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Is Gold a Safe Haven During a Pandemic? A Case Study of Thailand

Budsabawan Maharakkhaka
Stamford International University, Thailand
budsabawan.maharakkhaka@stamford.edu
Boonyachote Suteerawattananon
North-Chiang Mai University, Thailand
boonyachote@northcm.ac.th
Suttatt Ramasoot
Stamford International University, Thailand
sutatt.ramasoot@stamford.edu

Abstract
The once-in-a-century pandemic that wreaked havoc around the world in the late 2019 and throughout 2020 infected more than three hundred million people and killed over five million. As economic activities virtually came to a halt and financial markets plunged, the sanitary crisis also soon became a source of high uncertainty for investors in search of assets that would preserve their wealth. One such asset long perceived to be a hedge to store value and a safe haven in time of crisis is gold. This current research extends prior studies regarding the property of gold as an all-time flight to safety in Thailand and Southeast Asia. Specifically, it investigates the safe-haven property of gold during the COVID-19 crisis in Thailand using the DCC-MGARCH model. The sample period includes several COVID-19 waves in the country over the period 2020-2021. The findings reveal that stock returns volatility was sensitive to its own shock and to the shock in gold returns volatility during the COVID-19 period. The volatility of stock returns was persistent to both its own previous volatility and to prior volatility of gold returns. The findings, however, do not support the assumption that gold was a safe haven during the COVID-19 crisis period. It is, instead, concluded that the property of gold as a safe haven varies across time. This is possibly attributable to the driving factors behind the current pandemic which differ from those typically found in other situations of financial turmoil. The study has implications in risk management and portfolio diversification.

Keywords: Gold Investment, COVID-19, Financial Crisis, Safe Haven, Volatility.

1. Introduction

At the end of 2019, the COVID-19 pandemic hit the city of Wuhan in China and spread through other areas in the country. The disease was subsequently transmitted to many other countries across the world causing the World Health Organization (WHO) to finally declare the outbreak of a world pandemic in March 2020 (World Health Organization, 2020). By that time, most countries had reported an increasing number of confirmed cases and deaths. Quarantine policies were then put in place to prevent the spread of the human-transmitted virus; national borders were closed, international flights banned, and travelling heavily restricted. Among other consequences, people engaged in fewer social activities and were more cautious in their spending as many lost their jobs while others had their revenues cut. Unsurprisingly, limited economic activities caused unemployment to rise, businesses to shut shutdown, and turmoil in global financial markets. In the US, the stock market fell dramatically in the days following the WHO announcement. The Down Jones Industrial Average and NASDAQ faced the biggest drop ever and circuit-breakers had to be put in place as a result.

In Europe, the London's FTSE, the index of the London stock exchange, hit its lowest point since the 2008 world financial crisis. Asian markets followed a similar pattern, including the

Shanghai Composite, and the Japanese, Singapore, and India indexes to name a few. Clearly, the COVID-19 pandemic was once-in-a-century pathogen that wreaked havoc on the world (Zhang, Hu, & Ji, 2020). While the Severe Acute Respiratory Syndrome (SARS) cost the world an estimated 30-100 billion US dollars at the beginning of the 21st century, its impact was mainly in China, unlike the COVID-19 pandemic, and pale in comparison. In Thailand, the country on which this study focuses, the first case was reported in January 2020. The number of infections spiked in March 2020 and Thailand declared a state of emergency after the WHO declared COVID-19 a pandemic (World Health Organization, 2020, September). The spread of the virus, together with the decline in stock markets all over the world caused the SET Index, Thailand stock exchange index, to plunge deeply in March. On March 12, 2020, the SET Index fell by 125.5 points (Bangkok Post, 2020) causing the trading circuit-breaker to be triggered for the first time in a decade. This was followed by more action meant to stabilize the nation's capital market. With the health situation starting to improve in the third quarter of 2020 as the number of new confirmed cases declined to less than ten a day, business activities started to resume. However, a second wave of outbreak began in late December. This was followed by a third wave in April 2021, which is still going on even as this paper is written. As a matter of fact, the highest number of daily confirmed cases was in August 2021 (Tourism Authority of Thailand, 2021).

During times of market turmoil, investors are in fear of uncertainties. It is during these times that portfolios are highly vulnerable (Bloom, 2009). Many investors search for assets that preserve their wealth (Forbes & Rigobon (2002). Traditionally, gold has always been considered a safe haven among both Western and Eastern investors, especially during an economic recession (Baur & McDermott, 2010; Ji, Zhang, & Zhao, 2020; Lucey & O'Connor, 2017; Wu & Chiu, 2017). It has become an alternative asset in the long-term and is often added to traditional portfolios to diversify risk (Ang & Weber, 2017; Baur & Lucey, 2010; Miyazaki & Hamori, 2013; Syahri & Robiyanto, 2020). The unexpected spread of the pandemic, which badly depressed financial markets, has motivated people to reemphasize the unique safe-haven properties of gold. All that said, alhough there have been several studies considering the flight to safety in this pandemic time, any determination regarding gold as a safe haven is still inconclusive (Bakas & Triantafyllou, 2020; Ji et al., 2020; Salisu, Vo, & Lawal, 2021; Syahri & Robiyanto, 2020). The mixed findings in these studies vary depending on the scope of the studies, the sample period, and the methodology. This present paper extends previous research to investigate the properties of gold as a safe-haven during the COVID-19 pandemic in Thailand. Section two discusses related literature on safe-haven properties of gold during a financial crisis. Section three looks at the sample data and methodology. The results are discussed in sections four and five respectively. The implications from this study will benefit portfolio diversification in emerging markets, including Southeast Asian markets.

2. Literature Review

This section first discusses the key concepts at the core of this research study. It then reviews the relevant literature in the context of COVID-19.

- ***Portfolio Risk Management***

In the light of portfolio risk management, it is suggested that managers combine various assets with low or negative correlation to reduce the total portfolio variance. However, before we proceed with the relevant literature on these issues, the concepts of a diversifier, a hedge, and a safe haven need to be defined first.

- *A Diversifier:* an asset can be considered a diversifier when it has a non-perfect positive correlation with other assets in the portfolio on average (Shrydeh, Shahateet, Mohammad, & Sumadi, 2019).

- *A Hedge:* a hedge, on the other hand, is an asset that has a negative correlation with the other assets in the portfolio on average. Though these two concepts reduce the risk of massive loss in a portfolio, they serve as all-time risk management tools but they do not possess the properties needed to minimize losses specifically during extremely volatile markets (Baur & Lucey, 2010).
- *A Safe Heaven:* an asset is considered a safe haven only if that asset has no negative correlation with other assets in the portfolio, especially during crisis (Baur & McDermott, 2012). Many studies in portfolio risk management have expanded from the traditional portfolios consisting of stocks and bonds to include commodities as an alternative investment (Daskalaki & Skiadopoulos, 2011; Maharakkhaka 2015; Hoang, Lean, & Wong, 2015). This is because the drivers behind commodity prices are different from the demand and supply that define financial asset value.

- Gold and Portfolio Diversification

Among notable alternatives, gold has been a celebrated commodity throughout history. Gold demand falls into three categories. Gold is needed as (i) jewelry, (ii) in dental and other industrial applications, and (iii) for investment purposes. The intrinsic value of gold is driven by a limited supply as a precious metal and investment in gold does not bring default risk. With its property to store value, gold stores wealth at all times and all places (Petty, 1960, as cited in Baur & McDermott, 2010, p. 1887). This characteristic differentiates gold from other commodities such as oil and agricultural products (Miyazaki & Hamori, 2013). The early work of Jaffe (1989) suggested that gold has a significant role in portfolio diversification since its returns are independent from the returns of other assets. The study examined the correlation between gold and its proxies and other assets. The findings indicate that gold offers diversification benefits to a diversified portfolio as adding gold and gold stocks to the portfolio increases portfolio returns and the standard deviation. An increase in returns, however, was more than compensated by an increase in risk.

Hoang et al. (2015) examined the diversification benefits of gold in French portfolios of stocks, bonds, and risk-free and mixed assets during the period 1949-2012 using a stochastic dominance approach. The results revealed that the stock portfolios with gold stochastically dominated the stock portfolios without gold in the second and third orders. The same evidence could not be found in portfolios of bonds and risk-free assets. Like portfolios of stocks, portfolios of mixed assets that included gold also stochastically dominated those that did not include gold. Aftab et al. (2019) followed Engle's (2002) DCC-MGARCH modelling to investigate conditional correlations between gold, equities, and currencies in twelve Asian markets from 1995 to 2013. Although the findings suggest time varying correlations between gold and stocks, negative correlations were dominantly evidenced during the Asian financial crisis and the subprime crisis in many of these countries. Additionally, the role of gold as a safe haven was reported only in Thailand. Gold was therefore recommended as a diversifier rather than as a hedge across Asian financial markets. Shrydeh et al. (2019) applied the VAR-ADCC-BVGARCH model to daily returns of US stocks and gold from 2007 to 2017. They found a negative dynamic conditional correlation between stocks and gold to support the role of gold as a safe haven during the 2007 global financial crisis. However, their results vary across the sample, leading to inconclusive findings in the long term. In addition, the effectiveness of a gold hedge diminished as market capitalization increases. A larger investment proportion of gold in an optimal portfolio is required as the portfolio expands. They concluded that investors might seek alternative commodities to effectively hedge against stock markets.

- Gold as a Hedge

The property of gold as a hedge is evidenced in several scholarly studies. Sarac and Zeren (2014), for example, considered the property of gold as a hedge against inflation and currency

risk of the Turkish Lira with respect to the US dollar. Employing cointegration tests with unknown endogenous breaks, they concluded that it is always rational to have gold in a well-defined portfolio. Conlon, Lucey, and Uddin (2018) adopted a continuous wavelet transformation to examine the capacity of gold as a hedge against inflation in the US, UK, Japan, and Switzerland. The paper confirmed the property of gold as a hedge against inflation both in the short- and long-term. With regard to gold as a hedging instrument among Thai investors, Padungsaksawasdi (2020) explored the relationship between gold investor sentiment and the stock market return as well as stock market volatility in Thailand in a panel auto regression analysis. The strong negative impact of stock's realized volatility on gold investor sentiment points to investors' attention to gold in time of market fluctuations.

- Gold as a Safe Haven in Times of Crisis

Baur and McDermott (2012) studied how bonds and gold are treated by investors in times of financial crisis. The evidence they gathered indicate that both bond and gold act as safe havens whenever the stock market experiences extreme negative returns but the response of gold to market shocks is quickly reversed, pointing to its property as a short-term haven. Compared to bonds, gold responses stronger and more persistently to most extreme shocks while bonds are more susceptible to inflation, credit, and foreign exchange rate risks. Coudert and Reymond (2012) applied bivariate ARMA-GARCH-X and regressions to analyse the correlation between gold and stock returns in several indices. Using monthly data sample between 1978 and 2009, their findings supported the property of gold as a safe haven against all stock indices in times of recession.

Evidence from Raza et al. (2016) adds to the body of studies on gold as a safe haven, in this case, for the Islamic index and BRICS markets during the Asian financial crisis and in times of global financial crisis. The wavelet coherence analysis they conducted revealed that the ability of gold as a safe haven was market specific. Gold strongly acted as a safe haven for BRICS and Islamic index during the Asian financial crisis. From the start of the economic contraction in 2005, gold showed a positive correlation with BRICS indices. Its ability to safeguard negative shock against BRICS markets was limited during the 2007-2009 financial turmoil. On the other hand, the property of gold as a safe haven for Islamic stock markets was evidenced in times of global financial crisis. Miyazaki and Hamori (2013) explored the causality in mean and variance between S&P500 index and gold. The results of unilateral causality both in mean and variance from the index to gold reveal that in times of financial turmoil investors were driven by the fear of financial collapse and headed towards gold or gold-linked investments.

Ang and Weber (2017) extended their analysis of safe haven to consider the property of gold to safeguard socially responsible investment. The paper analysed daily returns of socially responsible investment, conventional investment, and gold through an autoregressive distributed lag model. The authors focused on the sample period between January 2006 and December 2015 with an intention to include the 2009 South Korea's government subsidy program designed to stimulate the economy. Their findings, however, contradicted other studies on the safe-haven property of gold; no evidence was found during the global financial crisis for social responsibility investments or for conventional investments. The results were rationally linked to the stable fast-growing economy of South Korea that could withstand negative external shocks. Neither positive nor negative shocks had a greater impact on the index.

- Relevant Literature on Gold as a Safe Heaven during the Covid-19 Pandemic

Among the literature related to gold as a safe haven in times of crisis, some research studies focus specifically on the financial market distress that arose from the COVID-19 pandemic. Ji

et al. (2020) applied a sequential monitoring procedure to assess whether the tail change in equity index could be offset by the inclusion of safe haven assets into the mean-variance portfolio during the COVID-19 pandemic. The study examined gold, cryptocurrencies, foreign exchanges, and other commodities during the sample period August 2019-March 2020 and the sub-period December 2019-March 2020. Their results confirmed that gold has an irreplaceable role in preserving wealth. Interestingly, robust evidence was also conclusive in regard of soybean futures. Thus, both gold and soybean futures could act as safe havens in the latest financial turmoil driven by a health crisis. While gold has consistently been a flight to safety, the demand for agricultural products during the pandemic and the lockdown could hike up the price level as food security was a critical issue in many countries.

In another recent paper, Corbet, Larkin, and Lucey (2020) investigated the roles of gold and cryptocurrencies as safe havens during the COVID-19 pandemic. Using hourly data of Bitcoin and the Chinese stock markets during the period March 2019-March 2020 in a dynamic correlation analysis, the results support prior findings that gold has been a reliable preserver of value during the pandemic crisis. Crypto currencies, however, were found to amplify the effects of the contagion. Yousaf (2021) proposed empirical evidence to support why gold can serve as a safe haven during the COVID-19 outbreak. The paper follows Salisu and Akanni (2020) in the construction of COVID-19 Global Fear index. The risk transmission from the Global Fear index to the metal and energy markets was analyzed by the BEKK-GARCH model. The results show that current volatility of precious metals, including gold, is influenced by their own previous shocks and that the previous shocks in the COVID-19 index do not affect conditional volatility in the gold market. The risk transmission from COVID-19 to the gold market is therefore significantly negative.

Akhtaruzzaman, Boubaker, Lucey, and Sensoy (2020) applied a dynamic conditional correlation analysis and an analysis of hedging ratio during December 2019 through April 2020. The aim was to examine the capacity of gold as a safe haven and assess its hedging effectiveness. The results suggested that during the early months of the pandemic, gold exhibited its property of safe haven with its negative correlation to international equity returns. However, the safe haven property of gold subsequently disappeared with an increase of the optimal weight of gold in investors' portfolios. There was a greater cost of hedging as investors added gold to their portfolio. Cheemah, Faff, and Szulczyk (2020) compared the performance of precious metals, currencies, treasuries, and cryptocurrencies as safe havens during the 2008 global financial crisis and Covid-19 pandemic across ten of the largest markets. Using the econometric model of Baur and McDermott (2010) and a GJR-GARCH model introduced by Glosten, Jagannathan, and Runkle (1993), their evidence suggested that gold was a safe haven during the 2008 financial crisis (and potentially all financial crises) but not during the COVID-19 pandemic when investors opted to stay away from gold. This may be due to the instability in gold prices after September 2011, which caused investors to seek assets with greater liquidity and stability.

Pisedtasalasai (2021) also used the GJR-GARCH model to analyze the hedging property of gold, government bonds, and corporate bonds in Thailand at stock market and industry levels. The sample period January 2004-March 2020 covers five crises, including the major global financial crisis in 2008, the European debt crisis in 2011, the political turmoil in 2013, the stock market downturn in 2015, and the latest COVID-19 pandemic. The dynamic correlations between stock and gold returns were generally negative, especially during market turbulence. Yet, the safe haven property of gold was found only in some crises and varied across industries during the COVID-19 period. The negative correlations were mainly driven by the property and construction industries and the financial and technology sectors. Yousaf et al. (2021) analyzed time-varying correlations between stocks and gold and the hedging effectiveness of

stock-gold portfolios in thirteen Asian countries during the COVID-19 outbreak. Employing Engle's (2002) DCC-GARCH model to examine data from January 2015 to May 2020, they reported mixed findings that corroborated many of the above conclusions.

The safe haven property of gold was studied even more recently by Drake (2022) who used Granger causality and co-integration tests. The study employed data from January 1990 to March 2021 to analyze whether gold served as a safe haven during COVD-19 pandemic as it did in past recessionary periods. The results show a positive correlation between gold and stock returns, offering contradiction to the support of gold investment in times of crisis. In summary, this review of some of the most recent literature on gold as a safe haven in time of crisis reveals that the role of gold as a safe haven – but also as diversifier and a hedge – tends to be market specific. While gold can be added to the diversified portfolio to generally protect losses in many Asian stock markets, it offered protection only in few markets during the COVID-19 crisis period. For Thailand, it was found that gold generally served well as a diversifier but acted only as a weak safe haven for investors during the COVID-19 pandemic. With these varied conclusions from earlier literature in mind, the authors examined the safe haven property of gold during COVID-19 pandemic crisis specifically in Thailand using the DCC-MGARCH estimation. The next section of the paper discusses data sample and the model estimation.

3. Data and Methodology

The data samples in this study include returns from the Stock Exchange of Thailand (SET) and returns on gold. The daily closing prices of the SET index were gathered from Investing.com (2021) and 96.5 percent of the daily closing prices of the gold bullion were retrieved from Gold Traders Association (2021). The data were collected from the period running from January 2018 to October 2021 so as to cover pre-COVID-19 and COVID-19 periods. Altogether, there are 930 samples. This present study covers large sample periods specifically during the COVID-19 pandemic time, allowing for an inclusion of several COVID-19 waves/cycles in Thailand from January 2020 to October 2021.

Table 1: Data Sample

Data	Period	Frequency	Source
SET Index (Closing Price)	January 2018 – October 2021	Daily	www.investing.com
Gold Bullion 96.5% (Daily Price)	January 2018 – October 2021	Daily	Gold Traders Association

The returns were first calculated as a natural log of the ratio of asset price at period (t) to price in the period $(t-1)$:

$$r_t = \ln\left(\frac{p_t}{p_{t-1}}\right) \quad (1)$$

The returns on SET Index were calculated as:

$$SET_t = \ln\left(\frac{SETP_t}{SETP_{t-1}}\right) \quad (2)$$

where:

$SETP_t$ is the closing price of SET index at period (t)

$SETP_{t-1}$ is the closing price of SET index at pervious period $(t-1)$

The returns on gold (gold bullion 96.5%) were also calculated as:

$$GOLD_t = \ln\left(\frac{GOLDP_t}{GOLDP_{t-1}}\right) \quad (3)$$

where:
$GOLDP_t$ is the closing price of gold at period (t)
$GOLDP_{t-1}$ is the closing price of gold at previous period $(t-1)$

The returns on stock (SET_t) and gold $(GOLD_t)$ were examined for their stationarity properties. The Augmented Dickey-Fuller (ADF) unit root test was used to ensure that the data series were qualified for a generalized autoregressive conditional heteroscedasticity (GARCH) model estimation, which is the main analysis of this research (Dickey & Fuller, 1979). Then, given the authors' expectation that gold would turn to be a safe haven during the pandemic, pre-COVID-19 and COVID-19 periods were separated in the analysis. The authors identified a structural break using the Bai-Perron structural break test (Bai & Perron, 2003).

As guided by this structural break test, the first period thus runs from January 4, 2018, to January 24, 2020, and the second period from January 27, 2020 to October 29, 2021. These results from the structural break test were rationally used to divide the sample period into pre-COVID-19 and COVID-19 periods in Thailand since the first patient was confirmed in January 2020. Thus, this research was conducted to analyze three sample periods: the whole sample period, and the pre-COVID-19 and COVID-19 periods.

To critically examine the safe haven property of gold during the COVID-19 pandemic crisis, this paper applied the Dynamic Conditional Correlation (DCC) in a multivariate generalized autoregressive conditional heteroskedastic (MGARCH) model of gold and stock returns. The DCC-MGARCH model was proposed by Engle (2002) as an extension of Bollerslev's (1990) Constant Conditional Correlation (CCC) model to capture the time-varying conditional correlation among variables.

The model is widely used in financial applications since volatility is a major concern in financial markets. This is because financial assets' volatilities move together closely over time and the transmission of volatility shock can cause a spill-over across financial assets. In contrast to the univariate estimation which mainly focuses on the sensitivity and persistence of a variable volatility shock on itself, the multivariate model evaluates the impact of a variable's volatility shock on another asset.

The model is defined based on Engle (2002) and Orskaug (2009) as:

$$r_t = \mu_t + \varepsilon_t \quad (4)$$

$$\varepsilon_t = H_t^{1/2} z_t \quad (5)$$

$$H_t = D_t R_t D_t \quad (6)$$

where:
r_t = $n \times 1$ vector of log returns of n assets at time t.
μ_t = n x 1 vector of the expected value of the conditional r_t.

ε_t = $n \times 1$ vector of mean-corrected returns of n assets at time t,
i.e. $E[\varepsilon_t] = 0$. $Cov[\varepsilon_t] = H_t$
H_t = $n \times n$ matrix of conditional variances-covariance of ε_t at time t.
D_t = $n \times n$, diagonal matrix of conditional standard deviation of ε_t at time t.
R_t = $n \times n$ conditional correlation matrix of ε_t at time t.
z_t = $n \times 1$ vector of i.i.d. errors such that $E[z_t] = 0$ and $E[z_t z_t^T] = I$.

Asset 1 is denoted to represent returns on the SET Index (SET_t) and Asset 2 to represent returns on gold ($GOLD_t$). The DCC-GARCH (1,1) was estimated with the maximum likelihood method. The construction of the model starts from equations (7) and (8) as follows:

$$SET_t = a_1 + b_{11}SET_{t-1} + b_{12}GOLD_{t-1} + \varepsilon_{1,t} \quad (7)$$

$$GOLD_t = a_1 + b_{21}SET_{t-1} + b_{22}GOLD_{t-1} + \varepsilon_{1,t} \quad (8)$$

The conditional variance-covariance matrix is described as:

$$H_{11,t} = \alpha_{0,1} + \alpha_{11}\varepsilon_{1,t-1}^2 + \beta_{11}H_{11,t-1} \quad (9)$$

$$H_{22,t} = \alpha_{0,2} + \alpha_{21}\varepsilon_{2,t-1}^2 + \beta_{21}H_{21,t-1} \quad (10)$$

Where:

$$D_t = \begin{pmatrix} \sqrt{H_{1,t}} & 0 \\ 0 & \sqrt{H_{2,t}} \end{pmatrix}$$

$$R_t = \begin{pmatrix} 1 & \rho_{12,t} \\ \rho_{21,t} & 1 \end{pmatrix}$$

$$\varepsilon_t = (\varepsilon_{1,t}, \varepsilon_{2,t})$$

ε_t = $n \times 1$ vector of mean-corrected returns of n assets at time t,
i.e. $E[\varepsilon_t] = 0$. $Cov[\varepsilon_t] = H_t$

And $\alpha_{DCC} + \beta_{DCC} \leq 1$ for stability to hold

4. Results and Discussion

- *Descriptive Statistics*

Table 2 shows the descriptive statistics of gold and stock returns. Based on the whole sample period, the mean of gold returns is 0.0004 with a standard deviation of 0.0075. Stock returns has a mean of 0.0001 and a standard deviation of 0.0115. The mean returns of gold is higher than the mean returns of SET index and the standard deviation of gold returns is lower than the standard deviation of the returns on SET index during all the sample periods. Both the mean and standard deviation of gold returns are highest during the COVID-19 sample period. The mean returns of the SET index during the whole sample and during the COVID-19 period are similar but they are negative during the pre-COVID-19 period. The standard deviation of the SET index returns is highest during the COVID-19 outbreak. Figures A1 and A2 in Appendix A provide an illustration of the movement of the SET index and gold prices from January 2018 to October 2021.

Table 2: Descriptive Statistics

Period	**All Samples**		**Pre-COVID-19**		**COVID-19**	
Data	$GOLD_t$	SET_t	$GOLD_t$	SET_t	$GOLD_t$	SET_t
N	930	930	505	505	425	425
Mean	0.0004	0.0001	0.0002	-0.0002	0.0005	0.0001
Minimum	-0.0421	-0.1143	-0.0421	-0.0242	-0.0416	-0.1143
Maximum	0.0503	0.0765	0.0373	0.0227	0.0503	0.0765
S.D.	0.0075	0.0115	0.0059	0.0069	0.0090	0.0153

The correlation matrix between the returns on gold and the stock index is shown in Table 3. The correlation of the SET index and gold returns is negative during the whole sample and pre-COVID-19 periods. During the COVID-19 period, there is a small positive correlation between the returns of gold and the SET index. This preliminary evidence is consistent with Drake's (2022) study which identified a positive correlation between gold and stock market returns during the COVID-19 pandemic

Table 3: Correlation Matrix

All Samples		
	$GOLD_t$	SET_t
$GOLD_t$	1	
SET_t	-0.0010	1
Pre-COIVD-19		
	$GOLD_t$	SET_t
$GOLD_t$	1	
SET_t	-0.1183	1
COVID-19		
	$GOLD_t$	SET_t
$GOLD_t$	1	
SET_t	0.0278	1

- *Unit Root Test*

The stationarity of the data was examined with the Augmented Dickey-Fuller (ADF) unit root test. Table 4 presents the results of the unit root test. The data series has no unit root. Both series are stationary. They qualify for DCC-GARH estimation.

Table 4: Unit Root Test

	Augmented Dickey-Fuller	**Probability**	**Result**
$GOLD_t$	-27.9915	0.0000	Stationary
SET_t	-10.5962	0.0000	Stationary

- *DCC-MGARCH Estimation*

This section presents the results of the DCC-MGARCH estimation. Table 5 shows the results of the analysis using the whole data sample whereas Tables 6 and 7 present the results using sample data during the pre-Covid-19 and Covid-19 periods respectively. The derived estimations are consistent with the model requirements. The coefficient α_{DCC} is approximately equal to zero ($\alpha_{DCC} \approx 0$). The coefficient β_{DCC} is greater than zero ($\beta_{DCC} > 0$). The sum of α_{DCC} and β_{DCC} is less than one $(\alpha_{DCC} + \beta_{DCC} < 1)$. Coefficient α_{ij} indicates short-run dependence or sensitivity of asset *j* to the volatility shock of asset *i* and β_{ij} indicates long-run

volatility persistence of asset *j* to the volatility shock of asset *i*. As described in the previous section, asset 1 represents returns on SET index while asset 2 represents returns on gold.

The mean and variance equation coefficients of the DCC-MGARCH estimation shown in Table 5 use the 930 data samples. The mean equations suggest that none of the current returns on the SET index are significantly affected by the lagged gold returns. Similarly, none of the current returns on gold are significantly affected by the lagged SET index returns. Though, we can observe small negative coefficients in the mean equation, they are not statistically significant. The conditional variance equations show that the returns volatility on the SET index is significantly sensitive to its own volatility shock ($\alpha_{11} = 0.1060$) but is not significantly sensitive to the volatility shock of gold returns. The signification estimation shows that the impact of prior volatility in SET index returns on itself and the impact of prior volatility in gold returns on SET index returns volatility are highly persistent in the long run ($\beta_{11} = 0.8794$ and $\beta_{21} = 0.9521$). It is also observed that SET index returns volatility is slightly more persistent to the past volatility of gold returns than to the past volatility of itself.
The coefficient $\alpha_{11} + \beta_{11} = 0.1060 + 0.8794 = 0.9854 < 1$ and $\alpha_{21} + \beta_{21} = 0.0458 + 0.9521 = 0.9979 < 1$ which is consistent with the relevant theory. The sum of α_{DCC} and β_{DCC} is less than 1 ($0.0095 + 0.8609 = 0.8704 < 1$).

Table 5: DCC-MGARCH Estimation (All Samples)

Variable	Coefficient	Std. Error	t-value	Pr(>|t|)
$\mu_{2,1}$	-0.0001	0.0003	-0.3987	0.6901
$\mu_{1,2}$	-0.0001	0.0002	0.4219	0.6731
α_{11}	0.1060**	0.0422	2.5090	0.0121
β_{11}	0.8794***	0.0426	20.6645	0.0000
α_{21}	0.0458	0.0362	1.2672	0.2051
β_{21}	0.9521***	0.0327	29.0980	0.0000
α_{DCC}	0.0095			
β_{DCC}	0.8609			

** and *** indicate the level of significance at 5% and 1% respectively

The estimation results for the pre-COVID-19 period shown in Table 6 reveal that, based on the mean equations, there is no significant impact of the lagged measure of gold returns on the current returns on the SET index during the period before the COVID-19 outbreak and no significant impact of the lagged SET index returns on the current returns on gold. Before the current pandemic, SET index returns volatility was significantly sensitive to its own volatility shock ($\alpha_{11} = 0.0831$) and not significantly sensitive to the volatility shock of gold returns. In the long run, the volatility of SET index returns is persistence to its own prior volatility ($\beta_{11} = 0.7754$) and more persistence to the prior volatility of gold returns ($\beta_{21} = 0.9617$). The estimation is based on assumptions with coefficient $\alpha_{11} + \beta_{11} = 0.0831 + 0.7754 = 0.8585 < 1$ and $\alpha_{21} + \beta_{21} = 0.0373 + 0.9617 = 0.9990 < 1$. The sum of α_{DCC} and β_{DCC} is less than 1 $(0.0476 + 0.8683) = 0.9159 < 1$. These results mostly conform to those of the all-sample data analysis shown in Table 5.

Table 6: DCC–MGARCH Estimation (Pre-COVID-19 Period)

Variable	Coefficient	Std. Error	t-value	Pr(>|t|)
$\mu_{2,1}$	-0.0001	0.0003	-0.4565	0480
$\mu_{1,2}$	0.0003	0.0002	0.1253	0.9003
α_{11}	0.0831***	0.0060	13.8371	0.0000
β_{11}	0.7754***	0.0190	40.7584	0.0000
α_{21}	0.0373	0.5656	0.6593	0.5097
β_{21}	0.9617***	0.0550	17.4969	0.0000
α_{DCC}	0.0476			
β_{DCC}	0.8683			

** and *** indicate the level of significance at 5% and 1% respectively

Recall from above that the Covid-19 period sample in this study runs from January 27, 2020, to October 29, 2021. Table 7 describes the estimation results using data from 425 observations from the pandemic time. The mean equations suggest no significant evidence for the impact of gold returns on SET index returns, and vice versa. Furthermore, the conditional variance equations show that during the COVID-19 period, the SET index return volatility was significantly sensitive to both its own volatility shock and the shock of gold returns ($\alpha_{11} = 0.1152$ and $\alpha_{21} = 0.1230$). The persistence impact of the SET index volatility on itself and the persistence impact of gold returns volatility on the SET index returns volatility are both statistically significant ($\beta_{11} = 0.8761$ and $\beta_{21} = 0.7308$). Index return volatility during this period is more persistent with its own volatility than with the past volatility of gold. The coefficient $\alpha_{11} + \beta_{11} = 0.1152 + 0.8761 = 0.9913 < 1$ and $\alpha_{21} + \beta_{21} = 0.1230 + 0.7308 = 0.8538 < 1$. The sum of α_{DCC} and β_{DCC} is less than 1 ($0.000 + 0.9136 = 0.9136 < 1$ which is consistent with the relevant theory.

Table 7: DCC-MGARCH Estimation (COVID-19 Period)

Variable	Coefficient	Std. Error	t-value	Pr(>|t|)
$\mu_{2,1}$	-0.0001	0.0005	-0.1049	0.9165
$\mu_{1,2}$	0.0004	0.0005	0.8593	0.3902
α_{11}	0.1152**	0.0564	2.0439	0.0410
β_{11}	0.8761***	0.0526	16.6503	0.0000
α_{21}	0.1230***	0.0163	7.5333	0.0000
β_{21}	0.7308***	0.0444	16.4634	0.0000
α_{DCC}	0.0000			
β_{DCC}	0.9136			

** and *** indicate the level of significance at 5% and 1% respectively

In summary, there is no significant impact of the lagged gold returns on the current stock index returns and no significant impact of the lagged stock index returns on the current returns of gold. But since the main focus of this paper is an analysis of the dynamic conditional correlation, the authors then concentrated exclusively on the analysis of the variances. The variance equations suggest that the volatility of stock index returns is sensitive to its own prior volatility shocks but not to the prior shocks in gold return volatility during the whole period and the pre-COVID-19 period samples. But during the COVID-19 period, stock return volatility is significantly sensitive to prior volatility shocks in gold return volatility, implying

a dynamic conditional correlation in variances. The long-term persistence in variance suggests that stock returns volatility is persistent to both its own prior volatility and the prior volatility in gold returns. The persistence is significantly evidenced during the three study periods. That said, for the COVID-19 period sample, the returns on stocks are more persistence to its own volatility than to the volatility of the gold returns.

Therefore, these results do not lend support to the property of gold as a safe haven during the pandemic but, instead, strongly suggest that the safe haven property of gold varies across time. Indeed, our findings offer surprise contradictions to the prior studies that support the ability of gold to withstand all turbulence. The analysis of the variances challenges the idea that an increase in gold price during the COVID-19 period is a sign of safe-haven investment. Our findings are consistent with a number of prior studies that specifically examined the property of gold as a safe haven during the COVID-19 crisis. The results may be attributable to the fact that the COVID-19 crisis is pandemic-driven which is different from earlier risk-driven financial crises. When businesses locked down and health was the primary concerns, food and necessities were the first priority among investors. Variance and its shocks in the two investment assets exhibit dynamic correlations. This argument is in keeping with Ji et al.'s (2020) study. As we saw earlier, in this study, soybean futures were surprisingly recommended as one of the best safe haven assets during the COVID-19 crisis period.

The findings are also consistent with the work of Cheemah et al. (2020) who compared the property of gold as a safe haven during global financial crisis period and during the COVID-19 period. Their study concluded that this property of gold was present only in the times of global financial crisis but not during the on-going pandemic. Since there were times when returns on gold fluctuated and gold lost its value, this suggests that investors should seek more stable and liquid assets to preserve their wealth in this pandemic time. Another pertinent consideration is the cost of hedging with gold during the COVID-19 turmoil, which was positively shown to rise as investors allocated more gold to their international portfolios as determined by Akhtaruzzaman et al. (2020). Thus, while the property of gold as a safe haven may be preserved during this pandemic time, investing in gold may not always result in an efficient hedge.

Finally, it is also worth mentioning the findings of Raza et al. (2016), Ang and Weber (2017), and Drake (2022), whose studies conclusively propose that the safe haven property of gold may vary across markets, time, and sectors. While a safeguard during financial crises, gold may not necessarily perform well during the pandemic and not serve as a safe haven in all markets. The safe-haven property of gold against stock investment during the COVID-19 crisis in Thailand also varied as shown in various prior studies discussed above (see, for example, Pisedtasalasai, 2021 and Yousaf et al., 2021).

5. Conclusion, Recommendations, and Limitations

This paper had as its objective to empirically examine the safe haven property of gold during the COVID-19 pandemic crisis. It extends prior studies regarding the safe-haven property of gold in Thailand and Southeast Asia and as such has implications in risk management and portfolio diversification as gold is well known among researchers and investors for its perceived property as a safe haven. Since the COVID-19 crisis has arisen from circumstances quite different from those that typically drove earlier financial crises, the issue was whether gold could maintain this unique property to preserve wealth during market turbulence driven by a health crisis. The DCC-GARCH model was used to estimate dynamic conditional correlations and volatility impact between the returns of stocks and gold investment. Employing the DCC-GARCH model allowed the authors to capture the time-varying conditional correlations among variables and analyze exclusively the impact among variances.

The sample period included several COVID-19 waves in the country over the period 2020-2021. With regard to returns on the SET index and gold, data were examined during three study periods; the whole study period from January 2018 to October 2021, the pre-COVID-19 period, and the COVID-19 period. As shown by the mean equation estimations, the earlier movement in gold returns did not have any significant impact on the current stock returns and similarly, the prior movement in stock returns did not have any significant impact on current gold returns. The conditional variance equations suggest that, in the short-term, stock returns volatility was significantly sensitive to its own volatility shocks but not significantly sensitive to the volatility shock of gold returns in the whole sample and the pre-COVID-19 sample periods. During the COVID-19 crisis period, however, volatility in stock returns was sensitive both to the volatility shock of itself and the volatility shock in gold returns.

While in all three sample periods, the estimations suggest significant persistence of returns volatility, during the COVID-19 crisis, stocks return volatility was more persistent to its own past volatility than to the past volatility of gold. Given the main focus of this paper, it is important to note that the conclusion does not support the property of gold as a safe haven during the latest COVID-19 crisis. Instead, it is suggested that gold's unique property to preserve wealth varies across time. These results contradict some studies that find gold to be an all-time flight to safety (Ji et al., 2020; Corbet et al., 2020) but is also consistent with some that exclusively examine the safe-haven property during pandemic crisis and came to the same conclusion (Cheemah et al., 2020; Yousaf et al., 2021; Drake, 2022).

- *Recommendations and Limitations*

The evidence provided in this study adds to the body of literature on the issue of the flight-to-safety property of gold. It is recommended that investors aiming at portfolio diversification consider including various alternative assets to store their wealth. Moreover, investors should occasionally rebalance their portfolio and allocate their investment across various alternatives to ensure optimal diversification and risk management. All that said, it is important to bear in mind that since this study is limited to the single financial market of Thailand, these results can be susceptible to an individual country's specific factors and risks. It is therefore strongly recommended that future researchers further examine the property of gold in the pandemic time across countries with diverse macroeconomic factors to provide a more accurate assessment of the ability of gold to preserve wealth in times of crisis, most notably during pandemics. Additional studies could also address the benefits of portfolio diversification when gold is included. Moreover, further research may focus on a cross-country analysis to re-examine the safe-haven property of gold in various macroeconomic environments.

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Appendix A

Figure A1: SET Index Daily Closing Price January 2018 – October 2021
Source: Investing.com

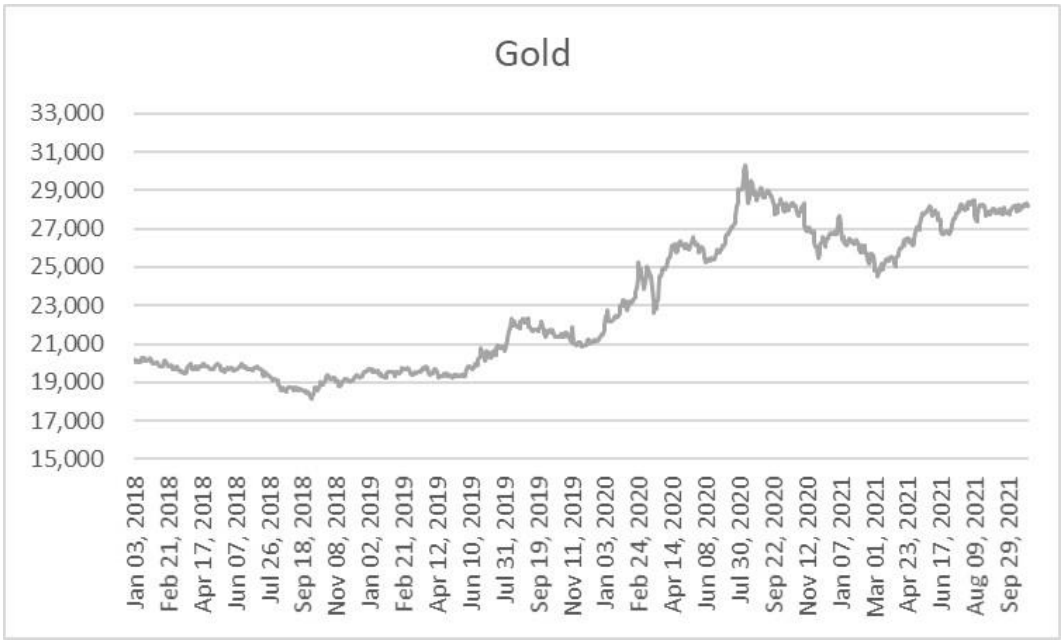

Figure A2: Gold Bullion 96.5% Daily Closing Price January 2018 – October 2021
Source: Gold Traders Association