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DOWNSIDE DEVIATION AS A MEASURE OF MARKET RISK

Quantitative measurement of market risk is one of the key tasks of modern financial management. Traditionally, standard deviation is used to characterize the risk of financial assets because it measures the overall variability of returns.

However, standard deviation has a fundamental limitation: it treats positive and negative deviations symmetrically. From an investor's perspective, this does not always correspond to the economic meaning of risk. A positive deviation of actual return from the target level represents an investment outcome above the target, whereas a negative deviation indicates failure to achieve the target return or the occurrence of potential losses [1].

Consequently, asymmetric risk measures have become increasingly important, among which Downside Deviation (*DD*) occupies a significant position.

Downside Deviation is defined as the square root of the mean squared negative deviations of actual returns from the minimum acceptable return [2–3]:

$$DD = \sqrt{\frac{\sum_{i=1}^{N} \min(0, R_i - \mathrm{MAR})^2}{N}}. \quad (1)$$

In the study, R_i denotes the annual return of the asset; MAR is the minimum acceptable return; and N is the number of observations. To provide a common benchmark, MAR is set at 5%.

The empirical analysis covers 2021–2026. Annual total returns are used for the S&P 500, i.e. returns incorporating reinvested dividends. Annual index changes are used for the NASDAQ-100, while annual price changes are used for Bitcoin. The sample therefore represents three assets with fundamentally different risk profiles: the broad U.S. equity market, a technology-oriented equity index, and a highly volatile cryptocurrency (Tables 1–2).

Table 1

Annual returns of the analyzed assets, %

Year	S&P 500	NASDAQ-100	Bitcoin
2021	28,71	26,63	59,67
2022	-18,11	-32,97	-64,27
2023	26,29	53,81	155,42
2024	25,02	24,88	121,05
2025	17,88	20,17	-6,34
2026 YTD	13,76	15,74	-9,16

Source: [4]

The data reveal substantial differences in the risk profiles of the three assets. The deepest negative observation during the analyzed period occurred for Bitcoin in 2022 (-64,27%). In the same year, the NASDAQ-100 declined by 32,97%, while the S&P 500 declined by 18,11%.

Table 2

Main risk and risk-adjusted performance indicators

Indicator	S&P 500	NASDAQ-100	Bitcoin
Average annual return, %	15,59	18,04	42,73
Standard Deviation, %	17,43	28,33	84,46
Downside Deviation, %	9,98	15,17	34,90
Sharpe Ratio*	0,61	0,46	0,45
Sortino Ratio*	1,06	0,86	1,08

Source: [4]

An important relationship is the ratio DD/σ. It is approximately 0,57 for the S&P 500, 0,54 for the NASDAQ-100, and 0,41 for Bitcoin.

If Bitcoin is evaluated solely by standard deviation, it appears to be an extremely risky asset, with volatility exceeding 84%. However, Downside Deviation indicates downside volatility of approximately 34,9%. The difference arises because of the very large positive price movements of Bitcoin in 2023-2024.

This demonstrates the key advantage of Downside Deviation: it does not penalize an asset for positive volatility.

Under the traditional approach, the S&P 500 has the highest Sharpe Ratio (0,61), followed by the NASDAQ-100 (0,46) and Bitcoin (0,45). When the Sortino Ratio is used, the ranking changes: S&P 500 – 1,06; NASDAQ-100 – 0,86; Bitcoin – 1,08.

Thus, in terms of return per unit of downside risk, Bitcoin produces a slightly higher result than the S&P 500 in the analyzed sample. This does not mean that Bitcoin is a safer asset. Its absolute Downside Deviation is several times higher than that of the equity indices. Rather, the result indicates that Bitcoin's exceptionally high returns within the sample compensated for its substantial downside risk.

Evaluating market risk solely through Standard Deviation may overstate the riskiness of assets with high positive volatility while failing to capture the economic asymmetry between gains and losses.

Downside Deviation addresses this issue by focusing only on deviations that are unfavorable to the investor. This is particularly evident for Bitcoin: its Standard Deviation in the sample is 84,46%, whereas Downside Deviation is approximately 34,90%. Consequently, the use of standard deviation effectively treats very large positive price movements as 'risk'.

The scientific contribution of the study consists in empirically substantiating the usefulness of Downside Deviation as an asymmetric measure of market risk and identifying its informational advantage over Standard Deviation when return distributions contain substantial positive deviations.

A differentiated measurement framework is proposed in which Standard Deviation captures overall volatility, Downside Deviation captures negative volatility and Sortino Ratio evaluates investment performance with respect to downside risk.

The study confirms that Downside Deviation is a meaningful alternative to Standard Deviation for measuring market risk. The empirical analysis of the S&P 500, NASDAQ-100, and Bitcoin over 2021–2026 demonstrates substantial differences between overall and downside volatility.

Bitcoin exhibits the highest absolute risk according to all major risk measures. At the same time, its ratio of Downside Deviation to Standard Deviation is the lowest, indicating a substantial contribution of positive volatility to its overall variability.

The S&P 500 demonstrates the most balanced risk profile, while the NASDAQ-100 occupies an intermediate position.

An important finding is the change in the asset ranking when moving from the Sharpe Ratio to the Sortino Ratio. This confirms that the choice of risk measure directly affects the assessment of investment-strategy performance [5].

Therefore, Downside Deviation should be considered an important component of modern market-risk measurement, particularly for assets with asymmetric return distributions and high positive volatility.

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