



# Analyze the Impact of Bitcoin on Stock Portfolio's Risk and Return Based on Past 3 Years' Data

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**Abstract.** Everyone is eager for high yield and low risk. In this research, we use Markowitz's investment theory and Monte Carlo simulation to find the optimal investment portfolio and then study the impact of adding Bitcoin to the traditional investment portfolio on the cumulative rate of return. Our results show that the return performance of the investment portfolio with Bitcoin is better than that of the traditional investment portfolio. Moreover, despite the impact of COVID-19 on the global economy and the Federal Reserve's quantitative easing policy, it is beneficial for investors to include Bitcoin in their portfolio allocation.

**Keywords:** Bitcoin · Monte Carlo Simulation · Investment Portfolio · COVID-19

## 1 Introduction

As an alternative currency system that can evade political and financial authorities, Bitcoin has attracted increasing investor attention in recent years [10]. Without going through an intermediary financial institution, bitcoin allows online payments to be traded directly from one party to another [12]. People crave the high returns of cryptocurrencies but stop short of the high risks. By contrast, stocks are a more traditional and acceptable form of investment [9]. The entry threshold of stock investment is low, easy to operate and the rate of return is considerable. Besides, portfolios could help spread risk. A portfolio can be viewed as a portfolio on several levels. Due to the dual needs of safety and profitability at the first level, the combination of risky assets and risk-free assets is considered. Risk-free assets need to be combined for safety, and risky assets need to be combined for profitability. The second level of portfolio considers how to combine risky assets. Since any two portfolios with poor correlation or negative correlation will get a greater risk-return than that of the single asset, the effective front of portfolio can be kept away from risks by constantly combining assets with poor correlation.

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Nevertheless, which portfolio is the best? This problem may be as old as the stock market itself. The analysis of mean-variance introduced by Markowitz [7] has long been a popular method to determine the optimal portfolio structure and composition. Fama and French [3] pointed out that a three-factor model can be established to explain the return on stocks. The model believes that its exposure to three factors can explain the excess return. Yoshino, Taghizadeh-Hesary and Otsuka [13] proposed a new type of sustainable optimal investment portfolio during the COVID-19 period. They called on investors to pay more attention to sustainability rather than profit and risk. Fabozzi et al. [2] mentioned, “The goal of portfolio selection is the construction of portfolios that maximize expected returns consistent with individually acceptable levels of risk.” So what happens when bitcoin is added to a traditional portfolio? According to Platanakis and Urquhart [8], many papers examine the benefits of adding alternative assets to a traditional portfolio, including stocks and bonds. Burnie [1] studied that there is a statistically significant positive correlation between different cryptocurrencies. In addition, cryptocurrencies share a common source of systemic risk associated with bitcoin returns [4]. Therefore, we chose Bitcoin to represent the cryptocurrency as the ultimate research object. This research aims to explore the influence of the addition of Bitcoin on the stock portfolio and bring some thoughts and feelings to investors by comparing the final return curve.

## 2 Methodology

### 2.1 Markowitz’s Portfolio Theory

American economist Harry Markowitz put forward the portfolio theory [7] for the first time in 1952 and conducted systematic, in-depth, and fruitful research. According to Markowitz’s theory, investors could use portfolios to maximize returns by accepting quantifiable risks. This theory contains two important contents: mean-variance analysis method and portfolio efficient boundary model.

#### 2.1.1 Mean-Variance Analysis Method

The mean-variance analysis is a process in which risks are expressed in terms of variance, and trade-offs are made for expected returns. Investors use mean-variance analysis to help make investment decisions and weigh how much risk they are willing to take in exchange for different levels of return. The target rate of return is:

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

Where  $x_i$  is the proportion or weight of funds invested in stock  $i$  as a percentage of the total investment,  $n$  is the total number of different stocks in the portfolio, and  $E(r_p)$  is the expected return on stock  $r_i$ . Let  $\sigma_i$  be the variance of asset  $i$ , then the variance of portfolio  $n$  is:

$$\sigma_p^2 = \sum X^2 \sigma_i^2 + 2 \sum_{i=1}^n \sum_{j=1}^n X_i X_j COV_{ij} \quad (2)$$

Where,  $X_i$  and  $X_j$  represent the proportion of the  $i^{th}$  and  $j^{th}$  stocks in the stock portfolio, and  $COV_{ij}$  represents the covariance of the  $i^{th}$  and  $j^{th}$  stocks.

### 2.1.2 Portfolio Efficient Boundary Model

All possible combinations of the different proportions of each asset in the portfolio form a feasible set with a shape similar to the left convex stereo region. The portfolio located at the edge of the upper half satisfies the condition that the risk is the least and the return is the highest under the same amount of risk, which is called the effective boundary of the portfolio.

## 2.2 Sharpe Ratio

The Sharpe ratio is based on Markowitz's mean-variance paradigm, which assumes that the mean and standard deviation of the distribution of returns over a period are sufficient statistics to assess the outlook for a portfolio [11]. There is a general characteristic in investment: the higher the expected return of the investment object, the higher the volatility risk investors can tolerate—conversely, the lower the expected return, the lower the volatility risk. Sharpe ratio in modern investment theory research shows that the size of the risk in determining portfolio performance has a fundamental role. Risk-adjusted rate of return is a comprehensive index that can consider both return and risk and eliminate the adverse effects of risk factors on performance evaluation in the long run.

$$\text{SharpeRatio} = \frac{E(R_p) - R_f}{\sigma_p} \quad (3)$$

Where  $E(R_p)$  is the expected annualized return rate of the portfolio,  $R_f$  is the annualized risk-free rate,  $\sigma_p$  is the standard deviation of the annualized return rate of the portfolio.

The Sharpe ratio is designed to calculate how much excess return a portfolio generates for each unit of total risk it takes.

## 3 Assumption

All the money can be converted into stocks or bitcoins exempt transaction costs [5].

In the Sharpe ratio, assume that the risk-free rate is 0% (convenient for calculation).

We do not consider the impact of the differences in cryptocurrency policies in different countries or the impact of social media on investment.

The correlation between Bitcoin and other traditional investments (stocks, bonds, Etc.) is 0.

The prices of Bitcoin and other cryptocurrencies are positively correlated [1].

The situation of short selling is not considered [5].

On the basis of similar research, we added the third and fourth assumptions. Because we consider that in some social platforms, the celebrity effect will have a certain impact on the price of Bitcoin. In addition, in some countries, the trading of cryptocurrencies such as Bitcoin is prohibited by law. The fourth assumption is to maintain independence between Bitcoin and other traditional assets, making it easier for us to draw conclusions.

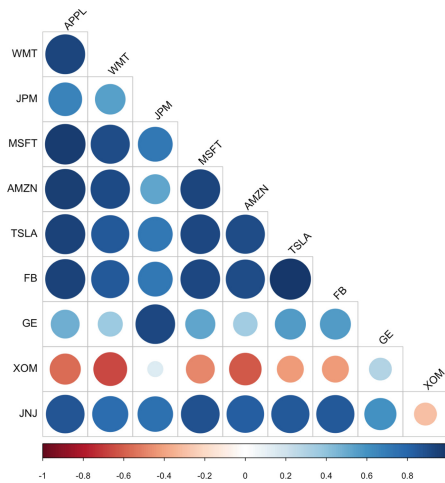
## 4 Results

To explore the impact of Bitcoin on stock portfolios, we first select the stocks of ten leading companies in different industries (Table 1) and obtain their daily closing prices of 751 trading days from November 13, 2018, to November 12, 2021. These data come from Yahoo Finance, a well-known financial data website. Our first step is to select the five stocks with the most negligible correlation from the following ten stocks.

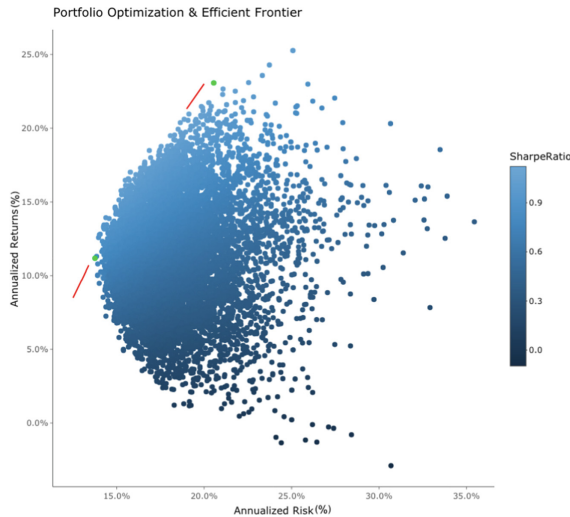
From the Fig. 1, we selected five stocks with low correlation coefficient, which are XOM, JPM, GE, JNJ, and AMZN.

**Table 1.** 10 companies and code names

Company	Code name
Apple	APPL
Walmart	WMT
JPMorgan	JPM
Microsoft	MSFT
Amazon	AMZN
Tesla	TSLA
Facebook	FB
General Electric	GE
Exxon Mobil	XOM
Johnson & Johnson	NJ



**Fig. 1.** 10 stocks correlation coefficient



**Fig. 2.** Visualization of the investment portfolio

In the second step, we need to analyze the best traditional investment portfolio (without adding Bitcoin). Therefore, to find the optimal traditional portfolio and efficient frontier that best meets the needs of investors, we first obtain 10,000 groups of random weight vectors through Monte Carlo simulation and record the expected return, standard deviation, and Sharpe ratio of each portfolio through an array.

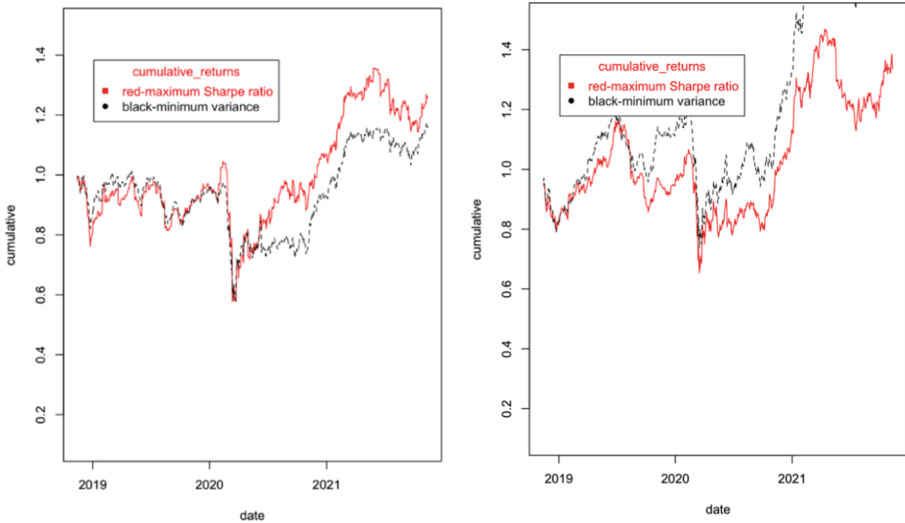
To combine all target returns, investors need to add the weight of target returns for each stock. Moreover, the risk-free rate is set at 0% when calculating the Sharpe ratio, and short-selling is not considered. Therefore, it is also necessary to limit the weight value of each equity to between 0 and 1. The distribution of these random combinations is shown in Fig. 2. They form a viable portfolio of assets. The top green dot represents the portfolio with the largest Sharpe ratio, and the leftmost green dot represents the portfolio with the minimum variance. Next, we analyze these two particular points.

In Table 2, we can observe each stock's weighting ratio and related value in the two investment portfolios. In the sum of all the weight is equal to 1, under the constraint of minimum variance are obtained by minimum function of the optimal portfolio weight vector is [0.223, 0.252, 0.09331, 0.169, 0.263]. Among them, the weighting order of the five stocks is JPM, AMZN, GE, XOM, and JNJ. The excess return, standard deviation, and Sharpe ratio vector of the portfolio are as follows: [0.118, 0.137, 0.859]. Moreover, in the optimal portfolio with the largest Sharpe ratio. The weight vector is [0.278, 0.549, 0.120, 0.00212, 0.0506], and the vectors of excess return, standard deviation and Sharpe ratio are [0.224, 0.204, 1.10].

Figure 3 shows the cumulative returns in these two traditional portfolios. The red is the Portfolio with the maximum Sharpe ratio, and the black one is the Portfolio with minimum variance. We can see that in the early 2020s, the cumulative return of the two investment portfolios has fallen sharply. From mid-2020 until now, the cumulative return of the two investment portfolios has rebounded significantly. In the end, the cumulative

**Table 2.** Comparison of the two investment portfolios

Type of Portfolio	Weight of each equity	Excess return	Standard deviation	Sharpe ratio
The Portfolio with minimum variance	[0.223, 0.252, 0.0931, 0.169, 0.263]	0.118	0.137	0.859
The Portfolio with maximum Sharpe ratio	[0.278, 0.549, 0.120, 0.00212, 0.0506]	0.224	0.204	1.10

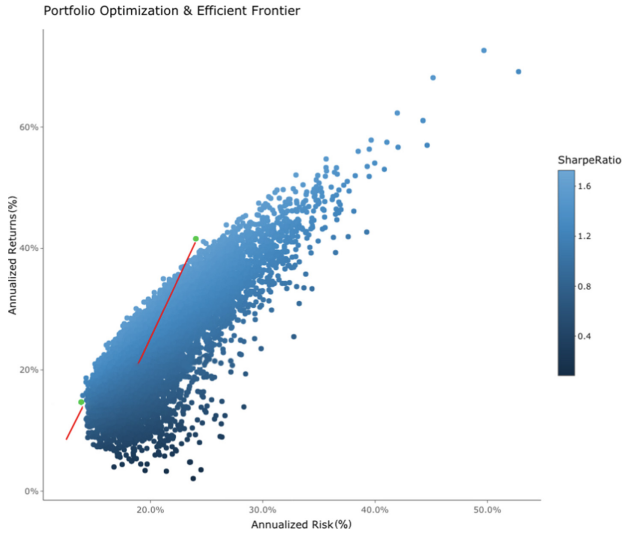


**Fig. 3.** Cumulative returns of the two portfolios in traditional portfolio and non-traditional portfolio

return of the portfolio with the largest Sharpe ratio is greater than the portfolio with the smallest variance.

Furthermore, according to reality, we know that the beginning of 2020 was precisely when the COVID-19 outbreak occurred, and the global economy has been hit hard. As a result, the yields of the two investment portfolios have fallen sharply. In the post-epidemic period, the blocked economy began to open up because of the development of vaccines, and the global economy began to recover. Thus the rate of return of these two investment portfolios began to rise significantly.

In the third step, we add bitcoin to the five stocks, repeat the second step, and get Fig. 4. Compared with the traditional investment portfolio (Fig. 2), the Monte Carlo simulation results of the investment portfolio with Bitcoin are flatter. In Table 3, the minimum variance of the optimal portfolio’s weight vector is [0.219, 0.215, 0.0474, 0.154, 0.313, 0.0519]. Among them, the weighting order of the five stocks is JPM, AMZN, GE, XOM, JNJ, and Bitcoin. The excess return, standard deviation, and Sharpe



**Fig. 4.** Visualization of the investment portfolio with Bitcoin

**Table 3.** Comparison of the two investment portfolios

Type of Portfolio	Weight of each equity	Excess return	Standard deviation	Sharpe ratio
The Portfolio with minimum variance	[0.219, 0.215, 0.0474, 0.154, 0.313, 0.0519]	0.147	0.138	1.06
The Portfolio with maximum Sharpe ratio	[0.151, 0.413, 0.0424, 0.00964, 0.111, 0.273]	0.416	0.24	1.73

ratio vector of the Portfolio are as follows: [0.147, 0.138, 1.06]. Moreover, in the optimal Portfolio with the largest Sharpe ratio. The weight vector is [0.151, 0.413, 0.0424, 0.00964, 0.111, 0.273], and the vectors of excess return, standard deviation and Sharpe ratio are [0.416, 0.24, 1.73].

Figure 3 shows the cumulative returns of the two investment portfolios that added Bitcoin. The red is the portfolio with the maximum Sharpe ratio, and the black one is the portfolio with minimum variance. Comparing with Fig. 3, it is evident that we can see that the overall volatility of the investment portfolio that joins Bitcoin is much greater than that of the traditional investment portfolio. In addition, in the early days of the COVID-19 outbreak, the cumulative return of the investment portfolio that added Bitcoin was also affected by an enormous influence. However, in the post-epidemic period, the cumulative returns of the two non-traditional investment portfolios have risen tremendously. Overall, the portfolio with the smallest variance is better than the largest Sharpe ratio.

**Table 4.** Summary of the returns of the four investment portfolios

Type of Portfolio	Cumulative returns	Maximum rate of return	Minimum rate of return
The Portfolio with minimum variance	0.16	0.17	-0.42
The Portfolio with maximum Sharpe ratio	0.26	0.36	-0.42
The Portfolio with minimum variance (Bitcoin)	0.83	0.86	-0.27
The Portfolio with maximum Sharpe ratio (Bitcoin)	0.34	0.46	-0.35

Table 4 shows the cumulative return and volatility of the four investment portfolios. Cumulative return refers to the current asset value minus the original asset value and divided by the original asset value. Obviously, the return on investment portfolios with Bitcoin is much better than traditional investment portfolios. In addition, the minimum variance portfolio with Bitcoin performed best, with a three-year cumulative return of 83%, an average of 27.7% per year. We believe that it may be that COVID-19 has brought more systemic risks to the global economy and financial markets, which has reduced the additional returns of investors. We originally expected the largest Sharpe ratio to have the highest cumulative return on the portfolio. However, the performance of the portfolio with the largest Sharpe ratio is not so ideal, far below our expectations.

## 5 Conclusion

In this project, we analyze and compare four investment portfolios and study the impact of adding Bitcoin to traditional investment portfolios. Our results show that the return performance of the investment portfolio with Bitcoin is better than that of the traditional investment portfolio. In the beginning of 2020, the cumulative returns of the four investment portfolios have all fallen considerably. Our analysis may be due to the global economic recession brought about by COVID-19, which has led to a decline in the rate of return on investment. From mid-2020 until now, the return on investment of the four portfolios has been rising, and the return on the Portfolio with Bitcoin has risen more rapidly. We believe that the success of vaccine research and development may have made investors from various countries optimistic about future economic development.

Moreover, we speculate that it is also possible that the Fed's quantitative easing policy has caused a large amount of US dollars to flow into the cryptocurrency market and the financial market. This needs to be studied later. Nevertheless, our analysis suggests that the inclusion of Bitcoin in portfolio allocation is beneficial to investors.

In the future, although in this study, we concluded that adding Bitcoin will make the return performance of the investment portfolio better, this is only based on Markowitz's



investment theory. Therefore, we hope to add different portfolio methods and compare them. In addition, we also need to consider the correlation between Bitcoin and traditional assets. We hope to improve our research in the future.

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