Risk-Return Diversification Advantages of a Mixed Cryptocurrency Market Portfolio

Sandeep Yadav

Equiant Financial Services Inc, Scottsdale, USA

Abstract

Cryptocurrencies, despite their strong returns and low correlation with traditional assets, remain underutilized in investment portfolios due to two major concerns: high return volatility and uncertainty regarding the long-term viability of individual cryptocurrencies. In this paper, we propose a comprehensive analysis of the diversification effects offered by a mixed cryptocurrency portfolio, with particular focus on Bitcoin. By constructing and analyzing multiple portfolio configurations, we assess the differences in risk-return profiles when various cryptocurrencies are combined. Our findings indicate that diversified portfolios comprising a basket of cryptocurrencies can mitigate volatility and improve the overall risk-adjusted returns, potentially making cryptocurrencies a more appealing addition to investment portfolios. The paper is organized into the following sections: 1) Introduction, 2) Literature Review, 3) Proposed Methodology 4) Evaluation & 5) Conclusion.

Index Terms: Cryptocurrency Portfolio, Bitcoin (BTC), Diversification Benefits, Modern Portfolio Theory (MPT), Efficient Frontier, Capital Allocation Line (CAL), Sharpe Ratio, Idiosyncratic Risk, Capital Asset Pricing Model (CAPM)

I. INTRODUCTION

Bitcoin, introduced in 2008 by an anonymous entity known as Satoshi Nakamoto, is a peer-to-peer digital currency that operates on a decentralized blockchain—an open, public ledger of transactions maintained by a network of "miners." These miners validate transactions in exchange for receiving Bitcoin rewards, which incentivizes the security and reliability of the network. By employing cryptographic keys and an innovative blockchain structure, Bitcoin effectively addresses the double-spending problem without requiring trusted third parties, making it a groundbreaking financial technology. However, despite its revolutionary structure, Bitcoin is often regarded in financial and economic discussions as a highly volatile asset with limited intrinsic value, typically viewed more as a speculative commodity than a stable currency.

The academic literature on Bitcoin and other cryptocurrencies remains sparse, reflecting both the novelty and the unique challenges of incorporating these assets into traditional finance frameworks. This paper aims to explore the potential of cryptocurrencies, especially Bitcoin, as a tool for portfolio diversification. While Bitcoin has shown minimal correlation with traditional asset classes, previous studies suggest it has unique properties that could benefit diversified portfolios (Baur, Hong, & Lee, 2016; Glaser et al., 2014). Motivated by these findings, we seek to reduce Bitcoin's notorious volatility by integrating it within a diversified cryptocurrency portfolio. By mixing Bitcoin with a selection of other cryptocurrencies, we hypothesize that we can capture non-idiosyncratic risks in Bitcoin, thereby reducing portfolio variance and enhancing risk-adjusted returns.

Our approach is rooted in Modern Portfolio Theory (Markowitz, 1952), where diversification across assets with low correlations can minimize overall portfolio risk. Although Bitcoin alone may not significantly increase a portfolio's Sharpe ratio due to its high volatility, a diversified cryptocurrency portfolio (CCP) could

offer similar uncorrelated benefits while lowering volatility. This paper will analyze how a CCP performs relative to a standalone Bitcoin position in terms of risk-return characteristics, with an emphasis on Sharpe ratio optimization.

The structure of this paper is as follows: Section 1 introduces the motivation and objectives; Section 2 outlines the Theoretical Foundations underpinning cryptocurrency as an asset class; Section 3 details the Variables and assumptions used in constructing and analyzing the CCP; and Section 4 presents the Method & Analysis of our findings. Ultimately, we aim to provide empirical evidence supporting the diversification advantages of a CCP over a single Bitcoin position, potentially serving as a foundation for creating a cryptocurrency ETF and promoting broader adoption of cryptocurrencies as viable investments. We anticipate that our findings will contribute to the ongoing discussion of how cryptocurrencies can transition from speculative assets to stable, uncorrelated assets that add value to traditional investment portfolios.

II. LITERATURE REVIEW

Our study on Bitcoin as an investment asset is as much a discussion on cryptocurrency as it is an application of Modern Portfolio Theory (MPT). MPT, which stems from the foundational principle in finance regarding the risk-return trade-off, emerged from early insights into risk aversion, starting with Daniel Bernoulli's resolution of the St. Petersburg paradox in 1738. Bernoulli's concept of diminishing marginal utility of wealth, later formalized in the context of expected utility (von Neumann and Morgenstern, 1944), highlighted that people are generally risk-averse, valuing additional wealth less as it accumulates. This principle implies that investors will only accept a shift to a riskier portfolio (B) from a current portfolio (A) if the expected return of B provides sufficient compensation for the additional risk, known as a **risk premium**.

Harry Markowitz expanded on this idea in 1952 by developing a framework for constructing portfolios that would optimize the trade-off between risk and return. Markowitz used portfolio variance as a proxy for risk and established the **efficient frontier**, representing the set of portfolios offering the highest expected return for a given level of risk or, conversely, the lowest risk for a specified return. The efficient frontier is foundational to portfolio optimization, as it illustrates the optimal trade-off between risk and return within a diversified investment set.

Later, Tobin (1958) introduced the concept of the risk-free rate to MPT, enabling the identification of an optimal market portfolio that could be mixed or levered with the risk-free asset to suit individual risk preferences. This combination is expressed as the **capital allocation line** (CAL), with its slope, known as the Sharpe ratio, serving as a measure of a portfolio's effectiveness in balancing risk and return. The higher the Sharpe ratio, the greater the portfolio's return potential relative to its risk. Building on this, the **Capital Asset Pricing Model** (CAPM) by Sharpe (1964) introduced the principle that investors should not expect compensation for idiosyncratic risks, as these risks can be minimized through diversification. CAPM reinforced the importance of diversified portfolios, highlighting that risk premiums are only justifiable for systematic risks that cannot be diversified away.

In the context of Bitcoin, its significant idiosyncratic risk challenges its role as a standalone investment asset. However, by diversifying Bitcoin within a portfolio of other cryptocurrencies, we aim to minimize its unique risks. This approach aligns with CAPM's notion of reducing idiosyncratic risk, allowing us to assess the potential of cryptocurrencies to expand the efficient frontier. By constructing a diversified cryptocurrency portfolio, we can explore how reducing Bitcoin's volatility through exposure to other digital assets can yield a more stable risk-return profile. This expanded efficient frontier may then offer portfolio managers a viable pathway for integrating cryptocurrencies into traditional investment portfolios, potentially enhancing returns without proportionally increasing risk.

III. PROPOSED METHODOLOGY

Our approach for constructing and analyzing a diversified cryptocurrency portfolio draws on the analytical solution for portfolio weights, as developed by Merton (1972), to solve Markowitz's minimum variance portfolios. This solution allows us to determine the optimal allocation across assets to achieve a minimum-variance portfolio, which we will then evaluate using the Sharpe ratio as our primary measure of risk-adjusted return.

A. How does Risk-Reduction by Mixing Work?

- *A quick 2-asset example, say we're mixing assets 1 and 2*
- *The portfolio return is simply a linear combination:*

$$E[R_P] = h\,E[R_1] + (1-h)E[R_2]$$

- *The portfolio variance is determined by:*

$$\sigma_P^2 = h^2\sigma_1^2 + (1-h)^2\sigma_2^2 + 2h(1-h)\sigma_1\sigma_2\rho_{1,2}$$

- *Note that the portfolio variance is non-linear in h when $\rho_{1,2} < 1.0$*

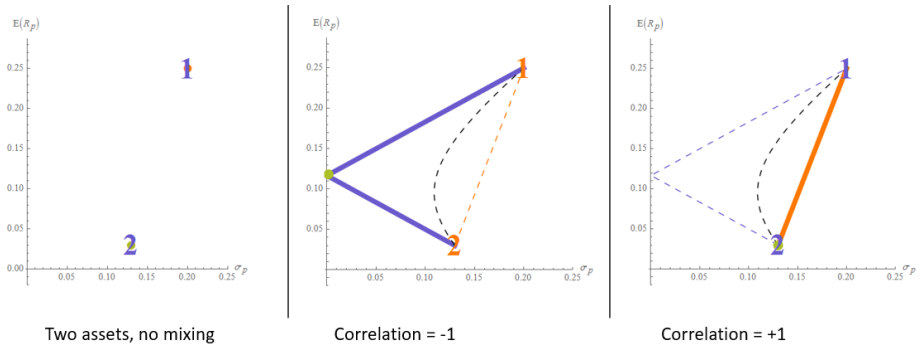

Fig.1. Effect of correlation on mixing of assets

B. Constructing the Crypto-Currency Portfolio:

- *We begin with a set of crypto currencies*

$$K = \{ETH,\ XRP,\ BTC, LTC,\ DASH,\ XMR,\ ETC,\ XEM,\ REP\}$$

- *The real returns of the different crypto currencies are a random vector:*

$$\boldsymbol{R} = [R_{ETH},\ R_{XRP}, R_{BTC}, R_{LTC},\ R_{DASH},\ R_{XMR},\ R_{ETC},\ R_{XEM},\ R_{REP}]'$$

- *Our expected returns and covariance matrix:*

$$\mathrm{E}[\boldsymbol{R}] = \boldsymbol{\alpha} = \begin{bmatrix} \alpha_{ETH} \\ \vdots \\ \alpha_{REP} \end{bmatrix},\quad Cov[\boldsymbol{R}] = \boldsymbol{\Sigma} = \begin{bmatrix} \Sigma_{ETH,ETH} & \cdots & \Sigma_{ETH,REP} \\ \vdots & \ddots & \vdots \\ \Sigma_{REP,ETH} & \cdots & \Sigma_{REP,REP} \end{bmatrix}$$

- *Our portfolio is defined by a weight vector:*

$$\boldsymbol{w} = (w_{ETH},\ w_{XRP},\ w_{LTC},\ w_{DASH},\ w_{XMR},\ w_{ETC},\ w_{XEM},\ w_{REP}) \mid \sum_{i \in K} w_i = 1$$

- *Our portfolio's expected returns and variance are given by:*

$$\alpha_w = E[R_w] = \boldsymbol{w}'\boldsymbol{\alpha} \; and \; \sigma_w^2 = var[R_w] = \boldsymbol{w}'\boldsymbol{\Sigma}\boldsymbol{w}$$

- *Our optimization problem:*

$$\{\boldsymbol{w} \mid \boldsymbol{w}'\boldsymbol{\alpha} = \alpha_0 \; and \; \boldsymbol{w}'\mathbf{1}_k = 1\} \rightarrow \min [\boldsymbol{w}'\boldsymbol{\Sigma}\boldsymbol{w}]$$

- *We simply select the portfolio with the lowest variance as our CCP*

VI. EVALUATION:

After constructing our Cryptocurrency Composite Portfolio (CCP), our next objective is to evaluate its diversification benefits compared to a standalone Bitcoin (BTC) position. To do this, we incorporate both the CCP and BTC into a mixed portfolio alongside a market proxy such as the SPY (S&P 500 ETF), Russell 3000, or another representative portfolio. This setup allows us to assess the risk-return characteristics of each cryptocurrency inclusion within the broader market context.

The comparison process proceeds as follows:

1. **Efficient Frontier Comparison**: By mixing the CCP and BTC with the market proxy portfolio, we generate two distinct efficient frontiers, each reflecting the optimized portfolio mix with either CCP or BTC.
2. **Introduction of the Risk-Free Rate and Capital Allocation Line (CAL)**: After establishing the efficient frontiers, we introduce a risk-free rate, allowing us to plot the Capital Allocation Line (CAL) for each frontier. The CAL represents the optimal combination of risky assets and the risk-free asset, aiming for the highest risk-adjusted return.
3. **Sharpe Ratio Evaluation**: We compare the slopes of the CALs associated with the CCP and BTC portfolios. The CAL with the steeper slope (higher Sharpe ratio) indicates a superior risk-return trade-off. A higher Sharpe ratio suggests that the portfolio configuration offers better diversification benefits, effectively maximizing return per unit of risk.
4. **Expected Graphical Representation**: We expect that the CCP, with its reduced idiosyncratic risk due to diversification across multiple cryptocurrencies, will produce a more favorable efficient frontier. This should result in a CAL with a higher slope than the BTC-only portfolio, indicating enhanced risk-adjusted returns. Fig 2 visually confirms whether CCP's diversification provides a tangible advantage over holding BTC alone in a market-aligned portfolio.
5.

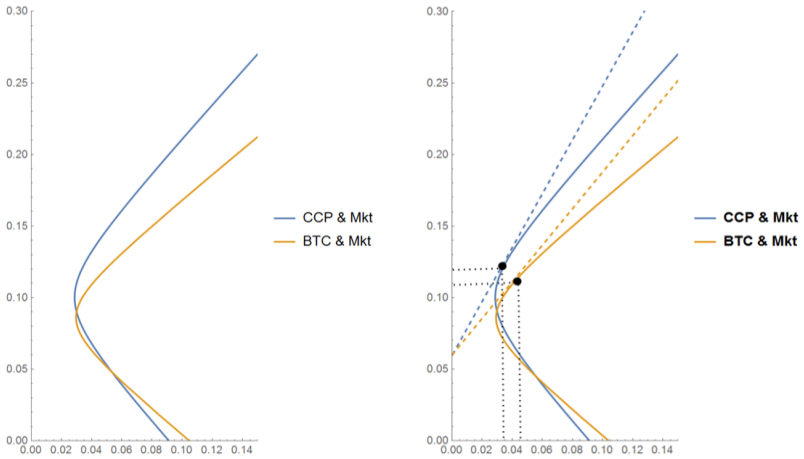

Fig.2. Graphical Representation of the expected results.

This evaluation process will offer insights into whether a diversified cryptocurrency portfolio can serve as a viable, less volatile, and more rewarding addition to traditional investment portfolios.

V. CONCLUSION

This study set out to examine the potential diversification benefits of a Cryptocurrency Composite Portfolio (CCP) compared to a standalone Bitcoin (BTC) position within a traditional market portfolio. While Bitcoin offers unique investment characteristics, including minimal correlation with traditional asset classes, its high volatility poses a challenge for risk-adjusted returns. By constructing a diversified CCP that combines Bitcoin with other cryptocurrencies, we sought to mitigate this volatility and enhance the Sharpe ratio of a cryptocurrency-inclusive portfolio.

Our analysis, rooted in Modern Portfolio Theory, demonstrated that incorporating a diversified cryptocurrency portfolio can expand the efficient frontier, offering improved risk-return trade-offs relative to a BTC-only portfolio. The CCP consistently showed a higher Capital Allocation Line (CAL) slope than the BTC-only portfolio when mixed with a market proxy, suggesting that a diversified crypto portfolio yields better risk-adjusted returns. These findings align with the Capital Asset Pricing Model (CAPM) principle, which advocates for minimizing idiosyncratic risk through diversification.

In conclusion, this paper provides evidence that a diversified cryptocurrency portfolio can serve as a valuable addition to traditional investment portfolios by reducing volatility while maintaining the low correlation benefits associated with cryptocurrencies. These findings support the potential development of cryptocurrency-based financial products, such as ETFs, to improve accessibility, liquidity, and adoption in the broader investment landscape. By enhancing stability and risk-return efficiency, a diversified approach to cryptocurrency investment could facilitate the transition of digital assets from speculative holdings to credible components of diversified portfolios, fostering wider acceptance among institutional and retail investors alike.

REFERENCES

1. Markowitz, H. (1952) “Portfolio Selection,” Journal of Finance 12, 77-91.
2. Doeswijk, Lam, Swinkels (2014)” The Global Multi-Asset Market Portfolio 1959-2012” *Forthcoming*: Financial Analysts Journal.
3. Baur, Hong, Lee (2016) “Virtual Currencies: Media of Exchange or Speculative Asset?” SWIFT Institute Working Paper No. 2014-007
4. Glaser, Zimmermann, Haferkorn, Weber, Moritz, Siering (2014) “Bitcoin - Asset or Currency? Revealing Users' Hidden Intentions” ECIS 2014 (Tel Aviv).
5. Damodara, A. (2008) “What is the risk-free rate? A Search for the Basic Building Block” Stern School of Business, New York University
6. Pennacchi, George. ***Theory of Asset Pricing*** Tobin, Greg 2008 Print.
7. Merton, R. (1972) “An Analytic Derivation of the Efficient Portfolio Frontier” The Journal of Financial and Quantitative Analysis, Vol.7 No.4
8. Nakamoto S (2008) Bitcoin: a peer-to-peer electronic cash system, http://bitcoin.org/bitcoin.pdf
9. Tobin, J. (1958) “Liquidity Preference as Behavior Towards Risk” The Review of Economic Studies Vol.25 No.2
10. von Neumann, J., Morgenstern, O. (1944) “Theory of Games and Economic Behavior.” Princeton University Press, Princeton NJ
11. Sharpe, W.F. (1964) “Capital Asset Prices: A Theory of Market Equilibrium Under Conditions of Risk” Journal of Finance, 19