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Risk-Adjusted Performance And Volatility Analysis Of Cryptocurrencies: A Multi-Metric Approach"

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Abstract:

This study aims to evaluate the performance and risk characteristics of selected assets, including cryptocurrencies (BTC, BNB, ETH, and USDT), using various financial metrics such as Sharpe Ratio, Sortino Ratio, Treynor Ratio, Maximum Drawdown, VaR, Expected Shortfall, and Calmar Ratio. The objective is to rank the assets based on risk-adjusted returns, volatility, and downside risk to provide a comprehensive analysis for different investor profiles. The findings suggest that BNB offers the best risk-return balance, while USDT provides the least volatility but minimal growth potential. BTC and ETH show moderate to high risk, making them suitable for risk-tolerant investors. These results provide valuable insights for portfolio allocation and risk management strategies.

Introduction:

Cryptocurrencies or crypto is an alternative asset class present challenges to traditional theories while offering new opportunities to test theories of investor behavior. Valuing crypto assets can be difficult due to their unique characteristics. Distinct fiat currencies, they lack economic fundamentals, and unlike traditional financial assets, they do not generate cash flows. Additionally, unlike precious metals, crypto assets do not have a long history of trust or cultural acceptance as a store of value. Cryptocurrencies have gained significant attention since the inception of Bitcoin in 2009. As decentralized digital assets, cryptocurrencies challenge traditional banking systems by offering an alternative means of transaction and value storage. This literature review explores the impact of crypto currency adoption on traditional banking systems, focusing on the potential disruption, regulatory responses, and integration strategies. The increasing number of cryptocurrencies in the market raises an important question: How do investors decide which crypto to invest in, or whether to invest at all? Historically, public perceptions of crypto currency were influenced by a series of scandals that likely contributed to negative moral evaluations of the technology and its users. For example, the first well-known platform on which Bitcoin was used as a form of payment was an online marketplace named “Silk Road” where people bought and sold illicit items such as narcotics and forged passports. Other early platforms adopting Bitcoin payments, such as SatoshiDice, were also used for unregulated gambling (Popper, 2015). In addition, a number of crypto services and projects have been revealed to be fraudulent attempts to scam users out of their financial investments. As a consequence, many public figures hailed cryptocurrencies as morally-dubious projects, such as Janet Yellen, the U.S. Secretary of the Treasury, expressing her view in January 2021 that cryptocurrencies are used “mainly for illicit financing” (De, 2021). Lay perceptions of the crypto currency community that were formed based on these historical events may generally associate it with negative moral values.

Headlines have significantly influenced the crypto asset class, sparking investor fear of missing out on the “crypto-rush.” This phenomenon has led studies (Sockin and Xiong, 2023; Cong et al., 2021) to suggest that the "network effect" - the increasing appeal of a platform as its user base grows - is a key driver in the evolution of the crypto market. However, how investors process attention-grabbing fluctuations in the crypto market and the potential consequences for future crypto returns have received less attention. Investors with a salience bias disproportionately prefer investments with prominent upward returns and avoid those with noticeable downward returns. According to the salience-based asset theory proposed by Bordalo et al. (2013a), investments with conspicuous upside potential (downside risk) are predicted to generate lower (higher) returns in equilibrium.

Cosemans and Frehen (2021) and Cakici and Zaremba (2022) provide evidence supporting the impact of theory on cross-sectional pricing in both the United States and international equity markets. Notably, the effect was more pronounced for stocks with higher limits to arbitrage and during periods of elevated investor sentiment, reinforcing the mispricing explanation (Cosemans and Frehen, 2021). Consistent with these findings, Cakici and Zaremba (2022) demonstrate the effect is evident when arbitrage opportunities are limited, such as in micro-cap firms, high idiosyncratic risk countries, and during extreme market conditions characterized by significant economic uncertainty and volatility. The crypto market, being

an emerging asset class, is marked by high uncertainty and limited fundamental information available to investors. Hirshleifer (2001) argues that such uncertainty allows investors to rely on their subjective estimations and disregard objective valuations.

Review of Literature:

García-Corral et al. (2022), observed the rapid growth in the number of publications on cryptocurrencies over the past three years, reflecting the increasing interest and the evolution of blockchain technology within this domain.

Corbet et al. (2018), examined cryptocurrencies as financial assets, discussing issues such as pricing bubbles, regulatory challenges, potential illicit use, and infrastructural breaches.

Makarov and Schoar (2023), discussed the benefits of DeFi in reducing transaction costs and the challenges related to regulatory compliance, tax enforcement, and anti-money laundering laws.

Trozze et al. (2022), identified various types of crypto currency fraud, highlighting 47 unique types in both academic and grey literature.

Sebastião and Godinho (2021), explored the use of machine learning techniques for predicting crypto currency trends and creating profitable trading strategies under varying market conditions.

Corbet et al. (2017), highlighted the potential diversification benefits of cryptocurrencies for investors with short investment horizons due to their relative isolation from other financial assets.

Rahardja (2023), explored the impact of cryptocurrencies on the Indonesian economy and discusses the government's stance on the technology, suggesting the potential for digital money to replace traditional currency in the future.

Suslenko et al. (2022), found that Bitcoin and Ethereum can reduce transaction costs for e-commerce businesses compared to traditional payment systems like LiqPay.

Auer et al. (2023), discussed the modest institutional adoption of cryptocurrencies among major banks, with a higher likelihood of adoption in regions with greater innovation capacity and advanced economic development.

Corbet et al. (2020), explored the impact of the COVID-19 pandemic on the volatility relationship between Chinese stock markets and Bitcoin, suggesting potential diversification benefits for mainstream portfolios.

Kohli et al. (2022), analyzed the significant energy consumption and carbon footprint of cryptocurrencies like Bitcoin, equivalent to the levels of countries like Sweden and Greece.

Mensi et al. (2023), used cross-quantilogram and quantile connectedness approaches to show the leadership influence of cryptocurrencies over volatility indices, providing diversification benefits for investors.

Foley et al. (2018), estimated that approximately one-quarter of bitcoin users are involved in illegal activity, with an annual illegal activity volume close to the scale of the U.S. and European illegal drug markets.

Haykir and Yagli (2022), identified speculative bubbles in various cryptocurrencies during the COVID-19 pandemic and highlighted the interconnected speculative behavior among different cryptocurrencies.

Agyei et al. (2022), investigated the high interdependencies between cryptocurrencies and the crypto currency-implied volatility index (VCRIX), influenced by idiosyncratic shocks rather than VCRIX.

Gilad et al. (2017), ensured users never have divergent views of confirmed transactions, even if some users are malicious and the network is temporarily partitioned.

Dowling (2021), indicated that crypto currency pricing behaviors might offer insights into understanding NFT pricing patterns, as shown by a wavelet coherence analysis demonstrating co-movement between the two markets.

The body of literature on financial performance metrics and risk management provides a strong foundation for analyzing both traditional assets and cryptocurrencies. Metrics like the Sharpe Ratio, Sortino Ratio, VaR, Expected Shortfall, and Tracking Error remain essential for evaluating risk-adjusted returns, volatility, and downside risk. As cryptocurrencies continue to gain traction, these metrics—along with modified and downside risk-focused measures—offer critical insights into the performance and risk profiles of these digital assets.

Research Methodology:

The research methodology for analyzing and ranking the investment performance of the assets—BTC, BNB, ETH, and USDT—focused on the application of well-established financial metrics to assess risk and return profiles. This approach involved the use of quantitative data analysis techniques, leveraging key performance metrics to evaluate the risk-adjusted returns, downside risk, volatility, and market performance of these assets over a specific period. The following steps detail the methodology:

The data used for this research comprises the historical returns of the four assets: BTC (Bitcoin), BNB (Binance Coin), ETH (Ethereum), and USDT (Tether). The data covers a period of six financial years from April 2019 to April 2024, sourced from financial market databases.

The risk-free rate used in this study was set at 6.71%, representing 365 days Treasury bill rate. Additionally, the return vector of the benchmark asset (Rb) was selected as 0.1753, representing average annual returns of BSE Sensex Index as the market return used for comparison purposes, particularly in calculations involving metrics like Beta, Treynor Ratio, and Information Ratio.

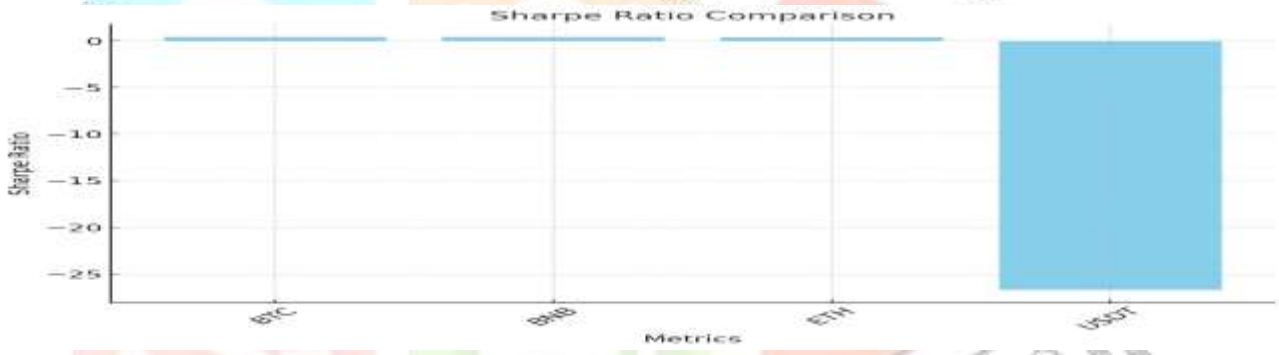
The key metrics chosen for evaluating the assets were selected based on their ability to measure both risk and return. These metrics Sharpe Ratio Sortino Ratio Max Drawdown Value at Risk (VaR) Expected Shortfall Tracking Error (TE), Calmar Ratio, Downside Deviation Ulcer Index, are widely accepted in financial performance analysis and portfolio management. The analysis was conducted using R, a statistical programming language. Additional tools, such as Microsoft Excel, were used for data visualization, comparison tables, and result presentations. Hence, the study aims

Objective of the Study:

1. To analyze the risk-adjusted performance, downside risk and loss potential, volatility and tracking error of selected assets using multiple metrics.

Table No. 1 : Sharpe Ratio of selected Crypto Currencies		
Metrics	**Sharpe Ratio**	**Rank**
BTC	0.441963	1
BNB	0.4246825	2
ETH	0.4127189	3
USDT	-26.72701	4

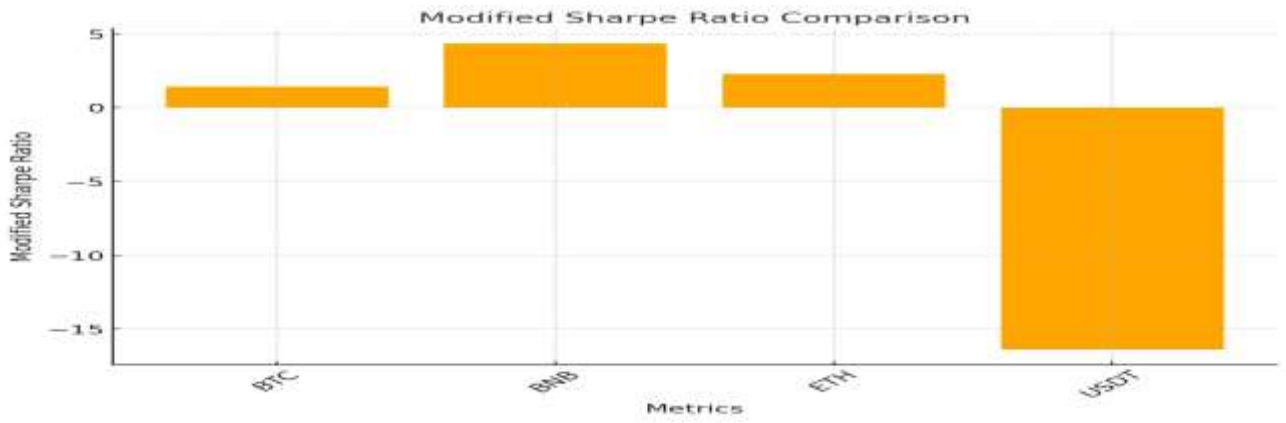
BTC offers the best balance of return versus risk, making it potentially the most attractive asset in terms of risk-adjusted performance. **USDT**'s negative Sharpe Ratio is a strong red flag, suggesting it is not performing well relative to the risk it carries, likely making it a poor investment choice based on this metric alone.



Here is the bar plot for the **Sharpe Ratio Comparison** across the four assets (BTC, BNB, ETH, USDT). The extremely low Sharpe Ratio for USDT is clearly visible, while the other assets are relatively close in comparison.

Table No. 2 : Modified Sharpe Ratio of selected Crypto Currencies		
Metrics	**Modified Sharpe Ratio**	**Rank**
BTC	1.431486	3
BNB	4.3507555	1
ETH	2.2846808	2
USDT	-16.37685	4

BNB has the highest Modified Sharpe Ratio, indicating the best risk-adjusted performance.**ETH** and **BTC** follow with moderate performance. **USDT** has a significantly negative Modified Sharpe Ratio, indicating very poor risk-adjusted performance.**BNB** is ideal for risk-adjusted returns. **USDT** should be avoided due to its poor performance.

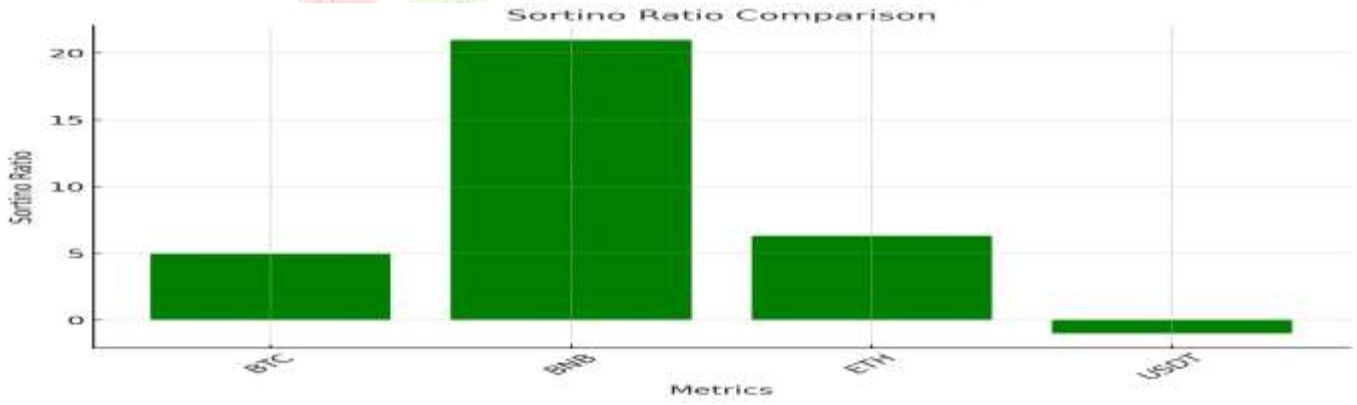


Here is the bar plot for the **Modified Sharpe Ratio Comparison** across the four assets (BTC, BNB, ETH, USDT). It illustrates the performance difference, with **BNB** showing the highest modified Sharpe Ratio and **USDT** displaying a significantly negative ratio.

Table No. 3 : Sortino Ratio of selected Crypto Currencies

Metrics	Sortino Ratio	Rank
BTC	4.9726284	3
BNB	20.9738837	1
ETH	6.3116437	2
USDT	-0.9994172	4

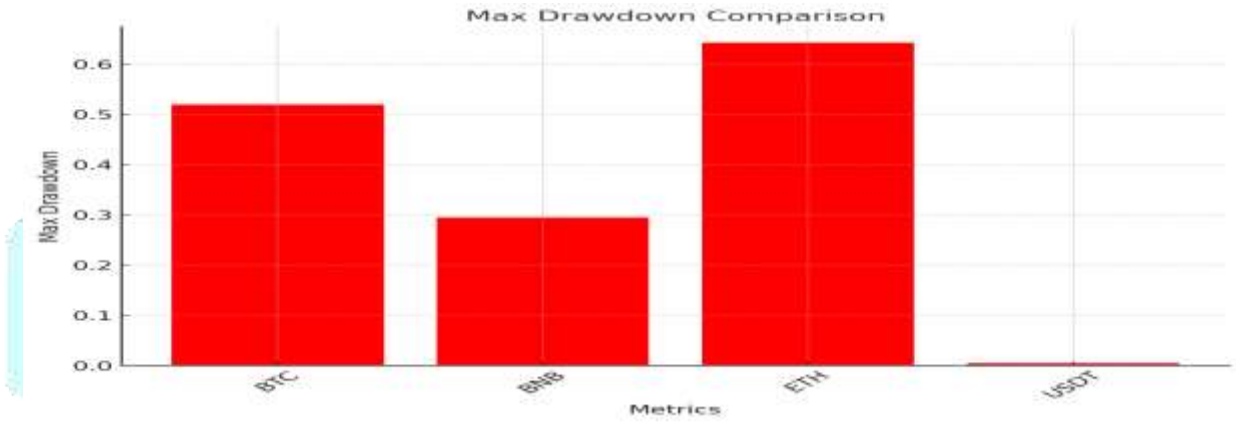
BNB has the highest Sortino Ratio, indicating the best risk-adjusted performance based on downside risk. **ETH** and **BTC** follow with moderate performance. **USDT** has a negative Sortino Ratio, indicating poor risk-adjusted returns relative to downside risk.**BNB** is highly favourable for minimizing downside risk while maximizing returns. **USDT** is the least favourable option due to its negative Sortino Ratio.



Here is the bar plot for the **Sortino Ratio Comparison** across the four assets (BTC, BNB, ETH, USDT). The performance difference is clearly visible, with **BNB** showing the highest Sortino Ratio, indicating a better risk-adjusted return in terms of downside risk.

Table No. 4 : Max Drawdown of selected Crypto Currencies		
Metrics	**Max Drawdown**	**Rank**
BTC	0.519241571	3
BNB	0.29419	2
ETH	0.642701216	4
USDT	0.004424299	1

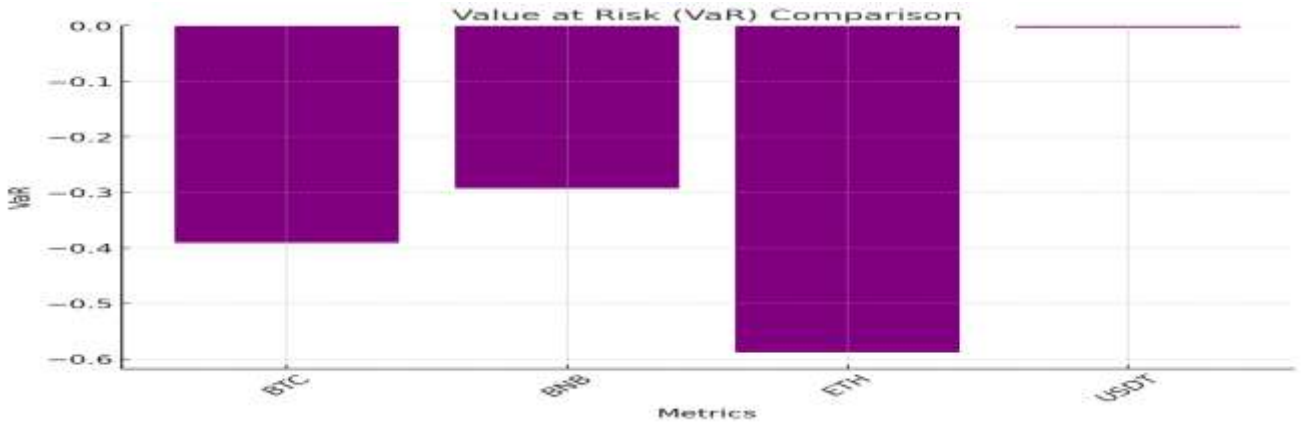
USDT is the safest in terms of limiting potential losses, making it ideal for conservative investors.**BNB** offers a balanced approach between risk and return.**BTC** and **ETH** are riskier with higher drawdowns, suitable for risk-tolerant investors aiming for higher returns.



USDT has the lowest drawdown, indicating the least risk, while **ETH** exhibits the highest drawdown, reflecting more volatility.

Table No. 5 : VaR of selected Crypto Currencies		
Metrics	**VaR**	**Rank**
BTC	-0.39087	3
BNB	-0.29319	2
ETH	-0.58833	4
USDT	-0.00322	1

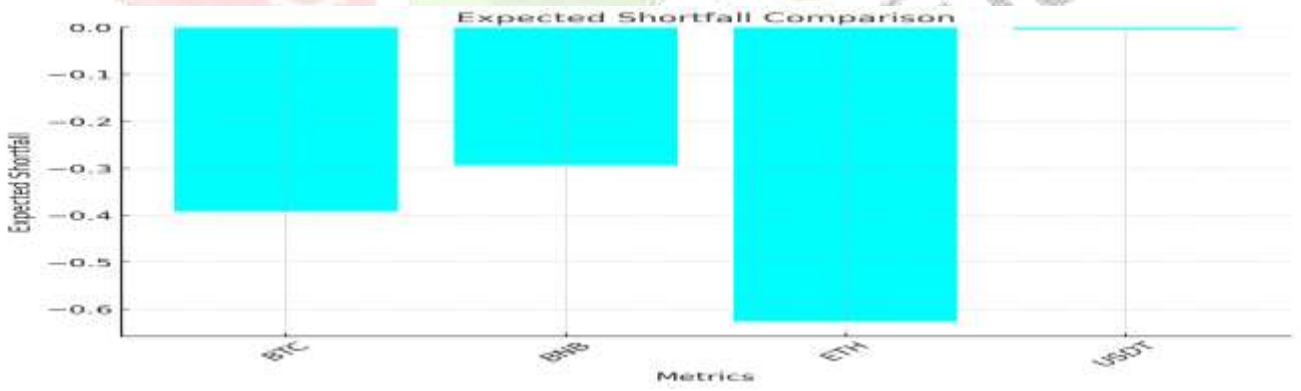
USDT is the safest in terms of value at risk, making it suitable for conservative investors.**ETH** carries the highest potential risk, suitable for risk-tolerant investors seeking higher returns.



USDT has the lowest risk, while **ETH** has the highest VaR, indicating greater potential loss in extreme adverse conditions.

Table No. 6: Expected Shortfall of selected Crypto Currencies		
Metrics	**Expected Shortfall**	**Rank**
BTC	-0.39245	3
BNB	-0.29419	2
ETH	-0.62638	4
USDT	-0.004262	1

USDT is highly suitable for conservative investors aiming to minimize loss in volatile markets.**BNB** and **BTC** are moderate-risk options.**ETH** is a high-risk asset in extreme market conditions, suitable for investors willing to bear larger losses.



USDT has the lowest expected shortfall, indicating it has the least potential loss during extreme negative market events, while **ETH** shows the highest expected shortfall.

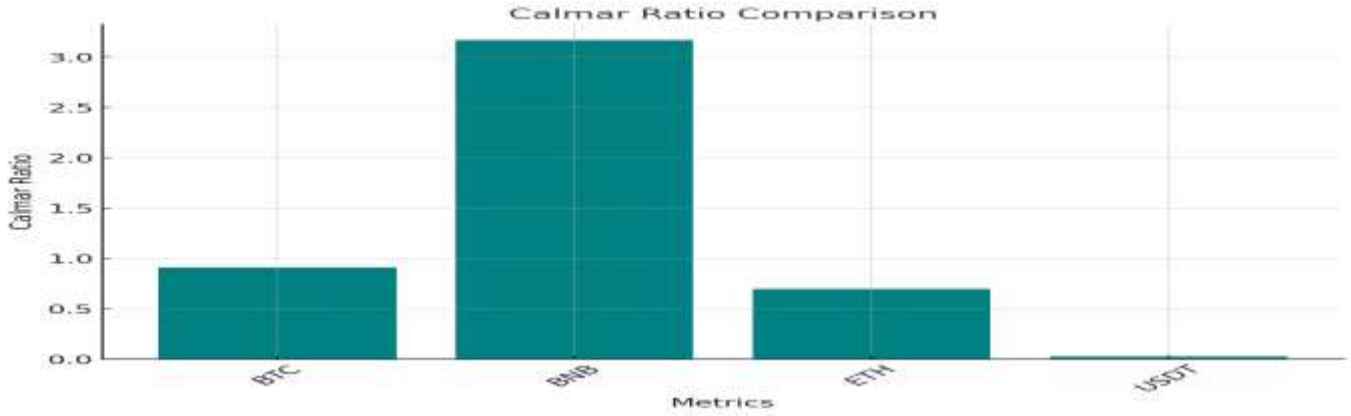
Table No. 7: Tracking Error of selected Crypto Currencies		
Metrics	**Tracking Error**	**Rank**
BTC	3.377855	2
BNB	11.226618	4
ETH	5.92987	3
USDT	0.377755	1

USDT is ideal for investors seeking stability with minimal deviation from the benchmark.**BNB** is riskier in terms of deviation from the benchmark, suitable for investors seeking more active management.

USDT has the lowest tracking error, indicating the smallest deviation from the benchmark, while **BNB** has the highest, reflecting greater variation.

Table No. 8: Calmar Ratio of selected Crypto Currencies		
Metrics	**Calmar Ratio**	**Rank**
BTC	0.9095341	2
BNB	3.1697368	1
ETH	0.6976956	3
USDT	0.0226882	4

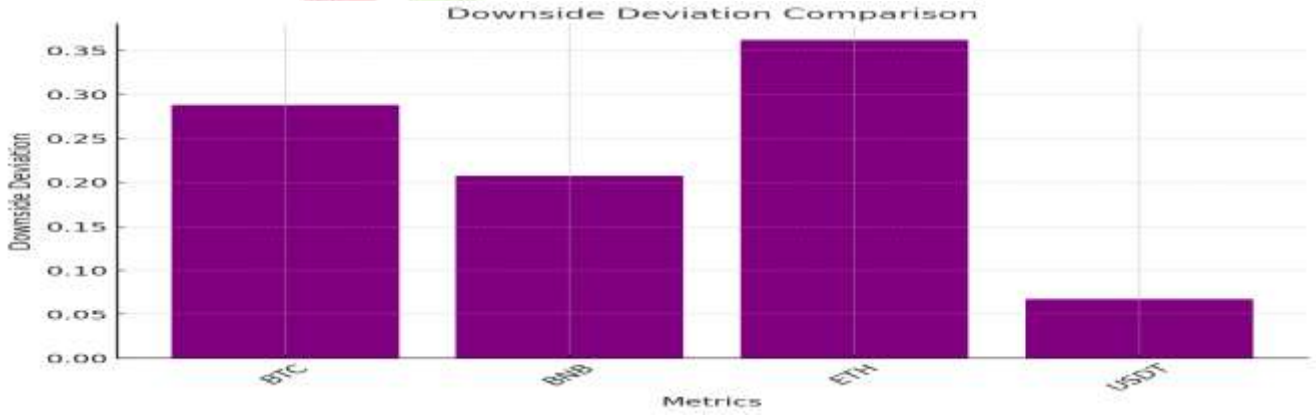
BNB is ideal for investors seeking the best return for the risk of drawdown.**USDT** offers limited return potential compared to the risk of drawdown, making it less favorable.



BNB has the highest Calmar Ratio, indicating it has the best risk-adjusted returns relative to maximum drawdown, while **USDT** has the lowest ratio.

Table No. 9: Downside Deviation of selected Crypto Currencies		
Metrics	**Downside Deviation**	**Rank**
BTC	0.28787311	2
BNB	0.20743681	3
ETH	0.36197874	4
USDT	0.06703607	1

USDT is the most stable investment option among the listed assets, suitable for risk-averse investors.ETH, with its higher downside deviation, may be more suitable for risk-tolerant investors looking for potentially higher returns but at greater risk.

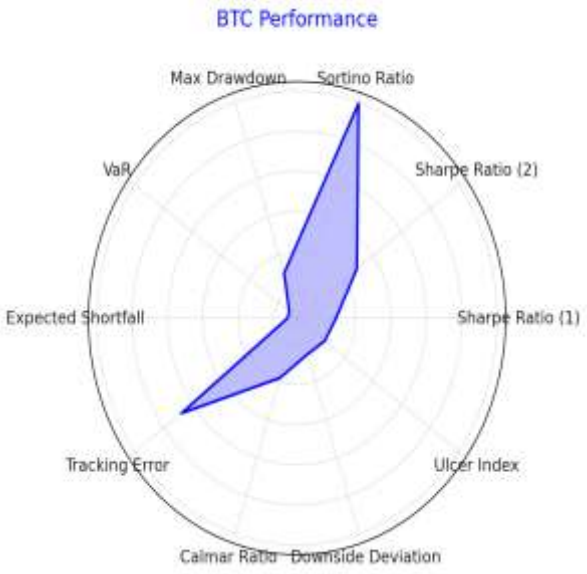


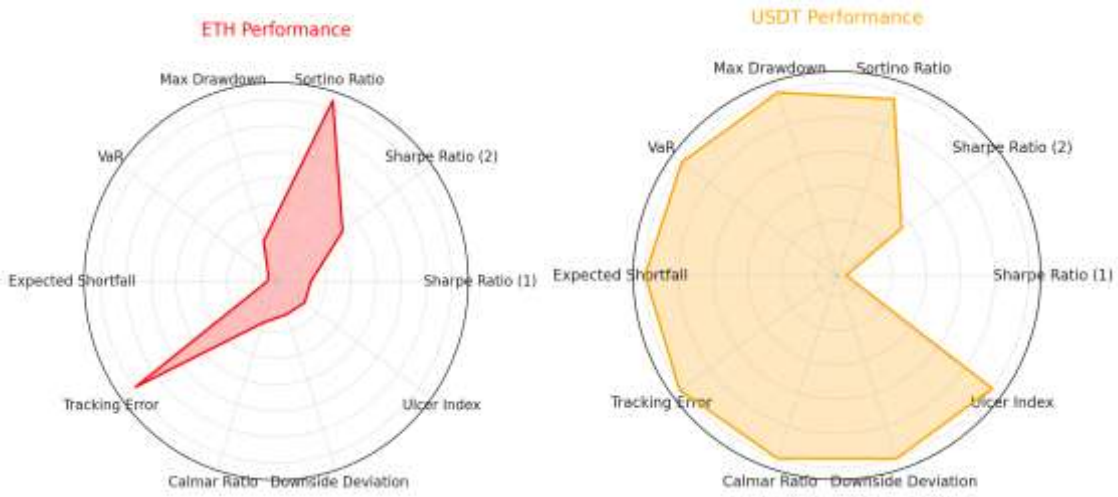
USDT has the lowest downside deviation, indicating it has the least downside risk, while **ETH** exhibits the highest.

Table No. 10: Ulcer Index of selected Crypto Currencies		
Metrics	**Ulcer Index**	**Rank**
BTC	0.306485561	2
BNB	0.168697347	3
ETH	0.4214692	4
USDT	0.003545776	1

USDT has the lowest Ulcer Index, indicating the least volatility and drawdown risk.**BNB** has a relatively lower Ulcer Index compared to **BTC** and **ETH**, which show higher volatility.**ETH** has the highest Ulcer Index, reflecting greater drawdown risk and price volatility.

Table No. 11: Overall analysis of selected Metrics				
Metrics	BTC	BNB	ETH	USDT
Sharpe Ratio (1)	0.441963	0.4246825	0.4127189	-26.72701
Sharpe Ratio (2)	1.431486	4.3507555	2.2846808	-16.37685
Sortino Ratio	4.9726284	20.9738837	6.3116437	-0.9994172
Max Drawdown	0.519241571	0.29419	0.642701216	0.004424299
VaR	-0.39087	-0.2931878	-0.58833	-0.003223
Expected Shortfall	-0.39245	-0.29419	-0.62638	-0.004262
Tracking Error	3.377855	11.226618	5.92987	0.377755
Calmar Ratio	0.9095341	3.1697368	0.6976956	0.0226882
Downside Deviation	0.28787311	0.20743681	0.36197874	0.06703607
Ulcer Index	0.306485561	0.168697347	0.4214692	0.003545776



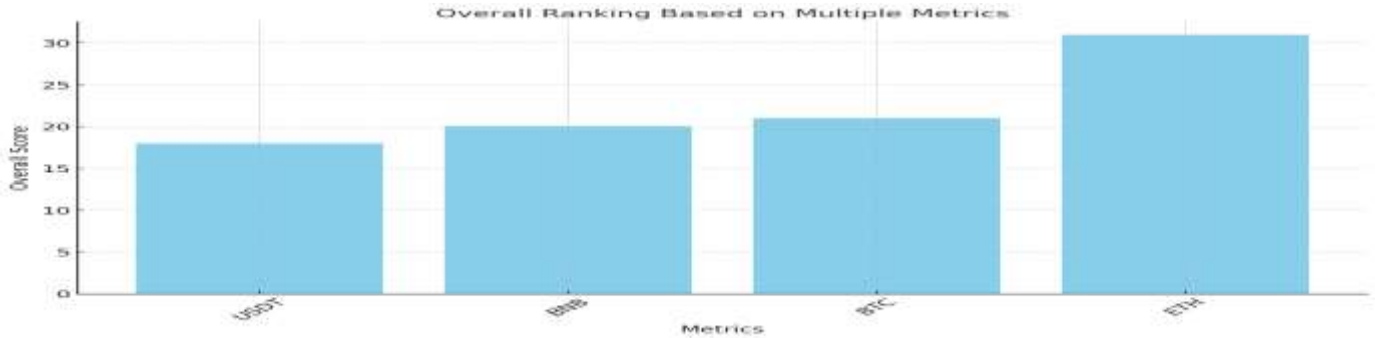


BNB is the best option for investors seeking high returns with moderate risk.BTC and ETH offer reasonable returns but come with higher volatility and greater risk.USDT is the safest but delivers poor returns, making it suitable only for the most risk-averse investors.

Table No. 12: Overall Ranking of selected Metrics

Metrics	S R	Sor.R	M D	VaR	ES	TE	Cal. R	DD	Ulc. I	Overall Score	Overall Rank
BTC	1	3	3	3	3	2	2	2	2	21	3
BNB	2	1	2	2	2	4	1	3	3	20	2
ETH	3	2	4	4	4	3	3	4	4	31	4
USDT	4	4	1	1	1	1	4	1	1	18	1

BNB offers the best balance between risk and return, making it an ideal option for investors seeking high risk-adjusted returns. BTC provides a moderate risk-return balance, suitable for investors seeking consistent returns with manageable risk. ETH has high volatility and risk, making it more suitable for risk-tolerant investors. USDT is the safest choice with the lowest risk, ideal for conservative investors looking to preserve capital but with minimal growth potential.



Conclusion:

BNB emerges as the best performing asset across multiple metrics, such as Modified Sharpe Ratio, Sortino Ratio, Calmar Ratio, VaR, and Expected Shortfall. It strikes the ideal balance between high returns and moderate risk. Investors' seeking high risk-adjusted returns with controlled volatility and drawdown would find BNB the most suitable asset. It's well-positioned for investors who aim for superior performance while managing downside risk effectively.

BTC ranks consistently in the middle for most metrics, offering moderate risk-adjusted returns. With lower volatility and drawdown compared to ETH, it's suitable for moderate-risk investors. BTC provides stable returns with manageable risk, making it attractive for those who seek steady growth without extreme fluctuations.

ETH, although offering decent returns, is characterized by higher risk in terms of VaR, Expected Shortfall, Max Drawdown, and Downside Deviation. It faces greater volatility and is more susceptible to significant losses in adverse market conditions. ETH is better suited to risk-tolerant investors who are prepared to handle larger fluctuations in search of potentially higher rewards.

USDT stands out as the safest asset in terms of minimal volatility and risk across metrics like Max Drawdown, VaR, Expected Shortfall, and Ulcer Index. However, it offers negative or minimal returns, making it unattractive for growth-oriented investors. USDT is ideal for conservative investors who prioritize capital preservation over returns, looking for stability rather than growth.

Limitations:

1. Limited Time Horizon: The study focuses on a specific period, which may not fully capture long-term performance trends or the impact of varying market conditions over extended periods.

2. Cryptocurrency Volatility: Cryptocurrencies like BTC, BNB, ETH, and USDT are highly volatile, and their performance can be influenced by factors such as regulatory changes and market speculation, making it difficult to generalize the findings to other asset classes.

3. Exclusion of Fundamental Factors: The analysis is based solely on quantitative metrics such as risk and return ratios. Fundamental factors like market sentiment, macroeconomic conditions, and geopolitical events are not considered, which may impact asset performance.

4.Focus on Specific Metrics: While a broad range of risk and return metrics are analyzed, other important factors like liquidity, transaction costs, and diversification effects are not considered in this study.

5. Lack of Granular Asset Classes: The analysis focuses on a limited set of assets, primarily cryptocurrencies, without including other traditional asset classes like equities, bonds, or commodities, which could provide a more comprehensive risk-return comparison.

Further Research:

1. Broader Asset Class Analysis: Future research could expand the scope to include traditional asset classes like equities, bonds, real estate, and commodities to provide a more diverse analysis and comparison across a wide range of investments.

2. Long-Term Performance Analysis: Extending the study to cover a longer time horizon could provide a more robust understanding of asset behavior through different economic cycles, including bull and bear markets.

3. Impact of External Factors: Future research could explore how macroeconomic variables, such as inflation rates, interest rates, and global events, impact the performance and risk of the analyzed assets.

4. Machine Learning and Predictive Models: Advanced predictive models, including machine learning and AI, could be employed to forecast future asset performance based on historical data and other influencing factors.

5. Incorporating Liquidity and Transaction Costs: Future studies could incorporate the effects of liquidity constraints, transaction costs, and slippage on performance metrics, which are critical, especially for cryptocurrencies.

6. Behavioral Finance Considerations: Future research could explore investor behavior in cryptocurrency markets, addressing issues such as market psychology, sentiment analysis, and behavioral biases that impact risk and return.

These steps can provide a more comprehensive understanding of asset performance and better equip investors with tools for effective portfolio management.

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