“Testing bitcoin’s safe-haven property and the correlation between Bitcoin, gold, oil, stock markets, and Google trends”

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TESTING BITCOIN'S SAFE-HAVEN PROPERTY AND THE CORRELATION BETWEEN BITCOIN, GOLD, OIL, STOCK MARKETS, AND GOOGLE TRENDS

Abstract

Since its public introduction in 2009, Bitcoin has grown to be the most well-known cryptocurrency worldwide. There is still debate as to whether Bitcoin may be used as a hedge against other assets. The purpose of this study is to investigate the correlation between Bitcoin and conventional commodity markets such as gold, crude oil, stock markets, and investor interest (quantified via Google Trends). In addition, the paper also tests Bitcoin's safe haven role compared to other commodity markets. The Vector Autoregression model using daily database collected during the period 2013–2021 is employed to investigate the relationship between Bitcoin and traditional commodity markets. The impulse response function is used to analyze Bitcoin price movements against economic shocks from gold, oil prices, and the Dow Jones Industrial Average. In addition, the value-at-risk (VaR) model is used to test Bitcoin's safe-haven property compared to other conventional commodity markets. The research results show that Bitcoin has negative impacts on gold, crude oil prices, and the stock market. Besides, Bitcoin responds negatively to a sharp decline in investor interest. Furthermore, the results of the VaR model show that Bitcoin is the second most volatile and risky asset, only after the crude oil market, and much riskier than gold. This result proves that Bitcoin cannot yet be considered a safe-haven instrument. These findings have several implications for investors and policymakers to minimize the risks associated with this cryptocurrency.

Keywords Bitcoin, gold, commodities, Google trends, safe haven

JEL Classification G10, G11, G15

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INTRODUCTION

Since the fourth industrial revolution has been spreading globally, technological achievements in many fields, such as artificial intelligence, biotechnology, and cloud technology, have brought many opportunities and challenges for the global economy. Blockchain technology was born and has become a global trend when applications from Blockchain have great potential for development in many industries, from financial services and manufacturing technology to supply chains, education, and energy. One of the best-known products based on Blockchain technology in the finance industry is cryptocurrency in general and Bitcoin in particular, replacing traditional payment tools.

Although considered a highly independent cryptocurrency, in economic terms, the price of Bitcoin is still affected by many factors such as supply and demand, political situation, its competitive markets, legal regulations of this currency, and the role of the media (Bloomenthal, 2023). With a worldwide supply limit of only 21 million Bitcoins and currently only 10% untapped, the scarce supply is Bitcoin's main at-

traction for investors, and the volatility of Bitcoin's price over the years is also greatly affected by its changing demand. Markets that compete with Bitcoin include other conventional commodity markets such as gold, crude oil, and stock markets. Nowadays, there are two legal systems for cryptocurrencies in the world, the first is the one that supports and legalizes cryptocurrencies, and the rest are countries that have not allowed or prohibited transactions in this currency. In addition, media factors, including positive or negative information about Bitcoin, also cause the price of this coin to fluctuate. In addition to being affected by the above factors, Bitcoin – the most popular cryptocurrency can impact long-standing commodity markets such as gold, oil, and stock markets. Therefore, it is necessary to analyze the interaction between Bitcoin and these markets to assess Bitcoin's safety and its future development potential. If the results show that Bitcoin has a large correlation with a stable market like the gold one, this will be a positive signal to assess Bitcoin's ability to become a hedge in uncertain economic times. On the contrary, if Bitcoin has a great correlation with volatile markets such as stock or crude oil ones, Bitcoin can hardly be assessed as a highly stable asset (Su et al., 2020).

1. LITERATURE REVIEW

Bitcoin is a digital money that is encrypted, decentralized, and controlled by algorithms. The existence and development of this currency is an innovation in the traditional monetary system. Not only the nature of Bitcoin but the relationship between Bitcoin and other assets is also a topic that attracts scholars' interest. Gajardo et al. (2018) applied multifractal asymmetric detrended cross-correlation analysis (MF – ADCCA) to study the correlation between the main currency rates and Bitcoin, the Dow Jones Industrial Average (DJIA), gold price, and the oil crude markets. This study found a cross-correlation between Bitcoin, the price of oil, gold, and the Dow Jones Industrial Average index, and concluded that Bitcoin's asymmetry was weaker and more stable than other currencies like the Euro (EUR), the Great Britain Pound (GBP) and the Yen (YEN). To determine the relationship between Bitcoin and other assets, Bhuiyan (2021) used the Wavelet multi-resolution transform method to determine the correlation between Bitcoin price and gold, currencies, commodities, stock, and bond indices. These findings reveal that there was a cross-correlation between Bitcoin and gold prices, but no relationship between Bitcoin and oil prices, the US dollar index, the US stock index S&P 100, and the bond index EMTX was found, contrary to the conclusions of Gajardo et al. (2018). In addition, Béjaoui et al. (2021) examined the relationship between Bitcoin and social networks at a time when there was a worldwide pandemic of COVID-19 using the fractional error correction model (FEC). This study result shows that the spread and fatality of COVID-19 negatively impacted the stock market, resulting in the fact that investors had to seek alternative investments like Bitcoin and increased the search for Bitcoin information on social media platforms. However, in the long term, COVID-19 can be controlled and no longer influences the price of Bitcoin.

In recent years, although Bitcoin has been going through the development process to become a digital currency officially traded and used worldwide, with its decentralized nature and independence from any regulatory authority, the existence of Bitcoin remains controversial, and it is considered a high-risk asset. For investors, the biggest risk comes from the price of Bitcoin itself as the coin is often volatile and has the potential to drop to zero due to its no intrinsic value feature (Carey, 2021). When there are dangers in the transaction such as being scammed, stolen, etc., the legal rights of Bitcoin holders are limited because Bitcoin is a cryptocurrency that is not under the management of any individual, organization, or government. One of the risks for governments accepting Bitcoin legalization is that this cryptocurrency is often used to commit illicit actions such as tax evasion, money laundering, etc. (Reiff, 2022). This risk of Bitcoin is the main reason why countries such as the UK, Spain, and Singapore had to adjust measures to limit domestic Bitcoin transactions. In addition, Bitcoin mining is considered to consume a lot of energy and cause adverse effects on the environment. Thus, many countries that support the use of green energy, such as the US and China, propose bills to stop mining this cryptocurrency. Therefore, further empirical evidence

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and studies on Bitcoin's risk measurement need to be carried out to help control the risks associated with this cryptocurrency.

Whether Bitcoin is a highly safe haven for investors is still a controversial topic. Prior studies emphasize that Bitcoin is a diversified investment tool against oil price crisis movements, and this ability depends on various market conditions (Selmi et al., 2018; Dutta et al., 2020). Another study by Long et al. (2021) indicates that when confronted with shocks of various uncertainties, Bitcoin is unable to function as a safe haven, whereas gold can act as a buffer against uncertainty to different degrees. During the COVID-19 outbreak, neither Bitcoin nor gold is safe haven, but they can be used as hedging solutions (Zhao, 2022). In addition, Chemkha et al. (2021) also confirm that cryptocurrencies are still far riskier compared to precious metals and other assets; thus investing in Bitcoin can cause an excessive amount of portfolio return volatility. Similarly, it is argued that under a highly market-capitalized index, Bitcoin did not show any safe haven characteristics (Kumar & Padakandla, 2022; Chan et al., 2023). In other words, Bitcoin is recognized as a risky asset (Baur et al., 2021; Baur & Hoang, 2021).

As an emerging cryptocurrency over the past 9 years, Bitcoin and its correlation with other conventional commodity markets have received a great deal of attention from researchers. However, the research results on this correlation are multidimensional. Numerous studies suggest that Bitcoin has a strong correlation with the prices of crude oil and the stock market (Gajardo et al., 2018; Nguyen, 2021; Bhuiyan, 2021), thereby rejecting the possibility of Bitcoin becoming a hedge (Chemkha et al., 2021; Long et al., 2021). On the contrary, other results show that Bitcoin and the gold market are both regarded as safe havens during periods of economic uncertainty, thus suggesting that Bitcoin should be considered as a kind of "digital gold" (Al-Yahyaee et al., 2018; Selmi et al., 2018; Kwon, 2020). In addition, in the context of volatile economic markets, investor attention measured by social media search queries shows a strong correlation with Bitcoin price (Béjaoui et al., 2021; Zhang et al., 2018). Previous studies are still controversial and inclusive about whether Bitcoin is a safe haven. Thus, this study fills in the research gap by testing the role of Bitcoin as a safe-haven instrument, and the correlation between Bitcoin, other commodity markets, and investor's interest.

The paper is organized into five sections, including Section 1 – Literature Review, followed by Section 2 – Research Methodology, Section 3 – Research Results, Section 4 – Discussion, and the last Section – Conclusions.

2. RESEARCH METHODOLOGY

2.1. Research model

The vector autoregression model (VAR) is considered the most suitable one for testing the correlation of multivariable time series (Zivot et al., 2006). Therefore, this study employs the VAR model to test the correlation between Bitcoin, other commodity markets, and Google Trends as a proxy for investor attention.

In this study, the VAR model (Sims, C. A. 1989) will be represented by 2 correlation equations, including Bitcoin price (BTC) and Bitcoin trading volume (VOLUME) as follows:

$$\begin{aligned} BTC_{1t} &= \alpha_1 + \sum_{i=1}^{k} \beta_{1i} BTC_{1t-i} \\ &+ \sum_{i=1}^{k} \gamma_{1i} VOLUME_{1t-i} + \sum_{i=1}^{k} \delta_{1i} XAU/USD_{1t-i} \\ &+ \sum_{i=1}^{k} \varepsilon_{1i} WTI_{1t-i} + \sum_{i=1}^{k} \zeta_{1i} DJIA_{1t-i} \\ &+ \sum_{i=1}^{k} \theta_{1i} GGTRENDS_{1t-i} + \omega_{1t}, \end{aligned} \quad (1)$$

$$\begin{aligned} VOLUME_{2t} &= \alpha_2 + \sum_{i=1}^{k} \beta_{2i} BTC_{2t-i} \\ &+ \sum_{i=1}^{k} \gamma_{2i} VOLUME_{2t-i} + \sum_{i=1}^{k} \delta_{2i} XAU/USD_{2t-i} \\ &+ \sum_{i=1}^{k} \varepsilon_{2i} WTI_{2t-i} + \sum_{i=1}^{k} \zeta_{2i} DJIA_{2t-i} \\ &+ \sum_{i=1}^{k} \theta_{2i} GGTRENDS_{2t-i} + \omega_{2t}, \end{aligned} \quad (2)$$

where k – lag value per variable; α, β, γ, δ, ε, ζ, θ – square coefficient matrix of the system of equations; ω – error of the model.

To measure the risk level of an asset class, the Value at Risk (VaR) model has been built to assess and remediate early to minimize losses from that asset's risk (Marshall et al., 1996). The VaR mod-

el is the minimum possible loss, in other words, this model determines the maximum amount of money that is likely to be lost when an investment asset class experiences negative volatility and goes into crisis within a given time period and with a certain degree of confidence. The VaR model is typically calculated on a day-to-day basis over the asset's holding period and is calculated to less than 2 common confidence levels of 95% (about 95% probability that the portfolio's losses will be lower than the VaR results) and same with 99%. Assuming that the return series of the asset r_t is stationary and normally distributed, we need to use the estimates of the standard deviation (σ) and the expectation (μ) to be able to calculate the value of VaR.

From the assumption $r_t \sim N(\mu, \sigma^2)$, we can infer $(r_t - \mu / \sigma) \sim N(0, 1)$. Thereby, the general formula of the VaR model is shown as follows:

$$VaR\left(1day,\ \left(1-\alpha\right)\cdot 100\%\right) = \mu + N^{-1}\left(\alpha\right)\cdot\left(\sigma\right). \quad (3)$$

2.2. Data

This paper selects daily closing-price data for Bitcoin (BTC), world gold price (XAU_USD), the Dow Jones Index (DJIA), world crude oil price (WTI) and Google Trends (GGTRENDS) during the period from January 01, 2013 to December 31, 2021. The data are sourced from https://coinmarketcap.com/ for Bitcoin price (BTC) and Bitcoin daily trading volume (VOLUME). The world gold price, the WTI crude oil price, and the Dow industrial average Jones are extracted from https://www.investing.com/. Following Béjaoui et al. (2021), this study refers to the variables "Google Trends" as social media metrics that reflect the queries of investor interest via searching keywords "Bitcoin" and "BTC" on the Google search engine. Google Trends data are derived from https://trends.google.com.vn/.

From the beginning, all the series are transformed into logarithmic form, including 3,287 observations collected from daily data for the period 2013–2021. However, with the characteristics of gold (XAU/USD), crude oil (WTI), and stock (DJIA) markets, trading is from Monday to Friday every week, closed on Saturdays, Sundays, and public holidays, Tet holiday, therefore, the data collected for these variables are often incomplete when compared with the data of Bitcoin and the variable GGTRENDS. After cleansing the data, 2,257 observations are obtained for 9 years. Table 1 summarizes descriptive statistics about the observed variables for the period 2013–2021. The table shows that Bitcoin (BTC) has a logarithmic average of 3.303, which is lower than the Stock Market Average (DJIA) of 4.335 but higher than the Gold Market (XAU_USD) and oil price (WTI) with levels of 3.14 and 1.772 respectively. However, Bitcoin is the variable with the highest standard deviation (0.849) in the comparison markets.

Table 1 shows that Bitcoin is a highly distributed variable, its values significantly fluctuate against the average Bitcoin value. The dispersion is most visible when the differences between the minimum and maximum value of Bitcoin price and of transaction volume are quite large (3.713 and 2.110, respectively), while in the other markets,

Table 1. Descriptive statistics of variables

Source: Authors' calculation using EViews 12.

	BTC	DJIA	GGTRENDS	VOLUME	WTI	XAU_USD
Mean	3.3028	4.3350	1.9585	3.9446	1.7719	3.1398
Median	3.4146	4.3290	2.0212	3.9368	1.7568	3.1148
Maximum	4.8297	4.5622	2.3096	5.1369	2.0435	3.3145
Minimum	1.1169	4.1248	1.0792	3.0268	1.0004	3.0219
Std. Dev.	0.8495	0.1136	0.2198	0.3181	0.1489	0.0691
Skewness	-0.0834	0.2286	-1.1247	0.1700	-0.2882	0.7742
Kurtosis	2.0879	1.9097	3.8917	3.0228	3.7554	2.3865
Jarque-Bera	80.8502	131.4554	550.5664	10.9177	84.9103	260.8775
Probability	0.0000	0.0000	0.0000	0.0043	0.0000	0.0000
Observations	2257	2257	2257	2257	2257	2257

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this gap is only around 0.3 to 1. The values of the Skewness and Kurtosis tests both have acceptable results, and the statistics of the Jarque-Bera test are all significant at the level of 5%, implying that the data series are normally distributed.

3. RESEARCH RESULTS

3.1. Unit root test

Unit root is a major cause of non-stationarity. If there is a unit root in the time series, it will make the statistical tests and the results of the model unreliable, and there will be phenomena such as pseudo-regression. To test the stationarity of the data series, the extended Unit Roof Test of Dickey-Fuller (1981) is used, and the results are shown in Table 2.

Table 2 shows that when the absolute value of the t-statistic is higher than the critical value, the variables BTC, GGTRENDS, VOLUME, and DJIA are stationary in level. However, the absolute values of t-statistic of the other two variables, XAU_USD and WTI in level, are smaller than critical values, implying that these two series are non-stationary. After first-differencing, XAU_USD and WTI become stationary given that these variables are first-order integrated (I(1)).

Lags of the model depend on the frequency of the data series. In this paper, the daily data are collected, so the maximum lag for the model is 30 (period). The optimal order of VAR model lags is chosen based on information criteria such as Akaike Information Criterion (AIC), Schwartz Criterion (SC), Hannan Quinn (HQ), and Final Prediction Error (FPE) (Lütkepohl, 2005). Using SC and HQ criteria, the optimal number of the VAR model is equal to 2 and 3, respectively. On the other hand, it appears to be 8 lags based on the FPE and AIC criteria. Theoretically, which lag is selected by the most criteria will be the optimal one, in the economic time series; the AIC criterion, followed by the SC criterion, provides the most accurate model results (Koehler et al., 1988). In this case, the lag of the VAR model to be 8 is selected, based on the AIC criterion.

3.2. Granger causality test

The Granger causality test is a commonly used method for examining the causal relationship between time series variables (Granger, 1969). Prior research often employs Granger causality test on Vector Autoregression (VAR) model in variable levels. In this study, we use the VAR model, which considers many time variables concurrently, therefore, it is required to carry out the causality test.

The causality test's findings demonstrate that only the gold price variable (DXAU_USD) has an impact on the price of Bitcoin (BTC), whereas all the other variables have statistical values greater than 5%. It is argued that Bitcoin and the stock market have an increasingly high correlation coefficient, and this statement is also confirmed by our results of the Granger test when the stock variable (DJIA)

Table 2. Results of testing the stationarity of the data series

Source: Authors' calculation using EViews 12.

	Dickey-Fuller test					
	BTC	**XAU_USD**	**WTI**	**GGTRENDS**	**VOLUME**	**DJIA**
In level						
Lags	0	0	5	2	9	9
Models	M1	M1	M1	M3	M2	M1
T-statistic	2.4711	0.1545	–0.3316	–7.9623	–6.9013	1.9818
Critical value of 5%	–1.9410	–1.9410	–1.9410	–3.4118	–2.8626	–1.9410
In first difference						
Lags	0	0	4	2	9	9
Models	M1	M1	M1	M3	M2	M1
T-statistic	2.4711	–47.0378	–19.4220	–7.9623	–6.9013	1.9818
Critical value of 5%	–1.9410	–1.9410	–1.9410	–3.4118	–2.8626	–1.9410

Notes: M1: Model without constant and trend. M2: Model with constant and without trend. M3: Model with constant and trend.

Table 3. Testing Granger causality

Source: Authors' calculation using EViews 12.

Explanatory variable	Explained variable	BTC	VOLUME	DWTI	DXAU_USD	GGTRENDS	DJIA
BTC	F-statistic	–	1.1802	1.8947	1.8488	1.2870	2.5028
	Prob	–	0.2420	0.0042	0.0057	0.1511	0.0000
VOLUME	F-statistic	0.9129	–	0.8659	1.6471	2.3898	0.9892
	Prob	0.5910	–	0.6599	0.0211	0.0001	0.4792
DWTI	F-statistic	0.7709	0.7160	–	1.1447	0.3954	2.5292
	Prob	0.7886	0.8513	–	0.2793	0.9974	0.0000
DXAU_USD	F-statistic	1.8559	0.7144	2.3880	–	0.9252	1.5030
	Prob	0.0054	0.8529	0.0001	–	0.5728	0.0493
GGTRENDS	F-statistic	1.2913	1.4285	0.8372	1.2910	–	0.3952
	Prob	0.1481	0.0743	0.7008	0.1483	–	0.4792
DJIA	F-statistic	0.9964	1.7395	7.9295	1.5420	0.8397	–
	Prob	0.4688	0.0117	0.0000	0.0395	0.6973	–

Notes: Variables with a stationary series at first difference are denoted by "D…".

influences the volume of Bitcoin traded during the day (VOLUME) with the statistical significance of 0.0117. This implies that Bitcoin shares some common features with traditional assets in the portfolio. This positive correlation indicates that if the stock market recovers, investors will be optimistic and choose to add Bitcoin to their portfolio; however, it also shows that Bitcoin is no longer seen as a safe-haven asset.

Bitcoin also has an impact on other variables such as crude oil price (WTI), gold price (XAU_USD), Google Trends (GGTRENDS) and stock market (DJIA). Although the WTI crude oil variable has no statistical significance with the Bitcoin price (BTC) and its trading volume (VOLUME), the WTI variable is affected by the Bitcoin price (BTC) as shown in Table 3. The Granger test indicates that the price of Bitcoin has a statistical correlation with crude oil price (0.0042). This consequence is likely because both Bitcoin and crude oil (WTI) have several similarities, such as being highly volatile and dependent on its own supply and demand.

Bitcoin daily volume (VOLUME) in the causal test shows that this variable has an impact on investor interest through the Google Trends variable. Following Table 3, Bitcoin price and volume usually move in the same direction, showing that Bitcoin trading volume will increase if Bitcoin price is on the rise and vice versa. The high volume of Bitcoin transactions will increase expectations of profits from investment in this cryptocurrency. Thus, investors will choose to search for information about Bitcoin through online search engines like Google to decide whether to invest in Bitcoin and evaluate its profitability.

3.3. Impulse response function analysis

This paper uses the impulse response function to analyze the relationship between Bitcoin and other variables. The impulse response function describes how one variable reacts when another one is subjected to shocks with a proper lag. All the series are converted to log values; shock number 1 is given for BTC, and other shocks of DJIA, WTI, XAU_USD, GGTRENDS, and VOLUME variables are numbered from 2 to 6, respectively.

From Figure 1, Bitcoin price has the highest reaction to shocks from itself (Shock 1), with the response function varying between 2.2 and 2.5 percent, whereas Bitcoin's response to other variables is roughly 0.7 percent or lower. For past shocks, Bitcoin price reacted quite negatively as it dropped sharply in the first 3 periods, then quickly recovered and peaked at the 15th period. However, the price of bitcoin responded slightly and returned to its original value of 0.023. This result shows Bitcoin can potentially be recovered, according to the Bitcoin halving cycle, Bitcoin fluctuates in certain patterns and is unrelated to the value of other assets.

Regarding Shock 2, Bitcoin showed a negative correlation with the shock from DJIA stock price.

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Source: Authors' calculation using EViews 12.

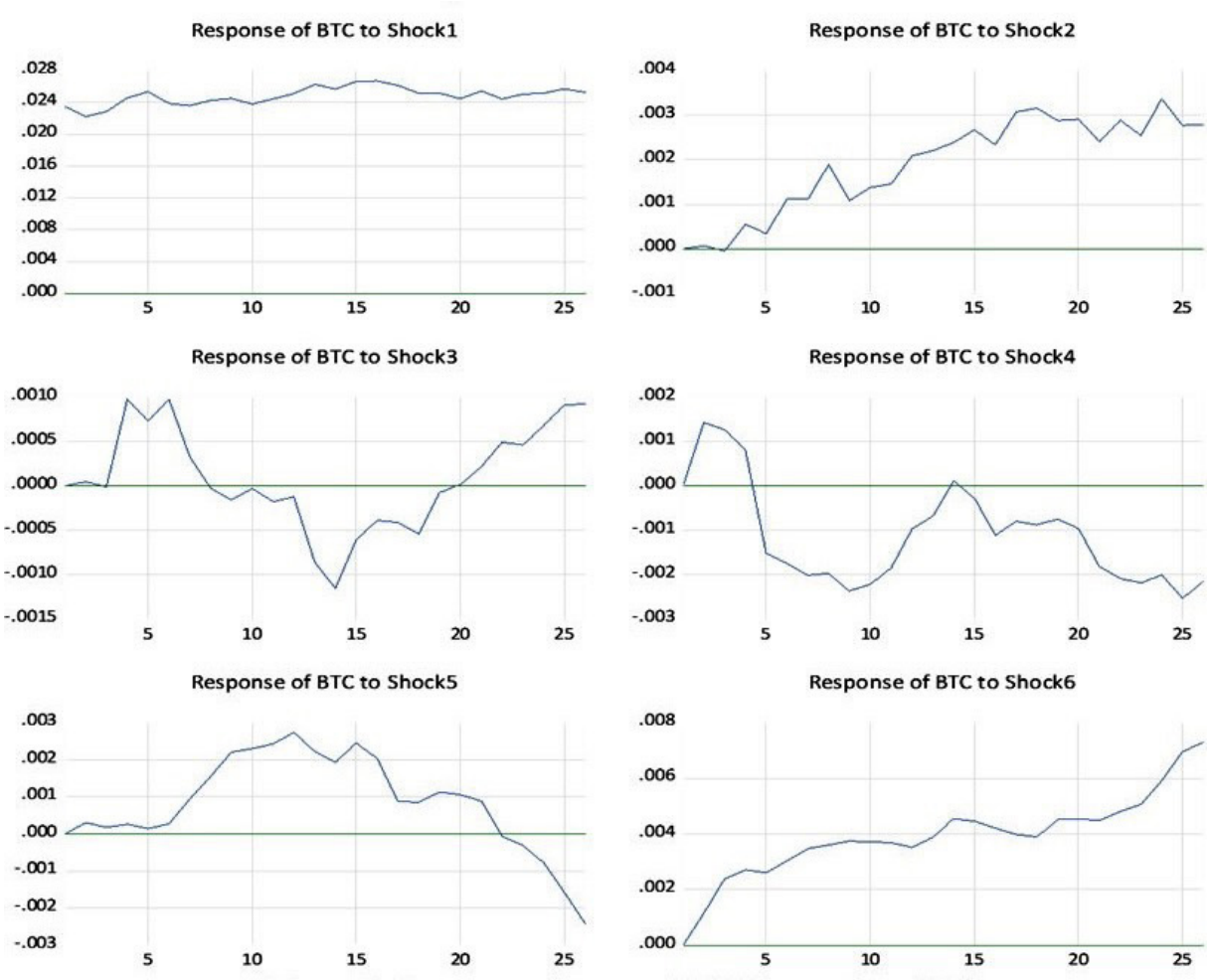

Figure 1. Response to structural VAR innovations

During the first periods when the DJIA shock occurred, Bitcoin reacted slightly in the 3rd period, then rose rapidly in subsequent ones. Bitcoin's opposite reaction to stock price shock can be explained by the psychological effect of investors. When there are negative movements in the stock market resulted in the higher risk of the DJIA, investors tend to look for safer markets. This has led to "digital gold" – Bitcoin bouncing up due to increased investment demand.

Contrary to the positive signal from the stock market, Bitcoin has an unusual bullish reaction to shocks from the WTI crude oil market (Shock 3). In the first 2 periods when receiving the oil shock, Bitcoin price decreased by 0.0002 points, then turned to increase to 0.0007 after only one period. After peaking at 0.0090 points in the 7th-8th periods, Bitcoin suddenly reversed, plummeting to a value of –0.0002 in the 9th period. In the following periods, although Bitcoin price recovered slightly in the 11-12 periods, it then continued to decrease during the 15th – 25th periods. In the final 25th period, Bitcoin's value could not return to its initial value. It is argued that the oil price is affected by various factors such as natural disasters, war, geopolitical instability, and the pandemic. In the history of the crude oil market, there were oil price crises, and up to five over seven crises stemmed from unstable political situations, showing that the prolonged tense political situation is a crucial factor causing crude oil to fall into an alarming state. As indicated in the previous section, Bitcoin is also affected by political instability. When an oil price shock occurs, investors tend to look for other alternative investments, and Bitcoin can be selected in the portfolio, explaining the

strong bullish reaction of Bitcoin in the first 7 periods. However, from the 8th period, Bitcoin was influenced by the same factors causing oil price shocks, such as politics, pandemics, or war, resulting in a sharp drop in Bitcoin's price to –0.0002 points. Compared to Bitcoin's volatility with other markets, Bitcoin fluctuates very little to WTI oil price over the range of ±0.003 points. In addition, based on the Bitcoin and oil price causality test in Table 3, although Bitcoin has impact on the crude oil price, the price of oil is not strongly correlated with changes in the price of Bitcoin. This result indicates that Bitcoin is relatively independent from a less stable market like crude oil.

As illustrated in Figure 1, Shock 4 shows Bitcoin price's response to the world gold price shock measured by XAU_USD variable. In the first 2 periods, Bitcoin reacted negatively to the fluctuations of the gold price. This reaction in the short run can be explained by investors' rush to find alternative investment tools like Bitcoin to diversify their investment portfolio and minimize losses when the gold price falls deeply. However, this negative movement did not last long as in the next periods, Bitcoin continuously dropped by more than 0.004 points to the level of –0.0025. Among all the commodity markets, Bitcoin exhibits the strongest reaction to the shock coming from the gold price. The spike in demand for Bitcoin makes its price more expensive. However, Bitcoin could not keep its growth momentum and started to decline sharply, from the 2nd to the 5th period, Bitcoin suddenly decreased from 0.001 to –0.0025 points. This reaction indicates that Bitcoin could not avoid a downtrend in the long run when facing a gold price shock.

The level of investor's interest quantified by the Google Trends variable in Figure 1, Shock 5 has shown the incredible reaction of Bitcoin. In the first period, when receiving the signal from the shock of the Google Trends variable, the Bitcoin price plummeted by more than 0.002 points. In the 7th – 8th periods, this cryptocurrency recovered slightly before decreasing sharply. Bitcoin price constantly fell to 0.005 compared to the initial point value in the 25th period, the steepest drop of all the reaction results. Based on Figure 1, there is still no positive signal that Bitcoin can rise in the last periods, which means that if the shock of investor interest is too big, the price of Bitcoin will continue to decrease, and it is difficult for Bitcoin to recover to its original price.

In contrast to Bitcoin's reaction to Google Trends as mentioned above, Figure 1, Shock 6, shows a negative correlation between Bitcoin price and its daily trading volume. During the first 4 periods, Bitcoin price increased as its trading volume decreased, however, Bitcoin price tended to move sideways around 0.004 points from the 5th to 23rd period. This result can be explained that Bitcoin was in a frozen state, investors were waiting for positive signals from the cryptocurrency market to make investment decisions. From period 24th – 25th, Bitcoin price started to increase sharply, approximately reaching 0.008 points. This result indicates a positive correlation between Bitcoin price and its trading volume in the short term. However, without an improvement in trading volume or a change in Bitcoin's supply and demand, this price uptrend would not continue or even reverse to a downtrend in the long term.

3.4. Value at Risk model results

To test the safety of Bitcoin, the Value-at-Risk model (VaR) is used to assess the risk in investments in Bitcoin, gold, oil and the Dow Jones index. In addition, volatility is also a statistical indicator of the return dispersion for financial markets over a given period of time. This study estimates 1% and 5% value at risk of Bitcoin and measures the commodity volatility (see Table 4).

Table 4. Volatility and VaR for the 1% and 5% during the period 2013–2021

Source: Authors' calculation using R version 4.1.2.

	Volatility	VaR 0,05	VaR 0,01
BTC	14.11%	–1.00%	–2.12%
WTI	15.39%	–1.16%	–2.06%
XAU_USD	2.76%	–0.32%	–0.33%
DJIA	2.19%	–0.23%	–0.24%

As shown in Table 4, the results of testing the volatility of Bitcoin compared to conventional commodity markets indicate that the dispersion of Bitcoin returns ranks the second highest only after the volatility level of WTI crude oil market. The two commodities with low volatility are the

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world gold and the US stock with the variances of 2.76% and 2.19%, respectively. Similar to volatility, the value at risk of Bitcoin is also much larger than the one of gold and US stocks, showing that Bitcoin is the 2nd risky asset after crude oil at the 5% level of significance.

4. DISCUSSION

Based on the Granger causality test and the impulse response function of the VAR model, the results show that there is a two-way correlation between Bitcoin and the gold market, especially if Bitcoin reacts in the same direction to incoming shocks from the price of gold. This shows a clear correlation between Bitcoin and world gold prices. This result is consistent with Moussa et al. (2021) indicating that Bitcoin is strongly influenced by the gold price. The reason for this can be explained given that Bitcoin and gold are similar in nature, so investors expect Bitcoin to play the role of a hedge as gold. During periods of economic instability and inflation, investors decide to seek safe havens in gold, causing gold prices to rise. However, because Bitcoin is a new and highly volatile market, investors are more hesitant to invest in Bitcoin than in gold, causing Bitcoin's price to rise in line with investor expectations but not as high as gold during these periods. Similarly, the strongly positive correlation between Bitcoin and gold price also agrees with the prior studies (Ermolaev, 2021; Jareño et al., 2020; Zhang, 2021).

As shown in Table 3, both the price and volume of Bitcoin transactions have an impact on the price of gold, which can be attributed to the fact that both variables share the same safe-haven role for periods of financial instability. Therefore, variations in the price and volume of Bitcoin can influence the world gold price. Gold is considered a low-volatility investment instrument and acts as a hedge against inflation. However, the fact that Bitcoin is increasingly popular and has an impact on the stability of gold indicates that Bitcoin shares the same features of being a safe haven with gold. The correlation between Bitcoin and the gold price has also been confirmed in the previous studies of Gajardo (2018), Bhuiyan (2021), and Bouri (2020).

On the other hand, Bitcoin has an impact on the price of DJIA stocks and WTI crude oil, implying that Bitcoin has affirmed its position in the world commodity market through its ability to impact other long-standing commodity markets. Thaker and Mand (2021) argued that every major Asian stock market index exhibits a long-term correlation with Bitcoin, of which four markets, including Japan, Korea, Singapore, and Hong Kong, show a negative association. Similarly, Wang et al. (2016) also indicate Bitcoin's price is negatively impacted by the stock price index in the long run. Similarly, the finding of the negative correlation between Bitcoin and the crude oil market is consistent with the previous studies' results (Wang et al., 2016; Gajardo et al., 2018; Jin et al., 2019).

As mentioned in Table 4, it is pointed out that the volatility of the US stock index – DJIA is the lowest of all four markets under investigation. This can be explained by the nature of the DJIA index, a value-oriented stock market index of 30 blue-chip companies in the US with less volatile stock prices. Nguyen (2021) indicates that stock market shocks affected the fluctuation of Bitcoin prices during COVID-19 and other turmoil periods. In addition, the negative correlation between Bitcoin and DJIA is also found in Gajardo et al. (2018).

The crude oil market is the most volatile, as shown in Table 4 because the crude oil price is not only affected by the law of supply and demand but also by other factors such as politics or the dollar index (Su et al., 2020). Our study indicates that Bitcoin and gold are less volatile than crude oil (WTI). Followed by Selmi et al. (2018), these two assets could play a better safe-haven role than oil during political and economic turmoil times.

The IRF function also shows that Bitcoin reacts negatively if investor interest (quantified via Google Trends) drops sharply. This result can be explained by the psychology of investors; when they have little interest in Bitcoin or even lose faith in the cryptocurrency market, the number of searches will decrease, resulting in a sharp decline in the price of Bitcoin (Kjærland et al., 2018). This cross-correlations between Bitcoin and online search tool like Google Trends agree with the studies by Zhang (2018) and Béjaoui (2021).

The results of the VaR model show that Bitcoin cannot be considered a safe haven alternative to gold because for the 5% VaR, Bitcoin's value-at-risk is higher than most other markets (only lower than the crude oil market), and even 5 times higher than the gold market. This result is consistent with the conclusion that Bitcoin can act as a safe haven during volatile oil shocks (Selmi et al., 2018). However, for the 1% VaR, Bitcoin is the highest risk asset among the four observed commodities. This result is similar to the studies by Stavroyiannis (2018) and Conlon et al. (2020) exhibiting that the most volatile cryptocurrency is Bitcoin compared to the stock and gold. Long et al. (2021) also confirm that Bitcoin is riskier than the stock and gold.

According to Chemkha et al. (2021), Bitcoin is neither a safe-haven asset nor "digital gold". In the development history of Bitcoin, investors in the cryptocurrency market had little confidence that it would become a safe-haven asset. This implies that investors are ready to withdraw their capital from Bitcoin investment as soon as there are negative market signals, causing Bitcoin price to fluctuate unstably. Therefore, Bitcoin should be regarded as a tool for portfolio diversification rather than a safe-haven asset.

As for the gold market, our study's result reveals that gold remains a highly stable asset which is able to function as a safe-haven investment instrument. In fact, it is argued that gold has intrinsic value that is resistant to inflation. Shahzad et al. (2020) and Das et al. (2020) indicate that both gold and Bitcoin hold hedging characteristics, however, gold is a better safe-haven asset than Bitcoin. However, in the COVID-19 pandemic crisis from March to April 2020, gold lost its safe-haven status because of US government stimulus package (Akhtaruzzaman et al., 2021). Similarly, Bouri et al. (2020) also highlight that gold is not a superior hedge compared with Bitcoin and other commodities.

CONCLUSION

The study attempts to assess the safety of Bitcoin and the association between Bitcoin and conventional commodity markets, including gold, crude oil, stocks, and investors' interest (quantified via Google Trends). The research results show that it is impossible for Bitcoin to become a safe-haven instrument because Bitcoin is the second most volatile and risky asset, only after the crude oil market and much riskier than gold. In addition, the results of the Granger causality test and the impulse response function (IRF) of the Vector Autoregression (VAR) model show that Bitcoin and the gold market have a two-way relationship, in which Bitcoin positively reacts to shocks from gold prices. On the other hand, Bitcoin also has an impact on the prices of the Dow Jones Industrial Average (DJIA) stock and the world crude oil (WTI), implying that Bitcoin has been increasing its position as the leading currency in the cryptocurrency market to have an impact on the conventional commodity markets. The IRF function also shows that Bitcoin price may tend to plummet if Google search volume is used as a proxy for investors' interest declines.

These findings have several implications for investors and policymakers to lower the risks associated with this cryptocurrency. Although Bitcoin cannot play the role as a safe-haven asset, this cryptocurrency can be used as a portfolio diversifier. First, Bitcoin is positively correlated with the gold price shock; thus, when the gold price plunges in the long run, investors should reduce their Bitcoin portfolio to avoid high returns dispersion risk. Second, Bitcoin is negatively correlated with the stock market shock. Therefore, this cryptocurrency can be a potential option for investors when stock prices dramatically drop. Finally, based on the relationship between Bitcoin and the other conventional commodity markets, governments and policymakers can enact comprehensive policies to maintain the financial market's stability.

The paper contributes to further empirical evidence that Bitcoin is not a safe haven, however, it still has limitations. Both the Vector Autoregression (VAR) and the Value at Risk (VaR) models are static and incapable of capturing the dynamic correlation between Bitcoin and other conventional commodity

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markets. Moreover, Bitcoin, gold, crude oil, and stock prices can follow their own cycles and are influenced by many external factors such as socio-economics, politics, culture, and pandemics. Thus, future research is necessary to examine the dynamic relationship between Bitcoin and other conventional commodities as well as their long-term correlation over various time periods.

AUTHOR CONTRIBUTIONS

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