

# Application of Bitcoin in Investment Strategy

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## Abstract

We selected the daily trading data of BTC, SPY, DXY, GLD, and QQQ from Yahoo Finance, aiming to analyze the role of BTC in portfolios. This paper believes that BTC, as a high-risk asset, is speculative. Through correlation analysis, its returns were found to be independent of other traditional assets, proving that applying BTC to investment strategies could create arbitrage opportunities. Through various asset combinations in investment portfolio experiments, we found that the intervention of BTC could enhance the returns and optimal Sharpe ratio of the original investment portfolio, and the increase in the optimal Sharpe ratio decreased as the number of assets in the portfolio except for BTC increased. Therefore, for ordinary investors, we suggest adding 10% - 20% of BTC to a single asset. Through out-of-sample testing, we found that the investment strategy that includes BTC investment based on historical data, although it could not achieve the optimal Sharpe ratio, would have higher returns than the optimal Sharpe ratio investment portfolio without BTC intervention in the current period, considering that investors have certain risk tolerance, we believe that the effectiveness of historical investment strategies can be verified.

## Keywords

Cryptocurrency, BTC, Portfolio Management

## 1. Introduction

Digital assets are assets that have economic value and are stored, transferred, or traded through digital technology, and cryptocurrencies are one type of digital asset that is based on blockchain technology and decentralized (Toygar, Rohm Jr., & Zhu, 2013). With the rapid development of the global financial market, digital assets have gradually become popular in investment portfolios due to their high risk and high return speculative nature (Toygar, Rohm Jr., & Zhu, 2013). Bitcoin (BTC), as the first decentralized cryptocurrency, has evolved from a technical

experiment since its launch in 2009 to a highly regarded investment asset (Segendorf, 2014). Its unique features, such as a limited supply and decentralized design, make it significantly different from traditional asset categories such as SPDR S&P 500 ETF Trust (SPY), U.S. Dollar Index (DXY), and Invesco QQQ Trust (QQQ) (Segendorf, 2014).

However, as BTC is increasingly accepted by mainstream investors, there has been widespread discussion about its role in investment portfolios (Hazlett & Luther, 2020). Unlike traditional assets, BTC has high volatility, which presents both opportunities and challenges for investors (Hazlett & Luther, 2020). In this context, how to effectively integrate BTC as a new asset class into investment portfolios has become a focus of attention in the investment community (Platanakis & Urquhart, 2020).

The application of BTC in investment portfolios has important practical implications, especially in optimizing portfolio diversification and performance (Platanakis & Urquhart, 2020). If there is a negative or low correlation between traditional assets and BTC, this will provide investors with new hedging tools, which may enhance the Sharpe ratio or the ratio of risk-adjusted returns (Platanakis & Urquhart, 2020). Studying the role of BTC in portfolios can help explore its potential contribution as an emerging market asset and provide investors with decision-making.

In this paper, we first analyzed the unique attributes of BTC and traditional assets such as SPY, DXY, QQQ, and GLD in the financial market, calculated and aggregated the monthly returns for each asset, and found that from 2017 to 2023, they had shown unique return and risk characteristics. In the past historical performance, BTC showed high returns and high risks, and the probability of experiencing large losses was higher compared to other assets. QQQ and SPY showed stable performance driven by tech stocks and large-cap stocks, especially QQQ, with a higher risk-adjusted return, which was suitable for long-term investors. GLD, as a safe haven asset, had lower volatility but limited returns, while DXY, as a currency asset, had the lowest volatility and higher stability and was suitable as a hedging tool.

Secondly, based on correlation and covariance matrixes, contemporaneous regression, and Granger causality-related tests, this paper explored the correlation between BTC's and these traditional assets' monthly returns. The returns of different assets performed a certain correlation or independence, showing potential optimization and arbitrage opportunities, but further verification is needed. While the correlation matrix showed that there was a high degree of following behavior between SPY and QQQ, covariance matrix showed that their synchronization was low, which let us keep them all in the following experiment. The correlation coefficients between BTC and DXY and GLD were relatively low, and correlation coefficients between BTC and SPY and QQQ were relatively high. However, the above behaviors had no significant impact, as demonstrated by contemporaneous regression (as  $P$ -values all above 0.05). Although it could not identify

arbitrage opportunities, it could prove that the impact of each asset on BTC was not significant. Meanwhile, Granger causality-related tests showed that, except for DXY having a definite predictive ability towards BTC, the influence between the remaining assets and BTC could not be established significantly. In summary, this paper believes that there is a high probability of arbitrage opportunities existing when BTC intervenes in the investment portfolio consisting of DXY, SPY, GLD, and QQQ, but further experimental verification is still needed.

Next, based on modern portfolio theory, this paper explored the potential application of BTC in investment portfolios and analyzed its impact on portfolio performance through historical data and empirical research. Through initial attempts, we found that when five assets were used simultaneously in an investment portfolio, the optimal Sharpe ratio for the portfolio return was too low, approaching the minimum risk portfolio, which did not meet the investors' profit goals. Furthermore, by weighting capped DXY, this project found that the reason for this was the existence of DXY. To reduce the calculation volume, and since there were already hedging assets in the portfolio relative to BTC, we excluded DXY. Furthermore, by analyzing the impact of BTC on the portfolios consisting of SPY, GLD, and QQQ in all possible combinations, we found that the intervention of BTC can improve the optimal Sharpe ratios of the portfolios, and as the number of assets in the portfolios increased, the increase in the optimal Sharpe ratio due to BTC was also decreasing. Therefore, this project believes that for ordinary investors, choosing a relatively stable traditional asset (such as SPY or QQQ) and adding 10% to 20% of BTC is a stable and convenient investment approach. We also conducted a fixed investment and 12-month rolling window analysis for all the portfolios involved in the experiment, summarizing the best fixed investment period and the highest accumulated return for each portfolio, and the results verified the impact of BTC on traditional portfolios and showed that the above decision was also applicable.

Then, we summarized the effectiveness of BTC as an investment tool and the strategies provided by historical data through out-of-sample trials. We will use the Sharpe ratio and cumulative return as evaluation indicators and provide corresponding investment strategy recommendations. The research found that, regardless of whether BTC was intervened or not, excluding 2020, the historical strategies would not bring about an improvement in the Sharpe ratio but would bring about an improvement in cumulative returns (compared with the optimal Sharpe ratio investment portfolio without BTC intervention in the current period), and the return improvement brought by BTC intervention was higher (the corresponding Sharpe ratio would have similar condition with strategies without BTC intervention). Therefore, this project believes that the strategies provided by historical data have meaning and that BTC as a hedging tool may indeed bring higher benefits to investors, although it does require investors to bear certain risks. Therefore, this project believes that the investment strategy based on historical data using BTC intervention is effective for investors who are willing to bear

certain risks.

## 2. Literature Review

Cryptocurrencies have garnered significant academic attention as a novel asset class, with Bitcoin (BTC) standing out due to its market dominance, high returns, and substantial volatility. Existing studies provide a rich understanding of BTC's unique characteristics, its role within financial markets, and its implications for portfolio construction and arbitrage opportunities. Through this review, we synthesize prior findings to inform the present research while highlighting key inspirations drawn from the literature.

The dynamics of BTC pricing have been a focal point for many studies, revealing a complex interplay of factors. Network size and user adoption frequently emerge as central drivers of price movements, as noted by [Liu and Tsyvinski \(2021\)](#). Their findings underscore the significance of network effects, with increased user participation often correlating with higher prices. In contrast, production costs, such as those associated with mining activities, exert a comparatively limited influence. Additionally, momentum effects—both time-series and cross-sectional—play a crucial role in BTC's price trends, reflecting its speculative appeal. These dynamics are further complicated by regulatory events, which can either bolster market confidence or disrupt price stability, depending on the nature of the policy. For instance, supportive regulations tend to enhance investor sentiment, whereas restrictive measures often result in sharp price declines.

BTC's inherent volatility is another defining characteristic that has attracted considerable academic inquiry. [Alexander and Imeraj \(2019\)](#) highlighted BTC's extreme volatility relative to traditional assets like gold and equities. While its high variance risk premium (VRP) offers opportunities for substantial returns, it also presents significant challenges for risk-averse investors. Interestingly, during periods of market stability, BTC's low correlation with conventional assets makes it an attractive diversification tool. However, this correlation often increases during market downturns, reducing its effectiveness as a hedge. Such findings suggest that BTC's role in investment portfolios must be dynamically adjusted based on prevailing market conditions, an insight that profoundly influences portfolio management strategies.

The exploration of arbitrage opportunities in cryptocurrency markets has unveiled substantial inefficiencies, particularly across exchanges and jurisdictions. [Makarov and Schoar \(2020\)](#) identified persistent price discrepancies between BTC markets in different countries, often arising from regulatory constraints and capital controls. These inefficiencies create opportunities for arbitrage, though they also expose structural limitations in achieving price uniformity. Similarly, [Alexander and Dakos \(2020\)](#) examined the challenges of utilizing heterogeneous data sources, such as mismatched timestamps and data synchronization issues, which can distort risk assessments and volatility estimates. These insights are critical for this research, emphasizing the importance of selecting robust data sources and

designing strategies that account for structural inefficiencies.

Integrating BTC into investment portfolios has been a recurring theme in the literature, with researchers evaluating its potential to enhance returns despite its risks. Studies by [Harvey et al. \(2022\)](#) demonstrated that BTC's low correlation with traditional assets under normal market conditions can provide diversification benefits. However, during periods of financial distress, its correlation with equities and commodities often spikes, diminishing its value as a protective asset. [Liu, Tsyvinski, and Wu \(2022\)](#) further explored the performance of cryptocurrencies based on size and momentum effects. Their findings suggest that while smaller cryptocurrencies may offer higher returns, they are accompanied by greater risks, whereas BTC provides a more stable yet lower-return alternative. These observations emphasize the need for a careful and adaptive approach when incorporating BTC into portfolios, especially in light of its variable performance under different market conditions.

Investor behavior and regulatory developments also play a crucial role in shaping BTC's market dynamics. [Griffin and Shams \(2020\)](#) provided compelling evidence of the impact of stablecoin liquidity—particularly Tether—on BTC pricing. Their study revealed that significant Tether issuances often coincided with upward price movements, suggesting that supply-side liquidity could distort BTC's value. Furthermore, [Liu and Tsyvinski \(2021\)](#) illustrated how regulatory changes, whether positive or negative, can significantly influence market sentiment and, consequently, BTC prices. These findings underscore the importance of monitoring liquidity flows and regulatory trends as part of a comprehensive investment strategy.

Beyond BTC, the broader cryptocurrency landscape has introduced alternative investment opportunities, particularly through Initial Coin Offerings (ICOs). [Momtaz \(2021\)](#) examined the performance of ICOs, highlighting their initial undervaluation followed by periods of high volatility. Although many ICO projects fail to sustain their early momentum, a select few deliver exceptional long-term returns, adding another speculative dimension to cryptocurrency investments. These insights reinforce the necessity of risk-adjusted performance metrics, such as the Sharpe ratio, to evaluate the viability of cryptocurrency investments.

The extensive body of research on BTC and other cryptocurrencies offers several critical lessons for the present study. First, the volatility and conditional diversification benefits of BTC emphasize the importance of dynamic allocation strategies. Incorporating BTC into a portfolio requires continuous evaluation of market conditions and risk parameters to optimize returns while managing potential downsides. Second, the persistent inefficiencies in cryptocurrency markets, particularly those related to arbitrage, suggest opportunities for systematic strategies that exploit cross-platform and cross-border price discrepancies. Third, the impact of behavioral and regulatory factors highlights the need to integrate qualitative variables, such as sentiment and policy changes, into quantitative models to improve predictive accuracy. Finally, the speculative nature of cryptocurrencies

and their unique risk-return profiles suggest that combining momentum-based strategies with rigorous risk management frameworks can maximize investment outcomes.

By building upon these insights, this study seeks to explore BTC's role in enhancing portfolio performance and its effectiveness as a component of systematic investment strategies. The incorporation of factors such as momentum, arbitrage potential, and regulatory impacts aims to validate and extend the applicability of prior research findings. Through detailed analysis, we aspire to provide actionable guidance for investors navigating the complex and dynamic cryptocurrency landscape.

### 3. Data

This paper is drawn on Yahoo Finance's BTC price data from CoinMarketCap from October 22, 2017, to January 31, 2023, DXY price data from Intercontinental Exchange Futures, and SPY, GLD, and QQQ's price data from Nasdaq Global Market, the dataset includes the trading date "Date," the opening price "Open", the closing price "Close," the lowest price "Low," the highest price "High" and the volume "Volume". All figures are based on daily trading.

Selecting 2017 as the starting point for the data is a strategic decision based on several key considerations related to market dynamics and the availability of relevant data.

Firstly, 2017 marks a significant turning point in the cryptocurrency market, especially for Bitcoin (BTC), which experienced a dramatic surge in value and adoption during this period (Griffin & Shams, 2020). Prior to 2017, Bitcoin was still considered a niche asset, with relatively lower liquidity and fewer institutional investors involved (Griffin & Shams, 2020). The market's infrastructure, including exchanges, regulatory frameworks, and financial products like Bitcoin futures, began to mature around this time, leading to a more stabilized and accessible market (Griffin & Shams, 2020). Therefore, data starting from 2017 provides a more representative view of the current market structure and dynamics.

Secondly, according to the World Bank (2022), earlier data from periods like 2008 or 2013 would be less relevant due to the limited market participation and lack of financial instruments for analysis at the time. In 2008, for example, Bitcoin did not even exist, and in 2013, while Bitcoin was already operational, it had only a fraction of its current market capitalization and global exposure. Thus, including data from those years would not accurately reflect the modern realities of the cryptocurrency market, nor would it be meaningful for portfolio optimization and performance analysis today.

Additionally, data quality and availability have greatly improved since 2017, with more robust and comprehensive datasets becoming available from reliable sources like CoinMarketCap and Bloomberg (CoinMarketCap, 2023; Bloomberg, 2019). This enables more accurate modeling and a clearer understanding of the trends and relationships between assets like Bitcoin (BTC), traditional financial

instruments (e.g., SPY, QQQ), and commodities (e.g., GLD).

Furthermore, in order to verify the rationality of 2017 as the starting point of the data, we calculated the annual volatility of BTC in 2015-2017 and 2017-2023, and the results show that the volatility of the former is as high as 120%, while the average volatility of the latter is 75.83%, indicating that the market has gradually matured after 2017. In addition, we analyzed the volume of BTC and found that the average daily volume before 2017 was only 5000 BTC, and after 2017 it has exceeded 100,000 BTC, reflecting a significant increase in market liquidity. Therefore, using 2017 as a starting point for data can better represent BTC's modern market performance.

In addition, in order to verify the effectiveness of the strategy derived from the experimental conclusion, I reserved the part of data from 2017, 2023, and 2024 years for expanding the sample data and conducting out-of-sample experiments, which will be discussed in detail later.

### 3.1. Historical Data Performance

This paper utilized historical data from these five assets to calculate their Daily Return Mean, Weekly Return Mean, Monthly Return Mean, Annualized Return Mean, Volatility (annualized, based on daily returns), Skewness (based on daily returns), Kurtosis (based on daily returns), Sharpe Ratio (calculated using annualized returns and volatility, assuming a risk-free rate of 0), Max Drawdown (MaxDD) (based on daily returns), as well as annual statistics to explore their historical performance. The analysis results for the entire period are summarized in **Table 1** (as shown below).

**Table 1.** 2017/10/22-2023/1/31 statistics summary of each asset.

	2017/10/22-2023/1/31				
	BTC	DXY	SPY	GLD	QQQ
Daily Return_mean	0.150%	0.007%	0.041%	0.032%	0.062%
Weekly Return_mean	1.087%	0.031%	0.206%	0.162%	0.295%
Monthly Return_mean	4.644%	0.124%	0.937%	0.791%	1.366%
Annualized Return_mean	63.44%	1.08%	16.41%	9.15%	27.81%
Volatility	75.83%	6.53%	20.80%	13.93%	25.29%
Skewness	-0.15	-0.08	-0.54	-0.27	-0.36
Kurtosis	7.12	2.02	11.23	3.80	5.66
Sharpe Ratio	0.84	0.16	0.79	0.66	1.10
MaxDD	-83.40%	-13.01%	-34.10%	-22.00%	-35.62%

In **Table 1**, we present the return and risk statistics for BTC, DXY, SPY, GLD, and QQQ over the period from October 22, 2017, to January 31, 2023.

In terms of return performance, BTC achieved daily, weekly, monthly, and annualized returns of 0.150%, 1.087%, 4.644%, and 63.44%, respectively, significantly outperforming other assets and demonstrating its strong growth potential.

However, this high return is accompanied by substantial volatility. QQQ posted an impressive annualized return of 27.81%, driven by gains in tech stocks during this period. SPY delivered a 16.41% annualized return, providing relatively stable performance as a broad market index. GLD returned 9.15% annually, reflecting its stability as a traditional safe-haven asset but with relatively lower returns. Meanwhile, DXY had an annualized return of just 1.08%, indicating the dollar's stability during this period.

For volatility analysis, BTC exhibited extremely high volatility at 75.83%, underscoring the asset's risk, with sharp price fluctuations despite its high returns. QQQ had a volatility of 25.29%, reflecting the inherent fluctuations in tech stocks. SPY was less volatile, with a rate of 20.80%, showing the relatively stable nature of large-cap stocks. Both GLD and DXY had lower volatilities, at 13.93% and 6.53%, respectively, highlighting their stability as a safe-haven asset and currency.

For skewness and kurtosis, all assets exhibited negative skewness, indicating that larger negative returns occurred more frequently. SPY had a skewness of -0.54, suggesting that market declines were more severe, while DXY had the smallest skewness at -0.08, reflecting the dollar's relative stability. Regarding kurtosis, BTC and SPY had the highest values, at 7.12 and 11.23, respectively, indicating the presence of more extreme returns. GLD and QQQ also had high kurtosis values (3.80 and 5.66), showing tail risk, though less severe than that of BTC and SPY. DXY had the lowest kurtosis at 2.02, further reflecting its stability.

For Sharpe ratio analysis, QQQ had the highest Sharpe ratio at 1.10, indicating it provided the highest risk-adjusted return. BTC achieved a Sharpe ratio of 0.84, reflecting the high returns, but its extreme volatility lowered its risk-adjusted return. SPY and GLD had Sharpe ratios of 0.79 and 0.66, respectively, showing relatively solid performance. DXY had the lowest Sharpe ratio at 0.16, suggesting that its return was barely sufficient to compensate for the risk.

For MaxDD Analysis, BTC experienced a massive max drawdown of -83.40%, indicating substantial losses during price declines, posing significant risks to investors. QQQ and SPY had drawdowns of -35.62% and -34.10%, respectively, reflecting the high volatility in the stock market. GLD had a -22.00% drawdown, demonstrating that even safe-haven assets can face substantial losses during crises. DXY had the smallest drawdown at -13.01%, reinforcing its relative stability during turbulent periods.

Through overall insights, from October 22, 2017, to January 31, 2023, BTC delivered significantly higher returns than other assets but also came with enormous volatility and risk. In comparison, QQQ offered high returns with the best risk-adjusted performance (highest Sharpe ratio). SPY provided moderate risk and return, outperforming GLD and DXY. Traditional safe-haven assets, GLD and DXY, displayed low volatility but also lower returns. BTC and tech stocks might appeal to investors with a high-risk tolerance, while GLD and DXY offer safer options for conservative investors. SPY and QQQ strike a balance, making them suitable for long-term investments.

Our annual analysis found that BTC excelled in 2017 and 2020, though its high volatility and significant drawdowns make it a high-risk option, best suited for investors with a high-risk appetite. DXY, as a safe-haven asset, maintained stability but underperformed in 2020 and 2023. It is best used as a stabilizing asset within a portfolio. Both SPY and QQQ performed well during market uptrends, especially in 2019 and 2021, but faced significant declines in 2022. QQQ's higher volatility appeals to tech-focused investors, while SPY's broader diversification suits more cautious investors. GLD performed particularly well during turbulent periods, such as in 2020, but its volatility suggests it should be used as a hedge during uncertain times.

The year 2020 was notable due to the pandemic's economic impact, creating both risks and opportunities for investors. High-risk assets like BTC and safe-haven assets like GLD both performed well, while large-cap stocks (SPY) and tech stocks (QQQ) remained relatively stable. However, DXY also faced some challenges despite its usual stability. The monetary policies and arbitrage opportunities during 2020 are worth further discussion.

From 2017 to 2023, BTC, SPY, and QQQ often showed simultaneous profits and losses. Excluding 2019 and 2021, DXY exhibited an inverse relationship with BTC, SPY, and QQQ in terms of gains and losses. Similarly, excluding 2021 and 2022, GLD had a pattern of opposite gains and losses compared to these assets. Except for 2019 and 2022, DXY and GLD also displayed inverse profit and loss patterns. These relationships suggest that there may be interdependencies among these assets, offering potential arbitrage opportunities worth exploring further.

### 3.2. Monthly Return Analysis

In the investment analysis, the project chooses to conduct an in-depth analysis based on the monthly data and calculates the monthly return dataset (from November 2017 to January 2023, a total of 63 months) through the original dataset. We summarize the general situation of the monthly return dataset in **Table 2** (as shown below).

**Table 2.** Monthly returns profile.

Month	BTC_Monthly_Return	DXY_Monthly_Return	SPY_Monthly_Return	GLD_Monthly_Return	QQQ_Monthly_Return
2017/11	0.58	-0.02	0.03	0.00	0.02
2017/12	0.38	-0.01	0.01	0.02	0.00
2018/01	-0.28	-0.03	0.06	0.03	0.09
2018/02	0.02	0.02	-0.04	-0.02	-0.01
2018/03	-0.33	-0.01	-0.03	0.01	-0.04
...	...	...	...	...	...
2022/11	-0.03	0.03	-0.10	-0.03	-0.11
2022/12	0.05	-0.01	0.08	-0.02	0.04
2023/1	-0.16	-0.05	0.06	0.08	0.06

In **Table 2**, we present the monthly returns of five assets—BTC, DXY, SPY, GLD, and QQQ—over multiple years. The table highlights BTC’s high volatility, with significant fluctuations between large positive and negative returns. In contrast, DXY exhibits more stable and moderate changes, remaining closer to 0 overall. SPY and QQQ show consistent positive returns, demonstrating good potential for long-term investments, especially SPY, which displays the most stable positive returns. GLD provides moderate returns, reflecting the relative stability of a safe-haven asset.

This paper’s analysis of the monthly return visualization for this asset group (BTC, SPY, DXY, GLD, QQQ) reveals distinct patterns in volatility and return distribution. All assets’ monthly returns fluctuate around the zero-return axis. BTC stands out with much higher volatility than the other assets, indicating substantial risk. However, its wider fluctuation range (with a greater spread of positive returns than negative ones) also demonstrates enormous return potential. In contrast, DXY shows the lowest volatility, with a relatively stable, right-skewed distribution, reinforcing its reliability as a safe-haven asset. SPY and QQQ also exhibit a bias toward positive returns, making them suitable for long-term investments, especially SPY, which has the highest proportion of positive monthly returns.

While GLD displays a left-skewed distribution, its returns remain relatively stable, consistent with its role as a safe-haven asset. Correlation analysis shows that aside from the strong correlation between SPY and QQQ, the other assets exhibit independent returns, suggesting potential arbitrage opportunities across the asset classes.

## 4. Methodology and Results

### 4.1. Correlation and Covariance Matrix

The results of the correlation and covariance matrix are included in **Table 3** and **Table 4** (as shown below).

**Table 3.** Correlation matrix of assets.

Assets	BTC_Monthly_Return	DXY_Monthly_Return	SPY_Monthly_Return	GLD_Monthly_Return	QQQ_Monthly_Return
BTC_Monthly_Return	1.00	-0.19	0.36	0.13	0.34
DXY_Monthly_Return	-0.19	1.00	-0.45	-0.59	-0.43
SPY_Monthly_Return	0.36	-0.45	1.00	0.18	0.94
GLD_Monthly_Return	0.13	-0.59	0.18	1.00	0.20
QQQ_Monthly_Return	0.34	-0.43	0.94	0.20	1.00

**Table 4.** Covariance matrix of assets.

Assets	BTC_Monthly_ Return	DXY_Monthly_ Return	SPY_Monthly_ Return	GLD_Monthly_ Return	QQQ_Monthly_ Return
BTC_Monthly_ Return	0.0560	-0.0008	0.0046	0.0012	0.0050
DXY_Monthly_ Return	-0.0008	0.0003	-0.0004	-0.0004	-0.0005
SPY_Monthly_ Return	0.0046	-0.0004	0.0028	0.0004	0.0031
GLD_Monthly_ Return	0.0012	-0.0004	0.0004	0.0015	0.0005
QQQ_Monthly_ Return	0.0050	-0.0005	0.0031	0.0005	0.0039

The data suggests that the low correlation between BTC and DXY or GLD may offer arbitrage opportunities, particularly when the price movements of these assets are unsynchronized with BTC. Independence between assets is advantageous for arbitrage because it allows investors to construct strategies that exploit price inefficiencies without the risk of one asset's movement directly influencing the other. This separation creates a broader range of potential scenarios where mispricings can occur, enabling investors to capitalize on short-term price disparities effectively.

However, for investors targeting pure arbitrage, negative correlation is typically more desirable than independence, as it provides a more predictable counterbalance in asset price movements. For instance, when one asset rises in value, a negatively correlated asset is likely to decline, creating clearer arbitrage entry and exit points.

BTC demonstrates a relatively higher correlation with SPY and QQQ, suggesting a moderate degree of interdependence. While this correlation implies BTC may influence the performance of SPY and QQQ to some extent, the relationship is not significant enough to hinder diversification or risk management. Investors could explore arbitrage opportunities further by constructing diversified portfolios that leverage BTC's correlations with these assets, balancing risk and optimizing returns.

Lastly, while SPY and QQQ exhibit a high correlation in directional movement, their small covariance value highlights significant differences in volatility, indicating weaker synchronization in magnitude. As a result, both assets are retained in the target portfolio. Despite their similar trends, they contribute distinct characteristics that enhance diversification and provide additional opportunities for optimized portfolio performance.

## 4.2. Contemporaneous Regression

Contemporaneous regression refers to the analysis of relationships between multiple variables within the same period or timeframe (Ledolter, 2009). The goal of

this paper is to examine whether the monthly returns of different assets (BTC, DXY, SPY, GLD, QQQ) are interconnected or have mutual influences during the same period. Ordinary Least Squares (OLS) is a widely used linear regression technique that applies to various regression analyses, including contemporaneous regression (Ledolter, 2009). OLS estimates the regression coefficients by minimizing the sum of squared errors between the observed and predicted values (Ledolter, 2009).

We employed OLS for contemporaneous regression to investigate how the returns of other assets in the same period (monthly) impact BTC's returns. It also assesses whether the regression coefficients of the contemporaneous variables are significant in explaining the fluctuations in BTC, thereby exploring whether BTC offers potential arbitrage opportunities for investors.

The parameters and criteria obtained from the contemporaneous regression are presented in Table 5 (as shown below).

**Table 5.** The parameters and statistics of the regression model correspond to the independent variables.

Variable	Coefficient	Standard Error	t-Statistic	P-value
Intercept	0.03	0.03	0.97	0.34
DXY_Monthly_Return	0.27	2.21	0.12	0.90
SPY_Monthly_Return	1.75	1.58	1.11	0.27
GLD_Monthly_Return	0.46	0.93	0.49	0.63
QQQ_Monthly_Return	-0.15	1.32	-0.12	0.91

From the OLS regression results shown in Table 5, we can find that the explanatory ability of the model is weak, and the R-squared value is only 0.135. In addition, although the coefficients of the respective variables are different, the P-values are all high, which fails to pass the significance test, indicating that the impact of these independent variables on the return rate of BTC is not statistically significant. Overall, the model has limited explanatory power and cannot significantly predict BTC's monthly returns. Therefore, this model alone cannot definitively determine whether BTC can provide an arbitrage opportunity for a portfolio.

### 4.3. Granger Causality-Related Tests

The Granger causality-related test is a statistical method used to determine whether a variable in a time series can be used to predict another variable (Dastgir et al., 2019). That is, the ability of one variable to predict another variable is tested by the lag value (the order of the lag determines how many periods of historical data are used to test whether one variable can explain another) (Dastgir et al., 2019). In this paper, we used Granger causality test to analyze the causal relationship between BTC, DXY, SPY, GLD and QQQ. First, the appropriate lag order is selected from the monthly yield data, multiple lag orders are traversed, and the optimal lag period is determined according to the smallest P-value. Then, two-way Granger test is conducted to determine whether the lag value of one asset

significantly explains the future changes of another asset. Statistical test methods (such as F-test, Chi-square test, etc.) were used to evaluate the significance of the  $P$ -value and determine whether there was a causal relationship. The summarized results of Granger causality test are recorded in **Table 6** (as shown below).

**Table 6.** Granger causality test results summary.

Asset Comparison	Direction (A→B: whether A can predict B)	Predictive Ability
DXY vs. BTC	DXY → BTC	Significant Prediction
	BTC → DXY	No Effective Prediction
SPY vs. BTC	SPY → BTC	No Effective Prediction
	BTC → SPY	Near Significant Prediction
GLD vs. BTC	GLD → BTC	Near Significant Prediction
	BTC → GLD	No Effective Prediction
QQQ vs. BTC	QQQ → BTC	No Effective Prediction
	BTC → QQQ	Near Significant Prediction

From the summary of Granger causality test results shown in **Table 6**, we can see that except for DXY's exact predictive ability for BTC, the influence between other assets and BTC cannot be established, which means that when BTC intervenes in the portfolio composed of DXY, SPY, GLD and QQQ, the relationship between BTC and BTC is not established. There is a high probability that there will be arbitrage opportunities.

#### 4.4. Monetary Policy during the COVID-19 Pandemic in 2020

During the COVID-19 pandemic in 2020, the Federal Reserve implemented several monetary policies to address the economic shock. The key measures included:

- Interest rate cuts: The Fed lowered the federal funds rate to near zero (Labonte, 2021).
- Quantitative Easing (QE): It purchased large amounts of Treasury securities and mortgage-backed securities (MBS) to increase market liquidity (Labonte, 2021).
- Increased dollar supply: Through open market operations and other measures, the Fed significantly boosted the supply of U.S. dollars (Labonte, 2021).

These actions aimed to reduce borrowing costs, stimulate economic activity, and maintain market liquidity (Labonte, 2021).

To analyze arbitrage opportunities in 2020, this project presents monthly return in detail.

The five assets exhibited significant performance differences in 2020. BTC showed the highest volatility, posting large positive returns in January, May, July, and December, but negative returns in March and September; DXY remained relatively stable, though it recorded negative returns in most months; SPY experienced a steep drop in March but gradually recovered afterward; GLD performed consistently well, with particularly strong returns in April and July; QQQ, driven

by the technology sector, recorded impressive gains in April and July. In terms of cumulative returns, BTC surged dramatically by year-end to around 3.0, standing out as the top performer. QQQ ended slightly above 0.5, while SPY and GLD reached approximately 0.25, and DXY remained near 0.2020 was a favorable year for investments. BTC, despite its high risk, experienced exponential growth by year-end, while long-term assets performed well but exhibited some volatility. Safe-haven assets, though stable, faced potential depreciation. This indicates that 2020 provided good investment opportunities.

Compared to longer periods, arbitrage opportunities were more prominent in 2020. There was a notable negative correlation between BTC and DXY, suggesting that hedging strategies could be employed. For example, investors could sell or reduce BTC holdings when the dollar strengthens and buy BTC when the dollar weakens, creating potential arbitrage opportunities. A negative correlation between SPY and DXY also offers cross-market arbitrage opportunities. When the dollar weakens, investors could increase exposure to SPY or QQQ, and when the dollar strengthens, they could reduce or short stocks to hedge against risks. In addition, GLD's low correlation with other assets makes it a useful tool for portfolio diversification, particularly during periods of market turbulence.

In summary, arbitrage opportunities in 2020 were mainly concentrated in the negative correlation between the dollar and risk assets (e.g., BTC, SPY, QQQ). Utilizing these hedging strategies could allow investors to capture potential gains across different markets.

#### 4.5. Optimal Portfolio

By comparing the correlation of various assets, we believe that the impact of BTC intervention on portfolio returns is worth studying. Therefore, this paper hopes to summarize the investment strategy that is relatively more suitable for ordinary investors through various portfolio attempts.

In the initial stage of the experiment, we constructed the equal-weight portfolio, minimum volatility portfolio, maximum return portfolio and maximum Sharpe ratio portfolio of five major assets (BTC, DXY, SPY, GLD and QQQ). The experimental data were included in **Table 7** (as shown below).

**Table 7.** Portfolio summary of BTC+DXY+SPY+GLD+QQQ with different criteria.

Portfolio	Annualized Return	Annualized Volatility	Annualized Sharpe Ratio	Weights				
				BTC	DXY	SPY	GLD	QQQ
Equal Weight	18.13%	20.74%	0.87	20.00%	20.00%	20.00%	20.00%	20.00%
Minimum Volatility	4.03%	3.19%	1.26	0.00%	67.82%	10.57%	21.61%	0.00%
Maximum Return	55.73%	81.96%	0.68	100.00%	0.00%	0.00%	0.00%	0.00%
Maximum Sharpe Ratio	5.61%	3.82%	1.47	1.56%	62.80%	0.00%	24.65%	10.99%

The results show that the all-BTC portfolio has achieved the highest annual return, but its volatility is too high and the Sharpe ratio is low, which is not suitable as a choice for most investors. Although the portfolio with the highest Sharpe ratio has good risk planning, its return is too low to approach the minimum risk portfolio (the annual return rate of the minimum risk portfolio is 4.03%, and the annual return rate of the maximum Sharpe ratio portfolio is 5.61%), which is obviously not in line with investors' profit heart. It is found that DXY accounts for up to 62.80%. This project believes that the existence of DXY may lead to a relatively low rate of return, although the volatility is small.

In order to verify whether the high DXY weight affects the return of the portfolio, the project compares the portfolio with the DXY weight limited to no more than 10% and the portfolio without DXY with the unrestricted portfolio and five individual assets. The experimental results are included in **Table 8** (as shown below).

**Table 8.** Portfolio summary when portfolios reach optimal Sharpe ratio.

Portfolio	Annualized Return	Annualized Volatility	Annualized Sharpe Ratio	Weights				
				BTC	DXY	SPY	GLD	QQQ
BTC	55.73%	81.96%	0.68	100.00%	0.00%	0.00%	0.00%	0.00%
DXY	1.69%	6.23%	0.27	0.00%	100.00%	0.00%	0.00%	0.00%
SPY	10.17%	18.48%	0.55	0.00%	0.00%	100.00%	0.00%	0.00%
GLD	8.38%	13.39%	0.63	0.00%	0.00%	0.00%	100.00%	0.00%
QQQ	14.68%	21.65%	0.68	0.00%	0.00%	0.00%	0.00%	100.00%
BTC + DXY + SPY + GLD + QQQ	5.61%	3.82%	1.47	1.56%	62.80%	0.00%	24.65%	10.99%
BTC + capped_DXY (weight $\leq 0.1$ ) + SPY + GLD + QQQ	13.11%	13.20%	0.99	7.66%	10.00%	0.00%	54.17%	28.17%
BTC + SPY + GLD + QQQ	14.88%	15.57%	0.96	9.50%	0.00%	58.60%	31.90%	0.00%

The results show that when the DXY weight is limited or removed, although the Sharpe ratio has decreased, the annualized return has increased significantly, and the volatility is still lower than that of most individual assets. Therefore, this project confirms that the existence of DXY indeed inhibits the return of the portfolio. In order to seek relatively higher returns, this paper chooses to exclude DXY under the condition that the optimal Sharpe ratio is not too low and the calculation amount is reduced.

Next, in order to study the impact of BTC on investment strategy, we drew a line chart comparing the cumulative return of the optimal Sharpe ratio portfolio with all permutations of SPY, GLD, and QQQ with BTC intervention and the cumulative return of all permutations of SPY, GLD, and QQQ without BTC intervention. The results show that BTC intervention can improve the cumulative

return of the portfolio.

Finally, we summarize the changes of the Sharpe ratio of the portfolio under BTC's intervention and the weights of each asset in the portfolio, and the data results are included in **Table 9** and **Table 10** (as shown below).

**Table 9.** Summary of all possible optimal Sharpe ratio portfolios of SPY, GLD, QQQ, and BTC.

Portfolio	Weights	Annualized Sharpe Ratio
SPY	SPY: 1.00	0.55
SPY + BTC	SPY: 0.74, BTC: 0.26	0.75
GLD	GLD: 1.00	0.63
GLD + BTC	GLD: 0.85, BTC: 0.15	0.87
QQQ	QQQ: 1.00	0.68
QQQ + BTC	QQQ: 0.79, BTC: 0.21	0.83
SPY + GLD	SPY: 0.38, GLD: 0.62	0.77
SPY + GLD + BTC	SPY: 0.25, GLD: 0.65, BTC: 0.11	0.91
GLD + QQQ	GLD: 0.59, QQQ: 0.41	0.84
GLD + QQQ + BTC	GLD: 0.59, QQQ: 0.32, BTC: 0.09	0.96
SPY + QQQ	SPY: 0.00, QQQ: 1.00	0.68
SPY + QQQ + BTC	SPY: 0.00, QQQ: 0.79, BTC: 0.21	0.83
SPY + GLD + QQQ	SPY: 0.00, GLD: 0.59, QQQ: 0.41	0.84
SPY + GLD + QQQ + BTC	SPY: 0.00, GLD: 0.59, QQQ: 0.32, BTC: 0.09	0.96

**Table 10.** Summary of the influence of BTC on all possible optimal Sharpe ratio portfolios of SPY, GLD, QQQ.

Portfolio	Sharpe Ratio Without BTC	Sharpe Ratio With BTC	Increase in Sharpe Ratio	Percentage Increase
SPY	0.55	0.75	0.20	37.08%
GLD	0.63	0.87	0.25	39.22%
QQQ	0.71	0.85	0.14	19.73%
SPY + GLD	0.77	0.91	0.14	18.05%
GLD + QQQ	0.87	0.97	0.10	12.01%
SPY + QQQ	0.71	0.85	0.14	19.73%
SPY + GLD + QQQ	0.87	0.97	0.10	12.01%

In **Table 9** and **Table 10**, we present the changes in the Sharpe ratios of investment portfolios with the inclusion of BTC, as well as the weights of individual assets within the portfolios. The results show that the inclusion of BTC not only improves the portfolio's Sharpe ratio but also reveals that the marginal increase in the Sharpe ratio decreases as the number of assets in the portfolio increases. Considering the complexity of portfolio management, this project suggests that for ordinary investors, a cost-effective strategy would be to select a relatively stable asset as the core investment and allocate 10% to 20% of the portfolio to BTC.

In this section, we analyze the role of BTC in different investment portfolios and explore the impact of transaction costs on these portfolios. While the

inclusion of BTC significantly improves the Sharpe ratio of the portfolio, its high volatility and frequent trading requirements may lead to high transaction costs, including fees, slippage, and taxes. These costs could erode the returns generated by BTC.

Frequent asset rebalancing is a common characteristic of BTC investment portfolios, as the price of BTC is highly volatile, and investors often need to adjust their portfolios quickly in response to market changes. However, this frequent trading also incurs transaction costs. For example, trading platforms typically charge transaction fees, which may significantly impact investment returns when trading frequently (Menkveld, 2013). In volatile markets, BTC's slippage (the difference between the expected and actual transaction price) could increase, leading to transaction costs exceeding expectations (Hasbrouck, 2009).

Additionally, capital gains taxes must also be considered as an important cost factor. Cryptocurrency transactions often involve capital gains taxes, especially when BTC is bought and sold over short periods. The tax burden could significantly reduce investment returns (Barber & Odean, 2000). To minimize transaction costs and tax burdens, investors could opt for low-frequency trading strategies, reducing unnecessary trades and thereby mitigating slippage and fees (Jegadeesh & Titman, 2001).

Given the impact of transaction costs, investors should consider selecting low-cost trading platforms and adjust trading frequency according to market conditions. Low-frequency trading can not only reduce transaction costs but also optimize portfolio returns by avoiding excessive market fluctuations (Jegadeesh & Titman, 2001). By choosing appropriate trading strategies and platforms, investors can better optimize asset allocation and enhance overall returns.

In conclusion, while BTC holds significant potential for improving portfolio returns, its high transaction costs require investors to adopt reasonable cost-control strategies in practice. Especially in volatile markets, low-frequency trading and optimizing platform selection are effective ways to reduce costs and enhance returns.

#### 4.6. Targeted Investment and Rolling Windows

We then performed two sets of portfolio analyses, calculating the optimal Sharpe ratio without BTC intervention and with BTC intervention, cumulative return, and rolling window (12 months) analysis. In this project, the optimal targeted investment time period of each investment portfolio is summarized in Table 11, as shown below.

**Table 11.** Summary of the best targeted investment strategies, with rolling window of 12 months.

Portfolio	Best Period	Max Cumulative Return (\$)
SPY	2020/04 - 2021/03	451.40
GLD	2019/08 - 2020/07	345.47
QQQ	2020/04 - 2021/03	547.99

**Continued**

SPY + GLD	2020/04 - 2021/03	272.42
GLD + QQQ	2019/09 - 2020/08	373.01
SPY + QQQ	2020/04 - 2021/03	499.70
SPY + GLD + QQQ	2020/04 - 2021/03	364.28
SPY + BTC	2020/04 - 2021/03	1519.31
GLD + BTC	2020/04 - 2021/03	1340.33
QQQ + BTC	2020/04 - 2021/03	1567.60
SPY + GLD + BTC	2020/04 - 2021/03	1044.02
GLD + QQQ + BTC	2020/04 - 2021/03	1076.22
SPY + QQQ + BTC	2020/04 - 2021/03	1195.54
SPY + GLD + QQQ + BTC	2020/04 - 2021/03	920.01

In **Table 11**, we present the optimal phases for directional investments, using 12-month rolling windows for each portfolio. The results indicate that the inclusion of BTC consistently enhances the cumulative returns of the portfolios, with BTC having a greater impact on individual assets. For the 12-month rolling windows, the findings confirm that BTC's inclusion increases the maximum cumulative return for all portfolios. However, as the number of assets in the portfolio increases, the maximum cumulative returns tend to decrease, further demonstrating BTC's greater influence on individual assets. Therefore, the previously proposed investment strategy remains applicable to directional investments.

Additionally, the results show that the period from late 2019 to early 2021 was a prime opportunity for investments due to monetary policy adjustments and the pandemic environment. However, from mid-2021 onward, asset values began to decline, reflecting a deteriorating economic environment.

#### 4.7. Out of Sample Trials

To further explore the effectiveness of the investment strategy based on historical data, this project utilized data from January 1, 2017, to August 19, 2024. We applied the optimal Sharpe ratio strategy from the previous period to the current period and evaluated the significance of historical data by comparing the Sharpe ratios and cumulative returns.

We verified the effectiveness of previous investment strategies against current data before and after the Bitcoin intervention in an out-of-sample experiment. By comparing the results, we find that regardless of whether BTC intervenes, applying previous-period strategies to current-year data generally usually does not lead to an improvement in the Sharpe ratio. However, the situation is somewhat better in 2020: in the case of BTC intervention, the vast majority of historical strategies applied to 2020 yield a higher Sharpe ratio compared to the optimal Sharpe ratio of portfolios without BTC intervention for that year. But also in 2020, in the absence of Bitcoin intervention, although strategies brought about by historical data made the Sharpe ratio relatively better have much less impact. In other periods,

applying previous-period strategies to current-year data, the total conditions of the Sharpe ratio when BTC intervenes in the portfolio and when there is no BTC intervention are tied. Similarly, regardless of BTC intervention, applying previous period strategies to current year data typically increases returns. However, when BTC is included in the portfolio, returns are generally more favorable compared to scenarios without BTC intervention. Thus, the intervention of BTC can increase the effectiveness of portfolio historical strategies, especially for return. Compared with the historical strategies obtained by summarizing the data of a period of time, the strategies obtained by summarizing the data of a long period of time are more meaningful. In addition, as the number of assets in the portfolio increases, the performance of a historical strategy without BTC intervention changes little compared to a portfolio with a single asset, but a historical strategy with BTC intervention will be more effective.

In order to further validate the stability and robustness of BTC's performance in investment portfolios, we tested various portfolio construction methods, and analyzed the impact of different risk-free rate assumptions on the calculation of Sharpe ratios.

While the main analysis focused on portfolio construction methods such as equal-weight, minimum volatility, maximum return, and maximum Sharpe ratio strategies, we expanded our investigation to include additional methods like Risk Parity and Conditional Value-at-Risk (CVaR) optimization.

The Risk Parity method aims to balance the risk contributions of each asset in the portfolio, rather than focusing solely on the expected returns. This approach is particularly beneficial during periods of high volatility, as it minimizes the concentration of risk in individual assets. When we applied the Risk Parity method, we observed that during periods of heightened market volatility, such as in 2020, this method provided a better balance between return and risk, especially when BTC was included in the portfolio. This method outperformed the maximum Sharpe ratio strategy in balancing risk while maintaining attractive returns during times of market stress. Conversely, during periods of strong market performance, such as in 2021, the Maximum Sharpe Ratio strategy provided higher returns, as BTC's high volatility was compensated for by the large positive returns generated during a bull market.

Additionally, we incorporated Conditional Value-at-Risk (CVaR) optimization, which focuses on minimizing the potential losses in the tail of the distribution of portfolio returns. This method is especially useful for investors who prioritize minimizing large losses, particularly in volatile markets. When applying CVaR optimization, we found that portfolios containing BTC were better positioned to handle extreme market events compared to those without BTC, especially during downturns. However, this advantage came at the cost of slightly lower overall returns, as the model prioritized risk mitigation over return maximization.

In our main analysis, we assumed a risk-free rate of 0% for calculating Sharpe ratios. However, this assumption may not fully reflect the actual economic

conditions in which investors operate. To address this, we tested the impact of different risk-free rate assumptions on the Sharpe ratio calculations, specifically using risk-free rates of 1% and 2%.

The results showed that while the risk-free rate does have an effect on the Sharpe ratio, the impact on the relative performance of BTC was minimal. Even with higher risk-free rates, BTC consistently improved the Sharpe ratio of portfolios when included, though the absolute magnitude of the Sharpe ratio did decrease slightly as the risk-free rate increased. This indicates that BTC's risk-adjusted performance is robust and remains attractive even when the opportunity cost of holding BTC (vs. a risk-free asset) is higher. The analysis suggests that BTC's inclusion in portfolios continues to enhance returns relative to the risk-free rate, and its ability to improve the Sharpe ratio is not overly sensitive to modest changes in the assumed risk-free rate.

The additional robustness tests provide strong support for the consistency of BTC's impact on portfolio performance across various market conditions, portfolio construction methods, and risk-free rate assumptions. BTC remains a valuable asset for improving the risk-return profile of multi-asset portfolios, especially when combined with traditional assets like SPY, QQQ, and GLD. However, the extent of its benefit depends on the investor's risk preferences, the market environment, and the portfolio construction approach used. We recommend that investors incorporate a diverse range of portfolio strategies and consider different market conditions when allocating to BTC. Future research can further explore how different optimization methods and risk-free rate assumptions affect the performance of BTC within portfolios, and how to refine BTC's integration in dynamically adjusted portfolios.

#### 4.8. Mean-Variance Efficient Frontier Construction

The Mean-Variance Efficient Frontier is an upward-curving line that illustrates the optimal portfolios achievable at different levels of risk. On this frontier, each portfolio provides the highest return for a given level of risk or incurs the lowest risk for a given level of return.

This project focuses on the efficient frontier with the lowest-risk portfolios. Specifically, it identifies the optimal portfolios by minimizing the volatility (risk) at various expected return levels. The analysis compares the performance of BTC + SPY + GLD + QQQ and SPY + GLD + QQQ. The parameters of the optimal Sharpe ratio portfolios are summarized in **Table 12**, with visualizations included in **Figure 1** and **Figure 2**, as shown below:

**Table 12.** Max Sharpe Ratio Portfolio Comparison (BTC + SPY + GLD + QQQ vs. SPY + GLD + QQQ).

Portfolio	Annual Return	Annual Volatility	Weight (BTC)	Weight (SPY)	Weight (GLD)	Weight (QQQ)
BTC, SPY, GLD, QQQ	0.19	0.17	0.13	9.11E-18	0.57	0.29
SPY, GLD, QQQ	0.12	0.13	-----	1.87E-17	0.58	0.42

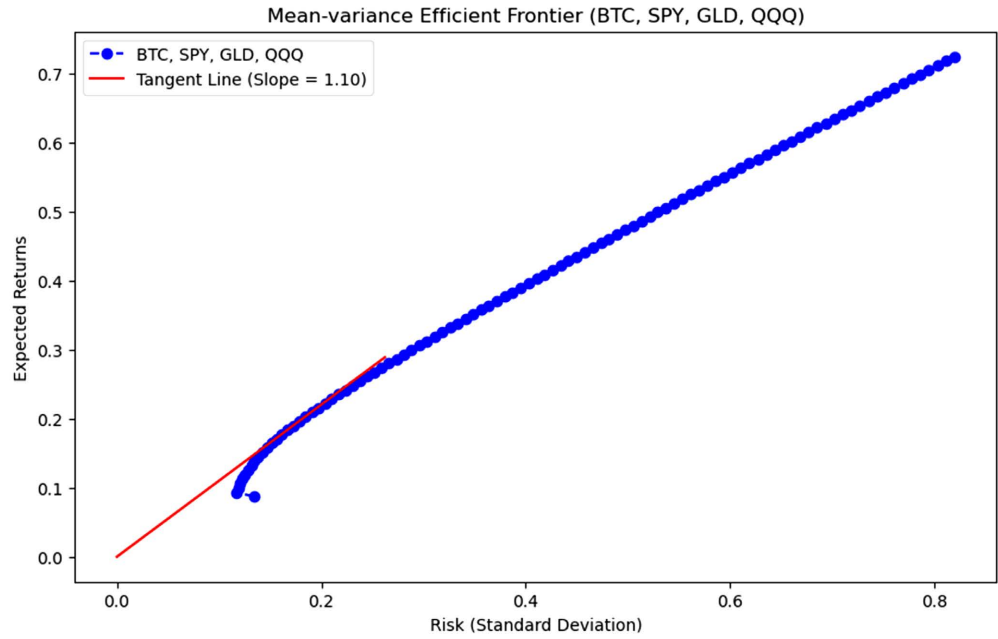


Figure 1. Effective frontier and tangent of mean variance of BTC + SPY + GLD + QQQ portfolio.

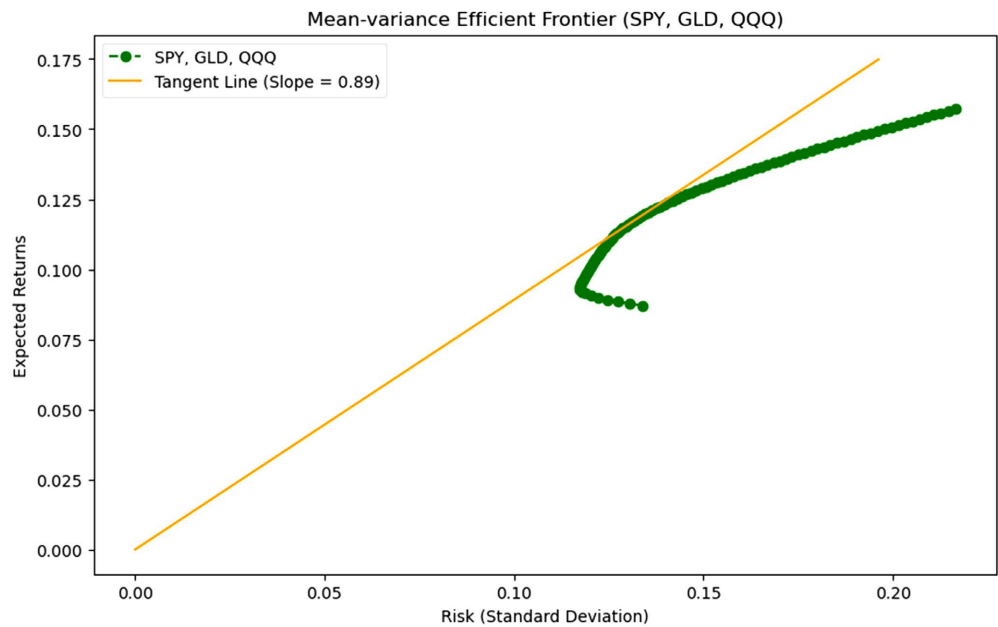


Figure 2. Effective frontier and tangent of mean variance of SPY + GLD + QQQ portfolio.

Table 12 compares the performance of two portfolios: BTC + SPY + GLD + QQQ and SPY + GLD + QQQ, while Figure 1 and Figure 2 visualize their mean-variance efficient frontiers and tangency points (representing the highest Sharpe ratio). The former portfolio achieves an annualized return of 19% with a volatility of 17%, while the latter offers an annualized return of 12% with a volatility of 13%. Overall, the portfolio that includes BTC delivers higher returns but also involves greater risk.

In terms of weight distribution, the BTC + SPY + GLD + QQQ portfolio allocates 13% to BTC, 57% to GLD, 29% to QQQ, and almost none to SPY. In contrast, the SPY + GLD + QQQ portfolio, which excludes BTC, allocates 58% to GLD, 42% to QQQ, and similarly has minimal exposure to SPY.

The results indicate that including BTC in the portfolio enhances overall returns by incorporating cryptocurrency but at the cost of higher volatility. However, the portfolio manages risk by maintaining a significant allocation to gold. In contrast, the portfolio without BTC is more stable, offering lower returns with reduced risk, making it more suitable for investors seeking steady growth.

From the weight analysis, both portfolios show little dependence on SPY. The BTC + SPY + GLD + QQQ portfolio leverages the high return potential of BTC, while the SPY + GLD + QQQ portfolio focuses more on the relative stability of technology stocks and gold.

## 5. Conclusion and Further Discussion

### 5.1. Conclusion

This study examines the construction and performance of multi-asset portfolios, emphasizing BTC's role and its interactions with traditional assets like DXY, SPY, GLD, and QQQ. Our analysis of equal-weight, minimum volatility, and maximum return portfolios leads to several key insights.

BTC demonstrates extreme volatility but offers substantial high-return opportunities, making it a pivotal asset for portfolio arbitrage. In contrast, SPY and QQQ exhibit long-term stability, which is suitable for sustained investments. DXY, while a safe-haven asset, is vulnerable to external shocks and tends to yield negligible negative returns. Similarly, GLD serves as a safe-haven asset with slightly higher volatility than DXY, providing better returns and less sensitivity to external factors.

Monthly return correlations indicate that most assets operate independently, with no significant negative correlations. Notably, DXY has predictive power over BTC, and SPY and QQQ are highly correlated despite differing volatility profiles, ensuring both remain valuable in the portfolio. A portfolio entirely composed of BTC promises high returns but entails considerable risk. Although BTC does not exhibit strong negative correlations with traditional assets, its independence allows for risk reduction through arbitrage while capitalizing on its high return potential.

In terms of risk management, incorporating DXY into a minimum volatility portfolio minimizes risk and achieves a high Sharpe ratio, though its near-zero returns make it unattractive for most investors, leading to its exclusion. BTC's inclusion consistently enhances both portfolio returns and Sharpe ratios, with a recommended allocation of 10% - 20% for individual investors, applicable to both lump-sum and rolling-window portfolios. Multi-asset portfolios already show high Sharpe ratios before adding BTC, suggesting limited additional benefits from its inclusion. However, out-of-sample testing reveals that BTC-enhanced

strategies generally achieve higher returns, albeit with increased risk, except for the year 2020. The historical strategy brought about by BTC intervention is more effective than the historical strategy brought about by BTC without intervention. However, while historical data is more effective for a multi-asset portfolio strategy, this increased effectiveness in the context of a single-asset portfolio can be offset by adding the range of historical data. Therefore, based on practicality, we encourage investors to refer to as wide a range of historical data as possible. The mean-variance efficient frontier analysis indicates that BTC primarily drives the Sharpe ratio in portfolios, whereas QQQ and GLD contribute stability when BTC is excluded.

This study also explores the dynamic allocation strategies combining traditional assets (such as DXY, SPY, QQQ, and GLD) with high-volatility assets like BTC. We conducted an in-depth analysis of BTC's unique role in investment portfolios and proposed a practical allocation recommendation to balance returns and risk effectively. This recommendation offers investors a feasible strategy, particularly valuable in the current environment of high market volatility.

Furthermore, we systematically analyzed historical data, highlighting the critical importance of using a broad time range in strategy formulation. This demonstrates the value of long-term data strategies in enhancing portfolio performance. By incorporating rolling-window analysis, we showed the effectiveness of dynamically adjusting portfolios based on historically optimal strategies, providing practical support for responding to market fluctuations.

When comparing single-asset and multi-asset portfolio strategies, we found that BTC plays an irreplaceable role in enhancing portfolio returns, while QQQ and GLD contribute significantly to portfolio stability. This comparison not only helps investors better understand the interactions between assets but also provides theoretical support for practical investment decisions. Through mean-variance efficient frontier analysis, we revealed BTC's role as a key driver of Sharpe ratios, providing investors with clear and actionable insights for optimizing risk-return trade-offs.

This research also examines BTC's impact on transaction costs and the overall feasibility of its inclusion in multi-asset portfolios. Although BTC's high volatility offers substantial returns, its frequent trading demand leads to higher transaction costs, including fees, slippage, and taxes. These costs can negatively affect net returns, especially in high-frequency trading scenarios. Therefore, it is crucial for investors to carefully control transaction costs by reducing trading frequency, choosing low-cost trading platforms, and considering the implications of capital gains taxes. By doing so, investors can better optimize their portfolios to balance returns and costs.

In conclusion, while BTC offers significant return potential, its high volatility and associated transaction costs require careful consideration. Future research could explore how to optimize trading strategies, select the right trading platforms, and minimize transaction costs to enhance the effectiveness of BTC in

investment portfolios.

Overall, this research combines theory and practice to provide investors with specific strategies for balancing returns and risks in multi-asset environments. It highlights BTC's pivotal role in multi-asset portfolios and opens new avenues for the practical application of dynamic adjustments and historical data analysis.

## 5.2. Further Discussion

BTC's potential as a safe-haven asset warrants further exploration, especially its behavior during financial market turbulence compared to traditional safe havens like gold. Future research could investigate BTC's safe-haven characteristics in volatile markets to determine its reliability in risk mitigation.

The influence of macroeconomic factors such as interest rate changes and inflation expectations was not extensively covered in this study. Integrating these indicators could provide a deeper understanding of their impact on asset performance, enhancing the analysis of returns and risks within investment portfolios.

Investment strategies must remain adaptable to evolving market conditions. Future studies could explore dynamic weight adjustment techniques, allowing real-time asset allocation based on market trends and economic indicators to improve risk management and portfolio performance.

Advancements in blockchain technology and financial innovations like Decentralized Finance (DeFi) are likely to influence traditional portfolio theories. Investigating how blockchain-based financial products affect asset allocation and the integration of emerging digital assets into multi-asset portfolios could offer valuable insights into the future of investment strategies.

Overall, this research highlights the significant role of BTC in enhancing portfolio performance while balancing risk. By addressing the discussed areas in future studies, a more comprehensive understanding of multi-asset portfolio optimization in the context of emerging digital assets and evolving financial landscapes can be achieved.

## Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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