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# Comparative Performance Analysis of Bitcoin, Ethereum, and Solana in The Crypto Market

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## Abstract

In today's globalized digital economy, investors face diverse instruments to optimize portfolios. This study examines the comparative financial performance of Bitcoin, Ethereum, and Solana from 2021 to 2024, evaluating return, risk, and risk-adjusted performance using the Sharpe Ratio. The methodology applies quantitative analysis on secondary data from *CoinMarketCap*, employing descriptive statistics, annual return, standard deviation, Value at Risk (*VaR*), Expected Shortfall (*ES*), and Sharpe Ratio. Statistical tests include ANOVA for return differences and the Kruskal–Wallis and Mann–Whitney U tests for risk and risk-adjusted performance due to non-normal data distributions. Results indicate no significant differences in average returns across the three cryptocurrencies. However, Solana exhibits the highest volatility, followed by Ethereum and Bitcoin, revealing significant risk disparities. Sharpe Ratio comparisons show no statistically significant difference, indicating comparable risk-adjusted returns. These findings align with broader literature demonstrating that while cryptocurrencies exhibit elevated absolute risk and return levels compared to traditional assets, their risk-adjusted performance is often balanced across major tokens. Hence, diversification among these cryptocurrencies may be a viable approach tailored to investors' risk tolerance. Given their distinctive volatility profiles and comparable Sharpe Ratios, these assets offer contrasting risk-return tradeoffs within a diversified crypto portfolio strategy. This supports the notion that risk-adjusted analysis is essential in cryptocurrency investment decisions.

*Keywords: Bitcoin, Ethereum, Solana, return, risk, Sharpe Ratio, ANOVA, Kruskal-Wallis*

## Introduction

In the era of globalization and digitalization, investors have access to various investment instruments to optimize their portfolios. Investment is the activity of allocating capital for a specified period with the goal of generating income in the future

(Tandelilin, 2021). To diversify risk, investors must understand the characteristics and performance of different instruments, including traditional assets such as stocks and gold, as well as digital assets. One rapidly growing investment alternative in the financial market is cryptocurrency, including Bitcoin, Ethereum, and Solana. Despite rapid growth, the crypto market faces significant adoption challenges. According to *Triple-A* (2024), global crypto users number about 420 million, roughly 5.3% of the world population. In Indonesia, *Bappebti* (2024) reports around 12.5 million crypto investors, about 4.6% of the population. Although global crypto market capitalization reached $2.5 trillion in April 2024, it remains far below the $109 trillion global stock market (Statista, 2024), highlighting a significant adoption gap for cryptocurrencies as mainstream investment instruments.

The 2021–2024 period was pivotal for the crypto market, marked by exponential growth, increased institutional adoption, regulatory developments, and technological innovation (World Economic Forum, 2024). Price volatility characterized this period, presenting both opportunities and challenges for investors. According to *CoinMarketCap* (2024), the top ten cryptocurrencies by market capitalization experienced diverse dynamics. Bitcoin remained dominant, increasing from $1 trillion in May 2021 to about $1.9 trillion in April 2024, a 90% growth. Ethereum's market cap grew from $458 billion to $720 billion (Messari Research, 2024). Other cryptocurrencies like XRP, Solana, and Dogecoin also showed significant growth. Notably, new entrants such as Solana, Cardano, and AI-based tokens like *The Graph* (GRT) and *Fetch.ai* (FET) joined the top 50 by 2024 (CoinGecko, 2024).

Bitcoin, Ethereum, and Solana exhibit contrasting risk-return profiles, making their combination valuable for portfolio optimization analysis. Bitcoin's annual volatility is approximately 65%, with a cumulative return of 70% from 2021 to 2024 (Statista, 2025), reflecting its capacity as a value-preserving asset in volatile markets. Solana recorded the highest volatility (130%) and a cumulative return of 300%, indicating aggressive growth potential paired with high risk (CoinDesk, 2025). Ethereum falls in between, with volatility around 85% and a return of 120%, driven by its role as the backbone of the decentralized finance (DeFi) ecosystem (CoinGecko, 2024). According to Tandelilin (2021), the expected returns of crypto assets are influenced significantly by liquidity and institutional adoption, which vary among these three assets. Cheah and Fry (2015) confirm that crypto market volatility creates unique opportunities for enhanced risk-adjusted returns through diversification. The substantial differences in risk-return characteristics emphasize the importance of portfolio analysis to determine optimal asset allocations tailored to conservative, moderate, or aggressive risk profiles.

Previous studies have assessed cryptocurrency performance, such as Setiawati and Diatmika (2023), who compared Bitcoin with stocks and gold from 2018 to 2022; Wuthisatian (2022), who analyzed cryptocurrency's impact on portfolio performance; and Kliber, Marszałek, Musiałkowska, and Świerczyńska (2023), who explored volatility factors and long-term allocation implications. However, research specifically comparing Bitcoin, Ethereum, and Solana during 2021–2024 remains limited. Thus, this study aims

to provide an objective comparative performance analysis of these leading crypto assets over this period.

The core issue addressed is the low adoption of crypto as an investment instrument, reflected in market capitalization and investor numbers compared to traditional assets. This is partly due to investors' limited understanding of crypto assets' heterogeneous risk-return profiles and technological fundamentals. Bitcoin, Ethereum, and Solana differ in consensus mechanisms and ecosystems: Bitcoin employs proof-of-work with a capped supply of 21 million coins, often dubbed "digital gold." Ethereum transitioned to proof-of-stake after *The Merge* and supports up to approximately 30,000 transactions per second, underpinning the DeFi ecosystem. Solana combines proof-of-history and proof-of-stake, achieving transaction speeds roughly twice Ethereum's and nearly 10,000 times faster than Bitcoin.

This research addresses four specific objectives: (1) analyze expected return differences among Bitcoin, Ethereum, and Solana during 2021–2024; (2) analyze corresponding differences in risk (volatility); (3) test differences in optimal portfolio performance across investor risk profiles (conservative, moderate, aggressive); and (4) provide crypto investment strategy recommendations tailored to diverse risk appetites.

The study is expected to offer: (1) theoretical contributions enriching literature on investment behavior and digital finance, particularly crypto adoption among younger investors, enhancing understanding of crypto assets as an alternative asset class and applying modern portfolio theory in digital markets with distinctive features; and (2) practical insights for investment decision-making in the crypto market, facilitating optimal allocation among Bitcoin, Ethereum, and Solana based on individual risk profiles and financial objectives.

## Research Method

This study employed a quantitative research design with a comparative approach to analyze the investment performance of Bitcoin, Ethereum, and Solana over the period 2021–2024. The quantitative method enabled statistical testing of differences in return, risk, and portfolio performance among the three cryptocurrencies using measurable historical data. The comparative approach facilitated a systematic evaluation of these assets and identification of statistically significant differences. Additionally, the study applied descriptive and inferential analyses to characterize each asset and test hypotheses.

The research objects comprised three major cryptocurrencies: Bitcoin (BTC), Ethereum (ETH), and Solana (SOL). These assets were selected based on their strategic and fundamental significance: Bitcoin as the first cryptocurrency and market leader; Ethereum as the largest smart contract platform with a substantial decentralized application (*dApp*) ecosystem; and Solana for its unique high-speed, low-cost technology. The study period spanned January 2021 to December 2024, covering bullish, bearish, and consolidation market phases to provide a comprehensive performance assessment.

Purposive sampling was applied to select cryptocurrencies meeting specific criteria: inclusion in the top ten by market capitalization in 2024, availability of complete

historical data for the study period, representation of different ecosystem categories, and sufficient liquidity measured by average daily trading volume. These criteria led to the selection of Bitcoin, Ethereum, and Solana.

Secondary data consisted of daily historical prices, trading volumes, and market capitalizations obtained from *CoinMarketCap* (coinmarketcap.com), supplemented by US Treasury Bills' risk-free rate data for Sharpe Ratio calculation. Data collection involved multiple stages: historical data acquisition, data cleaning (addressing missing values and outliers via linear interpolation if needed), transformation of price data into daily logarithmic returns to approximate normality for parametric tests, and data storage in structured formats.

The data analysis incorporated descriptive statistics to summarize each asset's characteristics, including measures of central tendency (mean, median, mode), dispersion (standard deviation, variance, range, interquartile range), distribution shape (skewness, kurtosis), and trend analysis (including cumulative returns). Visualization tools such as time series graphs, histograms, box plots, and scatter plots were used to illustrate data features. These descriptive analyses established the foundational risk-return profiles for subsequent inferential testing. Results were presented in tables and graphs to facilitate interpretation and comparison.

**Results and Discussion**

This chapter presents the empirical findings from the comparative analysis of the performance of Bitcoin, Ethereum, and Solana during the 2021-2024 period. The research results are presented in two main sections: the findings, which include descriptive statistical analysis, return, risk, performance calculations, and hypothesis testing; and the discussion, which interprets the findings in the context of investment theory and previous research. The analysis uses daily price data from 1460 observations for each cryptocurrency, providing a comprehensive quantitative foundation to answer the research questions. This section presents the quantitative findings from the performance analysis of Bitcoin, Ethereum, and Solana based on the methodology established in Chapter III. The research results include descriptive statistical analysis to understand the basic characteristics of each asset, return and risk calculations using established formulas, performance analysis through the Sharpe Ratio, and statistical testing to examine significant differences among assets using non-parametric methods.

***Return Calculation Results***

The return calculation using *logarithmic returns* with the formula $Rt= \ln((Pt)/(Pt_{-1})))\times 100\%$ according to the methodology of Alexander (2008) gave results that reflected the dynamics of the crypto market during the research period. The expected return is calculated as an arithmetic average using the formula $E(R) = (1/n)\ \Sigma\ Rt$ from Bodie et al. (2018).

**Table 1. Annual Return Expectation**

| Year | BTC | ETH | SOL |
|---|---|---|---|
| 2021 | 0.125% | 0.444% | 1.244% |
| 2022 | -0.282% | -0.308% | -0.778% |
| 2023 | 0.257% | 0.177% | 0.636% |
| 2024 | 0.217% | 0.104% | 0.170% |

Source: processed data

The analysis of annual returns shows the extreme volatility of the crypto market. **Table 1** shows the expected annual *return* of each asset per year. It can be seen that 2021 was a *bull market* year for crypto: all assets recorded *positive returns* (Solana 1.244%, Ethereum 0.444%, Bitcoin 0.125%). In contrast, 2022 was *a crypto winter* with sharp losses of all assets (Solana -0.778%, Ethereum -0.308%, Bitcoin -0.282%). Furthermore, 2023 and 2024 showed recovery with positive returns. In 2023, Solana recorded *a* return of 0.636%, Bitcoin 0.257%, Ethereum 0.177%. In 2024, all three assets will grow moderately again: Bitcoin 0.217%, Ethereum 0.104%, and Solana 0.170%.

***Risk Calculation Results***

The risk analysis uses standard deviation as the primary measure of volatility, with the formula $\sigma = \sqrt{[(\Sigma(R_i - \bar{R})^2)/(n-1)]}$ according to the methodology of Bodie et al. (2018). In addition, Value at Risk (VaR) and Expected Shortfall (ES) calculations were carried out to provide a more comprehensive picture of extreme risk. Table 4.3 presents the results of a risk analysis that includes a variety of risk measurement metrics.

The results of the risk calculation show a hierarchy consistent with the findings of descriptive statistics. Bitcoin's daily volatility of 3.24% indicates the lowest risk, followed by Ethereum 4.18% and Solana 6.26%. When converted to annual volatility, the difference becomes even more significant with Bitcoin 51.36%, Ethereum 66.24%, and Solana 99.18%.

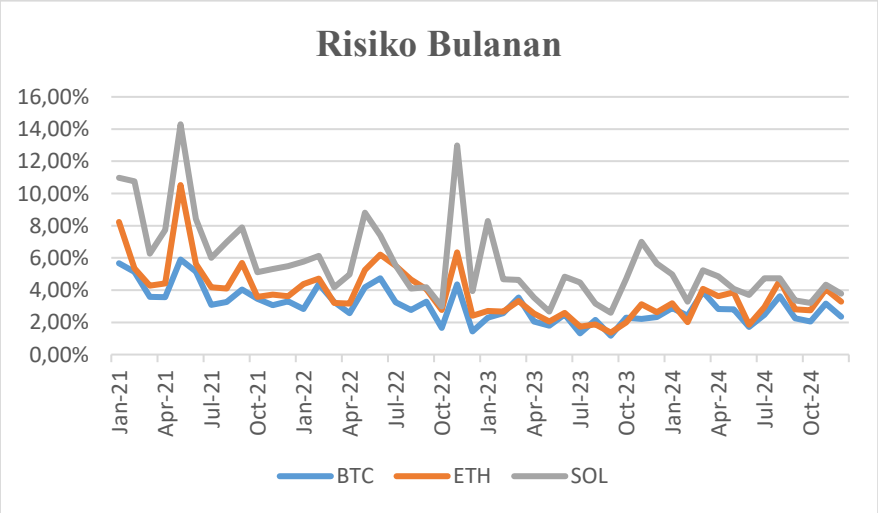


**Figure 1. Standard Monthly Risk Deviation**

Source: Author's Work

**Figure 1** illustrates the standard monthly deviation of each asset, illustrating the spike in Solana's volatility relative to the others. The 2022 period showed a dramatic spike in volatility for all assets, with Solana experiencing the most extreme increases in volatility.

***Performance Calculation Results (Sharpe Ratio)***

Performance analysis using the Sharpe Ratio calculated by the formula SR = (Rp - Rf)/σp from Sharpe (1966) provides a *risk-adjusted return perspective* for all three assets. *The risk-free rate* uses US Treasury Bill 3-month yields which vary from 0.05% (2021), 2% (2022), 5% (2023), to 5.20% (2024), with an average of 3.06% annually over the study period.

**Table 2. Performance Analysis**

| Sharpe Ratio Yearly | BTC | ETH | SOL |
|---|---|---|---|
| 2021 | -0.021997% | -0.021745% | -0.029408% |
| 2022 | -0.019481% | -0.030389% | -0.042281% |
| 2023 | -0.012258% | -0.009414% | -0.026697% |
| 2024 | -0.015080% | -0.020301% | -0.026412% |
| Average | -0.017204% | -0.020462% | -0.031200% |

Source: Processed by the author

The results of the Sharpe Ratio calculation show that Solana has the highest average performance with a value of 0.031%, followed by Ethereum 0.020% and Bitcoin 0.017%. 2021 showed an optimal period for crypto investing with Solana recording a high Sharpe Ratio of 0.185, reflecting a period of bull markets that favored high-volatility assets. The year 2022 showed a negative Sharpe Ratio for all assets, with Solana experiencing the most significant decline (-0.161), followed by Ethereum (-0.084) and Bitcoin (-0.062). The 2023 recovery period shows Solana back in the lead with 0.076, while 2024 shows a convergence of values with a relatively small difference.

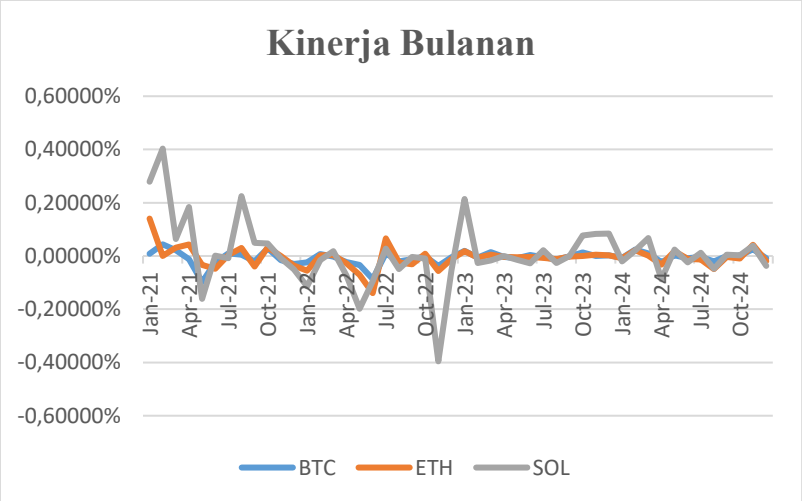


**Figure 3. Sharpe Monthly Performance Ratio**

Source: Author's Work

Figure 3 shows the monthly Sharpe Ratio trend, confirming the role of volatility in offsetting Solana's high returns. These results indicate that in *risk-adjusted returns*, Solana's return advantage does not consistently provide higher returns after accounting for the risk. Although Solana recorded the highest average *returns* , its volatility costs made the Sharpe Ratio of all three similar.

***ANOVA Analysis Results***

The ANOVA prerequisite test uses the Kolmogorov-Smirnov and Shapiro-Wilk tests to test the *returns,* risk, and performance of the three crypto assets. Before conducting the ANOVA analysis, a normality assumption test was carried out using the Kolmogorov-Smirnov and Shapiro-Wilk tests to test the distribution of returns, risk, and performance of the three crypto assets. Table 3 presents the results of the normality test that is the basis for selecting the right statistical analysis method.

***ANOVA Normality Assumption Test***

To test the significant differences between assets, ANOVA normality tests were performed. Table 4.5 presents the results of the Kolmogorov–Smirnov and Shapiro–Wilk normality tests. The results showed that only the *return variable* met the normality assumption (p-value > 0.05 in both tests for all three assets), while the risk and performance variable (Sharpe) failed normality (p-value < 0.05).

**Table 3. ANOVA Normality Assumption Test**

| Variable | Kolmogrov-Smirnov | P value | Shapiro-Wilk | P value | Normal Distribution |
|---|---|---|---|---|---|
| *Return* BTC | 0.0659 | 0.20 | 0.9479 | 0.31 | Yes |
| *Return* ETH | 0.1140 | 0.15 | 0.9368 | 0.68 | Yes |
| *Return* SOL | 0.0909 | 0.20 | 0.9264 | 0.46 | Yes |
| Risk BTC | 0.0942 | 0.20 | 0.9595 | 0.10 | Yes |
| Risk ETH | 0.1164 | 0.10 | 0.8839 | 0.00 | No |
| Risk ETH | 0.1731 | 0.00 | 0.8497 | 0.00 | No |
| Performance BTC | 0.1329 | 0.03 | 0.8738 | 0.00 | No |
| Performance TH | 0.1609 | 0.00 | 0.8992 | 0.00 | No |
| Performance SOL | 0.1643 | 0.00 | 0.8759 | 0.00 | No |

Source: SPSS 29, processed by the author

Because the assumption of normality is not met for the risk and performance variables, only the *return* variable will be tested with follow-up tests. Meanwhile, the risk and performance variables will be continued with the non-parametric method of the Kruskal-Wallis test as described in the research methodology.

***Results of ANOVA One-Way Analysis***

After conducting a normality assumption test that shows that the return data meets the normal distribution requirements, a One-Way ANOVA analysis was conducted to test for significant differences in returns between the three crypto assets. Table 4 presents the results of the ANOVA analysis with a significance level of 0.05.

**Tabel 4. One-way ANOVA (Return) Analysis**

| One-way ANOVA | Sum of Squares | Degrees of Freedom | Mean Square | F-Value | Sig. P-Value |
|---|---|---|---|---|---|
| Between Groups | 0.00017 | 2 | 0.00008 | 0.88394 | 0.41543 |
| Within Groups | 0.01348 | 141 | 0.00010 | | |
| Total | 0.01365 | 143 | | | |

Source: SPSS 29, processed by the author

The results of ANOVA's analysis showed that the f-value was 0.88394 and the p-value was 0.41543 with a significance value ($p > 0.05$), which means that the null hypothesis ($H_0$) is accepted. This indicates that there is no significant difference in the average *daily returns* between Bitcoin, Ethereum, and Solana over the 2021-2024 period. The findings found that there was no significant *difference in return* between Bitcoin, Ethereum, and Solana.

***Post-hoc test***

Although ANOVA did not show significant differences, post-hoc tests were still conducted to gain a better understanding of the crypto asset pair. To identify which asset pairs, have significant differences, a Post-Hoc test is carried out using the Tukey HSD (Honestly Significant Difference) test. Table 5 presents the results of the Post-Hoc analysis showing the comparison of *mean differences* between asset pairs.

**Table 5. Post-hoc test ANOVA (*Return*) Analysis**

| Analysis | | Asset | Mean | Std. Error | Sig. P-Value | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound |
| Turkey HSD | 1 | ETH | -0.00024 | 0.00200 | 0.992 | -0.0050 | 0.0045 |
| | | SOL | -0.00241 | 0.00200 | 0.452 | -0.0071 | 0.0023 |
| | 2 | BTC | 0.00024 | 0.00200 | 0.992 | -0.0045 | 0.0050 |
| | | SOL | -0.00217 | 0.00200 | 0.523 | -0.0069 | 0.0026 |
| | 3 | BTC | 0.00241 | 0.00200 | 0.452 | -0.0023 | 0.0071 |
| | | ETH | 0.00217 | 0.00200 | 0.523 | -0.0026 | 0.0069 |
| Bonferroni | 1 | ETH | -0.00024 | 0.00200 | 1.000 | -0.0051 | 0.0046 |
| | | SOL | -0.00241 | 0.00200 | 0.689 | -0.0072 | 0.0024 |
| | 2 | BTC | 0.00024 | 0.00200 | 1.000 | -0.0046 | 0.0051 |
| | | SOL | -0.00217 | 0.00200 | 0.836 | -0.0070 | 0.0027 |
| | 3 | BTC | 0.00241 | 0.00200 | 0.689 | -0.0024 | 0.0072 |
| | | ETH | 0.00217 | 0.00200 | 0.836 | -0.0027 | 0.0070 |

Source: SPSS 29, processed by the author

The results of the Post-Hoc test showed that all asset pairs did not have a significant difference in return (p>value 0.05), the difference between Bitcoin and Ethereum was only 0.024% (p≈1.0 after Bonferroni), and the difference between Ethereum and Solana was 0.241% (p≈0.689). Thus, no crypto asset pair has a significant *difference in return*. So that the *return* of the three assets is considered similar.

***Results of the Kruskal-Wallis Analysis***

Because the risk and performance variables did not meet the assumption of normality, a nonparametric analysis was performed using the Kruskal-Wallis test. Table 6 presents the test results for the risk and performance variables.
Kruskal-Wallis Test Results

**Table 6. Kruskal-Wallis Test (Risk and Performance)**

| Variable | Kruskal-Wallis | df | P-value |
|---|---|---|---|
| Risk | 43.175 | 2 | 0.00000000042129 |
| Performance | 0.279 | 2 | 0.86962682863573 |

Source: SPSS 29, processed by the author

The results of the Kruskal-Wallis test for the risk variables show the test results for each variable. For risk, the *Kruskal–Wallis value* = 43.175 with p ≈4.2e-10 (p < 0.05), so that the hypothesis ($H_0$) is rejected and there is a significant difference in the level of risk between assets. On the other hand, for performance (Sharpe Ratio) a value of p ≈0.869 (p > 0.05), so the hypothesis of zero ($H_0$) is accepted because there is no significant difference in the Sharpe Ratio between assets.

***Pos-hoc test Mann-Whitney U***

To identify which asset pairs, have significant differences in risk, a Post-Hoc test is performed using the Mann-Whitney U test. Although the results of the performance variables in the Kruskal-Wallis test did not show significant differences, the Mann–Whitney U test was still conducted to explore the possibility of hidden differences between asset pairs. These results are important to confirm the validity of the null (*$H_0$) hypothesis* that there is no difference in performance distribution between groups. Table 7 presents the results of the Post-Hoc analysis for risk and performance variables.

**Table 7. Post-hoc test Mann-Whitney U (Risk and Performance)**

| | | Risk | | | |
|---|---|---|---|---|---|
| **Group** | **Asset** | **Mann-Whitney U** | **Rank Sum Test** | **Z-value** | **Asymptotic Significance** |
| 1 | ETH / SOL | 549 | 1725 | -4.419 | 0.00000993604 |
| 2 | BTC / SOL | 295 | 1471 | -6.280 | 0.00000000034 |
| 3 | BTC / ETH | 827 | 2003 | -2.381 | 0.01724324225 |

| Performance | | | | | |
|---|---|---|---|---|---|
| **Group** | **Asset** | **Mann-Whitney U** | **Rank Sum Test** | **Z-value** | **Asymptotic Significance** |
| 1 | ETH / SOL | 1088 | 2264 | -0.469 | 0.63909229104 |
| 2 | BTC / SOL | 1107 | 2283 | -0.330 | 0.74159390317 |
| 3 | BTC / ETH | 1109 | 2285 | -0.315 | 0.75269477854 |

Source: SPSS 29, processed by the author

The results of the Mann–Whitney U test show a significant difference in risk across all crypto asset pairs. The Bitcoin vs Ethereum comparison, Bitcoin vs Solana, and Ethereum vs Solana all show a p<value of 0.05, so the zero ($H_0$) hypothesis is rejected. This confirms that there is a significant difference in the distribution of risk between the three assets, with a consistent risk hierarchy: Solana has the highest risk, followed by Ethereum, and Bitcoin as the lowest. For performance, no significant differences were found in all asset pairs ($p > 0.05$), so the zero ($H_0$) hypothesis was accepted. These results confirm the findings of the Kruskal-Wallis test that although there is an absolute difference in the Sharpe Ratio value, the difference is not statistically significant. Thus, all three crypto assets have relatively equivalent risk-adjusted return efficiency over the study period.

***Interpretation of Differences in Return, Risk and Performance***

Based on the results of the analysis that has been carried out, it is found that the characteristics of the three crypto assets show patterns that are consistent with the unique dynamics of the digital asset market during the 2021–2024 period. The crypto market is known for its high volatility and rapid price movements, which creates significant profit opportunities, but also substantial risk of losses based on research Liu & Tsyvinski (2021).

In terms of return, there is no significant difference in average daily returns between Bitcoin, Ethereum, and Solana ($F = 0.88394$, $p = 0.41543$). From the risk side, it shows a very significant difference ($p < 0.05$) in the volatility level of the three assets. The consistent risk hierarchy of Solana (6.26%) > Ethereum (4.18%) > Bitcoin (3.24%) reflects the fundamental characteristics of each asset. Bitcoin, as "digital gold," shows the lowest volatility consistent with its role as a store of value in the crypto ecosystem according to Nakamoto (2019).

Meanwhile, in terms of performance, the analysis results show that there is no significant difference in the Sharpe Ratio between the three assets. Although Solana has the highest absolute returns, high volatility offsets that advantage, so the risk-adjusted returns of all three assets are equal. These results are consistent with research by Cheah & Fry (2015) which found that cryptocurrencies with high volatility do not necessarily provide superior risk-adjusted returns.

The findings of the statistical test have strategic implications for investors in compiling portfolios in the crypto market. All three assets exhibit different risk-return characteristics, but risk-adjusted returns do not show significant advantages. Therefore, diversification becomes a relevant strategy for optimizing crypto portfolios, in line with Modern Investment Theory developed by Markowitz (1952).

Investors with a conservative risk profile can choose Bitcoin which has lower volatility and a smaller maximum drawdown. These characteristics make Bitcoin suitable as a core holding in crypto portfolios, providing exposure to the digital asset market with relatively manageable risks based on research by Trautman & Dorman (2018).

Investors with a moderate risk profile can consider a balanced allocation between Bitcoin and Ethereum. Ethereum offers a return on blockchain technology innovation that is rapidly evolving, but with volatility that is still tolerable. Ethereum's position as a crypto asset provides strong fundamentals for long-term growth as described by Conlon et al. (2020).

Investors with an aggressive profile can consider Solana as an investment option to earn higher potential returns. However, it's important to realize that Solana also has a greater level of volatility and risk of loss than other crypto assets. Therefore, Solana is more suitable as an actively managed investment asset or satellite-investment in a crypto portfolio.

## Conclusion

The study found no significant difference in daily returns among Bitcoin, Ethereum, and Solana during 2021–2024, despite Solana recording the highest annual and cumulative returns. However, there was a significant difference in risk levels, with Solana exhibiting the highest volatility, followed by Ethereum, and Bitcoin as the most stable asset. After adjusting for risk, the performance of the three cryptocurrencies showed no significant differences, indicating relatively balanced risk-adjusted returns throughout the period. For future research, it is recommended to explore the impact of macroeconomic factors and regulatory changes on the comparative performance of these cryptocurrencies, as well as to analyze portfolio optimization including a broader range of digital assets to enhance diversification strategies.

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