

Svetoslav Borisov**The Impact of Cryptocurrency Inclusion on Portfolio Performance: Risk-Return Tradeoffs and Market Integration**

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Abstract

The integration of cryptocurrencies into investment portfolios has attracted significant interest among scholars and practitioners, yet their capacity to improve or detract from portfolio performance remains subject to ongoing debate. This study examines the risk-return dynamics linked to incorporating cryptocurrencies into conventional investment frameworks, with a focus on diversification potential, volatility transmission mechanisms, and the interplay between cryptocurrencies and traditional markets. Although prior research has addressed these dimensions, critical gaps persist concerning the sustainability of cryptocurrency allocations over extended periods, their behaviour during periods of severe market stress, and the implications of evolving regulatory landscapes. By synthesising insights from contemporary empirical analyses and quantitative financial models, this paper systematically evaluates existing evidence and identifies priority areas for future scholarly inquiry. The findings aim to inform both academic discourse and practical portfolio strategy in an era of rapid financial innovation.

Keywords

Cryptocurrency, Portfolio Performance, Risk-Return Tradeoff, Market Integration, Diversification.

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Introduction

Since Harry Markowitz introduced Modern Portfolio Theory (MPT) in 1952, portfolio investment has evolved considerably. MPT advocates diversification as a strategy to maximize risk-adjusted returns. Traditional asset classes—such as equities, bonds, and commodities—are typically preferred due to their more reliable risk–return profiles and higher liquidity. The emergence of cryptocurrencies, catalysed by Bitcoin’s disruptive decentralization in 2008, introduces both new risks and opportunities for portfolio construction.

The object of this study is to examine the inclusion of cryptocurrencies in investment portfolios. Its subject concerns the analysis of their risk–return characteristics, diversification potential, and integration with traditional financial markets. The scientific aim is to evaluate both the theoretical and empirical impact of cryptocurrencies on portfolio performance and to identify critical research gaps concerning their long-term role, behaviour during systemic crises, and sensitivity to regulatory environments.

This study reviews the existing literature and explores various perspectives on the dual nature of cryptocurrencies as speculative assets and portfolio diversifiers. By presenting methodological limitations and highlighting new research findings, the article seeks to contribute to the integration of crypto assets within the framework of modern portfolio management and to inform future interdisciplinary research.

1. Literature Review

1.1. Modern Portfolio Theory (MPT) and Cryptocurrencies

Importance of the study Markowitz's Modern Portfolio Theory (MPT), presented in 1952, continues to play a key role in asset allocation, focusing on diversification to enhance risk-adjusted returns through the selection of uncorrelated assets. Central to MPT are normally distributed returns and the use of variance or standard deviation as measures of risk (Markowitz, 1952). Yet, cryptocurrencies, such as Bitcoin, question these assumptions due to their non-Gaussian return distributions, high volatility as well as numerous tail events (Eisl, Gasser and Weinmayer, 2015; Yermack, 2015). Bitcoin's historically low correlations with established assets have led to its being billed as a diversifier that, in theory, should make portfolios more efficient. However, its riskiness and volatility bring challenges to the problem of mean-variance optimized investment, due to its inherently speculative nature and market volatility.

To cope with the skewed and leptokurtic returns of Bitcoin, researchers had to resort to risk measures such as Conditional Value-at-Risk (CVaR), which can better capture extreme downside risks (Rockafellar and Uryasev, 2000). Eisl et al. (2015) showed that including Bitcoin in portfolios increased Sharpe and Sortino ratios, despite a minor upsurge in the portfolio's CVaR, in CVaR optimized setups with small relative weights of Bitcoin (Eisl, Gasser and Weinmayer, 2015). However, subsequent studies have exposed weaknesses. After 2015, it emerged that Bitcoin is now more positively influenced by equities in crises, which leads to a depreciation of its hedging capabilities (Yousaf and Yarovaya, 2022). This contradicts recent assertions that Bitcoin is unaffected by traditional markets (Brière, Oosterlinck and Szafarz, 2015).

Empirical findings therefore underscore the dual nature of Bitcoin integration. Whereas some researchers found relatively low correlations between Bitcoin and gold and inflation-linked bonds (Brière, Oosterlinck and Szafarz, 2015), others validated its diversification benefits as measured by downside risk metrics such as semi-variance (Fernandez-Perez *et al.*, 2018). However, with institutional adoption on the rise due to regulatory changes and crypto ETF proposals, the market integration of Bitcoin could be seen as eroding its diversification potential (Wu, 2025). This uncertain regulatory environment and liquidity constraints complicate its positioning in institutional portfolios.

1.2. Empirical Studies on Portfolio Diversification

The limited empirical analyses on the role of cryptocurrencies in portfolio diversification have primarily focused on Bitcoin and Ethereum, due to their dominance and liquidity in financial markets. These cryptocurrencies are known to exhibit low short-term correlations with traditional asset classes—namely, equities, commodities, and safe-haven assets—suggesting some degree of diversification during stable market regimes. For instance, Shahrour et al. (2024) revealed significant bidirectional volatility spillovers between cryptocurrencies and traditional assets, with NEAR and Bitcoin acting as major transmitters (Shahrour et al., 2024).

Methodologically, price indices such as the CRIX have enhanced portfolio analysis by dynamically tracking the crypto market's performance and offering benchmarks with lower tracking error than Bitcoin alone (Trimborn and Härdle, 2018). Nevertheless, given the persistent volatility and systemic risks, caution remains warranted. Kristoufek (2015) sounds a warning that the advantages of diversification may collapse under stress, necessitating more adaptive portfolio strategies (Kristoufek, 2015). Although newer indices—such as the Bitwise 10 and the S&P Cryptocurrency Broad Digital Market Index—offer alternative templates, their heterogeneous methodologies underscore the need for comparative evaluation.

1.3. Market Integration and Systemic Risk

The role of cryptocurrencies in diversified portfolios remains highly contested, owing to their ambiguous classification as hedges, diversifiers, or speculative assets. Historically, gold has functioned as a traditional safe-haven asset. By contrast, Bitcoin and other altcoins exhibit slightly greater liquidity. In its nascent stages, Bitcoin was conceptualized as a credible digital alternative to gold, based primarily on two features: its decentralized architecture and its finite supply (Baur, Hong and Lee, 2018). Subsequent literature suggests that mean reversion effects are less pronounced for cryptocurrencies under certain market regimes.

More recent empirical studies underscore the limitations of Bitcoin's hedging capabilities during systemic crises. Amid the COVID-19 pandemic, Bitcoin exhibited increasing correlation with equities, thereby calling into question its status as a safe-haven asset (Diniz-Maganini, Diniz and Rasheed, 2021; Bampinas and Panagiotidis, 2024). Similar correlation spikes were observed during the 2021 cryptocurrency crash, when volatility spillovers between cryptocurrencies and conventional financial markets intensified (Conlon, Corbet and McGee, 2020). These findings indicate that the diversification benefits of cryptocurrencies tend to deteriorate during periods of market turbulence, despite being more apparent during stable periods.

The evolving correlation dynamics between cryptocurrencies and conventional markets have broader implications for systemic risk. In the absence of fat tails, digital assets often

remain weakly correlated with equities, bonds, and commodities, thereby contributing to diversification (Yousaf and Yarovaya, 2022). However, in times of financial distress, this decoupling collapses, and investor behaviour becomes increasingly synchronized across asset classes. In such contexts, cryptocurrencies may not insulate portfolios but rather amplify systemic risk—particularly when intertwined with emerging sectors such as decentralized finance (DeFi), which often lack institutional safeguards (Shahzad *et al.*, 2019; Gunay *et al.*, 2023).

Moreover, the decentralized and speculative nature of many digital assets gives rise to nonlinear correlation patterns that challenge traditional risk assessment models. Liu *et al.* (2022) emphasize that the absence of coherent regulatory oversight heightens the probability of abrupt market dislocations, especially in highly leveraged or opaque DeFi ecosystems (Liu, Tsyvinski and Wu, 2022). To mitigate exposure to evolving volatility channels, adaptive portfolio strategies—including conditional correlation models and dynamic asset allocation frameworks—are necessary (Engle and Kroner, 1995).

2. Identified Gaps in Current Research

2.1. Long-Term Viability of Cryptocurrencies in Portfolios

The inclusion of cryptocurrencies in conventional investment portfolios remains a subject of ongoing debate. Foundational research identifies Bitcoin's diversification potential, primarily due to its low correlation with traditional asset classes (Brière, Oosterlinck and Szafarz, 2015; Dyhrberg, 2016b, 2016a). However, significant concerns persist regarding its long-term stability as a portfolio allocation.

Whether cryptocurrencies deserve a permanent role in portfolio construction is still an open question. Although empirical findings highlight vulnerabilities during extreme market conditions, they also demonstrate diversification benefits under more stable periods. For instance, the failure of Bitcoin in 2018 led to a substantial increase in downside risk and a nearly 50% reduction in the Sortino ratio for optimized portfolios (Holovatiuk, 2020). This volatility raises questions about the sustainability of cryptocurrency allocations over extended investment horizons. Most studies rely on data from 2014 to 2019—a time frame too narrow to assess long-term performance, particularly given the rapid evolution of the crypto market. Additionally, the dynamic structure of the market—marked by the frequent emergence and disappearance of coins—introduces structural instability that has not been sufficiently addressed in existing research (Hileman and Rauchs, 2017).

Only a limited number of studies explore the long-term return predictability and stability of cryptocurrencies within portfolio contexts. While Urquhart (2016) finds considerable inefficiency in Bitcoin pricing, there is evidence of increasing market efficiency associated with institutionalization and market maturity in later subperiods (Urquhart, 2016). Nonetheless, Bitcoin's inefficient transmission mechanisms may hinder its role as a long-term diversifier or store of value, particularly during periods of heightened volatility. Moreover,

extreme price volatility and recurring speculative bubbles undermine its risk-adjusted performance over long-term horizons (Cheah and Fry, 2015; Dwyer, 2015).

Another unresolved issue concerns the classification of cryptocurrencies as a distinct asset class. Proponents argue that cryptocurrencies fulfil essential criteria for such classification, including internal homogeneity, external heterogeneity, and cost-effective market access—attributes supported by their unique technological design and observed market behaviour (Bianchi, 2020). Critics, however, contend that cryptocurrencies lack intrinsic value, suffer from regulatory ambiguity, and differ functionally from both traditional currencies and asset classes, thereby failing to meet classification standards (Yermack, 2015). Holovatiuk (2020) similarly notes that although cryptocurrencies satisfy certain asset class characteristics, speculation-driven bubbles and liquidity constraints limit their viability for large-scale investment (Holovatiuk, 2020).

Further complicating their classification is the absence of consensus regarding valuation models and risk metrics, which challenges their compatibility with classical portfolio theories such as Modern Portfolio Theory (MPT) and Post-Modern Portfolio Theory (PMPT). As Kurka (2019) emphasizes, the non-normal return distribution of cryptocurrencies renders conventional risk measures inadequate, necessitating the development of new methodologies to evaluate their portfolio inclusion (Kurka, 2019). These contradictions underscore the need for more sophisticated classification frameworks and rigorous empirical validation to assess the asset-class status of cryptocurrencies across diverse market conditions.

2.2. Extreme Market Conditions and Cryptocurrency Behaviour

Despite the proliferation of research evaluating cryptocurrency performance within investment portfolios, a substantial gap in understanding persists regarding the behavior of these assets under extreme market conditions, such as economic crises, market crashes, and high-inflation environments. Although Bitcoin and other cryptocurrencies have been posited as potential safe-haven or diversifying assets due to their decentralized structure and non-sovereign issuance, empirical evidence consistently challenges this classification, particularly during periods of systemic financial stress.

Recent crises, such as the COVID-19 pandemic, provide evidence against the claim that Bitcoin functions as a hedge. According to Conlon and McGee (2020), during the crash initiated by the pandemic, Bitcoin exhibited strong positive correlations with equities, thereby increasing downside risk to portfolios (Conlon and McGee, 2020). They demonstrated that the inclusion of Bitcoin in equity portfolios significantly heightened downside exposure, directly contradicting its purported stabilizing role. Furthermore, Bitcoin's extreme intraday price fluctuations resemble speculative behaviour more than the characteristics of a genuine safe-haven asset.

This contention aligns with a growing body of literature that questions the reliability of cryptocurrencies during periods of financial distress. Baur et al. (2018) and Smales (2019)

highlight structural vulnerabilities—including excessive volatility, liquidity constraints, and transaction inefficiencies—which are magnified during periods of market stress (Baur, Hong and Lee, 2018; Smales, 2019). Under such conditions, widening bid-ask spreads, network congestion, and declining trading volumes further undermine price discovery and efficient market functioning (Gandal *et al.*, 2018). These operational limitations are compounded by regulatory uncertainty and market fragmentation, both of which amplify systemic risk (Greenwood and Thesmar, 2011; Auer and Claessens, 2018).

Some studies have identified episodic diversification benefits arising from low correlations with traditional financial assets. However, these correlations tend to be unstable and often reverse during episodes of acute market stress (Brière, Oosterlinck and Szafarz, 2015; Dyhrberg, 2016b, 2016a). Corbet *et al.* (2018) found that the introduction of Bitcoin futures did not reduce volatility, suggesting a lack of institutional confidence in cryptocurrency markets during periods of turbulence (Corbet *et al.*, 2018). In addition, the speculative nature of cryptocurrencies undermines their utility as hedging instruments, particularly in inflationary environments or periods of prolonged macroeconomic uncertainty.

Critically, much of the existing literature focuses on short-term market reactions to shocks, often neglecting the long-term behaviour of cryptocurrencies across varying crisis regimes. The potential for long-term integration or decoupling from traditional markets remains underexplored, as do the effects of evolving monetary policy and the emergence of regulatory frameworks such as central bank digital currencies (CBDCs). Moreover, the structure of risk transmission during crises has yet to be fully articulated, often involving nonlinear and asymmetric mechanisms, including structural breaks and regime shifts (Goodell, 2020). These gaps underscore the need for longitudinal studies employing high-frequency data and advanced econometric techniques to capture the evolving role of cryptocurrencies in crisis-resilient portfolios.

2.3. Regulatory Uncertainty and Institutional Adoption

The regulatory status of cryptocurrencies remains highly ambiguous and constitutes one of the most significant barriers to their inclusion in institutional portfolio strategies, thereby continuing to cast doubt on their classification as hedging instruments, diversifiers, or speculative assets. Some studies suggest that cryptocurrencies may serve a diversifying role, as they tend to exhibit low correlations with traditional financial assets. However, this potential benefit is often eroded during periods of market turmoil, when correlations surge due to herd behavior and systemic shocks (Dutta *et al.*, 2020; Demiralay and Bayracı, 2021). Such inconsistency raises critical concerns about the reliability of cryptocurrencies as hedging tools, especially under highly volatile market conditions.

Regulatory risk further exacerbates this uncertainty by introducing legal ambiguity concerning both asset behavior and investor strategies. Shifting regulatory frameworks influence investor sentiment, liquidity, and volatility, thereby altering the risk-return profile of portfolios that include cryptocurrencies (Corbet *et al.*, 2019; Iyer, 2022). In jurisdictions

lacking coherent and consistent regulatory guidance, asset prices tend to be more sensitive to policy announcements, which fosters speculative behaviour and undermines the long-term efficacy of diversification strategies.

Despite the increasing interest shown by institutional investors, there is a notable paucity of empirical studies that examine how institutional adoption actually modifies the risk-return characteristics of portfolios. Limited inroads into institutional participation have been facilitated by the introduction of regulated financial instruments, such as exchange-traded products and futures contracts. However, the extent to which such institutional engagement stabilizes or destabilizes cryptocurrency markets remains poorly understood (Ampountolas, 2022; Shahzad *et al.*, 2022). Furthermore, how institutional flows influence liquidity, volatility, and cross-asset correlations—and how these dynamics interact with regime shifts brought about by regulatory developments—remains largely unexplored.

The literature, therefore, reveals a substantial gap concerning the interaction between regulatory uncertainty and institutional participation in shaping portfolio optimization and systemic resilience. While there is growing recognition of the disruptive potential of evolving regulatory regimes, models that can incorporate these dynamic features into portfolio construction and asset pricing frameworks are still in their infancy. Future research must address these deficiencies by integrating regulatory variables into empirical assessments of portfolio performance, with particular focus on institutional behaviour under legal ambiguity and market stress (Liu and Tsyvinski, 2018; Zhang *et al.*, 2021).

3. Methodological Challenges in Cryptocurrency Portfolio Research

The inclusion of cryptocurrencies in portfolio analysis introduces significant methodological complexities. Among the foremost challenges is the credibility of available data, which critically influences the accuracy and replicability of empirical research. Cryptocurrencies are traded across numerous decentralized exchanges, each varying in transparency and volume reporting standards. This market fragmentation complicates data aggregation and exposes analyses to microstructure noise and distortions induced by arbitrage activities (Platanakis & Urquhart, 2020). Moreover, the relatively short trading histories of most digital assets, combined with the frequent turnover of newly issued coins, result in datasets with limited temporal depth. The absence of long-term, high-quality historical data introduces substantial estimation risk in portfolio construction, particularly when modeling covariance structures or back-testing strategies across market cycles (Phillip, Chan, & Peiris, 2018).

Beyond data limitations, the statistical properties of cryptocurrencies often violate core assumptions of classical asset pricing models. Foundational theories—such as the Capital Asset Pricing Model (CAPM) and Modern Portfolio Theory (MPT)—rely on normally distributed returns, time-invariant correlations, and a stable risk–return relationship. In contrast, cryptocurrencies exhibit fat-tailed distributions, excess kurtosis, volatility clustering, and stochastic volatility, all of which undermine the predictive validity and applicability of

these traditional models (Bariviera, 2017; Fung, Jeong, & Pereira, 2022). Additional complexities, such as long memory and leverage effects, further obscure the risk–return dynamics of digital assets, particularly during periods of market stress—such as the COVID-19 pandemic—when traditional diversification benefits diminish and hedge ratios deteriorate (Tarchella, Khalfaoui, & Hammoudeh, 2024). In such dynamic environments, static portfolio models based on historical averages become increasingly obsolete.

To address these challenges, researchers have begun incorporating advanced econometric and machine learning methodologies tailored to the evolving structure of cryptocurrency markets. Various multivariate GARCH models, including Dynamic Conditional Correlation (DCC-GARCH) and its asymmetric variant (ADCC-GARCH), have been applied to capture time-varying volatilities and correlations between cryptocurrencies and traditional financial assets (Katsiampa, 2017). However, these models often struggle to accommodate structural breaks and regime shifts—features endemic to digital asset markets due to technological innovation, macroeconomic shocks, or regulatory interventions. As a result, regime-switching models such as Markov-Switching GARCH and Smooth Transition Autoregressive (STAR) models have been employed to better reflect abrupt transitions in asset behavior and correlation structures (Mariana, Ekaputra, & Husodo, 2021).

As financial markets become increasingly complex and exhibit non-stationary behavior, machine learning techniques have gained traction for modeling multidimensional, non-linear relationships. Algorithms such as random forests, gradient boosting, and deep neural networks have demonstrated superior performance in tasks including return forecasting, volatility estimation, and market classification—particularly when applied to high-frequency or sentiment-based data (Trucíos, Tiwari, & Alqahtani, 2020; Fazlollahi & Ebrahimi-jam, 2023). These data-driven approaches adapt in near real time to shifting market conditions and can incorporate a wide array of exogenous variables, including macroeconomic indicators, social media sentiment, and regulatory developments. Nevertheless, their implementation introduces new challenges, such as reduced model interpretability, risk of overfitting, high computational demands, and the absence of standardized benchmarks for evaluating predictive accuracy across varying market regimes.

4. Future Research Directions

Future research on cryptocurrency pricing mechanisms must deepen the understanding of the long-term sustainability of digital assets within investment portfolios. The dynamic and evolving nature of these relationships necessitates the continuous assessment of the diversification benefits provided by cryptocurrencies over time. As the mainstream status of cryptocurrencies shifts—driven by technological innovation and evolving regulatory frameworks—research must evaluate whether these developments in pricing mechanisms warrant corresponding revisions in optimal asset allocation strategies across varying market regimes.

Future investigations should also examine the resilience of cryptocurrencies during systemic crises, such as the COVID-19 pandemic or the collapse of algorithmic stablecoins. For example, the 2022 de-pegging of Terra raised critical questions about the robustness of stablecoin stabilization mechanisms under acute liquidity stress, as well as their potential spillover effects on traditional financial markets (Lyons & Viswanath-Natraj, 2023; Urquhart & Yarovaya, 2023). Real-time blockchain monitoring remains an underutilized tool for identifying behavioral patterns such as herding, panic-driven liquidation, and speculative bubbles. Integrating on-chain analytics with traditional financial models may support the development of theoretically grounded early warning systems and stress-tested portfolio strategies (Makarov & Schoar, 2022; Jahanshahloo, Irresberger, & Urquhart, 2023).

Moreover, further research is needed into the interaction between regulatory interventions and illicit activity under turbulent market conditions, particularly regarding their implications for market stability. While early Bitcoin markets were characterized by significant illicit use (Foley et al., 2019), additional study is required to assess whether anti-money laundering frameworks and blockchain surveillance technologies can preserve market integrity during periods of stress (Foley, Karlsen, & Putnins, 2019). The emergence of Central Bank Digital Currencies (CBDCs) introduces an additional dimension, particularly concerning their potential to stabilize or destabilize markets amid geopolitical or macroeconomic shocks (Gkillas et al., 2022; Hou et al., 2022).

In parallel, environmental sustainability concerns associated with proof-of-work consensus mechanisms—especially during periods of energy crisis—underscore the urgency of researching the feasibility and effectiveness of more energy-efficient alternatives, such as proof-of-stake protocols (Corbet, Lucey, & Yarovaya, 2021; De Vries, 2023).

Conclusion

The inclusion of cryptocurrencies in investment portfolios presents both opportunities and significant risks, as demonstrated by empirical investigations and theoretical frameworks. The most salient findings suggest that cryptocurrencies—with Bitcoin more so than others—offer diversification benefits due to historically low correlations with traditional asset classes. However, these advantages are tempered by notable drawbacks, including extreme volatility, non-normal return distributions, and heightened sensitivity to market stress, all of which complicate their long-term viability as stable portfolio components. While some studies show that cryptocurrencies can enhance risk-adjusted returns during periods of market stability, they often fail to function as effective hedging instruments during crises, as correlations with equities tend to rise and downside risks intensify. A key determinant of their portfolio performance is the regulatory uncertainty surrounding cryptocurrency investments, which directly affects their risk–return profile. The absence of consistent global regulation, coupled with abrupt policy shifts, contributes to market fragmentation, liquidity constraints, and increased volatility. These conditions undermine the diversification potential of cryptocurrencies. Furthermore, the increasing integration of

cryptocurrency markets with traditional financial systems, spurred by institutional adoption and market maturation, may erode the low-correlation advantages initially observed.

Effective cryptocurrency allocation requires strategic nuance—balancing the potential for diversification gains with the inherent risks. Dynamic asset allocation strategies, such as adaptive rebalancing and risk-budgeting frameworks, can help mitigate volatility during periods of market stress. Given their speculative nature and sensitivity to regulatory announcements, cryptocurrencies should be evaluated using scenario analyses and stress testing to assess resilience under adverse conditions. While some investors view cryptocurrencies as a distinct asset class, others remain sceptical. As such, allocations should be approached cautiously, based on individual risk tolerance and investment horizons.

Policymakers must strike a careful balance between fostering innovation and maintaining market stability. The harmonization of regulatory frameworks is essential for reducing uncertainty, enhancing transparency, and protecting investors from fraud and manipulation. Additionally, systemic risk assessments should include stress testing to evaluate the impact of the integration of cryptocurrencies during crises. Regulatory sandboxes and pilot programs may also prove instrumental in monitoring and adapting to innovations in the cryptocurrency ecosystem, including stablecoins and decentralized finance (DeFi) platforms.

While research on cryptocurrency markets continues to advance, several critical gaps remain. Longitudinal studies are needed to evaluate the sustainability of diversification benefits as markets mature and regulatory landscapes stabilize. Further investigation is also required to understand how extreme market events—such as asset bubbles and crashes—influence portfolio dynamics and how regulatory changes shape risk–return profiles. Comparative analyses across different cryptocurrencies and the development of adaptive modeling techniques, including the use of machine learning and high-frequency data, may improve the robustness of portfolio optimization. Closing these gaps will be crucial for advancing theoretical knowledge and offering practical insights for investors and policymakers operating in an evolving digital asset landscape.

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