HEDGING CAPABILITY OF CRYPTOCURRENCIES TOWARD U.S. STOCK MARKET RETURNS: DOES STRUCTURAL CHANGE MATTER?

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LIST OF ABBREVIATIONS

ADF	Augmented Dickey-Fuller
BNB	Binance Coin
BTC	Bitcoins
CBOE	Chicago Board Option Exchange
CRYP	Return on Cryptocurrency
CSI	China Securities Index
DJIA	Dow Jones Industrial Average
EFFR	Effective Federal Fung Rate
EPU	Economic policy uncertainty
ETH	Ethereum
FGLS	Feasible Generalized Least Square
FTSE	Financial Times Stock Exchange
GARCH	Generalized Autoregressive Conditional Heteroscedasticity
LM	Langrage Multiple
MPT	Modern Portfolio Theory
PP	Phillips-Perron Test
S&P500	Standard & Poor's 500 Index
SSE	Shanghai Stock Exchange
VIX	Volatility Index

ABSTRACT

This research examines the relationship between cryptocurrency market and the U.S. market following a structural shift in China. The study reveals a positive correlation between the returns of the U.S. stock market and cryptocurrencies. Time series data collected on a weekly basis, spanning from January 4, 2017, to March 1, 2023, is utilized for this research. This research data has gone through various tests such as Augmented Dickey-Fuller (ADF) Test, Phillips-Perron (PP) Test, Generalized Autoregressive Conditional Heteroscedasticity model (GARCH), Feasible Generalized Least Square (FGLS), Jarque-Bera test, Breusch-Godfrey LM test, and ARCH Lagrange Multiplier (LM) Test. Hence, the regression model has proven to free from unit root, heteroscedasticity, autocorrelation and error term's normal distribution. The FGLS model is applied is to examine the hedging capability of cryptocurrencies against the U.S. stock market return before and after the structural change. The findings indicates that before the structural change cryptocurrencies return and U.S. stock market return exhibit a positive coefficient but insignificance. Whereas the outcome of cryptocurrencies returns and U.S stock market return becomes significant and positively correlated after the structural change. Furthermore, the finding of this research indicate that all independent variables have positive relationship toward U.S stock market. In brief, these results bring significant implication to investors, policymakers, and future researchers.

CHAPTER ONE: RESEARCH REVIEW

1.0 Introduction

This chapter will deliver an introduction related to the overview of cryptocurrency, which is Bitcoin, Ethereum, and Binance Coin. The course of China banning cryptocurrency will be discussed. Besides that, this chapter will also cover the relationship between cryptocurrency markets and U.S. stock markets. The following will cover problem statements, research questions, hypothesis statements, research objectives, and the significance of the study. The final section will detail the arrangement of chapters in this research.

1.1 Research Background

1.1.1 Cryptocurrency market

A new form of money referred to as cryptocurrency is produced digitally using cryptographic algorithms and exchanged online through protocols such as peer-to-peer networking (Hudson & Urquhart, 2019; Duque, 2020). Cryptocurrencies are built on the application of sophisticated cryptographic algorithms to offer customers a secure and safe medium of transaction which is another method to explain cryptocurrencies (Bulut, 2018). The first virtual money in the world, Bitcoin, was created by Satoshi Nakamoto in 2009. With the benefits of diversification and alternative investments in cryptocurrencies, transactions can be performed broadly (Qarni & Gulzar, 2021). The variety of

cryptocurrency investment opportunities has attracted market participants, decision-makers, and regulators to explore new market alternatives.

According to coinmarketcap.com (2022), the global cryptocurrency market worth is approximately 934.85 billion USD at the end of 2022， which was up slightly (4%) in the third Quarter of 2022 compared to the second Quarter of 2022. The market is projected to experience growth due to the rising demand for improved data security, transparency in operations, and the integration of blockchain technology into digital payment systems. Additionally, the legalisation of buying, selling, and trading digital currencies in various developed countries similar to the U.S. is contributing to the industry's trade expansion (Global Cryptocurrency Market Report 2022: Increasing Demand for Better Data Security & Operational Transparency Driving Growth - ResearchAndMarkets.com, 2022). As of November 2022, Bitcoin owns 36.62% of its dominance, with an estimated market cap of $318 billion in the market ("Crypto Market Cap Charts," 2022). The second largest cryptocurrency, Ethereum, has a total supply of $ 144 billion, accounting for 17.49% of the cryptocurrency market cap. Binance Coin has a market capitalisation of $49 billion with a market share of 5.93% (Cryptocurrency Market Capitalization, 2022). Over 12,000 cryptocurrencies have been created since the launch of Bitcoin (Daly, 2022). Cryptocurrencies depart from conventional currencies. The government and other institutions issue fiat currency, yet it is not pegged to the worth of commodities, gold, silver, or monetary instruments. Although cryptocurrencies are legal, law-unregulated currencies, this means that the supply of Bitcoin is not beneath the authority of any authorities or entities. It is not influenced by monetary policies; instead, they are regulated by technology.

According to Chiu and Koeppl (2017), the currency employs a digital ledger technology that maintains balances to keep track of the transaction without a central administrator from peer-to-peer trading, and that is decentralized, and accessible to all traders, known as the blockchain. Currently, tere are about

21,750 cryptocurrency projects out there that can represent the whole cryptocurrency market (Tretina, 2022). Among them, Bitcoin occupies the most significant market capitalization in the market, and the following are Ethereum and Binance Coin. The available variety of cryptocurrencies exceeds 12,000 because Bitcoin is rising in recognition and is accompanied by other cryptocurrencies. Admittedly, Ethereum and Binance coin are one of the most extensive uses of alternative cryptocurrencies.

1.1.1.1 Bitcoin (BTC)

Since Satoshi Nakamoto invented Bitcoin in 2009, it has received much attention. (Philippas, 2019; Zhu et al., 2021; Chen & Liu, 2021). Bitcoin has been traded for ten years, and various changes have been made, from the exchanges to the likelihood of their closure. Despite this, the nature of Bitcoin gives it particular default advantages and features. Bitcoin is a decentralized electronic in-cash system that allows transactions between parties without relying on mutual trust, which engages in peer-to-peer networks. It was first published in a paper by Satoshi Nakamoto (Kumpajaya & Dhewanto, 2015). The Bitcoin system was created to enable transaction carry in a short period and reduce transaction costs by excluding intermediaries.

As a result of the financial crisis and the financial system's collapse, digital currencies became a new class of assets because of their appeal. As a result, cryptocurrencies, typically Bitcoin, have attracted a great deal of attention (Bouri et al., 2017a; Castrén et al., 2020; Bakry et al., 2021). Moreover, it remains the most popular cryptocurrency even though other cryptocurrencies such as Ethereum, Litecoin, and Ripple have been introduced, especially after the ‘Bitcoin crash’ in 2018. Bitcoin’s nature and characteristics are the topics of a wide variety of viewpoints. Simultaneously, certain experts perceive it as a prospective substitute for official fiat currencies and a progressive stride

towards the advancement of digital financial systems (Bouri et al., 2017c). Conversely, a considerable number of practitioners and researchers regard it merely as an additional speculative asset (Glaser et al., 2014; Baek & Elbeck, 2015; Williamson, 2018). Selmi et al. (2018) compared both Bitcoin and gold, relating to it as ‘digital gold.’

Bitcoin is ‘digital gold’ despite how its amplified bubble-bust dynamics have frequently obscured the fundamentals of its pricing and connectivity to the rest of the traditional financial system. (Chiam & Laurini, 2019). Thus, the approach hypothesizes that Bitcoin and other crypto assets will become independent of conventional financial markets. The data of all Bitcoin is recorded in blockchain which is a shared ledger technology (Bouri et al., 2017c). The recorded data is validated using Proof of Work, a distributed consensus-based method (Quamara & Sigh, 2021). The central bank and other intermediaries have no involvement in the Bitcoin concept. The network's purpose is to incrementally expand the money supply, leading to a capped total of approximately 21 million BTCs (Nakamoto, 2009). The limit of 21 million BTC is expected to reach its peak by 2040. The process of creating new value is referred to as "mining," and it involves performing network activities, such as collecting and evaluating newly broadcast transactions and subsequently adding them to a block (Baur & Dimpfl, 2021).

The mining approach is the only way to generate Bitcoin. The miners need to provide Proof of authenticity to ensure the block is accepted in the network. The hash in nonce containing the previous block of the blockchain can generate complete order on all blocks in the chain network. Each block of Bitcoin initially includes 50 units of the digital currency, and when 210,000 blocks have been mined, the block size will be reduced by half. A block of Bitcoin is generated about every ten minutes. For every 2016 block that is mined, the mining difficulty, which is determined by hash rate, will be modified for purposes that regulate the rate at which blocks are generated. The amount of

computing power taken to mine a Bitcoin increases as the mining difficulty does. As of August 2022, 19,198706.25 bitcoins (BTC) are currently in existence. The outbreak of COVID-19 had an impression on the performance of cryptocurrencies, especially Ethereum and Bitcoin, but they exhibited a rapid recovery by the end of March 2020 (Naeem et al., 2021).

1.1.1.2 Ethereum (ETH)

Ethereum holds the position as the second leading cryptocurrency behind Bitcoin, boasting a market capitalisation of approximately £142 billion, and it operates with its native coin known as Ether (ETH). Ethereum was created by a Canadian programmer and writer called Vitalik Buterin in 2013 (Buccafurri et al., 2019). According to Urquhart (2022), Ethereum will provide a platform using blockchain technology. It is based on a peer-to-peer network that enables immutable transaction records on a public ledger. As a result, it can be transparent and more secure when transmitting information without third-party control (Hsain et al., 2021).

In contrast to Bitcoin, the Ethereum blockchain is more advanced and gives more advantages to Bitcoin blockchain, which not only provides a peer-to-peer transaction network. Ethereum can provide users several functions, such as smart contracts, development software, and decentralised autonomous organisations. We can see that many cryptocurrencies have already started using the Ethereum blockchain. It has become a dominant platform devoted to one country in development opportunities such as cultivating new markets and providing loans, registrations, and other resources (Buccafurri et al., 2019).

The Ethereum currency "Ether" (ETH) is a native coin platform to pay for gas. Gas is a unit measurement for any regional change in Ethereum, such as accounting services and transactions. Ether will be generated when a valid new

block is added to the network and carries the node that created this block. Therefore, users who have smart Ethereum should have their ether account (Buccafurri et al., 2019). Furthermore, Ethereum is different from Bitcoin as the maximum number is roughly 25 transactions per second, and we can see the average time between blocks is nearly 15 seconds. Furthermore, unlike Bitcoin, there is maximum mining. Therefore, the inventors anticipate switching to a PoS consensus technique in the future to increase network capacity (Wątorek et al., 2021).

The Ethereum platform can build decentralised applications without any possibility of downtime, censorship, fraud, or even code tampering with their users. It also enables the release of one's tokens using smart contracts, portions of computer code that execute a predetermined action following specific guidelines on the Ethereum blockchain. As a result, they managed to collect the funds for numerous projects by applying this application through Initial Coin Offer (ICO), which made ICO bloom in 2017 (Wątorek et al., 2021).

As mentioned above, Ethereum can provide smart contracts to its users. Smart contracts denote automated programs that can send and receive transactions, providing developers the power of high availability, auditability, neutrality**,** and transparency (Hsain et al., 2021). It has become a powerful world-class machine that uses custom blockchain. These applications work as planned, checked, closed, manipulated, or interrupted. Besides, the founder aims to create an open-source forum to streamline Blockchain (BC) technology process. Thus, major companies such as Microsoft and IBM have been attracted by Ethereum since it can be used in various business or financial sectors. The reason behind companies preferring the Ethereum platform is that it protects against system infiltration and guarantees security. Corporations and services built on Ethereum may transact with unknown businesses and services without the risk of fraud (Buccafurri et al., 2019). Other than that, one of the reasons the concept of the smart contract can be successful is because there is a spearheaded

competition that allows the creation of applications in a decentralised computing network such as EOS and Cardano (Wątorek et al., 2021).

1.1.1.3 Binance Coin (BNB)

Binance exchange has its cryptocurrency and has the tremendous daily trading volume of any cryptocurrency exchange in the world. Binance was originally founded in Hong Kong; after that, it needed to move out of its headquarters from China since China's government banned local cryptocurrency exchanges and initial coin offerings (ICO) in September 2017. Following months, Binance decided to transfer its headquarters to Malta when the regulatory framework for cryptocurrencies and blockchain technology was passed by the Maltese Parliament (Disli et al., 2022).

When it first started, only cryptocurrency trades were made on it. Binance, the cryptocurrency exchange, has introduced its proprietary cryptocurrency known as the Binance Coin (BNB), with the trading symbol "BNB." Upon its initial release in July 2017, Binance Coin (BNB) could be exchanged or traded for various other cryptocurrencies such as Ethereum, Bitcoin, Litecoin, and others. Initially, it functioned on the Ethereum blockchain as an ERC-20 token. However, it transitioned to become the native currency of Binance's independent blockchain platform in 2019 called Binance Chain. The native coin of the Binance Chain is the BEP-2 BNB (Academy, 2022). Users of Binance can use Binance coin to pay commissions on the exchange and provide the option to conduct transactions using almost 800 different cryptocurrency pairs (Mallick, 2020).

Further, the exchange also allows users to conduct ICO offerings there (Wątorek et al., 2021). By September 2020, Binance launched the BNB Smart Chain (BSC). BSC is the blockchain system that operates independently of the

BNB Beacon Chain. Consequently, BNB is accessible in three distinct forms now, which are BNB BEP-2, BNB BEP-20, and BNB ERC-20 (Academy, 2022). Until now, Binance has a vast trading volume similar to Bitcoin, with a market capitalization of 51.7 billion. It has become one of the most well-known cryptocurrencies in the world, the Binance coin. There is a tight cap of 200 million BNB tokens for Binance currency (Mallick, 2020).

The Binance Smart Chain can be used by Binance Coin (BNB) to execute hundreds of transactions. Besides, it shows that Binance Coin (BNB) is off to a wonderful start, with a gain of more than 24.7% in 2023. This proves that Binance Coin (BNB) has already become one of the popular crypto tokens in the market (Guest Columnist, 2023). When the Binance Coin was created through an initial coin offering (ICO), around 50% of the funds received were allocated for marketing and branding. In comparison, the development of the Binance trading platform earmarked 33% of the funding and other crucial upgrades within the ecosystem (Mallick, 2020). Further, Binance wants to ensure a limited supply of Binance Coin to foster scarcity and increase its value over time, thus becoming scarce and more valuable. Binance will use 20% of its revenues to buy back and destroy it until 50% of the total supply has been burned (Corporate Finance Institute, 2022).

Besides, when cryptocurrency exchanges become more popular, many investors shift to speculation in cryptocurrency instead of mining cryptocurrency. The idea of volatility is an essential factor to the investor when Binance has been released in the market. Therefore, more investors were speculating due to the Binance coin's volatility and rapid growth. In addition, many new investors do not grasp the fundamentals and mechanisms behind home prices. Therefore, they are determined to use cryptocurrency exchanges due to the convenience of entrance and the desire for profit (Mallick, 2020).

1.1.2 The event of China banned cryptocurrency

Cryptocurrencies have gained popularity as a preferred option among investors looking to hedge their investments and reduce risk (Hung, 2022). However, cryptocurrencies differ from the stock market in terms of volatility. Markus Vogl's research found that the S&P 500 has fluctuated between 13-50% over a 20-year period (Clark et al., 2023; Vogl, 2023). By comparison, the volatility of Bitcoin has been much higher. Between 2015 and 2019, the value of Bitcoin increased from 0.734 to 273 per USD, an increase of over 300 times (Zheng et al., 2023). However, this also means that the risk associated with cryptocurrencies is higher. For example, Bitcoin, as the leader in the cryptocurrency market, can drop by 75% in just one year, as seen from November 2021 to November 2022 (Figure 1.1.2.1). Thus, there is no correlation between the two trading markets. Moreover, the complete closure of bitcoin mining activities in China in 2021 led to market turmoil, with Bitcoin suppliers shifting their mining locations and the mining bitcoin hash rate in the United States increasing while decreasing in China, even linking to the S&P 500 stock market.

According to ElBahrawy et al.'s (2017) research, Bitcoin was established in 2009 as a medium of exchange, primarily aimed at reducing consumer costs through the use of cryptocurrencies. Remittances, which incur significant intermediary fees and payment delays across borders, are commonly utilized by individuals and institutions for transactions. Cryptocurrencies, such as Bitcoin, offer a compelling alternative as they have significant potential to address these challenges (ElBahrawy et al., 2017). Additionally, Bitcoin has gained popularity among investors as a hedge against market inflation and national government policy instability, particularly during the COVID-19 pandemic (Cheah & Fry, 2015). These observations underscore the significant potential of cryptocurrencies relative to the remittance values correlation between the

two trading markets. Moreover, the complete closure of bitcoin mining activities in China in 2021 led to market turmoil, with Bitcoin suppliers shifting their mining locations and the mining bitcoin hash rate in the United States increasing while decreasing in China, even linking to the U.S. stock market.

However, the People's Bank of China (PBC) declared that Bitcoin was not considered a legal tender in the market, classifying it as a virtual commodity by December 2013. As such, it lacks legal support and is subject to financial and payment institution restrictions in stages. The primary objective of the PBC in not recognizing Bitcoin was to safeguard the legal tender status of the Chinese yuan, protect against the risks of money laundering, and ensure overall financial stability (The Central People's Government of the People's Republic of China, 2013). China's central government contends that Bitcoin transactions pose a risk of money laundering and are frequently used by criminals as they offer anonymity and are not subject to national or regional regulations. Consequently, it is challenging for the government to monitor Bitcoin transactions and prevent illicit activities, such as drug and gun trading. Additionally, avoiding the hype surrounding Bitcoin is necessary to prevent undermining the national currency's status (Nasreen et al., 2022). Moreover, some investors are inclined to speculate and follow trends to obtain higher returns.

Conversely, some investors who lack a deep understanding of Bitcoin tend to overlook the speculative risk associated with it. The price of Bitcoin is subject to fluctuations with no upper or lower limits, and it can be easily manipulated by speculators, including foreign financial institutions, listed companies, and retail investors. Nonetheless, the Chinese government has emphasized that it will not interfere excessively with trading activities, buying or selling, and that all participants must bear the remaining risks and losses (Wu et al., 2022).

The swift rise of cryptocurrencies has enticed numerous retail investors and investment institutions to participate in the cryptocurrency market. However,

the launch of Initial Coin Offering (ICO) in September 2017 prompted a Chinese economist study in October, which concluded that ICOs could potentially impact the economy and financial markets. Consequently, the Chinese government banned ICOs, which led to losses incurred by Chinese investors when the Bitcoin market fell sharply by 200 points in a brief period (Okorie & Lin, 2020). Subsequently, Chinese investors adopted a new method to transact by transferring Tether for conducting cryptocurrency transactions, rendering the Chinese government's supervision of cryptocurrencies ineffective (Chen & Liu, 2021). Moreover, by the end of the year, the government established a trading currency framework and outlawed any exchange or financing activities (Rain Xie, 2019). However, it did not impede cryptocurrency mining in the country (Kliber et al., 2019). Thus, a country's economic policies impact cryptocurrencies, such as the Chinese government's ban, which inflicted severe damage on Bitcoin in a brief period (Cheng & Yen, 2019). From an investor's viewpoint, when a country's economic policy uncertainty (EPU) alters, investors may lose faith in the market, leading to frenzied selling by retail investors and a decline in stock prices.

With the continuous development of Bitcoin, the need for more instruments and networks to operate has become increasingly important for developers. Due to the significant returns received by developers in 2018, they have chosen to increase the speed of mining, resulting in a continuous rise in electricity consumption (Köhler & Pizzol, 2019). Figure 1.1.2.1 shows that China's Bitcoin electricity consumption and network consumption have been rising to new heights (de Vries, 2020). Research indicates that from 2014 to 2018, the hash rate cost of mining Bitcoin has more than doubled, with the primary reason being the rise in mining instruments rather than the increase in electricity prices (Kristoufek, 2020). Currently, China dominates the mining ratio of Bitcoin, accounting for 65%, while the United States follows at 7.2%. The significant energy requirements of mining are beginning to impact the environment in China, with developers using coal and natural gas to fill the power shortage and

maximize profits during the Bitcoin prosperity. Consequently, in 2019, the Chinese government gradually intervened in addressing Bitcoin's excessive energy use (Umar et al., 2022).

In 2021, the Chinese government imposed strict restrictions on Bitcoin mining due to environmental concerns, which led to many mining operations being shut down in Inner Mongolia, Xinjiang, and Sichuan. This resulted in a significant decline in China's share of the Bitcoin mining market. In September, the central government also announced a ban on cryptocurrency trading, which was listed as a criminal offence. Many merchants and developers chose to move their operations to other countries, including the United States, where the government has taken steps to promote environmentally sustainable mining practices.

In January 2022, Geosyn Mining co-founder Caleb established a mine in Texas that uses solar energy as its primary power source, further demonstrating the industry's shift towards environmentally friendly practices. As a result, the United States hashrate has been steadily increasing and is now among the highest in the world, while China's hashrate has declined. This shift has significant implications for the future of Bitcoin mining, as it highlights the importance of sustainable practices and the potential for other countries to emerge as major players in the industry.

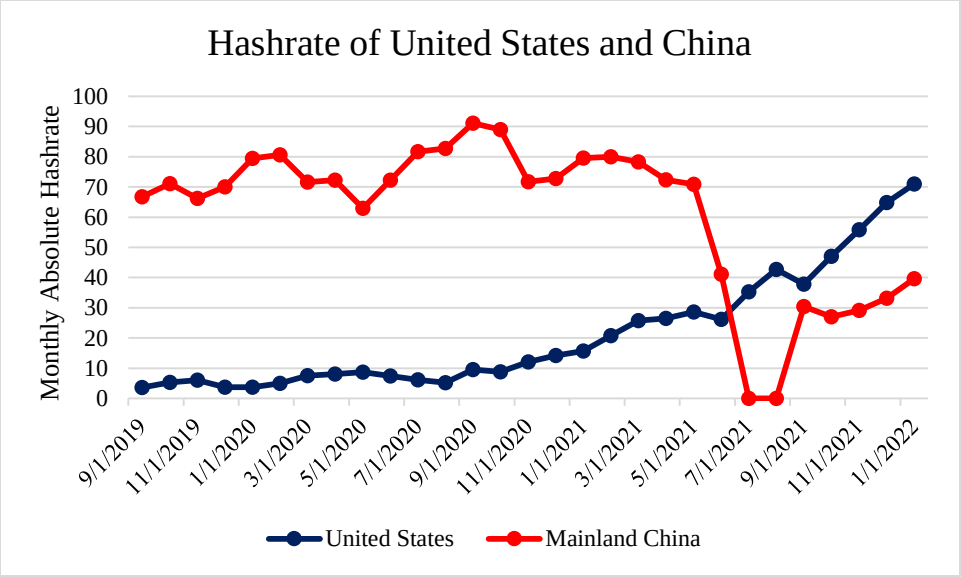

Figure 1.1.2.1. Monthly absolute hashrate of United States and China from 2019 to 2022.

1.1.3 The relationship between cryptocurrency and U.S. stock market

According to S&P Global (2022), the Standard & Poor's (S&P) 500 Index was introduced in 1957 by S&P Dow Jones Indices. S&P 500 Index represents a series of indices that monitors and tracks the significance 500 listed companies' stock performance on American stock exchanges, which meet the requirement set by the index committee (Kenton, 2021). The S&P 500 Index is widely considered the primary indicator of the U.S. equity market and serves as the performance benchmark for many funds. As a result, the index serves as both a benchmark for the performance of the U.S. equities market and a representation of the U.S. equity market (Asem & Alam, 2012). The S&P 500 Index is structured as a free-float capitalization-weighted index, which signifies that companies' weights within the index are determined based on their market capitalizations (S&P Global, 2022).

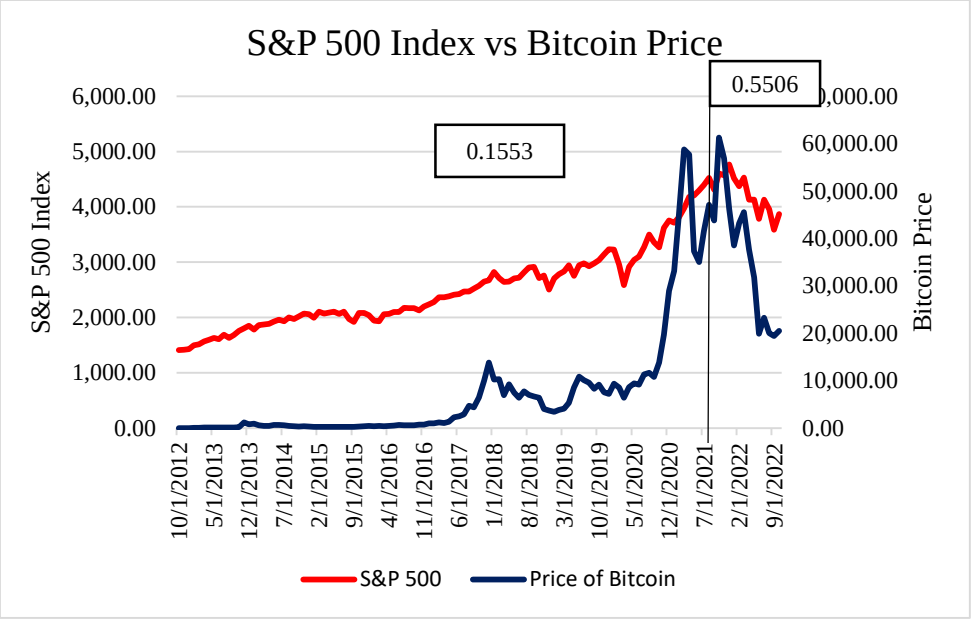

Figure 1.1.3.1. S&P 500 index and Bitcoin index from 2012 to 2022.

Figure 1.1.3.1. shows the trends of the S&P 500 and Bitcoin indexes from October 2012 to October 2022. We will use the Bitcoin index to represent the whole cryptocurrency market because Bitcoin has the largest market capitalisation among the cryptocurrencies.

There was a significant change in the S&P 500 index's movement during the financial crisis that engulfed the world in the fall of 2008 began in the credit market, especially the market for mortgage-backed collateralized bonds in the summer of 2007 (Birru & Figlewski, 2012). However, it took time before any noticeable effect on the stock market. The S&P 500 Index reached 1,576.09 in October 2007, when U.S. stock prices achieved an all-time high. The S&P 500 index remained at or near 1,300 at the end of August 2008, despite the fact that it has now been proven that the economy started a recession in December 2007.

Standard & Poor's (S&P) downgraded the credit rating of the U.S. fiscal for the first time, reducing it from AAA to AA+, owing to a previous debt ceiling standoff (Standard & Poor's, 2011). This action raised concerns among the

public that a hike in the debt ceiling might imply a potential government default on interest payments to creditors. As a consequence, both the U.S. and international stock markets experienced a decline on 8th August 2011, as investor confidence was negatively impacted by the struggling U.S. economy and the escalating European debt crisis (Johnson, 2011).

Bitcoin (BTC) was launched by Satoshi Nakamoto in 2019. Bitcoin was originally worth nothing. Although Bitcoin was worth nothing, it created a buying and selling service, which is the New Liberty Standard, on 5th October 2009. Hence, the first Bitcoin/USD exchange rate was $0.00764 per Bitcoin.

The first U.S. bitcoin exchange-traded fund (ETF) commenced trading on The New York Stock Exchange on 19 October 2021, and the Bitcoin price hit its highest price, which is $66,974.77. The Federal Reserve intends to raise interest rates due to rising inflation. Bitcoin fluctuated around the $40,000 level, but in March, as the Fed began to hike interest rates rapidly, it started to fall to the range of around $20,000 (Coryanne, 2020).

Bitcoin's growth was accelerated by the pandemic shut down and the ensuing government initiatives that affected investors' concerns about the world economy. It is because investors began considering cryptocurrency as a hedge against inflation and crisis. There are few academics that have analysed the relationship between Bitcoin and other traditional financial assets, and it showed that cryptocurrency might provide hedging and diversification benefits to investors (Corbet et al., 2018). Furthermore, according to Baur et al. (2018), Bitcoin exhibits a lack of correlation with other financial assets due to its distinct risk-return profile and adherence to a unique volatility process.

Moreover, according to the research by Briere et al. (2015), Bitcoin has a low correlation with the stock market but a significant correlation with gold and inflation-linked bonds. In addition, Dyhrberg (2016) found that Bitcoin has

similar hedging capabilities to gold. Due to its similarities to gold as a safe haven asset, some academics describe Bitcoin as a form of digital gold (Selmi et al., 2018). Furthermore, it implies that the properties of Bitcoin in hedging and diversifying portfolio risks are the same as gold. Therefore, many investors imply Bitcoin to their portfolio to offset the risk in the stock market.

Cryptocurrencies can be viewed as alternative investment tools to hedge due to their high average returns, decentralised, deflationary, non-cash-yielding, and low correlation with other financial assets (Urquhart & Zhang, 2019; Guesmi et al., 2019). In other words, if a portfolio holds various assets simultaneously, cryptocurrency may fill a variety of roles, including a safe haven, hedging asset, and diversification tool (Wang et al., 2019).

1.1.4 The relationship between cryptocurrency and Shanghai Stock Exchange (SSE) and CSI 300

China Securities Index 300 (SSE) is the largest stock exchange in China and the third largest in the world, founded in 1990 (Meng et al., 2023). In 2022, the number of listed companies classified under SSE reached a peak of 2,174, compared with 842 in 1991. The SSE 50 is used as a standard benchmark for many investment institutions and investors in the Chinese Stock Market. Additionally, the SSE plays a crucial role in enhancing predictive capabilities for future market trends, while the SSE 50 index represents the 50 largest Chinese Blue-Chip stocks (Wen et al., 2020). As a result, the index serves as both a performance benchmark for China's equities market and a representation of the Chinese Yuan (RMB) (China | Shanghai Stock Exchange: Number of Listed Companies and Securities | CEIC, 2022).

The CSI 300 represents the top 300 listed companies in China and is a combination of both the SSE and Shenzhen Stock Exchange listed companies.

The Shenzhen Stock Exchange stands as the second largest listed exchange in China, and the CSI 300 comprises competitive companies that exemplify China's robust economy. It is worth noting that the China Securities Index 300 (CSI 300) undergoes bi-annual reviews and adjustments to ensure it accurately reflects the latest performance of the top 300 stocks, thereby upholding the index's quality. These adjustments are dependent on factors such as the firm's stock price, the liquidity of A-share stocks, and market capitalization (Li et al., 2023; Liu et al., 2023). Therefore, the utilization of the CSI 300 also serves as a representation of China's economic system.

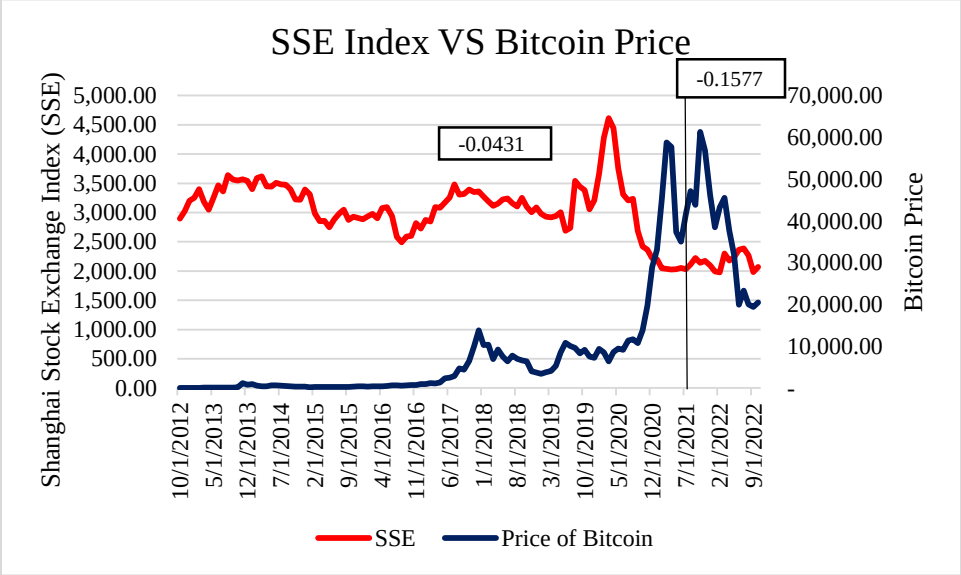

Figure 1.1.4.1. SSE index and Bitcoin price from 2012 to 2022.

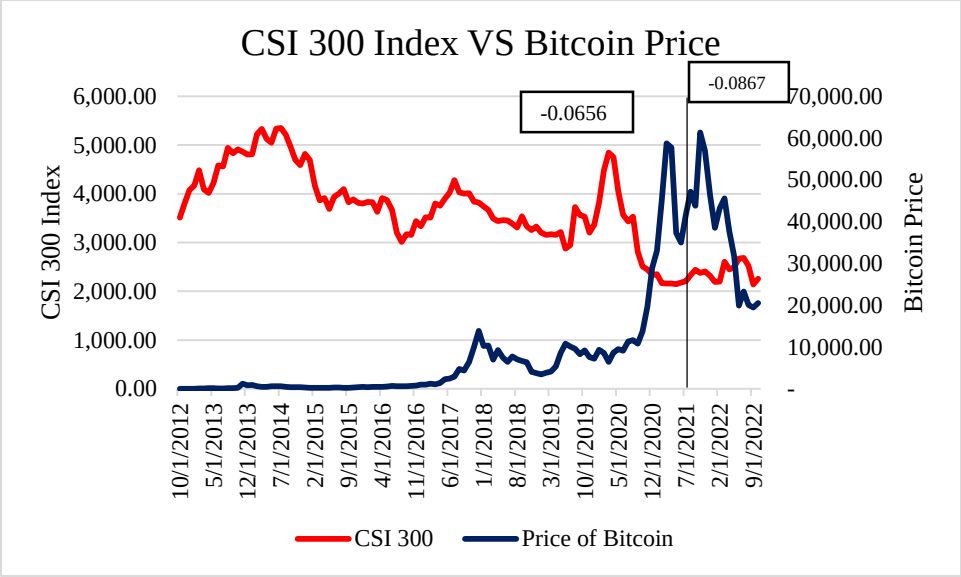

Figure 1.1.4.2. CSI 300 index and Bitcoin price from 2012 to 2022.

Figures 1.1.4.1 and 1.1.4.2 display the movement of SSE, CSI, and the Bitcoin index from October 2012 to October 2022, respectively. The Bitcoin index will be employed as a representative indicator for the entire cryptocurrency market due to its status as the cryptocurrency with the highest market capitalization among all available cryptocurrencies.

During the period from 2012 to 2022, distinct trends were observed in Bitcoin in comparison to the SSE and CSI indices. Between 2012 and 2019, the SSE index demonstrated relative stability, with fluctuations ranging between 2500 and 3500 points, lacking a clear market development trend. The highest point reached was 3558 in April 2015, whereas the lowest point was recorded at 2494 in August 2016. On the other hand, the CSI composite index experienced a peak at 5331 points and reached its lowest point at 2156 points.

In contrast to the trends observed in the Chinese market, Bitcoin's trajectory over the ten-year period showed distinct patterns and did not follow the same course (Yuan et al., 2023). Figures 1.1.4.1 and 1.1.4.2 illustrate that the correlation between the July 2021 SSE Index and CSI 300 Index with the price of Bitcoin was -0.0431 and -0.0656, respectively. However, beyond that point, there seemed to be no significant relationship between the Chinese market and Bitcoin, with correlations of -0.1577 and -0.0867, respectively.

On the other hand, when compared to the U.S. stock market, Bitcoin exhibited a substantial impact, with correlations of 0.1553 and 0.5506 (refer to page 19 Figure 1.1.3.1), indicating a relationship that was more than triple the association observed with the Chinese market. Although correlation does not imply causation, it can be a preliminary observation to identify potential relationships.

1.2 Problem Statement

Investor interest in safe-haven assets is typically piqued during times of heightened risk and volatility in financial markets, such as the 2008 global financial crisis and the COVID-19 epidemic. In such crises, stock markets often turn to safe-haven assets as a means of mitigating risk. The swift growth of the global economy has given rise to numerous currency-related events marked by volatility, including the Swiss franc black swan event, the U.S. subprime mortgage crisis, and the European debt crisis. The continuing COVID-19 pandemic, with its potential risks to public health, has had a substantial influence on global financial markets. Consequently, a thorough examination of the role of safe havens during pandemics is urgently required. The objective is to reduce currency exposure and aid investors in identifying "safe havens" during times of currency market volatility.

A safe haven asset that also serves as a hedge can be defined as an asset that is uncorrelated with another asset or portfolio and has a negative relationship during periods of market turbulence (Baur & Lucey, 2010a). Some reports suggest that neither Bitcoin nor gold can serve as a safe haven or hedge during economic policy uncertainty (Shan et al., 2019). However, Owusu et al. (2020) conducted research on gold and eight cryptocurrencies from April 2013 to April 2019. Using EEMD-based quantile-on-quantile regression, they found that gold and cryptocurrencies can serve as hedges and provide diversification against each other at different points in their returns (Barson et al., 2022). They also discovered that gold and cryptocurrencies exhibit the same characteristics as traditional assets such as crude oil and fiat currencies, which contradicts the study of Klein et al. (2018). Additionally, according to Yang et al. (2022), the relationship between assets and the currency market weakens as the time horizon increases, but Bitcoin remains the best diversification tool at any time scale (Yang et al., 2022).

In 2021, the Chinese government announced a ban on Bitcoin mining and trading, which caused widespread panic as China accounts for more than 50% of Bitcoin mining worldwide (Ferman, 2022). Prior to 2021, the Chinese government had already tightened its control over the cryptocurrency market through policies implemented in 2017 and 2019. The primary reason for China's policy shift was the migration of miners to the United States, particularly to Texas (Strachan, 2022). The Governor of Texas, Greg Abbott, even extended a welcoming hand to Chinese Bitcoin companies, such as BIT mining, which invested $26 million to build a global hub for Bitcoin mining in the state. The appeal of Texas lies in its reputation for low taxation and inexpensive electricity fees, which can significantly reduce mining costs (Strachan, 2022). However, Texas faces its own challenges, particularly during the winter season, when the primary energy supply is solar, and the electricity supply can be insufficient (Perez, 2022; Riggs, 2022). Nevertheless, the Texas government is committed to addressing this problem and has plans to increase the electricity supply by 500% by 2030, as seen in Figure

1.1.2.1. As a result of China's policy change, Figure 1.1.2.1 also reveals an increasing demand for hashrates in the United States.

As previously stated, cryptocurrencies are believed to be uncorrelated with the U.S. stock market, making them an attractive alternative asset for investors looking to diversify their portfolios and hedge against market risk. However, the 2017 ban on cryptocurrency transactions by the Chinese government may have introduced a structural change in the relationship between cryptocurrencies and the U.S. stock market, as depicted in Figure 1.1. Zeng et al. (2020) conducted an analysis of the spillover index framework to investigate the relationship between Bitcoin and traditional financial assets such as the U.S. market. Park et al. (2021) also noted that Bitcoin reacts more strongly to exchange rates and stock markets than new markets. Furthermore, as indicated by Documents et al. (2021), when Bitcoin exhibits high volatility relative to the S&P 500, there is a positive correlation between the two, implying that fluctuations in the cryptocurrency market may affect the tendency of the U.S. stock market, with the S&P 500 rising due to the increase in Bitcoin market value.

Investors have historically turned to cryptocurrency as a way to mitigate market risk, but since the changes in the relationship between the Bitcoin and U.S. stock markets due to China's ban on cryptocurrency have raised questions about its continued effectiveness as a hedge. There is a need to investigate whether cryptocurrencies can still provide an effective hedge against market risk, given the potential changes in the relationship between these markets. To date, there has been limited research into how the hedging capabilities of cryptocurrencies may have changed in response to China's policies, which have been implemented since 2013.

1.3 Research Questions

The research questions presented here were derived from the problem statement of this study:

1. Is there any correlation between the U.S. stock market and Cryptocurrency market?
2. Does the Cryptocurrencies have the hedging capability after structural change?

1.4 Hypothesis Statement

Hypothesis statements are created in accordance with the research questions mentioned above:

H_1: There is positive correlation between the cryptocurrency market and the U.S. stock market.

H_2: Cryptocurrencies have the hedging capability after structural change

1.5 Research Objective

1.5.1 General Objective

The general objective of this study is to examine the relationship between the Cryptocurrencies market and the U.S. stock market.

1.5.2 Specific Objectives

The specific objectives derived from the general objectives are:

1. To examine the correlation of the U.S. stock market to the Cryptocurrency market.
2. To analyse the hedging capability of cryptocurrency after the structural change.

1.6 Significance of Study

This study can provide important information to different parties involved in the financial market. Recently, cryptocurrency has been quite a popular topic, and many investors, speculators, experts, and regulators have all given Bitcoin much attention. Based on the best of the author's knowledge, the majority of research exclusively looks at Bitcoin; studies that look at the correlation between other cryptocurrencies and stock markets are relatively rare. Despite having the most significant market capitalization in the cryptocurrency market, Bitcoin only has the ability to represent some of the cryptocurrency industry. Therefore, researchers should also look into other cryptocurrencies to ensure no bias in the study. This study can fill the literature gap by further investigating the correlation between cryptocurrency and the U.S. stock market. Furthermore, it also wants to explore the potential of cryptocurrencies to act as a hedging tool to reduce investment risk after China banned cryptocurrency transactions. This study will come out of related research by including two distinct cryptocurrencies, namely Ethereum and Binance Coin. The reason behind choosing these two cryptocurrencies is that they have the second largest market capitalization in the cryptocurrency market and have the highest daily trading volume of any cryptocurrency exchange globally (Disli et al., 2022). Therefore, this study can contribute valuable and helpful information to different parties, especially policymakers and researchers.

This study is significant to policymakers. Through this study, they can better understand the trends in the market and changes in the relationship between the cryptocurrency market and the U.S. market after the China government banned cryptocurrency transactions. Besides, they can learn about the hedging powers of cryptocurrency after the China government. It is crucial for policymakers to know because they may develop new policies that can overcome the change in the market.

Moreover, this study can provide a more profound knowledge of the fluctuation of cryptocurrency and the stock market, and cryptocurrency can still be a hedging tool for investors and policymakers. Therefore, policymakers have more ideas on it and have a quick response to the market by exploring more alternative hedging tools for their portfolios in the future. Not only that, they can give some notice and advice to their citizens who still need to be made aware of this issue.

Furthermore, this study is significant to researchers related to this field. Most of the research focuses on the correlation between Bitcoin and the stock market. However, there needs to be more studies about the effect and situation between the cryptocurrency market and the stock market after the China government banned cryptocurrency transactions in 2017. Further, some researchers argue whether cryptocurrency can be a hedging tool like digital gold for their portfolio. This may be because this topic is still new, and only a few researchers have explored this area. Therefore, it makes it hard for other researchers to enter this study. Hence, this study can act as a reference to those researchers who are interested in this kind of research that relates to the relationship between cryptocurrency and the U.S. market. In addition, it also can give some ideas to other researchers who want to investigate relevant studies, and it may produce more valuable studies in the future.

1.7 Chapter Outline

This research consisted of a total of 5 chapters.

Chapter 1: This chapter is the introductory chapter with an overview of our topics.

Chapter 2: This chapter will provide the discussion on the empirical results of the previous studies about the cryptocurrency and the US stock market. Besides, the empirical studies about the cryptocurrency as a digital gold also will be discussed.

Chapter 3: In this chapter, the methodology used for conducting the research will be elaborated upon, encompassing the research design, data collection method, and research process employed in the study.

Chapter 4: This chapter will provide the discussion, analysis and interpretation on the reliability of empirical results using E-views.

Chapter 5: Concise summaries of the research findings will be presented, along with a discussion of the implications and limitations of the study. Lastly, the recommendation for future research into this topic also will be provided.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This chapter reviews the relationship between the cryptocurrency market and U.S. stock market return on previous studies. The following section will analyze whether the hedging ability of cryptocurrencies to the stock markets. Followed by the hedging ability of cryptocurrencies during economic policy uncertainty (EPU). Lastly, the chapter will conclude by discussing any gaps in the existing literature and areas that warrant further investigation.

2.1 Review of theoretical study

Based on our study on the hedging capability of cryptocurrencies towards the U.S. stock market, we want to know about the hedging roles of the cryptocurrency market against uncertainty in the stock market. Therefore, we will apply a few theories to support our study, including the correlation coefficient, safe haven, and Modern Portfolio theory. The correlation coefficient is utilized in this study to examine the relationship between the cryptocurrency markets with the U.S. stock market and examine whether cryptocurrency can serve as a safe haven against the U.S. stock market. Modern Portfolio Theory shows that investors need to diversify their investments by choosing low correlation assets to reduce portfolio risk.

2.1.1 Modern Portfolio Theory (MPT)

According to Pearson (1896), the correlation coefficient, also known as the Pearson correlation, is a statistical tool used to measure the strength and direction of the linear relationship between two variables. The concept of correlation and regression analysis was initially proposed by Francis Galton, a British statistician and social scientist (Stigler, 1989). Later, Pearson introduced the concept of correlation coefficients and developed methods for calculating them (Pearson, 1896).

As is commonly understood, correlation enables the estimation of the strength of the linear relationship between two variables. The correlation statistic, denoted as Pearson's r, is mathematically expressed as follows:

$$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

Where r is the correlation coefficient; x_i is represent the values of the x variables in a sample; $\bar{x}$ denote as mean of the values of the x variable; y_i serves as values of the y variables in a sample; $\bar{y}$ reveals as mean of the values of the y variable.

Pearson correlation is determined by dividing the covariance of two variables by the product of their standard deviations. The outcome is a coefficient that ranges from -1 to +1. Values closer to -1 indicate a strong negative correlation, while values closer to +1 indicate a strong positive correlation. Values near 0 indicate no correlation between the variables (Pearson, 1896).

Modern Portfolio Theory (MPT), formulated by Harry Markowitz in 1952, is a fundamental concept in portfolio construction. MPT suggests that investors can

achieve a more efficient portfolio by combining assets with low or negative correlations (Markowitz, 1952). The correlation coefficient is a statistical measure that plays a crucial role in MPT by quantifying the degree of the linear relationship between two assets or asset classes. The theory aims to optimize the expected return of a portfolio while considering a specified level of portfolio risk. Alternatively, MPT seeks to minimize portfolio risk while maintaining a predetermined level of expected return through the careful balancing of asset allocation. MPT operates on the basic philosophy of an investor's risk aversion, where a portfolio with a higher level of risk may be selected only when the return is higher than others. Conversely, if an investor demands a greater return, the investor must accept a higher level of risk.

In Modern Portfolio Theory (MPT), the expected return of a portfolio is determined as a proportion-weighted combination of the individual returns of its constituent assets. Additionally, the portfolio's volatility is influenced by the correlations between all pairs of component assets.

Expected Portfolio Return

$$E(R_p) = \sum_i W_i \; E(R_i)$$

Where Rp is represents the return of the portfolio; R_i reveals the return of asset i; and W_i refers the portfolio weight of asset i.

Portfolio Return Variance

$$\sigma_p^2 = \sum_i W_i \, \sigma_p^2 + \sum_i \sum_{j \neq i} W_i \, W_j \sigma_i \sigma_j P_{i\,j}$$

Portfolio Return Volatility (Standard Deviation)

$$\sigma_p = \sqrt{\sigma_p^2}$$

In conclusion, Modern Portfolio Theory (MPT) provides a reliable framework that investors often employ to create scenarios of optimal portfolio allocations to various assets. Investors are encouraged to use the same MPT approach for a quantitative examination of Bitcoin when determining the place of Bitcoin in their portfolios. MPT approach indicates that Bitcoin's history of good returns and uncorrelated nature make it an appealing addition compared to traditional portfolios (Galaxy Digital Announces 2021 Financial Results, 2021).

Despite its volatility, adding Bitcoin to a portfolio improves the total expected return and enhances the portfolio's expected risk-adjusted returns. In the financial system, most modern portfolios exhibit substantial intrinsic systemic risk. Therefore, adding Bitcoin to an investment portfolio may diversify away some of this systemic risk and offer additional portfolio benefits (Galaxy Digital Announces 2021 Financial Results, 2021).

2.1.2 Safe haven

A safe haven asset is characterized as an asset that demonstrates a negative correlation with another asset or portfolio during specific periods, particularly in times of financial crisis. The most significant characteristic of a hedge is its ability to maintain its value on average, while the crucial feature of a safe haven is its ability to retain its value during specific periods. In times of financial crisis, assets that act as a safe haven against stocks may co-movement with stocks, but some of these assets may occur negatively correlated with stocks. Investors tend to acquire safe haven assets exclusively during these times when they are

considered a reliable means of retaining their value. Therefore, such assets are considered a dependable safe haven, as they can reliably maintain their value during these specific periods (Baur & McDermott, 2010b).

It is essential for investors to distinguish between a strong and weak safe haven, as this knowledge can help them benefit from positive returns during periods of financial strain or disturbance. When an asset exhibits a negative correlation with another asset or portfolio, investors can reap the rewards of positive returns if the other asset or portfolio experiences negative returns. Such positive returns can be instrumental in improving market stability by reducing overall losses. Thus, it is crucial to differentiate between the weak and strong hedging power of assets (Baur & McDermott, 2010b). To protect against any uncertainty in the stock market, investors must identify a suitable asset.

Following a previous study from Baur and McDermott (2010b), they aimed to determine the potential role of gold as a safe haven in the stock market. Given the desire of many investors to protect their wealth during uncertain events, the study sought to establish whether gold could serve as a reliable asset in this regard. Historically, gold has been perceived as a hedge against inflation, with investors seeking to use it as a safe haven during periods of economic uncertainty. This is due to the fact that gold is priced in dollars, and a weakening of the dollar typically causes the nominal (dollar) price of gold to increase, thereby preserving the actual value of gold. As a result, gold can also function as a hedge against exchange-rate risk for investors holding dollars.

Baur and McDermott's (2010b) study has revealed that gold is most effective as a safe haven asset in developed country stock markets. The study suggests that investors should consider using gold as a safe haven during periods of extreme shocks. The research further indicates that gold exhibits a very strong safe haven effect when developed markets experience financial crises. However, the study also found that gold has a weak safe haven effect in emerging markets.

As a result, safe haven assets may have limited impact in emerging markets, and investors may need to accept losses rather than relying on safe haven assets to protect their portfolios.

In conclusion, it is essential for investors to differentiate between weak and strong safe haven assets to protect their portfolios during times of market stress. A weak safe haven can provide protection to investors as long as it remains uncorrelated with other assets during negative market shocks. In contrast, a strong safe haven can help mitigate overall losses for investors by moving in opposition to other assets during such times. Baur and McDermott's (2010b) study highlights that gold serves as a strong safe haven for the majority of major developed world stock markets, suggesting that it has the potential to promote stability in the global financial system by minimizing losses during periods of market stress.

2.2 Cryptocurrency and U.S. stock market

2.2.1 Hedging ability of cryptocurrencies to U.S. stock market

Cryptocurrency is an emerging digital currency that is distinct from traditional assets. Traditional hedging assets such as gold, U.S. dollar index, commodities and the crude oil are often used to protect against stock market shocks (Arfaoui & Rejeb, 2017). Increasingly more research has focused on cryptocurrencies' hedging, safe haven, and long-term memory. Evaluating the economic nature of cryptocurrencies is essential yet challenging given the challenges of supervision (Corbet et al., 2018). The studies are as evaluations of Bitcoin price formation (Ober et al., 2013; Kristoufek, 2015; Yelowitz and Wilson, 2015;

Bouoiyour et al., 2016; Ciaian et al., 2016). In addition, Bitcoin's market long-term memory and the efficiency in Bitcoin (Urquhart, 2016; Bariviera, 2017; Jiang et al., 2021). Balcilar et al. (2017) employed instead nonparametric causality in quantile test to find out causal relation between Bitcoin return or volatility and traded volume. Most studies examine cryptocurrencies' roles in stock markets due to the generality of stock investment (Dyhrberg, 2016; Bouri et al., 2017a). There is no widely recognized establishing a clear way cryptocurrency and stock markets react. It is due to common price factors for the two types of assets being rare (Kristoufek, 2015; Bouoiyour et al., 2016). Bouri et al. (2017c) claim that the short-term hedging and safe haven potential of cryptocurrencies may be diminished due to the speculative nature of cryptocurrencies (Yermack, 2013; Blau, 2017) and the risk contagion this may cause between cryptocurrency and stock markets. In the short term, it reduces the ability of cryptocurrency hedge with safe haven potential.

Cryptocurrency could provide hedging advantages in the face of a decline in the stock market (Baur et al., 2018; Al-Yahyaee et al., 2019). Bitcoin, as a form of payment with virtual coins, has gradually become accepted as a fundamental hedge within the international financial market. Bouri et al. (2017c) stated individuals can use Bitcoin as a safe-haven asset or hedging tool to counteract the loss of confidence in the financial system. Baur and Lucey (2010a) indicated that hedges are investment vehicles that have a zero or negative correlation with alternative assets. A strong hedge is an asset that has negative correlation with another asset overall. Then, an asset is a weak hedger if it is uncorrelated with another asset or a portfolio on average (Shahzad et al., 2019).

The investment alternative that was widely used before the development of cryptocurrencies is gold. It provides a greater sense of certainty during unpredictable market conditions (Baur & McDermott, 2010b). The characteristics of gold is that its intrinsic value does not most likely not correspond to its current market price. Furthermore, gold is not under the

control of the government (Dyhrberg, 2016). Wijaya and Ulpah (2022) mentioned that gold can be utilized as a hedging asset for a certain period of time. Baur & McDermott (2010b) stated that gold is considered a hedge and safe haven. The result is proved by employing the GARCH model, gold's behavior has a tendency to become more unpredictable during market downturn. However, Baur & Lucey (2010a) proclaimed that among other developed nations such as the U.K. and U.S., gold is used as the hedging tool. The statement further supported by Shahzad et al. (2019) gold serves as a safe-haven asset in a number of developing countries and developed.

There are many similarities between Bitcoin and gold, so the two assets were compared (Som & Kayal, 2022). Bitcoin has been likened to "digital gold" (Popper, 2015). Few studies have examined the linkage between Bitcoin and gold. Gold is a well-known hedge against stocks, bonds, and the US dollar. Dyhrberg (2016) showed Bitcoin is a reliable hedging tool against conventional investing options like the Financial Times Stock Exchange Group (FTSE) index by applying asymmetric power ARCH. In addition, Bitcoin may be utilized as a hedge against the US dollar. The findings are in line with the notion that Bitcoin reduces risk overall and is effective for hedging purposes in portfolios. This resulted in the theory that Bitcoin and gold share a lot of similar abilities. Furthermore, the hedging potential of Bitcoin and Gold against stocks and the US dollar is compared by Dyhrberg (2016). In the advanced economies in the United States, Canada, and Finland, Bitcoin is recognized as a commodity on par with gold. Regardless of the fact that neither has identifiable cash flows, it can be implemented as a currency hedge. Capie et al. (2005) discovered gold to have potential for exchange-rate hedging.

The main value of gold and Bitcoin come from the limited supply, which is not supervised by governments but instead by independent agents. It resulted in significant price volatility and a limited total supply for both assets. Few studies evaluated the correlation between gold and other financial assets (McCown &

Zimmerman, 2006; Miyazaki & Hamori, 2016) the studies found that gold and other financial assets were small or even negative. (Capie et al., 2005). A further study is conducted to investigate the hedging of Bitcoin and proves the capability of Bitcoin can hedge against USD in a short period (Dyhrberg, 2016). Due to its unique anti-government characteristics and independence from government authorities, Bitcoin is seen as a remedy for fragile markets (Wang et al., 2021). Another study by Goodell and Goutte (2021) stated that the relationship between Bitcoin and stock markets has become stronger compared to previously during the pandemic. Bitcoin can reduce portfolio risk and provide hedging capability during financial market turmoil based Bitcoin is negatively correlated with other traditional assets and unaffected by monetary policy (Narayan et al., 2019). Thus, Bitcoin can be assumed as a safe haven for the S&P 500 when the marketplace declines during the pandemic.

Followed by study by Maitra et al. (2022) applied DCC-GARCH to test the suitability of the risk diversifier of Bitcoin. The model showed that Bitcoin can be a good hedger with safe havens in the global stock market. In addition, Bitcoin can mitigate the risk of the Asian stock market during market turbulence (Bouri et al., 2017b). Hence, cryptocurrencies have attracted many investors' interests. Some studies have examined the hedging properties of Bitcoin against developed economy equity indices. In the U.S. stock market, cross-quantilogram approach examines the safe-haven and hedging properties of eight cryptocurrencies in relation to the S&P 500. The results indicate that Bitcoin, Stellar, Ripple and are safe havens for all U.S. equity indices, while Dash, Nem, and Ethereum are hedges for some U.S. equity indices (Bouri et al., 2020). Moreover, according to Goodell and Goutte (2020), there exists a significant negative co-movement between bitcoin prices and COVID-19, implying that bitcoin could potentially serve as a hedge in certain situations.

Inversely, Conlon and McGee (2020) found that Bitcoin offers no protection against the extreme market decline of the S&P 500, in fact, it increases the

portfolio's downside risk. Corbet et al. (2017) supported the statement and indicated that Bitcoin served as contagion amplifiers rather than as a hedge or safe instrument during the COVID-19 pandemic. Similarly, another study by Corbet et al. (2020) mentions that Chinese financial market risk will be mitigate by the gold rather than Bitcoin. Furthermore, Bouri et al. (2017b) mentioned Bitcoin has restrained hedging properties and only has safe-haven traits for Asian stocks.

Attention is being paid on whether cryptocurrencies are a safe-haven investment in the near term. The study by Almeida and Gonçalves (2022) evaluating the properties of Bitcoin, Ethereum and Ripple on safe haven and hedge against commodities, foreign exchange, and stocks. Baur et al. (2018) display that Bitcoin is hired explicitly as a speculative investment. Melki and Nefzi (2021) employed second order LSTR models, Ripple acted as a weak safe haven for the foreign exchange market during the crisis triggered by the pandemic. Similarly, the research indicates Bitcoin and Ripple do not exhibit the characteristics of either a safe haven or a hedge for stock markets downturn (Melki & Nefzi, 2021). Yet, they behave as safe havens for the commodity and foreign exchange markets. In addition, Mariana et al. (2021) argued that Ethereum performed better than Bitcoin as a short term safe haven. However, the study has also stated Ethereum volatility in return compared to Bitcoin, aligning with the findings of Gil-Alana et al. (2020) and Stensås et al. (2019). The result shows that other cryptocurrencies like Ripple and Ethereum are better safe havens than Bitcoin. Therefore, portfolio investors should avoid relying solely on Bitcoin as a representative of cryptocurrencies because the performance of Bitcoin is not suitable as a safe haven during the crisis triggered by the pandemic. However, the question remains as to whether Bitcoin can take the place of commodities, USD, crude oil and gold when used as a hedge against stock market shocks.

2.2.2 Hedging ability of Bitcoin during economic policy uncertainty（EPU)

A country's economic development is significantly impacted by its economic policies, and any uncertainty or ambiguity in these policies can have a substantial effect on the economy's growth (Raza et al., 2018). Antonakakis et al. (2013), Arouri et al. (2016), Chiang (2019) mentioned that stock returns have a negative correlation with the EPU and, followed by high volatility in the stock market (Baker et al., 2016). Antonakakis et al. (2013) used the DDC-GARCH model to analyze the extent of time-varying correlations between inferred volatility, stock market returns, and policy uncertainty. The results showed that the dynamic association between stock market returns and policy uncertainty has been continuously negative over time. Based on linear and market switching models, Arouri et al. (2016) mentioned that stock returns will decrease when there is an increase in policy uncertainty;. However, the correlation between stock returns and EPU is not linear, especially during instances of high volatility, the impact of EPU on stock returns is more enormous and more enduring. Chiang (2019) also introduced that when EPU arises, it leads to a decline in excess stock return, and it is the same as global EPU hits the market.

Due to heightened economic policy uncertainty, many market participants and researchers are trying to determine whether the cryptocurrency market can act as a hedge in portfolio diversification and become a safe haven during economic uncertainty. Thus, some investors began to move to the Bitcoin market because they thought the hedging capability of Bitcoin could solve the distrust and tension in the existing financial system. Besides, it also has similar characteristics to gold. For instance, many people turned to Bitcoin as a safe haven to avoid risk and uncertainty during the 2010-2013 European sovereign

debt crisis and the 2012-2013 Crypto financial crisis (Bouri et al., 2017; Lucey et al., 2017).

Economic policy uncertainty has become a significant indicator of volatility in the cryptocurrency market (Bouri & Gupta, 2021; T. Fang et al., 2020). The strong ability of Bitcoin to rebound during periods of volatility has raised the possibility that this cryptocurrency may act as a hedging tool and a safe haven against global uncertainty (Selmi et al., 2018). Based on Weber (2014) documented that Bitcoin could take advantage of the economic uncertainty during the 2008 crisis. From this incident, researchers realized that Bitcoin could hedge against economic uncertainty (Bouri et al., 2017a). Further, the demand for Bitcoins increased due to their inexpensive transaction costs. (Ciaian et al., 2015).

Based on previous studies, there are an increasing number of studies examining the potential relationship between Bitcoin and EPU to investigate whether Bitcoin can be the safe haven against any economic uncertainty. Firstly, some studies found that Bitcoin can act as a hedging tool against the EPU index Demir et al., (2018); Wang et al., (2018a); Colon et al., (2021); Shaikh (2020). Demir et al. (2018) claim that EPU can predict the Bitcoin return after applying the BGSVAR model, OLS, and Q.Q. Estimations found that Bitcoin can act as a hedging tool against EPU, although returns on Bitcoin are inversely correlated with EPU changes. Further support for this view is given by Wu et al. (2019), who reported that Bitcoin could have a better hedging ability than gold in the market. Calon et al. (2021) demonstrated that the Bitcoin market could be a weak hedging tool against GEPU when a bull market occurs.

Still, another study by Fang et al. (2019) employed the GARCH-MIDAS model to analyse determinants of bitcoin's long-term volatility from the perspective of the U.S. stock market and global economic activity. Fang et al. (2019) claim that the long-term volatility of Bitcoin is significantly positively correlated with

global EPU. In addition, they found that EPU had a significant positive impact on the correlation between Bitcoin and stocks and commodities while having a negative effect on the correlation between Bitcoin and bonds. This suggests that Bitcoin might perform as a hedge in certain situations of economic uncertainty. Hence, they conclude that the effect is minimal. In this regard, Smales (2019) challenged the arguments of Wu et al. (2019). The studies documented that Bitcoin has more volatility and illiquidity compared with gold. As a result, Bitcoin should only be viewed as a safe haven once its market is more developed.

On the other hand, C. C. Wu et al. (2022) come to a different conclusion. This study showed that EPU negatively impacts Bitcoin's long-term volatility. Further, Bitcoin can hedge against the EPU of several developed and developing countries and the global market. To sum up, most EPU indices were shown to have positive predictive abilities for Bitcoin returns. The empirical results prove that Japan, Chile, Singapore, and China's EPU have better hedging power compared with the global model. Among them, Japan has greater hedging capacity and long-term volatility than the global EPU. Further, it was discovered that most EPU indices had a positive tendency to forecast Bitcoin returns.

Al-Khazali et al. (2018) examined how positive and negative macroeconomic news shocks affected gold and bitcoin. They discovered that although gold consistently responded to such surprises with its capacity as a safe-haven asset, Bitcoin did not respond in a similar way. In contrast, Selmi et al. (2018) likened Bitcoin to gold in terms of its potential to act as a safe haven and hedge against dramatic changes in the price of oil. They demonstrate how both Bitcoin and gold serve as a safe haven for changes in oil prices, concluding that both are investments that investors may place their money in during political and economic unrest.

Apart from the multi studies, some authors focus on the country's situation. As Evans and Archer (1968) and Kristjanpoller and Bouri (2019) mentioned, a successful hedging strategy should consider the correlation between the two instruments. Koumba et al. (2019) employed the D-Vine Pair-Copula method to analyze Ethereum and whether it has a hedging capacity. The results showed that Ethereum has a stronger correlation with U.S. and EPU than other cryptocurrencies (Bitcoin, Ripple). However, there are limited studies about whether Ethereum can be a hedging tool against EPU for other countries.

Moreover, some studies have been taken into account looking for cryptocurrencies that can hedge against national EPU. Wang and Yen (2018b) while utilizing a regression framework to investigate the future volatility of Bitcoin and Litecoin. Cheng and Yen (2019) documented that, except for the U.S., Korea, and Japan, they could not anticipate their future EPU. The results showed that the Chinese EPU was more sensitive to predicting the volatility of Bitcoin and Litecoin. Therefore, Bitcoin and Litecoin are the best hedging tools against national EPU. In this regard, Qin et al. (2020) challenged these results, and these studies assessed that Bitcoin could not constantly be a safe haven against global EPU. Several external factors, such as EPU and GEPU, can affect Bitcoin's volatility and prices. Still, some Bitcoin-specific factors like cyber-attacks and speculation may also be involved.

Bouri et al. (2017b) mentioned that Bitcoin has different effects against uncertainty under certain market conditions. This statement is strongly supported by Demir et al. (2018) by using OLS methods and the quantile-on-quantile method to prove that Bitcoin has a negative relationship during economic policy uncertainty. Bitcoin only can do hedging against when there is a bull market. Besides, they also found that Bitcoin can act as a hedging tool against global financial stress by using copula-based approaches to explore the correlation between Bitcoin and the global financial stress index (Bouri et al., 2018). Wang et al. (2018a) also found similar results using a multivariate

quantile model and the Granger causality risk test. They discover that under most circumstances, there will be little risk spillover from EPU to Bitcoin and that Bitcoin can behave as a safe haven or a diversifier in the event of EPU shocks. However, Fasanya et al. (2021) employed a nonparametric quantile approach to examine the correlation between precious metals and Bitcoin with EPU, and the results found that both are not appropriate to act as a hedge or safe haven.

Furthermore, Wang et al. (2018a) highlighted that the impact of the U.S.'s economic policy uncertainty on Bitcoin was small and insignificant. Hence, Multivariate Quantile Model and Granger Causality validate Bitcoin as a diversifier or safe haven against uncertainty in the market. In contrast, based on the empirical results from Wu et al. (2019) showing that gold and Bitcoin are not a safe haven against EPU. Therefore, under normal circumstances, neither gold nor bitcoin can act as the best hedge or safe haven against EPU. However, when an extraordinarily bearish and bullish market exists, gold and Bitcoin can still serve as a weak hedge against EPU. Therefore, since the hedging power of Bitcoin and gold depends on market situations, it will be more suitable as a portfolio diversification or alternative instrument to hedge with uncertainty.

Moreover, one study demonstrates that Bitcoin can behave as a safe haven and a hedge against market volatility, especially since Bitcoin's return reacts more sensitively to economic policy uncertainty in the U.S., China, and Japan. (Shaikh, 2020). Bouri et al. (2020) examined Bitcoin's capacity to hedge against trade and economic policy uncertainty. They employed linear regression and found the volatility in monthly numbers, and the results showed that Bitcoin could be used as a hedge against trade and economic risks. Paule-Vianez et al. (2020) also found similar results where Bitcoin can take the role of a safe haven against economic uncertainty. Consequently, they can hedge against EPU and uncertainty in cryptocurrency. Following Jiang et al. (2021) also claim that Bitcoin and XRP can be used against high EPU. However, when there is low or

moderate EPU, cryptocurrencies will be considered not a good hedging tool. In 2021, Hasan et al. (2022) used OLS, Quantile regression, and Quantile on Quantile regression to examine the effects of cryptocurrency policy uncertainty on Bitcoin and gold. They discovered that Bitcoin is neither a hedge nor a safe haven, while gold is the traditional hedge in the market.

Followed by recent studies by Chen et al. (2021) used a Predictive Model (OLS-GQS generalized quantile regression) to investigate the return of Bitcoin and EPU during Covid-19, and they found that Bitcoin can act as a hedge or safe haven the Covid-19. Foglia and Dai (2021) also get similar results showing that EPU can predict the return of Bitcoin while utilizing time-varying parameter vector autoregression. On the other hand, they categorised Bitcoin qualifies as a stronger hedge or safe haven than gold since it generally negatively affects stock returns during a pandemic. Będowska-sojka and Kliber, (2021) and Chkili et al. (2021) come to a different conclusion. Będowska-sojka and Kliber (2021) report that both Bitcoin and Ether should not be considered safe-haven assets. Chkili et al. (2021) highlighted that Bitcoin provides a favourable diversification opportunity to reduce the risks of major Islamic equity markets by using the DCC-FIGARCH model. Besides, the hedging ability also will change depending on the market conditions. Goodell and Goutte (2021) argue that Bitcoin's co-movement with COVID-19 instances may make it a safe haven during the outbreak. This also explains why investors resort to other assets like cryptocurrency when the market rises in the United States. Meanwhile, the decline in correlation will only occur in the short duration.

2.4 Literature Gap

A few literature gaps have been identified from the literature review above. First and foremost, the research and studies primarily focus on the largest blockchain based-digital asset, Bitcoin, with a market capitalization of USD473.7 billion as of February 2023. Most of the empirical research discussed and focused on Bitcoin price formation (Ober et al., 2013; Kristoufek, 2015; Yelowitz & Wilson, 2015; Ciaian et al., 2016; Bouoiyour et al., 2016). Furthermore, the studies discussed the hedging ability and role as a safe haven of Bitcoin towards global uncertainty (Ciaian et al., 2016; Bouri et al., 2017; Selmi et al., 2018; Paule-Vianez et al., 2020). In addition, Demir et al. (2018); Fang et al. (2019); Wang et al. (2018a); Wu et al. (2019); Colon et al. (2021); Paule-Vianez et al., 2020; Shaikh (2020) found that Bitcoin can act as a hedging tool against the EPU index. Similarly, Chen et al. (2021), Foglia and Dai (2021), and Goodell and Goutte (2021) categorized Bitcoin as a strong hedger or safe haven during a pandemic. However, Będowska-sojka and Kliber, (2021); Chkili et al. (2021); Hasan et al. (2022) come with different conclusions. Hasan et al. (2022) discovered that Bitcoin is neither a hedge nor a safe haven.

As discussed earlier, most of the studies focused on the cryptocurrency Bitcoin. There are only a few studies that relate to the three cryptocurrencies we focus on in our study: Bitcoin, Ethereum, and Binance Coins. There are some studies that link Bitcoin and Ethereum against EPU for other countries (Koumba et al., 2019), and a study by Wang and Yen (2018) examines the future volatility of Bitcoin and Litecoin. Our thesis have identified a gap in the literature concerning the nexus of hedging capabilities of Binance Coins against the stock market or economic uncertainty. One of the reasons contributing to the conflict may be outdated ranking or information on the cryptocurrency of past studies, which contrasts with our current study. According to Nesbit (2023), the top three cryptocurrencies are Bitcoin, with the highest high capitalization of USD433.01 billion, Ethereum recorded second highest with USD191.83 billion, and Binance Coins, recorded at USD45.85 billion.

Furthermore, there is no research specifically discussed on the structural change of policy in China, which imposed restrictions on all cryptocurrency transactions. Past empirical studies have showed the overall event of economic uncertainty (Weber, 2014; Arouri et al., 2016; Bouri et al., 2017; Lucey et al., 2017; Baur & McDermott, 2010b) instead of the detailed event of the policy change in China. China announced restrictions on cryptocurrency mining and trading in 2021. As a result, a shock wave was created in the blockchain sector in September 2021, significantly impacting the cryptocurrency market. The price of Bitcoin fell by more than U$2,000 after the announcement of restrictions on Bitcoin mining and trading. The global price of cryptocurrency is affected by fluctuation in the Chinese market. Therefore, our study aims to investigate whether cryptocurrencies can act as a hedging tool after the event of China's policy change.

CHAPTER 3: METHODOLOGY

3.0 Introduction

This chapter seeks to provide a thorough explanation of the method of data collection and the research techniques used to carry out this study, including the sources of data, description of variables included and the explanation of the methodology which applied in this research.

3.1 Research Design

In order to effectively address research objectives, the research design is viewed as a framework of strategies and methodologies used to link the research components in a relatively logical and sound manner. Therefore, the study plan must be established before the data collection. As a result, this research adopts a quantitative method that focuses on drawing inferences from available data.

This study examines if there is a link between the markets for cryptocurrencies and US stocks after China banned cryptocurrency transactions. All data employed in this study are secondary data at a weekly frequency. The time frame that was used is from the year 2017 to the year 2023. Gathering secondary data helps generalize the results because quantitative approaches have the advantage of being easy to generalize in terms of data collection and analysis. It demands the absence of intelligent guesswork, impartial data collection and analysis, and complete control over alternative interpretations, explanations, and conclusions.

3.2 Data

The general objective stated in Chapter 1 aims to investigate the relationship between the cryptocurrency market and the U.S. stock market. Hence, the Standard and Poor's 500 indexes (S&P 500) and the closing price of Bitcoin, Ethereum, and Binance Coin will be utilized to conduct this research. Besides that, the control variables are the interest rate and inflation rate. The sample size of the cryptocurrencies differs from each other due to the established dates of cryptocurrencies being different. The data observations are in weekly frequency, from 4th January 2017 to 1st March 2023.

The S&P 500 index and the daily closing price of the cryptocurrencies (Bitcoin, Ethereum, and Binance Coin) are obtained from the website of Investing.com. In addition, the effective federal fund rate is obtained from the Federal Reserve Bank of New York website, and the Consumer Price Index is obtained from the U.S. Bureau of Labor Statistics. The table 3.2.1 below depicts the sources of data and the definition of each variable.

Table 3.2.1 Variables and Source of Data

Variables	**Proxy**	**Narration**	**Data repository**
U.S. Stock Return	S&P 500	**Standard and Poor's 500 Index** A stock market index that monitors the performance of 500 large-cap U.S. based companies across various sectors.	Investing.com

Cryptocurrency Return	BTC	**Bitcoin Price** A decentaralized digital currency that was introduced by Satoshi Nakamoto in 2008.	Investing.com
Cryptocurrency Return	ETH	**Etheruem Price** A decentralized global software platform powered by blockchain technology in 2014 and launched on 30 July 2015.	Investing.com
Cryptocurrency Return	BNB	**Binance Coin Price** A decentralized cryptocurrency coin which was initially based on the Ethereum network and launched with an initial coin offering on 14 July 2017.	Investing.com
Interest Rate	EFFR	**Effective Federal Fund Rate** A rate calculated as a volume-weighted median of overnight federal funds transactions, used to determine the rate at which banks lend and borrow short-term cash.	Federal Reserve Bank of New York
CBOE Volatility Index	VIX	**CBOE Volatility Index** An index that measures the market expectations for the volatility of the S&P 500 index of U.S. stocks over the next 30 days.	Investing.com

3.3 Rationalization of Variable Selection

3.3.1 U.S. stock market return

Information technology, health care, financials, consumer discretionary, communication services, industrials, consumer staples, energy, utilities, real estate, and materials are just a few of the 11 sectors and 79 sub-sector whose daily stock values are covered by the S&P 500. The S&P 500 index can effectively inform investors of the U.S. market trends and economic conditions (Sun et al., 2021; Al-Momani & Dawod, 2022). Otherwise, the Public Listed Company included in S&P500 is not estimated by valuation but determined according to the company's data and market competitiveness (Denis et al., 2003). Therefore, all companies that can be included in the S&P500 are selected through a layer of strict and rigorous screening. In order to ensure the quality of the S&P500, the committee will regularly update the company's market positioning. Moreover, the main reason why S&P500 can be trusted is that there are a large number of institutional investors involved (Mateus et al., 2019), such as Vanguard total stock market index fund admiral shares (VTSAX), Vanguard 500 Index Fund Admiral Shares (VFIAX) and others involved in the share the market because of trust by investors, and the S&P500 is also volatility that occupies a large part of the entire investment market (Ma & Cheok, 2022). There are several past studies that also use S&P500 to do the research (Chen, 2023; Bouri et al., 2022; Mensi et al., 2022; Caferra, 2022).

3.3.1.1 S&P 500 return

The S&P 500 will be used in this study's literature review and gap analysis to calculate the U.S. stock market return. The index value for the S&P500 will be recorded between 2100 and 0400 (GMT+8) each trading day. It is the most prospective firm in the U.S. market and may represent the majority of the U.S. stock market.

By using the weekly closing price of the S&P500 index, this study computes the weekly log returns of the U.S. stock market as follow:

$$S\&P\ 500 = \ln\left(\frac{S\&P\ 500_t}{S\&P\ 500_{t-1}}\right)$$

Where the market index's weekly closing price as of the week, which is recorded on the last trading day of each week. A positive value of (Formula) indicates that the U.S. stock market is bullish on week t as compared to the closing price at the previous week t – 1 conversely, when the answer becomes negative, which indicates the bearish in that week.

3.3.2 Cryptocurrency Return

Since traditional currencies require a system to function, cryptocurrencies are viewed as an alternative. Simple economic principles like scarcity, usefulness, and market forces of supply and demand, such as those that govern the prices of Bitcoin and Ethereum, define the value of a currency (Ciaian et al., 2015). Similar to gold, bitcoin is valuable and rare, which has led to the development of ETFs, futures, options, and investment products that necessitate regular trading of bitcoin on cryptocurrency exchanges (Brauneis et al., 2022). In addition, Bitcoin's macroeconomic and financial growth serves as an economic determinant due to the BTC/USD price and the analysis of each factor's contribution to the development of this price (Koch & Dimpfl, 2022). Due to the speculative nature of the cryptocurrency market and the fact that institutions and retail investors determine currency prices, psychological barriers, remarkably convergent trading or herding, are bound to arise in such a market (Fonseca et al., 2019; Gurdgiev & O'Loughlin, 2020). However, Bitcoin's maximum existence or creation is capped at 21 million. The constant trading between buyers and sellers that defines the price of Bitcoin is known as price formation. Generally, coin prices will increase when demand is high (Guizani & Nafti, 2019).

3.3.2.1 Return of bitcoin

There is the same formula as the U.S. stock market return, this index is to calculate Bitcoin's weekly return by using the bitcoin price. The calculation of the weekly return is presented as follow:

$$BTC = \ln(\frac{BTC_t}{BTC_{t-1}})$$

Where is the weekly closing price of bitcoin at week t, which is recorded every single day, the price quotes of bitcoin usually appear in the format of the currency exchange rate, such as the exchange rate from one country to another country constantly floating. Moreover, it constantly floats, and the price of Bitcoin is presented to investors based on the valuation of the international currency, which is USD (Ahmed, 2021).

Bitcoin remains the representative of the leading cryptocurrencies today, but we cannot ignore altcoins such as Ethereum and BNB. They are also a formidable type of cryptocurrency, and in terms of market share, they have already captured a significant portion of the market alongside Bitcoin. Ethereum represents the altcoins. Instead of using Tether, we will use BNB, as its growth in recent years has far surpassed that of Tether, with BNB's release in 2017. In five years, BNB has become the fourth largest cryptocurrency in terms of market capitalization, compared to other altcoins. This is enough to prove BNB's potential in this study. Its outstanding performance over time is not the only reason, but also its background, which is a factor that makes it an element in this study. Furthermore, BNB is a virtual currency invented by the world's largest trading platform, further proving its superiority and value.

3.3.3 Control Variable

3.3.3.1 Interest rate (Effective Federal Fund Rate)

Short-term funds are borrowed and lent between banks and lenders can indicate interest rates by charging interest to borrowers (Shahiduzzaman & Naser, 2019). Interest rates are often applied to short-term and long-term loans and are determined by how the bank perceives the market's present and future liquidity conditions. Additionally, this rate illustrates the supply and demand dynamics for bank reserves, providing crucial cues for the central bank to comprehend market forces. Interest rates are the primary element that will affect the market return of the stock market, according to Christiana, Setiana, and Mamduch's (2016) study, since they regulate investors' purchasing power. When the bank raises the interest rate, it indicates that the borrower is prepared to make a larger payment to the business. As a result, the company may issue more shares to attract investment capital, lowering the payout (Otieno, Ngugi, & Wawire, 2017). Conversely, when the central bank lowers the loan interest rate, more money will be available on the market for business development.

The New York Fed examined the methodology for determining the federal funds rate in light of the current attention on best practices for reference rates on a global scale. The New York Fed plans to improve the federal funds rate calculation procedure as a consequence of this evaluation by switching the data source from transaction-level data obtained directly from depository institutions to data given by federal funds brokers. The effective federal funds rate (EFFR)

is measured as a volume-weighted mean using data from major federal funds brokers.

Bernanke (2003) and Kuttner (2000) made an attempt to gauge how the equity market responded to changes in monetary policy and examine at how asset prices responded as anticipated by changes in the federal funds rate. Stock prices are significantly impacted by changes in the Federal Funds target rate, claim Rigobon and Sack (2002). Both monetary policymakers and players in the financial markets should pay attention to this issue.

3.3.3.2 Chicago Board Option Exchange (CBOE) Volatility index (VIX)

It is popular to use the Chicago Board Option Exchange (CBOE) Volatility index (VIX) to measure market expectations and participants' views on how the S&P 500 index will fluctuate during the ensuing 30-day period. (Das & Gangopadhyay, 2023; Li et al., 2023). The revised VIX index is computed as follow:

Formula

$$\sigma^2 = \frac{2}{T}\sum_{t}\frac{K_{t+1} - K_{t-1}}{2}\, e^{RT}\, Q(K_t) - \frac{1}{T}\,(\frac{F}{K_0} - 1)^2$$

where T is the time to expiration, F is the option-implied forward index, K_0 is the first strike price immediately below the forward index, K_t is the strike price of the t[th] out-of-the-money option, where K_t is a call if $K_t > K_0$ and a put if $K_t < K_0$. In addition, $\frac{K_{t+1} - K_{t-1}}{2}$ is the interval between the strike prices of the side of K_t. R is the risk-free rate to maturity and $Q\ (K_t)$ is the midpoint of the bid-ask spread for option with strike.

Likewise, CBOE will compute the implied volatility σ^2 for both the near-term options and the next-term options to obtain the 30-day weighted average of σ^2_1 and σ^2_2. Likewise, a single parameter $\sigma^2$is obtained by interpolating σ^2_1 and σ^2_2 based on maturity T_1 and T_2.

$$VIX = 100 \times \sigma$$

Finally, the VIX is computed as $\sigma \times 100$. Spot VIX Index values are computed using mid-quote options prices. The VIX index is produced directly utilising market characteristics and without the use of pricing modelling based on the revised model-free approach. As a result, neither the Black-Scholes framework nor any other modelling is used to underpin the revised VIX.

According to Qadan, Kliger and Chen (2019), investors are prompted to diversify their holdings in response to a spike in the VIX. Given the ripple effect of shocks in the U.S. stock market, the VIX index is a great gauge of volatility in global equities markets. The literature frequently uses the VIX index to represent equities market volatility. See, for example, Abuzayed et al. (2018), Sarwar and Khan (2017), and Mensi et al. (2022).

3.4 Empirical model

In this paper, an econometric model is proposed wherein U.S. stock market returns are considered as a function of CRYP, EFFR, and VIX. The research includes models with one dependent variable and three independent variables.

Economic Function

$$\text{S\&P 500} = \int (\text{CRYP}, \text{EFFR}, \text{VIX})$$

Where,

S&P 500 = Return on S&P 500

CRYP = Return on Crytocurrencies

EFFR = Effective Federal Fund Rate

VIX = CBOE Volatility Index

Economic Model

$$\Delta \ln S\&P\ 500 = \beta_0 + \beta_1 \Delta \ln CRYP + \beta_2 \Delta \ln VIX + \beta_3 \Delta \ln EFFR + \varepsilon$$

Where,

S&P 500 = Return on S&P 500

CRYP = Return on Crytocurrencies

EFFR = Effective Federal Fund Rate

VIX = CBOE Volatility Index

3.5 Methods

3.5.1 Generalized Autoregressive Conditional Heteroscedasticity model (GARCH)

Bollerslev (1986) introduced the Generalized ARCH (GARCH) model as a solution to the issue of high ARCH orders. The idea behind the ARCH model is that by taking into account previous periods' data, the volatility estimation will be more accurate. Therefore, the volatility for the current time is dependent on data from earlier periods. However, the ARCH model is flawed because it resembles a moving average specification more than an autoregression. (Engle, 1995) The transformation of the ARCH process into the GARCH process is similar to the transformation of the time series AR process into the general

ARMA process (Bollerslev, 1986). This transformation is necessary to prevent negative variance issues by calculating a constant lag structure.

The GARCH model is used to analyze time-series data where the variance error is considered serially autocorrelated. The variance of the error component follows an autoregressive moving average process in GARCH models. The conditional variance in Bollerslev's GARCH model is a linear function of previously calculated conditional variances and historical squared innovations (Elkhouly, n.d.). Therefore, it can capture the volatility of financial assets, even though the volatility of financial assets frequently changes and displays patterns throughout time. The GARCH model has become popular because it can accurately fit data with fewer parameters than a highly specified ARCH model.

GARCH offers a measure of volatility similar to standard deviation, which can be used in financial calculations for risk analysis, portfolio selection, and derivative pricing. The most common application is in financial asset return modeling, where it can be used to predict a financial asset's volatility. For example, the model can be used to calculate the likelihood of a significant market crash or to determine the best degree of risk management for a portfolio of assets.

In the model GARCH (p, q), p represents how many lags of the squared residual returns, and q represents how many lags of variances are in the model. When p and q are one, as in GARCH (1, 1), it signifies that the current period lags behind of preceding period's variance and squared residual return.

The standard GARCH (1, 1) model expresses the variance at time, t as:

$$\sigma_t{}^2 = \lambda_0 + \alpha_1 \varepsilon^2{}_{t-1} + \beta_1 \sigma^2{}_{t-1} + \lambda_1 \ln CRYP^2 + \lambda_2 \ln VIX^2 + \lambda_3 \ln EFFR^2 + \varepsilon_t$$

Where $\sigma_t{}^2$ is the conditional variance at t; λ_0 represents the weighted long run average variance; $\varepsilon^2{}_{t-1}$ serves as the squared residual return in the previous period; $\sigma^2{}_{t-1}$ exhibits the conditional variance in the previous period; ε_t refers to the residual returns. Likewise, with high ARCH coefficients, the parameter α_1 captures the volatility reaction to the market movements is significant, whereas the high GARCH coefficients, β_1 reveals that the shocks are persistent (Mcneil et al., 2015).

After obtaining the residual variance from the GARCH variance series, then construct the weighted covariance matrix using the inverse of the error variance and use it to estimate the GARCH model parameters via FGLS.

3.5.2 Feasible Generalized Least Square (FGLS)

Feasible generalised least squares (FGLS) have been used to finance to estimate risk premiums and simulate the volatility of asset returns (Harvey, 1981; Bollerslev, 1986). In econometrics, FGLS is a statistical method for estimating the parameters of a linear regression model when the assumptions of ordinary least squares (OLS) are breached. The fundamental premise behind OLS is that the mistakes are distinct, uniformly distributed, and have a fixed variance. Nevertheless, real-world data frequently contradict this assumption, producing inaccurate and ineffective estimates. FGLS is a well-liked OLS substitute that accepts heteroscedasticity and autocorrelation in the data.

FGLS is an effective statistical method for estimating the parameters of a linear regression model when the errors are heteroscedastic and autocorrelated. Hence, FGLS can be used to estimate the error variance in GARCH (1, 1) when the disturbances do not have a constant variance. Furthermore, it also can model the error variance as a function of lagged error variances and other explanatory variables. FGLS estimates the parameters of the model by minimizing a weighted sum of squared residuals, where the weights depend on the estimated variance-covariance matrix of the errors. The resulting estimates will be more accurate and efficient than those obtained using the maximum likelihood method.

3.6 Diagnostic Checking

Econometric models are susceptible to autocorrelation, heteroscedasticity, and the error term's normal distribution. To validate the specification of the GARCH model (FGLS), three essential tests need to be conducted, namely the Breusch-Godfrey LM test, ARCH-LM test, and Jarque-Bera test. These tests are crucial in ensuring the accuracy and adequacy of the GARCH model's specification.

3.6.1 Jarque-Bera test – Normality

A normality test assesses whether a sample of data is representative of a population that has a normal distribution. Usually, it is performed to ensure that the variable's distribution follows the normal distribution.

One of the most well-known tests for the normality of regression residuals is the Jarque-Bera test, which has gained more acceptance among researchers. Jarque-Bera test is a goodness-of-fit test that is computed based on the kurtosis and skewness measure of the OLS residuals (Jarque & Bera, 1987).

The hypothesis is defined as:

$$H_0 = \text{Error terms are normally distributed.}$$

The test statistic value for Jarque-Bera (JB) test:

$$JB = n[\frac{s^2}{6} + \frac{(K-3)^2}{24}]$$

Where,

n = Sample size

S = Skewness

K = Kurtosis

If the Jarque-Bera (JB) test statistics are lower than the critical value, it indicates that the null hypothesis should be rejected. The result concludes that the disturbances in the model are not normally distributed.

3.6.2 Breusch-Godfrey LM-test – Autocorrelation

The classical linear regression model makes the crucial assumption, which is the error terms do not exhibit autocorrelation. If there is autocorrelation in the error terms, the Gauss-Markov theorem (Plackett, 1950; Greene, 2018) does not apply because it violates the assumption that the error terms are uncorrelated; therefore, ordinary least squares estimators are no longer the best linear unbiased estimators.

Breusch (1978) and Godfrey (1978) have proposed a more adaptable and flexible test of autocorrelation. Moreover, the Breusch-Godfrey LM test is superior to the other test (Uyanto, 2020), such as Durbin-Watson Test, which can only detect first-order autoregressive model. The Breusch-Godfrey (BG) LM test can identify lagged dependent variables as well as higher-order autocorrelation (Gujarati & Dawn, 2009).

The hypothesis is defined as:

$$H_0 : p_1 = p_2 = p_3 = 0$$

The test statistic value for Breusch-Godfrey LM test:

$$(n - p)R^2$$

If the Breusch-Godfrey LM test statistics, represented as $(n - p)R^2$, exceeds the critical chi-square value with p degrees of freedom, it implies the rejection of the null hypothesis. Consequently, the conclusion drawn from this result suggests that the model is experiencing an issue of autocorrelation.

3.6.3 ARCH Lagrange Multiplier (LM) Test – Autoregressive Conditional Heteroscedasticity

The classical linear regression model has an assumption which is that the disturbances should have a constant variance. Suppose the disturbance has an inconstant variance, meaning the model has a heteroscedasticity problem (William, 2002). The heteroscedasticity problem will tend to underestimate the variances and standard errors and cause the hypothesis testing is unreliable (Long & Laurie, 1998).

Engle (1982) claims that the Langrage Multiple (LM) tests is used to evaluate the ARCH effect's significance level and determine whether or not the residual exhibits heteroscedasticity. This test can detect the heteroscedasticity problem on time-series data.

The hypothesis is defined as:

$$H_0 : p_1 = p_2 = p_3 = 0$$

The situation is analogous to the LM test for autocorrelation. If the LM test statistics, denoted as$(n - p)R^2$, surpasses the critical chi-square value with r degrees of freedom, it leads to the rejection of the null hypothesis. As a result, the conclusion drawn from this outcome suggests that the model is encountering a heteroscedasticity issue.

CHAPTER FOUR: DATA ANALYSIS

4.0 Introduction

The unit root test for all variables begins in the analysis using the ADF test and PP test. The unit root tests are used to investigate the presence of stationarity in the data. The rejection of the null hypothesis means that the particular variable is stationary and has no unit root. Table 4.1.1 encapsulates the outcomes obtained from the ADF and PP test at both level forms for all variables, respectively, and considers the intercept and trend with the AR.

4.1 Unit Root Test

The unit root test for all variables is done first throughout the analysis, utilising the ADF and PP tests. Null rejection assumes that the specific variable is stationary. Table 4.1.1 show the results of the Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test conducted on six variables: S&P 500 return, Bitcoin, Ethereum, Binance coin, EFFR and VIX at both level and first difference and in addition accounting for the intercept and trend.

Table 4.1.1 Results of Augmented Dickey-Fuller (ADF) Test and Phillips-Perron (PP) Test

Variables	Augmented Dickey-Fuller (ADF) Test		Phillips-Perron (PP) Test	
	Intercept	Trend and Intercept	Intercept	Trend and Intercept
	Level	Level	Level	Level
SP	-17.28286***	-17.27348***	-17.43448***	-17.43693***
	0.0000	0.0000	0.0000	0.0000
BTC	-17.05730***	-17.18286***	-17.13246***	-17.22295***
	0.0000	0.0000	0.0000	0.0000
ETH	-16.53022***	-16.65097***	-16.69417***	-16.73349***
	0.0000	0.0000	0.0000	0.0000
BNB	-14.88606***	-14.92659***	-15.19955***	-15.23268***
	0.0000	0.0000	0.0000	0.0000
VIX	-22.12325***	-22.09149***	-24.70086***	-24.68424***
	0.0000	0.0000	0.0000	0.0000
FFR	-9.460029***	-9.493945***	-16.78394***	-16.79861***
	0.0000	0.0000	0.0000	0.0000

*Notes: ***, **, * represent rejection of null hypothesis at 1%, 5% and 10% significance level, respectively. Figures in parentheses are p-values. The determination of the lag length for the ADF test relies on the Schwarz Information Criterion (SIC), with a maximum of lags considered. The bandwidth selection for PP test is depend on Neway-West Bandwidth using the Bartlett kernel method.*

The results of the ADF and PP tests indicate that at the level form, the null hypothesis for all variables is rejected at a 1% significance level. This rejection occurs as the p-value is negative and falls below the significance level, considering both the intercept and trend and intercept. It indicates that they are I(0) regressors, meaning the variables are stationary and do not have a unit root.

The outcomes from the ADF and PP tests indicate that all variables are stationary and provide more reliable estimates of the regression coefficients for time series analysis. Moreover, it also can help improve the model's overall performance in terms of goodness-of-fit measures.

4.2 GARCH Model

Equation 4.2.1 presented in this paper aims to achieve the specific objective of analyzing the hedging capability of cryptocurrencies concerning the U.S. stock market after a structural change.

$$\Delta \ln S\&P\ 500 = \beta_0 + \beta_1 \Delta \ln CRYP + \beta_2 \Delta \ln VIX + \beta_3 \Delta \ln EFFR + \varepsilon \qquad (4.2.1)$$

Where $S\&P\ 500$ denotes return on S&P 500, the abbreviation "CRYP" represents the Bitcoin, Ethereum and Binance coin, VIX is CBOE Volatility Index, EFFR refers to Effective Federal Fund Rate. Each model is developed for two different split samples.

Table 4.2.1 demonstrates the estimation results of Model (I), II), (III), (IV), (V) and (VI) in the GARCH model, for which the purpose is to ascertain the presence of short-run relationship between the variables of interest. Models (I), (III), and (V) are designed to investigate the hedging capability of Bitcoin, Ethereum, and Binance Coin toward the U.S. stock market, respectively, before the structural change, covering the period from 11th January 2017 to 28th July 2021. Conversely, models (II), (IV), and (VI) are constructed to assess the hedging capability of Bitcoin, Ethereum, and Binance Coin,

respectively, after the structural change, spanning from 29th July 2021 until 1st March 2023. Additionally, models (III), (IV), (V), and (VI) serve the purpose of conducting robustness checks.

Table 4.2.1 Result of FGLS Approach

	Dependent variable: S&P 500					
	BTC		ETH		BNB	
	I	II	III	IV	V	VI
CRYP	0.0005	0.0501**	0.0060	0.0519***	0.0068	0.0460*
	(0.9302)	(0.0297)	(0.1804)	(0.0005)	(0.1500)	(0.0529)
VIX	-0.0793***	-0.1043***	-0.0786***	-0.1010***	-0.0857***	-0.1039***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
EFFR	-0.0021	-0.0231	-0.0016	-0.0194	-0.0040	-0.0242
	(0.8042)	(0.2000)	(0.8583)	(0.1357)	(0.6659)	(0.1661)
C	0.0035***	-0.0004	0.0034***	-0.0005	0.0036***	-0.0007
	(0.0000)	(0.7806)	(0.0000)	(0.7154)	(0.0000)	(0.6738)

*Notes: ***, **, * represent rejection of null hypothesis at 1%, 5% and 10% significance level, respectively. Figures in parentheses are p-values. CRYP is measure with BTC, ETH AND BNB respectively.*

Table 4.2.1 tabulates the estimated results that reveal some key findings. First, Model I shows an insignificant and positive estimate (0.0005) for U.S stock market return since the p-value of 0.9302 is greater than the 1%, 5% and 10% significance level, respectively, we failed to reject the null hypothesis. It indicates that there is not sufficient evidence to say that there is no relationship between the U.S. stock market

return and Bitcoin return. This result of the impact of BTC return on the U.S. stock market before the structural change is in conformity with the findings reported in Dyhrberg (2016), Bouri et al. (2020) and Goodell and Goutte (2021), which Bitcoin can as a solid hedging tool against investing alternative and EPU.

However, Model II reports a significant and positive estimate (0.0501) for the U.S. stock market return at a 10% and 5% significance level. It indicates that the null hypothesis is that there is a relationship between the S&P 500 stocks return and Bitcoin return. Specifically, it is evident that the Bitcoin return imposes a strong influence on the U.S. stock market return after the structural change. This result is in conformity with the early empirical evidence as Bouri et al. (2017b), and Conlon and McGee (2020) demonstrated that Bitcoin is unable to reduce the negative impact of the S&P 500's fluctuations. In other words, Bitcoin does not serve as a secure choice for inclusion in an investment portfolio to provide protection during market downturns.

The robustness testing has been done to ensure that the results are reliable by interchanging the Bitcoin return with the Ethereum return and Binance coin return while figuring out the effect of cryptocurrency on the U.S. stock market return. This set of results is similar to the result in the case of examining the impact of Bitcoin return on U.S. stock market return; the coefficient of the Ethereum return is also a positive sign in Model III, which will supportively affect the S&P 500 stock market return. But, the p-value in Model III exceeds the 10% significance level, it implies that there is no relationship between the S&P 500 stock market return and Ethereum returns before the structural change. Next, the result from Model IV indicates that Ethereum returns significantly increase the return of the S&P 500 stock market return at all significant levesl. The p-value in Model IV is smaller than 10%, 5%, and 1% significance levels, it indicates that there is a relationship between the Ethereum return and the S&P 500 stock market return. Likewise, the finding above shows that the hedging capability of Ethereum is changing after the structural change, it cannot be a tool to hedge and reduce the risk of portfolio.

In terms of Binance coin return, Model V investigates the impact of BNB return on the U.S. stock market return before the structural change reports positive estimates and is insignificant at the 10%, 5% and 1% levels of significance. The results regarding BNB may be used as a tool to hedge and lower portfolio risk. Besides, Model VI reveals a significant and positive relationship between S&P 500 stock market return and BNB return at the 10% level of significance. Specifically, it has enough evidence to reject the null hypothesis, which means that the BNB return does not have hedging capability toward the U.S. stock market return.

In terms of the controlled variables, focusing on the coefficients of VIX index in Table 4.2. All regression models also reveal significant and have a negative sign for the coefficient of the VIX index. It implies that an increase in VIX will lead a significant adversely impact on the S&P 500 stocks market return. For examine the Bitcoin, Ethereum and Binance coin at the period before the structural change, when the VIX index increment by 1%, on average, the S&P 500 stocks market return will drop by 0.079347%, 0.078607%, and 0.085696%, respectively, holding other variables constant. Besides that, when examine the Bitcoin, Ethereum and Binance coin at the period after the structural change, if the VIX index increments by 1%, on average, the S&P 500 stocks market return will drop by 0.104265%, 0.101036%, and 0.103890%, respectively, ceteris paribus. The difference in the S&P 500 stock market return between before and after the structural change when investigating three of the cryptocurrencies is very familiar, close to 0.18. The results regarding the VIX return are consistent with several past evidence, including Gaies et al. (2021), which showed that the fear index VIX will have an impact on investors' mindsets as well.

Apart from that, the coefficient of effective federal fund rate, for all the regression models, was observed to negatively influence the U.S. stock market return; nonetheless, the impact is considered insignificant since the p-value is greater than 10% significance level. While in the extent of examining the impact of Bitcoin, Ethereum, and Binance coin on the stock market return before the structural change, for every 1% increase in

EFFR, S&P 500 return will drop by 0.002156%, 0.001563% and 0.004005% respectively, ceteris paribus; for every 1% increase in EFFR after the structural change, the stock market return will decline by 0.023127%, 0.019445% and 0.024183% subsequently, ceteris paribus. This outcome coincides with Fang et al. (2019) and Smales (2019), who proved that the changes in interest rate have no impact on the stock market return.

4.3 Diagnostic Checking

There will be three tests conducted to ensure the robustness of the result. The diagnostic tests include the Jarque-Bera test, Breusch-Godfrey LM test and ARCH-LM test which is used to detect normality, autocorrelation and autoregressive conditional heteroscedasticity respectively.

4.3.1 Normality

Table 4.3.1.1 Result of Jarque-Bera Test

	BTC		ETH		BNB	
	I	II	III	IV	V	VI
Jarque-Bera	123.0027***	0.394645	138.0217***	0.557869	94.9737***	0.600939
	(0.000)	(0.8209)	(0.000)	(0.7566)	(0.000)	(0.7405)

*Notes: ***, **, * represent rejection of null hypothesis at 1%, 5% and 10% significance level, respectively. Figures in parentheses are p-values with lag length of 12.*

Table 4.3.1.1 tabulates the estimation results that testing the data observation is normally distributed or not. While investigating the effects of BTC, ETH, and BNB on the U.S. stock market return following the structural change, the p-values is 0.8209, 0.7566, and 0.7405 respectively. The result presents that the data observation is normally distributed. While scrutinising the ramifications of BTC, ETH, and BNB on the U.S. stock market return prior to the structural change, the p-value of all of it presents significant and it implies that the data set is not normally distributed. Notwithstanding, the data is not distributed normality, our data result is still considered efficient since our data observation is more than 30. According to the research from Kwak and Kim (2017), the central limit theorem states that the sampling distribution can considered normal if the sample size is 30 due to the sample means clustering more closely spaced around the true mean.

4.3.2 Autocorrelation

Table 4.3.2.1 Results of Breusch-Godfrey LM test

	BTC		ETH		BNB	
	I	II	III	IV	V	VI
Breusch-Godfrey	0.201801	0.936969	0.211392	1.762157*	0.503105	1.487536
	(0.9979)	(0.4503)	(0.9974)	(0.0685)	(0.8965)	(0.1329)

*Notes: ***, **, * represent rejection of null hypothesis at 1%, 5% and 10% significance level, respectively. Figures in parentheses are p-values with lag length of 12.*

According to Table 4.3.2.1, the generated F-statistic from the Breusch-Godfrey LM test of each model had a p-value of chi-square distribution that is larger

than 1% and 5% significance level. This means that no evidence to reject the null hypothesis of there is no autocorrelation. Hence, all of the models are not autocorrelated in 5% and 1% significance levels, this proved by the LM test.

4.3.3 Autoregressive Conditional Hetescedasticity

Table 4.3.3.1 Results of ARCH LM Test

	BTC		ETH		BNB	
	I	II	III	IV	V	VI
ARCH	1.133549	1.487103	1.096033	1.675147	0.884093	1.379072
	(0.3292)	(0.1604)	(0.3587)	(0.1070)	(0.5504)	(0.2019)

Notes: Figures in parentheses are p-values with lag length of 12.

Table 4.3.3.1 revealed that the p-value of chi-square distribution of every model is larger than 1%, 5% and 10% significance levels in the ARCH test. This means no evidence to reject the null hypothesis of there is no heteroscedasticity in the model. Hence, the ARCH test has implied that all of the models are not heteroscedasticity in 10%, 5% and 1% significance levels. The result depicts that the error term in the FGLS model does not experience ARCH issues.

4.4 Chapter Summary

As a summary, the unit root test was performed in order to verify that all of the variables of interest are stationary at level. Moreover, there are cointegration relationship is found between the U.S. stock market return and cryptocurrency return after the structural change through the GARCH model testing. According to the finding above, all the dependent variables, which is BTC, ETH, and BNB return can influence the U.S. stock market return positively and significant after the structural change. For VIX, these variables is significant adversely on the U.S. stock market return; nonetheless, another control variable which is EFFR had no relationship with the U.S. stock market return. Afterwards, LM test and ARCH test were conducted for diagnostic testing, there testing proved that the models are not autocorrelation and homoscedasticity respectively, it implies that each of the six estimated models is adequately specified. The empirical results and conclusion will be displayed in Chapter 5.

CHAPTER FIVE: DISCUSSION, CONCLUSION AND IMPLICATION

5.0 Introduction

This chapter will present a thorough discussion about the effect of this research in line with the overall results and findings form the prior chapters. Section 5.1 will focus on the major findings and section 5.2 will provide implications of study. Next, section 5.3 and 5.4 will deliver a discussion for the limitations of this research and suggestion for the future research respectively.

5.1 Discussion of Major Findings

In conclude, the main significance of the present study is to analyse the relationship between the cryptocurrency market and the U.S. stock market before and after the structural change. Meanwhile, this study can determine the hedging capability of cryptocurrencies against the U.S. stock market return before and after the structural change. As such, FGLS methodologies in being applied, inclusive of unit root tests and assorted diagnostic tests.

By employed the FGLS approach, the results show that there is a positive coefficient and insignificant in explaining the relationship between cryptocurrencies return and U.S. stock market return over the period before the structural change. The result above showing that Bitcoin, Ethereum and Binance coin before the China event is not

significant. Based on previous study from Baur and McDermott (2010b), the hedging power of the assets can be categories to weak and strong hedge. Therefore, it can be concluded that these three cryptocurrencies can act as a weak hedging tool for the investors. Whereas, the outcome demonstrates that there is positive relationship between the cryptocurrencies returns and U.S. stock market return after the structural change, as it is positive coefficient and significant in all the model. It indicating that there is positive correlation between cryptocurrencies and U.S. stock market return, which means that a rise in the independent variables which are BTC, ETH, and BNB can result in higher U.S. stock market return. Consequently, the cryptocurrencies do not have hedging capability toward the U.S. stock market for diversify the risk.

Besides that, the VIX index were found that to there is significant and the coefficient is in negative sign on U.S. stock market return, which mean that there is negative correlation between U.S. stock market return and VIX. Consistent with the major findings of existing studies, the relationship between U.S. stock market return and VIX is found to be negative (Thielen, 2016; Bae et al., 2006; Olbrys & Majewska, 2017).

According to the findings in this research, the control variable of EFFR were implied an insignificant and negative impact with U.S. stock market return. All of the model were illustrated to be insignificantly affecting the U.S. stock market return in an adverse direction. The results of our study are alike to the other major findings of other researches as in Bernanke and Kuttner (2005) and Crowder (2006), however, Park and Paul Choi (2011) and Maskay and Chapman (2017) found that there is a positive relationship between the interest rate and stock market return.

5.2 Implications of Study

The implications of the major findings in this research are various ramifications. First, the correlation between the U.S. stock market return and cryptocurrencies return is positive. In other words, U.S. stock market return is likely to be positively influenced by the cryptocurrencies return after the structural change due to the China government banned the cryptocurrency trading. From the aforementioned findings, investors are well-informed that the three largest cryptocurrencies have proven to be ineffective as hedging tools in the investment due to the recent restrictions on cryptocurrency trading in China. Hence, investors are strongly recommended to explore alternative investment options or find a more appropriate hedging tool with the intention to minimize the risk exposure and maximize the return on the investment.

Furthermore, the empirical findings from this study will have significant implications for portfolio managers and risk managers when making investment decisions. They may explore alternative virtual currencies that have not been mentioned or traditional investment approaches.

By understanding the positive correlation between U.S. stock market returns and cryptocurrency returns, they can develop and manage an optimal investment strategy that aligns with their budget, goals, and risk preferences. Moreover, virtual currencies have the potential to fulfill various investment objectives rather than hedging or risk mitigation in the stock market. While some empirical research suggests that Bitcoin can serve as a safe-haven asset in investment portfolios (Baur & McDermott, 2010b; Popper, 2015; Wijaya & Ulpah, 2022), our research results observed that Bitcoin. Ethereum and Binance Coin did not have the hedging capability toward the U.S. stock market. Hence, managers should exercise prudence and thoroughly assess their decisions regarding these research findings.

Based on our empirical findings, we have observed a positive correlation between the returns of the U.S. stock market and cryptocurrencies. In subsequent times, should circumstances like the imposition of trading restrictions on cryptocurrencies by the Chinese government occur, leading to consequential alterations in the overall economic system, it is plausible likelihood that it could impact the fundamental nature of cryptocurrencies. This possibility remains a distinct consideration. Hence, policymakers can leverage this valuable knowledge to make informed adjustments to their policies. Given that the stock market serves as a reflection of a country's economic performance, policymakers should consider the impact of cryptocurrencies on stock market returns and take necessary measures to modify policies in the cryptocurrency market. By designing and implementing appropriate regulations and policies, they can mitigate unexpected exposure and anticipate substantial growth in the stock market in the future.

Furthermore, the future researchers can obtain a deeper understanding of the structure of U.S. stock market and cryptocurrencies market through our study of the relationship between U.S. stock market return and cryptocurrencies market after the structural change. Likewise, this research offers guidance for future researchers to expand their scope of study on the most recent issues in the field by investigating the correlation between cryptocurrencies and other stock markets.

5.3 Limitation of study

This paragraph will go over the limitations of the research, which were highlighted in the preceding paragraph. It is important for researchers to identify the weaknesses of the research so that they may improve from it and look for the better ways to remedy or expand these constraints in future studies.

First and foremost, the period of research has limited to the emergence period of policy changes in China. The distribution points of data applied in the research do reach the optimal point, which were the period of before and after the accident. There are greater amounts of information were being gathered compared to the earlier of incident, fewer were being captured succeeding it. Since our study explores the implications of China's policy changes, some of the former datasets were not suitable to apply in the research. In order to avoid inconsistent data caused by cryptocurrencies' varying creation timeframes, the study period has been limited to year 2017 to 2023 instead of year 2009. Meanwhile, the Binance coin data is only available from year 2017, which may cause to overlook certain important data because it does not fit to the issue of study.

On top of that, this study focuses solely on the U.S. stock market, specifically utilizing the S&P 500 index within a specific timeframe. However, it is important to note that the composition of the S&P 500 may vary over time, which could potentially show different results. Consequently, different companies within the S&P 500 might exhibit diverse reactions to stock market performance. Furthermore, due to the complexity and uniqueness of the research topic, locating studies directly relevant to the research topic is challenging, necessitating an extended period to collect and validate the gathered information.

5.4 Recommendations for Future Research

Recommendations are seen as solutions to limitations, it can help to mitigate the occurrence of repeated mistakes and enhance performance. It will make the results more accurate if the data observation is larger enough, that is why many researchers try to collect as much data as observations to help them analyze their research study. Since the event of China banned cryptocurrency transactions is happening in July 2021, the data that the researchers can collect is limited. In the study, researchers can only collect the data from July 2021 until March 2023 because of the time limit. Therefore, it is strongly advised that future researchers interested in continuing to explore this study can improve by adding more data observation to the research. The reason is that they have more time to collect data observation after March 2023. This will make the result more solid and accurate than this study.

For future researchers, they use another stock index besides S&P 500 to represent the whole U.S. stock market return, which can give the researchers a clearer picture and clear trend. Additionally, there are better indicators for researchers to measure U.S. stock return than S & P 500 index. Researchers can still choose various types of stock indexes to determine the U.S. stock return, such as Dow Jones Industrial (DJIA), Nasdaq Composite Index, Russell 2000 Index, and Wilshire 5000 Total Market Index. These alternative indicators can provide additional perspectives and complement S&P 500 when examining the U.S. stock market. Some of the indexes can capture a broader range of companies and market segments in the U.S. market, which can help the researcher get more detailed and specific information.

Another recommendation to future researchers is to look into other countries when they want to do the research, such as Europe, South Africa, and so on. The reason behind is different countries may have different result. Therefore, it can help them to make a comparison with this study and contribute more information in this field to other

interested people in the future. Other than that, researchers also can try to analyze other financial markets or even financial instruments to see whether the China event will bring the significantly impact to other instruments.

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