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ABSTRACT

This study aims to analyze the role of cryptocurrency investment in optimizing the performance of a portfolio comprising traditional assets, such as stocks, foreign exchange, and gold. This quantitative research employs the Markowitz Mean-Variance Optimization model and Sharpe ratio analysis. The data used consist of monthly closing prices from January 2019 to December 2024 for three cryptocurrencies (BTC, ETH, and XRP), three banking stocks (BBCA, BBRI, and BMRI), three foreign exchange pairs (USD/IDR, EUR/IDR, and GBP/IDR), and gold. A comparison was made between an optimal portfolio without a cryptocurrency and an optimal portfolio with a cryptocurrency. The results indicate that the inclusion of cryptocurrency significantly increased the portfolio's expected return from 14.07% to 32.08%. This increase was accompanied by a rise in risk (standard deviation) from 11.39% to 19.49%. However, portfolio efficiency improved dramatically, as evidenced by the Sharpe ratio surging from 70.89% to 133.83%. In both scenarios, gold consistently played a dominant role as a stabilizing asset in the portfolio. It is concluded that, during the study period, cryptocurrency served as a significant return enhancer and efficiency booster in the investment portfolio.

Keywords: cryptocurrency; portfolio optimization; markowitz model; mean variance optimization; sharpe ratio.

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RESEARCH & PUBLISHING

1. INTRODUCTION

Technological developments have significantly influenced every aspect of human life, including the financial sector. Cryptocurrency is a technology-based financial innovation that has emerged as a result of technological developments. According to Jing et al. (2023), cryptocurrency is a digital currency that uses cryptographic technology to verify every transaction. Cryptocurrency has become an attractive asset due to its characteristics, one of which is being a decentralized asset or currency. This means that this asset is not controlled by any authority, such as a central bank. Currently, cryptocurrency has rapidly developed into an attractive investment asset class for both individual and institutional investors. This growth is reflected in the total market capitalization. Data from coinmarketcap.com show that as of January 1, 2025, the total market capitalization of cryptocurrency assets reached 3.26 trillion US dollars. According to Lee et al. (2018), the explosive growth of the cryptocurrency market has confirmed its functional shift, not only as an alternative medium of exchange but also as an increasingly popular investment asset for both individual and institutional investors. The decentralized characteristic, without affiliation to any authority, is the main reason investors are attracted to cryptocurrency assets, especially Bitcoin (DeMatteo, 2022). Additionally, the limited supply mechanism of some cryotocurrency assets, such as Bitcoin, which has a maximum supply of only 21 million coins, creates scarcity for the asset. The characteristics of a limited and programmed supply mechanism (especially Bitcoin) and increasing demand from various investor segments have been the main drivers of significant price appreciation, even though this asset has high volatility (Boiko et al., 2021).

Currently, the adoption of cryptocurrency is expanding in various financial aspects, both as a payment system, a state financial system, and as an investment instrument. Adoption by large corporations, such as Tesla and Microsoft, as a means of payment and investment instruments is a strong signal of increasing confidence in the long-term potential of cryptocurrency assets. Furthermore, cryptocurrency has also been adopted into state financial systems, and El Salvador was the first country to recognize Bitcoin as a legal tender and as their currency. This step aims to increase financial inclusion and reduce transaction costs. Bitcoin adoption has the potential to increase GDP through remittance efficiency and improved financial inclusion. Moreover, making Bitcoin a legal tender and currency can reduce their dependence on the dollar and lower import costs. Cryptocurrency adoption does not stop there; the adoption of cryptocurrency as an investment instrument is also growing rapidly, marked by the approval of spot BTC and ETH ETFs in the United States. The approval of exchange-traded funds (ETFs) for Bitcoin and Ethereum in the United States provides legal clarity and opens up wider access for institutional investors and huge funds, while also strengthening the position of cryptocurrency assets as an attractive investment instrument for investors. According to Babalos et al. (2025), the introduction of this Spot Bitcoin ETF increases investor participation due to the ease of information and access for both individual and institutional investors, which may lead to a decrease in the volatility of cryptocurrency asset prices.

In Indonesia, the trading of cryptocurrency assets is regulated and supervised by the Otoritas Jasa Keuangan (OJK), based on OJK regulation Number 27 of 2024 concerning the implementation of digital financial asset trading, including cryptocurrency assets (OJK, 2024). This regulation transferred the supervisory function of cryptocurrency assets from Bappebti to OJK, signifying the recognition of cryptocurrency assets as financial and investment instruments, not just as commodities. Interest in cryptocurrency in Indonesia is growing rapidly. Data from an OJK press release in January 2025 showed that the number of cryptocurrency investors in Indonesia reached 22.11 million in November 2024, with an annual transaction value of IDR 556.53 trillion (OJK, 2025). However, this rapid growth presents challenges, especially because it is dominated by young investors, whose decisions are often influenced by psychological factors such as overconfidence (Danurwenda & Suhartini, 2024). This phenomenon underscores the urgency of understanding based on empirical data, as decisions not based on measured analysis can increase the risk of loss. Investors in Indonesia need a clear framework on how to effectively integrate these volatile assets into a portfolio that already contains traditional assets such as stocks, gold, and foreign exchange.

Several studies have examined the role of cryptocurrency in portfolios, with varying results. Some studies support the addition of cryptocurrency as an effective means of diversification to improve portfolio performance. For example, Andrianto and Diputra (2018) found that the inclusion of cryptocurrency can significantly increase returns while lowering risk through diversification. Conversely, other studies, such as the one conducted by Kajtazi and Moro (2019), highlight that the potential for high returns is often accompanied by a significant increase in risk and volatility, without a guarantee of consistent hedging. The debate over the potential allocation composition is still ongoing. For example, Putra (2022) succeeded in forming a portfolio for conservative investors with a minority allocation of 24% in cryptocurrency assets. In contrast, Semeru and Nainggolan (2023) for the 2018-2022 period found that the optimal portfolio consisted only of Bitcoin (18%) and Gold (82%). These inconsistent results, which may be due to differences in time periods, asset coverage, and methodology, create a clear and urgent research gap.

Therefore, this study aims to quantitatively analyze the impact of adding three cryptocurrencies (BTC, ETH, and XRP) to the optimization of a portfolio consisting of assets commonly owned by Indonesian investors. This is done by applying the Modern Portfolio Theory (MPT) framework, a fundamental modern portfolio theory proposed by Markowitz (1952), using a Mean-Variance Optimization (MVO) approach. MPT states that investors can form portfolios to optimize the portfolio's return based on a certain level of risk (Markowitz, 1952). The MVO approach is used to determine the optimal allocation by considering the balance between risk and return. Furthermore, to measure portfolio performance, an analysis using the Sharpe ratio, which measures risk-adjusted return. The sharpe ratio is a matric developed by Sharpe (1966). The Sharpe ratio function evaluates the performance of an investment based on its risk-adjusted return, which is the difference between the return of the portfolio and the risk-free rate divided by the standard deviation or risk portfolio (Sharpe, 1966).

2. METHOD

This research uses a quantitative approach with a descriptive method to analyze data and provide an overview of the impact of cryptocurrency on investment portfolios. This approach was chosen because it allows for systematic and objective measurement and analysis of data to explain the observed phenomena. The population in this study is all investment instrument assets. A sample was selected using a non-probability sampling technique with with a convenience sampling approach based on the availability of complete historical data, high liquidity, and its relevance to investors in Indonesia. The sample criteria were used to ensure that the analysis results are more easily understood and relevant. The research sample consists of: (a) Cryptocurrency: Bitcoin (BTC), Ethereum (ETH), Ripple (XRP), as the three assets with largest market capitalization and widest adoption; (b) Stocks: PT Bank Central Asia Tbk (BBCA), PT Bank Rakyat Indonesia (Persero) Tbk (BBRI), PT Bank Mandiri (Persero) Tbk (BMRI), as representative of blue-chip stocks from the dominant banking sector on the Indonesia Stocks Exchange; (c) Foreign Exchange: Currency pairs USD/IDR, EUR/IDR, GBP/IDR, as major world currencies often used for diversification; (d) Gold (XAU), as one of the oldest and most widely used investment instruments by the public.

The data used is secondary quantitative daya collected from pre-existing source. The data is in the form of monthly prices obtained from the investing.com website. The research period is set from January 2019 to December 2024. Which cover various market conditions, including bull markets and significant corrections. For the risk-free rate, the Bank Indonesia (BI) interest rate as of December 2024 which was 6.00%, is used.

Data analysis was carried out though a series of systematic and interrelated stages. The first stage involves calculating the risk and return. This fundamental step converts historical price data into monthly return data for the stock. From this data series, the average annual return (expected return) and standard deviation (as a measure of risk) are calculated for each individual asset. After the risk and return are known, the second stage is covariance analysis. Covariance is a statistical measure that indicates how the return of two assets moves in relation to each other (Bodie et al. 2014). A variance-covariance matrix is constructed to measure the interaction between assets in a portfolio, which is the mathematical basis for the benefits

of diversification and a core component in calculating combined portfolio risk. The next step is to form an optimal portfolio using the Markowitz Mean-Variance Optimization (MVO) model with the help of the solver feature in Microsoft Excel. Optimization is performed to find the combination of asset weights that maximizes the Sharpe ratio, with the constraints that the total investment weight must be 100% (fully invested) and no short selling (all weights ≥ 0). There are two portfolio scenarios: a portfolio without cryptocurrency and a portfolio with cryptocurrency. Subsequently, using the Modern Portfolio Theory by Markowitz (1952), the expected return of each portfolio is calculated. The expected return of a portfolio is calculated by summing all expected returns of each asset multiplied by their weight in the portfolio. Mathematically, the expected return can be calculated using the following equation:

$$E(R_p) = \sum_{i=1}^{n} w_i E(R_i)$$

Where:
$E(R_p)$ = Expected return portfolio
w_i = Weight of asset i in the portfolio
$E(R_i)$ = Expected return asset i

The portfolio risk is calculated based on the respective standard deviations. The calculation of the portfolio's standard deviation is done by taking the square root of the sum of the interaction between assets (covariance) multiplied by the respective weights of the assets in the portfolio, or it can be mathematically defined as follows:

$$\sigma_p = \sqrt{\left(\sum_{i=1}^{n} \sum_{i=1}^{n} w_i w_j Cov_{ij} \right)}$$

Where:
σ_p = Standar deviation portfolio
w_i = Weight of asset i
w_j = Weight of asset j
Cov_{ij} = Covariance i & j

After the two scenarios are formed, the next step is to compare the expected return, standard deviation, and Sharpe ratio of the two optimal portfolio scenarios to evaluate the impact of including cryptocurrency quantitatively and objectively. In addition, portfolio performance is also measured using sharpe ratio to obtain the optimal portfolio based on risk-adjusted return. The sharpe ratio calculation depends on the difference between return portfolio and risk-free rate, known as excess return, and its comparation with porfolio's standar deviation (Sharpe, 1966). Mathematically, the sharpe ratio is calculated using following equation:

$$S = \frac{R_{pi} - R_f}{\sigma_{pi}}$$

Where:
S = Sharpe ratio
R_{pi} = Return portfolio i
R_f = Risk free rate
σ_{pi} = Standard deviation portfolio

3. RESULT AND DISCUSSION

3.1. Asset Characteristics

The descriptive analysis shows that cryptocurrency assets have high-risk, high-return characteristics. XRP recorded the highest average annual return (123.34%) and the highest risk (standard deviation of 177.22%), meaning that its value fluctuates extremely. Gold (XAU) offers an attractive combination owing to the balance between a relatively high return (15.11%) and a fairly low risk (standard deviation of 14.75%), making it an efficient asset. Stock assets show moderate returns with medium risk, while foreign exchange assets have the lowest return and risk profiles, making them less attractive from a growth potential perspective.

3.2. Composition & Performance of Optimal Portfolio

3.2.1 Portfolio Without Cryptocurrecy

In this scenario, the portfolio comprises only conventional assets. The optimization results show that the composition tends to be defensive, dominated by gold (XAU) with a weight of 76%. This indicates that gold has the most efficient return-to-risk ratio among all the assets, making it the main foundation of the portfolio. BMRI (17%) and BBCA (7%) stocks complete the portfolio with contributions to diversification and increased expected returns. This portfolio yielded an expected return of 14.07% and a standard deviation of 11.39%. The sharpe ratio of 70.89% indicates that this portfolio provides reasonably good return compared to the risk involved. The absence of foreign exchange assets and BBRI stocks suggests that their contribution to portfolio efficiency is suboptimal. The asset weight allocation in the portfolio without the cryptocurrency is presented in Table 1.

Table 1. Optimal Portfolio Without Cryptocurrency Assets

Asset	XAU/IDR	USD/IDR	EUR/IDR	GBP/IDR	BBCA	BBRI	BMRI	TOTAL
Weight	76%	0%	0%	0%	7%	0%	17%	100%
Expected Return	14.07%							
Standard Deviation	11.39%							
Sharpe ratio	70.89%							

Source: Processed data, 2025

3.2.2. Portofolio dengan Cryptocurrecy

When cryptocurrency assets are included in the investment options, the portfolio structure changes significantly. The allocation to gold decreased to 69% but remained the largest component. A total of 23% of the portfolio was allocated to cryptocurrency, divided into Bitcoin (15%), Ethereum (6%), and XRP (2%). The only remaining stock is BMRI, with an 8% weight. Meanwhile, other stocks (BBCA and BBRI) and all foreign currencies (USD, EUR, and GBP) received no allocation (0%) because they were deemed not to contribute optimally to the portfolio's risk-return profile. See Table 2

Table 2. Optimal Portfolio with Cryptocurrency Assets

Asset	XAU/IDR	USD/IDR	EUR/IDR	GBP/IDR	BBCA	BBRI	BMRI	BTC	ETH	XRP	TOTAL
Wight	69%	0%	0%	0%	0%	0%	8%	15%	6%	2%	100%
Expected Return	32.08%										
Standard d	19.49%										

Deviation												
Sharpe ratio	133.83%											

Source: Processed data, 2025

Overall, this portfolio generated returns (*expected returns*) of 32.08% with a risk (standard deviation) of 19.49%. Although the risk is higher, *the Sharpe ratio, which* reached 133.83%, shows that this portfolio has very superior efficiency because it can provide much higher returns for each unit of risk borne.

3.3. Portfolio Comparison Analysis

A comparative analysis of portfolios with and without cryptocurrency assets (period 2019-2024) which includes banking stocks, foreign exchange, and gold, shows a significant increase in effectiveness. *Cryptocurrency* (BTC, ETH, XRP) managed to double the expected *return portfolio*. In Figure 1, it can be seen that the portfolio with assets*cryptocurrency* shows improvement *expected return*A very significant increase, more than doubling from 14.07% to 32.08%. This increase in returns was accompanied by an increase in risk, as seen in the increase in the standard deviation from 11.39% to 19.49%, in line with the volatility characteristics of the asset.

Although riskier, portfolio performance improves when cryptocurrency assets are added. This is evident from the surge in the sharpe *ratio from* 70.89% to 133.83%. This much higher figure indicates that the portfolio with cryptocurrency is much more efficient in providing better compensation returns for each unit of risk taken and is therefore considered more optimal. This is driven by the asset's superior historical performance, increased adoption, and regulatory clarity (Figure 1).
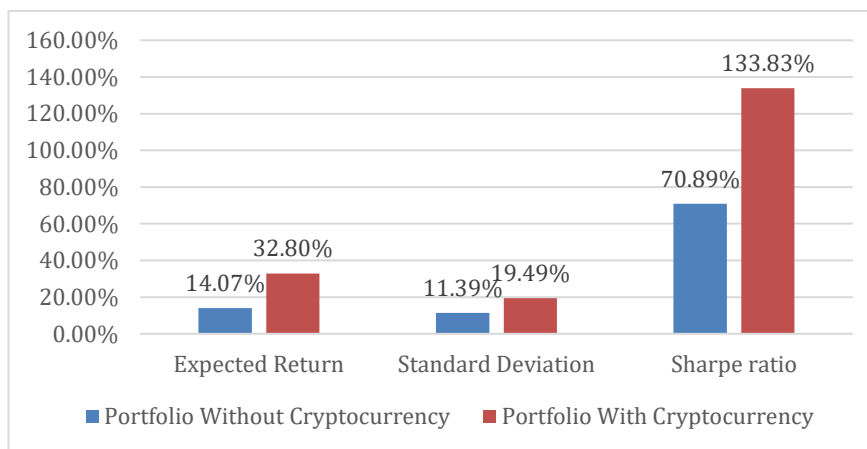

Figure 1. Portfolio Performance Comparison
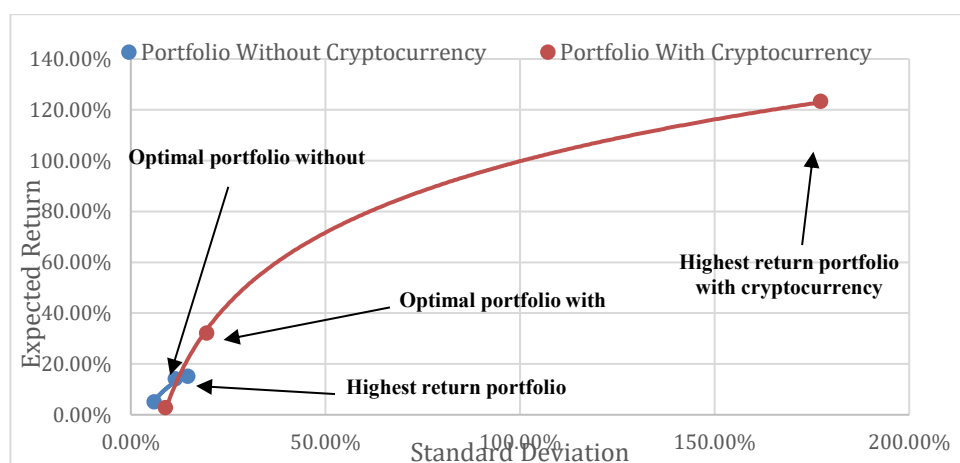
Source: Processed data, 2025

An interesting aspect of the optimization results is the elimination of all foreign currency assets and BBRI shares from both optimal portfolio scenarios. This is due to their extremely low historical returns, even below the risk-free rate (6.00%), which makes them inefficient within the optimization framework (MVO). BBCA shares are included only in the portfolio without any risk. cryptocurrency, while BMRI holds up in both scenarios because of its superior historical returns. Another interesting aspect of both portfolios is the dominant role of gold (XAU), which retains the highest share in both portfolio types (76%, excluding crypto, and 69% with *crypto*). This finding confirms the important role of gold as an asset*safe haven*dominant, whose function in stabilizing the portfolio remains relevant even when high-risk assets such as*cryptocurrency* are also included.

Meanwhile, in terms of the curve efficiency *frontier, the* addition of cryptocurrency assets to a portfolio presents a fundamental shift in the investment opportunity landscape. This can be seen in Figure 2, where the curve *efficiency frontier* portfolio with cryptocurrency is in a much superior position, higher, more extended to the right, and wider than the curve *efficiency frontier* portfolios without cryptocurrency assets. This shift indicates that the inclusion of cryptocurrencies has opened up a wider range of asset combinations, demonstrating a much greater diversification function.

The upward shift of the curve is caused by the expected return. The extremely high yields of crypto assets (such as BTC, ETH, and XRP) mathematically increase the maximum portfolio return limit far beyond what conventional assets can offer. Conversely, the curve also extends to the right because of the high-risk characteristics of crypto. This broadens the range of strategic options for investors with very highrisk tolerances, which were previously unaccommodated in portfolios with conventional assets such as gold, stocks, and foreign exchange.

This change in the shape of the curve also moves the optimal portfolio point, namely the point with the Sharpe ratio. The optimal point shifts from a relatively conservative position (11.39% risk, 14.07% return) to a much more aggressive quadrant (19.49% risk, 32.08% return). This shift results in a superior optimal point because the more than twofold increase in return far outweighs the increase in risk, thus increasing the Sharpe *ratio significantly*. See Figure 2

Figure 2. Comparison of Curves *Efficiency Frontier*

Source: Processed data, 2025

Overall, the results indicate that asset allocation in cryptocurrency Measurable assets can be a valuable component in enhancing the efficiency of modern portfolios for Indonesian investors, provided they are managed with an understanding of risk and appropriate allocation strategies, and with the caveat that their role is as a return accelerator that needs to be balanced by stability assets such as gold.

4. CONCLUSION

Results of the analysis of the influence of including cryptocurrency (BTC, ETH, XRP) on the effectiveness of an investment portfolio that includes a combination of traditional assets, namely banking stocks, foreign exchange, and gold. The MVO method and Sharpe ratio analysis were used on historical data for the period January 2019 to December 2024. The study produces several main conclusions as follows: (1) *Cryptocurrency as* a Driver of Yields (*Return Enhancer*): Asset inclusion *cryptocurrency* significantly improve *expected return* portfolio from 14.07% to 32.08%; (2) Portfolio Efficiency Improvement: Although the risk (standard deviation) increased from 11.39% to 19.49%, this increase was very efficient. This is evidenced by the surge in *Sharpe ratio* from 70.89% to 133.83%, which shows that the risk-adjusted return (*risk-adjusted return*) become much more superior; (3) Gold's Dominant Role as a Stabilizer: Gold consistently dominates the optimal portfolio allocation (69% with *crypto* and 76% without *crypto*), underlining its role as a defensive asset (*safe haven*) which is vital for stability, even in the presence of volatile

assets such as *cryptocurrency*; (4) Selectivity of the MVO Model: The MVO model eliminates assets with less efficient risk-return profiles. All foreign exchange assets and some stocks (BBRI and BBCA in certain scenarios) are excluded from the optimal portfolio, indicating their minimal contribution to the optimization sharpe *ratio during* the research period.

The overall research results indicate that investment in cryptocurrency during the period January 2019 to December 2024 for investors, especially investors in Indonesia, plays a significant role as a driver of returns (*return enhancer*) and portfolio efficiency enhancer (*efficiency booster*), which also provides diversification benefits. This positive impact is reflected primarily through a significant increase in *expected return* And *sharpe ratio*, although this is also accompanied by an increase in the level of risk (standard deviation) of the portfolio.

Ethical Approval

Ethical approval was not required for this study

Informed Consent Statement

Not Applicable

Authors' Contributions

RAPP contributed to data collection, quantitative analysis using the Markowitz and Sharpe ratio models, interpretation of results, and drafting of the manuscript. MC contributed to research conceptualization, methodological design, validation of analysis, supervision of the study, and critical revision of the manuscript.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data Availability Statement

The data presented in this study are available on request from the corresponding author due to privacy reasons.

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Notes on Contributors

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