“The contribution of cryptocurrencies to portfolio diversification”

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THE CONTRIBUTION OF CRYPTOCURRENCIES TO PORTFOLIO DIVERSIFICATION

Abstract

Cryptocurrencies have attracted significant attention due to their high risk, extreme volatility, regulatory controversies, and scandals. Investors and policymakers are drawn to them for their potential to enhance diversification and deliver high returns. This study examines the impact of incorporating cryptocurrencies into investment portfolios, focusing on their ability to improve risk-adjusted returns and diversification. A rolling asset allocation strategy employing the maximum Sharpe Ratio within a Markowitz framework was applied to weekly data from 2018 to April 2024.

The analysis compares two unconstrained portfolios and two constrained portfolios, which impose a concentration limit on cryptocurrency investments. Results reveal that in 70% of the rolling periods examined, portfolios with cryptocurrency allocations outperformed non-cryptocurrency portfolios in terms of Sharpe Ratios. However, the heightened volatility of cryptocurrencies significantly increased portfolio risk, with annualized weekly standard deviations ranging from 18% to 25%, compared to 12% to 15% for portfolios without cryptocurrency exposure.

These findings illustrate the dual nature of cryptocurrencies: they can act as both a source of instability and an opportunity for diversification. The study underscores the necessity of a cautious and strategic approach to incorporating cryptocurrencies into investment plans, given their inherent risks and unpredictable behavior.

Keywords cryptocurrency, alternative assets, active management, behavioural finance, data vetting

JEL Classification G11, G15, G23

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INTRODUCTION

At the beginning of January 2025, the global cryptocurrency ('crypto') market cap was, according to the website CoinMarketCap, $3.78 trillion. The cryptocurrency market has grown substantially, both in market capitalization and in the number of digital assets available. In recent years, the rise of new digital assets has reshaped the market, driven by growing investor interest and blockchain innovation.

The dynamic interplay between social media and cryptocurrencies underscores the power of digital platforms in shaping investor perceptions, influencing price movements, and encouraging widespread participation in the cryptocurrency space.

The absence of comprehensive regulations heightens investor risks, such as fraud, price manipulation, and extreme volatility. In a portfolio context, cryptocurrencies present unique diversification opportunities that can enhance returns due to their high growth potential and low correlation with traditional assets. Cryptocurrencies' high growth potential and low correlation with traditional assets make them appealing for diversification, though their risks demand thorough evaluation.

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This study investigates the changes in the performance of a portfolio, based on ten market indices, from 2018 to April 2024, incorporating cryptocurrencies as a new asset class. It utilizes a rolling asset allocation approach based on the Max Sharpe Ratio criterion within a Markowitz framework.

This approach employs dynamic allocation strategies through rolling analysis and non-parametric risk measures to enhance the understanding of cryptocurrencies' role in investment portfolios. The paper explores how cryptocurrencies can enhance diversification and optimize risk-adjusted returns in investment portfolios. Additionally, it addresses gaps in existing research on dynamic allocation strategies, highlighting the importance of incorporating non-parametric risk measures to capture the complexities of cryptocurrency investments. Although not directly focused on social media, this paper indirectly touches on social media influence by addressing the volatility and speculative nature of cryptocurrencies. Moreover, the study acknowledges the broader market dynamics, which are often influenced by social media-driven hype and investor sentiment, especially when analyzing risk and return optimization in a volatile market.

Addressing these gaps will contribute to the academic literature and provide valuable insights for practitioners navigating the complexities of the evolving cryptocurrency landscape, recognizing that cryptocurrencies' efficacy as diversification tools may fluctuate based on market conditions, necessitating a more careful investment strategy.

1. LITERATURE REVIEW

Previous studies have examined diversification's impact, suggesting that cryptocurrencies contribute to optimizing risk-adjusted returns due to their low correlation with traditional asset classes. The studies discussed below explore the diversification effects of cryptocurrencies through various methodologies.

Kajtazi and Moro (2019) apply the mean-CVaR approach to explore the effects of adding Bitcoin to an optimal portfolio of U.S., European and Chinese assets. They confirm Bitcoin speculative characteristics. Ma et al. (2020) investigate the impact of diversification with the addition of five cryptocurrencies from November 2015 to November 2019 on four traditional asset portfolios. The results show that diversification increased the returns in most cases and reduced the portfolio volatility in all portfolios. They argue that the addition of multiple cryptocurrencies in a portfolio provides enhanced results for diversification. Aliu et al. (2021) study the diversification risk of the crypto portfolio (with 20 cryptocurrencies) with those of equity portfolios. They apply Markowitz's diversification formula with the following programs: Numpy, Jupiter Notebook, and Python.

Gupta and Chaudhary (2022) examine the relationship between the return and volatility among different currencies, applying the DCC GARCH model and EGARCH model, to explore the spillover and asymmetric effect of volatility. They highlight the different volatility comparing Bitcoin and Ether and Litecoin and XRP.

Bruhn and Ernst (2022) study the returns for extreme tail risks by applying Extreme Value Theory. They use the GARCH-EVT approach in combination with a novel algorithm to automatically determine the optimal threshold to model the tail distribution. The empirical analysis indicates that all examined cryptocurrencies show high volatility in their price movements.

Contreras-Valdez et al. (2022) adjust a multivariate semi heavy-tailed distribution to portfolios containing indexes, currencies, and commodities and one cryptocurrency. Then they apply a rolling window to obtain the dynamic parameters of the distribution on a weekly basis. Araújo and Barbosa (2023) use Markov chains of orders one to eight to forecast the dynamics of three major cryptocurrencies. Their results show that predictions obtained from using the empirical probabilities are better than random choices.

Sahu et al. (2024) apply portfolio optimization methodologies and short-term investment strategies in the context of the cryptocurrency market. Their study shows the presence of volatility,

skewness, and kurtosis in cryptocurrencies. They point out the importance of dynamic portfolio management.

However, the current literature predominantly relies on parametric risk measures, such as standard deviation and variance, which may not adequately capture the complexities of cryptocurrency investments. By integrating these non-parametric measures into portfolio analysis, investors could gain a more comprehensive understanding of the risks involved, leading to better-informed decision-making. Although these studies focus on measuring the impact of cryptocurrencies as a tool to improve diversification, the researcher should establish rigorous criteria for data vetting of digital assets, which is crucial for ensuring the quality and significance of research findings.

Kroeger and Sarkar (2017) highlight that price differences are also higher on exchanges with smaller trade sizes compared to the US cryptocurrencies market. Borri and Shakhnov (2020) show that changes in domestic regulation have effects on the domestic and international cryptocurrency market.

This study introduces a novel approach by incorporating dynamic allocation strategies and non-parametric risk measures to better capture the diversification effects of cryptocurrencies.

2. METHODS

This study uses weekly return data from 2018 to April 2024, based on ten market indices chosen to represent a diverse range of asset classes and provide a comprehensive understanding of global investment trends. The MSCI Developed Markets and MSCI Emerging Markets indices reflect performance in developed and emerging equity markets, respectively. The debt market is covered by the FTSE World Government Bond Index, Bloomberg Barclays Global Aggregate Corporate Index, and Bloomberg Global High Yield Index, which represent government, investment-grade corporate, and high-yield bonds. The MSCI World Real Estate Index tracks the global real estate sector, while the S&P Listed Private Equity Index offers insight into private equity performance. The Bloomberg Commodity Index represents commodity futures, often seen as a hedge against inflation, and the S&P Global Infrastructure Index covers infrastructure-related investments. Lastly, the S&P Cryptocurrency Large Cap Index captures trends in the volatile cryptocurrency market. These indices, downloaded by Bloomberg and Eikon Refinitiv data providers, together provide a broad, diversified view of asset class performance over the study period.

The paper employs a rolling asset allocation strategy based on the Max Sharpe Ratio criterion within the Markowitz framework. The objective of this approach was to optimize capital allocation across assets by maximizing the Sharpe Ratio, a metric that quantifies the trade-off between expected return and risk. The Max Sharpe Ratio criterion within the Markowitz framework was applied iteratively to optimize portfolio weights across the rolling windows. The Sharpe Ratio is expressed as:

$$S = \frac{E\left[R_p\right] - R_f}{\sigma_p}, \tag{1}$$

where $E\left[R_p\right]$ represents the expected return of the portfolio, R_f is the risk-free rate, and σ_p is the portfolio's standard deviation, serves as the metric to maximize. The expected portfolio return is calculated as:

$$E\left[R_p\right] = \omega^t E\left[R\right], \tag{2}$$

where ω denotes the vector of portfolio weights and $E\left[R\right]$ is the vector of expected returns for each asset. The portfolio's standard deviation is computed as:

$$\sigma_p = \sqrt{\omega^t \sum \omega}, \tag{3}$$

where $\sum$ represents the covariance matrix of asset returns. The optimization problem to maximize the Sharpe Ratio is formulated as:

$$max_\omega \left(\frac{\omega^t E\left[R\right] - R_f}{\sqrt{\omega^t \sum \omega}} \right) \tag{4}$$

subject to the constraints $\sum_{i=1}^{N} \omega_i = 1$ and $\omega_i < \theta \, \forall i.$

These constraints ensure that the portfolio weights sum to one and that no individual asset weight exceeds the threshold θ, limiting concentration risk.

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The optimization process, well-suited to quadratic programming techniques, was applied iteratively across the rolling window, continuously adjusting portfolio weights in response to updated estimates of expected returns and covariance, capturing dynamic relationships between asset classes, particularly during periods of heightened market volatility.

The analysis was conducted over a rolling 52-week window (Burghof & Prothmann, 2011; Chang et al., 2016), during which both expected returns, and the covariance matrix were estimated. This specific time frame was selected to strike a balance between capturing relevant market dynamics and avoiding overfitting to short-term fluctuations. The rolling window estimation approach allowed for continuous updates of expected return and risk estimates, thereby reflecting the evolving nature of market conditions. The realized portfolio return was calculated by applying the optimized portfolio weights to the returns of the subsequent week, based on the best allocation for each 52-week window.

To assess portfolio performance, the actual returns for each subsequent period were computed using the portfolio weights:

$$R_{p,actual} = \omega' R_{t+1}, \quad (5)$$

where $R_{p,\,actual}$ is the actual return of the portfolio for the next period, and R_{t+1} represents the vector of actual returns for the subsequent period.

This iterative process was repeated across the sample period, producing a time series of realized returns and associated equity lines.

Four distinct portfolios were constructed to examine the effects of including cryptocurrency assets and imposing allocation constraints. The first portfolio, serving as the benchmark, was unconstrained and excluded the cryptocurrency index. The second portfolio, also unrestricted, incorporated the cryptocurrency index, enabling an assessment of its impact on the overall portfolio, particularly in terms of risk-return dynamics. The third portfolio included an upper constraint on asset weights to limit concentration, thereby promoting diversification across traditional assets. The fourth portfolio applied the same constraint but included cryptocurrency, allowing for an analysis of how the inclusion of a highly volatile asset, such as cryptocurrency, influences diversification under a constrained allocation regime.

The implementation of asset allocation constraints is a widely discussed strategy in the literature. Ibbotson and Kaplan (2000) argue that such constraints can explain a significant portion of performance variability, asserting that these restrictions play a pivotal role in shaping portfolio outcomes. Similarly, Wang (2023) emphasizes that constraints, particularly on asset weights, significantly influence the optimization process, ultimately affecting portfolio performance. These studies highlight the importance of well-calibrated allocation limits to enhance portfolio efficiency and stability. In this study, the upper constraint on asset weights was set to prevent over-concentration in any individual asset, with a particular focus on fostering diversification, especially in portfolios containing volatile assets like cryptocurrency. While these constraints promote diversification, they may also limit the optimizer's ability to fully capitalize on high-risk, high-return assets. Therefore, the trade-off between diversification and return potential is a critical consideration in evaluating portfolio performance. A 40% asset weight limit was applied in this analysis, though the results remain consistent across a broader range of constraints (20% to 50%), with these supplementary results available upon request.

It is important to note that this study does not account for transaction costs, slippage, or other practical trading considerations, which could influence realized portfolio performance, especially in strategies involving frequent rebalancing. However, the primary focus of this study was on understanding the effects of diversification and risk-adjusted performance of various portfolio configurations, particularly with respect to the inclusion of cryptocurrency.

3. RESULTS

The results, summarized in Figure 1, show the equity lines of the four portfolio strategies, highlighting key differences in performance. Portfolios that included cryptocurrency exhibited higher volatility, with the

unconstrained portfolios experiencing significant drawdowns during market stress but also notable periods of growth. This highlights the inherent risk-return trade-off of including cryptocurrency. In contrast, portfolios with a 40% concentration constraint demonstrated more stable performance, as diversification limited exposure to the volatility of any single asset.

The unconstrained portfolios, especially those including cryptocurrency, showed pronounced value swings, while the 40% constrained portfolios maintained a more balanced risk profile, characterized by fewer extreme drawdowns. This suggests that imposing a concentration limit may mitigate the risks associated with high-volatility assets like cryptocurrency.

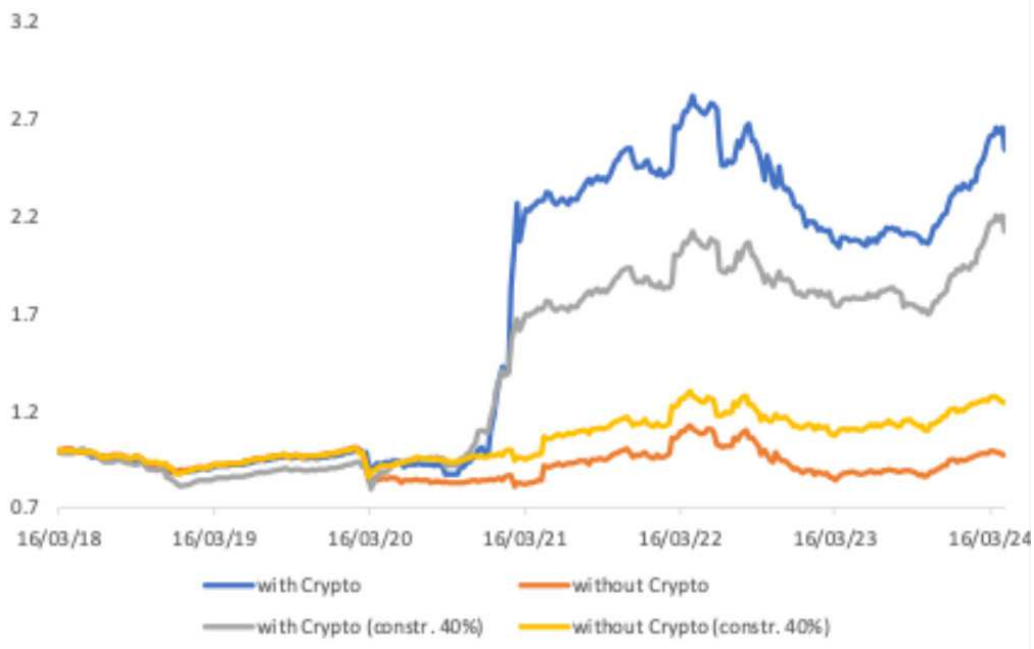
Additionally, Figure 1 indicates that the inclusion of cryptocurrencies boosted portfolio returns, particularly during the period from December 2020 to March 2021, when the cryptocurrency market saw a significant surge. This highlights the potential influence of market conditions, especially during speculative growth, on the contribution of cryptocurrencies to portfolio returns.

To further investigate these results, weekly returns were calculated for each year to offer a more detailed understanding of performance across different market conditions. This analysis aimed to determine whether the observed increase in returns was consistent over time or concentrated in specific periods of high volatility or market rallies, such as the surge observed between December 2020 and March 2021.

In addition to the weekly return analysis, two key performance metrics were computed: the effective Sharpe Ratio (ex-post values) and the maximum drawdown (using a non-parametric approach) for each portfolio configuration. The Sharpe Ratio evaluated risk-adjusted performance, offering insight into whether the returns from including cryptocurrencies justified the additional volatility.

Meanwhile, the maximum drawdown measure helped us understand the extent of the largest peak-to-trough decline experienced by the portfolios, which is particularly important when considering the risk of severe losses during downturns.

The analysis of these metrics will help determine whether the observed performance gains from including cryptocurrency were sustainable and consistent across different time frames, or whether they were primarily driven by short-term speculative gains. The use of risk-adjusted measures, like the Sharpe Ratio, and risk-focused metrics, such



Note: The figure contains equity lines of different portfolios. Indices started on March 16, 2018 (=1).

Figure 1. Equity lines of portfolios

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Table 1. Weekly returns by year

Year	With Crypto	Without Crypto	With Crypto (constr. 40%)	Without Crypto (constr. 40%)
2018	−0.30%	−0.25%	−0.49%	−0.30%
2019	0.18%	0.18%	0.21%	0.21%
2020	0.26%	−0.27%	0.50%	−0.01%
2021	1.70%	0.31%	0.97%	0.34%
2022	−0.18%	−0.19%	−0.08%	−0.05%
2023	0.11%	0.13%	0.16%	0.15%
2024	0.51%	0.24%	0.60%	0.26%
All periods	0.32%	0.00%	0.25%	0.08%

Note: The table presents the weekly returns of four portfolios: (1) including cryptocurrencies, (2) excluding cryptocurrencies, (3) including cryptocurrencies with a 40% weight cap per asset, and (4) excluding cryptocurrencies with a 40% weight cap per asset.

as maximum drawdown, allows for a more comprehensive evaluation of cryptocurrency's role in diversified portfolios, especially when considering the extreme volatility that characterizes this asset class. Drawdown risk measures are critical in assessing financial performance and risk management. One prominent measure is Conditional Drawdown at Risk (CDaR), which quantifies the potential loss from a portfolio's peak value, thus providing insights into downside risk (Ding & Uryasev, 2020; Goldberg & Mahmoud, 2016). This measure has been extended to include systemic risk assessments, which evaluate the drawdown risk across multiple institutions (Ding & Uryasev, 2020). Moreover, integrating drawdown measures into portfolio theory has gained traction, with studies highlighting their effectiveness in optimizing asset allocation and improving risk-adjusted returns (Maier-Paape & Zhu, 2018; Geboers et al., 2022). For instance, the average drawdown risk has been proposed as a more intuitive measure, compared to traditional metrics like standard deviation, allowing for better alignment with investor behavior (Baghdadabad & Glabadanidis, 2013; Baghdadabad et al., 2013). Additionally, recent literature emphasized the importance of path-dependent risk measures, which account for the historical performance of assets in a more nuanced manner, thus enhancing the robustness of risk assessments (Geboers & Depaire, 2023). Overall, the evolving landscape of drawdown risk measures reflects their growing significance in both theoretical and practical applications within finance.

Over a 5-year span, in seven different portfolio configurations, those that incorporated cryptocurrencies consistently outperformed the portfolios without them (Table 1). Both total return and risk-adjusted indicators, such as the Sharpe Ratio, showed this outperformance. Despite the well-documented volatility of cryptocurrencies, their inclusion led to higher returns, suggesting that the diversification benefits outweighed the potential risks, particularly during periods of high market appreciation for this asset class.

These results provide robust evidence of the positive impact that cryptocurrencies can have on portfolio performance, although we remain cautious of the inherent volatility. The findings suggest that, over an extended period, the allocation of a portion of the portfolio to cryptocurrencies may enhance overall returns, particularly in environments characterized by significant price appreciation. However, the influence of specific market conditions, such as the rally between December 2020 and March 2021, needs to be considered when interpreting these results.

The analysis of the portfolios revealed that the standard deviation, which measures volatility, is consistently higher for portfolios that include cryptocurrencies compared to those without. This higher volatility is in line with the well-known price fluctuation characteristics of cryptocurrencies. However, two notable exceptions were observed. In 2018 and 2019, for portfolios without constraints, the standard deviation of portfolios without cryptocurrencies exceeded that of portfolios with cryptocurrencies. Similarly, in 2019, for portfolios with a 40% concentration constraint, the volatility of the portfolio without cryptocurrencies was higher than the portfolio that included them (Table 2).

These exceptions may reflect specific market conditions during these periods, such as corrections

Table 2. Weekly standard deviation by year

Year	With Crypto	Without Crypto	With Crypto (constr. 40%)	Without Crypto (constr. 40%)
2018	0.73%	0.83%	1.11%	0.75%
2019	0.38%	0.39%	0.37%	0.37%
2020	2.37%	1.70%	2.37%	1.48%
2021	5.10%	1.77%	2.41%	1.69%
2022	2.44%	2.38%	2.09%	2.06%
2023	1.19%	1.11%	1.24%	1.22%
2024	1.71%	0.65%	1.66%	0.71%
All periods	2.63%	1.51%	1.81%	1.38%

Note: The table presents the weekly standard deviation of four portfolios: (1) including cryptocurrencies, (2) excluding cryptocurrencies, (3) including cryptocurrencies with a 40% weight cap per asset, and (4) excluding cryptocurrencies with a 40% weight cap per asset.

or shifts in asset performance, where traditional asset classes experienced higher volatility than cryptocurrencies. Such findings highlight the nuanced relationship between risk and return when including emerging asset classes like cryptocurrencies. While crypto assets generally increase portfolio risk, their effect is not always straightforward and can vary, depending on market dynamics and portfolio structure.

Throughout all periods examined, portfolios with cryptocurrencies had a consistently higher Sharpe ratio – a measure of risk-adjusted returns – than those without. This indicates that, despite the higher volatility typically associated with cryptocurrencies, their inclusion tends to enhance the overall performance of the portfolio when adjusted for risk (Table 3).

In particular, the years 2020 and 2021 stand out as periods where portfolios containing crypto assets significantly consolidated their performance. The extraordinary returns observed in the cryptocurrency market during these years, particularly during the post-pandemic recovery and the boom in decentralized finances, boosted the risk-adjusted returns of these portfolios, making them more favorable compared to traditional portfolios.

These findings underscore the potential for crypto assets to enhance portfolio efficiency, although their higher risk needs to be carefully managed, particularly during periods of market instability or correction.

The higher performance of portfolios including the crypto asset class is accompanied by a significantly higher drawdown, particularly for the constrained portfolios (Table 4). This indicates that while the inclusion of cryptocurrencies can enhance returns, it also introduces periods of more pronounced losses. The constraint, which limits concentration to 40%, seems to heighten this effect as it restricts diversification, thereby exacerbating the impact of volatility from the crypto asset class.

In summary, the high returns driven by cryptocurrencies come at the cost of increased risk, re-

Table 3. Weekly ex-post Sharpe Ratio by year

Year	With Crypto	Without Crypto	With Crypto (constr. 40%)	Without Crypto (constr. 40%)
2018	–42.90%	–33.12%	–46.27%	–42.04%
2019	41.84%	40.49%	52.87%	50.81%
2020	9.93%	–17.07%	20.10%	–2.12%
2021	33.03%	16.08%	39.47%	19.25%
2022	–8.14%	–8.62%	–4.63%	–3.35%
2023	7.94%	9.56%	10.92%	10.38%
2024	28.79%	33.73%	35.14%	34.54%
All periods	11.59%	–1.13%	12.78%	4.22%

Note: The table presents the weekly Sharpe Ratio of four portfolios: (1) including cryptocurrencies, (2) excluding cryptocurrencies, (3) including cryptocurrencies with a 40% weight cap per asset, and (4) excluding cryptocurrencies with a 40% weight cap per asset.

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Table 4. Weekly drawdown by year

Year	With Crypto	Without Crypto	With Crypto (constr. 40%)	Without Crypto (constr. 40%)
2018	–11.00%	–11.54%	–18.36%	–11.77%
2019	–1.18%	–1.19%	–1.09%	–1.19%
2020	–10.80%	–16.04%	–12.79%	–12.19%
2021	0.00%	0.00%	–1.68%	–5.23%
2022	–19.71%	–20.27%	–14.27%	–12.99%
2023	–4.80%	–5.26%	–6.72%	–3.69%
2024	–3.14%	–1.44%	–2.66%	–1.56%
All periods	–26.24%	–23.63%	–19.76%	–15.92%

Note: The table presents the weekly drawdown of four portfolios: (1) including cryptocurrencies, (2) excluding cryptocurrencies, (3) including cryptocurrencies with a 40% weight cap per asset, and (4) excluding cryptocurrencies with a 40% weight cap per asset.

flected in both elevated drawdowns and volatility. This highlights the trade-off between pursuing higher returns and managing risk, particularly when allocation constraints are applied.

4. DISCUSSION

The inclusion of cryptocurrencies in investment portfolios reveals a complex interplay between risk and return dynamics, aligning with and expanding upon findings in existing literature. By incorporating insights from both theoretical perspectives and empirical evidence, this discussion highlights the opportunities and challenges posed by cryptocurrencies as a novel asset class.

The results demonstrate that portfolios including cryptocurrencies consistently outperformed those without them in terms of both total returns and risk-adjusted metrics, such as the Sharpe Ratio (Tables 1 and 3). This is consistent with findings from Maier-Paape and Zhu (2018) and Geboers et al. (2022), which highlight the potential of innovative asset classes to enhance portfolio efficiency when combined with robust risk management techniques. However, the observed concentration of performance gains during speculative market rallies – such as the extraordinary rise between December 2020 and March 2021 – underscores the dependency of cryptocurrencies on specific market conditions. This aligns with literature noting the cyclical nature of speculative asset classes, which tend to exhibit outsized performance during high-growth periods but may underperform or destabilize portfolios during corrections (Ding & Uryasev, 2020).

In line with studies emphasizing the significance of downside risk measures, including Conditional Drawdown at Risk (CDaR) (Goldberg & Mahmoud, 2016; Ding & Uryasev, 2020), this analysis shows that portfolios with cryptocurrencies exhibit higher volatility and drawdowns (Tables 2 and 4). This reflects the inherent price fluctuations of the cryptocurrency market. Interestingly, the application of a 40% weight constraint did not uniformly mitigate risk: instead, constrained portfolios often experienced higher drawdowns, indicating limited diversification benefits. This phenomenon could be tied to the path-dependent nature of risk measures, as highlighted by Geboers and Depaire (2023), which suggest that historical performance and market dynamics significantly influence asset-level risk contributions.

The improved Sharpe Ratios for cryptocurrency-inclusive portfolios (Table 3) demonstrate that the high returns can outweigh the additional volatility, particularly in bullish periods. This finding aligns with Baghdadabad et al. (2013), who noted that innovative risk-adjusted measures could better capture the efficiency gains provided by emerging assets. Moreover, the constrained portfolios with a 40% cap displayed slightly higher Sharpe Ratios than unconstrained portfolios, suggesting that concentration limits, despite their mixed effects on drawdowns, might balance risk and return more effectively during certain market conditions.

Our findings add to the growing body of literature advocating for the inclusion of alternative assets, such as cryptocurrencies, in portfolio construction (Maier-Paape & Zhu, 2018; Geboers et al., 2022). However, the elevated drawdowns and sensitivity to market cycles

point to the need for careful allocation strategies. The evolving landscape of drawdown risk measures, including extensions to systemic risk assessments, offers promising avenues for refining portfolio theory and mitigating extreme losses (Ding & Uryasev, 2020).

CONCLUSIONS

Examining capital allocation among various assets and optimizing the Sharpe Ratio, this paper evaluates the diversification effect of cryptocurrencies as an asset class in terms of performance and risk. This method, which uses a rolling analysis, addresses a critical gap in the literature on how cryptocurrencies are allocated dynamically under different market conditions and time periods.

While highlighting the risks involved, this study offers solid proof of how cryptocurrencies can improve portfolio performance. According to the analysis, portfolios with cryptocurrency outperformed those without in terms of both total return and risk-adjusted metrics like the Sharpe Ratio. However, especially for unconstrained portfolios, this better performance came at the expense of increased volatility and more noticeable drawdowns.

Conforming to the analysis, portfolios with a 40% concentration limit performed more steadily and successfully balanced return and risk. This result is consistent with the ideas of controlled exposure to high-volatility assets and diversification. Interestingly, the addition of cryptocurrencies made a substantial contribution to returns during periods of speculative growth, such as December 2020 – March 2021, which underscores their potential in bull markets.

The study's findings warn against the use of cryptocurrencies while also emphasizing their vital role in portfolio diversification. According to research, allocation strategies that take into consideration cryptocurrencies' unique risk-return characteristics are necessary. Techniques like concentration limits have been shown to be successful in reducing risks while maintaining the benefits of diversification.

These findings have important policy ramifications for both institutional and individual investors. Given their increasing inclusion in diversified portfolios and their capacity to influence market dynamics during speculative growth, such as December 2020–March 2021, demonstrating their potential in bull markets.

To maximize the performance of cryptocurrency-containing portfolios, future studies should investigate more sophisticated risk-management strategies, such as dynamic rebalancing and the incorporation of path-dependent risk measures. The incorporation of cryptocurrencies into scholarly research and real-world investment frameworks will be further improved by deepening our understanding of their function in diversification across different economic cycles.

AUTHOR CONTRIBUTIONS

Conceptualization: Claudio Boido, Mauro Aliano.
Data curation: Claudio Boido, Mauro Aliano.
Formal analysis: Mauro Aliano.
Investigation: Claudio Boido, Mauro Aliano.
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Software: Mauro Aliano.
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