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THE CONNECTEDNESS BETWEEN BITCOIN, STOCK MARKET, GOLD, OIL, BOND AND EXCHANGE RATE: EVIDENCE FROM QUANTILE VAR APPROACH AND PORTFOLIO STRATEGIES

Şenol, Z., Tekin, B.F.

Zekai Şenol / Sivas Cumhuriyet University, Faculty of Economics and Administrative Sciences, Department of Finance and Banking, Türkiye. Email: zsenol@cumhuriyet.edu.tr (corresponding author)

Bahri Fatih Tekin / Sivas Cumhuriyet University, Cumhuriyet Social Sciences Vocational School, Department of Finance, Banking and Insurance, Türkiye. Email: ftekin@cumhuriyet.edu.tr

Abstract

This study examines the dynamic connectedness between Bitcoin and various financial assets, including the stock market, gold, oil, bonds, and exchange rates, as well as explores portfolio strategies involving these assets. The study covers the period from January 2, 2015, to March 1, 2024. The quantile connectedness approach and portfolio strategies are utilized in the analysis. The findings are as follows: Intermarket volatility spillover significantly increases under extreme conditions. Bitcoin emerges as a transmitter during bullish markets and acts as a receiver in bearish and normal market conditions. Gold serves as a receiver in extreme conditions and a transmitter in normal conditions. Unlike gold, oil acts as a transmitter under extreme conditions and functions as a receiver under normal conditions. Among the fundamental markets, the stock market is the most significant shock transmitter. In risk-mitigating portfolios, the proportion of Bitcoin is low, while the proportions of gold and the dollar index are high. Bitcoin has been found to have low hedging properties.

Implications for Central European Audience: Since the emergence of Bitcoin in 2008, the cryptocurrency market has developed rapidly. Bitcoin and cryptocurrencies have come to occupy an important place in financial markets in terms of value and volume. Bitcoin can affect portfolio management in the financial system in terms of diversification, hedging, risk management, portfolio strategies, and linkages between financial assets. This study investigates the linkages, hedging and portfolio strategies between Bitcoin and the stock market, gold, oil, bond and exchange rate markets. The results of the study are important for portfolio managers, risk managers, financial analysts and economic managers.

Keywords: Bitcoin; Gold; Stock; Quantile Connectedness; Portfolio Strategies; Hedging

JEL Classification: G11, G15, C22

Introduction

Bitcoin, a digital payment instrument/system based on blockchain technology, was first proposed by Nakamoto in 2008 and launched for transactions in 2009. The purpose of Bitcoin was to enable transfers between parties in a decentralized system where intermediaries do not operate (Dodd, 2018). Since its emergence, Bitcoin has been acknowledged as both an investment asset and a medium of payment (Zhang et al., 2023). Bitcoin can be regarded as a currency, commodity, or investment instrument.

Bitcoin can be classified as money because it functions as a medium of exchange, allowing for the purchase and sale of goods and services globally. Bitcoin can be considered an investment asset because it appears in investment portfolios. Bitcoin is created by mining, and the quantity is restricted. As a result, it can be considered a digital commodity (Kwon, 2020).

Kristoufek (2013) stated that Bitcoin price cannot be explained by standard economic and financial theories such as purchasing power parity, future cash-flows model, and uncovered interest rate parity. In terms of portfolio theory, Bitcoin is seen as an investment shelter due to its diversification and risk mitigation benefits in the face of negative price movements in traditional financial assets (Huang et al., 2021). Due to the fact that Bitcoin is a crypto asset, it does not represent any country or financial institution, and has no physical representation, the smallest connection between Bitcoin and the currency market (Yang et al., 2022). The fact that cryptocurrencies are not under the control of central banks reduces the privacy concerns of those who pay and invest in crypto (Chu et al., 2021).

Bitcoin is comparable to gold in terms of portfolio hedging and safe-haven features (Shahzad et al., 2020; Khalfaoui et al., 2022; Zhang et al., 2023; Duan et al., 2023), as well as decentralization and scarcity (Zeng et al., 2020). On the other hand, Kwon (2020) does not consider Bitcoin as a commodity due to its different characteristics from gold. Bitcoin is likened to gold due to some of its characteristics (Bouri et al., 2020): The first is that gold and Bitcoin are characterized as commodities and are subject to legal regulations within this framework. A second feature is that Bitcoin is similar to gold as a non-political, individual commodity. At this point, Bitcoin mining, buying, selling, and brokerage transactions make Bitcoin dependent on inflation. Thirdly, similar to gold, Bitcoin is generated through mining, has a limited supply, and its production is safeguarded by the Bitcoin protocol.

As Bitcoin has started to gain an important place in the markets, there is evidence that Bitcoin is a safe- haven (Bouri et al., 2020; Jareno et al., 2020 and Shahzad et al., 2021), partial safe-haven (Ghorbel & Jeribi, 2021) and weak safe-haven (Shahzad et al., 2019) due to its resemblance to gold in some of its characteristics, while Wu et al. (2019) found that Bitcoin does not provide a safe-haven function. Pal and Mitra (2019) argue that Bitcoin provides hedging, while Naeem et al. (2021) argue that Bitcoin can be used to manage portfolio risk in contrast to conventional stock markets. Although Bitcoin is positively correlated with financial markets (Maghyereh & Abdoh, 2020) and there is a volatility spillover from Bitcoin to oil and gold (Le et al., 2021), Bitcoin is not integrated with the global financial system and is relatively isolated from financial assets (Bhuiyan et al., 2021).

Throughout history, gold has been seen as a precious stone, a portfolio stabilizer and a source of liquidity in times of financial turmoil (Chemkha et al., 2021). Due to its high economic value, gold is used for investment purposes and serves as a reserve asset for central banks (Yaya et al., 2022). Since gold has the dual attributes of a currency and a commodity, it is highly correlated with other financial assets (Yang et al., 2022). When the value of other assets collapses, gold is seen as a reliable asset as it can be easily sold in case of need without a decrease in its value (Chemkha et al., 2021).

Among the commodities, crude oil and gold are two strategic commodities in terms of monetary policies and economic development (Mensi et al., 2021). Gold prices do not tend to increase during crisis periods and tail events, unlike risky assets such as stocks, making them an effective hedge and safe-haven instrument for numerous assets (Kang et al., 2023; Bani-Khalaf & Taspinar, 2022). In conditions of heightened financial risks and uncertainties, investors allocate their investments to gold as a strategy for managing portfolio risk.

Crude oil and stock markets are related for several reasons. Crude oil is a fundamental production input for businesses (Han et al., 2019; Mensi et al., 2023b; Wang et al., 2023). Fluctuations in oil prices can affect firms' investment and financing decisions (Wang et al., 2023), as well as their cost of capital and expected cash flows. Increases in oil prices raise production costs, leading to decreased cash flows and equity prices (Fisher, 1930). The volatility of oil and stock markets is important for the development and stability of economies (Mensi et al., 2023b). High oil prices can lead to an increase in inflation expectations and nominal interest rates (Han et al., 2019). Decreases in interest rates reduce the cost of carrying inventories, leading to an increase in commodity prices (Frankel, 2006). Inflation and interest rate hikes increase discount rates used in business valuations, resulting in a decrease in the expected values of stocks.

A hedge is an asset that is, on average, uncorrelated or negatively correlated with another asset or portfolio. An asset is a safe-haven if it is uncorrelated or negatively correlated with another asset or portfolio during periods of stress or turmoil in financial markets. Gold can be seen as a safe-haven if it is not correlated with other assets when the stock and bond markets show very high negative returns (Baur & Lucey, 2010). Commodities, crude oil, gold, Bitcoin, and the U.S. dollar index are conventional hedging assets against shocks in stock markets and are widely used for hedging purposes (Wang et al., 2021; Zhang et al., 2022).

Volatility spillovers are price movements between world financial markets due to economic and political events, investor behavior etc. (Jiang et al., 2022). Volatility spillovers are risk spillovers and increase volatility in financial markets. Increased volatility may lead to a decrease in price stability in the markets.

This study has the following objectives. The first one is to determine the levels of pricing, risk spillovers and interconnectedness among fundamental markets at the global level. Accordingly, fundamental markets are considered as cryptocurrencies, bonds, foreign exchange, commodities and stock markets. Mensi et al. (2022) defined S&P 500, US Treasury bonds, US dollar index, Bitcoin, Brent oil, and ounce gold as fundamental asset classes. Similar classifications were made by Naeem et al. (2021), Zhang et al. (2021), Jiang et al. (2022) and Li et al. (2023). In this study, Bitcoin, US 2-year bond yield, Brent oil, ounce of gold, dollar index, and MSCI (Morgan Stanley Capital International) world index were used.

The second is to explore the role of Bitcoin in fundamental markets. Baur et al. (2018), Zeng et al. (2020), Uzonwanne (2021), Bhuiyan et al. (2021), Wang et al. (2021) investigated the volatility relationship of Bitcoin with traditional assets. Explaining this role is important for investors, portfolio managers, financial institutions, supervisory and oversight authorities. The third is to investigate the hedging qualities of Bitcoin with conventional assets and draw conclusions for managing portfolio risk. In the literature, Ciaian et al. (2016), Das (2020), Jiang et al. (2022), Hsu et al. (2021), Chu et al. (2021) focus on the hedge characteristics of Bitcoin. In the study, Minimum Variance Portfolio (MVP), Minimum Correlation Portfolio (MCP), Minimum Connectedness Portfolio (MCoP), and Risk-Parity Portfolio (RPP) were obtained. In addition, portfolio weights and hedge ratios are calculated as in Yaya et al. (2022), Shahzad et al. (2020), Ustaoglu (2022), Wang et al. (2021), Jabeur et al. (2024). Fourth, we explore the connectedness under different market conditions. For this purpose, the quantile VAR approach is used. Similar to Ahmed (2021), Khalfaoui et al. (2022) and Duan et al. (2023) in the literature, we use the quantile connectedness approach to examine the connectedness in bearish, normal, and bullish market conditions. Fifth, we identify the time-varying role of Bitcoin within the underlying markets. The last one is to examine the volatility spillovers across fundamental markets during the COVID-19 pandemic, the Russia-Ukraine war and the Israeli-Hamas conflict. This study is expected to contribute to the literature on the above-mentioned topics.

1 Literature

In parallel with the use of Bitcoin as a cryptocurrency, commodity, and investment instrument, issues such as the characteristics of the Bitcoin price, its volatility, its relationship with traditional assets such as gold, stock market, oil, exchange rate, and whether it can be used as a safe-haven, hedge, and diversification tool in managing portfolio risk have been included in the literature.

As in this study, some studies have investigated the role of Bitcoin at the fundamental market level. In these studies, it was observed that Bitcoin has a volatility relationship with fundamental markets, has high volatility and generally receives net volatility from these markets. Baur et al. (2018) found that Bitcoin has the highest volatility among financial assets (bond, currency, FTSE 100 and gold), that Bitcoin is the most persistent when compared to other assets, and Bitcoin has an asymmetric volatility relationship with other assets. According to Urom et al. (2020), Bitcoin is a risky asset and Bitcoin is a net receiver for developed country stock markets, gold, and oil under all market conditions. Contrary to the general results in the literature, Jiang et al. (2022) found that Bitcoin, gold, and the dollar index are net volatility transmitters in the basic financial system, while crude oil and stock markets are volatility receivers.

Zhang et al. (2021) investigated whether Bitcoin is independent of the global financial system and found bidirectional downside risk spillovers between Bitcoin and major asset classes (stocks, bonds, currencies and commodities). Senol and Koc (2022) discovered that Bitcoin is a net volatility receiver for stock market (MSCI), bonds, gold, US Dollar, and crude oil. Duan et al. (2023) found that Bitcoin is negatively or weakly positively correlated with traditional assets in different quantiles. Wang et al. (2021) concluded that the connectedness that Bitcoin transmits and receives from other assets is relatively low. This indicates that Bitcoin is isolated from other assets.

As cryptocurrencies gain prevalence in financial markets, studies investigating the spillovers of cryptocurrencies across financial markets have increased (Uzonwanne, 2021; Khalfaoui et al., 2023; Lu et al., 2022; Elsayed et al., 2022; Bhanja et al., 2023; Karimi et al., 2023; Hanif et al., 2022; Joo & Park, 2023; Mensi et al., 2023; and Naeem et al., 2023). Uzonwanne (2021) identified negative spillover from S&P 500, Nikkei 225, FTSE 100, and DAX indexes to Bitcoin, and positive spillover from Bitcoin to S&P 500. Khalfaoui et al. (2023) determined that BRICS stock markets received spillovers from crypto markets in both bearish and bullish market conditions. Naeem et al. (2023) investigated that American and crypto markets were net volatility transmitters, whereas Asian markets were high volatility receivers among commodity, stock markets, and crypto markets. Bhanja et al. (2023) noted low total connectedness among equity, precious metals, and cryptocurrencies, with Bitcoin being identified as a low-level spillover receiver and transmitter.

In the studies of Maghyereh and Abdoh (2021), Ahmed (2021) and Naeem et al. (2021), the relationship between Bitcoin and stock markets stands out. According to the results of Maghyereh and Abdoh (2021), high return dependence and risk-tail dependence between Bitcoin and stock markets in the long run are the strongest between Bitcoin and the US stock market. Ahmed (2021) explained that developed markets respond positively to Bitcoin volatility under normal market conditions while emerging markets respond positively under bear market conditions. Naeem et al. (2021) stated in their study that Bitcoin receives volatility spillovers from other financial assets during COVID-19.

Zhao and Zhang (2023) identified both positive and negative relationships between Bitcoin return and stock market return before COVID-19, while positive return dependence and risk spillover increased in the post-COVID-19 period. Li et al. (2023) observed an asymmetric volatility spillover between Bitcoin and Chinese financial markets and that Bitcoin is a net receiver. Jabeur et al. (2024) reported a strong dependency between Bitcoin and quantum computing stock, especially after 2020. Khalfaoui et al. (2022) found that volatility spillover is high in extreme market conditions, Bitcoin is a net receiver in bearish and normal market conditions, net transmitter in bullish market conditions, and Bitcoin's net transmitter feature increased during the COVID-19 period.

A significant number of studies on Bitcoin include gold. Some studies have directly examined the relationship between Bitcoin and gold. Bhuiyan et al. (2021) found a lead-lag relationship between Bitcoin and gold at different levels but not with other financial assets (U.S. Dollar Index, WTI, S&P Global 100 and Dow Jones Commodity Index). Yaya et al. (2022) found a bidirectional volatility spillover between Bitcoin and gold, Bitcoin shows the highest volatility persistence and more gold should be held in Bitcoin portfolios for risk minimization and diversification. Senol (2023) detected a time-varying unidirectional volatility spillover from Bitcoin to gold. Hoque et al. (2023) found that Bitcoin and gold are net receivers in the short and average periods and net transmitters in the long run for financial stress indexes. Elsayed et al. (2022) determined that cryptocurrencies were net transmitters from cryptocurrencies to gold under bearish, bullish, and normal market conditions. Karimi et al. (2023) found a low level of spillover between crypto assets and gold and oil. Wang et al. (2024) revealed an asymmetric dynamic spillover effect from cryptocurrency markets to energy markets where the Brent oil and natural gas markets were consistently volatility receivers. Joo and Park (2023) identified that Bitcoin spilled volatility over other commodities in rising market conditions while it absorbed volatility in falling markets. Mensi et al. (2023) demonstrated that gold received volatility from cryptocurrencies in lower and mean quantiles while it spilled volatility over the upper quantile.

Li et al. (2022) and Meiryani et al. (2022) investigated the relationship between Bitcoin and oil. Li et al. (2022) found a bidirectional relationship between crude oil and Bitcoin under extreme shocks, and the causal link is stronger under extreme conditions than under normal conditions. Meiryani et al. (2022) determined that crude oil price positively affects Bitcoin prices. Lu et al. (2022) concluded that cryptocurrencies were net transmitters, with clean energy and oil being net receivers. Zhang et al. (2022), Moussa et al. (2021), and Zhang et al. (2023) include oil and gold in their studies. In Zhang et al. (2022), it was found that Bitcoin has a high connectedness with gold and a low volatility relationship with oil, gold emits net volatility to Bitcoin, and the short-term relationship between Bitcoin and gold is higher than the long-term relationship. Moussa et al. (2021) found that gold and oil prices significantly affect Bitcoin prices, and oil and gold have a negative effect on Bitcoin. Zhang et al. (2023) uncovered a bidirectional causal relationship between Bitcoin-gold and Bitcoin-oil, and unidirectional causality from gold to Bitcoin. Positive shock responses from Bitcoins to gold and oil and negative shock responses to dollars were determined.

Uyar and Kahraman (2019) and Yang et al. (2022) focus on Bitcoin and currency variables. Uyar and Kahraman (2019) found that Bitcoin has seven times more risk than major exchange rates. Yang et al. (2022) showed that Bitcoin is less correlated with six major developed currencies (AUD, EUR, GBP, CAD, CHF, and JPY) than traditional assets, is a net receiver in the short term, and a net transmitter in the longer term, and that Bitcoin is the best diversification and hedging instrument in the longer term to reduce portfolio volatility.

In some other studies (Bouri et al., 2018; Jareno et al., 2020; Basher & Sadorsky, 2022), Bitcoin and the bond market are at the forefront. Bouri et al. (2018) revealed that in the long run, MSCI, USD, and commodities affect the Bitcoin price symmetrically while bond affects it asymmetrically, while in the short run, these assets affect the Bitcoin price symmetrically. Jareno et al. (2020) highlighted that bond interest rates negatively affect Bitcoin returns. Basher and Sadorsky (2022) demonstrated that the ten-year bond yield and Oil Volatility Index (OVX) are the most important macroeconomic variables for Bitcoin. Bouteska et al. (2024) indicated that a decrease in the price of Bitcoin leads to an increase in the price of bonds and that Bitcoin acts as a strong safe-haven for bonds.

Some studies on Bitcoin (Kang et al., 2019; Shaikh, 2020) include crisis and uncertainty indicators. Kang et al. (2019) found that the contagion effect between gold and Bitcoin increased during the European debt crisis. Shaikh (2020) highlighted that Bitcoin returns are very sensitive to economic policy uncertainty in the US, Japan, and China. Uncertainty in the US and Japan has a negative impact on Bitcoin, and uncertainty in the Federal Open Market Committee (FOMC) has a negative impact on Bitcoin.

The fact that Bitcoin and other crypto assets are produced due to energy consumption raises the issue of clean energy. Khalfaoui et al. (2022) found that for the clean energy commodity market, Bitcoin is a high net volatility receiver in a bear market and normal market conditions, while it is a low net volatility transmitter in a bull market.

During the COVID-19 pandemic, it was observed that oil acted as a net transmitter (Ha & Nham, 2022; Zhang et al., 2022), while gold and Bitcoin acted as net receivers (Zhang et al., 2022). Wang et al. (2023) noted an increase in interaction between commodity and stock markets during the 2008 global crisis and the COVID-19 shocks. Coskun et al. (2023) found that geopolitical oil price risk, clean energy stocks, and global stocks were net volatility transmitters, whereas gold was a net volatility receiver. Additionally, they determined that the volatility linkages were associated with events such as the Arab Spring, oil supply decisions, and the COVID-19 pandemic. According to Zhang et al. (2022), COVID-19-related news indexes acted as transmitters, while gold, crude oil, and Bitcoin were net receivers. Khalfaoui et al. (2023) stated that in extreme market conditions, the spillover effect was lowest for the 1-year US Treasury bonds.

Many studies in the literature have investigated the use of Bitcoin as a hedging instrument and its diversification effects in managing portfolio risk. Symitsi and Chalvatzis (2019), Chu et al. (2021), Jiang et al. (2022), Nekhili and Sultan (2022), Ciaian et al. (2016), Das (2020), Hsu et al. (2021) and Pal and Mitra (2019) have generally determined that Bitcoin can be used as a hedging instrument and Bitcoin can be used as a diversification tool in portfolios. Symitsi and Chalvatzis (2019) found that in portfolios consisting of gold, stock markets, and oil, Bitcoin reduces portfolio risk due to its portfolio diversification benefit, but increases portfolio risk due to its high volatility. Jiang et al. (2022) noted that Bitcoin exhibits hedging properties in a portfolio consisting of Bitcoin, gold, dollar index, oil, and stock markets. Hsu et al. (2021) found that Bitcoin is a diversification tool against exchange rates and gold, and a hedging tool against exchange rates. Pal and Mitra (2019) determinedthat gold and Bitcoin provide hedging, but gold provides more protection than Bitcoin. Similarly, Chemkha et al. (2021) Found that the hedging efficiency of gold is better than that of Bitcoin.

Bouri et al. (2020) explained that Bitcoin and gold exhibit diversification properties. Chu et al. (2021) found that Bitcoin provides diversification against global stock markets and that Bitcoin provides hedges against the US Dollar, Euro, and Korean Won when these markets are bullish (bearish). Similarly, Das (2020) encountered that Bitcoin exhibits a weak hedge feature and that these conditions are also valid in bullish market states. Shahzad et al. (2021) found that Bitcoin and gold provide weak hedging against BRICS stock markets. Naeem et al. (2021) saw that Bitcoin can used to hedge conventional stocks, Islamic stocks, and oil. Hanif et al. (2022) indicated that Bitcoin and Litecoin served as hedge instruments for the world equity index, while Dash acted as a safe-haven, and Bhanja et al. (2023) determined that cryptocurrencies assumed a hedging role for the S&P500. Yousaf and Yarovaya (2022) uncovered that Islamic Sharia-based cryptocurrencies served as hedge instruments for Islamic equity sectors during the COVID-19 period.

Ciaian et al. (2016) concluded that Bitcoin price does not depend much on economic and financial indicators. The fact that Bitcoin price is not affected by economic and financial indicators shows that Bitcoin can be used as a diversification and hedging tool in terms of portfolio management. Nekhili and Sultan (2022) constructed a dynamic hedging model and found that Bitcoin portfolio risk can be mitigated through selected stock markets (DAX, DOW, Nikkei, S&P500), currencies (US Dollar, Euro), bonds and commodities (Brent, and WTI). Therefore, this result suggests that the price movements of Bitcoin are inconsistent with the price movements of a conventional financial asset and that conventional financial assets provide effective risk management.

A significant number of studies on Bitcoin have investigated the safe-haven properties of Bitcoin, that is, the ability of Bitcoin to protect portfolios during periods of financial crisis and collapse. Hsu et al. (2021) determined that Bitcoin has safe-haven characteristics against exchange rates and gold during the COVID-19 period. Bouri et al. (2020) discovered that Bitcoin and gold exhibit safe-haven characteristics, while there is no strong relationship between Bitcoin, gold, the S&P Goldman Sachs Commodity index, and stock markets. Ren et al. (2022) identified that Bitcoin was a safe-haven in oil-related portfolios during the COVID-19 period, while gold provided weak diversification, and that the price relationship between Bitcoin and oil gradually decreased during the COVID-19 pandemic, so the safe-haven role of Bitcoin against oil increased with the intensification in pandemic conditions. Shahzad et al. (2021) showed that Bitcoin can be used as a safe-haven against extreme price declines in BRICS countries and that Bitcoin and gold provide weak hedging. Shahzad et al. (2019) observed that Bitcoin, gold, and commodities exhibit weak safe-haven characteristics against stock market indices. Similarly, Das (2020) revealed that Bitcoin has a weak safe-haven feature. Ghorbel and Jeribi (2021), on the other hand, assessed that Bitcoin has a lower risk level than oil and a higher risk level than gold, so it may have a partial safe-haven feature after gold. Huang et al. (2021) found that Bitcoin is a portfolio diversifier against the Australia and the US bond markets, and a weak safe-haven against Canada, Europe, and the UK bond market.

Wen et al. (2022) found that gold and Bitcoin were hedging tools before the pandemic, while gold was a safe-haven for both oil and stock markets during the COVID-19 pandemic, while Bitcoin was not considered a safe-haven. Chemkha et al. (2021) stated that during the COVID-19 pandemic, gold maintained its safe-haven feature, albeit at a low level, while Bitcoin did not show safe-haven feature. Nedved and Kristoufek (2023) found that gold is a strong safe-haven, oil is a weak safe-haven and stock market is not a safe-haven for Bitcoin. Hoque et al. (2023) stated that Bitcoin and gold could serve as hedge and diversifier assets during periods of financial stress. López-Cabarcos et al. (2021) professed that Bitcoin can be used as a safe-haven during periods of high volatility in stock markets, while Bitcoin turns into a speculative investment instrument when stock markets are stable. As can be seen, the studies have come to different conclusions as safe-haven, weak safe-haven, and no safe-haven.

Zeng et al. (2020) found weak connectedness between Bitcoin and conventional assets, negative return connectedness increased after 2018, Bitcoin is a transmitter in bullish markets, and Bitcoin has diversification benefits with conventional assets. According to the results of Shahzad et al. (2020), Bitcoin is a strong hedge for the Canada and Japan stock markets and a weak hedge for France and Italy. Wang et al. (2021) found that Bitcoin has low connections with financial assets and in the short run, Bitcoin is an isolated hedging asset. Echaust et al. (2024) reported that Bitcoin provides low hedging efficiency for stock markets. Ustaoglu (2022) stated that Bitcoin can be a low-cost hedge for emerging stock markets and that the relationship between stock markets and cryptocurrencies increased during the pandemic period. The aim of this study is to examine the dynamic connectedness between Bitcoin and various financial assets, including the stock market, gold, oil, bonds, and exchange rates, as well as explores portfolio strategies involving these assets.

2 Data and Methodology

In the study, markets with different characteristics in terms of portfolio management, including cryptocurrency, stock market, bond, currency, and commodity markets were used. In this respect, Bitcoin, gold, Brent oil, U.S. 2-year bond yield, Dollar Index, and MSCI world stock market index were used. The data subject to analysis are at a daily frequency and are sourced from Refinitiv Eikon. The data of the variables cover the period from January 2, 2015, to March 1, 2024. The study period includes significant global events such as the U.S.-China trade conflict, the COVID-19 pandemic, the Russia-Ukraine war, and the military conflict between Israel and Palestine. The abbreviations for the variables used in this study are provided in Table 1.

Table 1 | Abbreviations for variables

Variable	Abb.	Variable	Abb.
Bitcoin	BTC	**USA 2 Year Bond Yield**	USA2Y
Gold (Ounce)	GOLD	**US Dollar Index**	DXY
Brent Oil	BRENT	**MSCI World Index**	MSCIW

Sources: www.investing.com, www.msci.com, www.eia.gov.tr, www.gold.org

2.1 Connectedness Approach and Quantile VAR

Diebold and Yilmaz (2012, 2014) allowed more precise identification of spillovers between financial variables and variable-market interactions. The connectedness approach is frequently used in the literature. This VAR (Vector Autoregressive) based approach can reveal the total connectedness of the variables under analysis as well as the structure of the network they form with each other. In addition, both the bilateral interconnectedness between variables and the net effects of these variables can be determined by the connectedness approach.

The study aims to investigate how the connectedness approach and connectedness affect the relationships between variables at different quantiles. For this reason, in order to use the connectedness approach at various quantile levels, Ando et al. (2018) quantile connectedness approach, which is designed by the VAR-based approach and allows for calculations to be made at each quantile level. To perform the calculations related to the quantile connectedness approach, a Quantile-VAR (Q-VAR) model was first created. Q-VAR model;

$$y_t = \mu(\tau) + \Sigma_{j=1}^{p} \Gamma_j(\tau) y_{t-j} + u_t(\tau) \tag{1}$$

In this model y_t and y_{t-j}, $m\, x\, 1$ dimensional endogenous variable vectors. τ, quantile levels between [0,1], p is the lag length of the Q-VAR model. *M(τ)*, at a given quantile level

$m\,x\,1$ dimensional conditional mean vector, $\Gamma_j(\tau)$ is a $m\,x\,m$ dimensional coefficient matrix at a certain quantile level and $u_t(\tau)$ is a $m\,x\,1$ dimensional vector of error terms. The Q-VAR(p) model is then transformed into a moving average model using Wold's theorem, i.e. QVMA (∞) model. Thus;

$$y_t = \mu(\tau) + \Sigma_{j=1}^{p}\Gamma_j(\tau)y_{t-j} + u_t(\tau) = \mu(\tau) + \Sigma_{i=0}^{\infty}\Psi_i(\tau) + u_{t-i}(\tau) \quad (2)$$

expression is obtained. Q-VAR(p), QVMA(∞) notation and then converted to Koop et al. (1996) and Pesaran and Shin (1998) The H-step ahead Generalized Forecast Error Variance Decomposition (GFEVD) is calculated as follows.

$$\psi_{ij}^{g}(H) = \frac{\Sigma(\tau)_{ii}^{-1}\Sigma_{h=0}^{H-1}\left(e_i'\Psi_h(\tau)\Sigma(\tau)e_j\right)^2}{\Sigma_{h=0}^{H-1}\left(e_i'\Psi_h(\tau)\Sigma(\tau)\Psi_h(\tau)'e_i\right)} \quad (3)$$

$$\tilde{\psi}_{ij}^{g}(H) = \frac{\psi_{ij}^{g}(H)}{\Sigma_{j=1}^{m}\psi_{ij}^{g}(H)} \quad (4)$$

In Equation 3 $\psi_{ij}^{g}(H)$ expression indicates what the effect of the variable in row j on the variance of the variable in row i will be at *H* step ahead distance. *Σ(τ)* at a given quantile level $m\,x\,m$ dimensional variance-covariance matrix, e_i represents a vector with rank i as 1 and 0 in other ranks. Thanks to this normalization process $\Sigma_{j=1}^{m}\tilde{\psi}_{ij}^{g}(H) = 1$ or $\Sigma_{j=1}^{m}\tilde{\psi}_{ij}^{g}(H) = m$ in the variance decomposition matrix. The values in the calculated variance decomposition matrix are normalized as in Equation 4.

The formula in Equation 5 is used to calculate the total impact of variable i on all other j variables. This calculation also expresses the total impact of any variable on the market under analysis. Thus, the direct total connectedness from variable i to others can be calculated as follows.

$$TO\ others = C_{i\rightarrow j}^{g}(H) = \Sigma_{j=1,i\neq j}^{m}\tilde{\psi}_{ji}^{g}(H) \quad (5)$$

Similarly, the total effect of all other j variables on variable i, in other words, the total direct effect of variable i from others is calculated as follows.

$$FROM\ others = C_{i\leftarrow j}^{g}(H) = \Sigma_{j=1,i\neq j}^{m}\tilde{\psi}_{ij}^{g}(H) \quad (6)$$

The difference between these spillovers to others and spillovers from others is net total connectedness. Net total connectedness is the net effect of variable i on the market under analysis. Net total connectedness is calculated as in Equation 7.

$$NET\ total\ connectedness = C_i^{g}(H) = C_{i\rightarrow j}^{g}(H) - C_{i\leftarrow j}^{g}(H) \quad (7)$$

The calculation of the total connectedness index as in Chatziantoniou and Gabauer (2021) and Gabauer (2021) is adapted as in Equation 8. With this adaptation, the Total Connectedness Index (TCI) takes values between [0,1].

$$TOTAL\ connectedness\ index = TCI(H) = \frac{\Sigma_{i,j=1,i\neq j}^{m}\tilde{\Psi}_{ij}^{g}(H)}{m-1} \quad (8)$$

2.2 Portfolio Diversification

In the study, various portfolios are constructed and the performance differences between these portfolios are revealed. The portfolios are evaluated based on their hedge effectiveness under the frameworks of the Minimum Variance Portfolio (MVP), Minimum Correlation Portfolio (MCP), Minimum Connectedness Portfolio (MCoP), and finally Risk Parity Portfolio (RPP). This section presents the calculations of the constructed portfolios.

2.1.1 Minimum Variance Portfolio (MVP)

The minimum variance portfolio is concerned with the optimization of the portfolio variance at the point of determining the weights of the instruments used in portfolio construction (Markowitz, 1959). The calculation of the weights that can minimize the portfolio variance can be realized with the help of the following formula.

$$w_{\Sigma_t} = \frac{\Sigma_t^{-1} U}{U \Sigma_t^{-1} U} \tag{9}$$

In the above equation w_{Σ_t} and U, represents $m\,x\,1$ dimensional portfolio weight vector and the m- dimensional unit vector, respectively. Σ_t is the $m\,x\,m$ dimensional conditional variance-covariance matrix at time *t*.

2.1.2 Minimum Correlation Portfolio (MCP)

Another approach used in portfolio diversification is to ensure minimum correlation in the portfolio to be formed. With this method developed by Christoffersen et al. (2014), correlation can be minimized while calculating portfolio weights. Weights for the minimum correlation portfolio can be calculated as in the equation below.

$$\mathrm{R}_t = diag(\Sigma_t)^{-0.5} \Sigma_t diag(\Sigma_t)^{-0.5} \tag{10}$$

$$w_{\mathrm{R_t}} = \frac{\mathrm{R}_t^{-1} U}{U \mathrm{R}_t^{-1} U} \tag{11}$$

The correlation matrix is obtained with the first equation above. The second equation calculates the portfolio weights. In Equation 11 R_t, represents $m\,x\,m$ the dimensional correlation matrix.

2.1.3 Minimum Connectedness Portfolio (MCoP)

One of the new portfolio construction strategies introduced to the literature by Broadstock et al. (2022) is the minimum connectedness portfolio. The main logic in this portfolio is to reduce connectedness. In order to reduce connectedness, the pairwise connectedness index (PCI) is minimized. The weights in the minimum connectedness portfolio can be found as follows.

$$w_{C_t} = \frac{PCI_t^{-1} U}{UPCI_t^{-1} U} \tag{12}$$

In Equation 12 PCI_t denotes the pairwise connectedness index matrix at time *t*.

2.1.4 Risk Parity Portfolio (RPP)

Finally, another portfolio diversification approach in the literature is the risk parity portfolio. This approach is related to the calculation of weights such that the risks of the instruments to be included in the portfolio have an equal impact on the total portfolio risk (Maillard et al., 2010). Weights can be determined based on the following constraint. H_t represents the variance-covariance matrix that allows the portfolio risk to be measured at time *t*.

$$\min \sum_{i,j=1}^{m} \left(w_{it}(H_t w_t)_i - w_{jt}(H_t w_t)_j \right)^2 \tag{13}$$

2.3 Measuring Portfolio Performance

In the finance literature, various methods can be used to measure portfolio performance. In this study, the hedge effectiveness method proposed by Ederington (1979) is used to evaluate portfolio performance. Hedge effectiveness calculations are based on the study of Antonakakis et al. (2020). Hedge effectiveness can be calculated as follows.

$$he_i = 1 - \frac{var_p}{var_i} \tag{14}$$

In the above equation var_p and var_idenotes the portfolio variance and the variance of asset *i*, respectively. he_i represents where i is the level at which the risk of asset *i* can be reduced. Therefore, if the objective is to reduce risk, high hedge effectiveness will be preferred to low hedge effectiveness.

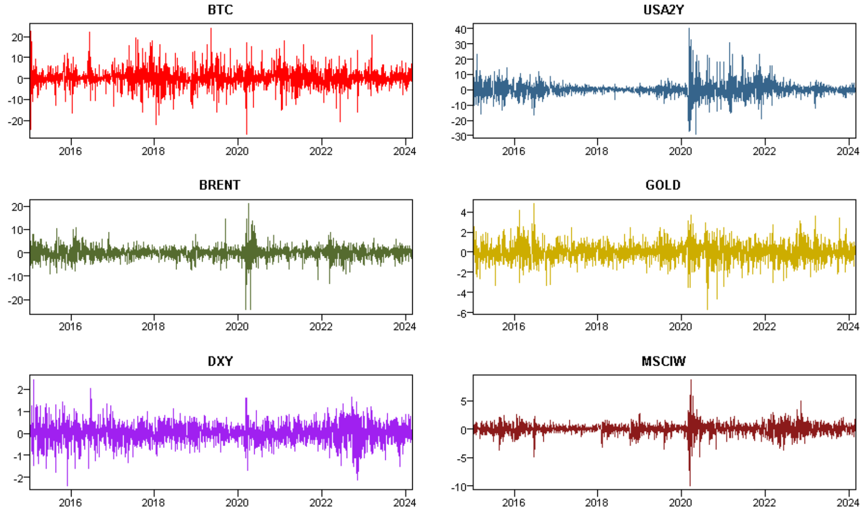
3 Findings

Return series of the variables are obtained in the study. Returns are calculated with the following equation.

$$r_{i,t} = \left(\frac{p_{i,t}}{p_{i,t-1}} - 1 \right) \times 100 \tag{15}$$

In Equation 15 $r_{i,t}$ represents the rate of return of variable *i* at time *t*, $p_{i,t}$ denotes the value of variable *i* at time *t*, and $p_{i,t-1}$ indicates the value of variable i at time *t-1*. The calculated rates of return for the variables are shown in Figure 1.

Figure 1 | Rates of return for each series



Source: Authors' own calculations.

Descriptive statistics of the data are presented in Table 2. According to the descriptive statistics, the returns of the variables are positive and the variance values of Bitcoin and US bonds are high. The skewness values of the data are mostly negative, i.e. skewed to the left, while the kurtosis values show that oil, US bonds, and MSCI world index are quite pointed. Jarque-Bera test is significant for all series, it means that all series do not have normal distribution. According to the ERS (Elliott, Rothenberg, & Stock, 1992) unit root test results, all series are stationary. *Q* and *Q2* denote Box-Pierce return correlograms and return squares correlograms. There are volatility clusters in series, hence ARCH effects are observed.

According to the correlation test results (Table 3), there is a positive correlation between Bitcoin and gold, Brent oil, and the stock market, and a negative correlation between Bitcoin and the dollar index. The correlation coefficient between Bitcoin and the stock market is higher than the others, while the variable with a low and insignificant correlation coefficient with Bitcoin is the bond. The stock market is positively correlated with Bitcoin, oil, bond, and gold, and negatively correlated with the dollar index. The dollar index has a negative correlation with gold, oil, and Bitcoin while a positive correlation with bond.

Table 2 | Descriptive statistics of variables

	BTC	GOLD	BRENT	USA2Y	DXY	MSCIW
Mean	0.348	0.029	0.057	0.190	0.006	0.037
Variance	19.250	0.804	7.203	21.099	0.211	1.029
Skewness	0.038	-0.095	-0.333	0.773	-0.084	-0.798
Ex. Kurtosis	4.634	2.774	10.702	10.968	1.732	14.250
JB	1,926.58 ***	693.43 ***	10,313.8 ***	11,006.4 ***	271.65 ***	18,444.5 ***
ERS	-19.884 ***	-6.368 ***	-5.667 ***	-6.620 ***	-17.681 ***	-8.043 ***
Q (20)	11.949	11.146	15.195	42.469	7.220	77.227
Q2 (20)	141.697 ***	129.828 ***	565.478 ***	1,236.86 ***	263.829 ***	2,092.27 ***

Notes: ***, **, * indicates 1%, 5% and 10% significance level respectively.
Source: Authors' own calculations.

Table 3 | Kendall correlations between variables

	BTC	GOLD	BRENT	USA2Y	DXY	MSCIW
BTC	1					
GOLD	0.048 ***	1				
BRENT	0.040 ***	0.050 ***	1			
USA2Y	-0.0004	-0.257 ***	0.087 ***	1		
DXY	-0.062 ***	-0.338 ***	-0.077 ***	0.169 ***	1	
MSCIW	0.124 ***	0.037 ***	0.191 ***	0.101 ***	-0.163 ***	1

Notes: ***, **, * indicates 1%, 5% and 10% significance level respectively.
Source: Authors' own calculations.

Table 4 | Static connectedness under bearish market (extreme lower quantile: τ = 0.05)

	BTC	GOLD	BRENT	USA2Y	DXY	MSCIW	FROM
BTC	24.86	14.98	14.82	14.27	15.00	16.08	75.14
GOLD	15.79	27.39	16.47	12.46	12.18	15.70	72.61
BRENT	14.12	14.97	25.04	15.34	13.84	16.68	74.96
USA2Y	13.87	12.27	16.02	24.30	17.51	16.03	75.70
DXY	14.46	12.25	15.02	17.61	26.34	14.31	73.66
MSCIW	15.49	14.64	16.58	15.89	13.13	24.26	75.74
TO	73.73	69.12	78.92	75.57	71.66	78.81	447.81
Inc. Own	98.59	96.51	103.96	99.88	98.00	103.07	cTCI/TCI
NET	-1.41	-3.49	3.96	-0.12	-2.00	3.07	89.56/74.64

Source: Authors' own calculations.

Table 4, Table 5, and Table 6 show the static connectedness under different market conditions. Under normal market conditions, the total connectedness index is 26.56

(Table 5). Of the volatility spillover between these markets, 26.56% of the volatility spillover is self-induced, while the remaining portion is attributable to factors not included in this study. Under extreme market conditions, the total connectedness index approaches three times that of normal market conditions (74.64 for 0.05 and 73.31 for 0.95). Khalfaoui et al. (2022) find that total connectedness increases significantly under extreme conditions. Under normal market conditions, most of the spillovers in the markets originate from the market itself, while under bearish and bullish market conditions, most of the spillovers originate from other markets.

In bearish market conditions (Table 4), Bitcoin is a net volatility receiver. In bearish market conditions, Bitcoin's connectivity with other markets is generally the same. Under bearish market conditions, oil, and stock market are net volatility transmitters, while the dollar index, gold, bond, and Bitcoin are net volatility receivers (Figure 2).

Table 5 | Static connectedness under normal market (intermediate quantile: τ = 0.50)

	BTC	GOLD	BRENT	USA2Y	DXY	MSCIW	FROM
BTC	87.36	2.33	1.32	1.08	2.03	5.88	12.64
GOLD	1.97	64.89	2.18	11.80	16.38	2.79	35.11
BRENT	1.58	2.52	82.38	3.13	1.48	8.91	17.62
USA2Y	1.27	12.40	2.71	70.18	6.99	6.45	29.82
DXY	2.41	16.37	1.6	6.51	64.84	8.27	35.16
MSCIW	5.05	2.88	7.6	6.60	6.90	70.98	29.02
TO	12.26	36.50	15.41	29.11	33.78	32.29	159.37
Inc. Own	99.63	101.39	97.79	99.30	98.62	103.28	cTCI/TCI
NET	-0.37	1.39	-2.21	-0.70	-1.38	3.28	31.87/26.56

Source: Authors' own calculations.

Under normal market conditions, Bitcoin's volatility relationship with other markets decrease significantly (Table 5). Bitcoin's connectedness with the stock market is higher than its connectedness with other markets. In normal market conditions, oil, the dollar index, bond, and Bitcoin are net receivers, while the stock market and gold are net transmitters (Figure 3).

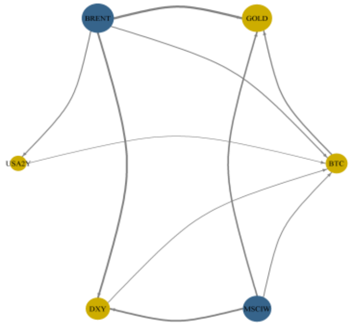
Table 6 | Static connectedness under bullish market (extreme upper quantile: τ = 0.95)

	BTC	GOLD	BRENT	USA2Y	DXY	MSCIW	FROM
BTC	26.28	15.65	14.82	13.92	13.80	15.52	73.72
GOLD	16.48	27.92	15.82	12.25	11.95	15.57	72.08
BRENT	14.51	15.05	25.47	15.01	13.38	16.57	74.53
USA2Y	13.87	11.40	15.50	26.27	17.11	15.85	73.73
DXY	14.58	11.86	14.26	18.13	27.80	13.37	72.20
MSCIW	15.33	14.11	16.33	15.60	12.23	26.41	73.59
TO	74.76	68.07	76.72	74.92	68.47	76.89	439.84
Inc. Own	101.05	95.99	102.20	101.19	96.28	103.29	cTCI/TCI
NET	1.05	-4.01	2.20	1.19	-3.72	3.29	87.97/73.31

Source: Authors' own calculations.

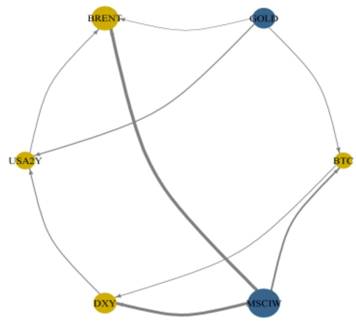
Under bullish market conditions (Table 6), Bitcoin is a net transmitter. In these conditions, Bitcoin's spillovers with other markets are balanced. In bullish markets, gold, and the dollar index are net receivers, while bond, stock market, oil, and Bitcoin are net transmitters (Figure 4). Bitcoin is a net receiver in bearish and normal markets and a net transmitter in bullish markets. This result is similar to the results of Khalfaoui et al. (2022). Bond, like Bitcoin, is a net receiver in bearish conditions and a net transmitter in bullish conditions. Gold is a net receiver in extreme conditions and a net transmitter in normal conditions. This may indicate that gold can be seen as a safe-haven asset. Oil, in contrast to gold, is a net transmitter in extreme conditions and a net receiver in normal conditions. These results may be due to the fact that gold is generally an investment commodity while oil is an industrial commodity.

Figure 2 | Network connectedness in bearish market (the 5th quantile)



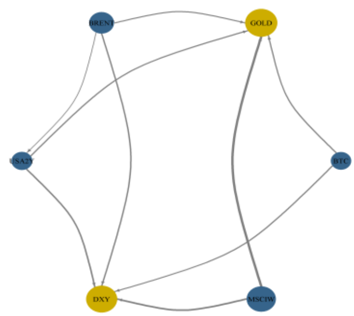
Source: Authors' own calculations.

Figure 3 | Network connectedness in normal market (the 50th quantile)



Source: Authors' own calculations.

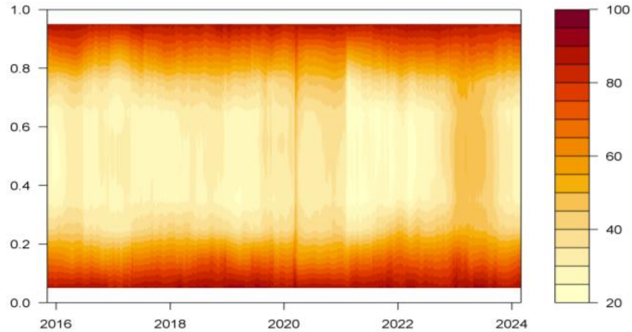
Figure 4 | Network connectedness in bullish market (the 95th quantile)



Source: Authors' own calculations.

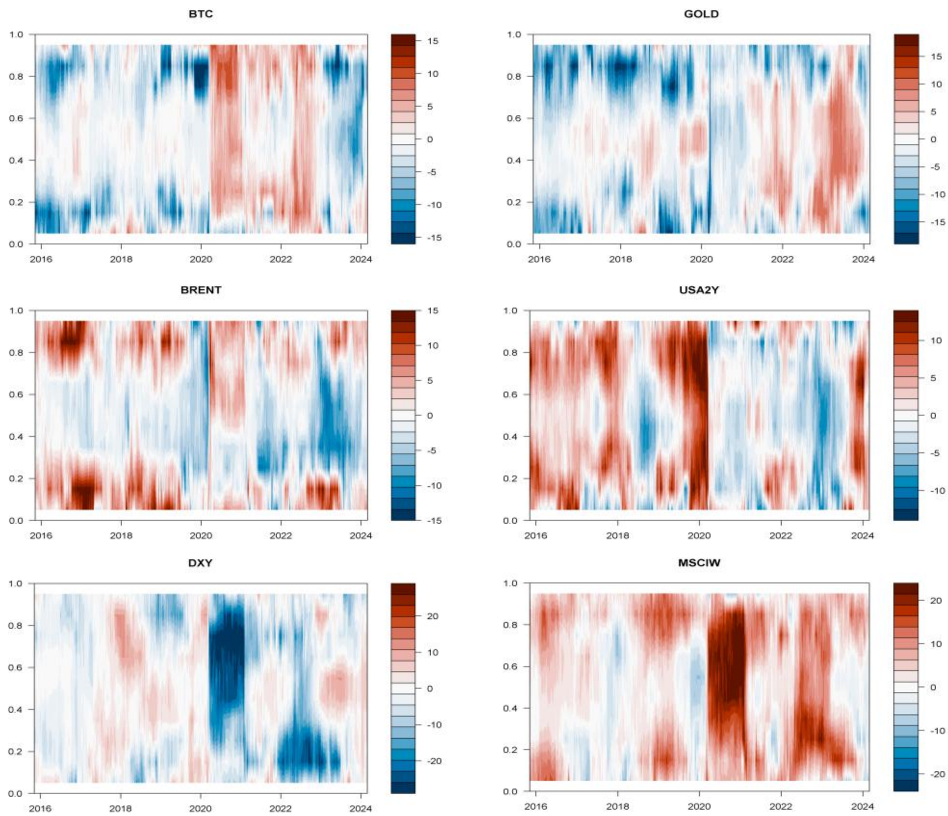
In bearish and bullish market conditions, dynamic total connectedness increases significantly due to market shocks, while in normal market conditions, connectedness decreases (Figure 5). Total connectedness followed a similar pattern over time. During the Israel—Hamas conflict period, connectedness increased slightly under normal conditions.

Figure 5 | Dynamic total connectedness



Notes: Results are based on a 200-days rolling-window QVAR model with lag length of order 1 (BIC) and a 20-step-ahead forecas.
Source: Authors' own calculations.

Figure 6 | Net total directional connectedness



Notes: Results are based on a 200-days rolling-window QVAR model with lag length of order 1 (BIC) and a 20-step-ahead forecast
Source: Authors' own calculations.

Bitcoin was a transmitter in 2020 when the COVID-19 pandemic was widespread, and in the first quarter of 2022, when news about the Russian-Ukrainian war intensified, while it is a net receiver in other market conditions (Figure 6). Bitcoin is a receiver in Li et al. (2023), Hoque et al. (2023), Zhang et al. (2022), Yang et al. (2022), Li et al. (2023), and a transmitter in Urom et al. (2020), Senol and Koc (2022), and Naeem et al. (2023). Gold is a transmitter during the periods of the Russia-Ukraine conflict and Israel-Hamas conflict, and generally a receiver at other times. Oil is a transmitter in bearish and bullish market conditions, but generally a receiver in other conditions. Bond is a transmitter in the pre-COVID-19 period and a receiver afterward. The dollar index is a transmitter during COVID-19 and the Russia—Ukraine war. Stock market's transmitter characteristics increased after the COVID-19 period.

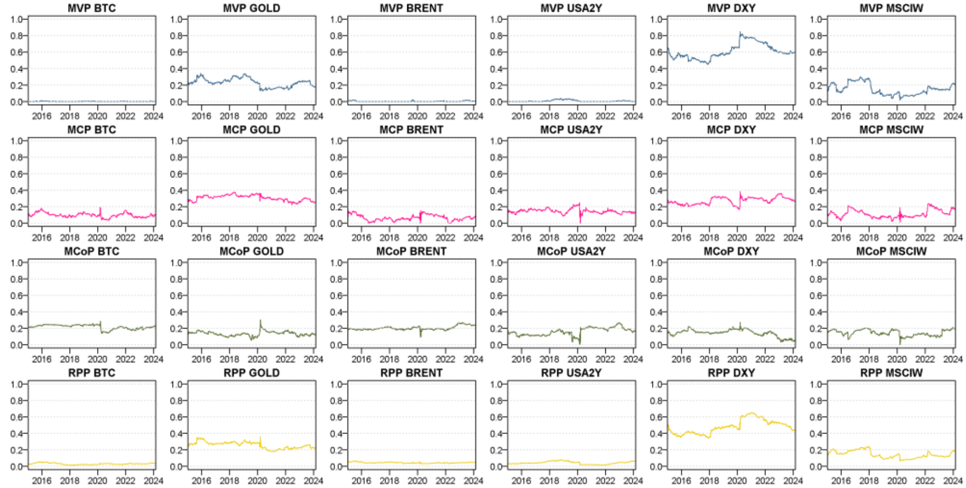
Figure 7 shows the total return performance of each portfolio approach over the sample period. Except for MVP, all portfolio returns increased again with a rapid recovery after a sharp decline during the COVID-19 period. RPP and MVP returns, on the other hand, increased continuously with a low rate of increase. MCP and MCoP returns are high and have increased significantly after 2016–2018 and COVID-19.

Figure 7 | Cumulative portfolio returns

Notes: MVP is minimum variance portfolio (Markovitz, 1959), MCP is minimum correlation portfolio (Christoffersen et al., 2014), MCoP is minimum connectedness portfolio (Broadstock et al., 2022), and RPP is risk-parity portfolio (Maillard et al., 2010).
Source: Authors' own calculations.

Figure 8 shows the dynamic portfolio weights of the individual assets that make up each portfolio. Bitcoin is not included in MVP, while it is low in RPP, medium in MCP, and high in MCoP. While the Dollar index and gold are high in MVP, Bitcoin is high in MCoP. It is observed that both return and volatility are high in MCP and MCoP portfolios with a high proportion of Bitcoin. The portfolio results for Bitcoin are similar to Jabeur et al. (2024).

Figure 8 | Dynamic multivariate portfolio weights



Notes: Results of MVP, MCP, MPC and RPP are based on Markovitz (1959), Christoffersen et al. (2014), Broadstock et al. (2022) and Maillard et al. (2010), respectively.
Source: Authors' own calculations.

In the MVP and RPP, where Bitcoin has a low share, the volatility reduction of other assets is statistically significant (Table 7). For example, in the RPP portfolio, if investing 3% in Bitcoin, 26% in gold, 4% in Brent, 4% in bond, 48% in dollar index and 14% in stock market, can statistically significantly reduce the volatility of each asset that is 99% for Bitcoin, 85% for gold, 98% for oil, 99% for bond, 41% for dollar index and 88% for stock market. In MCP and MCoP portfolios where the proportion of Bitcoin increases, the volatility reducing properties of other assets decrease. In the MCoP portfolio with the highest level of Bitcoin, the volatility reducing properties of gold, bond, and stock market disappear. In the MVP, MCP, McoP, and RPP portfolios, Bitcoin exhibits opposite characteristics to the precious metal commodity gold and similar characteristics to the energy commodity oil.

Table 7 | Multivariate averaged portfolio weights

	Mean	Std. Dev.	%5	%95	HE	Prob
Minimum variance portfolio						
BTC	0	0	0	0.01	1	0
GOLD	0.23	0.05	0.15	0.32	0.92	0
BRENT	0	0	0	0.01	0.99	0
USA2Y	0.01	0.01	0	0.03	1	0
DXY	0.61	0.09	0.48	0.87	0.69	0
MSCIW	0.15	0.07	0.06	0.27	0.94	0
Minimum correlation portfolio						
BTC	0.10	0.03	0.05	0.15	0.96	0
GOLD	0.31	0.03	0.25	0.36	0.12	0
BRENT	0.06	0.03	0.01	0.13	0.90	0
USA2Y	0.15	0.03	0.11	0.20	0.97	0
DXY	0.27	0.04	0.21	0.33	-2.33	0
MSCIW	0.11	0.05	0.06	0.20	0.32	0
Minimum connectedness portfolio						
BTC	0.22	0.03	0.16	0.25	0.90	0
GOLD	0.14	0.03	0.09	0.18	-1.49	0
BRENT	0.20	0.02	0.18	0.26	0.72	0
USA2Y	0.16	0.05	0.08	0.24	0.90	0
DXY	0.14	0.04	0.05	0.20	-8.46	0
MSCIW	0.14	0.04	0.09	0.20	-0.95	0
Risk parity portfolio						
BTC	0.03	0.01	0.02	0.05	0.99	0
GOLD	0.26	0.04	0.19	0.33	0.85	0
BRENT	0.04	0.01	0.03	0.06	0.98	0
USA2Y	0.04	0.02	0.02	0.07	0.99	0
DXY	0.48	0.08	0.36	0.63	0.41	0
MSCIW	0.14	0.04	0.08	0.22	0.88	0

Notes: Markowitz (1959) introduced the Minimum Variance Portfolio (MVP), while Christoffersen et al. (2014) developed the Minimum Correlation Portfolio (MCP). Broadstock et al. (2022) later proposed the Minimum Correlation Portfolio (MCoP). Additionally, Maillard et al. (2010) introduced the Risk-Parity Portfolio (RPP).
Source: Authors' own calculations.

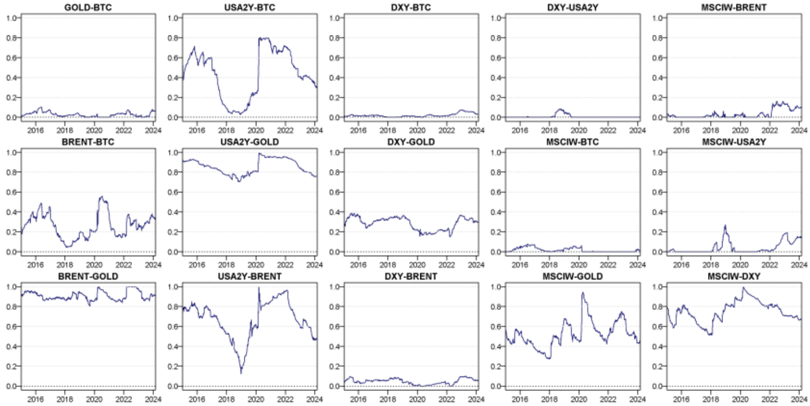
The optimal portfolio weight between Bitcoin and gold is 3% (Table 8). Accordingly, 97% of the portfolio should be invested in Bitcoin and 3% in gold to reduce risk with no change in expected return. The allocation of Bitcoins to gold, the dollar index, and the stock market is high. The portfolio allocation of Bitcoin to oil and bonds is 74% and 56% respectively. Hedge effectiveness increases when other assets are added to Bitcoin, while hedge effectiveness decreases when Bitcoin is added to other assets. This is an indication that Bitcoin is a risky asset.

Table 8 | Optimal portfolio weights

	Mean	Std. Dev.	Min	Max	HE	Prob
BTC/GOLD	0.03	0.02	0.00	0.07	0.96	0
BTC/BRENT	0.26	0.12	0.07	0.50	0.74	0
BTC/USA2Y	0.44	0.24	0.05	0.79	0.61	0
BTC/DXY	0.02	0.02	0.00	0.06	0.99	0
BTC/MSCIW	0.02	0.02	0.00	0.06	0.95	0
GOLD/BTC	0.97	0.02	0.93	1	0.04	0.36
BRENT/BTC	0.74	0.12	0.50	0.93	0.30	0
USA2Y/BTC	0.56	0.24	0.21	0.95	0.65	0
DXY/BTC	0.98	0.02	0.94	1	0.07	0.11
MSCIW/BTC	0.98	0.02	0.94	1	0.02	0.66

Notes: Optimal portfolio weights are developed by Kroner and Ng (1998). HE is hedge efficiency.
Source: Authors' own calculations.

Figure 9 | Dynamic optimal portfolio weights



Notes: Dynamic optimal portfolio weights are developed by Kroner and Ng (1998).
Source: Authors' own calculations.

Bitcoin's portfolio weights with oil, bonds, and stock markets have changed significantly (Figure 9). The portfolio allocation of oil and Bitcoin shifted in favor of oil during COVID-19 and the Russian invasion of Ukraine. Bond-Bitcoin portfolio allocation, on the other hand, increased in favor of bonds during the COVID-19 period. The stock market-Bitcoin portfolio weighting changed against the stock market after COVID-19.

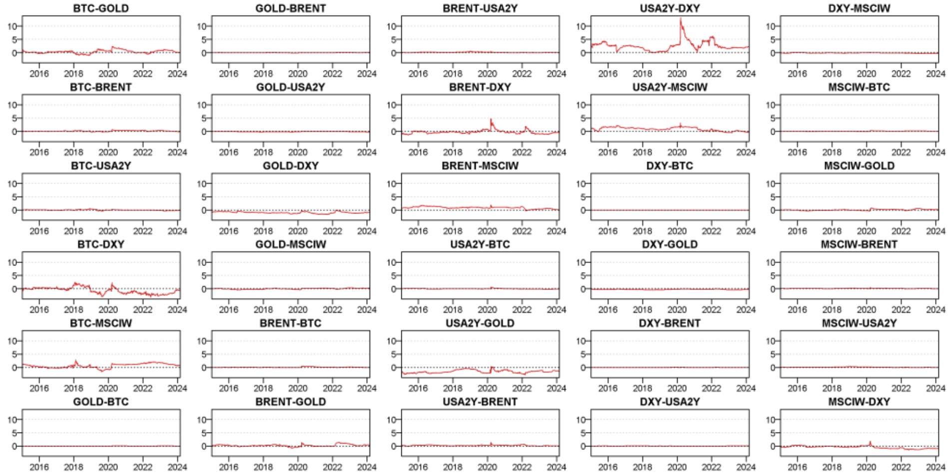
Table 9 | Optimal hedge ratios

	Mean	Std. Dev.	Min	Max
BTC/GOLD	0.36	0.62	-0.67	1.50
BTC/BRENT	0.10	0.17	-0.15	0.36
BTC/USA2Y	0.00	0.15	-0.26	0.26
BTC/DXY	-0.67	1.17	-2.39	1.33
BTC/MSCIW	0.64	0.80	-0.81	1.89
GOLD/BTC	0.02	0.03	-0.02	0.08
BRENT/BTC	0.05	0.11	-0.04	0.37
USA2Y/BTC	0.00	0.10	-0.15	0.15
DXY/BTC	-0.01	0.02	-0.05	0.01
MSCIW/BTC	0.05	0.07	-0.02	0.19

Note: The optimal hedge ratio is developed by Kroner and Sultan (1993).
Source: Authors' own calculations.

Table 9 shows the hedge ratios between the two assets. The hedge ratio is the average ratio of a $1 long position in the first asset to a short position in the second asset. For example, for Bitcoin gold, to hedge a $1 long position in Bitcoin, one would need to invest $0.36 in a short position in gold. The Bitcoin the dollar index hedge ratio is negative. To hedge a $1 long position in Bitcoin, invest $0.67 in a long position in dollar index. The dollar index is a good hedge against Bitcoin. The cost of hedging Bitcoin is high for the dollar index, the stock market (MSCIW), and gold. On the other hand, the proportion of Bitcoin that should be invested to hedge other assets is quite low. The proportion of Bitcoin that needs to be invested in other assets to hedge Bitcoin is high, while the proportion of Bitcoin that needs to be invested to hedge other assets is low. In other words, the hedging cost of Bitcoin is high while the hedging cost of other assets is low. These results suggest that Bitcoin is a highly risky asset against other assets and has low hedging properties. In the studies of Baur et al. (2018), Urom et al. (2020), Uyar and Kahraman (2019), Bitcoin is considered as a highly risky asset. Shahzad et al. (2019), Shahzad et al. (2020), Shahzad et al. (2021), Das (2020), Huang et al. (2021), Echaust et al. (2024) found that Bitcoin is a low hedging instrument. The results obtained are similar to the studies in the literature.

Figure 10 | Dynamic Hedge Ratios



Note: The dynamic hedge ratio is developed by Kroner and Sultan (1993)
Source: Authors' own calculations.

Figure 10 shows the hedge ratios changing over time. Regarding the hedging of Bitcoin, the Bitcoin hedge ratio has changed significantly over time for gold, the dollar index, and the stock market. Especially during COVID-19, the proportion of these assets in the hedge ratio increased. The hedge ratio for other assets, which is quite low, has not changed much over time.

Conclusion

Bitcoin has emerged as a means of payment that does not depend on a centralized authority and allows transfers to be made in the absence of financial intermediaries. Bitcoin studies based on blockchain technology. Over time, cryptocurrencies have become widespread and have reached an important place in financial markets in terms of market capitalization and transaction volume. At this point, the position of crypto assets and Bitcoin in financial assets, whether they are money or commodities, their relationship with financial assets, and their financial characteristics are of great interest. Crypto assets and Bitcoin have started to be followed by investors, portfolio managers, and risk managers. Country economic administrations, central authorities, and regulatory and supervisory bodies are closely interested in crypto assets and Bitcoin and are seeking to establish a legal framework on the subject.

This study investigates the linkages of Bitcoin with the stock market, gold, oil, bond, and exchange rates using a quantile connectedness approach. The study also examines portfolio strategies and hedging opportunities between these financial assets. The study period is from January 2, 2015, to March 1, 2024. The results of the study can be summarized as follows: The connectedness between markets decreases in normal conditions and increases significantly in extreme conditions. Bitcoin is a transmitter in bullish market conditions and a receiver in bearish and normal market conditions. It exhibited transmitter characteristics during COVID-19 and the Russian invasion of Ukraine. Gold is a transmitter in normal conditions and a receiver in extreme conditions. Oil, on the contrary, is a receiver under normal conditions and a transmitter under extreme conditions. After the Russian invasion of Ukraine and during the Israel-Hamas conflict, gold was a transmitter and oil was an receiver. The stock market (MSCIW) was the most important shock spillover among the major markets, especially during the COVID-19 period. In different portfolios constructed for risk mitigation, the proportion of Bitcoin is low, while the proportion of gold and dollar index is high. Bitcoin was found to have a low level of hedging.

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