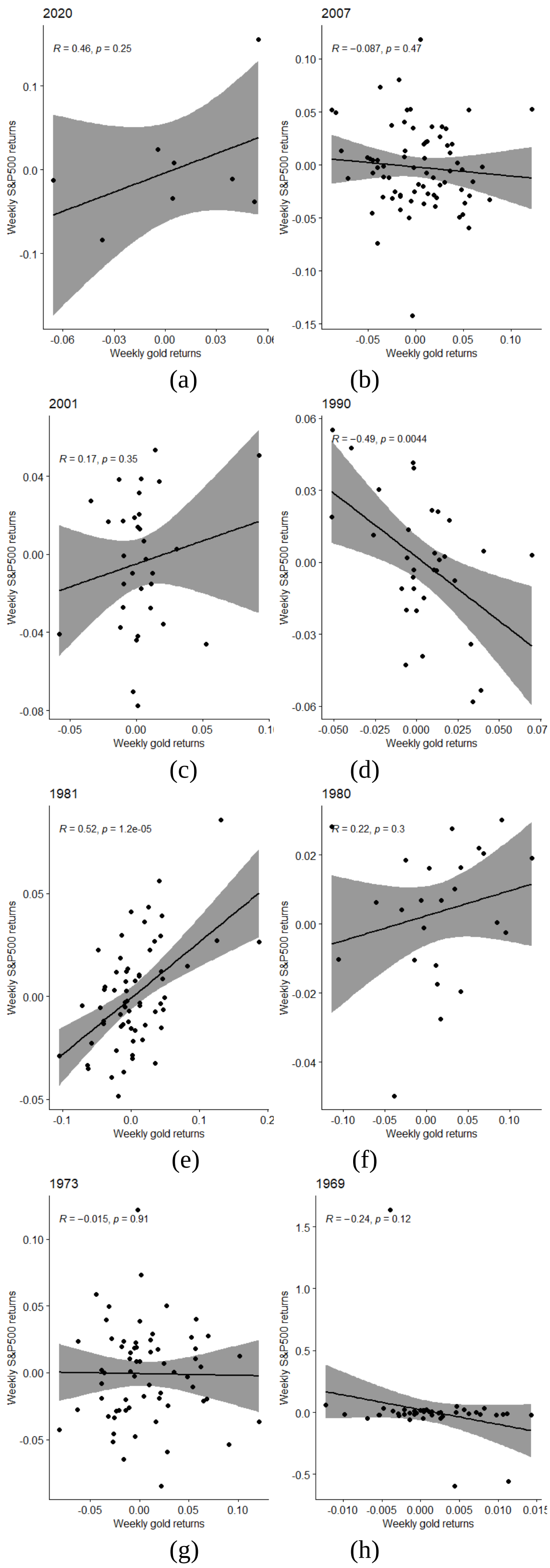

Figure 2. Plots for Pearson's correlation analysis of weekly data. (a) 2020, (b) 2007, (c) 2001, (d) 1990, (e) 1981, (f) 1980, (g) 1973, and (h) 1969.

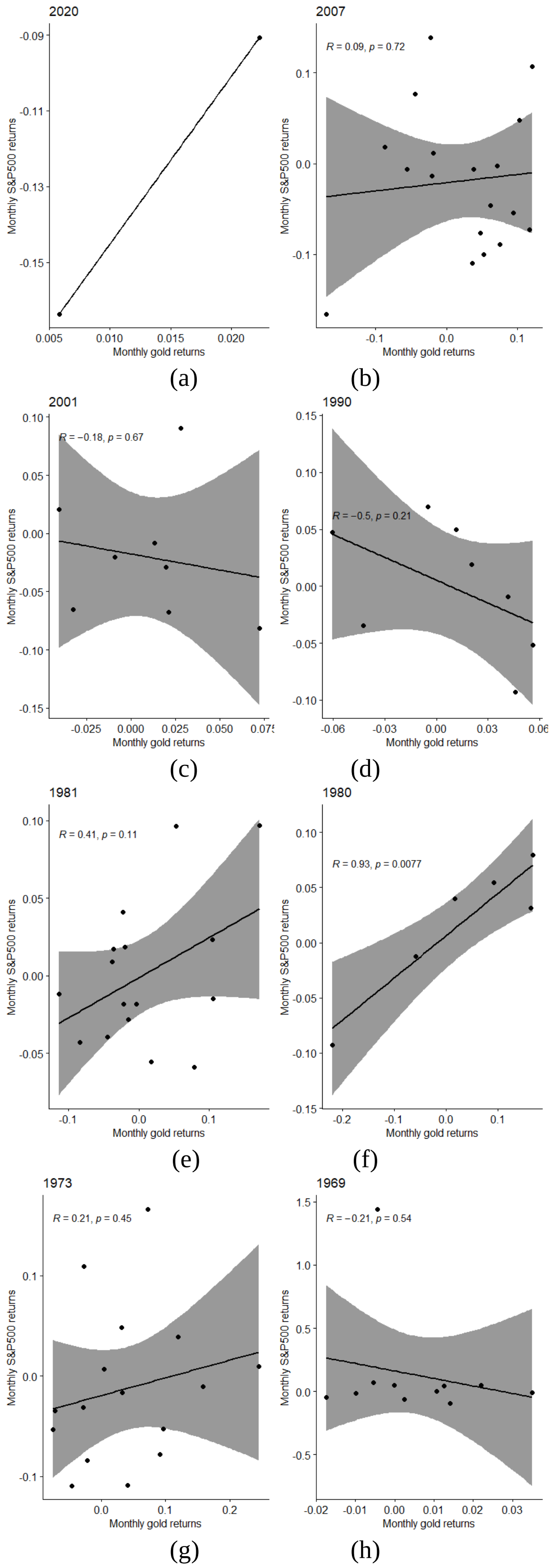

Figure 3. Plots for Pearson's correlation analysis of monthly data. (a) 2020, (b) 2007, (c) 2001, (d) 1990, (e) 1981, (f) 1980, (g) 1973, and (h) 1969.