Is It Worth to Include Bitcoin in Your Investment Portfolio? Risk-adjusted Returns Portfolio Optimization

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Abstract

Digital transformation has altered the world in a way we have never experienced. The fintech introduces new products and services into the financial market. Bitcoin represents one of the milestone developments in digital assets. It is the first peer-to-peer electronic cash and is the flagship cryptocurrency with the largest market capitalization. Bitcoin has gained popularity as an alternative investment asset. This study aims to examine whether investors should include Bitcoin in their portfolios. The present paper contributes to the literature on cryptocurrencies by proposing asset allocation in an optimal portfolio. Optimal portfolios that include and exclude Bitcoin are estimated with Python SciPy to find the best feasible asset allocations that offer the maximum Sharpe ratio. The three optimal the portfolios are portfolio with Bitcoin, gold, and stocks, the portfolio with Bitcoin and stocks, and the portfolio with gold and stocks. The expected returns and risk of the estimated optimal portfolios are compared.

The findings suggest that Bitcoin provides significant diversification benefits when it is added to the portfolio of stocks and gold. The optimal portfolio that performs best in this study invests 13 percent in Bitcoin, 43 percent in gold, and 43 percent in stocks. The optimal portfolio that consists of Bitcoin, gold, and stock can offer superior returns at relatively the same level of volatility as the optimal portfolio that includes only gold and stock. The optimal portfolio that contains only gold and stock shows the lowest expected returns and the least volatility among the three optimal portfolios calculated. It is concluded that even though Bitcoin is highly volatile when considered as an individual asset when it is allocated

together with gold and stock, the Sharpe ratio of the portfolio implies that the optimal portfolio delivers the best reward-to-variability.

Keywords: Cryptocurrency, Bitcoin, Portfolio Management, Risk Management, Diversification

Introduction

In the last decades, digital disruption has had a tremendous impact on every industry. It alters the way firms and consumers operate in an economy. It opens doors to innovative products, services, and business functions that consume fewer resources. In financial markets, the evolution brings about “fintech”, the short terminology of financial technology that replaces the fundamental function of financial services with advanced digital transactions. Automated fintech challenges financial institutions in offering frictionless transactions and serves the unserved market with a variety of new instruments (De Venn, 2023; Lestari & Rahmanto, 2023). In 2019, Pricewaterhouse Coopers (PwC) stated in the Global FinTech Report that “FinTech is a major disruptor in the financial services industry, and it affects the way financial services market players do business (Weerawarna, Miah, & Shao, 2023). Examples range from mobile banking applications to the invention of digital currencies (OECD, 2022; Valavan, 2023) The digital currencies called cryptocurrencies derive their name from cryptographic mathematics that enable secure electronic transactions. They attract investors and academics as a digital representation of values (Chuen 2018; Narayanan, et al. 2016; Ram, 2019). In addition, they have made possible value creation and ownership transfer in unfulfilled markets such as fine arts and distinguished properties (Ante, 2023; Bhandare & Kandi, 2024). The widely accepted cryptocurrencies today are Bitcoin and Ethereum. Bitcoin was introduced to the public in 2009 as a blockchain-based peer-to-peer payment. It removes the need for a third party in financial transactions. Compared to traditional fiat currencies, Bitcoin is created and stored in decentralized ledger systems (Kaushal, 2016; Mungoli, 2023; Omote & Yano, 2020; Panda, Sathya, & Das, 2023). The initial US dollar price value of Bitcoin at the early time was 0.00003 US dollars per 1 BTC (Panda Sathya, & Das, 2023). It reached 20,000 US dollars per BTC in 2017 and achieved over 70,000 US dollars per BTC in 2024 (Edward, 2024). Though the price of Bitcoin has been volatile since its initiation, it is recommended by researchers as an efficient hedging mechanism since the influencing factors differ from those of financial assets (Jana, Nandi, & Sahu, 2024; Terraza, Boru Ipek, & Rounaghi, 2024; Uddin, Ali, & Masih, 2020).

This study aims to investigate whether Bitcoin should be included in an optimal portfolio as an alternative investment asset. The optimal portfolios both including and excluding Bitcoin were formulated to maximize the Sharpe ratio. The performance optimal portfolios are compared based on risk, returns, and risk-adjusted returns. The optimal portfolio with a higher Sharpe ratio is deemed to be a better portfolio. The following section discusses prior literature related to Bitcoin and portfolio optimization. In section three, the data and methodology required in this study are considered. Sections four and five discuss the empirical results and conclusion of the study.

Research Objectives

This study aims to investigate whether Bitcoin should be included in an optimal portfolio as an alternative investment asset. The optimal portfolios both including and excluding Bitcoin were formulated to maximize the Sharpe ratio. The performance optimal portfolios are compared based on risk, returns, and risk-adjusted returns. The optimal portfolio with a higher Sharpe ratio is deemed to be a better portfolio.

Literature Review

Bitcoin as an alternative asset

In 2008, Bitcoin was introduced by Satoshi Nakamoto as the first decentralized peer-to-peer digital currency. It is described by Nakamoto (2008) as “A purely peer-to-peer version of electronic cash would allow online payments to be sent directly from one party to another without going through a financial institution”. With its rapid growth, Bitcoin has been the flagship of the cryptocurrency market with the largest market capitalization (Corbet, Lucey, Urquhart & Yarovaya, 2019; Ram 2019). It represents the standard example of cryptocurrency (Burniske & White, 2017). The value of Bitcoin has been volatile and influenced by several factors emerging from the dynamic interaction of fundamentals and speculation (Kukacka & Kristoufek, 2023). Bitcoin is distinct from other financial assets. It originated from blockchain-based mathematical algorithms while traditional financial instruments are backed by tangible assets or raised by business entities to finance their operation. The correlation between Bitcoin and other assets is exceptionally low (Brière, Oosterlinck, & Szafarz, 2015). The literature on Bitcoin debates its attractive features, risks, and potential for portfolio diversification. Liu and Tsyvinski (2021) compared a risk-return trade-off between stocks, commodities, currencies, and the three major cryptocurrencies. It was found that the returns on Bitcoin, Ripple, and

Ethereum are determined by momentum and investor attention, the factors that are different from those influence other asset classes. These characteristics set them apart from stock, foreign currency, and commodity. The studies by Li, Urquhart, Wang, and Zhang (2021), Liu, Liang, and Cui (2020), and Liu, Tsyvinski, and Wu (2022) proposed that the cross-sectional expected returns on cryptocurrency can be predicted by market, size, and momentum factors. The returns on cryptocurrency decrease with size and increase with momentum. Pele, et al (2023) separated cryptocurrencies from traditional assets by the maximum variance components split method. Due to its high volatility compared to stocks, bonds, exchange rates, real estate, and other commodities, the authors examined specifically the statistical property of the cryptocurrencies. The empirical evidence shows that the long tail of log-returns distribution a high variance property of cryptocurrencies differentiates them from other traditional assets, and extra supervision is required to include them in the portfolio. The variance of Bitcoin was examined in several studies Bhuiyan, Husain & Zhang, 2023; Brière, et al, 2015; Guesmi, Saadi, Abid, & Ftiti, 2019; Kumah & Mensah, 2022). The spillover effect of Bitcoin is minimal relative to other types of assets and the volatility of Bitcoin is negatively correlated with the volatility of other assets. Inclusion Bitcoin, even for a small proportion of the portfolio, can enhance the risk-return trade-off of a well-diversified portfolio. Bouri, Das, Gupta, & Roubaud (2018) examine the volatility spillover between Bitcoin and the four traditional assets: equities, bonds, currencies, and commodities using the VAR asymmetric ARCH model. This study found that Bitcoin has moderate integration with other assets in the study. Based on empirical evidence, Bitcoin acts more as a recipient of volatility transmission from other assets, and it does not impose substantial risk into the global financial markets. However, it is advised that investors monitor the Bitcoin market closely and be cautious in investment decisions. If an appreciation of Bitcoin's value allows it to become a large player in financial markets, the global financial system can be at risk. Uddin, Ali, & Masih, (2020) investigated the hedging property of Bitcoin against three types of equity investments: conventional, Islamic, and sustainable stocks using a DCC-MGARCH model and a continuous wavelet transformation. Bitcoin returns exhibit mean-reverting properties suggesting that it is one of the sustainable asset classes. The finding added that Bitcoin serves as a hedging tool for all equity indices in the study in the short and long term. Jana, Nandi & Sahu (2024) provide evidence from the Indian stock market. The four cryptocurrencies including Bitcoin, Ethereum, Binance coin, and Ripple were examined for their hedging properties against the NIFTY50 stock

index and using wavelet analysis. The findings show high returns volatility of stock and cryptocurrencies in economic crises. Cryptocurrencies are efficient hedges in normal economic situations but fail to offer diversification advantages during crises.

The benefit of including Bitcoin in the traditional stocks-bond portfolio was examined by Platanakis and Urquhart (2020). Portfolios with Bitcoin are constructed under various allocation strategies and risk aversions. The findings indicate that Bitcoin enhances the Sharpe, Omega, and Sortino ratios. The paper proposes holding Bitcoin can generate higher risk-adjusted returns. However, the investment in Bitcoin requires extra caution. Cryptocurrencies are highly volatile and not valued based on tangible assets or corporate profit. They arise instead from the security of an algorithm in a peer-to-peer system (Corbet et al., 2019). Elferich (2021) examined the impact of adding Bitcoin into the portfolio under Markowitz's efficient portfolio theory context. The Sharpe ratios of portfolios that include and exclude Bitcoin were compared. Based on the sample during 2019 and 2020, the inclusion of Bitcoin increases both returns and volatility of portfolios. Bhuiyan et al. (2023) employed the DCC-GARCH model and wavelet analysis to examine the dynamic diversification benefits of Bitcoin during the COVID-19 pandemic and the Russia-Ukriane war in advanced and emerging markets. Using data from 2014 to 2022, Bitcoin was found to provide diversification benefits similar to gold in the short run. But in the long term, gold is more stable than Bitcoin even in the normal market condition. Taera, et al., (2023) studied the impact of the Covid-19 and Russia-Ukraine war on volatility and shock persistence of financial and alternative assets. The study includes five classes of alternative assets: Islamic stocks, ESG stocks, Fintech index, cryptocurrencies, and commodities. The results show that all assets except Bitcoin exhibit higher volatility across the study period from January 2019 to July 2023 and all assets became more volatile during the Covid-19 period. Terraza, Boru Ipek, & Rounaghi, (2024) studied the markets for Bitcoin, gold, and U.S. equity using DCC-EGARCH estimation. The findings demonstrate the potential diversification opportunity of Bitcoin. The dynamic conditional correlations are evidenced among Bitcoin, stock market, and gold investment during the pandemic crisis. Bitcoin was efficient in managing portfolio risk during the COVID-19 period. Symss (2023) extends the literature on cryptocurrencies to examine their ability to replace traditional financial assets to meet firms' financial needs. Review of literature and theoretical perspectives, the authors concluded that cryptocurrencies are distinct from other financial assets. They can be a resort for diversification especially when the returns on traditional financial assets are low.

Portfolio Optimization

Investors have long been challenged to construct their optimal portfolios. Markowitz (1952) proposed the classical mean-variance method which states that investors minimize risk at any level of a given return. Markowitz's Modern Portfolio Theory (MPT) relies on quadratic problem-solving to achieve a high-quality investment scheme. The mean-variance model assumes investment in *n* risky projects in a single investment period. The r_i denotes an expected return on asset i. The portfolio's expected returns can be described as

$$E(r_p) = \sum_{i=1}^{n} x_i \, E(r_i) \quad (1)$$

where x represents the proportion of asset i in the portfolio.

The variance of the portfolio with n assets are described as

$$\sigma_p^2 = \sum_{i=1}^{n} w_i^2 \, \sigma_i^2 + \sum_{i=1}^{n} \sum_{j=1}^{n} cov(r_i, r_j) \;\; i \neq j \quad (2)$$

Where i and j represent asset i and asset j respectively,

$cov(r_i, r_j)$ is the covariance between asset i and asset j.

Equation (2) illustrates that the risk of the portfolio depends on the proportion of each asset and the covariance of assets in the portfolio. The investors are advised to select an investment with a lower variance and a low correlation coefficient between two assets.

The Sharpe ratio was introduced in 1966 by William F. Sharpe to quantify the risk-adjusted returns of the portfolio (Sharpe, 1966). Until recently, it has been one of the most popular reward-to-variability measures (Anelli, 2023; Ding, 2024; Farinelli, et al, 2008; Ma, 2023; Zhang, 2023). The Sharpe ratio can be described as

$$S_p = \frac{E(r_p) - r_f}{\sigma_p} \quad (3)$$

where S_p denotes the Sharpe ratio of a portfolio,

$E(r_p)$ denotes the expected return from the portfolio,

r_f denotes risk-free interest rate,

σ_p denotes volatility about the portfolio.

Earlier in the section, the diversification benefit of Bitcoin is supported by many literatures. However, there are limited studies that identify a suitable proportion of Bitcoin in an optimal portfolio. This present study, therefore, examines whether Bitcoin should be

included in the portfolio as an alternative asset and identifies the proportion that optimizes portfolio returns. Due to the well-accepted property of gold as a portfolio diversifier and a haven (Al-Nassar, Boubaker, Chaibi, & Makrama, 2023; Ang & Weber, 2017; Baur & McDermott, 2010; Drake, 2022; Ji, Zhang, & Zhao, 2020; Ming, Yang, Liu, 2023; Shrydeh, Shahateet, Mohammad, & Sumadi, 2019; Tarchella, Khalfaoui, & Hammoudeh, 2024), this present study compares the performance of the optimal portfolio that include Bitcoin to the performance of the optimal portfolios that do not include it. The finding of this study extremely benefits investors in selecting and allocating assets in their portfolio.

Methodology

To compare the performance of an optimal portfolio that includes Bitcoin with that of the portfolio that excludes Bitcoin, the historical data from the period April 20, 2015, to April 17, 2024, at the closing price of three ticker symbols namely, 'BTC-USD, 'GC=F' and '^GSPC' were retrieved from Yahoo Finance to be used as a proxy of daily price for Bitcoin, gold, and S&P500, respectively. The most recent treasury bill rate was retrieved from The Federal Reserve Bank of St. Louis Economic Data to serve as a proxy of a risk-free rate. Table 1 exhibits sample data employed in this study.

Table 1: Data Sample

Data	Period	Frequency	Sources
BITCOIN	20 April 2015 – 17 April 2024	Daily	Yahoo Finance
GOLD (COMEX gold futures price)	20 April 2015 – 17 April 2024	Daily	Yahoo Finance
S&P500	20 April 2015 – 17 April 2024	Daily	Yahoo Finance
US Treasury bill	20 April 2015 – 17 April 2024	Daily	Federal Reserve Bank of St. Louis

Source: Created by the Author for this Study.

The data series retrieved from Yahoo Finance was transformed into Pandas Data Frame under Python 3.11.5. Then the NumPy library is used to calculate the log return of each series as follows: the returns were first calculated as a natural log of the ratio of asset price at period (t) to price in the period $(t-1)$

$$r_t = \log\left(\frac{p_t}{p_{t-1}}\right), \quad (4)$$

the returns on Bitcoin were calculated as

$$BTC_r = \log\left(\frac{BTCP_t}{BTCP_{t-1}}\right), \quad (5)$$

where $BTCP_t$ is the closing price at period (t) and

$BTCP_{t-1}$ is the closing price at previous period $(t-1)$,

the returns on gold were calculated as

$$GLD_r = \log\left(\frac{GLDP_t}{GLDP_{t-1}}\right), \quad (6)$$

where $GLDP_t$ is the closing price of the gold futures index traded on COMEX at period (t) and

$GLDP_{t-1}$ is the closing price of the gold futures index traded on COMEX in the previous period $(t-1)$,

the returns on the S&P500 index were calculated as

$$SP500_r = \log\left(\frac{SP500P_t}{SP500P_{t-1}}\right), \quad (7)$$

where $SP500P_t$ is the closing price of the S&P500 index at period (t) and

$SP500P_{t-1}$ is the closing price of the S&P500 index at previous period $(t-1)$.

After deriving returns in all data series, three portfolios are formed as follows: the portfolio with Bitcoin, gold, and stocks, the portfolio with Bitcoin and stocks, and the portfolio with gold and stocks. The return from the portfolio can be defined as

$$r_p = \sum_{i=1}^{n} w_i r_i \quad \text{subject to} \quad \sum_{i=1}^{n} w_i = 1 \quad (8)$$

where r_p is the return from a portfolio

w_i is the proportion of investment in individual assets in the portfolio,

r_i is the return from each asset included in the portfolio

$\sum_{i=1}^{n} w_i = 1$ represents the constraint that the sum of weight must equal to 1.

The variance of the portfolio can be defined as

$$\sigma_p^2 = \sum_{i=1}^{n} w_i^2 \sigma_i^2 + \sum_{i=1}^{n}\sum_{j=1}^{n} cov(r_i, r_j), i \neq j \quad (9)$$

where i, j stand for individual assets,

$cov(r_i, r_j)$ is the covariance of the returns from different assets.

The Shape ratio of portfolios is defined as

$$S_p = \frac{E(r_p) - r_f}{\sigma_p} \quad (10)$$

where S_p denotes the Sharpe ratio of a portfolio,

$E(r_p)$ denotes the return from the portfolio,

r_f denotes a risk-free interest rate.

σ_p denotes a risk-free interest rate.

The three optimal portfolios are estimated using Python's SciPy library. Because it is a well-known application in data science to solve complex scientific problems efficiently and intuitively (Abdul & Bawa, 2023; Jain, 2023). Python SciPy library is efficiently employed in financial research which mostly requires advanced computation capability (Ma, 2023; Xu, 2024; Zhang 2023). To overcome the lack of maximization function in the SciPy library, for each portfolio, the Sharpe ratios of each distribution weight combination were calculated. Those Sharpe ratios were converted to negative and used as an input parameter for minimizing functions in SciPy using Sequential Least Square Programming, SLSQP, to find the distribution weight of assets that yield the lowest Sharpe ratio. The process can be written algebraically as follows,

$$\text{Max } (S_p) = \text{Min } (-S_p). \quad (11)$$

Results & Discussion

Descriptive Statistics

The descriptive statistics of all data series, Bitcoin, gold, and S&P500 index, are exhibited in Table 2. There are 1773 samples in this study. The mean returns of Bitcoin are higher than the mean returns of gold and S&P500. The standard deviation of Bitcoin is also the greatest. The preliminary statistics imply that Bitcoin, individually, is more volatile than gold and stock. The return from Bitcoin is also higher than returns on gold and stocks as compensation for the higher risk exposure.

Table 2: Descriptive Statistics

BTC_r		GLD_r		$SP500_r$	
N	1773	N	1773	N	1773
Mean	0.0015	Mean	0.0004	Mean	0.0005
Standard Deviation	0.0395	Standard Deviation	0.0091	Standard Deviation	0.0113
Minimum	-0.4647	Minimum	-0.0474	Minimum	-0.0999
Maximum	0.2251	Maximum	0.0578	Maximum	0.0897

Source: Created by the Author for this Study.

Optimal Portfolios with Maximum Sharpe Ratio

Optimal portfolios estimated by the Python SciPy library to search for a combination of assets that maximizes the Sharpe ratio of each portfolio are exhibited in Table 3. Three portfolios are estimated: the portfolio that includes Bitcoin, gold, and stocks, the portfolio that includes Bitcoin and stocks, and the portfolio that includes gold and stocks. The first optimal portfolio that includes Bitcoin, gold, and stock proposes that the combination of three assets is optimized when an investor invests 13 percent of the portfolio in Bitcoin, 43 percent of the portfolio in gold, and 43 percent of the portfolio in stocks.

As mentioned in the earlier section, the optimal portfolios containing Bitcoin and stocks and the portfolio containing gold and stocks are estimated as comparative benchmarks. The portfolio with Bitcoin and stocks is optimized when 24 percent of the portfolio is invested in Bitcoin and 76 percent of the portfolio is invested in the stock. The last optimization problem is estimated for the portfolio that contains gold and stocks. The portfolio is optimized when the two assets account for nearly half of the portfolio. That is when 49 percent of the portfolio is invested in gold and 51 percent of the total portfolio value is an investment in stocks.

Table 3: Optimal Portfolio Asset Allocation

Optimal Portfolio Summary			
Assets	**BTC-GLD-SP500**	**BTC-SP500**	**GLD-SP500**
Optimal Weight			
BTC	0.1317	0.2412	
GLD	0.4340		0.4941
SP500	0.4343	0.7588	0.5059

Source: Created by the Author for this Study.

The performance of the three optimal portfolios is compared. Table 4 below presents the performance of each optimal portfolio. Performance indicators are described in terms of expected return, volatility, and risk-adjusted returns or Sharpe ratio. The findings conclude that the optimal portfolio that invests in Bitcoin, gold, and stocks results in the highest Sharpe ratio implying that the portfolio offers the best risk-adjusted returns in this study (68.55 percent). It offers 14.16 percent expected returns and 14.51 percent standard deviation. The portfolio including only gold and stock portfolios provides the lowest Sharpe scores. It offers the lowest expected returns compatible with the lowest risk it is exposed to. An investment

of stocks together with Bitcoin (without gold) results in the highest returns (17.65 percent) among the three optimal portfolios that also come with the highest risk measured in standard deviation. The Sharpe ratio for the optimal portfolio containing Bitcoin and stocks offers higher risk-adjusted returns than the optimal portfolio consisting of only gold and stocks but is still lower than that of the optimal portfolio consisting of Bitcoin, gold, and stocks altogether.

Table 4: Summary of Optimal Portfolio Performance

Optimal Portfolio Performance Summary			
Assets	**BTC-GLD-SP500**	**BTC-SP500**	**GLD-SP500**
Expected Return	0.1416	0.1765	0.0871
Standard Deviation	0.1451	0.2200	0.1191
Sharpe Ratio	0.6855	0.5928	0.3782

Source: Created by the Author for this Study.

To conclude the findings, The three optimal portfolios were estimated to maximize the Sharpe ratio. The optimal portfolio that offers the finest performance in the study of reward-to-variability is investing 13 percent in Bitcoin, 43 percent in gold, and 43 percent in stocks. It is found that Bitcoin to the stock portfolio largely increases portfolio expected returns and increases the portfolio risk. However, when Bitcoin is added to the optimal portfolio that consists of stocks and gold, the optimal portfolio with three assets shows remarkable performance compared to the optimal portfolios without Bitcoin. Though the portfolio provides less expected returns than the optimal portfolios with stocks and Bitcoins, the highest Sharpe ratio from this portfolio indicates that the return might be high enough to compensate for the risk taken by some investors. The inclusion of gold into a stock portfolio offers the lowest standard deviation and the lowest reward-to-variability.

This study extends previous literature on cryptocurrencies to suggest optimal asset allocation weight for each asset in the portfolio. The optimal portfolios that include and exclude Bitcoin are estimated with Python SciPy to maximize the reward-to-variability before they are compared to evaluate the benefit of Bitcoin. There are prior studies that support the diversification property of Bitcoin in the short-term and during economic crises (Bhuiyan, et al., 2023; Terraza, Boru Ipek, & Rounaghi, (2024). However, this present study supports the inclusion of Bitcoin in a portfolio as a long-term investment asset. This supposition follows suggestions in Kukacka and Kristoufek (2023), Liu and Tsyvinski (2021), Platanakis and Urquhart

(2020). The empirical findings lend support to Elferich (2021), Kumah and Mensah (2022), Platanakis and Urquhart (2020), for the benefit of Bitcoin to enhance portfolio risk-returns trade-off. Bitcoin can be beneficial as an alternative asset in the long term. It is recorded to show stability in the long term since the variability of Bitcoin is steered by factors different from that of financial assets and the variance property of cryptocurrencies is distinct from traditional investment (Pele et al, 2023; Uddin, Ali, & Masih, 2020).

The findings discussed in this paper rely on the passive portfolio management technique assuming a buy-and-hold strategy in long-term value investment. To further contribute to the research in risk management and fintech, further analysis on cryptocurrencies is extremely beneficial. For example, research on the allocation of digital assets under varied economic conditions can extend the findings of this current paper. The highly volatile returns and complex algorithms of digital assets have been challenges for academics and investors. The knowledge of the nature of cryptocurrencies and their diversification advantages will certainly enhance opportunities in portfolio management

Conclusion

This study examines whether investors should include the cryptocurrency, Bitcoin, in their portfolios. Bitcoin has been discussed in various literatures and among investors as an alternative investment asset. Even though, in the past, it exhibits high volatility, it yields erratic returns. However, the inclusion of Bitcoin increases portfolio diversification. This study has extended previous literature on cryptocurrencies to suggest asset allocation in an optimal portfolio. Optimal portfolios that include and exclude Bitcoin are estimated with Python SciPy to find the best feasible asset allocations that offer the maximum Sharpe ratio. The findings suggested that Bitcoin provides significant diversification benefits when added to the portfolio of stocks and gold. The optimal portfolio that performs best in this study contains 13 percent in Bitcoin, 43 percent in gold, and 43 percent in stocks. The Optimal portfolio that consists of Bitcoin, gold, and stock can offer much higher expected returns with relatively the same level of volatility as the optimal portfolio that includes only gold and stock. On the other hand, the optimal portfolio that contains only gold and stock shows the lowest expected returns and the least volatility among the three optimal portfolios calculated. In summary, even though Bitcoin is highly volatile when considered an individual asset, when it is allocated together with gold and stock, the Sharpe ratio of the portfolio implies that the optimal portfolio delivers the best reward-to-variability

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