

GEOPOLITICAL RISK AND RESPONSES TO FINANCIAL MARKETS

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Abstract

The Geopolitical risk (GPR) generated by the Russian invasion of Ukraine has triggered various impacts and responses in terms of financial markets and investors' sentiments regarding sensible actions. The purpose of this study was to focus on GPR and responses to financial assets and commodities using a vector autoregressive (VAR) model. The results uncovered differences in the various responses of financial assets and commodities in different durations. It was found that under increasing GPR, gold is a safe haven for energy commodities, while bitcoin is safe haven for the capital market, and treasury bonds and US dollars are a safe haven for other various financial assets as well as commodities such as energy. Since gold's behavior is determined by itself, investment in gold can help reduce risk in portfolios when there is an increase in geopolitical risk and at times of a bearish market.

Keywords: Financial assets, Commodities, Responses, Geopolitical risk

JEL Classification: G15, F51

1. INTRODUCTION

Geopolitical risk (GPR) always has an impact on investing sentiments which can affect business sectors and the movements of global financial markets (Bouri et al., 2019; Caldara & Iacoviello, 2022). The situation of the Russian invasion of Ukraine on February 24, 2022, was an antecedent of a higher GPR Index (Figure 1) transformed into financial and economic sanctions by the European Union and America. New investments have been prohibited, while Russian foreign exchange reserves and assets have been frozen, and SWIFT has deserted Russian banks (Rapporteur, 2022); such counteraction imposes damages to the Russian economy through rising GPR and has brought a negative impact on the financial market in the region as well as internationally (Umar et al., 2022).

The break out of the Russian invasion of Ukraine caused an impact on GPR which is tremendously affecting the global economy since Russia and Ukraine are major exporters in the global market for important commodities such as crude oil, natural gas, and wheat⁴. Russia,

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⁴ Russia was the world's 2nd largest crude oil exporter, 4th largest natural gas exporter and the largest wheat exporter. Ukraine was world's 5th largest wheat exporter in 2021 (Statista, 2022; UN Comtrade Database, 2022a, b).

specifically, plays a significant role in the energy market which has led to significant increases in the price of crude oil, as evidenced by the West Texas Intermediate values, which rose from USD 92.10 per barrel to USD 110.60 per barrel just one week after the initial invasion (Bloomberg, 2022). This drives higher production costs and brings volatility in commodity prices, necessitating the implementation of a strict monetary policy by the Federal Reserve. The resulting spill-over is an inverted yield curve of the US treasury bond as well as other assets, along with the global financial market. Long and Guo (2022) mentioned the impact of pandemics from 1998 to 2021 (bird flu, swine flu, MERS, Ebola, and COVID-19) on the capital market, additionally impacting other financial assets and commodities, viz., gold and bitcoin (Choi & Shin, 2022; Wen et al., 2022), as well as the European debt crisis (Wang et al., 2022a).

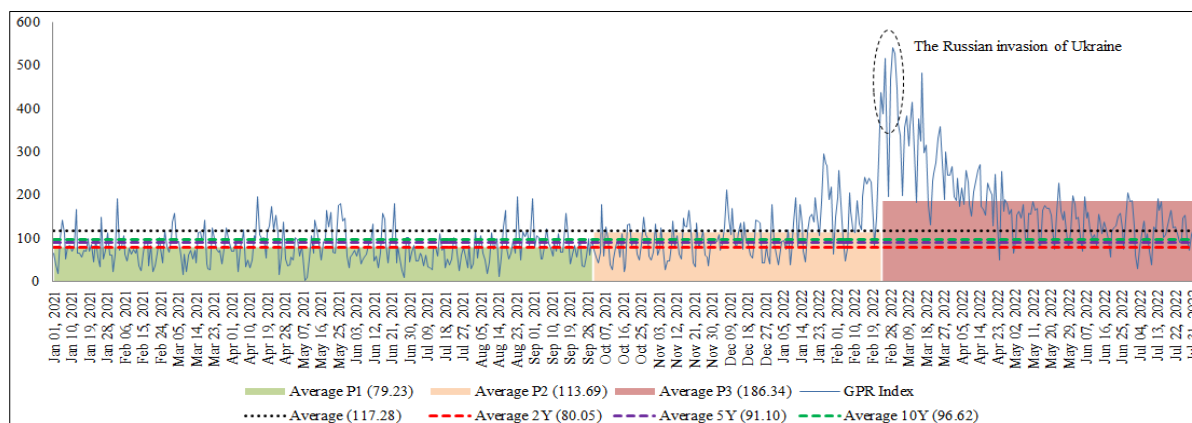


Figure 1 Geopolitical Risk Index⁵

The GPR situation generated by the Russia-Ukraine conflict differs from other public health and financial crises, as GPR usually impacts the financial market, other financial assets and commodities viz., exchange rate (Aliu et al., 2023), treasury bonds, the capital market in the rival country (Hoffmann & Neuenkirch, 2017; Umar et al., 2022), capital markets of the G20 (Yousaf et al., 2022), G7 and BRIC countries (Alam et al., 2022), crude oil, gold, and agricultural commodities (Wang et al., 2022b). Investors' anxiousness and risk management challenges are the result of GPR, consequently encouraging migration of their investments to highly secured financial assets and commodities to maintain wealth and reduce demand for other risky assets. While the responses to the event differ, wealth may decrease due to the variation of return and risks, which are in the same direction (Bedowska-Sójka et al., 2022). Past studies have discussed the positive and negative correlations among assets in various portfolios, including which assets could be a hedge during uncertainties or recessions (Baur & Lucey, 2010). Investing in hedge assets may help to reduce losses and manage risk. However, there is a missing period and timing as the response of financial assets and commodities at each period is not considered.

Considering the absence of responses to financial markets in a particular period, this study discusses GPR and the associated responses of financial markets. To address the research gap, this study considers three phases based on GPR i.e. phase 1, which covers the period from January 4, 2021, to September 30, 2021, eliminating the impact of the public health crisis where over 90 million people around the world were infected by COVID-19 and possessed group immunity (Wen et al., 2022; Umar et al., 2022; Bedowska-Sójka et al., 2022), and which has a low average GPR index (Average P1) in reference to the entire study as shown in figure 1; phase 2, which covers the period from October 1, 2021, to February 23, 2022, when there was

⁵ The Geopolitical risk index. Available at: <https://www.matteoiacoviello.com/gpr.htm>

a movement of Russian troops into Ukraine (Troianovski & Sanger, 2022) and when the average GPR index (Average P2) is close to the average of the overall study period, as shown in figure 1; and phase 3, which covers the period from February 24, 2022, to July 29, 2022, when the Russian invasion into Ukraine began, and when the average GPR index (Average P3) was high in reference to the entire study, as shown in figure 1. The results exhibited will contribute accordingly as advice for suitable portfolios guiding investors to invest in safe haven assets to avoid losses from the effect of GPR.

2. LITERATURE REVIEW

According to the capital asset pricing model (CAPM) by Sharpe (1964), investment return and risk are correlated. Investors are eligible for return according to systematic risks which are unavoidable although diversified under macroeconomic factors. The black swan, viz., financial crisis, extreme climate, public health crises, terrorism, political issues, etc., always strongly influence investors' sentiments and the global capital markets (Yousaf et al., 2022). Investors usually demand high investment returns and escape risks; therefore, they would need to diversify their financial assets or commodities as hedge assets. However, the concern of investors is to avoid risk while receiving high returns, thus diversification to other financial assets or commodities should be employed. Baur and Lucey (2010) classified assets into 3 categories, i.e., safe havens, hedge assets, and diversifiers. A safe haven is an asset that is uncorrelated or negatively correlated with other assets in the portfolios during high volatility. A hedge is an asset that is uncorrelated or negatively correlated with other assets in the average portfolios, and a diversifier is an asset that has a positive but imperfect correlation with other assets in the average portfolios.

The financial market has been impacted by the very recent public health crisis which has resulted in an increase in the demand for hedging assets by investors. Additionally, during the public health crisis, gold was identified as a hedge asset for energy commodities (Syuhada et al., 2022) in the US capital market (Wen et al., 2022), global capital market, capital markets in emerging countries (Wang et al., 2022a), the Islamic capital market, and crude oil (Chkili, 2022), as well as being a hedge asset for economic policy uncertainty (Xiao, 2022). While traditional assets have always been in sight, the digital asset of cryptocurrency is a new trend of investment as a financial asset. Bitcoin, as the first cryptocurrency, has been presented as a hedge asset among traditional financial assets. Dyrberg (2016a, 2016b) pointed out that bitcoin could act as a substitute for gold as well as being a hedge asset for the British capital market. Wang et al. (2019) also agreed that bitcoin can act as a hedge asset for the Chinese stock market and treasury bonds. Despite past studies, Bouri et al. (2017a) and Shahzad et al. (2020) expressed the conclusion that bitcoin is merely a risk diversifier. Many scholars have shared the explanation that bitcoin cannot act as a substitute for gold in the regular period (Klein et al., 2018) or even under uncertainties (Choi & Shin, 2022) and cannot act as a hedge asset for gold (Zhu et al., 2017) but can only play the role of diversifier for gold, crude oil, and the capital market (Guesmi et al., 2019).

The Russian invasion of Ukraine has caused a surge in GPR, driving volatility in agricultural and energy commodity markets. During the Russian invasion, there was a stronger correlation between crude oil and financial assets i.e. treasury bonds, US dollars, the capital market (Adekoya et al., 2022), and safe haven assets such as gold (Alam et al., 2022), generating a surge of negative impacts on the capital market of the G20 (Yousaf et al., 2022). The consequence of the Russian invasion brought about 50% of the volatility spill-over (Wang et al., 2022b) which affects the correlation between the capital market, bond, and commodity market differently during the regular period (Umar et al., 2022). GPR is associated with changing behavior that has led to different reactions to financial assets (Bedowska-Sójka et al.,

2022) and investor expectations (Bouri et al., 2019). Therefore, this study contributes to the body of knowledge on geopolitical risk and responses to financial markets (viz., bonds, stock, commodities, and digital assets), widening insights regarding the impact of GPR on financial markets during different periods, using a vector autoregressive (VAR) model to analyze the correlation between the financial markets. The VAR model is a popular method (Choi & Shin, 2022; Xiao, 2022; Aliu et al. 2023) which explains simultaneous multivariate effects in a single equation.

3. METHODOLOGY

3.1 Vector Autoregressive Model

This study applied the vector autoregressive (VAR) model by Sims (1980) which is suitable for analyzing multivariate time series financial data with dynamic behavior (Choi & Shin, 2022). The VAR model assigns endogenous variables, where each variable has its own lag length. The values of lag length in the VAR model are selected by the lowest value of the Akaike information criterion (AIC) and Schwarz information criterion (SIC). The VAR(p) process is constructed as shown in equation (1).

$$X_t = A_0 + \sum_{i=1}^p A_i X_{t-i} + u_i \quad (1)$$

Where X_t is the vector of endogenous variables at time t, A_0 is the vector of the constant, A_i is the vector of the coefficient of X_{t-i} , p is optimal lag length, and u_i is the vector of the error term at time t. This is a white-noise process with a zero mean and covariance matrix.

However, the approach does not explain clear relations between financial assets and commodities. Therefore, to satisfy the study objectives it is necessary to also analyze the impulse response function (IRF) and variance decomposition to describe the magnitude of the impact of changes in financial assets and commodities in all aspects. In the results of the IRF explanation using the error of the standard deviation and displaying the dynamic impact of the unit shock from one financial asset to another during the same period and in the future, the variance decomposition of financial assets and commodities explains the overview of changes, comparing the proportion of the relationship and variance within the model during each time, to provide a forecast error variance decomposition.

3.2 Data and Descriptive Statistics

The study of geopolitical risk and responses to financial markets consists of financial assets (viz., treasury bonds, currency, cryptocurrency, and capital markets) and commodities (viz., gold, agriculture, and energy) (Bedowska-Sójka et al., 2022; Umar et al., 2022) variables which are taken into consideration (Table 1) as they are correlated with each other. Likewise, Russia and Ukraine are the world's major exporters of agricultural and energy commodities (Wang et al., 2022b). The study employed time series data from Investing.com and spglobal.com, for the time period January 4, 2021, to July 29, 2022, a total of 385 days. The period employed was the duration that the average GPR index was higher than the 2 year, 5 year, and 10 year averages (Figure 1). To analyse the GPR, the full duration was separated into 3 periods according to the GPR risk and responses to financial markets at different periods viz., the first period dated from January 4, 2021, to September 30, 2021; the second period from October 1, 2021, to February 23, 2022; and the third period from February 24, 2022, to July 29, 2022.

Table 1 Asset Construct

Asset Class	Symbol	Definition
Gold	Gold	Gold Price (USD per ounce)
Agricultural Commodity	Agr	S&P Goldman Sachs Commodity Agriculture Index
Energy Commodity	Ene	S&P Goldman Sachs Commodity Energy Index
Capital Market	MSCI	Morgan Stanley Capital International: MSCI All-Country World Index
Bitcoin	BTC	Bitcoin Price (USD)
Long-term Bonds	GBL	S&P U.S. Treasury Bond Current 10-Year Index
Short-term Bonds	GBS	S&P U.S. Treasury Bond Current 2-Year Index
US Dollar	USD	US Dollar Index

Data examinations were in the form of returns, use the subsequent equation (2) as follows:

$$R_{it} = \ln\left(\frac{P_{it}}{P_{it-1}}\right) \quad (2)$$

Where R_{it} is the return of the financial assets and commodities i at time t and P_{it} is the closed price of financial assets and commodities i at time t while \ln is the natural logarithm that helps reduce the volatility on time series data analysis.

Regarding the descriptive statistics of the financial assets and commodities return of all series, unit root tests display the data stationary of the financial assets and commodities return by Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) in Table 2.

Table 2 Descriptive Statistics and Unit Root Tests

Assets	Average	S.D.	Max	Min	Skewness	Kurtosis	Unit root test (Level)	
							ADF	PP
Phase 1: January 4, 2021 – September 30, 2021								
Gold	-0.0552%	0.9210%	2.3974%	-3.4167%	-0.6404	1.2319	-12.559***	-12.526***
Agr	0.0681%	1.5249%	4.8350%	-5.4750%	-0.2255	1.6338	-13.668***	-13.666***
Ene	0.2621%	1.8422%	5.0598%	-6.4751%	-0.4972	1.6928	-14.292***	-14.423***
MSCI	0.0541%	0.6887%	2.0141%	-2.0614%	-0.3637	0.9261	-12.597***	-12.573***
BTC	0.1725%	5.3292%	19.3756%	-15.5413%	-0.1770	0.8528	-13.895***	-13.911***
GBL	-0.0236%	0.3856%	1.2732%	-1.4415%	0.0409	1.1046	-13.985***	-14.039***
GBS	-0.0002%	0.0226%	0.0782%	-0.0932%	-0.5232	2.2726	-13.279***	-13.278***
USD	0.0260%	0.3276%	0.8305%	-0.7948%	0.2017	-0.4166	-14.275***	-14.292***
Phase 2: October 1, 2021 – February 23, 2022								
Gold	0.0858%	0.7325%	1.8421%	-2.1680%	-0.3176	0.6113	-8.949***	-8.917***
Agr	0.2053%	1.1397%	4.7746%	-2.9886%	0.3581	1.9108	-8.619***	-8.572***
Ene	0.1755%	1.9809%	3.4448%	-10.3729%	-1.8597	7.4030	-8.050***	-7.931***
MSCI	-0.0222%	0.8531%	2.0827%	-2.3212%	-0.1648	-0.0439	-8.059***	-8.011***
BTC	-0.1702%	3.7517%	10.8655%	-10.9978%	0.2498	1.0372	-8.680***	-8.658***
GBL	-0.0378%	0.4557%	1.1389%	-1.1009%	0.0196	-0.2697	-10.208***	-10.254***
GBS	-0.0205%	0.0979%	0.3036%	-0.5178%	-1.1249	7.1842	-13.008***	-13.236***
USD	0.0214%	0.3406%	0.9428%	-0.7533%	0.1513	0.1172	-9.723***	-9.735***

Table 2 (Continued)

Assets	Average	S.D.	Max	Min	Skewness	Kurtosis	Unit root test (Level)	
							ADF	PP
Phase 3: February 24, 2022 – July 29, 2022								
Gold	-0.0732%	1.0249%	2.6813%	-4.0519%	-0.7672	2.0231	-10.831***	-10.841***
Agr	-0.0989%	1.9530%	4.2900%	-5.0490%	-0.2261	0.0654	-9.378***	-9.344***
Ene	0.1424%	3.4924%	8.3620%	-13.9258%	-0.8221	2.3772	-10.206***	-10.206***
MSCI	-0.0806%	1.3569%	2.7212%	-3.7231%	-0.1576	-0.2041	-8.781***	-8.770***
BTC	-0.4230%	4.9131%	10.3603%	-25.8963%	-1.5823	7.0195	-10.220***	-10.222***
GBL	-0.0473%	0.6836%	1.4418%	-1.8292%	-0.1377	-0.4571	-9.381***	-9.357***
GBS	-0.0127%	0.1604%	0.4054%	-0.5017%	-0.1461	0.5867	-9.048***	-8.979***
USD	0.0907%	0.5547%	1.8470%	-1.4656%	-0.0738	0.2923	-11.033***	-11.016***

*** $p < 0.01$, Unit root tests included the intercept and trend for all series.

4. RESULTS AND DISCUSSION

4.1 Vector Autoregressive Model Analysis

The stationary data in Table 2 displays the normal level of financial assets and commodities returns. Equation 2 indicates the first difference of the financial assets and commodities prices or $I(1)$ at the stationary level and is suitable for VAR model analysis. The preferred value of the lag length, during the 3 phases, is the one that generates the lowest value of AIC and SIC (Appendix Table 1) as well as bearing stability (Appendix Figure 1) without having serial correlation (Appendix Table 2). Therefore, the preferred lag length is 1 or $I(1)$.

The VAR analysis indicated that there are relations between the current financial assets and the commodities return and the past financial assets and commodities return. Each financial asset and commodity is related to each other significantly in the different phases. In phase 1, the values of gold (Gold), bitcoin (BTC), and US dollars (USD) for the previous day affect the energy commodity (Ene) with a positive relationship while the Ene affects gold with a negative relationship. The capital market (MSCI) was affected by MSCI and USD showing a positive relationship with the previous day. BTC was affected by USD showing a positive relationship with the previous day. Long-term bonds (GBL) were affected by agricultural commodities (Agr) showing a negative relationship with the previous day. Short-term bonds (GBS) were affected by MSCI showing a negative relationship with the previous day. Finally, USD was affected by USD, gold, MSCI, and GBL, displaying a negative relationship with the previous day (Table 3).

In phase 2, MSCI was positively influenced by the BTC of the previous day. Also, BTC was positively influenced by Ene and BTC of the previous day. GBS was negatively influenced by GBS of the previous day. Finally, USD was positively influenced by Agr but was negatively influenced by the MSCI and GBL of the previous day (Table 3).

During phase 3, gold was impacted through a positive relationship by the MSCI of the previous day. Agr was impacted through a positive relationship by Ene of the previous day. The MSCI was impacted through a negative relationship by gold, while also being impacted through a positive relationship by the BTC of the previous day. BTC was impacted through a negative relationship by gold, but was impacted through a positive relationship by Ene, of the previous day. GBL was impacted through a negative relationship by USD of the previous day. Finally, USD was impacted through a negative relationship by MSCI and USD of the previous day (Table 3).

Table 3 Estimated Coefficients of the VAR(1) Model

Assets	Gold _t	Agr _t	Ene _t	MSCI _t	BTC _t	GBL _t	GBS _t	USD _t
Phase 1: January 4, 2021 – September 30, 2021								
Gold _{t-1}	0.0503	0.0954	0.4054**	0.1135	-0.0149	0.0112	0.0029	-0.0938***
Agr _{t-1}	0.0287	0.0074	0.0346	0.0180	-0.0820	-0.0327*	-0.0015	4.00x10 ⁻⁵
Ene _{t-1}	-0.1023**	-0.0492	-0.0836	0.0074	0.0417	-0.0284	-0.0002	0.0111
MSCI _{t-1}	-0.0267	0.1959	0.2972	0.1538*	1.0258	-0.0732	-0.0051*	-0.0912**
BTC _{t-1}	-0.0033	0.0209	0.0467*	-0.0037	-0.0588	-0.0064	-0.0003	-0.0003
GBL _{t-1}	0.0996	-0.0157	-0.0983	0.2533	-1.9050	-0.0550	-0.0050	-0.1459*
GBS _{t-1}	3.2642	1.3804	-5.2994	1.4419	22.1817	-1.4319	0.0161	1.5402
USD _{t-1}	0.1480	0.7296	1.0086*	0.5697***	2.9055*	-0.0613	2.56x10 ⁻⁵	-0.2784***
c	-2.83x10 ⁻⁴	4.30x10 ⁻⁴	2.29x10 ⁻³	3.82x10 ⁻⁴	-3.51x10 ⁻⁴	-6.77x10 ⁻⁵	3.78x10 ⁻⁶	2.95x10 ⁻⁴
Phase 2: October 1, 2021 – February 23, 2022								
Gold _{t-1}	0.1940	0.0015	0.3734	0.1222	0.0867	2.24x10 ⁻⁵	0.0006	-0.0154
Agr _{t-1}	-0.1136	0.0119	0.0204	-0.0977	-0.5761	-0.0457	-0.0177	0.0759**
Ene _{t-1}	0.0014	0.0179	0.1143	0.0025	0.3720*	-0.0424	-0.0056	-0.0008
MSCI _{t-1}	0.1011	-0.0292	-0.1105	0.1681	-0.7156	0.0839	0.0193	-0.1488***
BTC _{t-1}	-0.0051	-0.0074	0.0068	0.0451*	0.1790*	-0.0060	-0.0018	-0.0115
GBL _{t-1}	-0.1816	-0.2056	-0.9086	-0.2204	0.2938	0.0168	-0.0113	-0.1943*
GBS _{t-1}	-0.4975	-1.5883	0.0542	0.2687	-3.6778	-0.8540	-0.2524*	0.2347
USD _{t-1}	0.1428	0.5044	0.1342	0.4323	-1.2861	-0.0799	0.0160	-0.1408
c	6.87x10 ⁻⁴	1.42x10 ⁻³	8.77x10 ⁻⁴	-2.65x10 ⁻⁴	-2.67x10 ⁻³	-4.28x10 ⁻⁴	-2.30x10 ⁻⁴ **	1.17x10 ⁻⁴
Phase 3: February 24, 2022 – July 29, 2022								
Gold _{t-1}	-0.0409	-0.4107	-0.2249	-0.3966**	-1.4324**	-0.1077	-0.0149	-0.0873
Agr _{t-1}	0.0920	0.0233	0.0179	-0.0552	-0.2118	0.0198	0.0046	-0.0002
Ene _{t-1}	-0.0522	0.1509*	0.0289	0.0442	0.3831*	-0.0392	-0.0087	0.0341
MSCI _{t-1}	0.1908*	0.0789	0.5304	-0.0098	0.1305	0.0332	0.0078	-0.1042*
BTC _{t-1}	-0.0026	0.0201	0.0611	0.0589*	-0.0297	-0.0075	-0.0020	-0.0054
GBL _{t-1}	0.0054	0.0634	1.5390	-0.0917	0.2018	0.0492	-0.0047	-0.0331
GBS _{t-1}	0.8171	-0.1179	-2.4035	1.2559	5.0985	0.4465	0.1491	0.0195
USD _{t-1}	0.2529	-0.1474	0.9750	-0.0330	-0.0632	-0.2716*	-0.0440	-0.2438**
c	-5.61x10 ⁻⁴	-1.30x10 ⁻³	1.34x10 ⁻³	-7.41x10 ⁻⁴	-5.61x10 ⁻³	-1.78x10 ⁻⁴	-7.20x10 ⁻⁵	8.09x10 ⁻⁴

* $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

4.2 Impulse Response Function

The following section details the results of responses to the financial markets shown using the impulse response function (IRF) to study how other financial assets and commodities in the system responded to shock which occurred on various financial assets and commodities. The results indicate that the responses of each financial asset and commodity to shock are in different forms at different times and will adjust to the equilibrium within 5 days (Figure 2 to Figure 9). The study of Baur and Lucey (2010) explained that assets which show an increase or positive response to the shock of another asset cannot act as a hedge to the other asset. On the contrary, when an asset shows a decrease or negative response to the shock of another asset, can be treated as a hedge to the other asset (Choi & Shin, 2022; Wen et al., 2022).

In the study of responses to financial markets, the analysis involved a comparison of gold and bitcoin as financial assets and commodities that bear the lowest and highest risk respectively without considering treasury bonds and USD which bear lower risk (standard deviation) than gold during the period of study (Table 2). The results indicate gold can be used as a hedge for energy commodities, agricultural commodities, bitcoin, and capital markets during phase 1. In phase 2, as the geopolitical risk situation or hostility tension becomes higher, the hedging property of gold changes while it cannot act as a hedge for energy commodities and capital markets but can still work as a hedge for short-term bonds and long-term bonds. During phase 3, when the geopolitical risk rises or during hostility, gold can act as safe haven for energy commodities only (Figure 2). This outcome is associated with Syuhada et al. (2022), who showed that gold can reduce the downside risk on portfolios in energy commodities such as crude oil (Wen et al., 2022).

In phase 1, bitcoin can be used as a hedge for the capital market, agricultural commodities, long-term bonds, and gold. In phase 2, bitcoin can still be used as a hedge for short-term bonds and USD, but would not be suitable as a hedge for gold. However, bitcoin can still be a safe haven for gold in phase 3, consistent with Wang et al. (2022a), who explained that bitcoin is a hedge as well as safe haven for capital markets, but cannot act as a hedge for energy commodities (Figure 6). This is also consistent with Bouri et al. (2017b), who summarized that bitcoin can be a hedge for energy commodities before December 2013 only. Thus, it can be concluded that bitcoin and gold bear the same property which is consistent with Dyrberg (2016a, 2016b) who explained that the properties of bitcoin are similar to gold, and also that it can be a hedge for the capital market and treasury bonds similarly to gold (Wang et al., 2019).

Regarding bonds, in phase 1, long-term bonds can hedge for all financial assets and commodities except energy, while short-term bonds can hedge for all financial assets and commodities except agricultural and energy commodities. In phase 2, long-term bonds can hedge for gold, short-term bonds, and USD, while short-term bonds can hedge for gold, agricultural commodities, and long-term bonds. In phase 3, long-term bonds are a safe haven for gold, bitcoin, energy commodities, and USD; additionally, short-term bonds are a safe haven for all financial assets and commodities except agricultural and capital markets (Figure 7 and Figure 8). On the contrary, the result from Choudhury et al. (2022) elaborated that treasury bonds are a safe haven of capital markets during a public health crisis since the situation of geopolitical risk differs from a public health crisis. In addition, the results unveil that bonds bear a low-risk property and therefore can be used as a hedge and safe haven for other financial assets and commodities, consistent with Kaczmarek et al. (2022).

During phase 1, USD can only hedge for long-term bonds. Additionally, USD can also hedge for the capital market and bitcoin during phase 2, while being a safe haven for bitcoin, long-term bonds, agricultural commodities, and energy commodities in phase 3 (Figure 9). This result is consistent with Siemaszkiewicz (2021), who stated that USD is safe haven for agricultural products (soybean and corn) as well as bitcoin (Choi & Shin, 2022). Therefore, geopolitical risk has sequenced the sensible sentiments of investors on the issue of food security, accelerating the price of agricultural commodities. Meanwhile energy commodities have imposed a rise in production and transportation costs due to the Russia-Ukraine conflict as these countries were the world's largest exporters of agricultural and energy commodities. Moreover, USD has appreciated due to an increase in the interest rate policy of the Federal Reserve to prevent inflation. Hence, USD is a safe haven for agricultural and energy commodities under high geopolitical risk.

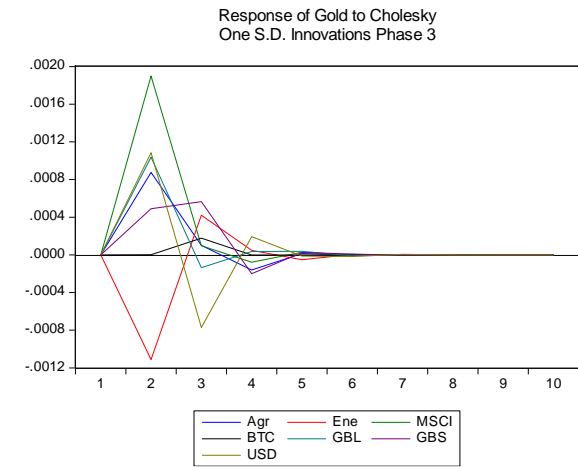
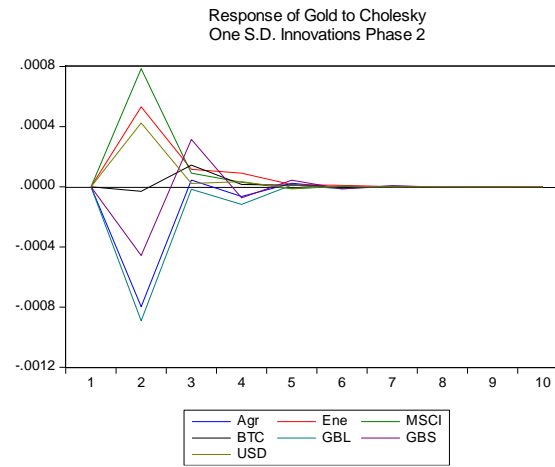
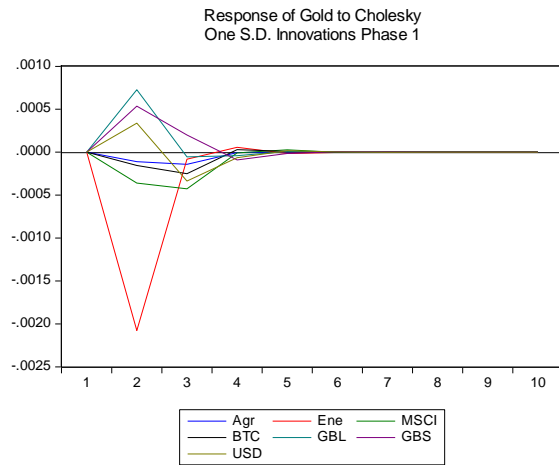


Figure 2 Response of Gold

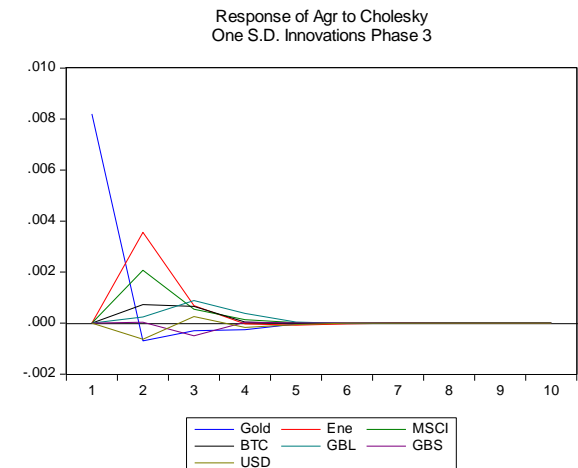
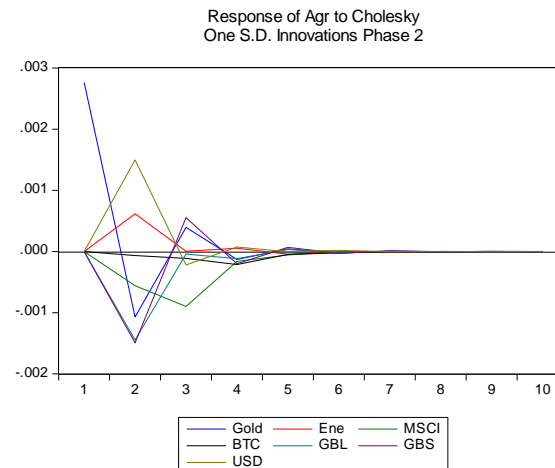
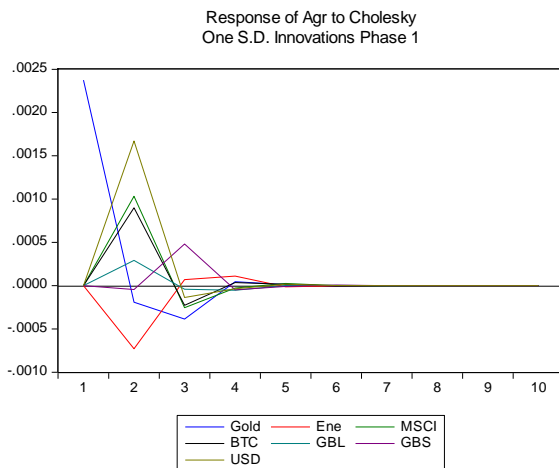


Figure 3 Response of Agricultural Commodities (Agr)

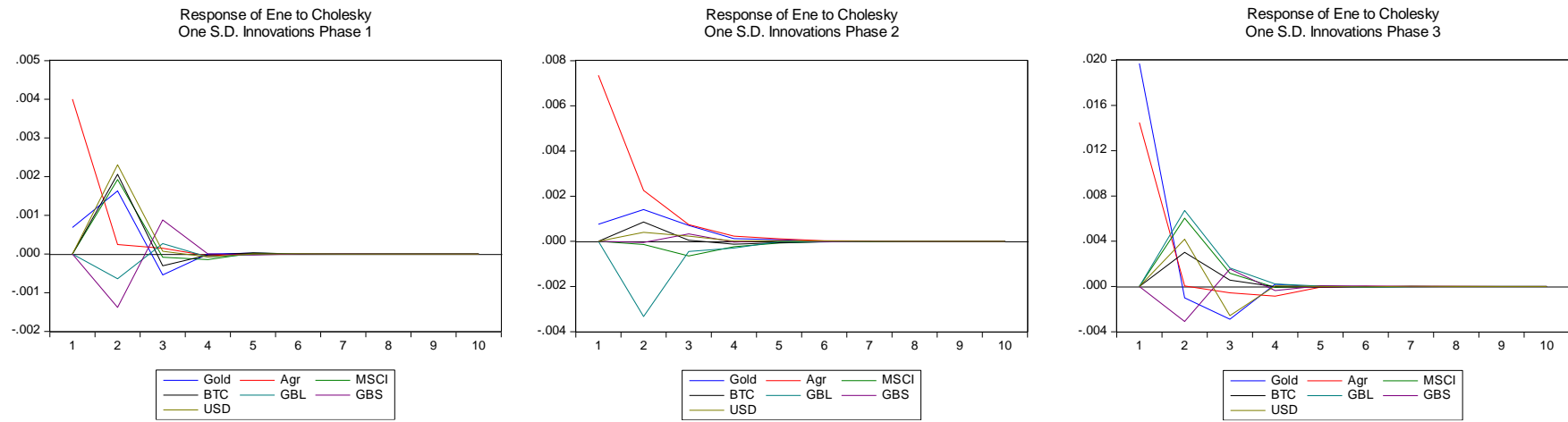


Figure 4 Response of Energy Commodities (Ene)

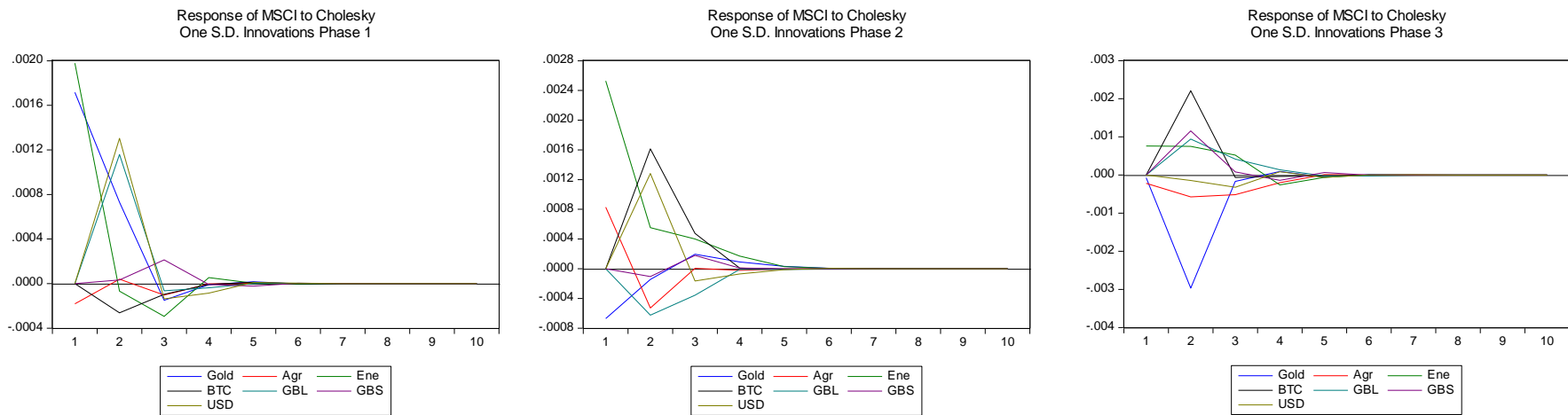


Figure 5 Response of Capital Market (MSCI)

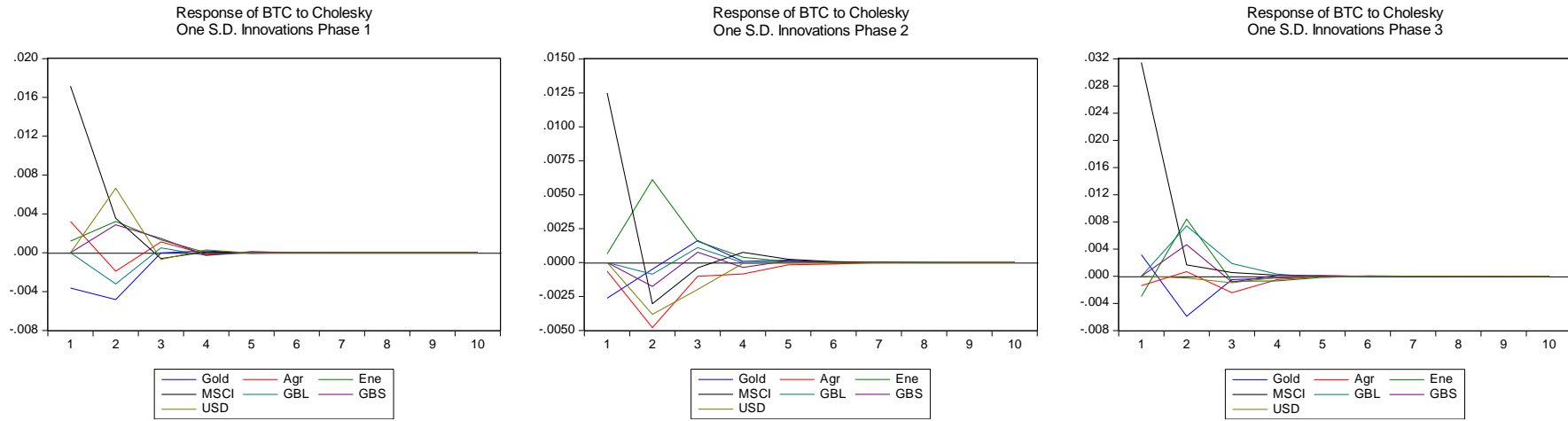


Figure 6 Response of Bitcoin (BTC)

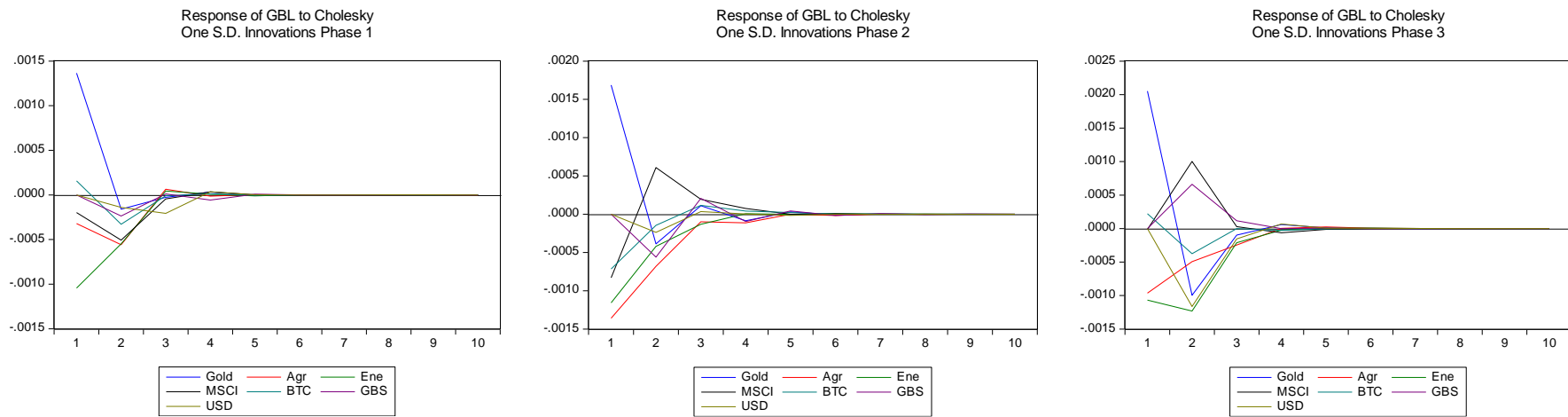


Figure 7 Response of Long-Term Bond (GBL)

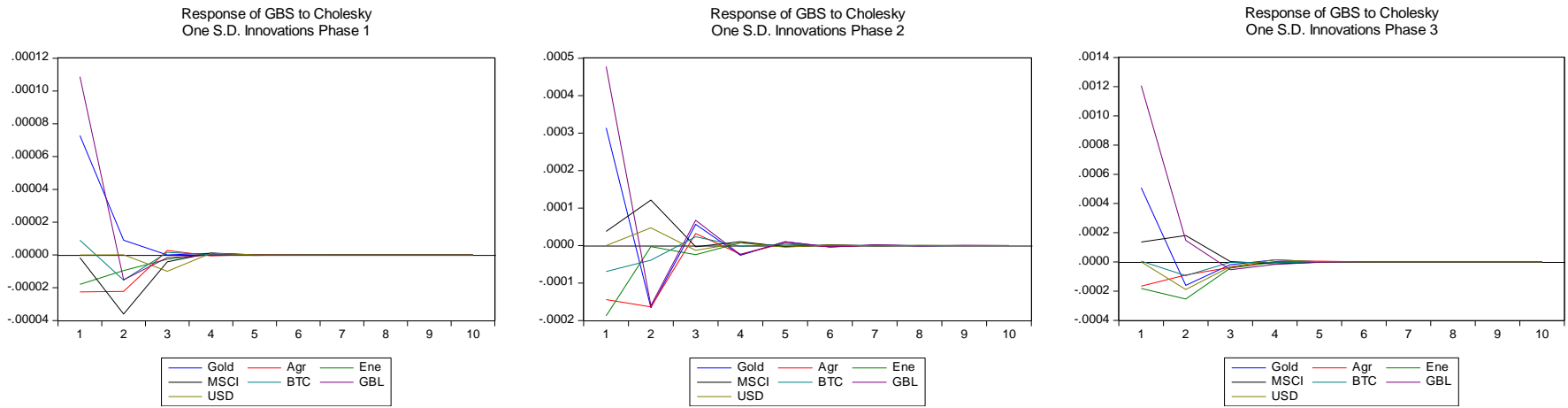


Figure 8 Response of Short-Term Bond (GBS)

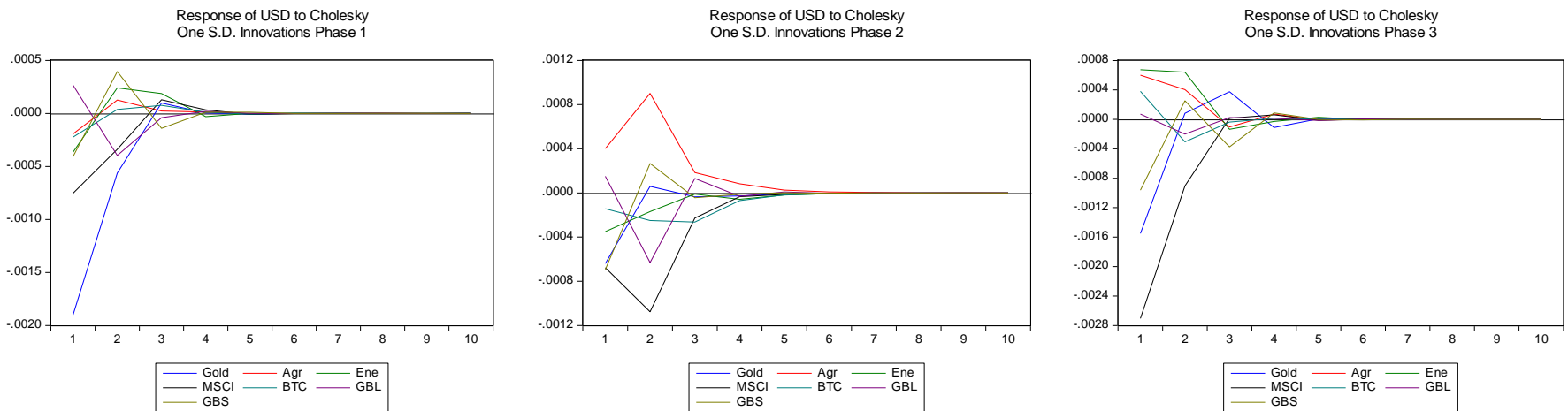


Figure 9 Response of US Dollar (USD)

4.3 Variance Decomposition

The result of variance decomposition over 5 days indicates the volatility of other financial assets and commodities to the volatility of gold, which reached a maximum of 8.1%, while the volatility of other financial assets and commodities is linked with each other. During phase 3 the volatility of gold impacts various financial assets and commodities i.e., agricultural, energy, short-term bonds, and long-term bonds at a minimum of 10%, impacting capital markets at 4.3857%, while the volatility of capital markets has the highest impact on the volatility of gold at 3.1248% (Table 4), consistent with Umar et al. (2022). Capital market volatility always impacts bitcoin volatility, reaching a maximum at 37.4320% in phase 3. It also impacts USD at 24.5495% in the same phase (Table 4).

The movement of other financial assets and commodities cannot define the behavior of gold. The result confirms that gold is a hedge and safe haven for energy commodities during geopolitical risk situations. This is consistent with contributions from Baur and Smales (2020) and Bedowska-Sójka et al. (2022), who stated that investing in gold can hedge portfolios under a high geopolitical risk. Wang et al. (2022b) pointed out that geopolitical risk in the case of the Russia-Ukraine conflict has greatly impacted agricultural and energy commodities; therefore, gold possesses an overseas hedging property while bitcoin can act as a diversifier in portfolios only. Likewise, Bouri et al. (2017a) and Shahzad et al. (2020) also stated the same conclusion that bitcoin can act as a diversifier only.

Table 4 Variance Decomposition in 5 days

Phase	Gold	Agr	Ene	MSCI	BTC	GBL	GBS	USD
Gold								
Phase 1	93.4486	0.0361	4.8346	0.3488	0.0980	0.5981	0.3763	0.2595
Phase 2	95.1636	1.0722	0.5072	1.0440	0.0366	1.3479	0.5261	0.3025
Phase 3	91.9098	0.6925	1.2233	3.1248	0.0273	0.9472	0.5161	1.5590
Agr								
Phase 1	2.3865	95.2895	0.2246	0.4635	0.3524	0.0365	0.0964	1.1507
Phase 2	6.2131	87.8418	0.2665	0.7977	0.0454	1.4613	1.7857	1.5885
Phase 3	16.2023	78.9220	3.1359	1.0995	0.2277	0.2342	0.0599	0.1186
Ene								
Phase 1	0.9823	4.6299	89.6264	1.0716	1.2470	0.1395	0.7694	1.5342
Phase 2	0.6976	13.6126	82.7403	0.1143	0.1725	2.5890	0.0256	0.0481
Phase 3	29.6152	15.7205	44.8867	2.8188	0.7011	3.5622	0.8987	1.7967
MSCI								
Phase 1	7.0052	0.0901	8.0206	78.4799	0.1572	2.6966	0.0943	3.4561
Phase 2	0.6329	1.1835	8.4414	83.5344	3.4651	0.6351	0.0534	2.0541
Phase 3	4.3857	0.3377	0.7370	90.8347	2.4239	0.5365	0.6785	0.0662
BTC								
Phase 1	1.2255	0.5109	0.4538	10.3054	85.2951	0.3570	0.3516	1.5006
Phase 2	0.6674	1.7154	2.7511	11.3331	81.8769	0.1341	0.2603	1.2618
Phase 3	1.7073	0.3236	3.0361	37.4320	54.4232	2.2010	0.8378	0.0390
GBL								
Phase 1	12.0649	2.6773	8.8852	1.9097	0.8463	72.8265	0.3817	0.4085
Phase 2	13.1098	10.1385	6.6750	4.7972	2.3820	61.0555	1.5914	0.2506
Phase 3	10.1479	2.4031	5.2553	1.9646	0.3714	76.2894	0.8778	2.6904

Table 4 (Continued)

Phase	Gold	Agr	Ene	MSCI	BTC	GBL	GBS	USD
GBS								
Phase 1	9.9588	1.8702	0.7807	2.4423	0.5925	22.2866	61.8833	0.1855
Phase 2	12.2359	4.6203	3.3703	1.5328	0.6492	24.3521	53.0063	0.2331
Phase 3	10.0262	1.3029	3.5084	1.8095	0.3126	52.2640	29.4736	1.3027
USD								
Phase 1	35.1309	0.4802	2.0273	6.2513	0.5119	2.0511	3.0448	50.5027
Phase 2	3.1046	7.5707	1.1631	12.4832	1.1789	3.2728	4.1349	67.0918
Phase 3	7.7340	1.6259	2.6670	24.5495	0.7226	0.1382	3.4352	59.1276

5. CONCLUSION AND SUGGESTIONS

The conflict between Russia and Ukraine has generated impacts within the interconnected global financial market, affecting investors' decisions to invest in hedging assets to avoid risks. This study of geopolitical risk and responses to financial markets using the VAR model with available data from January 4, 2021, to July 29, 2022, and divided into three phases, unveils that each financial asset and commodity type is linked in different ways and reacts differently at different times. Based on the impulse response function, the financial assets and commodities would act as hedges and safe havens when they respond negatively according to the definition of Baur and Lucey (2010). Results for phase 1 showed that gold and bitcoin are good hedges for other financial assets and commodities, while in phase 2, bitcoin and treasury bonds appeared to be good hedges for larger varieties of financial assets and commodities than gold. In phase 3, it is indicated that gold is safe haven for energy commodities only, while bitcoin is a safe haven for the capital market only. However, the low-risk financial assets such as treasury bonds (both short term and long term) and US dollar are safe havens for many other financial assets and commodities.

The variance decomposition demonstrates that gold bears the lowest impact from the volatility of other financial assets and commodities in each phase. Therefore, investors should increase their investment proportion in gold as a hedge under uncertain hostilities. Aggressive investors can invest in bitcoin to receive high returns while recognizing high risk (Table 2). Treasury bonds and US dollars are suitable for conservative investors. Despite these results, the study is merely a guideline for investment decisions as it reveals the connections and responses of each financial asset, but does not confirm the future risks and returns. Therefore, investors should invest according to their acceptable risk level, while policymakers can also consult the results as a guide for monitoring and managing or coping with the effect of geopolitical risks, which is a driving force behind systematic risk. However, with the continuous circumstances of the Russian invasion of Ukraine, the geopolitical risk situation may change (increase or decrease). Additionally, the economic policies implemented by each country, particularly the United States, could affect financial markets as well as financial and economic stability, representing possible challenges to the study's findings. In future studies, it is important to prioritize these factors along with sustainable stock investments as a potential strategy to minimize the risk caused by geopolitical events, especially given changing circumstances.

ACKNOWLEDGEMENTS

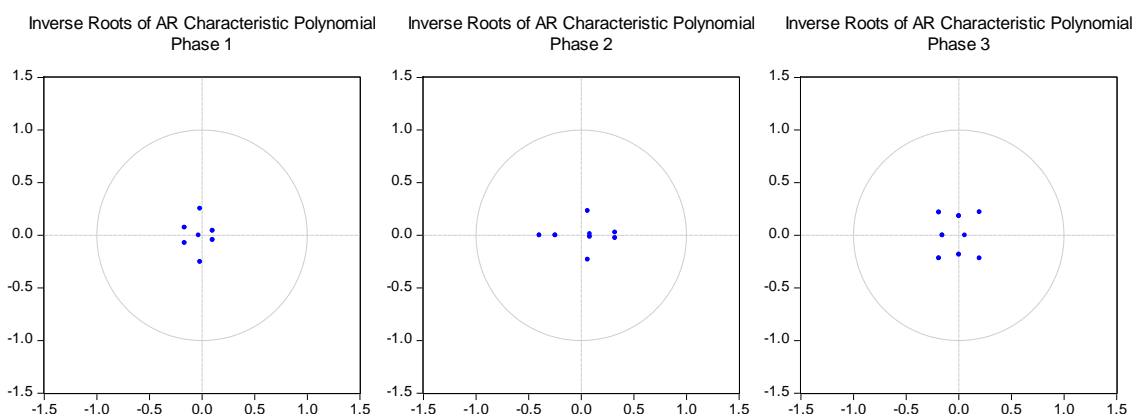
The authors gratefully acknowledge the financial support received for the publication of this article from Buriram Rajabhat University.

REFERENCES

- Adekoya, O. B., Oliyide, J. A., Yaya, O. S., & Al-Faryan, M. A. S. (2022). Does oil connect differently with prominent assets during war? Analysis of intra-day data during the Russia-Ukraine saga. *Resources Policy*, 77, 102728.
- Alam, M. K., Tabash, M. I., Billah, M., Kumar, S., & Anagreh, S. (2022). The impacts of the Russia-Ukraine invasion on global markets and commodities: A dynamic connectedness among G7 and BRIC markets. *Journal of Risk and Financial Management*, 15(8), 352.
- Aliu, F., Hašková, S., & Bajra, U. Q. (2023). Consequences of Russian invasion on Ukraine: Evidence from foreign exchange rates. *Journal of Risk Finance*, 24(1), 40-58.
- Baur, D. G., & Lucey, B. M. (2010). Is gold a hedge or a safe haven? An analysis of stocks, bonds and gold. *The Financial Review*, 45, 217-229.
- Baur, D. G., & Smales, L. A. (2020). Hedging geopolitical risk with precious metals. *Journal of Banking & Finance*, 117, 105823.
- Bedowska-Sójka, B., Demir, E., & Zaremba, A. (2022). Hedging geopolitical risks with different asset classes: a focus on the Russian invasion of Ukraine. *Finance Research Letters*, 50, 103192.
- Bloomberg. (2022). *Markets energy*. Available: <https://www.bloomberg.com/quote/CL1:COM>
- Bouri, E., Molnár, P., Azzi, G., Roubaud, D., & Hagfors, L. I. (2017a). On the hedge and safe haven properties of bitcoin: Is it really more than a diversifier? *Finance Research Letters*, 20, 192-198.
- Bouri, E., Jalkh, N., Molnár, P., & Roubaud, D. (2017b). Bitcoin for energy commodities before and after the December 2013 crash: Diversifier, hedge or safe haven? *Applied Economics*, 49(50), 5063-5073.
- Bouri, E., Demirer, R., Gupta, R., & Marfatia, H. A. (2019). Geopolitical risks and movements in Islamic bond and equity markets: A note. *Defence and Peace Economics*, 30(3), 367-379.
- Caldara, D., & Iacoviello, M. (2022). Measuring geopolitical risk. *American Economic Review*, 112(4), 1194-1225.
- Chkili, W. (2022). The links between gold, oil prices and Islamic stock markets in a regime switching environment. *Eurasian Economic Review*, 12(1), 169-186.
- Choi, S., & Shin, J. (2022). Bitcoin: An inflation hedge but not a safe haven. *Finance Research Letters*, 46, 102379.
- Choudhury, T., Kinatader, H., & Neupane, B. (2022). Gold, bonds, and epidemics: A safe haven study. *Finance Research Letters*, 48, 102978.
- Dyhrberg, A. H. (2016a). Bitcoin, gold and the dollar – a GARCH volatility analysis. *Finance Research Letters*, 16, 85-92.
- Dyhrberg, A. H. (2016b). Hedging capabilities of bitcoin is it the virtual gold? *Finance Research Letters*, 16, 139-144.
- Guesmi, K., Saadi, S., Abid, I., & Ftiti, Z. (2019). Portfolio diversification with virtual currency: Evidence from bitcoin. *International Review of Financial Analysis*, 63, 431-437.
- Hoffmann, M., & Neuenkirch, M. (2017). The pro-Russian conflict and its impact on stock returns in Russia and the Ukraine. *International Economics and Economic Policy*, 14, 61-73.
- Kaczmarek, T., Bedowska-Sójka, B., Grobelnym, P., & Perez, K. (2022). False safe haven assets: evidence from the target volatility strategy based on recurrent neural network. *Research in International Business and Finance*, 60, 101610.

- Klein, T., Thu, H. P., & Walther, T. (2018). Bitcoin is not the new gold - a comparison of volatility, correlation, and portfolio performance. *International Review of Financial Analysis*, 59, 105-116.
- Long, S., & Guo, J. (2022). Infectious disease equity market volatility, geopolitical risk, speculation, and commodity returns: Comparative analysis of five epidemic outbreaks. *Research in International Business and Finance*, 62, 101689.
- Rappeport, A. (2022, February 28). *U.S. escalates sanctions with a freeze on Russian central bank assets*. New York Times. <https://www.nytimes.com/2022/02/28/us/politics/us-sanctions-russia-central-bank.html>
- Shahzad, S. J. H., Bouri, E., Rouband, D., & Kristoufek, L. (2020). Safe haven, hedge and diversification for G7 stock markets: Gold versus bitcoin. *Economic Modelling*, 87, 212-224.
- Sharpe, W. F. (1964). Capital asset prices: A theory of market equilibrium under conditions of risk. *The Journal of Finance*, 19(3), 425-442.
- Siemaszkiewicz, K. (2021). Safe haven instruments - a comparison between the global financial crisis and the covid-19 pandemic. *Econometrics Ekonometria Advances in Applied Data Analysis*, 25(4), 1-16.
- Sims, C. (1980). Macroeconomics and reality. *Econometrica*, 48(1), 1-48.
- Statista. (2022). *Countries with highest value of crude oil exports worldwide in 2021*. Available: <https://www.statista.com/statistics/6571103/global-crude-oil-exporter-value-by-country/>
- Syuhada, K., Suprijanto, D., & Hakim, A. (2022). Comparing gold's and bitcoin's safe-haven roles against energy commodities during the COVID-19 outbreak: A vine copula approach. *Finance Research Letters*, 46, 102471.
- Troianovski, A., & Sanger, D.E. (2022, January 16). *Russia issues subtle threats more far-reaching than a Ukraine invasion*. New York Times. <https://www.nytimes.com/2022/01/16/world/europe/russia-ukraine-invasion.html>
- Umar, Z., Polat, O., Choi, S. Y., & Teplova, T. (2022). The impact of the Russia-Ukraine conflict on the connectedness of financial markets. *Finance Research Letters*, 48, 102976.
- UN Comtrade Database. (2022a). *Petroleum gases and other gaseous hydrocarbons, liquefied, natural gas*. Available: <https://comtradeplus.un.org/>
- UN Comtrade Database. (2022b). *Wheat and meslin*. Available: <https://comtradeplus.un.org/>
- Wang, G., Tang, Y., Xie, C., & Chen, S. (2019). Is bitcoin a safe haven or a hedging asset? Evidence from China. *Journal of Management Science and Engineering*, 4(3), 173-188.
- Wang, Q., Wei, Y., Wang, Y., & Liu, Y. (2022a). On the safe-haven ability of bitcoin, gold, and commodities for international stock markets: Evidence from spillover index analysis. *Discrete Dynamics in Nature and Society*, 2022, 9520486.
- Wang, Y., Bouri, E., Fareed, Z., & Dai, Y. (2022b). Geopolitical risk and the systemic risk in the commodity markets under the war in Ukraine. *Finance Research Letters*, 49, 103066.
- Wen, F., Tong, X., & Ren, X. (2022). Gold or bitcoin, which is the safe haven during the COVID-19 pandemic? *International Review of Financial Analysis*, 81, 102121.
- Xiao, B. (2022). A study on the hedging function of gold in the light of economic policy uncertainty. *Computational Intelligence and Neuroscience*, 2022, 1556475.
- Yousaf, I., Patel, R., & Yarovaya, L. (2022). The reaction of G20+ stock markets to the Russia-Ukraine conflict "black-swan" event: Evidence from event study approach. *Journal of Behavioral and Experimental Finance*, 35, 100723.
- Zhu, Y., Dickinson, D., & Li, J. (2017). Analysis on the influence factors of bitcoin's price based on VEC model. *Financial Innovation*, 3(1), 1-13.

APPENDIX



Appendix Figure 1 Inverse roots of characteristic AR polynomial test

Appendix Table 1 Lag Length Selection

Lags	Phase 1		Phase 2		Phase 3	
	AIC	SIC	AIC	SIC	AIC	SIC
1	-59.7794*	-58.4619*	-56.9154*	-54.9287*	-51.8402*	-49.9411*
2	-59.4590	-56.9702	-56.4380	-52.6855	-51.2107	-47.6234
3	-59.1949	-55.5350	-56.1924	-50.6740	-50.6830	-45.4075
4	-58.9581	-54.1270	-55.9036	-48.6193	-50.3382	-43.3747
5	-58.8173	-52.8151	-55.8286	-46.7785	-50.0781	-41.4263

* Optimal lag length

Appendix Table 2 Serial Correlation Test

Lags	Phase 1		Phase 2		Phase 3	
	Q-stat	Adj Q-stat	Q-stat	Adj Q-stat	Q-stat	Adj Q-stat
1	5.0209 [NA]	5.0488 [NA]	8.7444 [NA]	8.8375 [NA]	6.4671 [NA]	6.5293 [NA]
2	59.3542 [0.15]	59.9892 [0.14]	67.9791 [0.34]	69.3460 [0.30]	57.3965 [0.71]	58.4476 [0.67]
3	102.3222 [0.36]	103.6814 [0.33]	148.4067 [0.10]	152.3963 [0.07]	108.9476 [0.89]	111.5150 [0.85]

[] p-value