Technological and Economic Development of Economy
ISSN: 2029-4913 / eISSN: 2029-4921
2023 Volume 29 Issue 1: 23–44
https://doi.org/10.3846/tede.2022.17302

CAN GOLD HEDGE THE RISK OF FEAR SENTIMENTS?

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Received 07 January 2022; accepted 27 June 2022; first published online 16 December 2022

Abstract. This paper investigates the interaction between fear sentiments and gold price (GP) by utilising the full-sample and sub-sample rolling-window bootstrap causality tests. It can be observed that GP can hedge the risk of fear sentiments in a certain period. The result supports the inter-temporal capital asset pricing model, which demonstrates that the increase in fear sentiments can promote the rise in gold prices. Due to excessive panic, fear sentiments also have negative effects on GP. In contrast, GP positively impacts fear sentiments, which manifests that market sentiment can be forecasted based on changes in the gold market. In addition, the negative influences from GP to fear sentiments indicate there are diversified assets that can be alternatives to gold. In the complicated international environment and volatile market sentiments, investors can benefit by optimising their asset portfolio. The governments can mitigate the adverse effects of large fluctuations in both markets by grasping the movement of gold and fear sentiments.

Keywords: gold price, VIX, time-varying, causal relationship.

JEL Classification: C32, G12, G18.

Introduction

In this paper, the primary purpose is to discuss the causal relationship between fear sentiments and the price of gold (GP) and explore how gold prices move with fear sentiments. Traditionally, gold has played a safe haven role in multiple crises (Reboredo, 2013; Beckmann et al., 2015; Bouri et al., 2020), such as the sub-prime crisis of 2008, the European sovereign debt crisis in 2011. In the recurring turmoil in global financial markets, gold has proved to be a good hedge against certain market risks and a valuable asset (Bredin et al., 2015; Jin et al., 2019; Salisu et al., 2019). Investors hold gold investment portfolios to hedge against various market risks, such as monetary policy risks, foreign exchange risks, and inflation. It's also

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been considered a hedge for the stock market and currency (Baur & Lucy, 2010; Miyazaki et al., 2012; Pullen et al., 2014). Shahzad et al. (2020) show the action of a safe haven asset varies from one crisis to another, so the gold's hedging attribute may not work at some times. Furthermore, because of the unprecedented growth in financial markets and tools, the risk to the financial system is increasing (Baur & Lucey, 2010). Therefore, it is vital for investors to find effective safe-haven assets, especially risk-averse ones. Besides, periods of market turmoil are often accompanied by wild fluctuations in market sentiments, so safe havens are not kept from sentiment effects (Ben Nasr et al., 2018). The literature illustrates that there is less evidence on how fear sentiment changes dynamically correlate with the return of safe-haven assets. Therefore, exploring the gold-sentiments relationship can offer investors valuable insight into whether to choose gold assets as safe harbours when volatile markets. What's more, the role of assets as hedges or safe havens is not immutable (Hasan et al., 2021). Other assets can provide shelter during a crisis, such as commodities and currencies (Grisse & Nitschka, 2015; Henriksen, 2018). Thereby, it is necessary to explore whether gold is a hedge asset and a safe harbour at different points in a crisis. This study inspects the role of investor sentiments, especially fear sentiments, across gold assets and investigates whether or not investor sentiments can explain bubble risks and crash in the market. This is vital for investors to formulate strategies to alleviate the negative impact of a market collapse on their portfolios.

In traditional financial theories, asset prices are decided by the fundamental value rather than psychological or behavioural factors. Furthermore, the equilibrium asset price is determined by rational investors. However, there is no rational investor in real life; thus, behavioural finance studies supposed that how investors make investment decisions are ignored in traditional finance (De Long et al., 1990). A surge in fear sentiments can make investors behave become more irrationally, turning them into "noise traders". This causes the equilibrium price of the stock to drift off its internal value. These investors would suffer more losses until they get away from the markets. If the price of gold deviates much from its potential value, it may cause investors to misallocate their portfolios, resulting in asset losses. Besides, as an international reserve currency, the fluctuation of GP may affect a country's balance of payments (Brodsky & Sampson, 1980) and its intermediary policies. Hence, if the fear sentiments cause GP to swing violently, it could affect the equilibrium price of the gold market. We want to explore the role of investor sentiment in gold price dynamics in this paper.

In addition to being a reserve asset for an international currency, gold is also seen as a safe harbour in times of financial market turmoil (Hunt et al., 2018; Chen & Wang, 2019; Boubaker et al., 2020). Baur and Lucey (2010) point out that safe-haven investments are assets that are negatively correlated or unrelated to other portfolios in times of economic turbulence. Hence, gold is considered a potential safe-haven investment. Traders particularly attach great importance to gold during the financial crisis (e.g. 2008 financial crisis, 2011 European sovereign debt crisis) as a haven against other financial risks (Baur & McDermott, 2010; Reboredo, 2013). Moreover, gold can provide diversification benefits, such as protection against extreme currency shocks, falling stock prices, and inflation (Arouri et al., 2015). Wang et al. (2011) points out that gold is seen as a safe alternative investment because its price tends to change in response to capital market conditions. Hence, when the market fluctuates sharply, the fear sentiments heat up, and the public becomes pessimistic about

the market's prospects, which will cause the demand for safe assets to cope with the future downside risk (Karalevicius et al., 2018; Su et al., 2022b). That could lead to an increase in gold trading. Besides, Hunt et al. (2018), Chen and Wang (2019) and Boubaker et al. (2020) also suggest that gold could be used as a safe-haven asset. Garone (2020) points out that fear sentiment measured by the Volatility Index (VIX) increases flight-to-quality activities by raising the demand for gold. Under extreme market conditions, Low et al. (2016) reveal gold as a reliable inflation hedge in Europe, the U.S., and Australia.

However, gold's properties as safe-haven assets are also controversial. Lucey and Li (2015) show that gold's strength as a hedging tool will vary over time. Bekiros et al. (2017) indicate that for some large emerging markets and BRICS countries (Brazil, Russia, India, China and South Africa), gold cannot be viewed as a safe haven or hedge. Robiyanto (2018) considers that gold could not act as a safe haven role in the Malaysian market. Liu (2020) shows that gold should not be considered a safe haven asset in France and Hungary. He et al. (2018) evidence that gold cannot hedge against UK or U.S. stock markets, finding that gold is not a safe haven in times of the 1987 crash and the 2008 financial crisis. According to Cheema et al. (2020), gold is not a safe haven asset to protect investor wealth during the COVID-19 pandemic, and it might lose investors' trust. Cheema and Szulczuk (2020) and Bouri et al. (2020) provide evidence that gold is not a safe harbour during COVID-19. Furthermore, it is suggested that investors may be losing faith in the stability of gold assets, and they have more alternative assets for shelter, so the hedging role of gold may be questioned. Qureshi et al. (2018) investigate that gold's hedging ability only works in the short term, so central banks should reserve other safe-haven assets to avoid risk. In addition, Da et al. (2015), Ali et al. (2020), and Su et al. (2022c) show that fear sentiments will affect returns and even exacerbate financial market volatility, causing asset prices to fall rapidly. According to Li and Lucey (2017) and Ji et al. (2020), an asset's safe-haven role varies from other crises, so fear sentiments in different crises could affect gold's safe-haven role.

This paper has several marginal contributions. Firstly, we explore the gold's hedging properties by studying the fear sentiments. Thus, investors could draw inspiration from the mutual influences between GP and fear sentiments to deal with economic downside risks in portfolio or risk management. The inter-temporal capital asset pricing model (ICAMP) (Cifarelli & Paladino, 2010) indicates that VIX positively affects GP, and empirical results also show the same conclusion. Secondly, because the changes in investor sentiment can significantly affect investment choice, the sentiment will be a driving factor for gold price fluctuations in times of economic turmoil. But in previous studies, fear sentiments are often measured by using the Financial and Economic Attitudes Revealed by Search (FEARS) index (Georgoula et al., 2015; Karalevicius et al., 2018; Kjærland et al., 2018; Dastgir et al., 2019), which is constructed by Da et al. (2015), cannot reflect the overall fear sentiments correctly and objectively. Hence, we use VIX as an indicator of fear sentiment to test the risk hedging ability of gold. Thirdly, previous studies demonstrate the non-constant relationship between gold prices and fear sentiments (Qadan & Yagil, 2012; Boscaljon & Clark, 2013; Ghosh et al., 2017; Pan, 2018) the time-varying property of model parameters are ignored. Therefore, we employ the bootstrap sub-sample rolling window to explore the time-varying correlation between the two variables.

The remainder of this study is organised as follows. The literature review is outlined in Section 1. The inter-temporal capital asset pricing model with VIX and GP is in Section 2. Section 3 discusses the relevant methodology. Section 4 and 5 involve the data and empirical results. Section 6 applies the results of the empirical analysis and the main findings. The final section concludes the paper.

1. Literature review

According to Bollen et al. (2011) and Guo et al. (2017), investor sentiments can affect investment choices, such as gold. Balcilar et al. (2017) find a bi-directional causal relationship between gold and investor sentiment. Sethi and Gupta (2014) imply a positive and negative correlation between consumer sentiments toward precious metals. Smales (2014) shows that negative news sentiments (e.g. fear sentiments) have generated a more contemporary reaction in the gold market than positive news. Furthermore, Pan (2018) indicates that the bubble of gold tends to occur when fear sentiments increase. Garcia (2013) and Baur and Lucey (2010) argue that, during periods of economic crisis, investors are easily affected by pessimism to hold a higher proportion of gold in the portfolio. Jiang et al. (2014) suggest that heterogeneous investor sentiment influences gold prices. Ghosh et al. (2017) reveal that increased fear sentiments will cause a certain asset transfer to gold. Boscaljon and Clark (2013) show the sharp rise in the VIX has led to positive abnormal returns in the gold-related investment products. Hence, the price of gold is affected by investor sentiment. Ciner et al. (2013) suggest that fear and uncertainty can measure the hedging properties of the underlying risky assets during periods of stress and turmoil. Meanwhile, further evidence shows that the VIX can serve as a forward-looking indicator of investor sentiment and market uncertainty (Bagchi, 2012; Kumar, 2012; Bahadur & Kothari, 2016). Also, Bilgin et al. (2018) indicate that economic uncertainty, constructed by VIX and other indexes, can affect gold prices. Furthermore, gold can retain its values in times of market turmoil (Salisu et al., 2020; Salisu & Adeniran, 2020; Sun et al., 2021), which confirms the importance of gold in reducing downside risks and hedging effectiveness.

However, gold has not always been a safe harbour at all times. Ji et al. (2020) and Tao et al. (2021) argue that the severity of the crisis caused by COVID-19 exceeds that of the previous crisis, with broader and deeper impacts, so gold may not protect during this period. Besides, several studies have questioned the gold's hedging ability in times of the financial crisis in 2008 because, during this period, it was unable to play a role in protecting investors' assets (Bekiros et al., 2017; Klein, 2017; Su et al., 2022a, 2022b). Therefore, the idea that gold is a safe harbour during economic turmoil is not always supported. Wang (2013) finds that gold cannot hedge risks in the short run because of the overshoot in the exchange rate and the excessive depreciation of the U.S. dollar. Cheema et al. (2020) indicate that investors are disappointed with gold due to its failure to play a role in preserving the value of the asset in a crisis. Wang et al. (2016) provide evidence that the speculative value of gold will increase the downside risk during the period post-crisis. According to Baur and Glover (2012) and Reboredo (2013), the level of speculation may influence the safe-haven properties, such as gold. Qureshi et al. (2018) also show that speculative activities could weaken the hedging ability of gold as an investment asset. In addition, the characteristics of the crisis and time

factors will change the hedging role of assets (Hansen & Borch, 2021), so gold may not be a haven asset during some periods. Furthermore, Baur and McDermott (2010) stress that the gold hedging will vary from country to country. In U.S. and European markets, gold is both a hedging tool and a safe harbour, but not in large emerging markets and markets in Canada, Australia and Japan, and large emerging markets. Moreover, Iqbal (2017) points out that gold plays different roles as a safe habour for stock markets, inflation and exchange rates under bear and bull market conditions.

A safe-harbour asset is a security that is negatively correlated or unrelated to another asset or investment portfolio during periods of crisis (Baur & McDermott, 2010). Hence, it is vital for an investor in economic crises. During financial crises, fear sentiments would dominate investor behaviour and drive them to choose safer (higher liquidity) assets like gold, cash and government bonds rather than risky (lower liquidity) securities (Kindleberger, 1978). There are two hypotheses about safe-haven asset properties: flight-to-quality and flight-to-liquidity (Liu, 2020); the latter refers to the phenomenon of investors shifting their capital away from riskier investments to the gold (Baur & Lucey, 2010). Hence, the liquidity and quality characteristics of assets must be considered when examining the effect of asset hedging. It is vital to analyse whether gold can hedge against market risks caused by panic. The studies on GP and VIX are mixed and complicated. Qadan and Yagil (2012) find that the VIX positively affects GP, which confirms the gold's hedging properties. At the same time, Bilgin et al. (2018) indicate that there is a negative correlation between VIX and GP, which may negate the importance of gold in hedging downside risks. In addition, Cohen and Qadan (2010) employ a bidirectional correlation between fear sentiments and the price of gold.

To sum up, previous studies did not explain the mechanism of interaction between VIX and GP from a global perspective, and there is a question of whether gold can be viewed as a hedging tool under fear sentiments. This paper aims to study if gold can be used as a safe harbour to deal with market turmoil. It is possible to question the influence of the fluctuation of the gold price to market fear sentiment. In the current study, the time-varying effect between VIX and GP is ignored, making the Granger causality not constant. Hence, the bootstrap rolling-window causality test can be used to re-exam the interaction between VIX and GP. This article attempts to study the interaction between VIX and GP to justify whether gold can hedge the fear sentiment's risks and provide investors with a new prediction tool.

2. Inter-temporal capital asset pricing model

We use the inter-temporal capital asset pricing model (ICAPM) proposed by Cifarelli and Paladino (2010) to explore the relationship between VIX and GP. It supposes that there are two kinds of groups in the gold market: rational investors who seek to maximise profit by measuring the risks of VIX the other is feedback trading investors who engage in market activities based on the previous trends of GP. We suppose the VIX index can represent systemic risks, and then the demand for gold of this group can be expressed in the following:

$$RGOLD_t = \frac{E_{t-1}\left(GP_t\right) - GP^f}{\mu(VIX_t)}, \tag{1}$$

where $RGOLD_t$ is the proportion of gold demanded by rational investors at time t. $\mu(VIX_t)$ has always been positive, which also means that the VIX is a monotonically increasing func-

tion. GP^f is the risk-free return rate. $E_{t-1}(GP_t)$ is the GP conditional expectation based on $t-1$ time information. GP_t is an ex-post GP during the t period. If there is only one group (rational investors), the value of $RGOLD_t$ is 1. We can rewrite Eq. (1) which was developed Sharpe (1964) as Eq. (2). Therefore, we found that high VIX index indicates a high $\mu(VIX_t)$, and an increase in $\mu(VIX_t)$ leads to a rise in GP.

$$E_{t-1}(GP_t) = GP^f + \mu(VIX_t). \tag{2}$$

Since the previous GP determines the current investment, we consider another factor: feedback traders, whose gold demand ratio ($FGOLD_t$) is as follows:

$$FGOLD_t = \gamma GP_{t-1}, \tag{3}$$

where $\gamma > 0$ means that if GP moves in a positive direction, feedback traders will demand more gold and buy gold from the market. Likewise, $\gamma < 0$ implies less demand for gold for feedback traders, and they will sell gold. If there are two kinds of groups (rational investors and feedback trading investors) in the gold market, then the $RGOLD_t$ and $FGOLD_t$ add up to 1, in that case, we rewrite Eq. (1) as follows:

$$E_{t-1}(GP_t) = GP^f + \mu(VIX_t) - \gamma\mu(VIX_t)GP_{t-1}. \tag{4}$$

Compared to Eq. (2), $-\gamma\mu(VIX_t)GP_{t-1}$ is a term that can make GP fluctuate. The total coefficient of $\mu(VIX_t)$ we can calculate is $1-\gamma GP_{t-1}(\gamma GP_{t-1} = FGOLD_t < 1)$, thereby, there is a positive effect from VIX to GP. Therefore, according to ICAPM, the VIX index has a significant positive effect on the GP. High VIX means that there is a heightened fear sentiment in investors, for example, the financial crisis and so on. During these periods, the price of gold rose as the VIX, which means gold can be a hedge against high VIX risks. Therefore, we can conclude that gold is a safe-haven for fear sentiments.

3. Methodology

3.1. Bootstrap full-sample causality test

The Granger causality test statistics that are underpinned by the model of traditional vector autoregression (VAR), cannot follow the standard asymptotic distribution, which will distort the test results. Therefore, we perform Granger causality test under the bivariate VAR framework (Balcilar et al., 2010) to explore the correlation between GP and VIX. Furthermore, we assume that the time series in Granger causality statistics of VAR framework is stationary. However, Sims et al. (1990) shows that the variables under VAR are unstable. The commonly used test statistics will fall into the problem of non-standard asymptotic distribution, which may lead to errors in test results. Therefore, Shukur and Mantalos (2000) propose the residual-based bootstrap (*RB*) method could be used for standard asymptotic tests. Because this method has size properties and relatively good power in small sample modified *LR* tests. Therefore, we test the correlation between the VIX and GP by the *RB*-based modified-*LR* statistic.

We construct the bivariate VAR (p) process using the RB-based modified-*LR* causality test as follows:

$$X_t = \beta_0 + \beta_1 X_{t-1} + ... + \beta_p X_{t-p} + \varepsilon_t, \ t = 1, 2, ... , T, \tag{5}$$

where $\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t})'$ denotes a white noise process, which follows zero mean and independent. The optimal lag order p is acquired from the Schwarz Information Criterion (SIC). We divide X into VIX and GP, that is $X_t = (VIX_t, GP_t)'$. The control variable is the U.S. dollar index (USDX) because gold has a negatively correlated with the dollar. Periods of high VIX are usually accompanied by increased economic uncertainty, which may cause the dollar's value to appreciate or depreciate (Mensi et al., 2020). Therefore, we can combine the VIX with the U.S. dollar to analyse the movements of the gold market. We can write Eq. (6) as follows:

$$\begin{bmatrix} VIX_t \\ GP_t \end{bmatrix} = \begin{bmatrix} \beta_{10} \\ \beta_{20} \end{bmatrix} + \begin{bmatrix} \beta_{11}(L) & \beta_{12}(L) & \beta_{13}(L) \\ \beta_{21}(L) & \beta_{22}(L) & \beta_{23}(L) \end{bmatrix} \begin{bmatrix} VIX_t \\ GP_t \\ USDX_t \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}, \tag{6}$$

where $\beta_{ij}(L) = \sum_{k=1}^{p} \beta_{ij,k} L^k$, $i, j = 1, 2, 3$ and L denotes the lag operator, defined as $L^k X_t = X_{t-k}$.

Based on Eq. (6), if GP has an important impact on the VIX, we can reject the null hypothesis that GP does not Granger cause VIX ($\beta_{12,k} = 0$ for $k = 1, 2, p$). Likewise, the null hypothesis that VIX cannot affect GP ($\beta_{21,k} = 0$ for $k = 1, 2, ... , p$) can be examined in the same way.

3.2. Parameter stability test

The assumption of the bootstrap full-sample causality test is that the structural change does not exist in the parameters. If parameters change structurally and causal connection becomes unstable, we may acquire null full-sample results. Thus, we test the short-run parameter stability by the *Sup-F*, *Ave-F* and *Exp-F* tests proposed by Andrews and Ploberger (1994), which can be used to explore the structural changes of parameters over the time trajectory. Then the L_c statistics test (Nyblom, 1989) is applied to verify whether the parameters obey the random walk process. If parameters are not constant, we will use the bootstrap rolling window test to investigate the causal interaction between VIX and GP.

3.3. Bootstrap sub-sample rolling-window causality test

The rolling-window bootstrap estimation developed by Balcilar et al. (2010) shows that the entire time series is decomposed into multiple small samples according to the rolling-window width l, which has l observation values. Assuming that the total length of the time series is T, the end of each segmented subsample l, $l + 1$, ……, and we can obtain T and $T - l + 1$ sub-samples. Then we can obtain the Granger causal links between the VIX and GP based on the *RB*-based modified-*LR* test. Finally, by calculating the p-values and *LR* statistics, we can acquire the result of the bootstrap sub-sample rolling-window test (Yuan et al., 2022). The mean of a significant number of estimates $N_b^{-1} \sum_{k=1}^{p} \hat{\beta}_{12,k}^{*}$ shows the influence of GP to VIX and $N_b^{-1} \sum_{k=1}^{p} \hat{\beta}_{21,k}^{*}$ indicates the VIX's effect on GP. We choose the 90% confidence interval and corresponding lower (5^{th} quantiles of $\hat{\alpha}_{12,k}^{*}$) and upper (95^{th} quantiles of $\hat{\alpha}_{21,k}^{*}$) bounds (Balcilar et al., 2010; Su et al., 2021c, 2021b).

4. Data

This article examines the causal relation between the VIX and GP by considering monthly data between 2000:M1 and 2021:M10. The VIX is often considered a gauge of investor sentiment (Bagchi, 2012; Kumar, 2012; Bahadur & Kothari, 2016), even the surge in VIX could indicate an increase in investor activity and changes in investment portfolios. According to Meera and Larbani (2004), a weakening of the U.S. dollar and the rise of commodity prices set a bullish trend in the gold price. This trend affects the gold investment. Besides, the Internet bubble burst in 2000 caused the VIX to fluctuate wildly. The strong reaction to the Internet bubble is starting to give investors more insight into the role of fear sentiments as the premier barometer. We acquire data on the gold price[1], which is influenced by U.S. dollars. The VIX is calculated from the equity S&P 500 index (Stanescu & Tunaru, 2013). The VIX index can be applied to measure the market fear sentiments (Smales, 2014). We can observe that VIX increased sharply during the financial crisis from July to November, and then the price of gold fell as investors sold it. When the VIX is high, it can be accompanied by a rise in gold prices (GP). It is dependent on the market fear sentiment that GP fluctuations. Besides, we acquire VIX data from the Chicago Board Options Exchange (CBOE) to measure fear sentiments (Traub et al., 2000; López & Navarro, 2012). The higher VIX indicates a greater degree of investors panic and vice versa. Therefore, the relationship between GP and VIX can affect investor sentiments, which will affect investors' decision-making about the investment portfolio. Besides, the dollar is used as a measure of gold, so its fluctuations may influence the gold market. Baker et al. (2016) show that there exists a positive correlation between VIX and Economic Policy Uncertainty (EPU), which means political events may affect fear sentiments. Furthermore, USDX is closely related to EPU (Qin et al., 2020), thus the VIX may affect the fluctuations of gold by U.S. dollar (USDX). Thereby, USDX is selected as a control variable because it can influence the correlation between VIX and GP. Figure 1 reveals the movements of VIX, and GP.

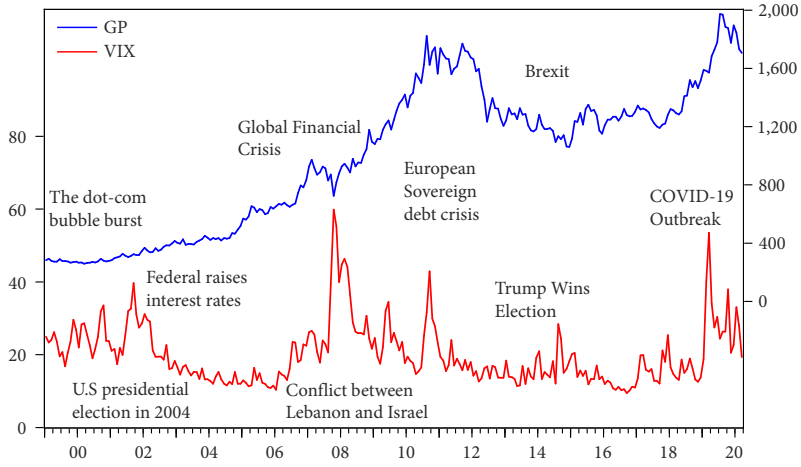

Figure 1. The trends of VIX and GP

[1] Gold prices in U.S. dollar are taken from Eastmoney.

From Figure 1, it can be observed that the VIX move in a different direction from GP. The bursting of the dotcom bubble, which peaked in March 2000, has pummeled U.S. stocks, dented investor confidence and left the VIX index at high levels, but did not make the level of gold fluctuate significantly. The 9/11 terrorist attacks also lead to spikes in VIX (Stanescu & Tunaru, 2013), but do not cause drastic gold fluctuations because the financial market impact is controllable. The Federal Reserve started a cycle of raising interest rates in June 2004 to prevent the U.S. housing market bubble from overheating the economy. This measure eased market fear sentiments, and the VIX fell. At the same time, the U.S. dollar exchange rate fluctuates, and the trend is weak, which makes public demand for a gold increase, and the GP continues to rise. Also, this negative correlation can be noticed in October 2008. The outbreak of the European debt crisis in 2011 has affected the fear sentiments in the global market. The U.S. stock market al.o plummeted, and investors' demand for safe-haven assets rose sharply. During this period, VIX has increased, and GP is on an escalating trend, which shows a positive correlation between fear sentiments and gold price. In addition, both internal events (e.g., the stock market plummeting, subprime mortgage crisis) and external events (e.g., trade war, an outbreak of COVID-19) are likely to promote the rise of VIX. At the same time, GP does not necessarily move upwards. To sum up, the interaction between these two variables is changeable and intricate.

The average value of the VIX, GP and USDX is 20.084, 986.674 and 90.922, respectively (see Table 1). The skewness of VIX is positive, but GP and USDX are negative, which means asymmetry. The kurtosis of VIX is 7.04, which means the feature of fat-tails, while the kurtosis of GP and USDX are 1.75 and 2.87, which demonstrate a platykurtic distribution. Furthermore, the results of the Jarque-Bera test show non-normally distributed at a 1% level for these three series. Thereby, it is inappropriate to apply the traditional Granger causality. This article applies the bootstrap rolling-window method and *RB* method to increase the credibility of the results and avoid the possible non-normal distributions between the VIX and GP.

Table 1. Descriptive statistics for VIX and GP

	VIX	GP	USDX
Mean	20.025	1008.207	90.961
Median	17.915	1169.620	90.005
Maximum	59.890	1974.690	120.590
Minimum	9.510	257.950	72.165
Standard Deviation	8.201	503.450	11.313
Skewness	1.719	–0.075	0.647
Kurtosis	7.04	1.75	2.87
Jarque-Bera	307.567***	17.311***	18.458***

Note: *** denotes significance at the 1% level.

5. Empirical results

The bivariate VAR model based on VIX and GP is applied to estimate the causality of full sample according to Eq. (6). The optimal lag length is 1 in the light of the Schwarz information criterion (SIC). In Table 2, the results of the full-sample causality test are shown. The bootstrap *p*-values indicate that the correlation between VIX and GP is not obvious, revealing that VIX cannot cause GP, and similarly, GP does not Granger cause VIX. The above results are inconsistent with existing studies (Balcilar et al., 2010; Qadan & Yagil, 2012) and the hypothesis of ICAPM, which emphasise there exists a positive effect from VIX to GP.

Table 2. Full-sample Granger causality tests

Tests	H_0: VIX does not Granger cause GP		H_0: GP does not Granger cause VIX	
	Statistics	*p*-values	Statistics	*p*-values
Bootstrap *LR* test	0.052	0.810	1.302	0.200

Note: We calculate *p*-values using 10,000 bootstrap repetitions.

In the bivariate VAR model for GP and VIX, the parameters of the full-sample test are assumed to be fixed. According to Balcilar et al. (2013), structural changes may exist in the VAR models, making the interaction between the two variables have time-varying characteristics. According to Andrews (1993) and Andrews and Plobergers (1994), the *Sup-F*, *Ave-F* and *Exp-F* tests can be applied to test whether the parameters of the VAR model are stable. Furthermore, the *Lc* statistics test (Nyblom, 1989; Hansen, 1992) that examines all parameters of the whole VAR system can improve the reliability and accuracy of the causality test.

In Table 3, the *Sup-F* test highlights a sudden structural change of GP and VIX at a 1% level, while the VAR model is at the 5% level. Through the *Ave-F* test, it can be concluded that GP, VIX and VAR systems have structural changes at the 1% level. The *Exp-F* test indicates that in GP, VIX and VAR systems, parameters in the variables will change gradually over time. Besides, the L_c statistics test (Hansen, 1992) shows that parameters in the VAR model do not follow the principle of the random walk at the 1% level, which illustrates the time-varying characteristics of variables. Hence, the results obtained through the bootstrap full-sample causality test are not reliable. Then we investigate the time-varying correlation between GP and VIX by applying the bootstrap sub-sample causality test. A larger width could increase the accuracy of the results but might reduce the times of scrolls, while a smaller width will cause biased test results. Furthermore, Pesaran and Timmermann (2005) consider that the optimal rolling-window width is greater than or equal to 20. Hence, the rolling-window width we have chosen is 24-months[2] in this paper to ensure the credibility of causality analysis.

In Figures 2, the *p*-values highlight the direction and extent of the influence from VIX to GP. The VIX Granger causes GP at the 10% level of significance in the periods of 2004:M6–2004:M9, 2008:M10–2008:M11 (VIX has a negative influence on GP), and 2011:M5–2011:M10, 2020:M2–2020:M3 (VIX positively affects GP).

[2] We tested the robustness of results by using the rolling-window widths of 20-, 28-, 32-months, the results are identical to the 24-months rolling-window.

Table 3. The results of parameter stability test

Tests	GP		VIX		VAR system	
	Statistics	*p*-value	Statistics	*p*-value	Statistics	*p*-value
Sup-F	19.913***	0.004	20.753***	0.002	44.257***	0.000
Ave-F	9.803***	0.003	10.948***	0.001	12.472**	0.012
Exp-F	7.347***	0.004	7.056***	0.005	17.099***	0.000
L_c					2.172***	0.008

Notes: We calculate *p*-values using 10,000 bootstrap repetitions; ***denotes significance at the1% levels.

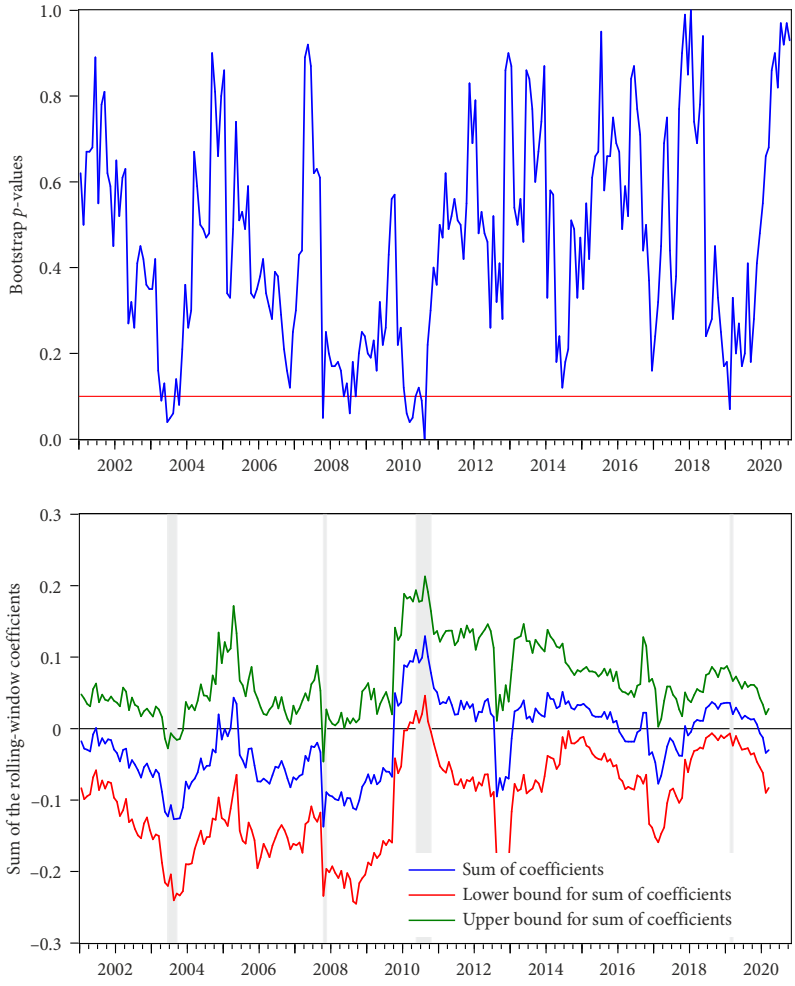

Figure 2. Impact of VIX on GP

From June 2004, the Fed Reserve started a rate-rise cycle, and then the VIX dropped significantly (Fernandez-Perez et al., 2017) after the Federal Open Committee (FOMC) issued this announcement, which indicated a decrease in market fear sentiment. During the period of 2004:M6–2004:M9, GP has risen to a certain extent. This negative effect shows that gold is not a safe harbour for fear sentiments. We consider the following two aspects of the mechanism of VIX on GP. Firstly, the U.S. government has devalued the dollar to help cut the federal deficit. Since the negative relationship between gold and the dollar (Baur & Glover, 2015; Bialkowski et al., 2015), the gold price is influenced by the appreciation and depreciation of the dollar. Secondly, during the U.S. presidential election cycles, the impact of political process and uncertainty may affect market fluctuation (Goodell & Vahamaa, 2013; Su et al., 2021a). It may affect gold prices and cause them to fluctuate and rise in 2004:M4–2004:M9. Therefore, gold maybe not the safe haven for fear sentiments.

In 2008, the global financial crisis broke out, and the economies of almost all countries were affected. Neffelli and Resta (2018) divide the financial crisis into three research stages, pre-crisis, during the crisis and post-crisis, and evidence that the VIX fear transmission mechanism mainly worked during the 2008 financial crisis and the post-crisis period. In September 2008, American International Group and Lehman Brothers collapsed, and the VIX soared to the highest point during the period of 2008:M10-2008:M11. This incident caused investors to overreact pessimistic to the market (Gennaioli et al., 2015). Investors' excessive fear has led to an outflow of $200 billion from money market mutual funds (Cornett et al., 2011), which means investors prefer to hold more cash than any other assets, including gold. On the other hand, the increase in debt pressure and the loss of consumer confidence may lead to investor liquidity tension (Tong & Wei, 2008). In order to obtain more liquidity, investors may sell value-preserved assets, such as gold. Li and Lucey (2017) manifest that the choice of safe-harbour assets will be affected by economic and political determinants. Due to various crises, safe-haven assets often play different roles (Hasan et al., 2021). Furthermore, Wang et al. (2016) indicate that extreme risks are transmitted faster between gold markets in the post-financial crisis era than in the pre-financial crisis era, so the safe-haven demand for gold will be affected in the post-crisis period. Therefore, even if the VIX is high, GP is still at a low level. In addition, according to Gopalakrishnan and Mohapatra (2018), in developing economies and emerging markets, the amount of central bank gold reserves rises rapidly in the years following the 2008 worldwide financial crisis. It may be evidence that these countries have not yet appreciated the hedging role of gold before 2008, so GP will not rise with VIX.

However, there is a positive effect from VIX to GP in 2011:M5–2011:M10. The European debt crisis began with the Greek debt crisis, resulting from the downgrading three global major rating companies. Subsequently, other European countries have also started to suffer from a debt crisis (Lane, 2012). As the European debt crisis spread to the global stock market (Morales & Andreosso-O'Callaghan, 2012), the U.S. stock market plummeted in May 2011. The euro debt crisis led to the rise in global risk aversion and a sell-off of equities (Stracca, 2015). During the period of 2011:M5–2011:M10, the VIX increased. Gold may be held by investors again to hedge against risks in this period (Wang et al., 2016). Consequently, as the demand for gold increases and the price rises, the direction of fluctuations in GP and VIX is similar. It can prove that gold is a hedge against risks in times of panic.

In December 2019, there was an outbreak of COVID-19 in the world. The U.S. president announced a travel ban on European Union countries on 11 March and a national emergency for the COVID-19 on 13 March. Investors expect the real (nonfinancial) shocks from the COVID-19 pandemic to be magnified by financial channels (Ramelli & Wagner, 2020; Tao et al., 2022). On March 16, the VIX launched by Chicago Board Options Exchange soared above its previous all-time high, reached during the global financial crisis more than a decade ago. From March 9 to March 18, U.S. stocks triggered four circuit breakers and experienced a strong rally in this time period. Even in periods of extremely high volatility, the VIX index has a negative correlation with the stock markets (Hood & Malik, 2013). Therefore, the VIX index broke through its all-time high and has remained high. After the jump in the VIX, risk became more recognised by people, and risk aversion around the world is on the rise. Baur and McDermott (2010) show that when global economic uncertainty rises, investors take gold as a hedge. In the face of high levels of uncertainty in capital markets, investors see gold as an alternative investment (Cohen & Qadan, 2010). Akhtaruzzaman et al. (2021) examine the character of gold as a safe-harbour asset at different stages of the COVID-19 pandemic crisis. The results show that gold can act as a safe-haven asset in the first phase of the pandemic (December 31, 2019 – March 16, 2020), but in the second stage (March 17 – April 24, 2020), gold lost its role as a safe-haven asset. A surge in hedging or safe-haven demand for gold sends its price to $2000/oz. Therefore, the positive influence of VIX on GP can be evidenced during the period of 2020:M2–2020:M3. These two periods indicate that VIX positively affects GP, which is supported by the ICAPM.

In Figures 3, the bootstrap *p*-value and the direction of GP's influence on VIX are shown. The null hypothesis that GP does not Granger cause VIX cannot be accepted in 2006:M05–2007:M06, 2012:M07–2013:M09 (GP has a positive influence on VIX), 2016:M07–2017:M1 and 2017:M10–2018:M1 (GP has a negative impact on VIX) at 10% significance level.

The GP's positive impact on VIX suggests that through gold, we can observe whether market sentiment is stable; that is, gold can be regarded as an indicator of market sentiment. During the periods of 2006:M07–2007:M06 and 2012:M07–2013:M09, the influences from GP to VIX are positive. In July 2006, the conflict between Lebanon and Israel began to loom, this caused the demand for gold as a hedge. Caldara and Iacoviello (2018) and Su et al. (2021c) show the definition of geopolitical risk (GPR) as the risk related to tensions between states, terrorists, acts and wars that affect international relations. Hence, the 2006 Lebanon War may exacerbate geopolitical risks and uncertainty, so VIX may fluctuate and rise sharply as the conflict intensifies. That means the VIX and GP are in the same direction. Hence, gold is a great predictor of market fear sentiment.

On September 16th, 2011, gold rose sharply to the highest point of $1912/oz. Due to the European debt crisis and international politics (this record is broken until the COVID-19 pandemic). Bialkowski et al. (2015) point out that the attractiveness in gold may bring the price boom and speculative bubble. Pan (2018) investigates that the bubbles for gold increased as VIX increased in the 2011 European sovereign debt crisis. The level of speculation in gold may destroy the hedging potential of gold (Baur & Glover, 2012; Reboredo, 2013), so gold will become less of a safe haven. Then after the impact of the crisis fades in 2012:M07–2013:M09, the price of gold began to slide. Cheema et al. (2020) show that investors lose 45% of gold's value from 2011 to 2015, indicating a loss of trust in gold. Meanwhile, the policies

for the European debt crisis (e.g. the European Stability) improved investors' confidence for the market thereby, the fear sentiments decreased, and the VIX fell. Therefore, we can conclude that GP can positively impact VIX in times of the two periods.

The negative impact of GP on VIX occurred in times 2016:M07–2017:M1 and 2017:M10–2018:M1. Su et al. (2020) indicate that the dollar's value will be affected by the Federal Reserve's interest rate hikes and the implementation and withdrawal of quantitative easing policies. The Federal Reserve continued to raise interest rates several times from 2016 to 2017, so growing expectations have boosted the dollar, but the gold will decrease due to the negative correlation with the dollar (Fang et al., 2012). There were many black swans' events in 2016 (Chen et al., 2017), such as Brexit, Donald Trump has been elected president of the U.S., and immigration problems, which means economic uncertainty is high this year. Given the long-term political uncertainty and consequences that this process could bring, investors' fear sentiments have, in most cases, become more persistent and severe (Caporale, et al., 2018).

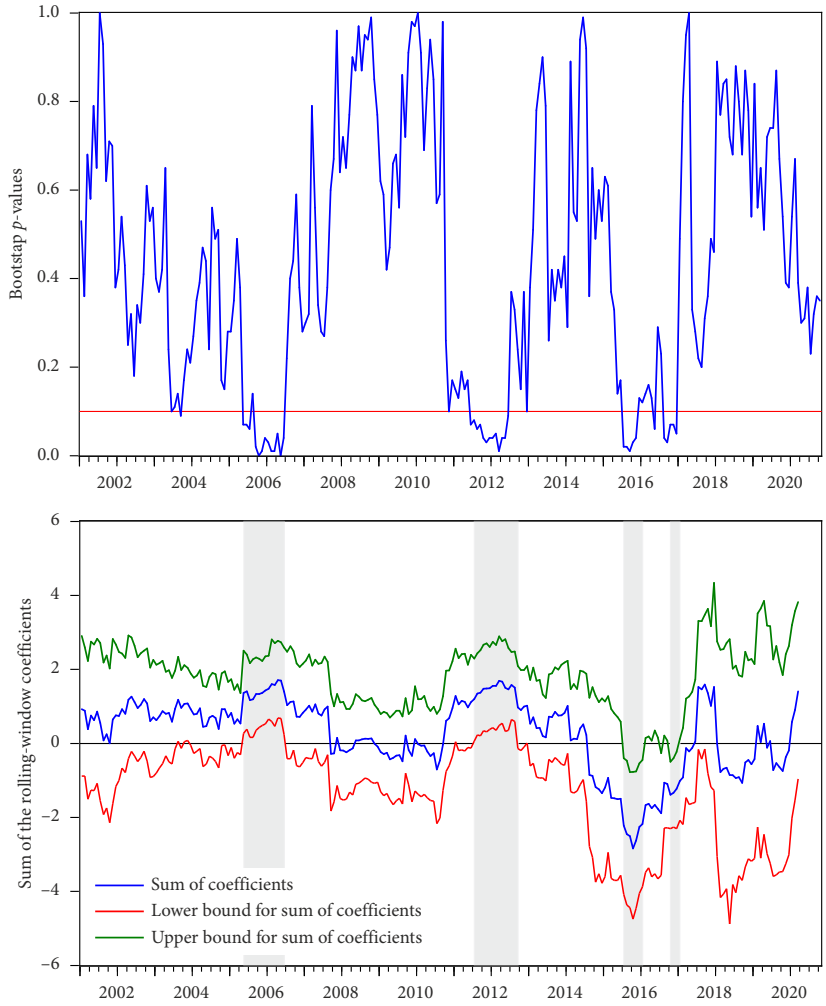

Figure 3. Impact of GP on VIX

İskenderoglu and Akdag (2020) consider that uncertainty and volatility have increased the fear sentiments and exhibit a fear of investment. In the case of low GP, consumers' confidence in the government is reduced (Qadan & Yagil, 2012). Hence the negative consequences of high VIX will be exacerbated. Thereby, during the period of 2016:M07–2017:M1, there was a negative impact from GP on VIX.

Similarly, the Trump administration's ambiguities in policies and the Tax Reform Act, which passed in December 2017, increase the political uncertainty and thus result in the fear sentiments rising in the market. Nevertheless, the decline in GP during this period also made the public reluctant to hold gold (Qadan & Yagil, 2012). An investor cannot hedge against the VIX by buying or selling gold, which would further damage the U.S. political conditions. Therefore, GP's negative impact on VIX can be proved in the period of 2017:M10–2018:M1.

To sum up, as the assumption of parameter values is fixed, the results of the Grange full-sample test indicate that the causal interaction between the two variables does not exist. Furthermore, we realize that structural changes exist in both VAR and time-series systems through stability tests. We perform the bootstrap sub-sample rolling-window causality to probe into the time-varying interaction between the two variables. The results reveal that the increase in VIX may positively affect GP, suggesting that gold can be deemed as a hedge of fear sentiments' risks. This result is consistent with the ICAPM. Moreover, VIX is also associated with policy uncertainty, the dollar value and liquidity, which have a combined impact on the gold market. This suggests GP can be negatively affected by VIX. In turn, since GP can change investors' confidence in higher returns, GP had positive and negative effects on VIX. Through the correlation between these two variables, we can demonstrate that gold can be a hedge against the risks of fear sentiments.

Conclusions

In this paper, we examine the causal interaction between fear sentiments and the price of gold to investigate whether GP can hedge the risk of VIX and how GP affects the trend of VIX. The results obtained through the full-sample Granger causality test do not support the causality of these two variables because dynamic parameters cannot be captured. Next, we use the subsample test, which considers the time-varying relationship between variables. The results show that VIX positively affects GP, which is consistent with the theoretical model of ICAMP. It illustrates fear sentiments can drive the price of gold, and gold can be viewed as a safe haven against fear sentiments. High VIX causes GP to increase, mainly because the increased fear sentiments generated investors' demand for hedging. Therefore, they choose to buy and hold gold to avoid risks, increasing the price. However, VIX has negatively affected GP, dependent on dollar value and the liquidity of safe-haven assets. This indicates that the gold market can reflect the market sentiments.

Although gold is traditionally seen as a hedge or safe-haven asset, it cannot hedge all risks for investors. It can provide the government and investors with reference by understanding the interrelationship between GP and VIX and the role of sentiment on gold demand. Above all, VIX can positively affect GP for a certain period of time. It means gold can play a hedging role to a certain degree. Investors can grasp the trend of gold, build a reasonable portfolio,

and hold gold to protect its value in a crisis. If fear sentiments decline, they can combine with a dollar to judge the direction of gold to avoid loss. Governments can monitor the GP based on VIX, analyse whether there is excessive panic in the market, and take action to stabilise market sentiment and restore investor confidence. Secondly, there are positive effects from GP to VIX, which means GP can be viewed as a predictor of market sentiment. Investors can be rational if there is more speculation on gold and cut loss in time. The government may be able to change international reserves to avoid losses and take early steps to prevent bubbles. On the other hand, a rise in VIX could simultaneously lead to a decline in GP. This means there are other safe-haven assets, and investors have more choices about safe haven assets to diversify risks than just gold. Governments should also pay attention to these new hedge assets and regulate them to ensure security.

References

Akhtaruzzaman, M., Boubaker, S., Lucey, B. M., & Sensoy, A. (2021). Is gold a hedge or a safe-haven asset in the COVID-19 crisis? *Economic Modelling*, *102*, 105588. https://doi.org/10.1016/j.econmod.2021.105588

Ali, M., Alam, N., & Rizvi, S. A. R. (2020). Coronavirus (COVID-19) – An epidemic or pandemic for financial markets. *Journal of Behavioral and Experimental Finance*, *27*, 100341. https://doi.org/10.1016/j.jbef.2020.100341

Andrews, D. W. (1993). Tests for parameter instability and structural change with unknown change point. *Econometrica: Journal of the Econometric Society*, *61*(4), 821–856. https://doi.org/10.2307/2951764

Andrews, D. W., & Ploberger, W. (1994). Optimal tests when a nuisance parameter is present only under the alternative. *Econometrica: Journal of the Econometric Society*, *62*(6), 1383–1414. https://doi.org/10.2307/2951753

Arouri, M. E. H., Lahiani, A., & Nguyen, D. K. (2015). World gold prices and stock returns in China: Insights for hedging and diversification strategies. *Economic Modelling*, *44*, 273–282. https://doi.org/10.1016/j.econmod.2014.10.030

Bahadur, G. C., & Kothari, R. (2016). The forecasting power of the volatility Index: Evidence from the Indian stock market. *Management & Social Sciences*, *4*(1), 230–243. https://doi.org/10.21013/jmss.v4.n1.p21

Bagchi, D. (2012). Cross-sectional analysis of emerging market volatility index (India VIX) with portfolio returns. *International Journal of Emerging Markets*, *7*(4), 383–396. https://doi.org/10.1108/17468801211264306

Baker, S. R., Bloom, N., & Davis, S. J. (2016). Measuring economic policy uncertainty. *The Quarterly Journal of Economics*, *131*(4), 1593–1636. https://doi.org/10.1093/qje/qjw024

Balcilar, M., Bonato, M., Demirer, R., & Gupta, R. (2017). The effect of investor sentiment on gold market return dynamics: Evidence from a nonparametric causality-in-quantiles approach. *Resources Policy*, *51*, 77–84. https://doi.org/10.1016/j.resourpol.2016.11.009

Balcilar, M., Ozdemir, Z. A., & Arslanturk, Y. (2010). Economic growth and energy consumption causal nexus viewed through a bootstrap rolling window. *Energy Economics*, *32*(6), 1398–1410. https://doi.org/10.1016/j.eneco.2010.05.015

Baur, D. G., & Glover, K. (2012). *A gold bubble*? (Working Paper Series 175). Finance Discipline Group, UTS Business School, University of Technology, Sydney. https://ideas.repec.org/p/uts/wpaper/175.html

Baur, D. G., & Glover, K. J. (2015). Speculative trading in the gold market. *International Review of Financial Analysis*, *39*, 63–71. https://doi.org/10.1016/j.irfa.2015.02.004

Baur, D. G., & Lucey, B. M. (2010). Is gold a hedge or a safe haven? An analysis of stocks, bonds and gold. *Financial Review*, *45*(2), 217–229. https://doi.org/10.1111/j.1540-6288.2010.00244.x

Baur, D. G., & McDermott, T. K. (2010). Is gold a safe haven? International evidence. *Journal of Banking and Finance*, *34*(8), 1886–1898. https://doi.org/10.1016/j.jbankfin.2009.12.008

Beckmann, J., Berger, T., & Czudaj, R. (2015). Does gold act as a hedge or a safe haven for stocks? A smooth transition approach. *Economic Modelling*, *48*, 16–24. https://doi.org/10.1016/j.econmod.2014.10.044

Bekiros, S., Boubaker, S., Nguyen, D. K., & Uddin, G. S. (2017). Black swan events and safe havens: The role of gold in globally integrated emerging markets. *Journal of International Money and Finance*, *73*, 317–334. https://doi.org/10.1016/j.jimonfin.2017.02.010

Ben Nasr, A., Bonato, M., Demirer, R., & Gupta, R. (2018). *Investor sentiment and crash risk in safe havens*. https://doi.org/10.2139/ssrn.3116554

Białkowski, J., Bohl, M. T., Stephan, P. M., & Wisniewski, T. P. (2015). The gold price in times of crisis. *International Review of Financial Analysis*, *41*, 329–339. https://doi.org/10.1016/j.irfa.2014.07.001

Bilgin, M. H., Gozgor, G., Lau, C. K. M., & Sheng, X. (2018). The effects of uncertainty measures on the price of gold. *International Review of Financial Analysis*, *58*, 1–7. https://doi.org/10.1016/j.irfa.2018.03.009

Bollen, J., Mao, H., & Zeng, X. (2011). Twitter mood predicts the stock market. *Journal of Computational Science*, *2*(1), 1–8. https://doi.org/10.1016/j.jocs.2010.12.007

Boscaljon, B., & Clark, J. (2013). Do large shocks in VIX signal a flight-to-safety in the gold market? *Journal of Applied Finance*, *23*(2), 120–131.

Boubaker, H., Cunado, J., Gil-Alana, L. A., & Gupta, R. (2020). Global crises and gold as a safe haven: Evidence from over seven and a half centuries of data. *Physica A: Statistical Mechanics and its Applications*, *540*, 123093. https://doi.org/10.1016/j.physa.2019.123093

Bouri, E., Shahzad, S. J. H., Roubaud, D., Kristoufek, L., & Lucey, B. (2020). Bitcoin, gold, and commodities as safe havens for stocks: New insight through wavelet analysis. *The Quarterly Review of Economics and Finance*, *77*, 156–164. https://doi.org/10.1016/j.qref.2020.03.004

Bredin, D., Conlon, T., & Potì, V. (2015). Does gold glitter in the long-run? Gold as a hedge and safe haven across time and investment horizon. *International Review of Financial Analysis*, *41*, 320–328. https://doi.org/10.1016/j.irfa.2015.01.010

Brodsky, D. A., & Sampson, G. P. (1980). The value of gold as a reserve asset. *World Development*, *8*(3), 175–192. https://doi.org/10.1016/0305-750X(80)90008-X

Caldara, D., & Iacoviello, M. (2018). *Measuring geopolitical risk*. Social Science Electronic Publishing. https://doi.org/10.17016/IFDP.2018.1222

Caporale, G. M., Gil-Alana, L., & Trani, T. (2018). Brexit and uncertainty in financial markets. *International Journal of Financial Studies*, *6*(1), 21–30. https://doi.org/10.3390/ijfs6010021

Cheema, M. A., Faff, R. W., & Szulczuk, K. (2020). *The 2008 global financial crisis and COVID-19 pandemic: How safe are the safe haven assets?* SSRN. https://doi.org/10.2139/ssrn.3590015

Cheema, M. A., & Szulczuk, K. (2020). *COVID-19 pandemic and its influence on safe havens: An Examination of Gold, T-Bills, T-Bonds, US Dollar, and Stablecoin*. SSRN. https://doi.org/10.2139/ssrn.3590015

Chen, K., & Wang, M. (2019). Is gold a hedge and safe haven for stock market? *Applied Economics Letters*, *26*(13), 1080–1086. https://doi.org/10.1080/13504851.2018.1537469

Chen, X., Tian, Y., & Zhao, R. (2017). Study of the cross-market effects of Brexit based on the improved symbolic transfer entropy GARCH model-An empirical analysis of stock-bond correlations. *PloS ONE*, *12*(8), e0183194. https://doi.org/10.1371/journal.pone.0183194

Cifarelli, G., & Paladino, G. (2010). Oil price dynamics and speculation: A multivariate financial approach. *Energy Economics*, *32*(2), 363–372. https://doi.org/10.1016/j.eneco.2009.08.014

Ciner, C., Gurdgiev, C., & Lucey, B. M. (2013). Hedges and safe havens: An examination of stocks, bonds, gold, oil and exchange rates. *International Review of Financial Analysis*, *29*, 202–211. https://doi.org/10.1016/j.irfa.2012.12.001

Cohen, G., & Qadan, M. (2010). Is gold still a shelter to fear. *American Journal of Social and Management Sciences*, *1*(1), 39–43. https://doi.org/10.5251/ajsms.2010.1.1.39.43

Cornett, M. M., McNutt, J. J., Strahan, P. E., & Tehranian, H. (2011). Liquidity risk management and credit supply in the financial crisis. *Journal of Financial Economics*, *101*(2), 297–312. https://doi.org/10.1016/j.jfineco.2011.03.001

Da, Z., Engelberg, J., & Gao, P. (2015). The sum of all FEARS investor sentiment and asset prices. *The Review of Financial Studies*, *28*(1), 1–32. https://doi.org/10.1093/rfs/hhu072

Dastgir, S., Demir, E., Downing, G., Gozgor, G., & Lau, C. K. M. (2019). The causal relationship between Bitcoin attention and Bitcoin returns: Evidence from the copula-based granger causality test. *Finance Research Letters*, *28*, 160–164. https://doi.org/10.1016/j.frl.2018.04.019

De Long, J., Shleifer, A., Summers, L., & Waldman, R. (1990). Noise trader risk in financial markets. *Journal of Political Economy*, *98*(4), 703–738. https://doi.org/10.1086/261703

Fang, S., Fan, W., & Lu, T. (2012). *Gold pricing model during the financial crisis*. https://doi.org/10.2139/ssrn.2055266

Fernandez-Perez, A., Frijns, B., & Tourani-Rad, A. (2017). When no news is good news – The decrease in investor fear after the FOMC announcement. *Journal of Empirical Finance*, *41*, 187–199. https://doi.org/10.1016/j.jempfin.2016.07.013

Garcia, D. (2013). Sentiment during recessions. *The Journal of Finance*, *68*(3), 1267–1300. https://doi.org/10.1111/jofi.12027

Garone, F. G. (2020). *Market sentiment and gold: investors' and miners' bet*. https://tesi.luiss.it/id/eprint/29452

Gennaioli, N., Shleifer, A., & Vishny, R. (2015). Money doctors. *The Journal of Finance*, *70*(1), 91–114. https://doi.org/10.1111/jofi.12188

Georgoula, I., Pournarakis, D., Bilanakos, C., Sotiropoulos, D., & Giaglis, G. M. (2015). *Using time-series and sentiment analysis to detect the determinants of Bitcoin prices*. SSRN. https://doi.org/10.2139/ssrn.2607167

Ghosh, B., Roux, C. L., & Ianole, R. (2017). Fear estimation-evidence from BRICS and UK. Social Science Electronic Publishing. *International Journal of Applied Business and Economic Research*, *15*(4), 195–207.

Goodell, J. W., & Vähämaa, S. (2013). US presidential elections and implied volatility: The role of political uncertainty. *Journal of Banking & Finance*, *37*(3), 1108–1117. https://doi.org/10.1016/j.jbankfin.2012.12.001

Gopalakrishnan, B., & Mohapatra, S. (2018). Turning over a golden leaf? Global liquidity and emerging market central banks' demand for gold after the financial crisis. *Journal of International Financial Markets. Institutions and Money*, *57*, 94–109. https://doi.org/10.1016/j.intfin.2018.07.002

Grisse, C., & Nitschka, T. (2015). On financial risk and the safe haven characteristics of Swiss franc exchange rates. *Journal of Empirical Finance*, *32*, 153–164. https://doi.org/10.1016/j.jempfin.2015.03.006

Guo, K., Sun, Y., & Qian, X. (2017). Can investor sentiment be used to predict the stock price? Dynamic analysis based on China stock market. *Physica A: Statistical Mechanics and its Applications*, *469*, 390–396. https://doi.org/10.1016/j.physa.2016.11.114

Hansen, K. B., & Borch, C. (2021). The absorption and multiplication of uncertainty in machine-learning-driven finance. *The British Journal of Sociology*, *72*(4), 1015–1029. https://doi.org/10.1111/1468-4446.12880

Hansen, B. E. (1992). Testing for parameter instability in linear models. *Journal of Policy Modeling*, *14*(4), 517–533. https://doi.org/10.1016/0161-8938(92)90019-9

Hasan, M. B., Hassan, M. K., Rashid, M. M., & Alhenawi, Y. (2021). Are safe haven assets really safe during the 2008 global financial crisis and COVID-19 pandemic? *Global Finance Journal*, *50*, 100668. https://doi.org/10.1016/j.gfj.2021.100668

He, Z., O'Connor, F., & Thijssen, J. (2018). Is gold a Sometime Safe Haven or an Always Hedge for equity investors? A Markov-Switching CAPM approach for US and UK stock indices. *International Review of Financial Analysis*, *60*, 30–37. https://doi.org/10.1016/j.irfa.2018.08.010

Henriksen, T. E. S. (2018). Properties of long/short commodity indices in stock and bond portfolios. *Journal of Alternative Investments*, *20*(4), 51–68. https://doi.org/10.3905/jai.2018.1.060

Hood, M., & Malik, F. (2013). Is gold the best hedge and a safe haven under changing stock market volatility? *Review of Financial Economics*, *22*(2), 47–52. https://doi.org/10.1016/j.rfe.2013.03.001

Hunt, D. A., le Roux, C. L., & Oberholzer, N. (2018). Precious metals as safe haven assets in the South African market. In *4th 2018 Academy of Business and Emerging Markets* (*ABEM*) *Conference* (pp. 75–81). https://www.researchgate.net/publication/348555592

Iqbal, J. (2017). Does gold hedge stock market, inflation and exchange rate risks? An Econometric Investigation. *International Review of Economics and Finance*, *48*, 1–17. https://doi.org/10.1016/j.iref.2016.11.005

İskenderoglu, Ö., & Akdag, S. (2020). Comparison of the effect of VIX fear index on stock exchange indices of developed and developing countries: The G20 case. *South East European Journal of Economics and Business*, *15*(1), 105–121. https://doi.org/10.2478/jeb-2020-0009

Ji, Q., Zhang, D., & Zhao, Y. (2020). Searching for safe-haven assets during the COVID-19 pandemic. *International Review of Financial Analysis*, *71*, 101526. https://doi.org/10.1016/j.irfa.2020.101526

Jiang, W., Luan, P., & Yang, C. (2014). The study of the price of gold futures based on heterogeneous investors' overconfidence. *China Financial Review International*, *4*(1), 24–41. https://doi.org/10.1108/CFRI-12-2012-0115

Jin, J., Yu, J., Hu, Y., & Shang, Y. (2019). Which one is more informative in determining price movements of hedging assets? Evidence from Bitcoin, gold and crude oil markets. *Physica A: Statistical Mechanics and its Applications*, *527*, 121121. https://doi.org/10.1016/j.physa.2019.121121

Karalevicius, V., Degrande, N., & De Weerdt, J. (2018). Using sentiment analysis to predict interday Bitcoin price movements. *Journal Risk Finance*, *19*(1), 56–75. https://doi.org/10.1108/JRF-06-2017-0092

Kindleberger, C. P. (1978). *Manias, panics and crashes: A history of financial crises*. Palgrave Macmillan.

Kjærland, F., Khazal, A., Krogstad, E. A., Nordstrøm, F. B. G., & Oust, A. (2018). An analysis of Bitcoin's price dynamics. *Journal of Risk and Financial Management*, *11*(4), 1–18. https://doi.org/10.3390/jrfm11040063

Klein, T. (2017). Dynamic correlation of precious metals and flight-to-quality in developed markets. *Finance Research Letters*, *23*, 283–290. https://doi.org/10.1016/j.frl.2017.05.002

Kumar, S. (2012). A first look at the properties of India's volatility index. *International Journal of Emerging Markets*, *7*(2), 160–176. https://doi.org/10.1108/17468801211209938

Lane, P. R. (2012). The European sovereign debt crisis. *Journal of Economic Perspectives*, *26*(3), 49–68. https://doi.org/10.1257/jep.26.3.49

Li, S., & Lucey, B. M. (2017). Reassessing the role of precious metals as safe havens – What colour is your haven and why? *Journal of Commodity Markets*, *7*, 1–14. https://doi.org/10.1016/j.jcomm.2017.05.003

Liu, W. H. (2020). Are gold and government bond safe-haven assets? An extremal quantile regression analysis. *International Review of Finance*, *20*(2), 451–483. https://doi.org/10.1111/irfi.12232

López, R., & Navarro, E. (2012). Implied volatility indices in the equity market: A review. *African Journal of Business Management*, *6*(50), 11909–11915. https://doi.org/10.5897/AJBM12.272

Low, R. K. Y., Yao, Y., & Faff, R. (2016). Diamonds vs. precious metals: What shines brightest in your investment portfolio? *International Review of Financial Analysis*, *43*, 1–14. https://doi.org/10.1016/j.irfa.2015.11.002

Lucey, B. M., & Li, S. (2015). What precious metals act as safe havens, and when? Some US evidence. *Applied Economics Letters*, *22*(1), 35–45. https://doi.org/10.1080/13504851.2014.920471

Meera, A. K. M., & Larbani, M. (2004). The gold dinar: The next component in Islamic economics, banking and finance. *Review of Islamic Economics*, *8*(1), 5–34.

Mensi, W., Sensoy, A., & Vo, X. V. (2020). *Pricing efficiency of major asset classes during COVID-19 outbreak*. https://www.researchgate.net/publication/342521156

Miyazaki, T., Toyoshima, Y., & Hamori, S. (2012). Exploring the dynamic interdependence between gold and other financial markets. *Economics Bulletin*, *32*(1), 37–50.

Morales, L., & Andreosso-O'Callaghan, B. (2012). The current global financial crisis: Do Asian stock markets show contagion or interdependence effects? *Journal of Asian Economics*, *23*(6), 616–626.

Neffelli, M., & Resta, M. R. (2018, March 23). *Is VIX still the investor fear gauge? Evidence for the US and BRIC markets*. SSRN. https://doi.org/10.2139/ssrn.3199634

Nyblom, J. (1989). Testing for the constancy of parameters over time. *Journal of the American Statistical Association*, *84*(405), 223–230. https://doi.org/10.1080/01621459.1989.10478759

Pan, W. F. (2018). Sentiment and asset price bubble in the precious metals markets. *Finance Research Letters*, *26*, 106–111. https://doi.org/10.1016/j.frl.2017.12.012

Pesaran, M. H., & Timmermann, A. (2005). Small sample properties of forecasts from autoregressive models under structural breaks. *Journal of Econometrics*, *129*(1–2), 183–217. https://doi.org/10.1016/j.jeconom.2004.09.007

Pullen, T., Benson, K., & Faff, R. (2014). A comparative analysis of the investment characteristics of alternative gold assets. *Abacus*, *50*(1), 76–92. https://doi.org/10.1111/abac.12023

Qadan, M., & Yagil, J. (2012). Fear sentiments and gold price: testing causality in-mean and in-variance. *Applied Economics Letters*, *19*(4), 363–366. https://doi.org/10.1080/13504851.2011.579053

Qin, M., Su, C. W., Hao, L. N., & Tao, R. (2020). The stability of US economic policy: Does it really matter for oil price? *Energy*, *198*, 117315. https://doi.org/10.1016/j.energy.2020.117315

Qureshi, S., Rehman, I. U., & Qureshi, F. (2018). Does gold act as a safe haven against exchange rate fluctuations? The case of Pakistan rupee. *Journal of Policy Modeling*, *40*(4), 685–708. https://doi.org/10.1016/j.jpolmod.2018.02.005

Ramelli, S., & Wagner, A. F. (2020). Feverish stock price reactions to COVID-19. *The Review of Corporate Finance Studies*, *9*(3), 622–655. https://doi.org/10.1093/rcfs/cfaa012

Reboredo, J. C. (2013). Is gold a safe haven or a hedge for the US dollar? Implications for risk management. *Journal of Banking and Finance*, *37*(8), 2665–2676. https://doi.org/10.1016/j.jbankfin.2013.03.020

Robiyanto, R. (2018). Gold vs bonds: What is the safe haven for the Indonesian and Malaysian capital market? *Gadjah Mada International Journal of Business*, *20*(3), 277–302. https://doi.org/10.22146/gamaijb.27775

Salisu, A. A., & Adediran, I. (2020). Gold as a hedge against oil shocks: Evidence from new datasets for oil shocks. *Resources Policy*, *66*, 101606. https://doi.org/10.1016/j.resourpol.2020.101606

Salisu, A. A., Ndako, U. B., & Oloko, T. F. (2019). Assessing the inflation hedging of gold and palladium in OECD countries. *Resources Policy*, *62*, 357–377. https://doi.org/10.1016/j.resourpol.2019.05.001

Salisu, A. A., Raheem, I. D., & Ndako, U. B. (2020). The inflation hedging properties of gold, stocks and real estate: A comparative analysis. *Resources Policy*, *66*, 101605. https://doi.org/10.1016/j.resourpol.2020.101605

Sethi, N., & Gupta, S. (2014). Impact of consumer sentiments on precious metals. *TMIMT*, *International Journal*, *1*(1), 1–8. http://tmimtjournal.org/papers/Impactconsumersentimentsonprecious-metals_Nitin.pdf

Shahzad, S. J. H., Bouri, E., Roubaud, D., & Kristoufek, L. (2020). Safe haven, hedge and diversification for G7 stock markets: Gold versus Bitcoin. *Economic Modelling*, *87*, 212–224. https://doi.org/10.1016/j.econmod.2019.07.023

Sharpe, W. F. (1964). Capital asset prices: A theory of market equilibrium under conditions of risk. *Journal of Finance*, *19*(3), 425–442. https://doi.org/10.1111/j.1540-6261.1964.tb02865.x

Shukur, G., & Mantalos, P. (2000). A simple investigation of the granger-causality test in integrated-cointegrated VAR systems. *Journal of Applied Statistics*, *27*(8), 1021–1031. https://doi.org/10.1080/02664760050173346

Sims, C. A., Stock, J. H., & Watson, M. W. (1990). Inference in linear time series models with some unit roots. *Econometrica: Journal of the Econometric Society*, *58*(1), 113–144. https://doi.org/10.2307/2938337

Smales, L. A. (2014). News sentiment in the gold futures market. *Journal of Banking and Finance*, *49*, 275–286. https://doi.org/10.1016/j.jbankfin.2014.09.006

Stanescu, S., & Tunaru, R. (2013). *Investment strategies with VIX and VSTOXX futures*. SSRN. https://doi.org/10.2139/ssrn.2351427

Stracca, L. (2015). Our currency, your problem? The global effects of the euro debt crisis. *European Economic Review*, *74*, 1–13. https://doi.org/10.1016/j.euroecorev.2014.10.009

Su, C. W., Huang, S. W., Qin, M., &and Umar, M. (2021c). Does crude oil price stimulate economic policy uncertainty in BRICS? *Pacific-Basin Finance Journal*, *66*, 101519. https://doi.org/10.1016/j.pacfin.2021.101519

Su, C. W., Meng, X. L., Tao, R., & Umar, M. (2021a). Chinese consumer confidence: A catalyst for the outbound tourism expenditure? *Tourism Economics*. https://doi.org/10.1177/13548166211065250

Su, C. W., Pang, L., Umar, M., & Lobonț, O. R. (2022a). Will gold always shine amid world uncertainty? *Emerging Markets Finance and Trade*. https://doi.org/10.1080/1540496X.2022.2050462

Su, C. W., Pang, L., Umar, M., Lobonț, O. R., & Moldovan, N. C. (2022b). Does gold's hedging uncertainty aura fade away. *Resources Policy*, *77*, 102726. https://doi.org/10.1016/j.resourpol.2022.102726

Su, C. W., Qin, M., Tao, R., & Zhang, X. (2020). Is the status of gold threatened by Bitcoin? *Economic Research-Ekonomska Istraživanja*, *33*(1), 420–437. https://doi.org/10.1080/1331677X.2020.1718524

Su, C. W., Qin, M., Zhang, X. L., Tao, R., & Umar, M. (2021b). Should Bitcoin be held under the U.S. partisan conflict. *Technological and Economic Development Economy*, *27*(3), 511–529. https://doi.org/10.3846/tede.2021.14058

Su, C. W., Xi, Y., Tao, R., & Umar, M. (2022c). Can Bitcoin be a safe haven in fear sentiment? *Technological and Economic Development of Economy*, *28*(2), 268–289. https://doi.org/10.3846/tede.2022.15502

Sun, T. T., Su, C. W., Mirza, N., & Umar, M. (2021). How does trade policy uncertainty affect agricultural commodity prices? *Pacific Basin Finance Journal*, *66*, 101514. https://doi.org/10.1016/j.pacfin.2021.101514

Tao, R., Su, C. W., Naqvi, B., & Rizvi, S. K. A. (2022). Can Fintech development pave the way for a transition towards low-carbon economy: A global perspective. *Technological Forecasting and Social Change*, *174*, 121278. https://doi.org/10.1016/j.techfore.2021.121278

Tao, R., Su, C. W., Yaqoob, T., & Hammal, M. (2021). Do financial and non-financial stocks hedge against lockdown in Covid-19? An event study analysis. *Economic Research-Ekonomska Istraživanja*, 1–22. https://doi.org/10.1080/1331677X.2021.1948881

Tong, H., & Wei, S. J. (2008). *Real effects of the subprime mortgage crisis: is it a demand or a finance shock*? (Working Paper No. 14205). National Bureau of Economic Research. https://doi.org/10.3386/w14205

Traub, H. D., Ferreira, L., Mcardle, M., & Antognelli, M. (2000). Fear and greed in global asset al.ocation. *Journal of Investing*, *9*(1), 27–31. https://doi.org/10.3905/joi.2000.319396

Wang, G. J., Xie, C., Jiang, Z. Q., & Stanley, H. E. (2016). Extreme risk spillover effects in world gold markets and the global financial crisis. *International Review of Economics and Finance*, *46*, 55–77. https://doi.org/10.1016/j.iref.2016.08.004

Wang, K. M. (2013). Can gold effectively hedge risks of exchange rate? *Journal of Business Economics and Management*, *14*(5), 833–851. https://doi.org/10.3846/16111699.2012.670133

Wang, K. M., Lee, Y. M., & Thi, T. B. N. (2011). Time and place where gold acts as an inflation hedge: An application of long-run and short-run threshold model. *Economic Modelling*, *28*(3), 806–819. https://doi.org/10.1016/j.econmod.2010.10.008

Yuan, X., Su, C. W., Umar, M., Shao, X., & LOBONȚ, O. R. (2022). The race to zero emissions: Can renewable energy be the path to carbon neutrality? *Journal of Environmental Management*, *308*, 114648. https://doi.org/10.1016/j.jenvman.2022.114648