The puzzling role of Bitcoin

Petropoulos Leonidas

School of Humanities, Social Sciences and Economics

February 2024

Thessaloniki-Greece

A thesis submitted for the degree of **MSc in Banking, Financial Technology (Fintech) and Risk Management.**

Student Name: Petropoulos Leonidas

SID: 1103220003

Supervisor: Prof. Catherine Kyrtsou

I hereby declare that the work submitted is mine and that where I have made use of another's work, I have attributed the source(s) according to the Regulations set in the Student's Handbook.

Abstract

Bitcoin has become a significant asset in the global financial market. This dissertation examines the dynamic relationship between the cryptocurrency and the S&P 500 index, focusing on whether Bitcoin can be used as a hedger for portfolio diversification and contribute to amplification of overall market risk. Hedging is a fundamental risk management strategy utilized by investors to mitigate potential losses and protect against adverse market conditions. Traditional financial instruments, such as stocks, bonds, and commodities, have long served as hedging assets. However, the recent rise of Bitcoin as a decentralized digital currency has sparked interest in its potential as an alternative hedging instrument.

The dissertation begins by reviewing the existing literature on Bitcoin, hedging theory, and the integration of cryptocurrencies into financial markets. A thorough analysis of the characteristics and properties of Bitcoin is conducted, exploring its volatility, and correlation with the market represented by Standard and Poor's 500 (S&P500). Furthermore, the dissertation examines the two asset classes and investigates whether Bitcoin Granger causes the index utilizing all available information. This analysis serves as a foundation for understanding the potential effectiveness of Bitcoin as a hedging instrument shedding light on potential implications for investors, portfolio managers, and policymakers.

The findings of this research contribute to the existing body of knowledge by providing empirical evidence on the role of Bitcoin as a hedging instrument. They indicate that Bitcoin can act as a hedger when extreme volatility spreads between the cryptocurrency and S&P500 occurs. The results offer insights for investors, financial institutions, and policymakers seeking to understand the potential benefits and risks associated with integrating Bitcoin into their risk management strategies. The dissertation ends with a discussion of the research's implications and suggestions for future avenues of study.

Keywords: Bitcoin, S&P500, cryptocurrency, hedging instrument, risk management, financial markets, financial technology.

Acknowledgements

I am profoundly thankful to the professors and academic mentors of the International Hellenic University, whose teachings, guidance, and scholarly pursuits have enriched my academic journey. I also want to acknowledge the staff of the University, whose assistance has facilitated this project's completion.

I would like to express my deepest gratitude to my supervisor, Professor Catherine Kyrtsou, whose expertise, support, and insightful feedback have been invaluable throughout the process of composing this dissertation.

Lastly, I am indebted to my family for their unwavering love and understanding throughout this endeavor. Your encouragement has been a source of strength and motivation to constantly keep chasing my dreams.

Table of Contents

Chapter 1: Introduction

In periods of economic crises investors try to place their money in safer investments than stocks to protect them from the extensive volatility created, even though they may be compensated less.

This technique is called hedging and suggests that investors should turn from equity markets to markets with hedging properties such as gold, commodities, and derivatives as alternative assets which increase in value during economic crises to protect their money from various risks. Research shows that the hedging and safe-haven ability of gold has been significantly reduced, making investors search for other investment vehicles with hedging abilities.

In the last decade, a new asset class has arisen in the name of cryptocurrencies and empirical research has found evidence that its price tends to increase in periods of recession.

In the present study, we will examine the case of Bitcoin, the most famous and first widely adopted cryptocurrency, which acts as a benchmark in its asset class, having the largest market capitalization and high correlation with most of the smaller capitalization cryptocurrencies.

Bitcoin was considered a potential hedging instrument based on its decentralized nature, determined supply, store value, and most importantly its low correlation with traditional assets, with many authors placing it alongside gold, acting as a safe haven while others supporting that its nature as a hedging instrument has changed exhibiting a weak diversification performance.

This dissertation will aim to investigate the role of Bitcoin as a hedging instrument, by exploring its hedging properties in the stock market over time.

1.1 About Fintech

Through the years, change has been essential to all aspects of human life driving economic growth and prosperity. Kuhn (1962) provides a concept of paradigm shift, as the author defines the turn-of-the-century revolutions while highlighting the fact that change can be slow in certain periods and faster in others. Technology has had a major impact on the financial industry since the 1850s, but it was the adaptation of the Internet and related technologies during the 2000s that ultimately transformed traditional finance and

economic systems. With the banking system as a pioneer, most financial institutions adopted that combination of technology and finance which resulted in a shift from production-based value creation processes towards financial markets, with positive impacts on traditional procedures in transactions, such as reducing cost and making their nature more reliable and transparent (Gozbasi, et al., 2021). This resulted in an increase in financial participation as it was easier for individuals to trade online. As a result, in the past two decades, the term FinTech (Financial Technology) rose to describe initiatives in technology that affect financial services and drive the creation of financial applications, while yielding advantages for consumers. (Murinde et al., 2022)

1.2 About Bitcoin

One of the most promising financial innovations of the last decade considered by many a crucial financial technological breakthrough was the Blockchain system and its by-product: Bitcoin, which was developed as a decentralized alternative to the banking system. Bitcoin is a digital currency and peer-to-peer cash system proposed by Nakamoto (2008) as a remedy to the U.S. mortgage crisis of 2007 to change the banking system as we know it, by eliminating problems such as brokerage costs, opaque actions., personal data exploitation, and the accumulation of wealth among specific groups. To do so Bitcoin has specific characteristics such as its fully decentralized nature and its dependance on a sophisticated protocol due to its innovative 'distributed ledger.' By decentralization, Bitcoin is not regulated by a central authority making it independent from sovereign governments and central banks. Until then, Bitcoin has established itself as the most famous and first widely adopted cryptocurrency, which acts as a benchmark in its asset class, having the largest market capitalization and high correlation with most of the smaller capitalization cryptocurrencies. (Bouri et al., 2017)

Since launching, Bitcoin's value has grown rapidly to an eye-watering US $568,46 billion on 25/7/2023 (coinmarketcap.com), provided to investors based on its limited supply by the design of the protocol, making extreme profits for early investors while establishing itself as the biggest cryptocurrency. As displayed in Figure 1 it is included in the ten biggest Companies and Assets in the world according to its market capitalization.

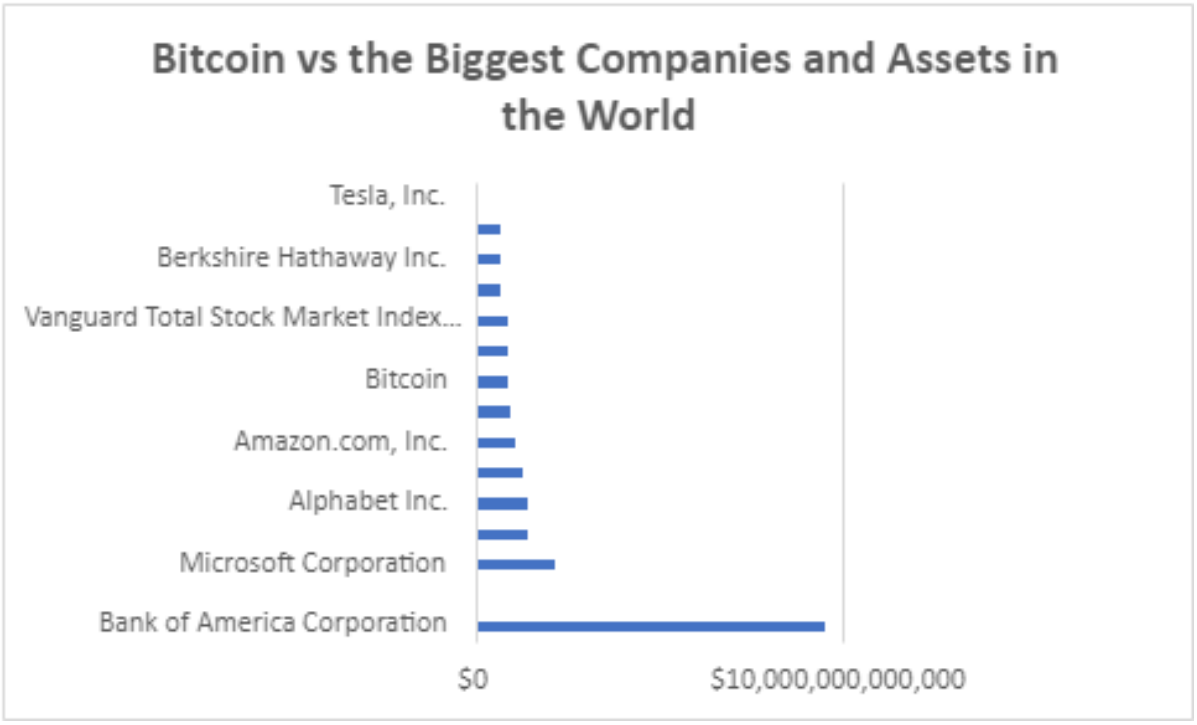

Figure 1. Bitcoin's Capitalization amongst the Biggest Companies in the World

Sources: CoinMarketCap

Alternatively, whether one treats Bitcoin as an investment or a medium of exchange, it is unquestionable that its price is affected by excess volatility with Baek and Elbeck (2014) demonstrating that the cryptocurrency can be 26 times more risky than the market benchmark index and Baur and Dimpfl (2021) proving that this heavy influence by the level and nature of volatility, make Bitcoin unable to work as a currency currently while Yermack (2013) complementing that it behaves more like a speculative investment. Furthermore, the absence of fundamental value and regulation makes Bitcoin a mysterious asset that many investors have trouble understanding. Finally, according to Smales (2019) Bitcoin presents excessive volatility, while lacking liquidity, and being more expensive to transact than other traditional safe havens even in normal market conditions. Although Bitcoin's price volatility is many times greater than that of stocks, bonds, traditional currencies, and commodities its volatility is influenced by variables distinct from those affecting traditional assets. As a result, researchers and investors examine whether this newly established asset is suitable for investment from a risk perspective.

1.3 About Volatility

Volatility is a statistical gauge of fluctuation of the market's mean price over a specific period and as described thoroughly it is of at most significance as it quantifies the risk associated with assets.

Economists have tried to measure this uncertainty which causes volatility in the financial markets with various indexes. For example, the St. Louis Fed Financial Stress Index is provided by the Federal Reserve Bank to capture market stress with values from late 1993 and an average value designed to be zero (representing normal financial market conditions). Less financial stress is presented by below zero values, while values above zero suggest more financial stress exists in capital markets. (Federal Reserve Bank of St. Louis, 1993)

The primary representative index when it comes to the United States market is Standard and Poor's 500 (S&P500) index, traded in the New York stock exchange. Comprising 500 prominent companies, it represents about 80% of the total market capitalization. Therefore, we are going to use this index as the best to describe the market in our attempt to capture the effect Bitcoin has on that volatility.

In Figure 2, we illustrate the temporal progression of the prices of Bitcoin and the S&P 500 index spanning the period from 2014 to 2023. The graphical representation distinctly reveals that Bitcoin emerges as a considerably more volatile asset, exhibiting superior performance. This heightened volatility is evident through the phenomenon of volatility clustering observed in Bitcoin's price movements.

In contrast, the S&P 500 demonstrates a measured and consistent appreciation in value over the same temporal span. Notably, the index portrays a discernible absence of pronounced volatile episodes, exhibiting a relatively stable and incremental ascent in value. This dichotomy underscores the divergent risk profiles inherent in these two assets, with Bitcoin characterized by its propensity for more pronounced and clustered volatility, while the S&P 500 follows a comparatively steady and less tumultuous trajectory.

In our analysis, we will measure and try to unveil the patterns hidden when comparing the volatilities of our two assets.

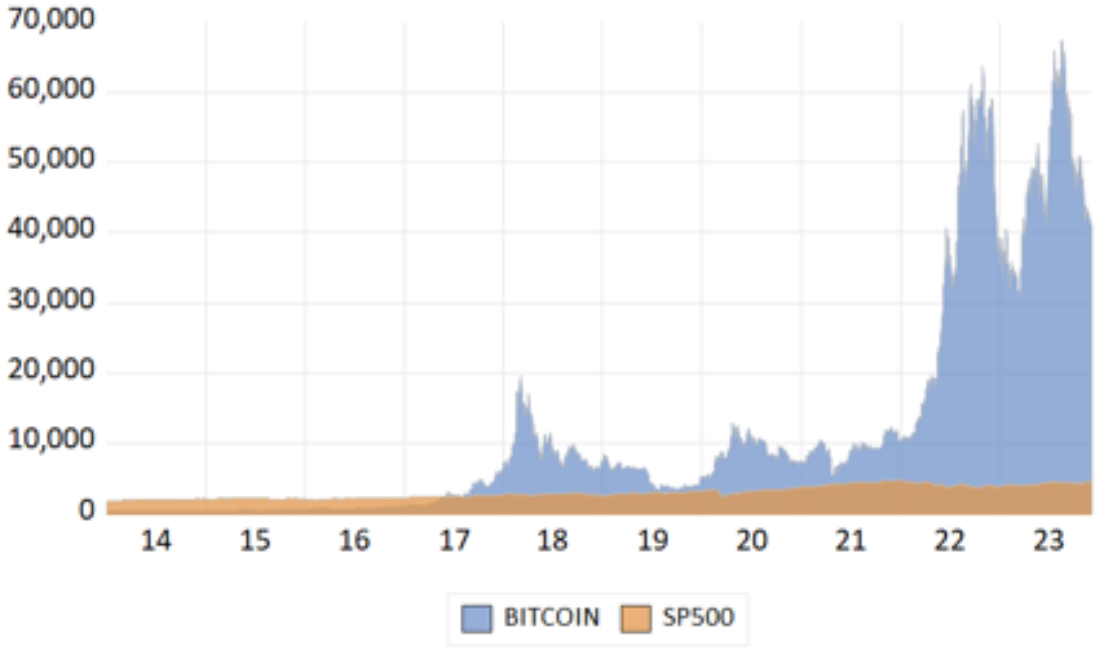

Figure 2. Comparison of Bitcoin and S&P500 prices over the year

Source: Yahoo Finance; author's calculations. Note: Figure 2 uses daily data from January 2014 to November 2023 on the asset's prices. Bitcoin's price is blue while S&P500's is orange.

1.4 About Hedging

In periods of economic turbulence where there is uncertainty in the stock markets, participants try to place their money to safer investments than stocks to protect them from the extensive volatility created, even though they may be compensated less.

This technique is called hedging and suggests that investors should turn from equity markets to markets with hedging properties such as gold, commodities, and derivatives as alternative assets that increase in value during economic crises to protect their money from various risks to maximize the profits and minimize the losses in their portfolio. These financial instruments can be described as diversifiers, hedgers, and safe havens according to their capabilities.

Historically such financial instruments were broadly used by investors, but it was Baur and Lucey (2010) that to our knowledge first tried to establish the definitions of a diversifier, hedge and safe haven, by highlighting the asset's relationship with a portfolio by stating: "A diversifier is defined as an asset that is positively (but not perfectly correlated) with another asset or portfolio on average. A hedge is an asset that is uncorrelated or negatively correlated with another asset or portfolio on average. A strict hedge is (strictly) negatively correlated with another asset or a portfolio on average. A safe haven is defined as an asset that is uncorrelated or negatively correlated with another asset or portfolio in times of market stress or turmoil." Baur and McDermott (2010) expanded more on the weak and strong form of diversification restating the initial definition: "A strong (weak) hedge is defined as an asset that is negatively correlated (uncorrelated) with another asset or portfolio on average. A strong (weak) safe haven is defined as an asset that is negatively correlated (uncorrelated) with another asset or portfolio in certain periods only, e.g., in times of falling stock markets."

1.5 About Gold as a Hedger

Investors and financial media have treated gold through the years as a safe-haven asset due to its minimal or negative correlation with traditional paper assets such as bonds and stocks combat inflation and safeguard capital, but no consensus on whether gold serves with certainty as a safe haven or hedge for stock market participants has been reached in the academic community. Examples in the literature are the paper of Barro and Misra (2016) presenting indications that gold may not act as a hedging tool against volatility in the market while Su et al. (2022) suggest that investors can involve gold in their strategies to hedge against the world uncertainty index. Som and Kayal (2022) suggest that people think that, through time, Bitcoin will present analogous characteristics to gold, Emphasizing the commonality that they possess a speculative nature as neither generates income independently, yielding returns to investors solely when demand rises, while at the same time, investors keep them in their portfolio considering that they have diversifying abilities.

Bitcoin has been placed alongside gold in many other research papers as they share many similarities. According to Dyhrberg (2016), other similarities are that their primary value is derived from the interaction of demand-supply forces with supply being finite and not regulated by a central authority but independent agents.

Despite their similarities, the two assets vary in multiple other facets, with Bouri et al. (2017a) mentioning that Bitcoin represents an intangible asset with notable counterparty risk, which is not the case with gold

while presenting characteristics of small capitalization market assets, including auto-correlation and non-stationarity, high standard deviation, and high tail risk in its returns with Klein, Pham Thu and Walther (2018) claiming the two assets have fundamentally different properties and a different relationship with equity markets.

Several studies compared Bitcoin's performance with gold, with mixed results. Some concluded that gold remained a preeminent hedger and safe haven asset (Naeem et al., 2020), while others found Bitcoin to be a viable alternative (Kayral et al., 2023).

Chapter 2: Literature Review

In this sense, researchers try to identify whether Bitcoin has this well-discased diversifier capabilities against stocks, bonds, and the American dollar, as gold does by being a value holder and a transaction medium for thousands of years. The answer to whether the cryptocurrency can have hedging capabilities can be found by observing how its price interacts with financial market indicators. To examine that exact phenomenon, previous literature investigates how Bitcoin prices are reacting to changes in prices in commodities, the S&P 500 index, and other indexes which try to capture volatility in the market, which according to Gozbasi et al. (2021) provide a suitable representation of the financial risk environment.

Specifically, Dyhrberg (2016) investigated the use of Bitcoin as a hedging tool to find that in the short-term it can hedge the equity in the Financial Times Stock Exchange Index and the American dollar aligning it with gold's hedging attributes stating that it possesses some of the same hedging abilities and can be included in the variety of tools available to market analysts to deal with market specific risk.

Later, Bouri et al. (2017b) extended the examination by measuring the first principal component of the VIXs of 14 developed and developing equity markets to assess whether Bitcoin can hedge global volatility and concluded that it reacts positively to uncertainty and fear at shorter investment horizons and thus presents characteristics of a hedger. However, as research progressed, it became apparent that Bitcoin's role was nuanced with Bouri et al. (2017c) generalizing in their second study, the hedging ability of Bitcoin in the financial environment by measuring its correlation with bonds, oil, gold, the general commodity index and the US dollar index and suggest that it is suitable for diversification purposes only, with different hedging and safe haven properties between horizons. Feng et al. (2018) confirmed that this behavior continues to exist when testing seven representative cryptocurrencies but mentioned that it is not sufficient to be considered a volatility hedger, albeit not a strong one, prompting a cautious outlook.

Moving on, Demir et al. (2018) investigated the forecasting ability of the Economic Policy Uncertainty (EPU) index on the cryptocurrency's returns. By highlighting the negative relationship between them, they show a positive effect at the cryptocurrency's returns and the Economic Policy Uncertainty Index proving that Bitcoin cannot hedge against uncertainty, falling out with the rest of the literature.

From this point on, we observe this shift in Bitcoin's hedging behavior with Klein, Pham Thu and Walther (2018) indicating a positive correlation with downward markets and therefore previous evidence for clear hedging capabilities could be denied in the long-term investment horizon. Also taking into consideration the broad cryptocurrency index CRIX the authors concluded that the cryptocurrency also has not retain any properties of gold except for the asymmetric response in volatility. Smales (2019) echoed the idea that Bitcoin may not be a reliable safe haven until the cryptocurrency market matures with Stensås et al. (2019) provide a different view to the subject questioning whether Bitcoin serves as a diversifier, hedge, or safe haven tool in developed and developing markets, as well as for commodities. They show that it does work in most developing countries but can be considered only as a diversifier in developed countries and the same in the case of commodities. Wu et al. (2019) complement this side of the literature when measuring the hedge and safe-haven properties of Bitcoin by demonstrating that it cannot serve as a strong hedge or safe-haven for the EPU index at the average condition of the market but can work as a weak hedge and weak safe-haven during the extreme bearish and bullish markets and thus used for portfolio diversification during the normal market period.

Fang et al. (2019) also presented historical information to predict Bitcoin's return based on global economic uncertainty. They studied the correlation analysis of the cryptocurrency and other financial assets traded worldwide, focused on financial volatility's created in the market impact on Bitcoin and concluded that Bitcoin can function as a hedger only when taking under consideration particular volatility conditions. Nevertheless, Bitcoin's hedging effectiveness against both global equities and global bonds sees a slight increase when factoring in the level of global Economic Policy Uncertainty (EPU), implying that market participants are not able to improve significantly the diversification strategy of their portfolios when building a dynamic strategy under different economic uncertainty conditions. reinforced the notion of Bitcoin's minimal hedging effectiveness but acknowledged its potential for specific industries and emphasized that overall gold has superior safe-haven and hedging potential than Bitcoin.

There was a notable shift in the prevailing consensus within the literature regarding Bitcoin's contribution in diversification strategies with Uddin et al. (2020) study challenging the notion that Bitcoin lacked significant diversification benefits highlighting opportunities within sustainable, conventional, and Islamic

asset classes, and indicating that its returns display mean-reverting tendencies, suggesting that its value is inclines to its mean in the long term horizon while doesn't completely diminish to zero regardless of price fluctuations. This points towards cryptocurrencies being positioned as a sustainable asset class. Furthermore, they concluded that Bitcoin offered opportunities for portfolio diversification, with particularly positive results when integrated with Dow Jones Islamic and FTSE 4 Good indexes, both in the short and long run.

Gozbasi et al. (2021) conducted research that corroborated these findings when exploring the impact gold and oil, the S&P 500 index, and the volatility index and financial stress index have on Bitcoin returns. Their conclusions supported the idea that Bitcoin could serve as a valuable component of a diversified portfolio. Specifically, their research revealed that, in both the short and long run, changes in gold prices did not significantly impact Bitcoin while a boost in oil prices influences the short-term Bitcoin price but has no impact on it in the long term. Notably, the S&P 500 stock market index exhibited a positive influence on Bitcoin in both short and long-term horizons. The results demonstrate that developments indicating increased risk, in the long run, tend to reduce Bitcoin returns.

Koutmos et al. (2021) conducted research to determine if cryptocurrencies could serve as effective minimum-variance hedging instruments. They found that during the COVID-19 crisis, optimal portfolio weights in cryptocurrencies, with Bitcoin as a proxy, faced a significant increase, highlighting Bitcoin's introduction to portfolios for hedging during times of market turmoil. Also, their study confirms the crucial fact that most cryptocurrencies exhibit zero or negative betas with the market consistently across time, demonstrating their natural hedging ability for investors seeking to reduce their portfolio's co-movement with the market.

In a related study, Wang et al. (2022) contributed to existing academic works by examining the relationship between Bitcoin prices and macroeconomic variables such as EPU, money distribution, and consumer price index, spanning both the long and the short-term horizons. Their results demonstrate that EPU and money supply adversely impact Bitcoin prices during the short term, CPI has a positive effect on Bitcoin prices. These results aligned with existing literature and reinforced the notion that Bitcoin could be considered as a diversification tool under certain economic conditions.

The shifting nature of the cryptocurrency’s investment properties is a central theme as we can clearly see that Bitcoin investment properties shifted once during the 2017 crash of Bitcoin’s price and once more following the onset of the COVID pandemic. This is what Gadi and Sicilia (2022) examined by considering blockchain technology and the pre-and during-COVID health crisis periods across G7 and BRICS countries.

Their results show that both attributes play a key role in the hedge, safe haven, and diversifier properties associated with the asset. Xu and Kinkyo (2023) also investigate the risk-hedging effects of Bitcoin and Gold in the stock markets of the G7 countries by adding the Russo-Ukrainian War period to the timeframe. Their discoveries indicate that Bitcoin offers more robust short-term risk mitigation within the G7 stock markets when juxtaposed with gold, particularly evident during the COVID-19 and Russo-Ukrainian War periods. with China and Russia's correlation with cryptocurrencies decreased after the COVID crisis, suggesting changing dynamics in response to global events, adding significant value to the sparse literature available on the subject.

During the same time period, Kayral et al. (2023) focused on constructing the optimal portfolio diversification strategy for the G7 stock indices, by including gold as a traditional asset and Bitcoin as a newly established one. Their findings suggest that Bitcoin serves as a more effective short-term risk hedge in the G7 stock markets compared to gold, especially during the COVID-19 and Russo-Ukrainian War periods.

Su et al. (2023) continued the examination of the hedging characteristics of gold and Bitcoin during panic situations by measuring the changeable interrelationship between the volatility index (VIX), gold prices, and Bitcoin prices in the U.S. Their findings suggested that gold initially exhibited resilience against panic but could not maintain this ability because of the strength of the U.S. dollar or the limited duration of its safe-haven attributes. Conversely, Bitcoin’s diversification benefits to prevent investors’ fear are much weaker than gold’s showing no clear evidence of being a panic-resistant asset. Finally, they also present a mediating effect of VIX on both asset prices and an adverse relationship by the value of U.S. dollars on them.

This extensive review of the literature provides valuable insights into the evolving role of Bitcoin as a potential hedging instrument within the modern financial landscape. The analysis encompasses a range of studies that have explored Bitcoin's behavior in relation to traditional financial assets and market indicators.

2.1 Our Contribution

After looking into the literature, it is evident that the cryptocurrency initially demonstrated clear hedge and safe-haven properties with early studies, such as Dyhrberg (2016), indicating that it can serve as a short-term diversifier to hedge equities and the United States dollar, placing it in a category similar to gold. Later studies, including Klein et al. (2018), challenged the notion that it can act as a strong hedger, suggesting a shift in its behavior over time with this perspective climaxing during its price crash of 2017. These findings suggested Bitcoin's potential as a tool for market-specific risk management. However, the hedging abilities of Bitcoin become more evident, with authors confirming these properties during periods of economic

uncertainty, like the COVID-19 pandemic and the Russo-Ukrainian war suggesting that Bitcoin may indeed serve as a hedge, especially in the context of evolving macroeconomic conditions and geopolitical events, making it a subject of continued interest and exploration in financial research.

Comprehending the role of Bitcoin is crucial for financial market participants aiming to safeguard themselves against market turbulence and downturns. So far, the safe-haven property of Bitcoin has not been tested extensively during periods of extreme market stress. Our research aims to fill that gap by trying to measure the changeable interrelationship among the S&P500 returns and bitcoin returns to detect safe-haven properties of Bitcoin from the perspective of panic and the ability to hedge economic uncertainty.

This information can be especially meaningful in times of widespread financial crisis or economic turmoil, such as during the recent COVID-19 pandemic and the Russo-Ukrainian War, which affected stock, energy, exchange rate, and commodities markets. The understanding of Bitcoin's puzzling role as a newly established asset can help market participants in terms of risk management to protect their portfolios from downward market movements. Moreover, our discoveries hold significance for regulators and governments, urging them to delve deeper into discussions regarding the role of Bitcoin in financial markets. This thesis adds to the ongoing discourse surrounding the utility of Bitcoin for investment purposes.

In this research endeavor, the primary objective is aimed at meticulously estimating the intricate relationship between the cryptocurrency and the prominent financial indicator: S&P 500. The overarching aim is to discern whether Bitcoin possesses the capacity to serve as an effective hedge against market volatility within the United States. To achieve this, a rigorous quantitative analysis will be employed, involving a comprehensive examination of historical data encompassing a variety of market conditions. By applying advanced statistical techniques, including correlation analysis and regression modeling, we will dissect the dynamics and potential causal connections between Bitcoin and these key indices. Through this systematic exploration, we seek to contribute valuable insights to the ongoing discourse surrounding Bitcoin's role as a hedging instrument and its impact on managing risk in the ever-evolving landscape of the US financial market. Further, we will expand our analysis to encompass various time periods featuring pivotal events and instances of extreme market conditions when testing possible interrelationships among selected indexes, to evaluate whether these characteristics stand over time.

Chapter 3: Data

The data on the S&P 500 and Bitcoin prices used for the analysis on this paper is scoured from Yahoo Finance, containing daily sequences from 01/01/2014 until 28/11/2023 yielding 2584 observations. The timeframe under selection is constrained by the availability of Bitcoin prices. The selection of Yahoo Finance as the data source was based on its reputation for providing high-quality and extensive financial information. Its robust data compilation makes it particularly well-suited for amassing and scrutinizing numerical data fitting this study's context. Yahoo Finance provides up to date historical pricing data and market details for the two time series under examination, which is essential for conducting a thorough and reliable assessment of the connection between them over the chosen designated period.

Nonstationary is common in time series as means and variances vary over time, so this section will delve into the statistical analysis associated with returns, to overcome this phenomenon. From a mathematical perspective, return series often exhibit more favorable statistical properties that are not observed in price. The conversion of Bitcoin and S&P500 price to returns is achieved using the first differences of their natural logarithms. This decision was also made as the return indicates the performance of an investment in the world of finance.

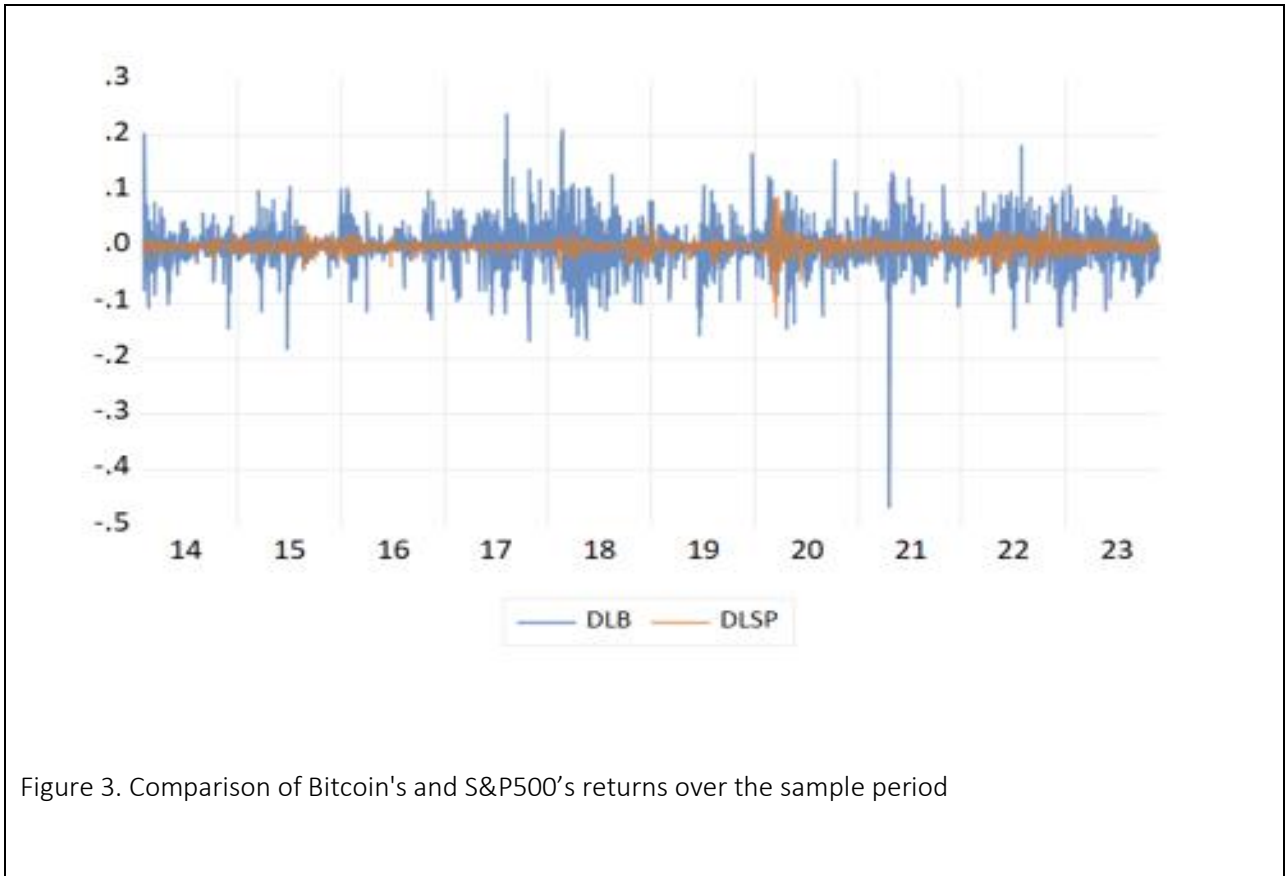

Figure 3. Comparison of Bitcoin's and S&P500's returns over the sample period

Source: Yahoo Finance; author's calculations. Note: Figure 3 uses daily data from January 2014 to November 2023 on returns. Bitcoin's returns are in blue while S&P500's are in orange.

The summary statistics for the daily returns and changes are presented in Table 1.

Table 1. Bitcoin's summary statistics

Mean	0.001852
Median	0.001671
Maximum	0.531706
Minimum	-0.77319
Std. Dev.	0.043511
Skewness	-1.964486
Kurtosis	56.99185
Jarque-Bera	315523.2
Probability	0
Sum	4.784945
Sum Sq. Dev.	4.890136
Observations	2584

Table 2. S&P500's summary statistics

Mean	0.000349
Median	0.000289
Maximum	0.089683
Minimum	-0.127652

Std. Dev.	0.01105
Skewness	-0.814487
Kurtosis	19.64246
Jarque-Bera	30106.28
Probability	0
Sum	0.901903
Sum Sq. Dev.	0.315383
Observations	2584

As we can see in Tables 1 and 2, S&P500 has the lowest negative mean return and Bitcoin has the greatest standard deviation amongst the two financial assets. The skewness, kurtosis and Jarque Bera statistics of Bitcoin returns suggest that the series are found to be leptokurtic and have a negative skewness, indicating a non-normal distribution and volatility clustering. Finally, the augmented Dickey–Fuller unit root test suggests that both the financial series returns are stationary.

Chapter 4: Methodology

Next, the dissertation employs various quantitative techniques to evaluate the hedging capabilities of Bitcoin. The efficacy of Bitcoin as a hedging instrument is assessed by employing traditional hedging models, including dynamic correlation, constant correlation, and Granger Causality.

4.1 Dynamic Correlation

Our discussion begins with a brief outlook of the correlation between the returns for Bitcoin and S&P500 over the years. Capturing correlation is going to be a great first indicator on whether Bitcoin can be considered as a diversifier when it comes to managing the risk of market movements. As discussed above, in investing, correlation is vital for creating a diversified portfolio to mitigate systematic risk with the use of non-correlated assets blend. Correlation indicates the relationship between two assets and is expressed numerically by the correlation coefficient which ranges between -1.0 and 1.0. For portfolio diversification, investors prefer negative correlation coefficients between asset classes to achieve the best possible risk management.

Pearson's correlation coefficient (r), developed by Karl Pearson in the early 1900s, is a statistical tool used to evaluate the strength and direction of the linear relationship between two continuous variables. It is commonly used to analyze whether there is a linear association between the S&P 500 and Bitcoin within specific time periods.

In our study, we will use moving correlation analysis to quantify the appropriateness of using Bitcoin returns to hedge adverse market movements over our sample's period.

Moving correlation represents the correlation coefficient between our assets in a chosen window for every observation. The data undergoes a shifting process where a window is moved at regular intervals, and calculations are performed at each fixed interval. The central point of this moving correlation window aligns with the time axis of the resulting outcomes. In our case we use 250 period backwards moving correlation, correlation between Bitcoin and S&P500 of the current and previous observations.

As a last endeavor, we calculate the constant correlation within each sub-sample to develop a greater understanding of the nature of the correlation existing between the two financial instruments under investigation. This process involves capturing the linear relationship between the assets across the sub-samples, providing deeper insight into their correlated behavior over specific periods.

The correlation coefficient is an easy-to-understand indicator when trying to measure how strong a relationship is between data. Nevertheless, it comes with significant limitations and drawbacks. One crucial pitfall is its inability to be interpreted as causal. While there might be a causal relationship between one variable and another, the correlation coefficient may not account for alternative explanations that could also be valid. That is why it is crucial to expand our analysis using a measure which captures causation.

4.2 Rolling Window Technique

A rolling window strategy is applied to capture the dynamic relationship between Bitcoin's and S&P500 returns.

In a rolling window, the length of the in-sample period used to estimate the model remains constant, with the start date and end date progressively advancing by a fixed number of observations. (Brooks, 2019)

The selection of the rolling window approach is necessary as it can be very useful to capture dynamic causality as it measures relationship between variables which change over time and the nature of structural changes makes this approach capable of estimating instability via the technic of different sub-samples. The rolling window approach involves systematically moving a fixed-size subsample through the entire dataset, progressing sequentially from the start to the end. Specifically, with a fixed-size rolling window containing

l observations, the entire dataset is transformed into a series of T-l subsamples, denoted as τ-l+1, τ-l, ..., T for τ= l, l+1, ..., T. Instead of conducting a single causality test for the entire dataset, the Granger causality test is applied to each of these subsamples. All variations amongst the causal links between Bitcoin and S&P500 for the period of 2014-2023 are detected by calculating and comparing p-values of observed VAR rolling through sub-samples. More importantly, the hedging ability that these result on causality can indicate mainly is also assessed in this study. The impact of Bitcoin on the market and vice versa is defined in this model with dlb representing Bitcoin returns and in a similar manner dlsp indicates S&P500 returns.

The rolling window estimation method is both convenient yet simple, but its effectiveness heavily relies on the chosen window size, which significantly influences the estimation of future correlations. Also, the significant challenge we face is determining the optimal size (N) for the window, as the outcome of the tests will heavily depend on this decision. The trade-off lies in the fact that if we chose to shape a small window, the analysis could lead to more volatile correlations, while a larger window could shape a smoother correlation plot.

Finally, it is important to note that when using the rolling estimator, equal weight is distributed between both old and new observations which may not be ideal, as the more recent observations are, the more likely to be more representative of current correlations than older ones. Therefore, the real challenge arises in the balancing of incorporating enough data for stability and ensuring that the most recent information has a more pronounced impact.

Although this approach comes with various challenges, the rolling correlation estimator is a helpful tool when it comes to assessing the nature of correlations over time.

We therefore created 9 sub-samples of data to efficiently determine how causality has changed as the two financial series matured, depicted in Table 3.

Table 3. 2-year sub-sample dataset with a 1-year rolling window
1/01/2014-12/31/2015
1/01/2015-12/30/2016
1/01/2016-12/29/2017
1/02/2017-12/31/2018
1/01/2018-12/31/2019
1/01/2019-12/31/2020

1/01/2020-12/31/2021
1/01/2021-12/30/2022
1/03/2022-11/28/2023

As depicted in Table 3 and 4, our comprehensive sample spans from January 1, 2014, to November 28, 2023. For our analysis, we utilize sub-samples of 2 years, employing a rolling window of one year. To ensure the robustness of our findings, we also conducted a parallel analysis on sub-samples per 3 years with one year rolling window presented in Table 4.

Table 4. 3-year sub-sample dataset with a 1 year-rolling window

1/01/2014-12/30/2016
1/01/2016-12/31/2018
1/01/2018-12/31/2020
1/02/2020-11/28/2023

4.3 Eagle Granger Causality

The Granger causality test is an advanced statistical approach utilized to "determine whether one time sequence can anticipate another time sequence" (Granger, 1969). Granger (1969) presents a practical definition of causality in the realm of economics, particularly focused on its application in forecasting. The definition of Granger causality is as follows: "Consider X_t and Y_t as two time series variables. X_t Granger causes Y_t if the previous values of X_t can help to improve the forecasting of variable Y_t statistically; if X_t cannot help to improve the prediction of Y_t ,it will not Granger cause Y_t. In other words, consider two strictly stationary time series X_t and Y_t. X_t Granger-causes Y_t if its current and previous values contain information, in addition to what is contained in the current and previous values of Y_t, that can significantly affect future values of Y_t."

The objective of this study is to analyze the causal relationship between Bitcoin and S&P500 for as available data collected as possible. To do so we deploy a Vector autoregressive models (VAR) proposed by Sims (1980). A Vector Autoregression (VAR) is a statistical framework employed to express the time- variant

relationship between multiple quantities. VAR, a form of stochastic process model, expands upon the single-variable (univariate) autoregressive model by accommodating multivariate time series. We consider the most basic scenario: a bivariate Vector Autoregression (VAR) model. In our case, the model includes the current values of two financial assets, Bitcoin and S&P500, which are influenced by distinct combinations of the preceding k values of both variables, along with error terms.

The theoretical equations are:

$y1t = \beta10 + \beta11\ y1t-1 + \cdots + \beta1k\ y1t-k + \alpha11\ y2t-1 + \cdots + \alpha1k\ y2t-k + u1t$

$y2t = \beta20 + \beta21\ y2t-1 + \cdots + \beta2k\ y2t-k + \alpha21\ y1t-1 + \cdots + \alpha2k\ y1t-k + u2t$

Where:

• y1t and y2t These are the values of the variables Bitcoin's returns and S&P500's returns at time t, where Δ signifies the difference from the previous period. The t subscript denotes the current time period.

• β10 and β20 are the intercept terms for both equations. They show the expected value of y1t and y2t when all other variables (the changes in Y or X at previous time periods) are zero.

• β1, β2: These are the coefficients of the lagged values of y1t and y2t respectively. They show the degree of influence that the changes in the value of y1t (or y2t) in the previous periods have on the change in the current period.

y1t−k and y2t−k, These are the lagged differences of the va ariables Bitcoin's returns and S&P500's returns respectively from the previous k periods.

•uit is a white noise disturbance term with E(uit) = 0, (i = 1, 2), E(u1tu2t) = 0.

4.4 Choosing the optimal lag length for a VAR

Our approach for selecting the appropriate lag length for VAR involves utilizing the Bayesian information criterion (BIC), also known as the Schwarz information criterion (SIC), SBC, or SBIC. These information criteria do not necessitate assumptions about the normality of error distributions. Instead, they balance the reduction in the residual sum of squares (RSS) for each equation as more lags are included, with an increase in the penalty term value. While the univariate criteria could be separately applied to each equation, we prefer to ensure that the number of lags remains consistent across all equations. This necessitates the use of multivariate versions of the information criteria, defined as:

$MSBIC = \log \hat{\Sigma} + k' T \log(T)$

where $\hat{\Sigma}$ represents the estimated variance-covariance matrix of residuals, T denotes the number of observations, and k indicates the total number of regressors across all equations. This total will equal p2k

+ p for p equations in the VAR system, each incorporating k lags of the p variables along with a constant term in each equation. As before, the information criteria values are computed for 0, 1, ..., k^- lags (up to a predetermined maximum value of k^-), and the selected lag length is the one that minimizes the Schwarz information criterion. (Brooks, 2019)

Table 5 describes Granger causality tests and implied restrictions on VAR models.

Table 5. Hypothesis Implied restriction

1 Lags of y1t do not explain current y2t	$\beta 21 = 0$ and $\gamma 21 = 0$ and $\delta 21 = 0$
2 Lags of y1t do not explain current y1t	$\beta 11 = 0$ and $\gamma 11 = 0$ and $\delta 11 = 0$
3 Lags of y2t do not explain current y1t	$\beta 12 = 0$ and $\gamma 12 = 0$ and $\delta 12 = 0$
4 Lags of y2t do not explain current y2t	$\beta 22 = 0$ and $\gamma 22 = 0$ and $\delta 22 = 0$

4.5 P-Values

In statistics, a p-value is employed to assess the statistical significance of findings. While it might indicate a correlation between two variables, the evidence might not be robust enough to make a strong assertion. A high p-value suggests there is adequate evidence to confidently assert that the population correlation coefficient differs from zero. In our analysis, we will utilize p-values to ascertain whether the null hypothesis (H0) is accepted at a significance level of 5%.

VAR approach has many advantages. The greatest advantage offered by this approach is that since only lagged variables are used on the right-hand side to model and forecasting, forecasts of the future values of the dependent variables can be measured entertaining only information coming from within the system. Since they are not developed conditionally on a specific set of assumed values, we could state these unconditional forecasts. On the other hand, upon already investigated values of other variables in the system it may be useful to generate forecasts of the future values of some variables conditional.

Consider a scenario where the values of certain variables are known before others. In such cases, it's logical to prioritize the use of known values in forecasting, as this approach is expected to yield more accurate results than unnecessarily relying on estimated values, which may lead to the neglect of valuable information. On the other hand, conditional forecasts offer an alternative avenue for analysis, allowing us to explore the potential impact of various scenarios by considering specific conditions or circumstances. In our bivariate VAR system incorporating Bitcoin returns and S&P returns, we are aiming to answer the

question: ‘What is the likely impact on the stock market over the next months of a percentage point increase a 1% rise in Bitcoins price?’

4.6 Volatility Spreads

The last pivotal measurement under scrutiny in our result interpretation of volatility between the two financial instruments is going to be the spread observed between their volatilities in every sub-sample. This analytical endeavor will be done by employing the simple yet informative statistic of standard deviation per sub-sample period. Standard deviation is essentially determined as the square root of the mean variance of the data from its mean.

Chapter 5: Results

In this section we describe the main findings of the models we entertained. As explained in ‘‘Methodology’’ section, we are going to initially apply a dynamic and a constant correlation analysis, an Eagle-Granger Test and finally measure volatility spreads to investigate the relationship between Bitcoin and S&P500 during the period of 2014-2023. This endeavor will be achieved by examining in parallel the two sub-sample datasets which we created after breaking the whole sample in sub periods, the first one containing 2-year sub-sample periods and the second 3-year ones.

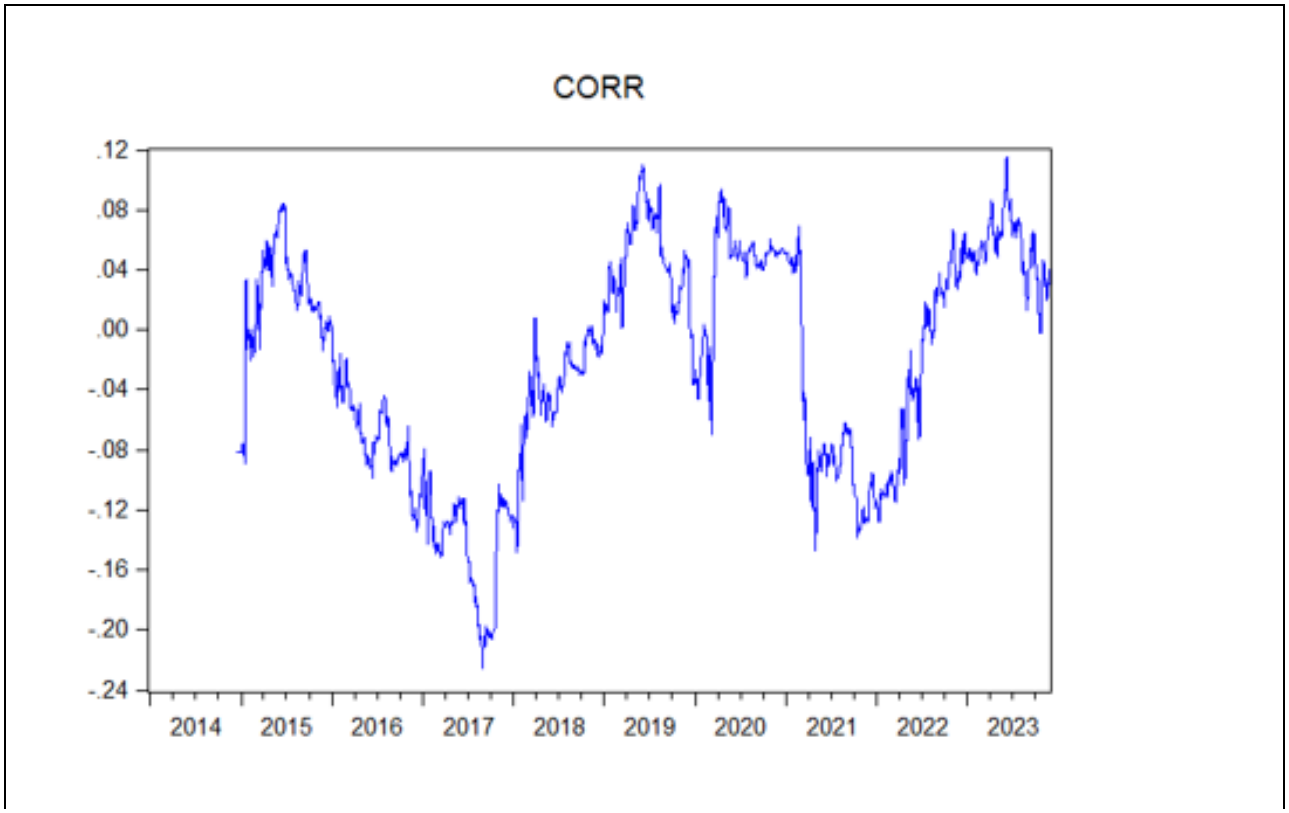

Figure 4. Dynamic Correlation between Bitcoin and S&P500

Source: Yahoo Finance; author's calculations. Note: Figure 4 uses daily data from January 2014 to November 2023

We begin our analysis looking at the correlation in returns, we notice that the correlation between the two-time series varies through the years. In 2014, correlation coefficient between Bitcoin and S&P500 is positive while this behavior shifts in 2017 when Bitcoin's price toped the eye-watering 20,000 milestone and achieving the lowest correlation coefficient till day at below -.20. This status did not last long as Bitcoins and S&P500 correlation coefficient kept rising after Bitcoin's price bubble burst on June 6, 2018- recording a loss of 625%, the biggest to date. This rise in the correlation coefficient suggests that Bitcoins use as a risk diversification asset was not functional during this time period, indicating investors disbelief in it. The correlation coefficient dropped below 0 with the announcement of the pandemic while it fluctuated around 0 to drop below –0.16 after the end of Covid-19 outbreak. During the post-pandemic period we observe an increase in the correlation between the two assets reaching an all-time high greater than 0.10 right before 2023. Due to all these constant fluctuations, it is very difficult to recognize a clear pattern yet between the relationship of the two financial instruments under investigation and thus we seek an approach to take a better look into their relationship.

Table 6. Constant correlation per sub-sample in the first selected dataset

SUB-SAMPLE PERIODS	Correlation
1/01/2014-12/31/2015	-0.04679586
1/01/2015-12/30/2016	-0.055090458
1/01/2016-12/29/2017	-0.09993025
1/02/2017-12/31/2018	-0.014606764
1/01/2018-12/31/2019	0.007012064
1/01/2019-12/31/2020	0.034606592
1/01/2020-12/31/2021	0.001695213
1/01/2021-12/30/2022	-0.013807077
1/03/2022-11/28/2023	0.038007

The same behavior is derived when considering constant correlation in Table 7.

Table 7. Constant correlation per sub-sample in the second selected dataset

SUB-SAMPLE PERIODS	Correlation
1/01/2014-12/30/2016	-0.058994355
1/01/2016-12/31/2018	-0.035595822
1/01/2018-12/31/2020	0.026486744
1/02/2020-11/28/2023	0.015573327

We therefore generate constant correlations in for every subsample per data set. As displayed in Tables 6 and 7 in detail, full-sample Granger causality test found absence of a causal relationship between Bitcoin's returns and S&P500 throughout the whole sample except from the period of 1/01/2014-12/31/2015 which p-values indicate that Bitcoin returns Granger Cause S&P500. This may be a result of Bitcoin gaining trust of the public after the creation of Bitcoin ATMs which cash could provide a convenient and fast way for users to engage with the crypto market, placing the cryptocurrency alongside physical currencies. Also, this is accompanied by the large disappointment for investors in 2015, as S&P500 closed at 2,044 less than 1% from where it started, ending its growth spree of several years. Nevertheless, the one time period Granger Causality cannot lead us to any assumptions about the long-term interrelations between the two assets.

TABLE 8. GRANGER CAUSALITY CONCLUSIONS IN THE FIRST SUB-SAMPLE SET

P-values per sub-sample	Conclusions	Period
0.7714	DLSP does not Granger Cause DLB	1/01/2014-11/28/2023
0.584	DLB does not Granger Cause DLSP	1/01/2014-11/28/2023
0.4425	DLSP does not Granger Cause DLB	1/01/2014-12/31/2015
0.0083	**DLB does Granger Cause DLSP**	**1/01/2014-12/31/2015**
0.4981	DLSP does not Granger Cause DLB	1/01/2015-12/30/2016
0.149	DLB does not Granger Cause DLSP	1/01/2015-12/30/2016
0.3113	DLSP does not Granger Cause DLB	1/01/2016-12/29/2017
0.1265	DLB does not Granger Cause DLSP	1/01/2016-12/29/2017
0.9466	DLSP does not Granger Cause DLB	1/02/2017-12/31/2018
0.8389	DLB does not Granger Cause DLSP	1/02/2017-12/31/2018
0.9769	DLSP does not Granger Cause DLB	1/01/2018-12/31/2019
0.5496	DLB does not Granger Cause DLSP	1/01/2018-12/31/2019
0.5709	DLSP does not Granger Cause DLB	1/01/2019-12/31/2020
0.7389	DLB does not Granger Cause DLSP	1/01/2019-12/31/2020
0.981	DLSP does not Granger Cause DLB	1/01/2020-12/31/2021
0.9113	DLB does not Granger Cause DLSP	1/01/2020-12/31/2021

0.3361	DLSP does not Granger Cause DLB	1/01/2021-12/30/2022
0.5263	DLB does not Granger Cause DLSP	1/01/2021-12/30/2022
0.9401	DLSP does not Granger Cause DLB	1/03/2022-11/28/2023
0.1016	DLB does not Granger Cause DLSP	1/03/2022-11/28/2023

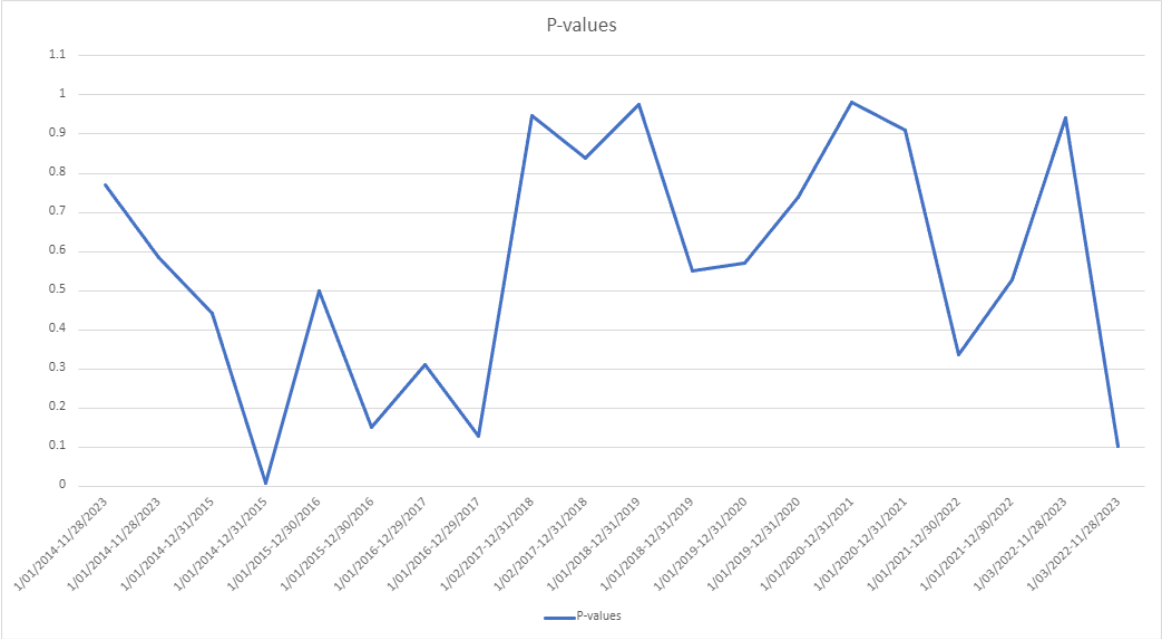

Figure 5. P-values of Null Hypothesis of the Granger Causality Test per subsample in the first dataset

Source: author's calculations. Note: Figure 5 uses daily data from January 2014 to November 2023 divided into sub-samples.

Table 5 represents a graph of p-values according to each VAR selected via the Schwarz Criterion. We can observe that there is not a p-value lower than the 5% significance level except from the 2014-2015 period. The same exact results are derived from the three-year period sub-samples with one year rolling window with Bitcoin's Returns Granger Causing S&P500 only on 1/01/2014-12/30/2016. This comes in line with decreasing correlation as displayed in the moving correlation graph above.

TABLE 9. GRANGER CAUSALITY CONCLUSIONS IN THE SECOND SUB-SAMPLE SET

P-VALUES PER SUB-SAMPLE	Conclusions	Period
0.7714	DLSP does not Granger Cause DLB	1/01/2014-11/28/2023
0.584	DLB does not Granger Cause DLSP	1/01/2014-11/28/2023
0.7518	DLSP does not Granger Cause DLB	1/01/2014-12/30/2016
0.0046	**DLB does Granger Cause DLSP**	**1/01/2014-12/30/2016**
0.8028	DLSP does not Granger Cause DLB	1/01/2016-12/31/2018
0.7131	DLB does not Granger Cause DLSP	1/01/2016-12/31/2018
0.7245	DLSP does not Granger Cause DLB	1/01/2018-12/31/2020
0.51	DLB does not Granger Cause DLSP	1/01/2018-12/31/2020
0.9865	DLSP does not Granger Cause DLB	1/02/2020-11/28/2023
0.3398	DLB does not Granger Cause DLSP	1/02/2020-11/28/2023

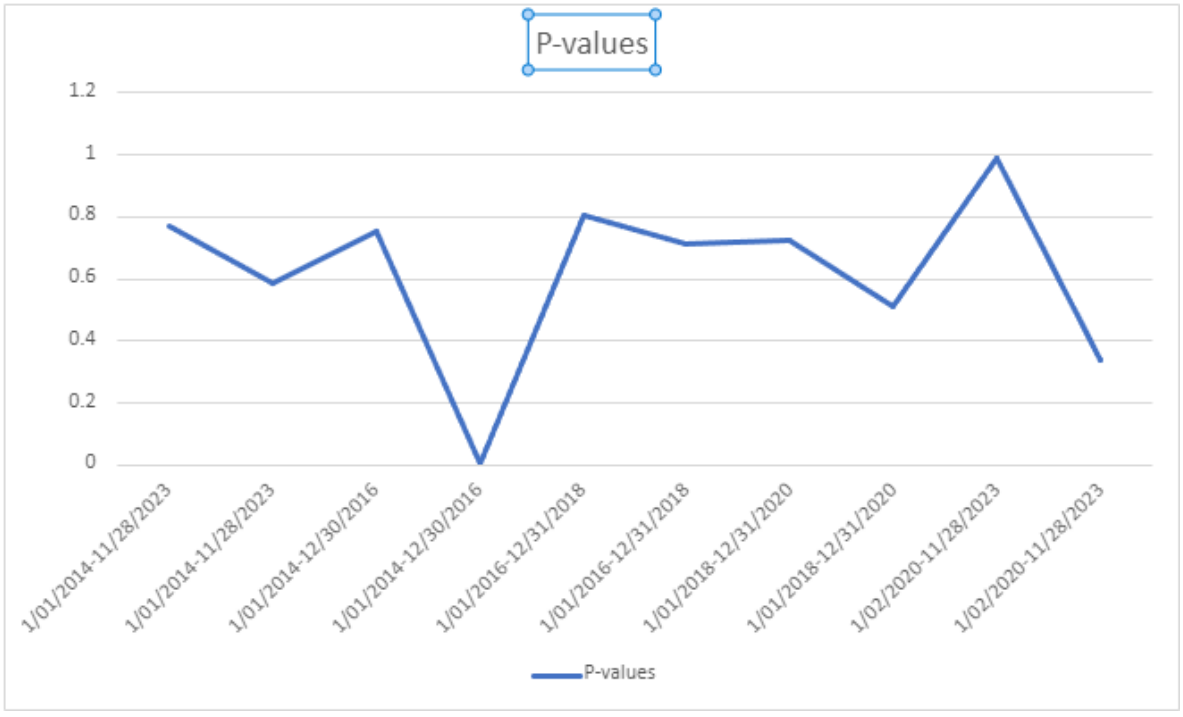

Figure 6. P-values of Null Hypothesis of the Granger Causality Test per subsample in the second dataset

Source: author's calculations. Note: Figure 6 uses daily data from January 2014 to November 2023 divided into sub-samples.

The empirical experiments based on daily data from January 1, 2014 to November 28, 2023 divided in 2 year sub-samples with 1 year rolling window show that the Granger causal effect of Bitcoin returns on S&P500 is week during the whole sample period with only exception the sub-sample period 1/01/2014-12/30/2016 for 5% significance level, while the reverse causal effect is weaker without any Granger Causality observed at 5% significance level.

The conclusion from the VAR methodology adopted in our study is that overall, Bitcoin returns fail to cause S&P500 returns and vice versa for the most part since the launch of the cryptocurrency. The results do not strongly suggest any significant influence on the market return series except from the first sub-sample in both considered datasets spanning from 2014 to 2016. This evidence shows that during periods of economic turbulence and uncertainty Bitcoin returns display a negative correlation with S&P500, meaning that it influences market returns. This influence is negative as Table suggests, which presents the constant correlation between the time series. Thus, Bitcoin during that time frame acted as a hedge against the S&P500 index.

Tables 7 and 8 depict the Volatility Spreads between Bitcoin and the S&P 500 index for the first and second sub-sample data respectively. As observed, the highest volatility buildout occurs in the sub-sample period between 1/01/2014 to 12/31/2015 in our first 2-year sub sample selection and this holds true for the 3-year sub sample dataset in the same period spanning from 1/01/2014-12/30/2016.

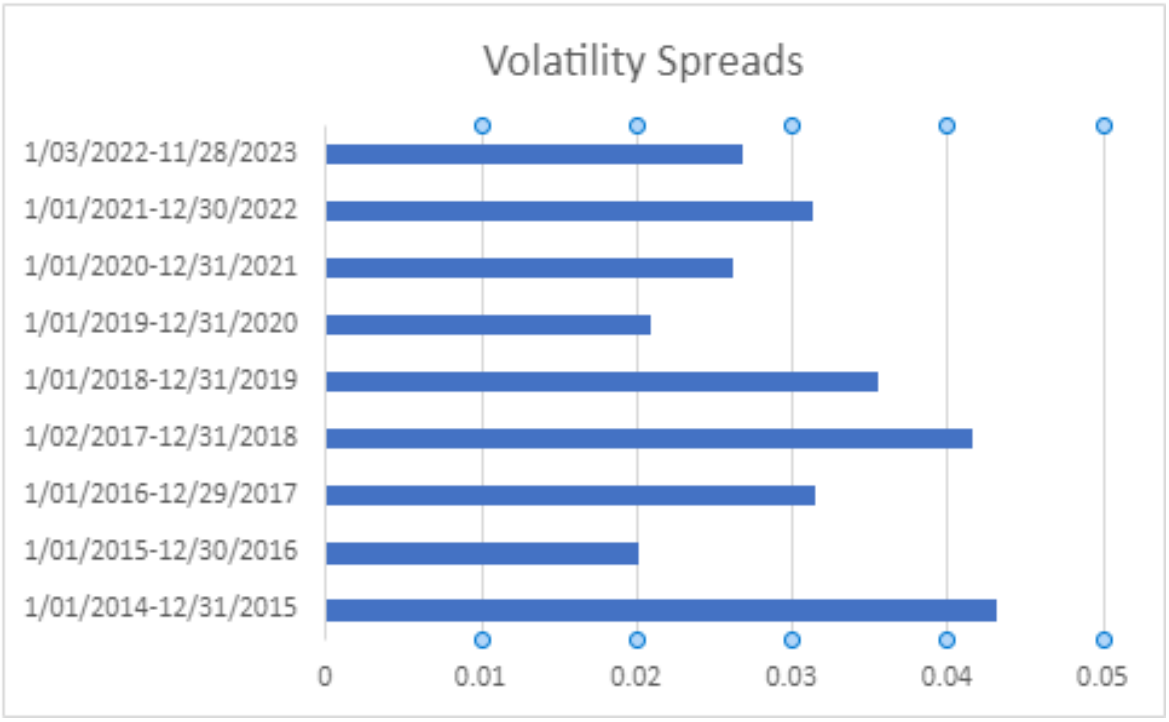

Figure 7. Volatility Spreads between Bitcoin's and S&P500's returns in the first selected dataset. Source: author's calculations

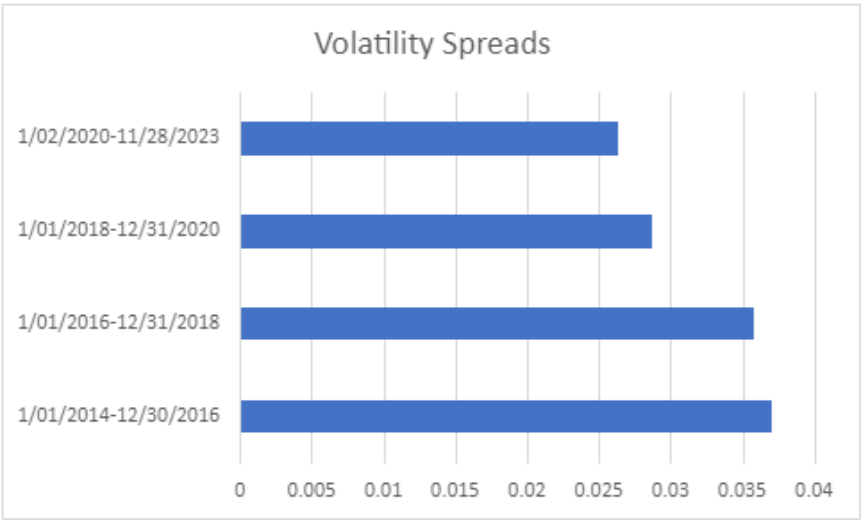

Figure 8. Volatility Spreads between Bitcoin's and S&P500's returns in the second selected dataset. Source: author's calculations

Understanding the historical volatility of Bitcoin can help investors assess the risk-return profile of including the cryptocurrency in their investment portfolios and define if it can ultimately be used as a hedger. Analyzing Bitcoin's standard deviation across sub-sample periods is going to offer us insights into the cryptocurrency's volatility dynamics, which can uncover investment decisions and behavior behind it, to enhance risk management strategies. The most interesting finding presented in Figure 8 is that Bitcoin's returns standard deviation peaked during the first sub-sample in both our datasets.

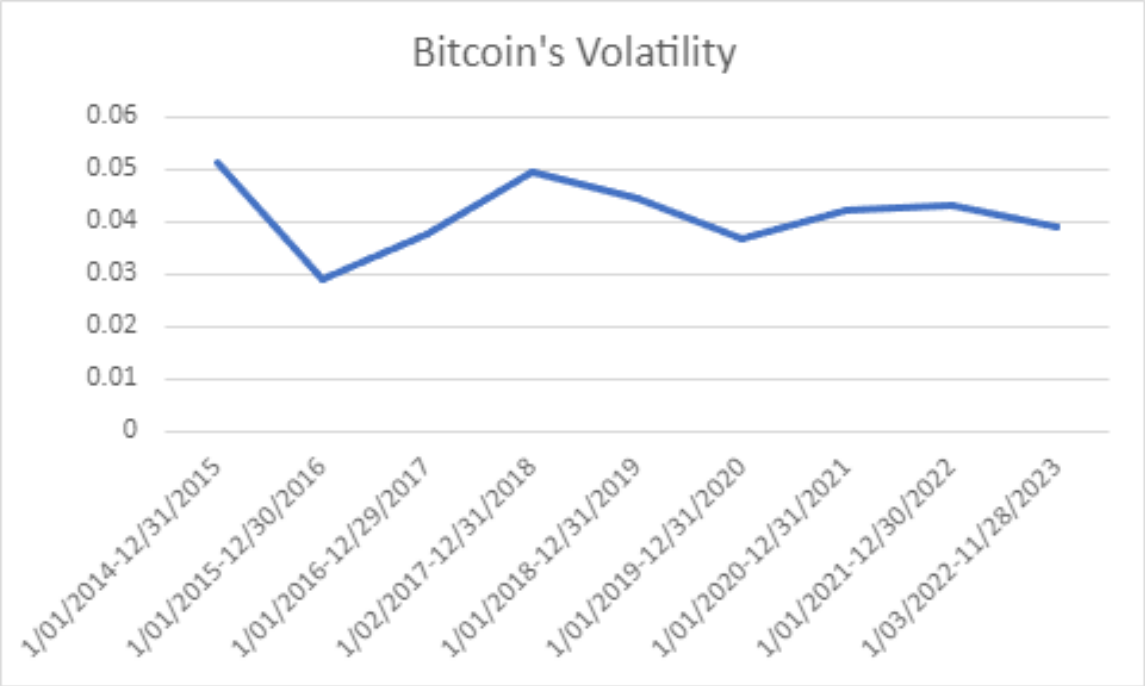

Figure 9. Bitcoin's Volatility per sub-sample in the first selected dataset.

Source: author's calculations

Chapter 6: Discussion

Bitcoin has earned its place alongside the greatest capitalization assets in the world and has rightfully established its position as the most important cryptocurrency until this day. This dissertation undertakes a comprehensive examination of the dynamic interplay between Bitcoin and the S&P 500, employing a

dynamic analytical framework that encompasses the most extensive period feasible given the available data. Central to its inquiry is the investigation of whether Bitcoin functions as a vehicle for portfolio diversification, thereby potentially mitigating exposure to systematic risks, or if its characteristics contribute to an amplification of overall market risk, all while considering the pronounced volatility inherent in the cryptocurrency. Although the initial conjecture suggested that a lack of clarity in this relationship during bear markets might render its efficacy in times of crises uncertain, the findings yielded unexpected insights. Our results are generally aligned with the literature proving once again that Bitcoin presents week casual links with the market. Our findings are consistent with Andersson and Fankl (2023) while they complement their research going further into the past and examining Bitcoin from its origins during distinct economic cycles. Time-varying causality tests between internet attention and trading volume show that each variable does not lead to the other with time and the causal effects are observed only at the maximum volatility spread. However, we emphasize when interpreting the results display above, proving that during the period of 2014-2016 in both the selected datasets, Bitcoin is found to Granger Cause S&P 500.

Concurrently, the analysis of constant correlation reveals that the relationship of the two assets was -0.0467 during the period 2014-2015 for our 2-year dataset and -0.0589 in 2014-2016 for our 3-year dataset. The common characteristic is that these correlations were negative making Bitcoin a hedger of S&P500. Consequently, the result deduced is that during instances of heightened volatility spreads such as the 2015–2016 stock market selloff including, the 2015–2016c Chinese stock market turbulence, the Greek debt default in June 2015 and Brexit, Bitcoin acted counteractive on the market dynamics, effectively assuming the role of a hedging instrument aligning with Shahzad et al. (2019), Bouri et al. (2017c) and Stensås et al. (2019). This confirms that great volatility spreads can be taken as an efficient signal of investor attention when it comes to hedging the market with the use of Bitcoin.

This characteristic was observed while our two assets volatility spread was the greatest of all time until today, aligning with López-Cabarcos et al. (2019) and Bakas et al. (2022) who presented that S&P500's returns have a major impact on the cryptocurrency's volatility and the former can act as a safe haven in periods of economic uncertainty. Nevertheless, as their findings suggest, Bitcoin's volatility is driven heavily on information about the stock market, making its investors rely more on sentiment and speculation.

Although this finding can be useful for investors, one should take into consideration the fact that during the same time Bitcoin acted as hedging instrument against market uncertainty, the cryptocurrency's volatility reached its greatest point, proving Baur and Dimpfl (2021) who demonstrated that this

asymmetric volatility stands in the way of firstly establishing Bitcoin as a medium of exchange but also as an investment.

Chapter 7: Conclusion

This dissertation undertakes a comprehensive examination of the dynamic interplay between Bitcoin and the S&P 500, utilizing a robust analytical framework that spans a considerable period to capture the evolving dynamics between these two assets. To accomplish this, we examined its properties, taking under consideration its price correlation with the market movements using S&P500 as market indicator.

To address the above, we estimated its dynamic correlation and Granger Causality with the representative index to capture its ability to take offsetting positions in related assets to reduce the risk of adverse price movements.

We demonstrate that significant volatility spreads, characterized by negative correlation coefficient between Bitcoin and the S&P 500, serve as potent signal of shifting investor behavior. As described extensively when volatility spreads widen, market participants are actively reassessing the role of Bitcoin as a hedging instrument. However, Bitcoin's volatility may reach extreme levels during periods of market uncertainty, which could pose challenges for its adoption as a medium of exchange or investment. This pronounced extreme volatility evident in Bitcoin's returns, coupled with its fluctuating correlation with market returns over time, prompts significant inquiries regarding its appropriateness as a hedging instrument, thereby rendering its role in portfolios puzzling.

It is crucial to analyze how Bitcoin’s volatility affects an individual's portfolio, as the asset is known for its price fluctuations in short periods, affecting its ability to hedge, in contrast to other hedging instruments which do not carry significant risk. Exploring the underlying factors driving Bitcoin’s volatility during specific periods of time can provide valuable insights into the dynamics of Bitcoin as a hedging instrument. By investigating potential factors contributing to Bitcoin's volatility during specific sub-sample periods, future research papers can advance our understanding of the cryptocurrency market and inform investors, policymakers, and market participants about the drivers of price fluctuations in the digital asset space.

Bibliography

Andersson, J. and Fankl, K. (2023). *Correlation and causality between the S&P 500 and Bitcoin: A comparative study before and during the COVID-19 pandemic*. [online] Available at: https://gupea.ub.gu.se/bitstream/handle/2077/77488/Correlation%20and%20causality%20between%20the%20S&P%20500%20and%20Bitcoin%20-%20A%20comparative%20study%20before%20and%20during%20the%20COVID-19%20pandemic.pdf?sequence=1 [Accessed 12 Feb. 2024].

Baek, C. and Elbeck, M. (2014). Bitcoins as an investment or speculative vehicle? A first look. *Applied Economics Letters*, 22(1), pp.30–34. doi:https://doi.org/10.1080/13504851.2014.916379.

Bakas, D., Magkonis, G. and Oh, E.Y. (2022). What drives volatility in Bitcoin market? *Finance Research Letters*, [online] 50, p.103237. doi:https://doi.org/10.1016/j.frl.2022.103237.

Barro, R.J. and Misra, S. (2016). Gold Returns. *The Economic Journal*, 126(594), pp.1293–1317. doi:https://doi.org/10.1111/ecoj.12274.

Baur, D.G. and Dimpfl, T. (2021). The volatility of Bitcoin and its role as a medium of exchange and a store of value. *Empirical Economics*, [online] 61(5). doi:https://doi.org/10.1007/s00181-020-01990-5.

Baur, D.G. and Lucey, B.M. (2010). Is Gold a Hedge or a Safe Haven? An Analysis of Stocks, Bonds and Gold. *Financial Review*, [online] 45(2), pp.217–229. doi:https://doi.org/10.1111/j.1540-6288.2010.00244.x.

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

Bouri, E. ;, Azzi, G., Dyhrberg, H., Anne, Bouri, E. and Anne Haubo Dyhrberg (2017a). *On the Return-volatility Relationship in the Bitcoin Market Around the Price Crash of 2013*. [online] Available at: https://www.econstor.eu/bitstream/10419/146870/1/869536516.pdf [Accessed 27 Jul. 2023].

Bouri, E., Gupta, R., Tiwari, A.K. and Roubaud, D. (2017b). Does Bitcoin hedge global uncertainty? Evidence from wavelet-based quantile-in-quantile regressions. *Finance Research Letters*, 23, pp.87–95. doi:https://doi.org/10.1016/j.frl.2017.02.009.

Bouri, E., Molnár, P., Azzi, G., Roubaud, D. and Hagfors, L.I. (2017c). On the hedge and safe haven properties of Bitcoin: Is it really more than a diversifier? *Finance Research Letters*, 20, pp.192–198. doi:https://doi.org/10.1016/j.frl.2016.09.025.

Brooks, C. (2019). *Introductory Econometrics for Finance*. [online] Higher Education from Cambridge University Press. Available at: https://www.cambridge.org/highereducation/books/introductory-econometrics-for-finance/75E9C608EA95A3AD87FB3BC683B9EBBF#overview.

Conlon, T. and McGee, R. (2020). Safe haven or risky hazard? Bitcoin during the Covid-19 bear market. *Finance Research Letters*, 35, p.101607. doi:https://doi.org/10.1016/j.frl.2020.101607.

Demir, E., Gozgor, G., Lau, C.K.M. and Vigne, S.A. (2018). Does economic policy uncertainty predict the Bitcoin returns? An empirical investigation. *Finance Research Letters*, [online] 26, pp.145–149. doi:https://doi.org/10.1016/j.frl.2018.01.005.

Dyhrberg, A.H. (2016). Hedging capabilities of bitcoin. Is it the virtual gold? *Finance Research Letters*, [online] 16, pp.139–144. doi:https://doi.org/10.1016/j.frl.2015.10.025.

Fang, L., Bouri, E., Gupta, R. and Roubaud, D. (2019). Does global economic uncertainty matter for the volatility and hedging effectiveness of Bitcoin? *International Review of Financial Analysis*, [online] 61, pp.29–36. doi:https://doi.org/10.1016/j.irfa.2018.12.010.

Federal Reserve Bank of St. Louis (1993). *St. Louis Fed Financial Stress Index*. [online] FRED, Federal Reserve Bank of St. Louis. Available at: https://fred.stlouisfed.org/series/STLFSI4.

Feng, W., Wang, Y. and Zhang, Z. (2018). Can cryptocurrencies be a safe haven: a tail risk perspective analysis. *Applied Economics*, 50(44), pp.4745–4762. doi:https://doi.org/10.1080/00036846.2018.1466993.

Gadi, M.F.A. and Sicilia, M.-A. (2022). Analyzing Safe Haven, Hedging and Diversifier Characteristics of Heterogeneous Cryptocurrencies against G7 and BRICS Market Indexes. *Journal of Risk and Financial Management*, 15(12), p.572. doi:https://doi.org/10.3390/jrfm15120572.

Gozbasi, O., Altinoz, B. and Sahin, E.E. (2021). Is Bitcoin a Safe Haven? A Study on the Factors that Affect Bitcoin Prices. *International Journal of Economics and Financial Issues*, [online] 11(4), pp.35–40. Available at: https://ideas.repec.org/a/eco/journ1/2021-04-5.html [Accessed 25 Jul. 2023].

Granger, C.W.J. (1969). Investigating Causal Relations by Econometric Models and Cross-spectral Methods. *Econometrica*, 37(3), p.424. doi:https://doi.org/10.2307/1912791.

Kayral, I.E., Jeribi, A. and Loukil, S. (2023). Are Bitcoin and Gold a Safe Haven during COVID-19 and the 2022 Russia–Ukraine War? *JRFM*, [online] 16(4), pp.1–22. Available at: https://ideas.repec.org/a/gam/jjrfmx/v16y2023i4p222-d1114375.html [Accessed 28 Jul. 2023].

Klein, T., Pham Thu, H. and Walther, T. (2018). Bitcoin is not the New Gold – A comparison of volatility, correlation, and portfolio performance. *International Review of Financial Analysis*, [online] 59, pp.105–116. doi:https://doi.org/10.1016/j.irfa.2018.07.010.

Koutmos, D., King, T. and Zopounidis, C. (2021). Hedging uncertainty with cryptocurrencies: Is bitcoin your best bet? *Journal of Financial Research*. doi:https://doi.org/10.1111/jfir.12264.

Kuepper, J. (2019). *CBOE Volatility Index (VIX) Definition*. [online] Investopedia. Available at: https://www.investopedia.com/terms/v/vix.asp.

Kuhn, T.S. (1962). *The Structure of Scientific Revolutions Second Edition, Enlarged*. [online] Available at: https://www.lri.fr/~mbl/Stanford/CS477/papers/Kuhn-SSR-2ndEd.pdf.

López-Cabarcos, M.Á., Pérez-Pico, A.M., Piñeiro-Chousa, J. and Šević, A. (2019). Bitcoin volatility, stock market and investor sentiment. Are they connected? *Finance Research Letters*, 38, p.101399. doi:https://doi.org/10.1016/j.frl.2019.101399.

Murinde, V., Rizopoulos, E. and Zachariadis, M. (2022). The impact of the FinTech revolution on the future of banking: Opportunities and risks. *International Review of Financial Analysis*, [online] 81(102103), p.102103. doi:https://doi.org/10.1016/j.irfa.2022.102103.

Naeem, M.A., Hasan, M., Arif, M. and Shahzad, S.J.H. (2020). Can Bitcoin Glitter More Than Gold for Investment Styles? *SAGE Open*, 10(2), p.215824402092650. doi:https://doi.org/10.1177/2158244020926508.

Nakamoto, S. (2008). *Bitcoin: a Peer-to-Peer Electronic Cash System*. [online] Available at: https://bitcoin.org/bitcoin.pdf.

Policyuncertainty.com. (2012). *Economic Policy Uncertainty Index*. [online] Available at: https://www.policyuncertainty.com/us_monthly.html.

Shahzad, S.J.H., Bouri, E., Roubaud, D., Kristoufek, L. and Lucey, B. (2019). Is Bitcoin a better safe-haven investment than gold and commodities? *International Review of Financial Analysis*, [online] 63(63). doi:https://doi.org/10.1016/j.irfa.2019.01.002.

Sims, C.A. (1980). Macroeconomics and Reality. *Econometrica*, [online] 48(1), p.1. doi:https://doi.org/10.2307/1912017.

Smales, L.A. (2019). Bitcoin as a safe haven: Is it even worth considering? *Finance Research Letters*, 30, pp.385–393. doi:https://doi.org/10.1016/j.frl.2018.11.002.

Som, A. and Kayal, P. (2022). A multicountry comparison of cryptocurrency VS gold: Portfolio optimization through generalized simulated annealing. *Blockchain: Research and Applications*, p.100075. doi:https://doi.org/10.1016/j.bcra.2022.100075.

Stensås, A., Nygaard, M.F., Kyaw, K. and Treepongkaruna, S. (2019). Can Bitcoin be a diversifier, hedge or safe haven tool? *Cogent Economics & Finance*, 7(1). doi:https://doi.org/10.1080/23322039.2019.1593072.

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

Su, C.-W., Yang, S., Qin, M. and Lobonţ, O.-R. (2023). Gold vs bitcoin: Who can resist panic in the U.S.? *Resources Policy*, [online] 85, p.103880. doi:https://doi.org/10.1016/j.resourpol.2023.103880.

Uddin, M.A., Ali, M.H. and Masih, M. (2020). Bitcoin—A hype or digital gold? Global evidence. *Australian Economic Papers*, 59(3), pp.215–231. doi:https://doi.org/10.1111/1467-8454.12178.

Wang, L., Sarker, P.K. and Bouri, E. (2022). Short- and Long-Term Interactions Between Bitcoin and Economic Variables: Evidence from the US. *Computational Economics*. doi:https://doi.org/10.1007/s10614-022-10247-5.

Wu, S., Tong, M., Yang, Z. and Derbali, A. (2019). Does gold or Bitcoin hedge economic policy uncertainty? *Finance Research Letters*, 31, pp.171–178. doi:https://doi.org/10.1016/j.frl.2019.04.001.

Xu, L. and Kinkyo, T. (2023). Hedging effectiveness of bitcoin and gold: Evidence from G7 stock markets. *Journal of International Financial Markets, Institutions and Money*, [online] 85, p.101764. doi:https://doi.org/10.1016/j.intfin.2023.101764.

Yermack, D. (2013). *Is Bitcoin a Real Currency? An economic appraisal*. [online] National Bureau of Economic Research Working Paper Series. Available at: https://www.nber.org/papers/w19747.

Zhang, Y., Zhu, P. and Xu, Y. (2021). Has COVID-19 Changed the Hedge Effectiveness of Bitcoin? *Frontiers in Public Health*, 9. doi:https://doi.org/10.3389/fpubh.2021.704900.