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# PORTFOLIO OPTIMIZATION USING MARKOWITZ METHOD FOR CRYPTOCURRENCY, INDONESIA STOCK MARKET, AND GOLD (2014–2024)

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**Abstract**

This research focuses on portfolio optimization by leveraging Markowitz Modern Portfolio Theory (MPT) along with Sharpe ratio to analyze the inclusion of Bitcoin in diversified investment portfolios along with the LQ45 Index and gold. The methodology begins with collecting historical data of the underlying asset and the risk-free rate during the period from October 2014 to October 2024, followed by calculating the expected returns, standard deviations, and covariances. This research compares two different portfolio scenarios, with and without Bitcoin. The results shows that portfolio that incorporate Bitcoin have higher return and have better risk-adjusted performance compared to portfolio without Bitcoin during this period. This highlighted the potential for Bitcoin to contribute for enhancing portfolio performance and yielding better return with a given level of risk, providing valuable insight for portfolio diversification and underscore Bitcoin as a high-risk and high-return asset in modern financial markets.

**Keywords**: ***Portfolio Optimization, Markowitz Theory, Bitcoin, LQ45 Index, Gold, Sharpe Ratio***

## 1. Introduction

Investment has always been a critical driver of wealth creation, enabling both individuals and institutions to strategically allocate resources with the expectation of generating future returns. According to Modern Portfolio Theory (MPT), optimal portfolios are those that maximize expected returns for a given level of risk (Chaube, 2023). Historically, investors have relied on well-established asset classes for their portfolios, such as stocks, bonds, and commodities like gold. These assets are supported by decades of data, which provide a certain degree of predictability. However, the investment landscape is being reshaped by cryptocurrencies, which are composed to transform the global financial system. Highlighting its characteristics like decentralization, volatility, and high risk-reward potential, cryptocurrencies have forced investors to rethink how they allocate their investments as it offers unique diversification benefits due to their low correlation with traditional assets (Goodwell, 2024). The convergence between traditional and digital markets provides both opportunities and risks, making portfolio optimization more critical than ever. Cryptocurrencies has become mainstream due to their potential high returns, attracting financial institutions to incorporate them into investment portfolios as a novel asset class distinct from traditional financial instruments like stocks and commodities. However, their extreme volatility and regulatory uncertainties present substantial number of risks. Meanwhile, the traditional financial instruments like stocks, or commodities offers more stable and already established regulatory framework.

According to the Indonesia's Commodity Futures Trading Supervisory Agency (Bappebti, 2024), Indonesia saw a whopping 260.9 trillion Rupiah flowed into the crypto market from January to May 2024, an increase of more than 75% compared to 149 trillion Rupiah for the whole year of 2023. The number of registered cryptocurrency accounts has also reached more than 20 million users. These phenomena reflect a strong interest in cryptocurrency as an alternative investment, likely driven by the recent launch of Bitcoin and Ethereum ETFs in the United States. Given the rise of cryptocurrency investment, it presents both challenges and opportunities for investors in Indonesia and globally. Traditional financial instruments such as stocks continue to provide stability and long-term growth, while gold often acts as a hedge against market downturns and inflation. This thesis aims to address the pressing business issue of how cryptocurrency can fit into a well-diversified investment portfolio by utilizing Modern Portfolio Theory (MPT) in combination with Sharpe ratio. This approach will find the best risk-adjusted returns for the portfolio, along with the designated allocation for each asset class.

## 2. Theoretical Foundation

### 2.1 Cryptocurrency

The roots of cryptocurrency occurred from an anonymous figure or group under the name of Satoshi Nakamoto, introducing Bitcoin in 2009 as a type of digital and decentralized currency with unique characteristics. It has become the most well-known and widely traded cryptocurrency people recognize and call the "digital gold". However, according to (Jianguo, 2023), Bitcoin does not yet match gold's performance as a safe-haven asset during market crashes and inflation, indicating that gold remains the preferred hedge asset. In contrast, (Kaibo, 2024) examine the interaction between Bitcoin and gold prices, particularly during the COVID-19 pandemic, revealing complex correlations and potential causal relationships that underscore Bitcoin's evolving role in the financial landscape, implying that Bitcoin might be increasingly seen as a safe-haven asset or hedge similar to gold during times of economic uncertainty. Research by (Karlo, 2019) shows that the inclusion of Bitcoin results in lower expected risks and higher returns, positioning Bitcoin on the efficient frontier and suggesting its potential as an efficient investment instrument depending on investor risk tolerance. Bitcoin, as an emerging asset class, has seen exponential growth since its inception and achieved a market capitalization of $1.25 Trillion as of September 2024, representing nearly 60% of the entire cryptocurrency market and is ranked 11th globally (CoinMarketCap, 2024).

However, its significant price volatility illustrated by a 60% decline during the COVID-19 pandemic followed by more than 1,500% increase within a year from 2020 until 2021 underscore the challenges investors face in relying on it as an alternative investment. In January 2024, the United States Securities of Exchange Commission (SEC) allowed Bitcoin spot currency exchange-traded-funds (ETFs) to be listed and traded, followed by Ethereum spot ETFs in May 2024. These actions raise cryptocurrencies in many aspects, such as increasing legitimacy, becoming more common in the global investment landscape, increasing investors' protection, and growing demand while the cryptocurrency supply is limited. Following the launch of Bitcoin spot ETFs, the price of Bitcoin surged by over 55%, accompanied by an inflow of more than 30,000 Bitcoins into ETFs. As cryptocurrencies continue to gain traction, they challenge traditional financial systems and prompt a reevaluation of economic policies, with the global cryptocurrency market expected to expand further (Suzana, 2023).

### 2.2 Indonesia Stock Exchange

The Indonesia Stock Exchange (IDX) is the primary stock exchange in Indonesia where public companies are listed and traded. Represented by the Indonesia Stock Exchange Composite Index (IHSG) also known as the Jakarta Composite Index, which reflects the performance of all listed company's stocks through their price movements. This index serves as a vital benchmark for investors, providing insight into overall market sentiment and reflecting Indonesia's economic condition (Muhammad, 2024).

### 2.3 LQ45 Index

The LQ45 index is a significant benchmark on the Indonesia Stock Exchange (IDX), comprise of 45 stocks selected due to their high liquidity and substantial market capitalization, making it an attractive option for investors to diversify their investment portfolio and development of various investment strategies. The LQ45 index has experienced notable decline over the past two years, highlighting the importance of strategic portfolio selection to navigate market volatility effectively (Bambang, 2024).

### 2.4 Gold

Gold is considered as one of the major investment commodities in the world. It has the characteristics of hedging against market volatility and a safe-haven asset in times of uncertainty in the financial market. It is an alternative investment to equity and shown an inverse relationship observed between the price of gold and stock indexes seen either in Hong Kong or Japan (Retno, 2024). Furthermore, gold's effectiveness as a hedge and safe haven has been validated across various economic scenarios, such as the dot-com bubble and the COVID-19 market crash, particularly in countries like Canada, Germany, Italy, the UK, and the US (Gomes et al., 2023).

### 2.5 Risk and Return

In the context of investment, the outcomes of financial and economic decisions are almost uncertain at the time they are made. Investment inherently carry risk, which refers to the possibility that future returns deviate from what was expected, potentially leading to unfavorable scenarios. This uncertainty or variability may result in outcomes opposite to an investor's expectations. Risk typically assessed over a specific time horizon with relative to a benchmark. It can be measured mathematically using the statistical concept of standard deviation, which

indicates the degree of variation in investment performance. Meanwhile, return signifies the financial gain obtained from an investment, typically expressed as a percentage increase in asset's value. Investors aim to maximize returns while effectively managing risk, which is characterized by the uncertainty or variability in returns that can lead to outcomes contrary to expectations (Peng, 2023). The concept of risk-return trade-off implies that higher potential returns are usually associated with higher risk, as seen in stocks compared to more stable investments like bonds (Peng, 2023).

### 2.6 Modern Portfolio Theory

Modern Portfolio Theory (MPT), proposed by Harry Markowitz in 1952, also known as Markowitz Theory, provides a framework for constructing efficient portfolios by balancing risk and return. This theory emphasizes the importance of diversification and the quantification of risk through the variance of investment returns, allowing investors to construct portfolios that maximize expected returns for a specified level of risk (Markowitz, 1952). MPT has been applied to various asset classes and demonstrated its versatility and relevance in today's evolving market condition (Liu, 2024). MPT assumes that investors are rational and aim to minimize risk while maximizing returns, that individual investors are too small in number to influence market prices, and that all investors have unrestricted access to borrowing and lending at the risk-free interest rate (J.Y., 2024).

### 2.7 Sharpe Ratio

Sharpe ratio introduced by William F. Sharpe in 1966 evaluates the portfolio performance by comparing the average return in excess of the risk-free rate to the standard deviation of returns. This ratio is widely used to assess the efficiency of a portfolio, providing insights into the trade-off between risk and return (Alexandrina, 2024). The greater the Sharpe ratio the better the risk performance, while the negative Sharpe ratio indicating the risk free or benchmark rate is greater than the investment expected return over period of time.

### 2.8 Conceptual Framework

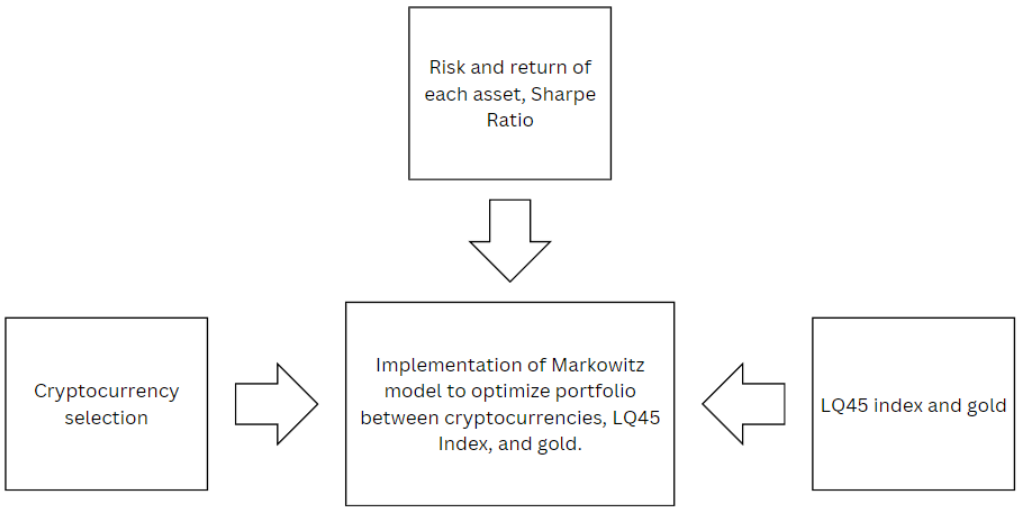


**Figure 1: Conceptual Framework**

## 3. Methodology

### 3.1 Data Collection

Historical prices of Bitcoin, LQ45 Index, IHSG Index, and gold were collected from Yahoo Finance as the secondary data source. The adjusting closing price is applied to ensure accuracy and relevance for this research, which represents all kinds of returns. This research used a decade of monthly historical data ranges from October 2014 until October 2024 to capture pivotal events and developments within financial markets worldwide. The year starting year of 2014 was chosen to coincide with the emergence of greater interest in Bitcoin as a widely accepted cryptocurrency and new instrument of investment, marking the transition from niece invention into a significant factor in financial markets worldwide. This period also allows the analysis for LQ45 Index, IHSG Index, and gold

under various economic conditions. The COVID-19 pandemic also disrupts the global financial markets that were never witnessed before, tested the relative strength of various asset classes.

### 3.2 Risk Free Rate

The risk-free rate return is the expected return from an investment that have zero risk and therefore assures the minimum rate of return the investor need over a period of time of the investment. In this research, the 10-year government bond yield is used for the risk-free rate, since it considers the relevance to local investors in Indonesia. The rate is determined based on average historical data between 2014 and 2024.


**Figure 2: Indonesia 10 Government Bond Yield**

### 3.3 Data Analysis

The quantitative methodology is used in this research, this approach emphasizes the collection and analysis of numerical data, utilizing statistical and mathematical techniques. Modern Portfolio Theory (MPT) by Markowitz serves as the core quantitative framework of this research. It applied to construct the most efficient portfolio by optimizing the trade-off between risk and return. This methodology focuses on maximizing return, minimizing risk, and achieving optimal diversification through strategic asset allocation. The efficiency of the constructed portfolio is evaluated using the Sharpe Ratio, a key performance metric that measures return relative to the risk taken. The research aims to provide actionable insights into creating portfolios that balance risk and reward effectively by applying those quantitative methodology.

Portfolio optimization was conducted under three distinct scenarios. The first scenario involves an equal-weight portfolio, where each asset allocated an equal proportion of the total investment. The second scenario focuses on a maximum return portfolio, prioritize the highest possible return regardless of the associated risk. The third scenario focuses on a minimum risk or minimum variance portfolio, prioritize minimizing risk by optimizing asset allocation to achieve the lowest possible variance. Followed by calculating Sharpe ratio to evaluate the performance of these scenarios, measures the risk-adjusted returns of the portfolios. The analysis compares two different portfolios:

1. Portfolio A: Consisting of LQ45 Index and gold.
2. Portfolio B: Incorporating Bitcoin alongside the LQ45 Index and gold.

## 4. Findings

The analysis will cover the period from October 2014 to October 2024, representing a decade of market performance. The risk-free rate calculated at 7.18% from the average of Indonesia 10-Year Government Bond Yield over the period.

| Market Data (Oct 2014 - Oct 2024) | | | |
|---|---|---|---|
| No | Asset | ER | SD |
| 1 | BTC | 70.49% | 74.76% |
| 2 | LQ45 | 0.60% | 15.68% |
| 3 | GOLD | 8.87% | 13.42% |
| 4 | IHSG | 4.06% | 12.46% |

| Sharpe Ratio | | |
|---|---|---|
| No | Asset | Sharpe |
| 1 | BTC | 84.69% |
| 2 | LQ45 | -41.96% |
| 3 | GOLD | 12.59% |
| 4 | IHSG | -25.05% |

**Figure 2: Market Performance of Individual Asset**

In figure 2, BTC has the highest expected return of 70.49% and exceptionally high Sharpe ratio of 84.69% when compared to other asset, reflecting its strong performance during this period, however it also carries the highest risk with a standard deviation of 74.76%. LQ45 shown low expected return of only 0.6% but having a higher risk of 15.68%, indicating its underperformance during this period.

| Covariance Matrix | | |
|---|---|---|
| | *Gold* | *LQ45* |
| Gold | 0.001488 | 0.00028047 |
| LQ45 | 0.00028 | 0.00203058 |

| Covariance Matrix | | | |
|---|---|---|---|
| | *Bitcoin* | *Gold* | *LQ45* |
| Bitcoin | 0.0461919 | 0.000735076 | 0.002515155 |
| Gold | 0.00073508 | 0.001487644 | 0.000280467 |
| LQ45 | 0.00251515 | 0.000280467 | 0.00203058 |

**Figure 3: Covariance Matrix of Two Portfolios**

The covariance matrix in figure 3 are derived from historical return data where positive covariance indicates that the returns of two assets tend to move in the same direction, while negative covariance suggest they move in opposite directions. A covariance close to zero have little to no relationship between the returns of the two assets. It can be observed that Bitcoin is the riskiest asset with 4.6% monthly covariance.

| Portfolio A | | | | |
|---|---|---|---|---|
| **Asset** | **Equal Weight** | **Maximum Return** | **Minimum Risk** | **Maximum Sharpe** |
| GOLD | 50.00% | 95.00% | 59.18% | 95.00% |
| LQ45 | 50.00% | 5.00% | 40.82% | 5.00% |
| **Summary** | | | | |
| Expected Return | 4.73% | 8.45% | 5.49% | 8.45% |
| Standard Deviation | 11.06% | 12.84% | 10.93% | 12.84% |
| Risk Free Rate | 7.18% | 7.18% | 7.18% | 7.18% |
| Total Weight | 100.00% | 100.00% | 100.00% | 100.00% |
| Sharpe Ratio | -22.10% | 9.93% | -15.43% | 9.93% |

**Figure 4: Portfolio A's Investment Strategies**

| Portfolio B | | | | |
|---|---|---|---|---|
| **Asset** | **Equal Weight** | **Maximum Return** | **Minimum Risk** | **Maximum Sharpe** |
| BTC | 33.33% | 90.00% | 5.00% | 90.00% |
| GOLD | 33.33% | 5.00% | 59.23% | 5.00% |
| LQ45 | 33.33% | 5.00% | 35.77% | 5.00% |
| **Summary** | | | | |
| Expected Return | 26.65% | 63.92% | 8.99% | 63.92% |
| Standard Deviation | 27.51% | 67.28% | 11.74% | 67.28% |
| Risk Free Rate | 7.18% | 7.18% | 7.18% | 7.18% |
| Total Weight | 100.00% | 100.00% | 100.00% | 100.00% |
| Sharpe Ratio | 70.79% | 84.34% | 15.44% | 84.34% |

**Figure 5: Portfolio B's Investment Strategies**

In Figure 4 and 5, various asset allocation strategies are shown by leveraging Modern Portfolio Theory, equally weighted, maximum return, minimum risk, and maximum Sharpe ratio. The performance of Portfolio B has better Sharpe ratio ranging from 15.44% to 84.34%, compared to Portfolio A that have minus Sharpe ratio from 2 out of 4 allocation strategies, indicating that these strategies failed to generate return to compensate for the risk during the period. Interestingly, the asset allocation in Portfolio A, gold dominate the optimization process, but with the addition of Bitcoin in Portfolio B, Bitcoin outperform gold and dominate in term of risk and return profile.

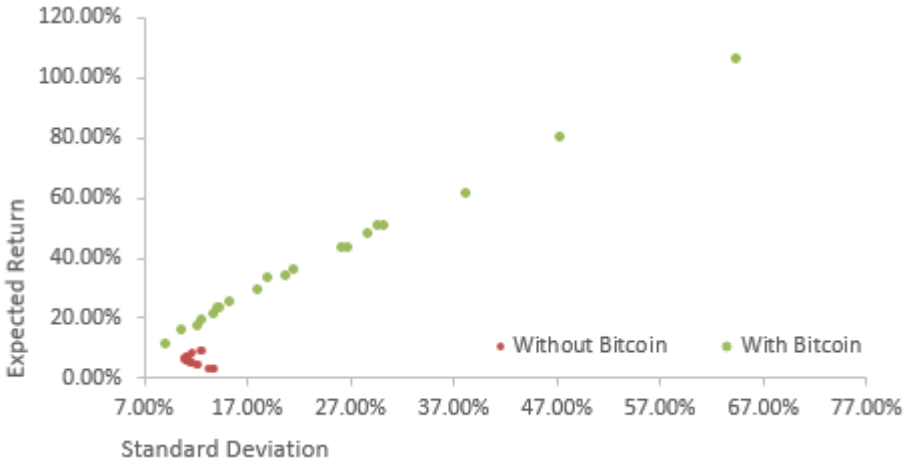


**Figure 6: Efficient Frontiers**

Figure 6 illustrates two efficient frontiers. The red efficient frontier represents a portfolio that exclude Bitcoin, while the green efficient frontier represents a portfolio that incorporates Bitcoin. It is shown from the graph that the efficient frontier with Bitcoin lies above the one without Bitcoin. This implies that for the same level of risk, the portfolio that incorporates Bitcoin generates higher returns compared to the portfolio without Bitcoin. This shift in the efficient frontier demonstrates the positive impact of incorporating Bitcoin into the portfolio, with its high return potential despite its high volatility, it enhances the portfolio efficiency by providing better risk-adjusted returns. In conclusion, incorporating Bitcoin into an investment portfolio increases its efficiency, allowing investors to achieve higher returns for the same level of risk.

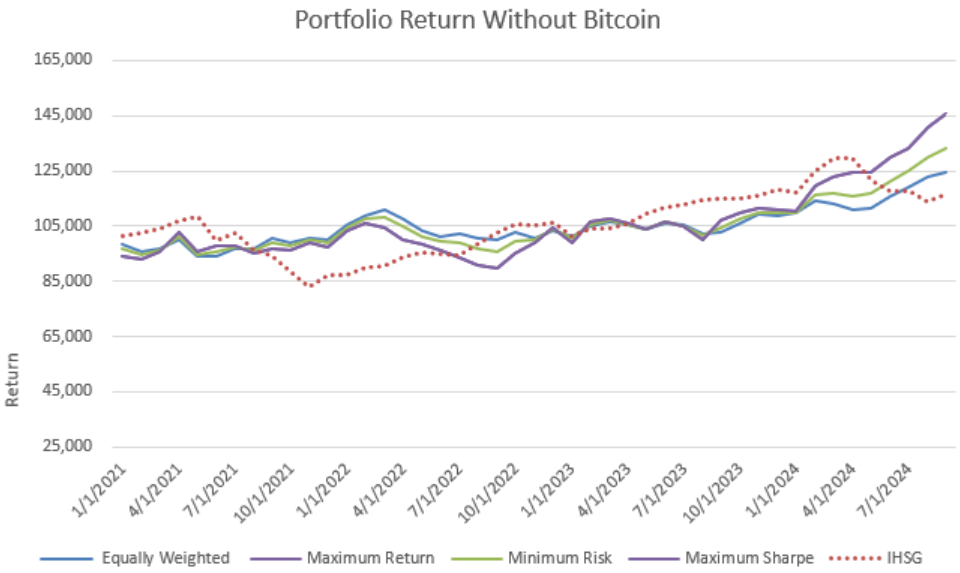


**Figure 7: Portfolio Return without Bitcoin vs IHSG**

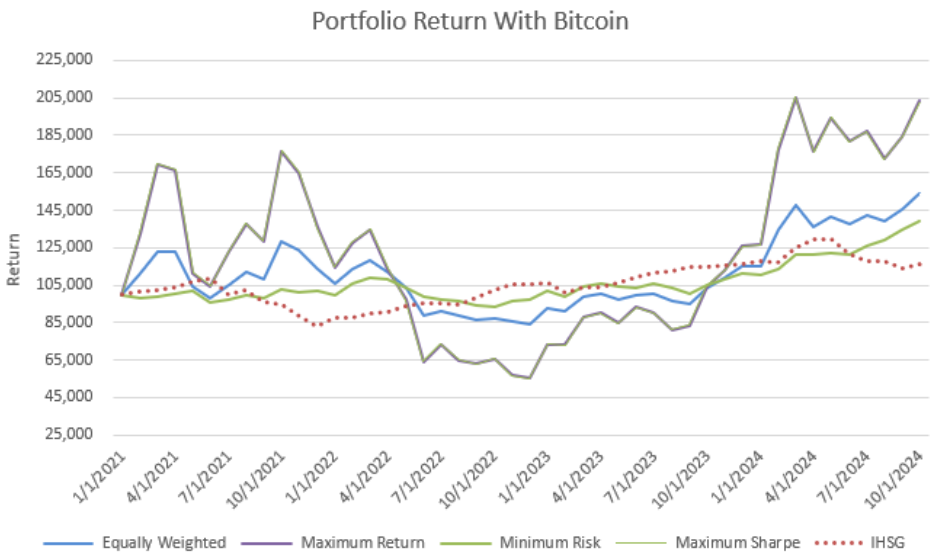


**Figure 8: Portfolio Return with Bitcoin vs IHSG**

Figure 7 and 8 compare portfolios performance under two scenarios, with and without Bitcoin against the IHSG Index as a benchmark. Portfolio without Bitcoin shown steady growth and slightly outperform during October 2021 until June 2022. The returns remain stable, but the growth is relatively subdued due to the absence of high-risk, high-return assets like Bitcoin. The addition of Bitcoin introduces a significant impact on portfolio performance. The Maximum Return and Maximum Sharpe portfolios experiences extreme volatility, with sharp peaks and drops early on, reflecting Bitcoin's high-risk nature.

However, from mid-2023 onward, the portfolios incorporating Bitcoin show a significant upward trend, far surpassing the IHSG Index especially the Maximum Return and Maximum Sharpe portfolios. This highlights Bitcoin's potential to drive higher returns over time that comes with greater volatility. The Minimum Risk strategy shown more stable with lower return compared to others. The analysis underscores the relationship between risk and return. The portfolios without Bitcoin have more stability and grow at slower rate. On the other hand, the portfolios that include Bitcoin show higher returns that outperform the IHSG Index and have significant volatility. It symbolizes Bitcoin’s position as a high-risk and high-return asset, thus fitting for investors who are willing to tolerate its short-term fluctuations for a higher return in the long-term.

## 4. Conclusion

The results of this research conclude that adding Bitcoin into the portfolio affect risk-return profile in the positive way, improving portfolio efficiency noticed in higher return at a given level of risk compared to portfolio without Bitcoin. By leveraging Modern Portfolio Theory and the Sharpe ratio, this research finds the optimal allocation between Bitcoin, LQ45 Index, and gold to achieve the efficient portfolios. Various portfolio strategies were conducted to emphasizes different risk tolerance that investors may have, allowing investors to construct portfolios that maximize expected returns for a specified level of risk. Furthermore, Bitcoin's position in the efficient frontiers shown higher Sharpe ratios and broader efficient frontiers compared to portfolios without Bitcoin. This would mean that Bitcoin could contribute towards the portfolio performance by yielding better risk-adjusted return. Thus, the research methodology used in this research offer a strong framework for constructing and optimizing investment portfolio based on historical data, a relevant tool for investor seeking returns with a given level of risk in the financial markets.

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