

PUBLISHER: https://journal.adlermanurungpress.com/
DOI: https://doi.org/10.63607/jcmb.v14i4

RETHINKING CRYPTOCURRENCY PERFORMANCE: EVIDENCE FROM SORTINO AND CALMAR RATIOS

Reksha Laksana[1], Erik Nugraha[2], Hadi Ahmad Sukardi[3], Agrie Wahyudi Kharisman[4]
[1234]Sangga Buana YPKP University
Email: reksha.laksana@usbypkp.ac.id[1], erik.nugraha@usbypkp.ac.id[2], hadi.ahmads@usbypkp.ac.id[3], agrie.wahyudi@usbypkp.ac.id[4]
Alamat: Jl. PH.H. Mustofa No.68, Cikutra, Kec. Cibeunying Kidul, Kota Bandung, Jawa Barat 40124
Koresprodensi Penulis: reksha.laksana@usbypkp.ac.id

Abstrak

Penelitian ini mengevaluasi kinerja investasi 20 mata uang kripto terbesar berdasarkan kapitalisasi pasar selama periode 2021–2025 dengan menggunakan metrik risiko penurunan (*downside risk*). Pendekatan deskriptif kuantitatif diterapkan terhadap 36.500 observasi return harian yang diperoleh dari 36.520 data harga penutupan harian yang bersumber dari CoinGecko. Kinerja investasi diukur menggunakan *Compound Annual Growth Rate* (CAGR), *annualized downside deviation*, *maximum drawdown*, *Sortino Ratio*, dan *Calmar Ratio*, dengan tingkat suku bunga bebas risiko ditetapkan sebesar nol.

Statistik deskriptif menunjukkan adanya *excess kurtosis* pada seluruh aset serta *positive skewness* pada 18 mata uang kripto, yang mendukung penggunaan metrik yang berorientasi pada risiko penurunan. Hanya enam aset yang mencapai *Sortino Ratio* di atas 1,0, dengan SHIB (10,0724), SOL (1,8578), dan BNB (1,7341) menempati nilai tertinggi. Sementara itu, hanya tiga aset yang memiliki *Calmar Ratio* di atas 1,0. Analisis kuadran mengidentifikasi tiga aset sebagai *Alpha Leaders*, tiga aset sebagai *High-Yield Fragility*, dan 14 aset sebagai *Value Destruction*.

SHIB menunjukkan paradoks spekulatif, yaitu kombinasi antara kinerja luar biasa yang telah disesuaikan dengan risiko dan *maximum drawdown* sebesar 91,98%, yang disebabkan oleh harga awalnya yang berada pada tingkat yang sangat rendah. Sementara itu, LTC merupakan satu-satunya aset yang memiliki CAGR negatif. Temuan penelitian ini menunjukkan bahwa metrik risiko penurunan dapat memberikan perspektif yang saling melengkapi dalam mengevaluasi kinerja mata uang kripto dengan menekankan *downside deviation* dan *drawdown*, sehingga dapat mendukung pengambilan keputusan investasi yang lebih terinformasi.

Kata kunci: *Calmar Ratio*, Mata Uang Kripto, Risiko Penurunan (*Downside Risk*), Kinerja Investasi, *Sortino Ratio*.

Abstract

This study evaluates the investment performance of the 20 largest cryptocurrencies by market capitalization during 2021–2025 using downside risk metrics. A quantitative descriptive approach was applied to 36,500 daily return observations derived from 36,520 daily closing prices obtained from CoinGecko. Performance was assessed using the Compound Annual Growth Rate (CAGR), annualized downside deviation, maximum drawdown, the Sortino Ratio, and the Calmar Ratio, with the risk-free rate set to zero. Descriptive statistics indicate excess kurtosis across all assets and positive skewness in 18 cryptocurrencies, supporting the use of downside-oriented metrics. Only six assets achieved a Sortino Ratio above 1.0, led by SHIB (10.0724), SOL (1.8578), and BNB (1.7341), while only three exceeded a Calmar Ratio of 1.0. Quadrant analysis identified three Alpha Leaders, three High-Yield Fragility assets, and 14 Value Destruction assets. SHIB exhibited a speculative paradox, combining exceptional risk-adjusted performance with a 91.98% maximum drawdown due to its near-zero initial price, whereas LTC was the only asset with negative CAGR. These findings demonstrate that downside risk metrics provide a complementary perspective on cryptocurrency performance by emphasizing downside deviation and drawdown, thereby supporting more informed investment decisions.

Keywords: Calmar Ratio, Cryptocurrency, Downside Risk, Investment Performance, Sortino Ratio

INTRODUCTION

The rapid advancement of digital technology has fundamentally transformed the global investment landscape. Traditional investment instruments such as stocks, bonds, and mutual funds

have been complemented by a new category of digital assets, most notably cryptocurrencies, which have gained significant traction among both institutional and retail investors worldwide. Cryptocurrency, originally conceived as a decentralized medium of exchange (Auer & Tercero-Lucas, 2022; Baur et al., 2018), has increasingly been adopted as an investment instrument, evolving from a niche technological curiosity into an integral component of modern portfolio strategies. This evolution was notably accelerated by the approval of Bitcoin exchange-traded products (ETPs) by the U.S. Securities and Exchange Commission on January 10, 2024 (SEC, 2024), which enabled investors to access Bitcoin exposure with the same ease as traditional equity investments. The subsequent institutional accumulation of Bitcoin from 2024 to mid-2025 reflects a significant paradigm shift, as instruments previously categorized as volatile and experimental have been formally integrated into long-term capital management and financial diversification strategies (Chiquitita, 2025).

This global trend is particularly pronounced in Indonesia, where the growth of cryptocurrency adoption has been remarkably rapid. Official data from the Financial Services Authority (OJK) shows a sharp upward trend in the number of cryptocurrency asset investors, from 13.3 million in February 2025 to 22.4 million in May 2026, representing an increase of approximately 68.4% over fifteen months (OJK, 2026a, 2026b). The OJK also reported that cryptocurrency asset transactions throughout 2025 reached 482.23 trillion rupiah, with an additional 122.02 trillion rupiah recorded in the first five months of 2026 alone. This explosive growth is mirrored in the traditional capital market, where the Indonesia Central Securities Depository (KSEI) recorded an increase in capital market investors from 7,489,337 in 2021 to 20,320,000 by the end of 2025, representing approximately 171% growth within four years (Heriyanto, 2025). These figures collectively demonstrate the escalating interest of Indonesian investors in both traditional and digital financial assets.

However, this rapid expansion of the investor base has not been without consequences. The surge in participation has triggered escalating speculative activity and significant market risk exposure. Studies and practical reports have documented substantial investor losses attributable to low analytical capability, susceptibility to social media hype, lack of risk management practices, and psychological biases (BBC, 2022; Engle et al., 2026; Hafishina et al., 2023). More critically, empirical evidence suggests that the majority of retail cryptocurrency investors ultimately incur financial losses (Auer et al., 2023). This situation raises significant concerns about consumer

protection and financial stability, highlighting the urgent need to improve financial literacy, particularly in understanding investment risks (Carbó-Valverde et al., 2025; Jones et al., 2024; Rahyuda & Candradewi, 2023). This urgency is further reinforced by POJK Number 27 of 2024, which mandates supervision, governance, risk management, and consumer protection in digital asset trading (POJK, 2024).

A fundamental consideration in investment decision-making is the assessment of potential returns and risks (Liu & Tsyvinski, 2021). Performance evaluation is therefore a critical step investors must undertake before making investment decisions, as stronger investment performance indicates a more effective investment. The Sharpe ratio, introduced by William F. Sharpe (1966), has been the most widely used metric in evaluating investment performance (Abdelmalek, 2024; Dombrowski et al., 2023; Laksana et al., 2026). However, this conventional metric possesses a fundamental limitation: it treats positive and negative deviations equally in risk calculations, thereby potentially obscuring the true downside risk profile faced by investors (Bacon, 2023; Sortino & Price, 1994). This limitation is particularly consequential in the cryptocurrency market, which is characterized by extreme volatility and asymmetric return distributions with positive skewness and excess kurtosis (Gupta & Chaudhary, 2022; Liu & Tsyvinski, 2021). The majority of existing Indonesian cryptocurrency research has relied on the Sharpe ratio for performance evaluation (Andaresta & Purwanto, 2023; Budiartomo & Setiyono, 2023; Laksana, 2024; Wiliyani & Purnamawati, 2023), leaving a significant gap in the application of downside-sensitive metrics.

The theory used in this research is Prospect Theory, first formulated by Kahneman and Tversky (1979). Prospect Theory explains that investors exhibit asymmetric sensitivity to gains and losses. This behavioral asymmetry provides a strong theoretical justification for employing downside-oriented performance metrics rather than symmetric measures such as the Sharpe ratio. Investors are demonstrably more sensitive to losses than to equivalent gains (Ruggeri et al., 2020; Yadav, 2024), making metrics that isolate and penalize downside risk more behaviorally congruent with actual investor preferences. Based on this theory, investors must consider the benefits and risk factors and investment performance rationally (Andaresta & Purwanto, 2023), and the selection of appropriate evaluation metrics is critical for producing assessments that align with how investors actually experience risk.

To address the limitations of the Sharpe ratio, this study employs two complementary downside risk metrics: the Sortino Ratio and the Calmar Ratio. The Sortino Ratio, developed by

Sortino and Van Der Meer (1991) and further refined by Sortino and Price (1994), assesses risk-adjusted returns by focusing exclusively on downside deviation, thereby isolating harmful volatility from desirable upside fluctuations. The Calmar Ratio, introduced by Young (1991), measures the efficiency of return generation relative to maximum drawdown, which represents the largest peak-to-trough decline during the observation period and is particularly relevant given the cryptocurrency market's susceptibility to sharp corrections (Dichtl et al., 2024; Dombrowski et al., 2023). By integrating these dual metrics, this research provides an evaluation framework that accounts for both downside volatility and extreme capital erosion, operationalizing the asymmetric loss-gain sensitivity that Prospect Theory predicts.

This study aims to evaluate the performance of 20 major cryptocurrencies by market capitalization using the Sortino Ratio and Calmar Ratio over the 2021 to 2025 period. This five-year observation window was deliberately selected to capture a complete market cycle encompassing the bull run of 2021, the crypto winter of 2022, the recovery phase of 2023 to 2024, and the correction period of 2025. The novelty of this research lies in three primary contributions: (1) the application of dual downside risk metrics (Sortino and Calmar Ratios) for cryptocurrency performance evaluation, which extends the predominantly Sharpe-based Indonesian literature; (2) a five-year observation period that encompasses the full spectrum of market conditions relevant to retail investor decision-making; and (3) a sample of 20 top-capitalization cryptocurrencies reflecting the current market landscape. The selection of assets based on the largest market capitalization was determined on the grounds that large-capitalization assets offer greater liquidity, more reliable and complete price histories, and collectively represent the majority of total cryptocurrency market value, making them the most relevant segment for retail investor decision-making. Although market capitalization is sometimes associated with greater market maturity, prior research indicates that its relationship with price stability is heterogeneous rather than universal (Pessa et al., 2023). This research is expected to provide important information for investors to support their investment decisions, directly supporting the consumer protection objectives established by POJK Number 27 of 2024.

RESEARCH METHOD

This study employs a quantitative descriptive approach, analyzing historical market data to evaluate and compare risk-adjusted performance across cryptocurrency assets. The population

consists of daily closing price data of cryptocurrency assets in USD for the period January 1, 2021 to December 31, 2025. The secondary data used in this study were obtained from CoinGecko, a widely recognized platform for transparent and reliable cryptocurrency market data. The data collected consists of numerical values, which can also be referred to as quantitative data. Descriptive analysis is the analytical technique used in this study. Downside deviation and the Compound Annual Growth Rate were annualized using a 365-day convention, and both the risk-free rate and the minimum acceptable return (MAR) were set to zero. To obtain the values of each variable, data processing was done using the Microsoft Excel program.

The sampling method used in this study employs a purposive sampling approach with specific inclusion criteria. The sample consists of the 20 largest cryptocurrencies based on market capitalization as of 11 July 2026, the date of data retrieval. This post-period snapshot was deliberately chosen to ensure that all sampled assets remained actively traded and had complete price histories throughout the 2021–2025 observation window, thereby avoiding the inclusion of assets that were subsequently delisted or discontinued. The inclusion criteria require that: (1) the asset has been actively traded since January 2021; (2) the asset has been consistently recorded throughout the observation period; and (3) the asset is listed on CoinGecko. The selection of data sources was based on CoinGecko's reputation as a transparent and reliable provider of cryptocurrency market data. Based on these criteria, 20 cryptocurrencies were selected, resulting in 1,825 daily observations per asset and a total of 36,500 observations. The selected cryptocurrency assets are presented in Table 1.

Table 1. List of Cryptocurrency Assets 2021–2025

No	Code	Name of Assets	Market Cap	No	Code	Name of Assets	Market Cap
1	BTC	Bitcoin	$1,279.41B	11	XMR	Monero	$6.06B
2	ETH	Ethereum	$215.80B	12	ADA	Cardano	$6.18B
3	BNB	BNB (Binance Coin)	$77.45B	13	LINK	Chainlink	$5.92B
4	XRP	XRP (Ripple)	$68.49B	14	BCH	Bitcoin Cash	$4.90B
5	SOL	Solana	$44.69B	15	DEXE	DeXe	$3.69B
6	TRX	TRON	$31.27B	16	LTC	Litecoin	$3.45B
7	DOGE	Dogecoin	$11.35B	17	HBAR	Hedera	$3.00B
8	ZEC	Zcash	$8.54B	18	AVAX	Avalanche	$2.83B
9	LEO	LEO Token	$8.80B	19	CRO	Cronos	$2.57B
10	XLM	Stellar	$6.37B	20	SHIB	Shiba Inu	$2.54B

Source: CoinGecko, data reprocessed

Asset performance data analysis is conducted by evaluating performance using the Sortino Ratio and Calmar Ratio. The performance evaluation follows a sequential seven-step process: (1) calculating daily asset returns; (2) computing the Compound Annual Growth Rate (CAGR) over the observation window; (3) computing descriptive statistics to validate distributional properties; (4) computing annualized downside deviation; (5) measuring Maximum Drawdown (MDD); (6) computing the Sortino Ratio; and (7) computing the Calmar Ratio. The formulas used to compute each research variable are presented in Table 2.

Table 2. Variable Measurement

Variable	Formula
Return	$R = \frac{P_t - P_{t-1}}{P_{t-1}}$
CAGR	$CAGR = \left(\frac{EV}{BV}\right)^{\frac{365}{T}} - 1$
Downside Deviation	$\sigma_d = \sqrt{\frac{\sum_{t=1}^{n} \min(R_t - MAR, 0)^2}{n}}$
Downside Deviation Annualized	$\sigma_{d,ann} = \sigma_d \times \sqrt{365}$
Maximum Drawdown	$MDD = \frac{Trough\ Value - Peak\ Value}{Peak\ Value}$
Sortino Ratio	$SR = \frac{CAGR - R_f}{\sigma_{d,ann}}$
Calmar Ratio	$CR = \frac{CAGR}{\lvert MDD \rvert}$

Source: (Sortino & Price, 1994; Sortino & Van Der Meer, 1991; Young, 1991)

In operationalizing these formulas, P_t and P_{t-1} denote the daily USD closing prices on trading days t and $t-1$, respectively. For the first observation date (January 1, 2021), the return is computed using the closing price of December 31, 2020 as the reference price P_{t-1}, thereby establishing a complete and uninterrupted return series of 1,825 daily observations. In the CAGR formula, EV represents the closing price on the last day of the observation period, BV represents the closing price on the first day of the observation period, and T equals the total number of calendar days between the first and last observation dates, normalized to a 365-day annual cycle. The risk-free rate (R_f) is set to zero, on the grounds that the cryptocurrency market operates globally on a 24/7 basis without a universally applicable domestic risk-free benchmark, and this approach avoids jurisdictional bias given that cryptocurrency investors originate from various countries with differing interest rate regimes. Consequently, the Minimum Acceptable Return

(MAR) used in the downside deviation calculations is also set to zero, consistent with the risk-free rate assumption. All return series and risk measures are computed using a 365-day annualization framework, consistent with the continuous trading nature of cryptocurrency markets.

The Sortino Ratio assesses risk-adjusted returns by focusing on downside deviation relative to the MAR, thereby excluding upside volatility and only calculating negative variations that are relevant to investors concerned about potential losses (Sortino & Price, 1994; Sortino & Van Der Meer, 1991). The Calmar Ratio quantifies the efficiency of return generation relative to maximum drawdown, using the simple formula of CAGR divided by the absolute value of maximum drawdown (Young, 1991). The maximum drawdown is reported as a negative value representing the largest peak-to-trough decline, while the Calmar Ratio uses its absolute value so that a higher ratio consistently indicates better performance. For comparative categorization, this study adopts an efficiency threshold of 1.0 for both ratios: a value exceeding 1.0 indicates that excess return adequately compensates for risk taken, while a value below 1.0 indicates that risk exposure outweighs historical return. This threshold framework underpins the quadrant-based quality matrix presented in the discussion section.

The conceptual framework of this study illustrates the performance evaluation flow for 20 cryptocurrency assets. Daily closing prices are processed to generate daily returns, which then serve as the basis for three parallel computations: CAGR, annualized downside deviation, and maximum drawdown. These intermediate metrics feed into the calculation of the Sortino Ratio (CAGR divided by annualized downside deviation) and the Calmar Ratio (CAGR divided by the absolute value of maximum drawdown). The resulting ratios are then used to construct performance rankings and a quadrant-based quality matrix to support investment decision-making.

RESULTS AND DISCUSSION

The results of descriptive statistics for the daily returns of 20 cryptocurrency assets over the 2021 to 2025 period are presented in Table 3.

Table 3. Descriptive Statistics of Daily Cryptocurrency Returns 2021–2025

Assets	Std. Dev	Std. Dev Ann.	Mean Return	Min Return	Max Return	Skewness	Kurtosis
BTC	0.0305	0.5818	0.11%	-15.85%	19.25%	0.1652	3.8468
ETH	0.0411	0.7847	0.16%	-26.30%	24.53%	0.1930	4.6376
BNB	0.0442	0.8450	0.26%	-31.88%	73.79%	3.0506	49.7511
XRP	0.0538	1.0275	0.25%	-32.06%	72.37%	2.7428	29.7929

Assets	Std. Dev	Std. Dev Ann.	Mean Return	Min Return	Max Return	Skewness	Kurtosis
SOL	0.0596	1.1391	0.42%	-42.20%	36.63%	0.4448	5.7081
TRX	0.0429	0.8205	0.21%	-31.40%	88.88%	5.3060	108.4142
DOGE	0.1055	2.0160	0.50%	-39.77%	338.90%	19.2680	589.4424
ZEC	0.0584	1.1161	0.28%	-40.56%	61.94%	0.9439	10.8620
LEO	0.0311	0.5935	0.15%	-22.77%	57.71%	3.8599	72.9484
XLM	0.0525	1.0031	0.15%	-30.24%	74.21%	3.5591	42.1027
XMR	0.0423	0.8078	0.15%	-39.96%	37.41%	-0.2388	15.0517
ADA	0.0519	0.9915	0.16%	-24.73%	72.93%	2.0557	24.4041
LINK	0.0525	1.0038	0.14%	-35.65%	32.19%	0.1573	3.6911
BCH	0.0507	0.9687	0.15%	-34.31%	59.06%	2.0240	22.1382
DEXE	0.0885	1.6912	0.34%	-49.14%	181.14%	8.4906	155.5137
LTC	0.0450	0.8598	0.08%	-35.46%	27.35%	-0.1382	5.8751
HBAR	0.0624	1.1924	0.25%	-34.43%	73.03%	2.7171	24.2657
AVAX	0.0626	1.1958	0.26%	-35.01%	75.70%	1.5035	15.2837
CRO	0.0539	1.0306	0.16%	-29.05%	67.01%	2.1719	24.0032
SHIB	0.8283	15.8245	3.14%	-62.26%	3437.42%	39.3492	1623.80

Source: Authors' calculation

Table 3 presents the distributional properties of daily returns for each asset. Within the sample, BTC exhibits the most conservative distributional profile with the lowest daily standard deviation of 0.0305, consistent with its position as the largest cryptocurrency by market capitalization. Conversely, SHIB records the highest daily standard deviation of 0.8283 with an annualized value of 15.8245, reflecting extreme price volatility attributable to its near-zero starting price in early 2021. Notably, 18 of 20 assets exhibit positive skewness, indicating return distributions that tend toward longer right tails. Only XMR and LTC show slightly negative skewness. All 20 assets display excess kurtosis well above zero, confirming fat-tailed distributions with a higher probability of extreme returns than implied by a normal distribution (Liu & Tsyvinski, 2021). These conditions provide empirical justification for the application of downside-risk-oriented evaluation metrics rather than conventional mean-variance frameworks.

The results of the Compound Annual Growth Rate (CAGR) for each year of observation are presented in Table 4.

Table 4. Annual Asset CAGR Ranking 2021–2025

Asset	2021	2022	2023	2024	2025
BTC	58.00%	-65.51%	154.67%	111.71%	-7.29%
ETH	407.14%	-68.45%	90.23%	41.98%	-11.44%
BNB	1,260%	-53.46%	27.98%	122.86%	22.36%
XRP	251.36%	-60.14%	81.25%	230.22%	-20.60%

Asset	2021	2022	2023	2024	2025
SOL	9,260%	-94.48%	922.47%	73.10%	-35.78%
TRX	180.90%	-29.17%	96.50%	136.04%	11.48%
DOGE	3,008%	-59.59%	27.19%	243.44%	-63.91%
ZEC	157.89%	-75.36%	-27.90%	100.79%	785.17%
LEO	171.12%	-5.42%	13.11%	126.34%	6.08%
XLM	102.60%	-74.40%	77.42%	152.16%	-52.62%
XMR	68.57%	-41.35%	10.84%	14.32%	122.45%
ADA	650.22%	-82.21%	137.91%	35.46%	-63.73%
LINK	65.80%	-73.04%	166.12%	28.76%	-43.69%
BCH	26.53%	-78.32%	168.94%	63.06%	33.56%
DEXE	735.07%	-79.62%	60.78%	264.77%	-78.43%
LTC	16.42%	-53.80%	2.97%	37.37%	-26.70%
HBAR	784.88%	-87.98%	124.66%	191.69%	-63.99%
AVAX	2,919%	-90.51%	256.03%	-14.95%	-67.39%
CRO	843.04%	-90.53%	74.06%	40.60%	-39.72%
SHIB	44,845,023%	-76.38%	26.94%	97.98%	-68.15%

Source: Authors' calculation

Table 4 shows that the level of return for each asset varies greatly each year, reflecting the highly dynamic and cyclical nature of the cryptocurrency market. In 2021, all 20 assets recorded positive returns, with SHIB achieving an extraordinary CAGR of 44,845,023% due to its price appreciation from near-zero levels, followed by SOL at 9,260% and DOGE at 3,008%. The year 2022 was characterized by a severe crypto winter driven by global monetary tightening, with all 20 assets recording negative returns. LEO demonstrated the most resilience with a loss of only 5.42%, while SOL experienced the deepest decline at 94.48%. The recovery in 2023 was selective, with SOL leading at 922.47%, while ZEC was the only asset with negative returns. In 2024, DEXE and DOGE led the recovery at 264.77% and 243.44% respectively, with only AVAX recording a negative return. The year 2025 saw a market correction with 14 of 20 assets declining, while ZEC surged 785.17% and XMR gained 122.45%.

The overall asset performance ranking based on the Sortino Ratio and Calmar Ratio for the period 2021 to 2025 is presented in Table 5.

Table 5. Overall Asset Performance Ranking 2021–2025

Rank	Code	CAGR	DD Annualized	Max Drawdown	Sortino Ratio	Calmar Ratio
1	SHIB	877.68%	87.14%	-91.98%	10.0724	9.5422
2	SOL	132.29%	71.21%	-96.30%	1.8578	1.3737
3	BNB	86.84%	50.08%	-70.76%	1.7341	1.2272
4	LEO	47.16%	35.69%	-56.22%	1.3215	0.8389
5	TRX	60.20%	47.37%	-69.82%	1.2709	0.8623

Rank	Code	CAGR	DD Annualized	Max Drawdown	Sortino Ratio	Calmar Ratio
6	DOGE	84.15%	71.49%	-92.21%	1.1771	0.9126
7	XRP	50.60%	59.05%	-83.17%	0.8570	0.6084
8	ZEC	55.19%	71.22%	-94.28%	0.7749	0.5854
9	BTC	24.42%	39.25%	-76.72%	0.6222	0.3183
10	ETH	32.37%	52.80%	-79.33%	0.6129	0.4080
11	XMR	26.10%	56.86%	-78.27%	0.4589	0.3334
12	HBAR	26.25%	67.46%	-92.82%	0.3892	0.2828
13	AVAX	27.41%	73.65%	-93.47%	0.3722	0.2933
14	DEXE	18.01%	79.90%	-93.55%	0.2254	0.1925
15	ADA	13.62%	60.52%	-91.86%	0.2251	0.1483
16	BCH	11.92%	59.45%	-94.27%	0.2005	0.1264
17	XLM	8.68%	57.41%	-90.19%	0.1511	0.0962
18	CRO	8.75%	62.88%	-94.50%	0.1391	0.0926
19	LINK	0.56%	68.16%	-90.14%	0.0083	0.0063
20	LTC	-9.44%	60.55%	-88.75%	-0.1559	-0.1063

Source: Authors' calculation

Table 5 presents the overall performance ranking based on both the Sortino Ratio and Calmar Ratio for the 2021 to 2025 period. SHIB records the highest Sortino Ratio of 10.0724 and Calmar Ratio of 9.5422, driven by its extraordinary CAGR of 877.68% from a near-zero starting price, despite experiencing a maximum drawdown of 91.98%. SOL follows in second place with a Sortino Ratio of 1.8578 and Calmar Ratio of 1.3737, supported by a CAGR of 132.29% with the deepest maximum drawdown in the sample at 96.30%. BNB ranks third with a Sortino Ratio of 1.7341 and Calmar Ratio of 1.2272, demonstrating a comparatively more moderate risk profile with a maximum drawdown of 70.76%. Six assets record Sortino Ratios exceeding 1.0, indicating that their excess returns adequately compensate for downside risk. At the bottom of the ranking, LTC is the only asset with a negative CAGR of 9.44%, resulting in negative Sortino and Calmar Ratios, indicating a complete failure to generate positive returns over the five-year period.

The results of this study indicate that the levels of return, risk, and asset performance during the 2021 to 2025 period vary greatly across cryptocurrency assets. This finding is in line with previous research which shows that cryptocurrencies have unique risk characteristics that differ from traditional assets (Laksana et al., 2026; Liu & Tsyvinski, 2021). The five-year observation window spans a full market cycle that is consistent with the liquidity expansion of 2021, the global monetary tightening of 2022, a recovery phase in 2023 to 2024, and a correction in 2025. While a formal sub-period decomposition is beyond the scope of this aggregate analysis, the wide

dispersion of outcomes across assets is consistent with the importance of timing and business cycle awareness in cryptocurrency investing.

Measuring performance using downside risk metrics provides a more comprehensive perspective than simply examining absolute returns. Assets with high CAGR do not necessarily achieve high risk-adjusted performance. For example, DOGE recorded a substantial CAGR of 84.15%, yet its Sortino Ratio of 1.1771 is lower than that of LEO (Sortino: 1.3215) despite LEO's lower CAGR of 47.16%. This occurs because LEO maintains a substantially lower downside deviation (35.69% vs. 71.49%), demonstrating superior capital protection efficiency. Similarly, BTC, despite being the largest cryptocurrency by market capitalization, records a moderate Sortino Ratio of 0.6222 and Calmar Ratio of 0.3183, indicating that its 24.42% CAGR does not fully compensate for its 76.72% maximum drawdown over the five-year period. These findings highlight the importance of evaluating performance not only based on absolute returns but also considering the risks taken, as emphasized in various asset performance comparison studies (Dombrowski et al., 2023; Laksana et al., 2026).

A notable finding of this study is the SHIB phenomenon. SHIB, a meme token, achieved the highest Sortino Ratio (10.0724) and Calmar Ratio (9.5422) in the entire sample, surpassing all other cryptocurrencies by a wide margin. This result is driven by SHIB's extraordinary price appreciation from approximately 7.73×10^{-11} on January 1, 2021 to 6.90×10^{-6} by December 31, 2025, representing a price multiplication over 89,000 times. While the resulting CAGR of 877.68% is mathematically correct, it must be interpreted with caution: SHIB's extreme metrics are a consequence of its near-zero starting price, which amplifies percentage returns to levels that are not replicable for assets with established market prices. Furthermore, SHIB's maximum drawdown of 91.98% indicates that investors who entered at the peak would have lost over 90% of their capital. This juxtaposition of extreme mathematical efficiency alongside catastrophic capital erosion risk constitutes what may be termed a speculative paradox, consistent with Prospect Theory's prediction regarding the overweighting of tail event probabilities by retail investors (Blau et al., 2020; Kahneman & Tversky, 1979).

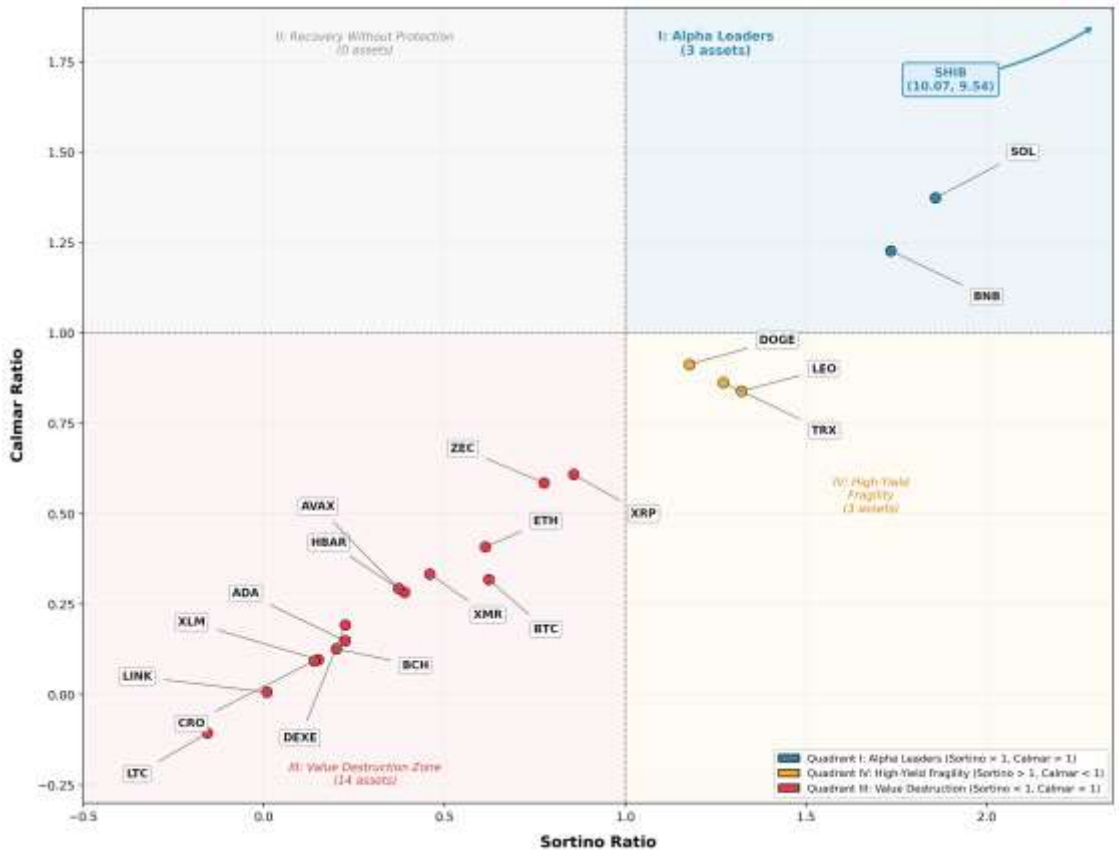


Figure 1. Quadrant Analysis of Risk-Adjusted Quality Matrix (2021–2025)

The quadrant analysis based on the efficiency threshold of 1.0 for both ratios reveals that the analyzed assets are categorized into three distinct performance profiles. Quadrant I (Alpha Leaders, Sortino > 1 and Calmar > 1) contains three assets: SHIB, SOL, and BNB. While SHIB's placement is driven by the speculative paradox discussed above, SOL (Sortino: 1.8578; Calmar: 1.3737) and BNB (Sortino: 1.7341; Calmar: 1.2272) represent strong performance, as their compounded growth adequately compensates for both downside deviation and maximum drawdown. Quadrant IV (High-Yield Fragility, Sortino > 1 and Calmar < 1) contains three assets: TRX, DOGE, and LEO. These assets demonstrate the capacity to manage daily downside deviations but their Calmar Ratios below 1.0 indicate that their returns do not fully compensate for the severity of their worst historical drawdowns. Quadrant III (Value Destruction Zone, Sortino < 1 and Calmar < 1) is the most densely populated quadrant, encompassing 14 of the 20 assets, including major cryptocurrencies such as BTC, ETH, XRP, and ADA. LTC stands out with negative values on both metrics, representing the most severe case of capital erosion. Notably, Quadrant II (Recovery Without Protection, Sortino < 1 and Calmar > 1) remains empty, suggesting

that within the cryptocurrency market during this observation period, no asset possessed robust long-term recovery capacity while simultaneously failing to protect investors from daily negative volatility.

The Sharpe ratio, which has dominated prior Indonesian cryptocurrency literature (Andaresta & Purwanto, 2023; Budiartomo & Setiyono, 2023; Laksana, 2024; Wiliyani & Purnamawati, 2023), treats all volatility as risk, an assumption that may be less appropriate for assets characterized by positive skewness and extreme kurtosis (Bacon, 2023; Gerunov, 2022). The Sortino Ratio addresses this limitation by focusing exclusively on downside deviation, while the Calmar Ratio provides an additional dimension by measuring returns relative to maximum drawdown, which represents the worst-case scenario investors may face (Sortino & Price, 1994; Young, 1991).

In the context of Prospect Theory (Kahneman & Tversky, 1979), these findings provide empirical support for the argument that investors should conduct a comprehensive evaluation of potential profits and losses before making investment decisions. The SHIB phenomenon illustrates how assets with extreme upside potential can attract significant investor interest despite carrying near-total capital loss risk, consistent with the probability weighting function described in behavioral finance literature (Yadav, 2024). Conversely, the strong performance of SOL and BNB across both metrics indicates that some established large-capitalization assets can deliver superior risk-adjusted returns while maintaining more acceptable drawdown profiles, although identifying the underlying drivers would require further fundamental analysis beyond the scope of this study. For risk-averse investors prioritizing capital preservation, BNB presents the most defensible position among the Alpha Leaders, given its lower maximum drawdown of 70.76% compared to SOL (96.30%) and SHIB (91.98%), based on historical data over the observation period and not as investment advice.

These findings offer important insights for investors in formulating investment strategies. The study also supports the importance of financial literacy and risk profiling in cryptocurrency investment (Carbó-Valverde et al., 2025; Jones et al., 2024). These findings are in line with the investor protection objectives of POJK Number 27 of 2024, and can be used as a reference by market supervisors and financial educators to support the categorization of cryptocurrency assets based on actual downside resilience.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that the level of return from 20 cryptocurrency assets during the period 2021 to 2025 varies greatly, with CAGR values ranging from -9.44% (LTC) to 877.68% (SHIB). The five-year observation window spans a complete market cycle, from universal positive returns in 2021, through a severe crypto winter in 2022 where all assets recorded negative returns and a partial recovery in 2023 to 2024, to a market correction in 2025 where 14 of 20 assets declined. Risk analysis further reveals that all 20 assets exhibit excess kurtosis, with 18 displaying positive skewness, confirming non-normal return distributions that justify the use of downside-risk-oriented evaluation metrics.

The Sortino Ratio analysis shows that only six assets exceed the efficiency threshold of 1.0, with SHIB recording the highest value of 10.0724, followed by SOL at 1.8578 and BNB at 1.7341. The Calmar Ratio analysis identifies only three assets exceeding the 1.0 threshold: SHIB (9.5422), SOL (1.3737), and BNB (1.2272). The quadrant analysis reveals three Alpha Leaders (SHIB, SOL, BNB), three assets in the High-Yield Fragility zone (TRX, DOGE, LEO), and 14 assets in the Value Destruction Zone. The SHIB phenomenon constitutes a speculative paradox: the mathematically highest risk-adjusted performance coexists with a 91.98% maximum drawdown, driven by its near-zero starting price. This study can be used as a reference to improve investors' understanding of asset performance and the risks of cryptocurrencies, and can encourage further research on investment analysis and risk management.

However, this study has limitations, specifically by analyzing only 20 cryptocurrency assets without including traditional asset classes as benchmarks. The use of a zero risk-free rate, while justified for global cryptocurrency markets, may produce different results compared to studies that employ domestic benchmarks. Furthermore, the extreme influence of SHIB's near-zero starting price on the overall rankings warrants interpretive caution. For future research, this study recommends comparing cryptocurrency performance against stocks, bonds, or gold using Sortino and Calmar metrics; employing domestic risk-free benchmarks such as the BI 7-Day Reverse Repo Rate for Indonesian investor perspectives; developing optimal portfolio models that integrate cryptocurrencies with traditional asset classes; and incorporating complementary tail risk metrics such as Maximum Drawdown Duration and the Ulcer Index.

REFERENCES

Abdelmalek, W. (2024). Cryptocurrencies and portfolio diversification before and during COVID-19. *EuroMed Journal of Business*, *19*(4), 1084-1120. https://doi.org/10.1108/EMJB-10-2022-0182

Andaresta, E. F., & Purwanto, E. (2023). Alternatif Keputusan Investasi: Analisis Perbandingan Kinerja Cryptocurrency Bitcoin, Saham IDX 30, dan Emas. *SEIKO: Journal of Management & Business*, *6*(2), 213-223. https://doi.org/10.37531/sejaman.v6i2.4381

Auer, R., Cornelli, G., Doerr, S., Frost, J., & Gambacorta, L. (2023). *Crypto trading and Bitcoin prices: evidence from a new database of retail adoption*. https://www.bis.org/publ/work1049.htm

Auer, R., & Tercero-Lucas, D. (2022). Distrust or speculation? The socioeconomic drivers of U.S. cryptocurrency investments. *Journal of Financial Stability*, *62*, 101066. https://doi.org/10.1016/j.jfs.2022.101066

Bacon, C. R. (2023). *Practical portfolio performance measurement and attribution*. John Wiley & Sons.

Baur, D. G., Hong, K., & Lee, A. D. (2018). Bitcoin: Medium of exchange or speculative assets? *Journal of International Financial Markets, Institutions and Money*, *54*, 177-189. https://doi.org/10.1016/j.intfin.2017.12.004

BBC. (2022). Investor token LUNA rugi nyaris 100%, bagaimana kondisi tren kripto di tengah keruntuhan pasar? *BBC NEWS INDONESIA*. https://www.bbc.com/indonesia/majalah-61436099

Blau, B. M., DeLisle, R. J., & Whitby, R. J. (2020). Does Probability Weighting Drive Lottery Preferences? *Journal of Behavioral Finance*, *21*(3), 233-247. https://doi.org/10.1080/15427560.2019.1672167

Budiartomo, R. F., & Setiyono, W. P. (2023). Comparative Analysis of Bitcoin, Stocks, and Gold Cryptocurrencies as Alternative Investment Portfolios. *Academia Open*, *8*(1), 10-21070. https://doi.org/10.21070/acopen.8.2023.3511

Carbó-Valverde, S., Cuadros-Solas, P. J., & Rodríguez-Fernández, F. (2025). Cryptocurrency ownership and cognitive biases in perceived financial literacy. *Journal of Behavioral and Experimental Finance*, *45*, Article 101019. https://doi.org/10.1016/j.jbef.2024.101019

Chiquitita, M. (2025). *10 Perusahaan Raksasa Dunia dengan Kepemilikan Bitcoin Paling Banyak*. CNBC Indonesia. Retrieved 12 February 2026 from https://www.cnbcindonesia.com/research/20250519120210-128-634304/10-perusahaan-raksasa-dunia-dengan-kepemilikan-bitcoin-paling-banyak

Dichtl, H., Drobetz, W., & Otto, T. (2024). Drawdowns in stock and crypto markets. What is the best bootstrapping method? *SSRN Working Paper No. 4811952*. https://doi.org/10.2139/ssrn.4811952

Dombrowski, N., Drobetz, W., & Momtaz, P. P. (2023). Performance measurement of crypto funds. *Economics Letters*, *228*, Article 111118. https://doi.org/10.1016/j.econlet.2023.111118

Engle, T. A., Connealy, N., & Dulisse, B. C. (2026). Trust me bro: An examination of the influence of cryptocurrency literacy and overconfidence on victimization and financial loss. *Technology in Society*, *86*, 103277. https://doi.org/10.1016/j.techsoc.2026.103277

Gerunov, A. (2022). Risk Management for Crypto Assets: Towards Volume-Adjusted Metrics. *Economic Alternatives*, *28*, 111-131. https://doi.org/10.37075/EA.2022.1.07

Gupta, H., & Chaudhary, R. (2022). An Empirical Study of Volatility in Cryptocurrency Market. *Journal of Risk and Financial Management*, *15*(11), Article 513. https://doi.org/10.3390/jrfm15110513

Hafishina, A. D. R., Abraham, J., Warnars, H. L. H. S., Manurung, R. H., & Nainggolan, T. (2023). Disrupting Money: Psychological Factors of Investment Biases in Cryptocurrency. *TEM Journal*, *12*(1), 482-493. https://doi.org/10.18421/TEM121-58

Heriyanto, M. (2025, 30 Desember). Jumlah investor pasar modal RI capai 20,32 juta SID di akhir 2025. *ANTARA News*. https://www.antaranews.com/berita/5327392/jumlah-investor-pasar-modal-ri-capai-2032-juta-sid-di-akhir-2025

Jones, M., Luu, T. J., & Samuel, B. (2024). The interdependence of financial literacy and crypto literacy. *Economics Letters*, *239*, Article 111737. https://doi.org/10.1016/j.econlet.2024.111737

Kahneman, D., & Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk. *Econometrica*, *47*(2), 263-292. https://doi.org/10.2307/1914185

Laksana, R. (2024). Looking for the Best Asset Class: Cryptocurrency, Gold or Stocks? *Ekonomi, Keuangan, Investasi dan Syariah (EKUITAS)*(Vol 6 No 2 (2024): November 2024), 162-169. https://doi.org/10.47065/ekuitas.v6i2.5117

Laksana, R., Avianty, R. R., Nugraha, E., & Sukardi, H. A. (2026). Cryptocurrencies vs Stocks: Analyzing Returns, Risks, and Performance to Determine the Best Investment. *Journal of Business and Economics Research (JBE)*, *7*(1), 99-109. https://doi.org/10.47065/jbe.v7i1.9075

Liu, Y., & Tsyvinski, A. (2021). Risks and returns of cryptocurrency. *The Review of Financial Studies*, *34*(6), 2689-2727. https://doi.org/10.1093/rfs/hhaa113

OJK. (2026a). *Rapat Dewan Komisioner Bulanan Desember 2025 (RDKB Desember 2025)* [Press Release]. https://ojk.go.id/id/berita-dan-kegiatan/siaran-pers/Pages/RDKB-Des-2025.aspx

OJK. (2026b). *Rapat Dewan Komisioner Bulanan Juni 2026 (RDKB Juni 2026)* [Press Release]. https://ojk.go.id/id/berita-dan-kegiatan/siaran-pers/Pages/RDKB-Juni-2026.aspx

Pessa, A. A., Perc, M., & Ribeiro, H. V. (2023). Age and market capitalization drive large price variations of cryptocurrencies. *Scientific reports*, *13*(1), 3351. https://doi.org/10.1038/s41598-023-30431-3

POJK Nomor 27 Tahun 2024 tentang Penyelenggaraan Perdagangan Aset Keuangan Digital Termasuk Aset Kripto, (2024).

Rahyuda, H., & Candradewi, M. R. (2023). Determinants of cryptocurrency investment decisions (Study of students in Bali). *Investment Management and Financial Innovations*, *20*(2), 193-204. https://doi.org/10.21511/imfi.20(2).2023.17

Ruggeri, K., Alí, S., Berge, M. L., Bertoldo, G., Bjørndal, L. D., Cortijos-Bernabeu, A., Davison, C., Demić, E., Esteban-Serna, C., Friedemann, M., Gibson, S. P., Jarke, H., Karakasheva, R., Khorrami, P. R., Kveder, J., Andersen, T. L., Lofthus, I. S., McGill, L., Nieto, A. E., Pérez, J., Quail, S. K., Rutherford, C., Tavera, F. L., Tomat, N., Reyn, C. V., Većkalov, B., Wang, K., Yosifova, A., Papa, F., Rubaltelli, E., Linden, S., & Folke, T. (2020). Replicating patterns of prospect theory for decision under risk. *Nature Human Behaviour*, *4*(6), 622-633. https://doi.org/10.1038/s41562-020-0886-x

SEC. (2024). *Statement on the Approval of Spot Bitcoin Exchange-Traded Products*. U.S. Securities and Exchange Commission. Retrieved 12 March 2026 from

https://www.sec.gov/newsroom/speeches-statements/gensler-statement-spot-bitcoin-011023

Sharpe, W. F. (1966). Mutual fund performance. *The Journal of business*, *39*(1), 119-138. http://www.jstor.org/stable/2351741

Sortino, F. A., & Price, L. N. (1994). Performance measurement in a downside risk framework. *the Journal of Investing*, *3*(3), 59-64. https://doi.org/10.3905/joi.3.3.59

Sortino, F. A., & Van Der Meer, R. (1991). Downside risk. *Journal of portfolio Management*, *17*(4), 27. https://doi.org/10.3905/jpm.1991.409343

Wiliyani, N. K., & Purnamawati, I. G. A. (2023). Analisis Perbandingan Kinerja Cryptocurrency Bitcoin, Reksa Dana Saham, dan Emas sebagai Pertimbangan Pengambilan Keputusan Investasi. *JIMAT (Jurnal Ilmiah Mahasiswa Akuntansi) Undiksha*, *14*(03), 654-665. https://doi.org/10.23887/jimat.v14i03.64224

Yadav, M. (2024). Behavioral biases of cryptocurrency investors: a prospect theory model to explain cryptocurrency returns. *Review of Behavioral Finance*, *16*(4), 643-667. https://doi.org/10.1108/RBF-07-2023-0172

Young, T. W. (1991). Calmar ratio: A smoother tool. *Futures*, *20*(1), 40.