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The diminishing lustre: Gold's market volatility and the fading safe haven effect

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ABSTRACT

For decades, gold has been considered as the most safe haven of assets in times of markets turmoil. However, this role has appears to have waned in recent years. This study aims to assess gold market behaviour over the past 37 years and examine the role of gold (and other precious metals) during periods of equity and bond market stress. Notably, we investigate whether gold lost its appeal as a safe haven asset due to its own market instability. Change point analysis, rolling mean, GARCH and DCC-GARCH approaches demonstrate that the gold market exhibits two distinct periods characterised by differing market movements, with a stable era followed by an unstable (highly volatile) era. Gold plays an insignificant role during the latter unstable period. Moreover, it exhibits a positive correlation in most high volatility periods with the S&P 500, again, especially during this latter period. This implies that gold is losing (or lost) its safe haven role during market stress and as the gold market encounters higher volatility periods, we anticipate a more positive correlation with the stock market in times of extreme stock market conditions. The outcomes challenge the prevailing definition of a gold safe haven, question the assumption of the stabilising role gold may offer to mitigate losses, and have important implications for investors seeking shelter in times of market stress.

1. Introduction

In recent years, stock markets face heightened volatility and unexpected downturns, prompting investors to grapple with a crucial question: which investment vehicles can be used as a safe haven during such periods of market turbulence. Inter-market relations have generally increased, leading to higher correlations between assets, generating an equally increased need for alternative assets that provide shelter in times of market stress.

Historically, gold is lauded as a reliable safe haven asset (Baur and Lucey (2010)). However, a recent examination of gold behaviour during the COVID-19 crisis raises doubts about its continued efficacy in this role (Akhtaruzzaman et al. (2020)). Ryan et al. (2024) further note that gold's safe-haven role is contingent upon the underlying causes of stock market downturns, and its protective efficacy diminishes or disappears in different conditions. Our research aims to understand whether gold has lost its safe haven role through examining the volatility of the gold market during turbulent periods. The answer to this question is critical for investors, as it directly impacts their ability to diversify effectively and safeguard their portfolios against market volatility and economic uncertainty.

Fig. 1 presents the history of the gold market from 1975 to 2024 and reveals that the gold price was broadly stable for 25 years

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(1980–2005), increasing only in response to stock market crashes, before returning to its average price. This is indicative of its safe haven role. In contrast, the latter 19 years (2005-2024) are characterised by high volatility and greater instability. For example, the gold price surged by 52 % during the financial crisis between July 2007 and February 2009. Furthermore, it fell by 29 % during 2008, including a sharply fall of 21 % in the month of October 2008, before recovering losses by February 2009.

The view of gold as a safe haven asset is a cornerstone of financial markets discourse. Early studies, such as Jaffe (1989) and Hillier et al. (2006), underscore its ability to enhance portfolio returns while mitigating risk, particularly during periods of market volatility. The work of Baur and Lucey (2010) rigorously test and confirm gold's dual role as a hedge against stocks on average and a safe haven during extreme market conditions. Baur and Lucey (2010) define a safe haven as an asset that exhibits either a negative or no correlation with other assets during times of market stress. They specifically identify gold as a safe haven asset as it demonstrates this characteristic, implying that its price tends to remain stable or increase when other assets, such as stocks, experience declines. However, this definition of a safe haven asset does not account for instability of the safe haven asset itself. The safe haven literature examines gold market behaviour under flight-to-safety conditions with the assumption that the gold market is stable when broader financial market volatility increases. However, we find that the gold market fluctuates significantly and behaves more akin to risky assets in the nineteen years after 2005, compromising this assumption and its appeal as a safe-haven asset.

This paper aims to assess gold market behaviour over the last 37 years, examine gold's viability as a safe haven, and investigate whether gold has lost its ability to act as a safe-haven asset due to market instability. The sample period spans from January 1987 to May 2024, covering several major crises (Black Monday in the 1987, the early 1990s recession, the dotcom crisis, the stock market crash of 2002, the global financial crisis in 2008, European Sovereign debt crisis, COVID-19 pandemic). This study moves the argument about gold as a safe haven asset forward by demonstrating how gold's role has faded over this period. This is important because, during market crises, investors look to place their money in safe haven assets, making it crucial to understand whether gold remains a safe haven asset.

This paper contributes to the existing literature by empirically examining and comparing gold market responses to extreme losses in stock and bond markets to investigate whether gold has lost its safe haven role. We compare gold's reaction over two different periods, before and after 2005, arguing that this represents a break in the dynamics of the gold market. We find that prior to 2005, gold has better safe haven properties during crises. However, after 2005, in most cases, it does not. Notably, gold becomes positively correlated with stocks in most post-2005 crises. Our findings indicate that gold is losing its appeal as a safe haven in response to stock market stress. This result has important practical implications as it suggests that investors should be cautious when adding gold to their portfolios as a means to manage risk. For risk-averse investors, gold is believed to provide stability, reduce portfolio volatility, and provide protection in times of market stress. Therefore, realising changes in gold volatility and its safe haven role will reshape their investment decisions.

The rest of the paper is structured as follows. Section 2 presents literature review. Section 3 introduces the data and outlines the properties of the gold market, including evidence of a break. Section 4 considers whether gold (and other precious metals) act as a hedge or safe haven for stocks and bonds. Section 5 seeks to understand why gold appears to have lost its safety net role, including changes in volatility and correlation with stocks. Section 6 summarises and concludes.

2. Literature review

The increasing interrelation among financial markets creates a need for assets that offer protection during periods of market stress. Modern portfolio theory (Markowitz, 1952) addresses the benefits of including low or negatively correlated assets within a portfolio to manage and minimize risk. In this context, gold often is regarded as a safe asset during times of economic and financial turmoil due to its historical elements as a store of value and low correlation with other asset classes.

Baur and Lucey (2010) provide a foundational definition of a safe haven asset that is uncorrelated or negatively correlated with another asset or portfolio during periods of market stress. This is distinct from a hedge, which maintains a negative or neutral correlation on average. Their study demonstrates that gold behaves as a safe haven asset following extreme market shocks. Their

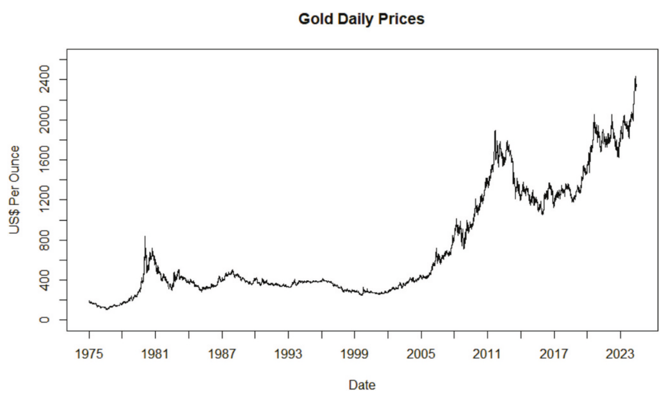


Fig. 1. Shows the gold prices movements from 1975 to 2024.

framework has since become widely used for identifying safe haven assets. However, their definition of a safe haven asset did not account for instability of the safe haven asset's market, i.e. implicitly assumes the stability of the safe haven asset itself, a premise that may not always hold.

Subsequent research produces mixed findings. Baur and McDermott (2016) report that gold functions as a strong but short-lived safe haven, while Bredin et al. (2015) highlight gold's safe haven behaviour during crises but not during economic contractions. He et al. (2018) argue that gold consistently acts as a hedge across different market states but question whether it qualifies as a distinct safe haven asset. Iqbal (2017) and Boubaker et al. (2020) offer additional evidence supporting gold's safe haven properties during crises, notably under bullish gold market conditions.

Recent research further complicates the narrative. During market stress and uncertainty, investors often engage in flight-to-quality behaviour, reallocating their capital from risky assets like equities to perceived safe asset such as gold and government bonds. Cross-market studies (e.g., Baur and McDermott (2010); Beckmann et al. (2015); Bulut and Rizvanoghlu (2020)) show that gold's safe haven properties vary significantly across markets and depend on specific economic environments and regional market characteristics. Ming et al. (2020) and Ming et al. (2023) find that in China, gold functions as a hedge and safe haven under certain conditions, though its role varies over time. Similarly, asset-specific studies (Ciner et al. (2013); Joy (2011); Reboredo (2013)) highlight inconsistencies in gold's role, particularly against currencies and oil markets.

There are reasons to believe that gold traditional roles may not be consistent over time. A large part of the literature assumes that the gold market remains stable when other markets exhibit volatility. However, evidence shows that since 2005, the gold market has fluctuated significantly and often behaved in a manner similar to risky assets and even moved in tandem with stock markets during major crises, thereby compromising its appeal as a safe haven asset. More recent evidence, such as the COVID-19 crisis, raise doubts about whether gold still plays a stabilising role. This behaviour may reflect shifts in gold market, and its evolving role in portfolios.

Research addressing major crises suggests that gold's safe haven behaviour is not consistent. Akhtaruzzaman et al. (2020), Cheema et al. (2020), and Baur and Dimpfl (2020) show that gold did not consistently protect investors during the early stages of the COVID-19 pandemic. Ryan et al. (2024) further question the consistency of gold's safe haven status, suggesting it is episodic rather than consistent, especially during periods of heightened global uncertainty. Similarly, during the 2008 global financial crisis, gold sometimes failed to maintain its expected negative correlation with equities, even exhibiting a positive correlation with S&P 500 at the peak of the crisis when the Lehman Brothers collapsed (Choudhry et al. (2015); Hood and Malik (2013)). Klein (2017) notes that gold's role in periods of market turmoil and shocks in US and European market has faded after 2013. Likewise, Lucey and Li (2015) find that gold has a safe haven role against equity market decline most of the time, while other precious metals individually and collectively act as a safe haven in times gold does not.

Despite the large and growing body of literature, one important aspect remains ambiguous, the effect of gold's own volatility on its ability to function as a safe haven asset. Most studies assume that gold remains stable and only becomes relevant during periods of market stress. However, gold market volatility has increased substantially in the past two decades, in particular after 2005, which may undermine its safe haven role. This shift in gold market behaviour raises the question of whether gold volatility compromises its safe haven role.

Baur (2012) examines this issue, showing that gold exhibits an inverted asymmetry in volatility, where positive shocks increase volatility more than negative ones. Baur argues that due to its safe haven role, rising gold prices are often perceived by investors as a signal for economic and financial uncertainty, leading to greater price volatility. Baur further notes that the increased volatility could either enhance or undermine gold's safe haven role, depending on the persistence of its negative correlation with equities and, yet the strength of this relation depends on the correlation between gold and other assets. Later studies (e.g., Chiarella et al. (2016); Todorova (2017)) acknowledge this volatility asymmetry but do not directly test its implications for gold's safe haven behaviour.

This study contributes to the literature by directly examining whether increased gold volatility has compromised its traditional safe haven role. Specifically, we assess whether gold's behaviour since the mid-2000s reflects a structural change, thereby providing new insights into gold's evolving role within financial markets.

3. Data and gold market behaviour

3.1. Data

The data consists of daily closing spot prices for gold, silver, platinum, palladium, bonds (10-year US Treasuries), and stocks (S&P 500). All precious metals prices are measured in US dollars per troy ounce. The data covers 37 years from January 5, 1987 to May 31, 2024 leading to a sample size of 9760 daily observations.[1] The data used is obtained from DataStream. Descriptive statistics for the data are presented in Table 1.

The average daily return of gold is lower than that of silver, stocks, and palladium, while platinum and bonds have the lowest average return. The standard deviation of gold and bonds are the lowest compared to other assets, with gold higher. Minimum and maximum return values also support this finding. Gold and bonds exhibited lower negative values (−0.096, −0.028) than other variables and lower positive values (0.076, 0.041). As such, bonds display the lowest average daily return and standard deviations across all assets, which is arguably consistent with the usual risk-return trade-off. Palladium is the riskiest asset, with a standard

[1] As can be seen in, for example, Fig. 1, we have earlier data but do not use this in the formal analysis due the effects from the oil price shocks (again, as can be observed in Fig. 1).

Table 1
Descriptive statistics.

Variable	Mean	Std. Dev.	Minimum	Maximum	Skewness	kurtosis
Gold	0.0002248	0.009494	−0.09663	0.07661	−0.23246	7.1030
Silver	0.0003250	0.017204	−0.21078	0.14642	−0.41747	7.9069
Platinum	0.0001766	0.014240	−0.15867	0.12443	−0.36358	7.1737
Palladium	0.0004169	0.020378	−0.16355	0.18485	−0.02202	7.1695
S&P 500	0.0003750	0.011436	−0.20467	0.11580	−0.77347	20.632
Bond	0.0000196	0.004598	−0.02834	0.04144	0.02104	3.4247

Note: the table present a statistic of daily returns observation (9755) of all variables in US dollar from January,51,987 to May 31, 2024.

deviation higher than that of stocks, but it yields a similar return to the stock market (although slightly higher). All data exhibit high kurtosis value except bonds, which implies high volatility and a high probability of extreme returns.

3.2. Is there a break in the gold market?

As shown in Fig. 1, the gold market appears to exhibit two different states of behaviour, a stable period (January 1987 to December 2005) and a volatile period (January 2006 to May 2024). Thus, we split the gold market into two periods to allow for further comparison of gold market responses to market stress. The high volatility period of the gold market covers major crises, including the global financial crisis, the eurozone debt crisis, several stock markets crashes, and ending with the recent economic turmoil caused by the COVID-19 pandemic. However, first, we wish to confirm that such a break exists statistically.[2]

Specifically, we argue that there is a change in the mean and variance within the gold market, and this allows the series to be split into stable and high volatility periods. These periods are illustrated in Fig. 2 below.

As observed, gold was stable from the 1980s to April 2006, when gold prices climbed significantly (there was a higher volatility period in the second half of the 1970s associated with the OPEC oil price shocks). To provide a brief overview, while gold peaked at $820 following the second oil price shock, over the period from the mid-1980s to 2005, the price fluctuated at $400. However, from 2005 to 2024, gold prices surged to historic highs, exhibiting significant volatility. During this latter period, gold prices began to rise gradually following the dotcom crash and a period of (then historically) low interest rates.

During the global financial crisis (GFC) of 2008, gold fluctuated around $900, peaking at $1000 before sharply dropping by 25 % between July and September 2008, with notable fluctuations attributed to different policy actions. Although the recession officially ended in June 2009 and stock markets recovered, gold prices did not decline as expected, maintaining their average before rising to $1200 in December 2009, possibly driven by the eurozone crisis. Gold continued to fluctuate between $1150 and $1250 and reached a record high of $1895 during a period of falling stock markets between May and September 2011. This represents a doubling of the gold price from $900 at the beginning of this period.

Following its peak in September 2011, gold experienced a sharp 15.5 % drop in just 20 days, ending the year with a 19 % decrease to close at $1531. Another significant decline of 31 % occurred between October 2012 and July 2013, due to greater stability in financial markets that encouraged investors to switch to higher yielding assets. In May 2019, gold surged by 19 %, but later plummeted by 21 % in 14 days in March 2020 before gradually climbing to a new high of $2067 in August 2020. Despite the significant fall in stock markets at the beginning of 2020 in response to increased COVID-19 concerns, the gold market response was weak and fell along with stock markets. Similarly, as stocks rebounded and entered a bull run in later 2020, gold followed suit, peaking in August 2020 before declining.

To conclude, during this second period, the gold market has experienced dramatic shifts in response to market events both negatively and positively.

To consider whether there is a change (break) point in the data, we follow the procedure in Killick et al. (2012) and Killick and Eckley (2014). Let's denote the observations as $X = \{x_1, x_2, \dots, x_n\}$ and the segment of this dataset from point i to j as $X_{ij} = \{x_i, \dots, x_j\}$. For each segment X_{ij}, the mean and variance is defined as follows:

$$M_{ij} = \frac{1}{j-i+1} \sum_{k=i}^{j} x_k$$

$$V_{ij} = \frac{1}{j-i+1} \sum_{k=i}^{j} \left(x_k - M_{ij} \right)^2$$

Then, the cost function for each segment X_{ij}, based on the likelihood of the normal distribution, can be expressed as follows:

[2] To obtain robust results, Chow test for structural break at observation 17-04-2006 supports and validates the shift in gold volatility occurring on the identifies breaking point, see Appendix 1.

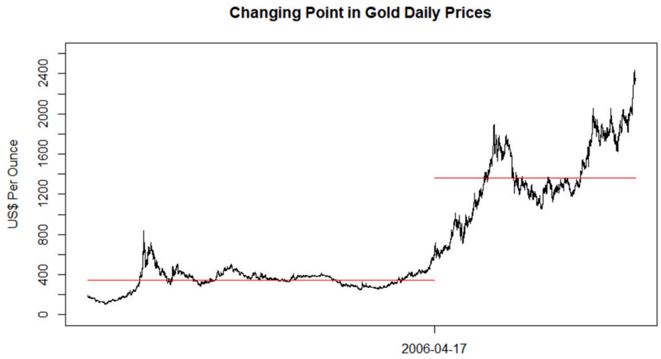


Fig. 2. Shows the gold prices from 1975 to 2024 and the date of detected changepoint in data.

$$C(i,j) = -\log\left[\frac{1}{(2\pi V_{ij})^{(j-i+1)/2}} \exp\left(-\frac{1}{2V_{ij}}\sum_{k=i}^{j}(x_k - M_{ij})^2\right)\right]$$

After computing the cost for each segment X_{ij}, the total cost for the dataset X segmented at each position i is the sum of the cost of all segments. Then, if the total cost is less than the cost of considering the whole data set as one segment, it implies one or more change points. The results from this procedure support a break in 17/04/2006 and this is represented by the horizontal lines in Fig. 2.

To further illustrate the changing nature of the gold market, we calculate the rolling average return using a window of 24 periods (months). This is to consider whether the mean of the gold return remains stable, or exhibits shifts that would justify dividing the sample period. More specifically, to consider whether the mean of the gold return time series (G_t) remains constant over a sample from $t = 1, \ldots T$, the rolling window calculation is given for windows $t = n, \ldots T$, where n denotes the window size (subset of the sample):

$$\widehat{\mu}_t(n) = \frac{1}{n}\sum_{i=0}^{n-1} G_{t-i}$$

Fig. 3 presents the rolling average return over the full sample period, while Figs. 4 and 5 present the same but for the sub-sample periods.

As can be observed, with the exception of the oil price related shocks, the first part of the sample reveals a relatively stable mean value. This contrasts with the second part of the sample, where the mean experiences more dramatic fluctuations. This, although largely an illustrative exercise, further demonstrates the changing behaviour of the gold market.

As a further exercise in this section, we estimate a GARCH(1,1) model for daily gold returns over the two sample periods. Again, this is largely illustrative but serves to highlight the change in the level of volatility within gold returns over the full sample period. Fig. 6 presents two graphs showing that gold exhibits low volatility in the first period (again, except for the OPEC oil price shock period) and higher volatility in the second period, with more frequent spikes in volatility.

Overall, both the formal tests and the illustrative figures highlight the view that the behaviour of the gold market has experienced a shift in the early 2000s, and this may affect its ability to act as a safe haven asset.

4. Is gold a safe haven?

In this section, we consider whether gold remains a safe haven asset over the extensive period from January 1987 to May 2024, which included multiple periods of market stress and crashes. We follow the definition of Baur and Lucey (2010) and Baur and McDermott (2010) in considering both strong and weak safe haven and hedge. A strong (weak) safe haven is an asset negatively correlated (uncorrelated) with stock returns on days of extremely negative returns. A strong (weak) hedge is an asset that is negatively correlated (uncorrelated) with stock returns on average. Furthermore, we follow the Baur and Lucey (2010) approach to test for safe haven and hedge properties by specifying the regression model as given:

$$R_{gold,t} = a + b_t R_{stock,t} + e_t \tag{1}$$

$$b_t = c_0 + c_1 D(R_{market,q10}) + c_2 D(R_{market,q5}) + c_3 D(R_{market,q1}) \tag{2}$$

$$h_t = \omega + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1} \tag{3}$$

where the return (R) of the potential safe haven asset, such as gold, depends on the changes in the stock or bond market. Additionally, we assume that the relation between gold (or other safe haven asset) and the stock or bond market is not constant and is influenced by certain extreme conditions in the stock market. More specifically, eq. (1) models the relation between gold (or other asset) and stock or bond return. The parameters to be estimated are α and b_t, with the error term is given by e_t. The parameter b_t is modelled as a dynamic process given by eq. (2). Here, the parameters c_1, c_2 and c_3 measure the effect of extreme events captured by the dummy variables

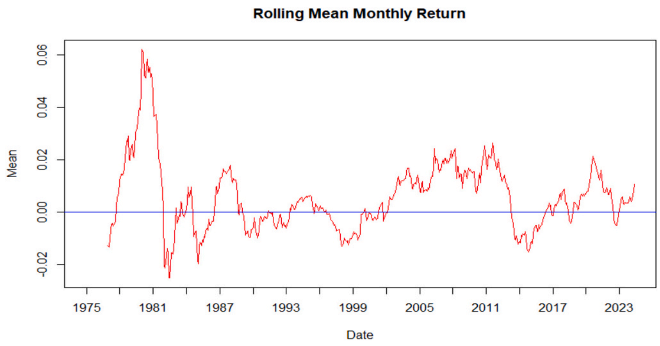


Fig. 3. Shows the gold monthly rolling mean from 1975 to 2024. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

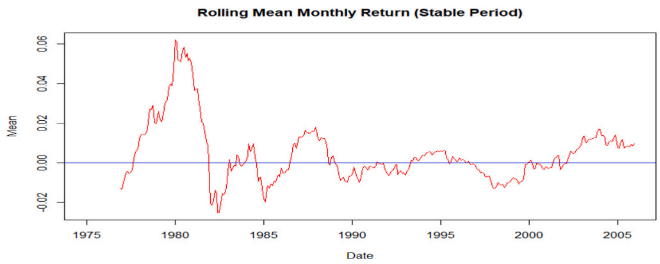


Fig. 4. Shows the gold monthly rolling mean from 1975 to 2005. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

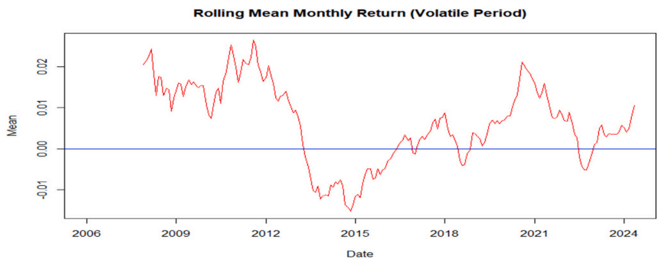


Fig. 5. Shows the gold monthly rolling mean from 2006 to 2024.

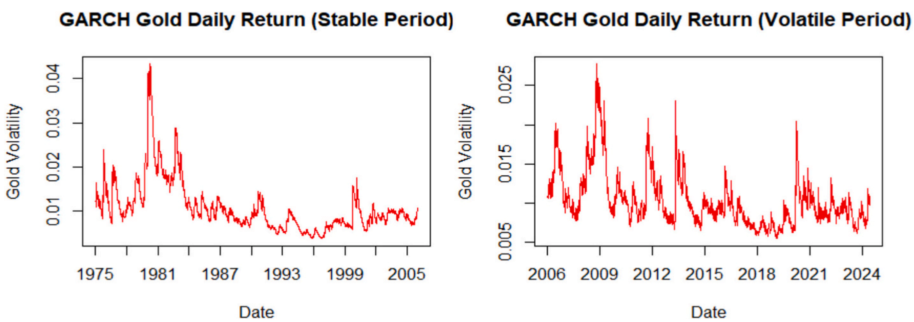


Fig. 6. Shows the gold volatility from 1975 to 2005 and 2006 to 2024. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

denoted as D(…) that are equal to one if the stock or bond market crosses a threshold given by the 10 %, 5 % and 1 % quantile of the return distribution. Eq. (2) focuses on extreme negative returns in the stock or bond market to model the non-linear relation between assets, implying that investors react differently under severe market shocks compared to less and normal conditions. Eq. (3) is a standard GARCH equation, which is used to account for heteroscedasticity in the time series data. All equations are jointly estimated with Maximum Likelihood. The daily returns for gold and other precious metals, bonds and S&P500 were computed based on the daily closing price (*Pt*), where the return $R_{i,t}$ is defined by $[(Pt/Pt{-}1) - 1]$. All time series returns were tested for unit root through the Augmented Dickey-Fuller test, with the null hypothesis of a unit root being rejected at a 5 % significant level (p-value <0.05). Thus, all series returns are stationary, meaning their statistical properties remain constant over time, which is necessary to generate unbiased and reliable results.

Of particular interest, if one of the parameters c_1, c_2 or c_3 is significantly different from zero, then there is evidence of a relation between gold and extreme movements in the stock or bond market (Baur and Lucey (2010)). If the parameters in eq. (2) are zero or negative, the gold (or alternative asset) acts as a safe haven for that market. Furthermore, if the joint effect of ($c_0 + c_1 + c_2 + c_3$) for all metals remains negative (positive) with stock or bond market, it is consistent with a safe haven effect or hedging (diversification) effect at a minimum. We use Wald test to examine the significance of the joint effect. Gold would serve as a hedge for the market if the parameter c_0 is zero or negative and the sum of the parameters c_1, c_2 and c_3 are not jointly positive exceeding the value of c_0.

The results are presented in Tables 2, 3, and 4 for the full sample, the first (stable) and second (volatile) sub-samples, respectively. As noted, the tables contain the estimates of c_0 (hedge) and the values for c_1, c_2, and c_3, which capture extreme market conditions. While gold is our main safe haven asset of interest, we also consider the role of silver, platinum, and palladium. Equally, although stocks are the usual asset to be protected, bonds are also considered.

Table 2 presents the results for the full sample from January 1987 to May 2024. The coefficient estimates for the average (c_0) effect of stocks on gold, silver, platinum, and palladium are −0.031, 0.020, 0.081, and 0.1220, respectively, with statistically significant only for platinum and palladium. The insignificant negative coefficient between gold and stocks suggests, at best, a hedge, while silver has an insignificant positive correlation, implying a diversifying effect. Platinum and palladium appeared to co-move by having a significant positive relation. As such, this implies that platinum and palladium cannot be used for hedging but for diversifying purposes. The same coefficient estimates for the average effect of bonds on gold, silver, platinum, and palladium are 0.114, −0.048, −0.127, and − 0.139, respectively, with only statistical significance for gold, platinum, and palladium. For the significant coefficients, the positive coefficient suggests a strong diversifying role for bonds, while the negative coefficient implies a strong hedge of platinum and palladium for bonds.

We now consider the coefficients designed to capture safe haven behaviour across different percentile cut-offs, i.e., c_1, c_2, and c_3, respectively. Here, we can see that at each of the 10 %, 5 %, and 1 % extreme negative return levels there are no significant results. This implies that these markets have no relation with extreme negative stock and bond returns. As argued in Baur and Lucey (2010), what matters is the joint effect between c_0 and each of c_1, c_2, and c_3. Thus, gold continues to have negative relation with stocks, but insignificant, consistent with a safe haven effect, or hedge at a minimum. Silver, platinum, and palladium only act as diversifiers. For bonds, each of silver, platinum and palladium have a joint negative or safe haven effect, while gold has a joint positive relation, which is perhaps more consistent with hedging behaviour.[3]

The reported results are broadly in agreement with Kopyl and Lee (2016) who show that gold insignificantly correlates with the stock market in periods of severe financial crisis between 1964 and 2014 and shows a strong hedge role on average. Additionally, they note that gold is not a hedge for the bond market while other precious metals showing a strong hedging role on average. It is encouraging to compare our results with Ciner et al. (2013), who find a relatively low relation between gold and bonds on average.

Table 3 presents the estimation results for gold, and the other assets role as a hedge or safe haven asset for the stable period between 1987 and 2005. Considering first stocks, the coefficient estimates for the average effect for gold, silver, platinum, and palladium are −0.082, −0.138, −0.012, 0.005, respectively, with the estimates for gold and silver being significant. The results suggest that all precious metals act as a hedge for stocks, with gold and silver as a strong hedge and palladium, with no statistical correlation, having a weaker hedging role. Examining the effects of extreme market movements presents a more mixed picture. At the 10 % level, the coefficients are all positive and significant for gold, silver and platinum, but not for palladium. At the 5 % level, the coefficients again become negative and are significant only for gold and platinum. This supports safe haven behaviour for gold and platinum, and potential safe haven or hedging behaviour for the remaining two.[4] At the 1 % level all the coefficients are statistically insignificant and negative, except for platinum. Moreover, the values are small and do not change the previous conclusion. Furthermore, the joint effect of c_0 and c_1, c_2, and c_3 for all metals remains negative with stocks, consistent with a safe haven effect. Thus, over this sample period, there is greater evidence of safe haven behaviour by gold and the other precious metals series for stocks.

Turning to the bond market, on average (c_0), the coefficients are negative, with values of −0.066, −0.212, −0.167, −0.002, respectively for gold, silver, platinum and palladium, and statistically significant for silver and platinum. This implies strong hedging behaviour for these two assets and weaker hedging (no correlation) for gold and palladium. For the extreme bond returns, the coefficients are predominantly statistically insignificant and negative, which continues to imply hedging and even safe haven behaviour, except for silver at the 1 % level. As with stocks, the joint effect negative sign suggests inverse movement with bond market during extreme downturns and, hence, the results here are generally more supportive of gold and the other precious metals acting as a safe haven.

Table 4 presents the estimation results for the role of gold and other assets as a hedge and safe haven asset for the volatile period

[3] A question arises with regard to insignificant coefficients. Notably, should the estimated value be treated as zero or taken as reported. The main discussion assumes the former, as the values are statistically indistinguishable from zero, however, if we allow the latter, the safe haven and hedge properties are weakened.

[4] As above, this depends on whether we treat insignificant coefficients as zero or take the numerical value.

Table 2
Hedge and safe haven assessment (Entire period 1987–2024).

Regression results of safe haven analysis				
	Gold	Silver	Platinum	Palladium
S&P 500				
Hedge	−0.0310	0.0200	0.0810***	0.1220***
Safe Haven quantiles				
0.1	0.0086	0.0740	−0.0135	0.0421
0.05	−0.0014	0.0214	−0.0621	−0.0868
0.01	0.0088	0.0396	0.1454	0.1572
Joint Effect	−0.0150	0.1550	0.1508	0.2345*
		Bond		
Hedge	0.1136**	−0.0479	−0.1272**	−0.1385*
Safe Haven quantiles				
0.1	−0.0169	0.0395	0.1698	−0.0374
0.05	0.0699	0.0321	−0.0984	0.1558
0.01	−0.1247	−0.0388	−0.0141	−0.2313
Joint effect	0.0419	−0.0151	−0.0699	−0.2514
Constant	0.0003**	0.0006***	0.0002	0.0004*

Notes: This table presents estimation results for the models in Eqs. (1)–(3). Hedge represents the parameter c_0. Quantiles 0.1, 0.05, and0.01 mean in extreme market conditions. *,**, and *** mean statistically significant at 10 %, 5 %, and 1 %, respectively. The significance of the joint effect is examined by Wald's test. ***, **, and * indicate statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

Table 3
Hedge and safe haven assessment (Early era 1987–2005).

Regression results of safe haven analysis				
	Gold	Silver	Platinum	Palladium
S&P 500				
Hedge	−0.0825***	−0.1383***	−0.0118	0.0046
Safe Haven quantiles				
0.1	0.1028**	0.1676**	0.1443*	0.0986
0.05	−0.1043*	−0.0780	−0.2039**	−0.0972
0.01	−0.0048	−0.0040	0.0037	−0.0296
Joint Effect	−0.0888**	−0.0527	−0.0677	−0.0236
		Bond		
Hedge	−0.0660	−0.2120**	−0.1671**	0.0015
Safe Haven quantiles				
0.1	−0.0701	−0.0383	0.1775	−0.1645
0.05	−0.0080	−0.1875	−0.3380**	−0.1095
0.01	0.1119	0.3687*	0.1582	−0.3218
Joint Effect	−0.0322	−0.0691	−0.1694	−0.5943***
Constant	0.0001	0.0004*	0.0002	0.0001

Notes: This table presents estimation results for the models in Eqs. (1)–(3). Hedge represents the parameter c_0. Quantiles 0.1, 0.05, and 0.01 mean in extreme market conditions. *,**, and *** mean statistically significant at 10 %, 5 %, and 1 %, respectively. The significance of the joint effect is examined by Wald's test. ***, **, and * indicate statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

between 2006 and 2024. Here emerges a different picture to Table 3, with much less evidence of the metals acting as a safe haven or hedge and instead resembling assets that can be part of a diversified portfolio but with a typically positive relation. Considering stocks, the average relation given by c_0 reveals a positive and significant effect for silver, platinum and palladium, indicting assets with diversifying behaviour only. The relation with gold is also positive but statistically insignificant, suggesting, at best, a hedging role. For the 10 % level (c_1), all the coefficients are negative but insignificant, except for platinum. Nonetheless, this continues to imply hedging and even safe haven behaviour. However, all the coefficients for gold, silver, and platinum are positive for the 5 % level (c_2) and significant suggesting strong diversifying role. At the 1 % level (c_3), all coefficients are insignificant and are negative for gold and silver and positive for platinum and palladium. If we consider all the estimated coefficients as are they are reported, the summed effect is positive for all assets, which implies no hedge or safe haven role.

The situation for bonds is broadly similar but arguably shows even less evidence of a safe haven effect. For the c_0 coefficient, this is positive and significant for gold and silver, and negative and insignificant for platinum and palladium. Thus, gold and silver can be described as a diversifying asset and the rest as potential hedging assets. For each of the extreme return cutoffs (c_1, c_2, and c_3), these are all statistically insignificant and thus could imply some safe haven behaviour (i.e., no correlation), this would seem to be a weak

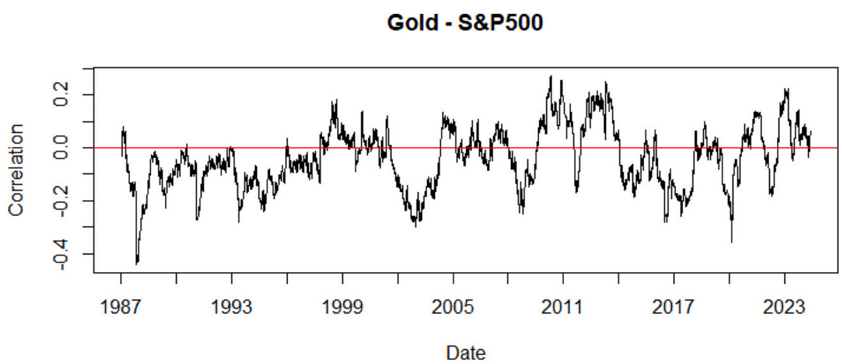
Table 4
Hedge and safe haven assessment (Volatile era 2006–2024).

Regression results of safe haven analysis				
	Gold	Silver	Platinum	Palladium
S&P 500				
Hedge	0.0451	0.2068***	0.1750***	0.2282***
Safe Haven quantiles				
0.1	−0.0992	−0.1363	−0.1619*	−0.1028
0.05	0.1308*	0.2861**	0.1472*	0.1131
0.01	−0.0262	−0.0574	0.1385	0.1676
Joint Effect	0.0505	0.2992**	0.2988**	0.4061**
		Bond		
Hedge	0.3202***	0.2408**	−0.0034	−0.1500
Safe Haven quantiles				
0.1	0.0964	0.1333	0.1216	0.0284
0.05	0.0153	0.1218	0.0650	0.3316
0.01	−0.2563	−0.3095	−0.0570	−0.0021
Joint Effect	0.1756	0.1864	0.1262	0.2079
Constant	0.0004**	0.0006*	0.0001	0.0007**

Notes: This table presents estimation results for the models in Eqs. (1)–(3). Hedge represents the parameter c_0. Quantiles 0.1, 0.05, and0.01 mean in extreme market conditions. *,**, and *** mean statistically significant at 10 %, 5 %, and 1 %, respectively. The significance of the joint effect is examined by Wald's test. ***, **, and * indicate statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

relation. Moreover, the sum of the coefficients, ignoring significance, is positive for each asset, which would negate any hedge or safe haven role.

We can now take the results in their entirety over both the full sample and the two sub-samples, and consider whether a significant negative relation or no relation exists between stocks and bonds as the invested assets and gold, silver, platinum, and palladium as the potential safe assets. A significant negative (no) relation would provide strong (weak) evidence of hedging or safe haven behaviour. A positive relation implies that while the asset may offer some diversification benefit, it nonetheless moves in the same direction as the



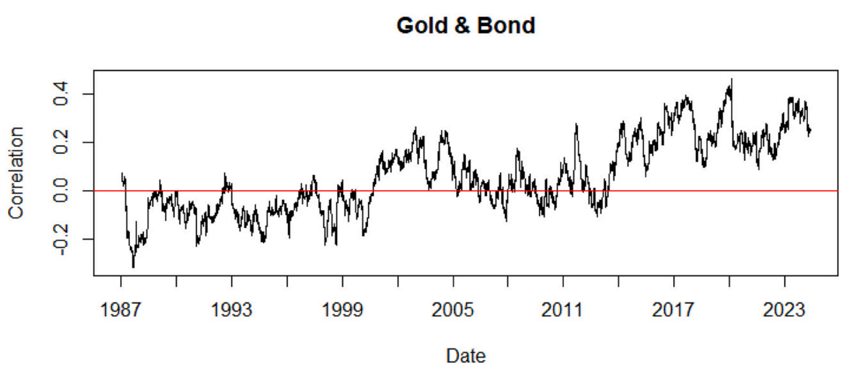


Fig. 7. Shows returns correlation between gold, S&P500, and bond markets. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

invested asset. Over the full sample, there is evidence that gold, on average, acts a hedge for stocks and a diversifier for bonds. There is weak evidence for silver to act as a hedge on average for stocks and bonds. For platinum and palladium, these both appear to act as a diversifier for stocks and strong hedge for bonds. When we consider the sub-sample periods, a change in behaviour is noted. In the first sub-sample, there is greater evidence of gold and silver acting as a hedge on average and a safe haven with extreme falls for both stocks and bonds. The effect for gold is stronger for stocks, while silver and platinum have a stronger effect for bonds. For the second sub-sample, however, the evidence indicates that each of these assets is more likely to act as a diversifier for stocks and bonds.

Our findings undermine the conventional view of gold as a safe haven in the post-2005 period. While it exhibited strong hedging properties and occasional safe haven role during the stable period (1987–2005), this pattern deteriorates in the more volatile period from 2005 onward. These findings align with recent literature questioning gold's continued reliability of playing safe haven role during crises. For instance, Ryan et al. (2024) find that gold's safe haven role is not consistent across different types of market shocks and may even diminish or disappear depending on the crisis structure. Similarly, Ming et al. (2023) note that gold's role is more dynamic and can co-move with risky assets during period of increased volatility.

5. Changing behaviour and gold and stocks

In seeking to understand the changing role of gold as a safe haven asset, we can consider its time-varying co-movements with stocks and bonds by estimating a DCC-GARCH model, which captures the dynamic conditional correlation between the series. Notably, the model captures the persistence and clustering of volatility alongside time-varying correlations. The DCC-GARCH model is well-known and so we only report the estimated correlations in Fig. 7. Although this is largely an illustrative exercise, it offers additional evidence and reinforces the view that the safe haven role of gold has weakened as identified through regression tests in the previous section.

As can be seen in the figure, the correlation between gold with stocks and bonds remains negative prior to 2000 (consistent with its hedging or safe haven role), it fluctuates between positive and negative regimes after 2000. This implies that while gold could be a hedge or safe haven for stocks and bonds before 2000, it is less likely to be after 2000.

To further consider if gold is losing its safe haven appeal, we apply the iterative cumulative sums of squares (ICSS) algorithm of Inclan and Tiao (1994), which is designed to detect multiple breaks in volatility. The mean (average daily returns) and standard deviation (risk) for the precious metals and stocks are calculated for each volatility period. Then, the above regression model is applied to explore the correlations between precious metals and S&P 500 during these periods. This is to further validate and extend the previous findings regarding the diminishing safe haven role of gold. The study focuses only on ten volatility periods in which significant crises occurred.

The results are presented in Table 5. The approach identifies a finer set of sub-sample regimes that define a series of crises events. Of particular interest is the correlation between stocks and gold. The results indicate that gold exhibits safe haven properties with a negative correlation with stocks during all the high volatility periods in the stable sub-sample period. This suggests that even as stocks experience increased volatility, gold retains its safe haven role. These findings are consistent with both the analysis in the previous section and Fig. 7, which shows a consistently negative volatility correlation between gold and the S&P 500 during the stable period.

In the volatile sub-sample, the most volatile periods for stocks correspond to the recent global financial crisis and the COVID-19 pandemic crisis, noted in the fifth and tenth periods, respectively. During these periods, the stock return standard deviation is notably high at 4.67 % and 5.23 %, with average daily returns of −0.63 % and − 0.71 %. Here, we can see that gold exhibits a positive correlation with stocks, indicating a departure from its safe haven role. The result reinforces the conclusions drawn by Hood and Malik (2013) who note that gold exhibits a positive correlation with S&P 500 at the peak of the global financial crisis when Lehman Brothers collapsed, and by Akhtaruzzaman et al. (2020) and Cheema et al. (2020), who also document that gold failed to act as a safe haven in certain phases of the pandemic. Moreover, during this period, gold only shows negative correlation with stocks in two periods (the sixth and ninth). The observed deterioration in gold's correlation with equities after 2005 in line with Choudhry et al. (2015), who find that gold sometimes failed to maintain its expected negative correlation with equities and with Klein (2017), who shows that gold's safe haven role diminished in developed markets post-2013. Again, Fig. 7 supports this observation, with the dynamic conditional correlation fluctuating between positive and negative values for gold and stocks. As the negative correlation diminishes and becomes positive, this undermines gold's role as a safe haven asset and suggests it exhibits similar behaviour to stocks and can only act as a diversifier.

6. Summary and conclusion

This study aims to analyse gold market behaviour over the past 37 years, assessing its role as a safe haven asset for both the stock and bond market, and investigates how changes in gold market behaviour impacts its safe haven ability. The findings reveal two distinct market eras: stable (1987–2005) and high volatile (2006–2024). During the stable period, the gold price remains broadly flat, with only a significant spike following the late-1970s oil price shock. In contrast, the volatile period sees dramatic fluctuations and substantial price surges, characterised with high volatility.

We estimate regressions designed to consider whether gold (as well as silver, platinum and palladium) act in a diversifying, hedging or safe haven role for stocks and bonds. We consider this over both the full sample and the identified sub-sample periods. Our analysis indicates that while gold serves as a strong hedge for stocks on average during the stable period, it loses this role during the volatile period. Platinum is the only precious metals to exhibit statistically significant safe haven role for stocks during extreme market shocks in the stable and volatile period.

One of the more notable findings to emerge from this study is that gold is losing its appeal as a hedge and safe haven. Despite its

Table 5
Relationship between Gold and precious metals with S&P 500 at different volatility period.

Crisis in each volatility period	Entire sample period	Black Monday in USA	Early 90 Recession, Iraq invaded Kuwait	Early 90 Recession	Stock Market Downturn 2002 following Sept 11 Attack	Financial Crisis 2007–2008	European Sovereign Debt Crisis	Markets Down from May 2011–October 2011	Stock Market Selloff	Cryptocurrency Crash	Stock and Oil Markets Crash by Covid-19 & Economic Lockdown
			Stable Era					**Volatile Era**			
Starting Date	1/12/1987	10/14/1987	8/2/1990	11/13/1990	6/17/2002	9/15/2008	4/27/2010	8/24/2011	8/19/2015	10/10/2018	2/24/2020
Ending Date	12/31/2020	10/27/1987	11/13/1990	12/31/1991	10/18/2002	12/3/2008	6/11/2010	12/21/2011	3/2/2016	1/7/2019	4/7/2020
Volatility Period	All	1	2	3	4	5	6	7	8	9	10
Mean											
S&P 500	0.03 %	−2.99 %	−0.02 %	−0.15 %	−0.15 %	−0.63 %	−0.31 %	0.08 %	−0.04 %	−0.19 %	−0.71 %
Gold	0.02 %	0.34 %	0.08 %	−0.03 %	−0.03 %	0.06 %	0.18 %	−0.18 %	0.07 %	0.13 %	0.02 %
Silver	0.02 %	−0.42 %	0.02 %	−0.12 %	−0.12 %	−0.18 %	−0.01 %	−0.44 %	0.01 %	0.13 %	−0.62 %
Platinum	0.01 %	−0.38 %	0.02 %	0.07 %	0.07 %	−0.67 %	−0.38 %	−0.33 %	−0.04 %	0.01 %	−0.86 %
Palladium	0.03 %	−0.88 %	0.005 %	−0.06 %	−0.06 %	−0.57 %	−0.71 %	−0.22 %	−0.10 %	0.31 %	−0.66 %
Standard Deviation											
S&P 500	1.16 %	8.67 %	1.06 %	2.23 %	2.23 %	4.67 %	1.93 %	1.74 %	1.27 %	1.58 %	5.23 %
Gold	0.96 %	1.65 %	0.59 %	0.87 %	0.87 %	2.76 %	1.12 %	1.80 %	1.06 %	0.59 %	2.05 %
Silver	1.73 %	3.66 %	0.82 %	1.10 %	1.10 %	4.58 %	2.09 %	2.98 %	1.62 %	0.93 %	3.91 %
Platinum	1.40 %	2.80 %	0.86 %	1.17 %	1.17 %	3.63 %	1.99 %	1.58 %	1.61 %	0.89 %	4.25 %
Palladium	1.97 %	3.00 %	1.08 %	1.84 %	1.84 %	4.70 %	3.97 %	2.73 %	2.33 %	1.46 %	6.34 %
Correlation with S&P 500											
Gold	−4.71 %	−10.67 %	−7.43 %	−15.06 %	−7.40 %	6.37 %	−35.73 %	2.89 %	1.67 %	−1.88 %	41.23 %
Silver	2.35 %	50.10 %	−5.54 %	14.84 %	−1.78 %	−34.10 %	68.89 %	6.09 %	12.16 %	20.32 %	−45.20 %
Platinum	4.19 %	20.50 %	−16.54 %	−0.94 %	4.04 %	11.11 %	8.18 %	−7.82 %	−5.50 %	−6.16 %	48.97 %
Palladium	5.91 %	−21.97 %	14.54 %	7.06 %	19.18 %	18.24 %	−15.48 %	23.01 %	15.19 %	−11.83 %	5.14 %

Note: The ICSS algorithm used to detect the breaking points (shift in variance) in the volatility of S&P 500 returns during our sample period. The sample period is from January 1987 to December 2024.

strong hedge performance in the stable period, gold's effectiveness declines in the volatile period. Furthermore, we use the DCC-GARCH model to consider the time-varying correlation between gold and stocks. We observe a negative correlation during the stable period, but a positive correlation begins to emerge in the latter period. Moreover, gold shows a significant positive correlation with stocks during extreme market shocks in volatile periods, suggesting its safe haven role is fading in times of higher stocks market volatility.

Considering more formal breaks within volatility identified by the ICSS algorithm reveals further evidence of gold losing its safe haven role, especially during the volatile period. To act as a safe haven, gold would be negatively correlated with stocks and while there is evidence for this in the stable period, this pattern does not persist in the volatile era. Instead, during the highest volatility periods, such as the global financial crisis and the COVID-19 pandemic, gold displayed a positive correlation with stocks. Thus, failing to act as a safe haven when it is most needed by market participants.

Overall, the main conclusion we present here is that investors should be aware of gold's positive correlation with the stock market during periods of market stress and increased volatility. As such, adding gold to a portfolio may raise volatility without providing expected protection.

CRediT authorship contribution statement

Hussain Faraj: Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **David McMillan:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Data curation, Conceptualization. **Mariam Al-Sabah:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

Appendix 1

Augmented Regression for Chow Test			
Variable	F-Statistics/(*P*-value)	Critical values	Decision
Gold prices	(0.0000)	At 5 %	Reject the null hypothesis "No Structural Break on 17th April 2006″

Chow test run to validate the identified breaking point.

Augmented regression for Chow test
OLS, using observations 1975-01-01:2024-05-31 (T = 12,893)
Dependent variable: Gold Price

	coefficient	std. error	t-ratio	p-value
const	305.447	3.62044	84.37	0.0000 ***
time	0.0102926	0.000768126	13.4	1.14e-040 ***
splitdum	−1355.29	18.8397	−71.94	0.0000 ***
sd_time	0.218752	0.00190335	114.9	0.0000 ***
Mean dependent var	719.5342	S.D. dependent var		549.4827
Sum squared resid	3.45E+08	S.E. of regression		163.5372
R-squared	0.911443	Adjusted R-squared		0.911422
F(1, 8087)	44,218.44	P-value(F)		0
Log-likelihood	−84,008.52	Akaike criterion		168,025
Schwarz criterion	168,054.9	Hannan-Quinn		168,035
rho	0.998235	Durbin-Watson		0.004021

Chow test for structural break at observation 2006-04-17
Null hypothesis: no structural break
F(2, 12,889) = 15,359.3 with p-value 0.0000

Data availability

Data will be made available on request.

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