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The Value of Cryptocurrency in an Efficient Portfolio

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by

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An Honors Thesis in partial fulfillment of the requirements for the degree Bachelor of Science in Business Administration in Finance.

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Abstract

With the recent approval of Bitcoin-backed exchange traded-funds, it is now easier than ever for mainstream investors to gain exposure to cryptocurrencies. This paper aims to employ the Markowitz efficient frontier model to determine the potential for cryptocurrency investment to increase the risk-adjusted performance of a diversified portfolio of stocks and bonds. The analysis finds that investors can expect a meaningful increase of 4.41% to the risk-adjusted performance of their portfolio when allocating 4.83% of their total investment to cryptocurrency. However, this potential increase is highly sensitive to cryptocurrency returns, volatility, and correlations to stock. As such, whether adding cryptocurrency investment to an investor's diversified portfolio is advisable is strongly dependent on that investor's expectations regarding the future performance of cryptocurrencies.

Introduction

Since their creation, cryptocurrencies such as Bitcoin have piqued interest among speculators and investors alike. Recently, the latter group has been especially engrossed with the fledgling asset's prospects. In January of 2024, the *Wall Street Journal* reported that the SEC had authorized the sale of Bitcoin-backed exchange-traded funds, a landmark decision that now enables "mainstream investors to buy and sell bitcoin as easily as stocks and mutual funds" (Huang & Kiernan, 2024). Leading investment firms such as Blackrock and Fidelity jumped to be among the first to offer Bitcoin ETFs, and some firms, such as Franklin Tempelton, have even begun advocating for customers to add Bitcoin to their traditional stock-bond portfolios (Greifeld, 2024). With mainstream investment advisors preaching the profit potential of cryptocurrencies, it has become ever salient for investors to understand whether they should include Bitcoin and its contemporaries in their portfolios. This paper aims to apply the Markowitz efficient frontier model to determine whether investments in cryptocurrencies have potential to significantly improve the risk-adjusted performance of an everyday investor's diversified portfolio.

Based on historical assumptions, cryptocurrency investment may have a small but meaningful role in increasing the risk-adjusted performance of a typical stock-bond portfolio. The addition of cryptocurrency investment to a simple portfolio of stocks and bonds can increase risk-adjusted performance by up to 4.41%. However, this impact on portfolio performance is highly sensitive to changes in the cryptocurrency landscape, such as shifts in cryptocurrency expected returns, standard deviations, and correlations to traditional assets. A 15% decrease in cryptocurrency returns, for example, would greatly reduce the asset's weight and lower the increase in risk-adjusted performance to just 1.47%. A decrease in cryptocurrency returns of 30% would practically eliminate cryptocurrency investment and any potential performance gains from the portfolio. Thus, whether an investor should decide to add cryptocurrencies to their traditional portfolio is heavily dependent on his or her individual expectations on the future of cryptocurrency risk and returns.

Literature Review

Engineered as a means of decentralized payment, Bitcoin was never intended to become an investment-grade asset (Nakamoto, 2008). As such, literature on the role of Bitcoin and its contemporaries in portfolio optimization is not abundant. What literature is available, however, generally agrees that investment in cryptocurrencies can improve the performance of a well-diversified portfolio.

Brière et al. (2015), one of the first published studies to examine a cryptocurrency's impact on portfolio performance, measures the effect of adding investment in Bitcoin to a portfolio of both traditional assets (stocks and bonds) and alternative assets (real estate and commodities). The paper concludes that a small investment in Bitcoin "may dramatically improve the risk-return trade-off of well-diversified portfolios." This study, however, only examines Bitcoin returns from 2010 to 2013, long before cryptocurrencies had entered the mainstream market. Thus, this study is not representative of what a typical investor may experience when investing in cryptocurrencies today.

Akhtaruzzaman et al. (2020) also concludes that Bitcoin has the potential to increase the risk-adjusted performance of a diversified portfolio. The paper examines Bitcoin in relation to industry portfolios, which would not be typical investments of the average investor.

Additionally, this study does not account for the diversification benefits present when investing in multiple cryptocurrencies simultaneously (Brauneis & Mestel, 2019).

Finally, Petukhina et al. (2021) provides thorough analysis of a portfolio of 52 cryptocurrencies and 16 traditional assets. The study determines that investors who seek a well-diversified portfolio, and are willing to bear some additional risk, can find benefit from investing in cryptocurrencies. A shortcoming of this paper is its inclusion of fiat currency and foreign bond investment, assets not typically included in the simple diversified portfolios of everyday investors.

Data

A diversified portfolio of traditional assets was created using the Vanguard 500 Index Fund Admiral Shares (VFIAX) and the iShares iBoxx $ Investment Grade Corporate Bond ETF (LQD). VFIAX was chosen as it is a consistent proxy for the entire stock market while LQD serves as a broad index tracking the corporate bond market. Returns for both assets over a 251-month period beginning August 2002 and ending June 2023 were collected from the Center for Research in Security Prices (CRSP) database. The average monthly risk-free rate over the same 251-month period was calculated using data sourced from the Wharton Research Database Service. Monthly returns and standard deviations were then converted to yearly rates.

[Insert Table 1 Here]

For the cryptocurrency investment, a market-cap weighted portfolio consisting of five of the largest cryptocurrencies as of June 2023 (Bitcoin [BTC], Ethereum [ETH], Binance Coin [BNB], Ripple [XRP], and Cardano [ADA]) was engineered from historical market cap and returns data provided by coinmarketcap.com. The way this portfolio is constructed does create potential for look-ahead bias, which could cause the performance of the cryptocurrency portfolio to be overstated. The expected impact of this bias is minimal, as will be discussed in detail within the limitations section. The returns data for the portfolio was collected over a 66-month period starting January 2018 and ending June 2023. It is important to note that crypto returns were calculated based on the last day of each month (rather than the last trading day, as in the case of stocks and bonds). This creates some noise between the monthly returns of the traditional assets and cryptocurrency but is not expected to have materially affected the results of the study.

To test the hypothesis, an efficient frontier for all asset combinations (stocks & bonds; stocks & crypto; bonds & crypto; and stocks, bonds, & crypto) was created using the Monte Carlo method. With Microsoft Excel, expected return and standard deviation were charted for 10,000 potential portfolios of each asset combination. Then, the optimal portfolio of each asset combination was calculated using Excel's built-in Solver function. Finally, several sensitivity and scenario analyses were run on the three-asset portfolio by changing one or more key variables to the efficient frontier calculation (returns, standard deviation, and/or correlation).

Control Condition

Before testing the hypothesis, a control condition had to be designated. A two-asset portfolio consisting of stocks and corporate bonds was chosen as the control because it represents a traditional portfolio that an everyday investor may consider. The optimal portfolio of this combination has an expected return of 7.67%, a standard deviation of 9.51%, and a Sharpe ratio of 0.68. The ideal weights are 49.81% in stocks and 50.19% in bonds.

Two Asset Portfolios

The first experiment examined crypto's potential as a key component in a traditional two-asset portfolio. A two-asset portfolio typically consists of a relatively safe asset such as bonds and a relatively risky asset such as stocks. Given its historical volatility, high returns, and lower correlation to bonds, crypto may have potential to replace stocks as the risky asset in a simple diversified portfolio. However, the analysis finds that investing in bonds & crypto (90.27% in bonds and 9.73% in crypto) produces a significantly lower Sharpe ratio of 0.58 compared to that of the control condition. Clearly, crypto cannot serve as an effective substitute to stocks in a traditional portfolio.

The next test was to determine the impact of replacing bonds with crypto in the two-asset portfolio. While a portfolio of stocks and cryptocurrency is certainly not traditional in the sense that it is two volatile assets put together, such a combination could prove ideal for investors seeking a larger risk appetite. When invested in stocks & crypto (90.47% in stocks and 9.53% in crypto), the optimal portfolio offers a similar Sharpe ratio to the control of 0.68. However, this portfolio's expected return and standard deviation are far greater than that of the control combination (13.39% and 17.87% respectively). Due to its similar risk-adjusted performance but greater overall risk level, investing in stocks & crypto may be a competent strategy for investors looking to increase their risk exposure. For typical investors, however, the lower overall risk of the control portfolio is likely superior.

[Insert Figure 1 Here]

Three Asset Portfolio

It is improbable that an investor would choose to completely replace one of the primary assets in their diversified portfolio with a volatile, unproven asset such as crypto. Stocks and bonds have decades of proven performance while cryptocurrencies are still in their infancy. Thus, a more realistic investigation would be to determine the effects of adding crypto to a portfolio of stocks and bonds, rather than using it as a substitution.

Adding crypto to the control combination produces an optimal portfolio with a Sharpe ratio of 0.71 (48.71% in stocks, 46.46% in bonds, and 4.83% in crypto). This portfolio of traditional assets and cryptocurrency presents markedly higher performance than a portfolio consisting solely of stocks and bonds.

[Insert Figure 2 Here]

Crypto's role in increasing the risk-adjusted performance of the portfolio is small, but meaningful. With just under 5% of the investment assigned to crypto, the portfolio now presents 4.41% greater Sharpe ratio performance (0.71 vs the control's 0.68). This performance gain, however, assumes that crypto's historical movements will match its future trajectory. A shift in the asset's returns, volatility, or even correlation to other assets could result in an entirely different conclusion.

Sensitivity Analyses: Crypto Expected Returns

Cryptocurrencies have historically averaged far greater returns than traditional asset classes such as stocks or bonds. The cryptocurrency landscape, however, is ever-changing. Shifts in regulatory policy, increases in fraudulent activity, or even changes of public opinion could all reduce crypto's returns going forward.

Reducing the expected return of the crypto portfolio by 15% results in a Sharpe ratio of 0.69 when invested 49.20% in stocks, 48.13% in bonds, and 2.67% in crypto. Under this circumstance, crypto's weight in the three-asset portfolio is nearly halved. Additionally, the

increase in Sharpe ratio over the control combination is now just 1.47%. Still, adding crypto does somewhat significantly increase the portfolio's risk-adjusted performance. An investor who foresees cryptocurrency returns falling by 15% or less would see performance increases by adding crypto to their portfolio.

[Insert Figure 3 Here]

When decreasing crypto's return by 30%, the optimal portfolio presents a Sharpe ratio of 0.68 (49.64% in stocks, 49.61% in bonds, and 0.74% in crypto). Crypto's role in this circumstance is largely negligible and its addition offers no significant increase in risk-adjusted performance over the control combination. Investors who expect cryptocurrency returns to fall by 30% or more would not find benefit in adding crypto to their traditional portfolio.

[Insert Figure 4 Here]

Beyond 30%, crypto's weight continues to shrink until it is eliminated from the portfolio at a decrease in returns of about 37%. Crypto's role in portfolio optimization is highly sensitive to changes in its expected return. As a result, investors looking to add cryptocurrency to their portfolio should cautiously consider their expectations regarding the asset's future performance.

Sensitivity Analysis: Standard Deviation of Crypto Returns

Cryptocurrencies are undoubtedly one of the most volatile assets available to investors. It is reasonable to assume that such a volatile asset class will continue to see frequent fluctuations in its returns. Future increases in the volatility of crypto could impact its potential in increasing the risk-adjusted performance of a traditional portfolio.

Increasing the standard deviation of the cryptocurrency portfolio's returns by 150% greatly reduces crypto's role in optimizing the portfolio. Invested 49.78% in stocks, 49.90% in bonds, and 0.31% in crypto, the portfolio produces a Sharpe ratio of 0.68. With this increase in volatility, crypto's weight is largely negligible and the portfolio does not provide a significant increase in Sharpe ratio over the control combination. Investors who expect large increases in cryptocurrency volatility going forward should not add crypto to their portfolio.

[Insert Figure 5 Here]

Sensitivity Analyses: Correlation between Crypto and Stock Returns

Another variable to consider is the correlation between crypto returns and stock returns. Historically, cryptocurrencies have held a higher correlation to stocks (0.41) than bonds have to stocks (0.38). An increase in crypto's correlation to stocks could impact the asset's diversification potential, while a decrease in correlation could see it become the preferred diversifier.

[Insert Table 2 Here]

When the correlation between the returns of crypto and stocks is increased to 150%, the optimal portfolio is invested 46.67% in stocks, 50.92% in bonds, and 2.41% in crypto with a Sharpe ratio of 0.68. Crypto's weight is decreased significantly, and no considerable increase in risk-adjusted performance is attained. While crypto still has a role in this portfolio, its presence offers no quantifiable benefit.

[Insert Figure 6 Here]

Setting the correlation between the returns of crypto and stocks to 50% produces an optimal portfolio that is invested 55.94% in stocks, 36.81% in bonds, and 7.24% in crypto.

This decrease in correlation results in a much higher weight for crypto and produces a Sharpe ratio of 0.74, which is higher than both that of the control portfolio and the original three-asset portfolio.

[Insert Figure 7 Here]

Whether significant changes in asset correlations are likely to occur remains uncertain. Cryptocurrency returns are affected by wide-reaching macroeconomic factors as well as technologic shifts and investor sentiment (Polizu et al., 2023). Unless cryptocurrency suddenly becomes immune to economy-wide circumstances, it is unlikely that the correlation between crypto and stocks will decrease. If investors continue to accept cryptocurrencies as viable alternative assets, however, crypto returns may become even more affected by the macroeconomic factors that impact stocks and bonds (Polizu et al., 2023). If this happens, it is reasonable to assume that crypto's correlation to stocks may increase. As mentioned above, investors who find this scenario likely would not benefit from including crypto in their diversified portfolio.

Scenario Analyses

The first scenario offers a pessimistic view of crypto's future performance, reducing the asset's returns by 10%, increasing its standard deviation by 10%, and setting its correlation with stocks to be 10% greater. With these values, the optimal portfolio produces a Sharpe ratio of 0.68 (49.10% in stocks, 49.27% in bonds, and 1.63% in crypto). In this scenario, crypto's role in optimizing the portfolio is minimal and no real increase in risk-adjusted performance is achieved.

[Insert Figure 8 Here]

An even more pessimistic scenario reduces crypto's returns by 20% and increases its standard deviation by 20%. Invested 49.75% in stocks, 49.91% in bonds, and 0.34% in crypto, the portfolio presents a Sharpe ratio of 0.68 under these circumstances. Crypto is practically eliminated from the portfolio and risk-adjusted performance is unchanged from the control.

[Insert Figure 9 Here]

Finally, an optimistic look at the future performance of cryptocurrencies reduces both crypto returns and standard deviation by 25%. The optimal portfolio in this scenario produces a Sharpe ratio of 0.71 when invested 48.00% in stocks, 45.87% in bonds, and 6.13% in crypto. The weight of crypto has increased slightly over the original three-asset portfolio (6.13% vs. 4.83%), and the Sharpe ratio is considerably higher than that of the control combination. However, the risk-adjusted performance of the portfolio in this scenario is not significantly different from that of the unchanged three-asset portfolio (0.71 vs. 0.71). Thus, under reasonable circumstances (wherein a decrease in standard deviation is accompanied by a proportional decrease in expected return), the performance increase from including cryptocurrency investments in a diversified portfolio is unlikely to exceed 4.41%.

[Insert Figure 10 Here]

Overall, crypto does not fare well in these analyses. If an investor expects cryptocurrencies to have reduced performance in coming periods, they will not find benefit in adding cryptocurrencies to their diversified portfolio. However, if an investor believes that cryptocurrencies will maintain their current trajectory, crypto investment could meaningfully boost the risk-adjusted performance of his or her diversified portfolio.

Limitations

One shortcoming of this study is the relatively short timeframe used to calculate the average expected return and standard deviation of the cryptocurrency portfolio. As a result, the calculated values are not as robust as those of the traditional assets. Unfortunately, it was not possible to avoid this limitation given that two of the assets chosen to make up the crypto portfolio, BNB and ADA, were only launched in 2017. The timeframe used to calculate crypto returns could have been extended by opting to include more mature currencies, such as LTC or DOGE. However, these cryptocurrencies, because of their consistently smaller market caps, are not as economically significant. LTC's highest achieved monthly market cap in April 2021 of $18.10 billion is only about 2% of Bitcoin's $1.08 trillion market cap that same month. BNB and ADA sustained market caps of $95.75 billion and $43.21 billion respectively, or about 9% and 4% of Bitcoin's cap in April 2021. Month over month, DOGE has maintained less than 1% of the total market cap of Bitcoin. Attempting to expand the timeframe by including less prominent currencies would have resulted in the crypto portfolio being effectively just a portfolio of Bitcoin. Additionally, the timeframe chosen is believed to be the best estimation of what an investor today may experience when investing in cryptocurrency, as it does not include the unreasonably high returns that would have only been available to those investing before the mainstream presence of cryptocurrencies.

Another limitation is that the analysis does not consider transaction costs when determining returns. Transaction costs on cryptocurrencies are typically higher than those of traditional assets, and these inflated costs would be incurred when opening or rebalancing the portfolio of cryptocurrencies. On average, Stocks are subject to transaction costs of 2.61 basis points (Hagströmer, 2021). Transaction costs for cryptocurrencies are often oblique and can vary greatly by vendor. Brokerage fees at popular cryptocurrency exchange Coinbase, for example, start at 60 basis points. Transactions through Webull, while not subject to any direct commissions, will face a built-in spread markup of 100 basis points. Since the cryptocurrency portfolio used for this analysis is a value-weighted portfolio of consistent assets, meaning transaction fees must be paid only upon opening the portfolio, the importance of this limitation is horizon-specific. Investors with short investment horizons will be much more sensitive to transaction fees and may find crypto's returns exaggerated because of their omission. Those investing long-term, however, should not see a large difference between their real returns and the returns presented in this study.

Finally, the analysis is subject to some look-ahead bias. The crypto portfolio was created from five of the largest cryptocurrencies as of June 2023, and thus only considers cryptocurrencies that have proven to be successful. One method to mitigate this is to re-run the test using a portfolio of just Bitcoin, the consistently largest cryptocurrency. Building the efficient frontier with stocks, bonds, and Bitcoin produces an optimal portfolio with a Sharpe ratio of 0.73 (49.47% in stocks, 44.10% in bonds, 6.51% in Bitcoin). What this shows is that the findings of the study are robust to the exclusion of the currencies potentially impacted by look-ahead bias. Thus, look-ahead bias is not expected to have materially affected the results of this paper.

[Insert Figure 11 Here]

Conclusion

With the SEC's recent authorization of Bitcoin ETFs, the everyday investor can now easily gain exposure to cryptocurrencies. The real question, though, is whether they should. Using the Markowitz efficient frontier model to analyze the impact of adding cryptocurrency

investments to a diversified portfolio of traditional assets finds that investors who bear a small exposure to cryptocurrencies can see an increase in risk-adjusted performance of up to 4.41%. This finding, however, is highly sensitive to the future performance of cryptocurrencies. If investors expect lower future performance from cryptocurrencies, then they will not see meaningful increases in risk-adjusted performance from including the asset in their portfolio.

There exists great opportunity for future research on this topic. As cryptocurrencies continue to break into the mainstream market, it will be interesting to see how their impact on diversification may change. As the asset class matures, it will be possible to make more concrete assertions regarding their potential for increasing a portfolio's risk-adjusted performance. This paper aims to provide a glimpse into what benefit investing in cryptocurrency may bring, but it will be up to future scholarship to provide final judgment on the viability of cryptocurrency investment for the everyday investor.

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Appendix A

Returns and Standard Deviations		
	Average Return (Yearly)	Standard Deviaton
Stocks	10.70%	15.01%
Bonds	4.66%	7.39%
Crypto Portfolio	38.93%	76.90%
Risk-free	1.24%	

Table 1: Average yearly returns (calculated as average monthly return multiplied by 12) and standard deviations (calculated as monthly standard deviation multiplied by the square root of 12) for each asset class.

Correlations			
	Stocks	Bonds	Crypto Portfolio
Stocks	1		
Bonds	0.375	1	
Crypto Portfolio	0.409	0.338	1

Table 2: Correlation between stocks & bonds calculated based on a 251-month return history beginning August 2002 and ending June 2023. Correlations between crypto & stocks and crypto & bonds calculated using a 66-month return history beginning January 2018 and ending June 2023.

Appendix B

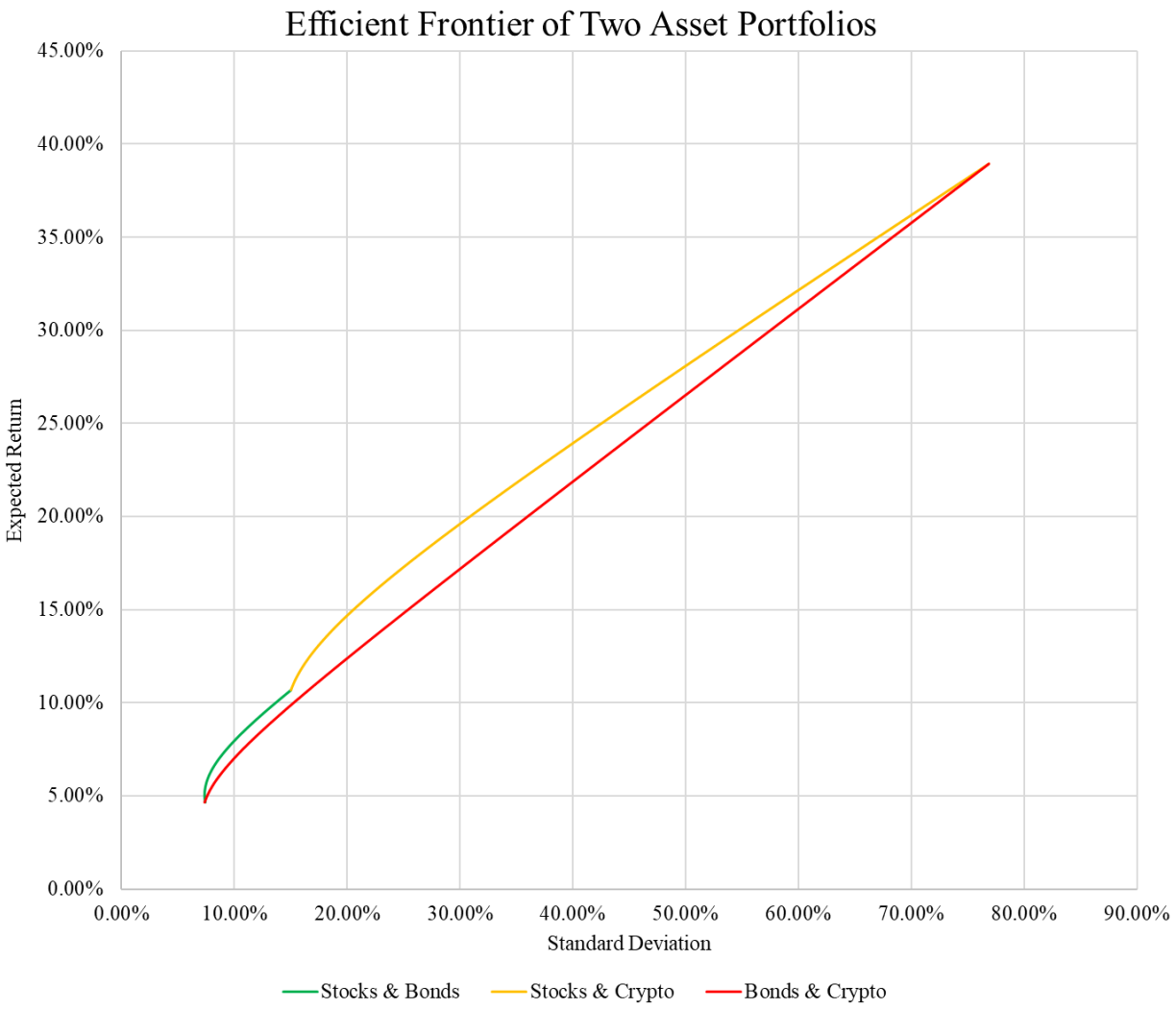

Figure 1: The optimal portfolio for stocks & bonds is invested 49.81% in stocks and 50.19% in bonds, producing a Sharpe ratio of 0.676185. The optimal portfolio for stocks & crypto is invested 90.47% in stocks and 9.53% in crypto, producing a Sharpe ratio of 0.679843. The optimal portfolio for bonds & crypto is invested 90.27% in bonds and 9.74% in crypto, producing a Sharpe ratio of 0.583140.

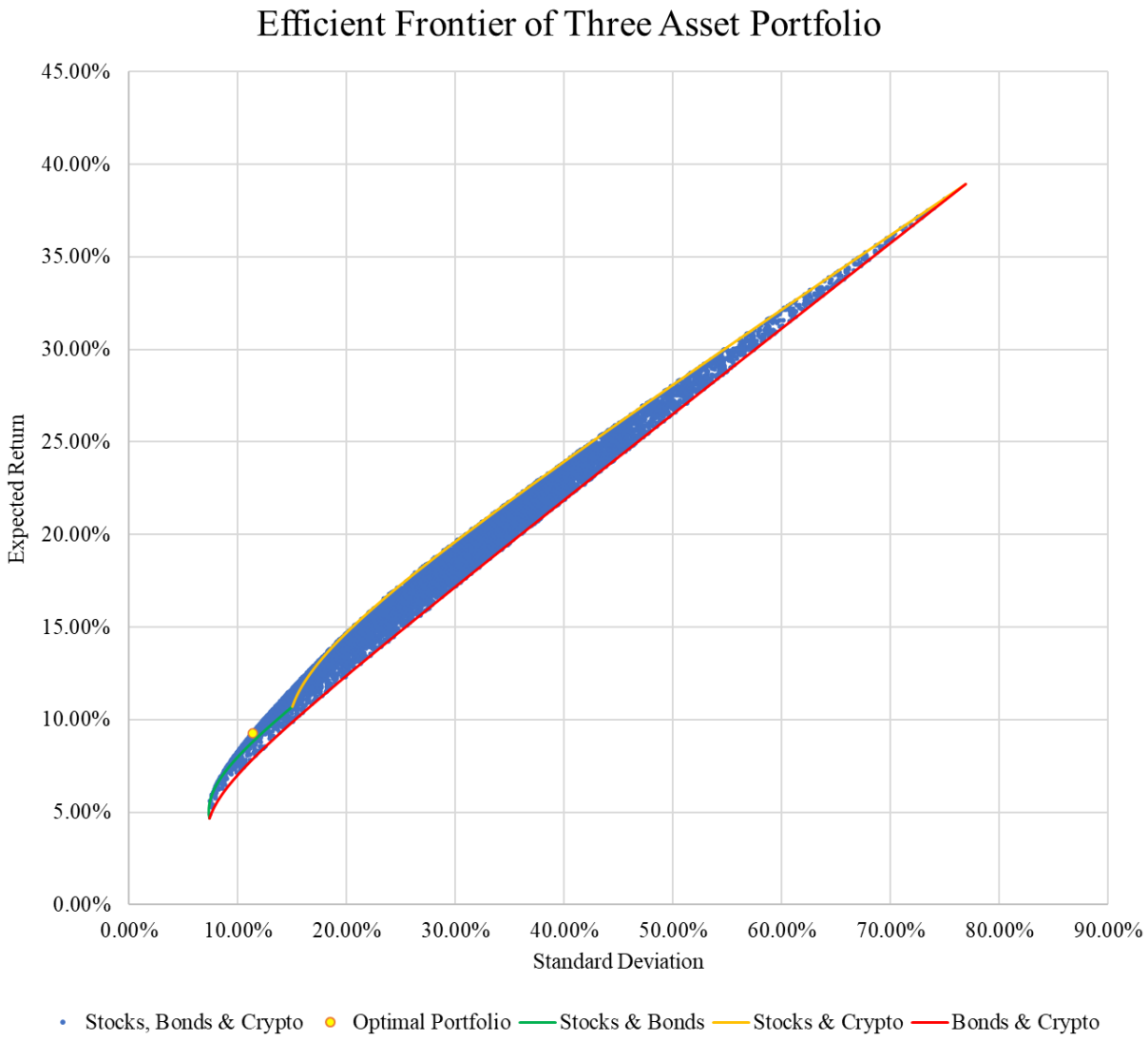

Figure 2: The optimal portfolio is invested 48.71% in stocks, 46.46% in bonds, and 4.83% in crypto. The portfolio produces a Sharpe ratio of 0.706863.

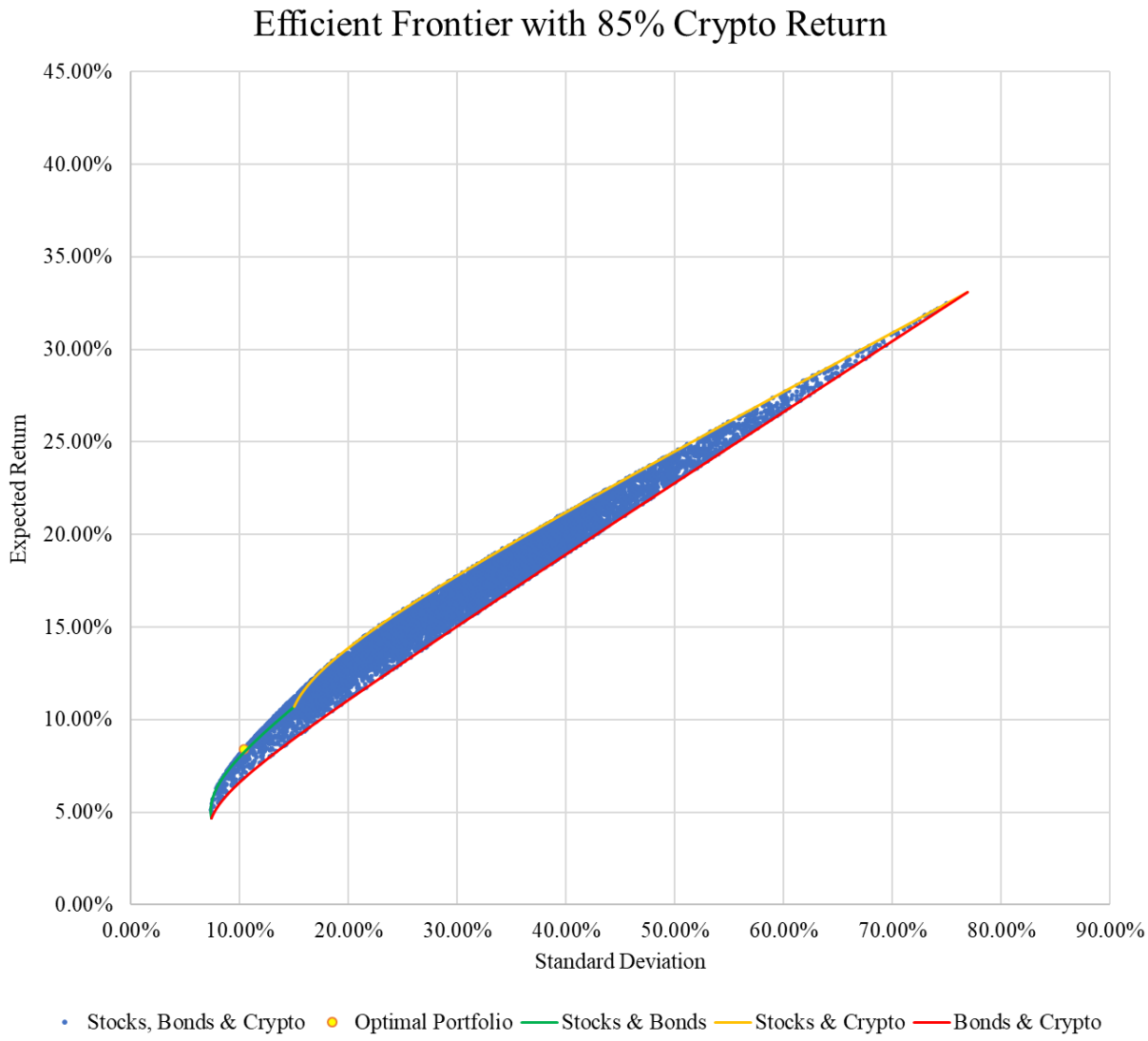

Figure 3: The optimal portfolio is invested 49.20% in stocks, 48.13% in bonds, and 2.67% in crypto. The portfolio produces a Sharpe ratio of 0.686870.

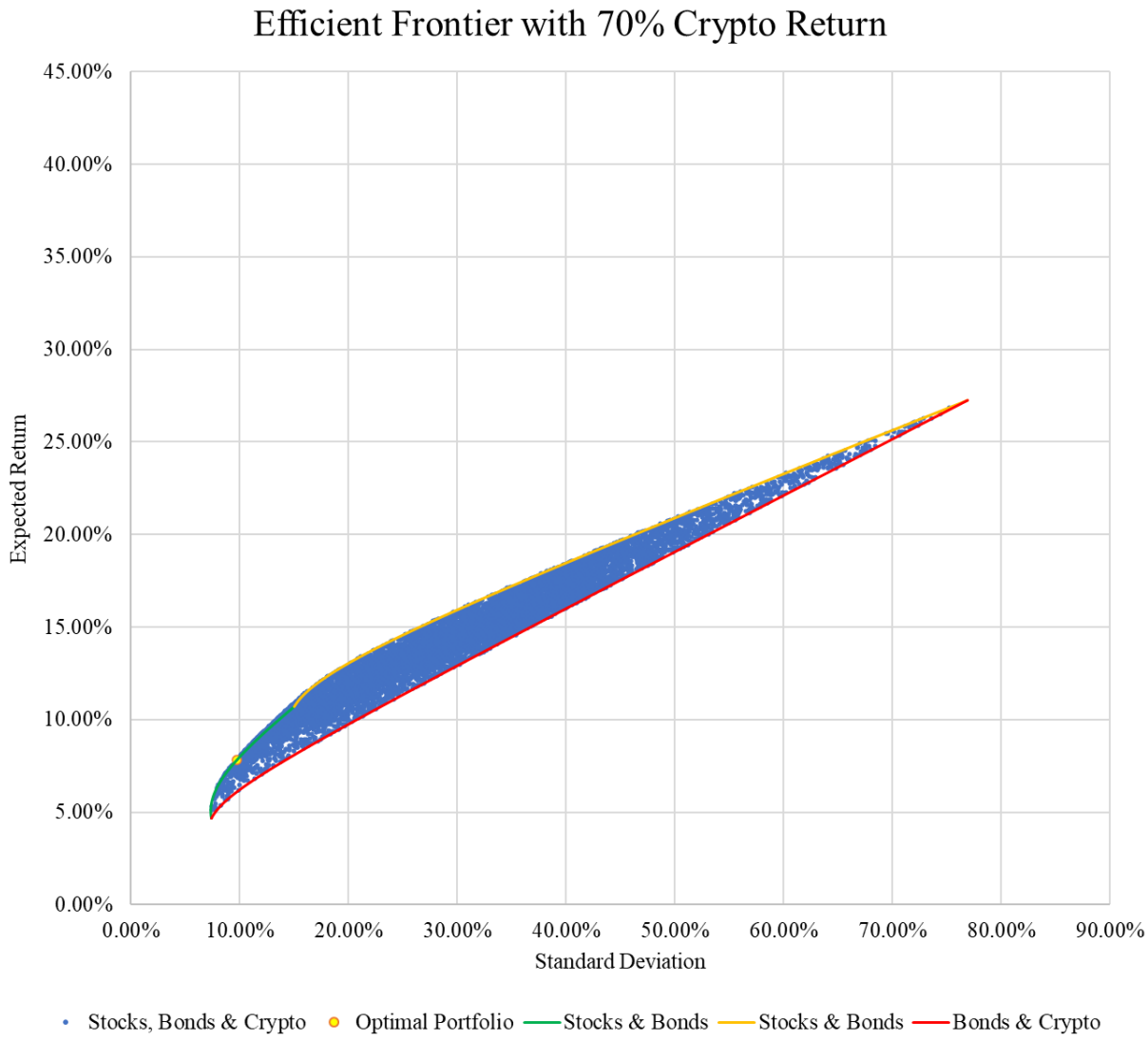

Figure 4: The optimal portfolio is invested 49.64% in stocks, 49.71% in bonds, and 0.74% in crypto. The portfolio produces a Sharpe ratio of 0.677110.

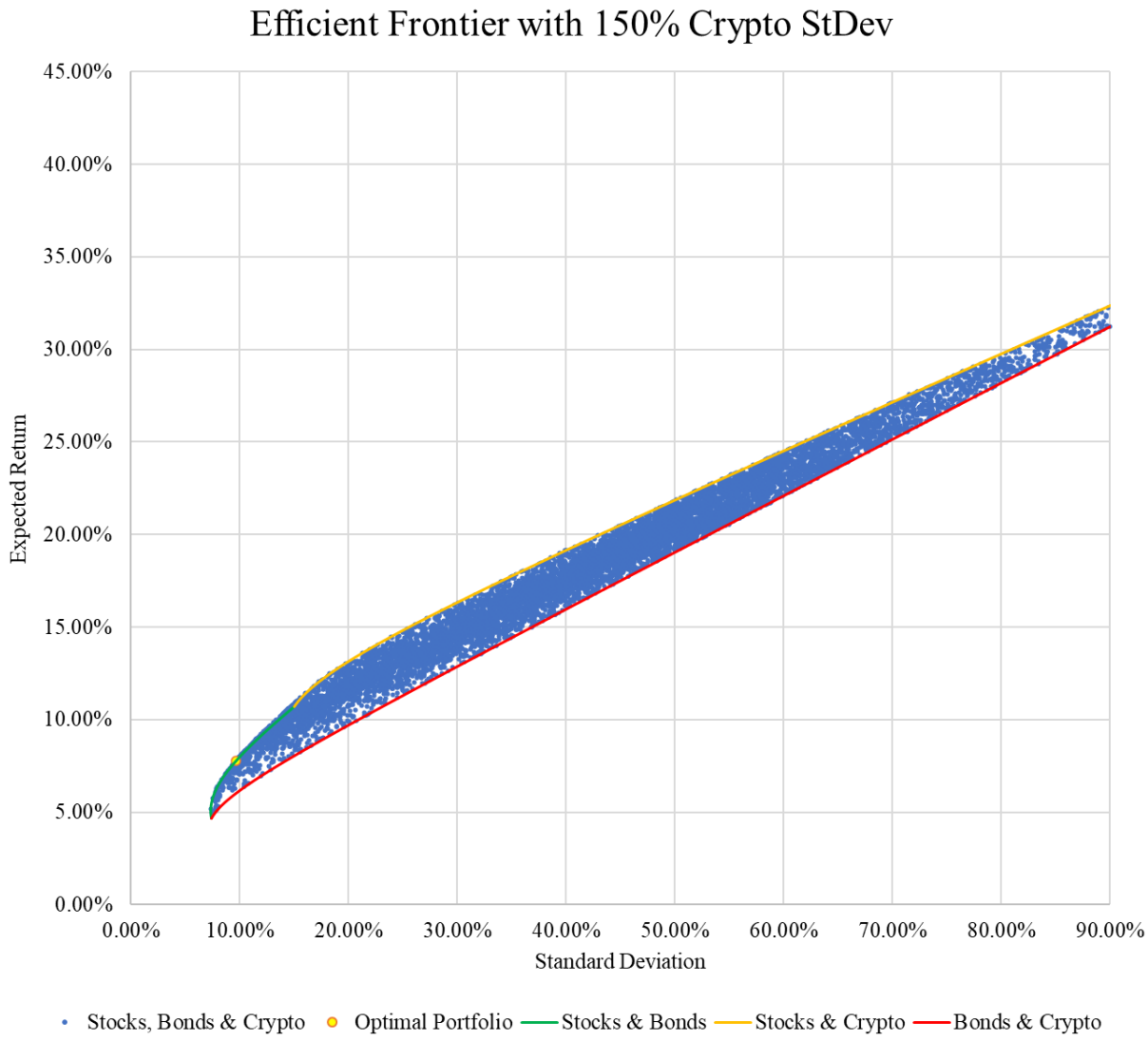

Figure 5: The optimal portfolio is invested 49.78% in stocks, 49.90% in bonds, and 0.31% in crypto. The portfolio produces a Sharpe ratio of 0.676558.

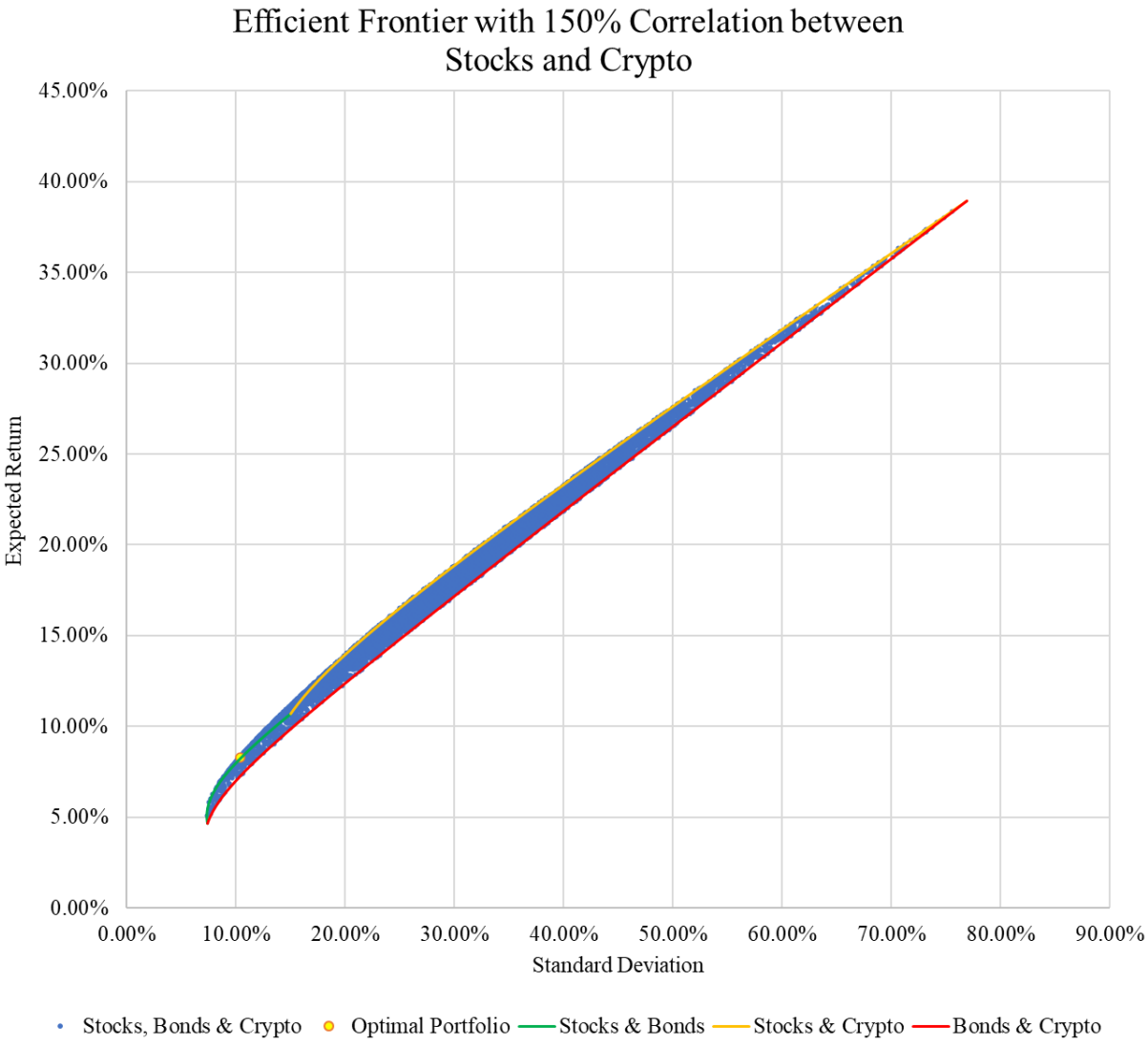

Figure 6: The optimal portfolio is invested 46.67% in stocks, 50.92% in bonds, and 2.41% in crypto. The portfolio produces a Sharpe ratio of 0.682907.

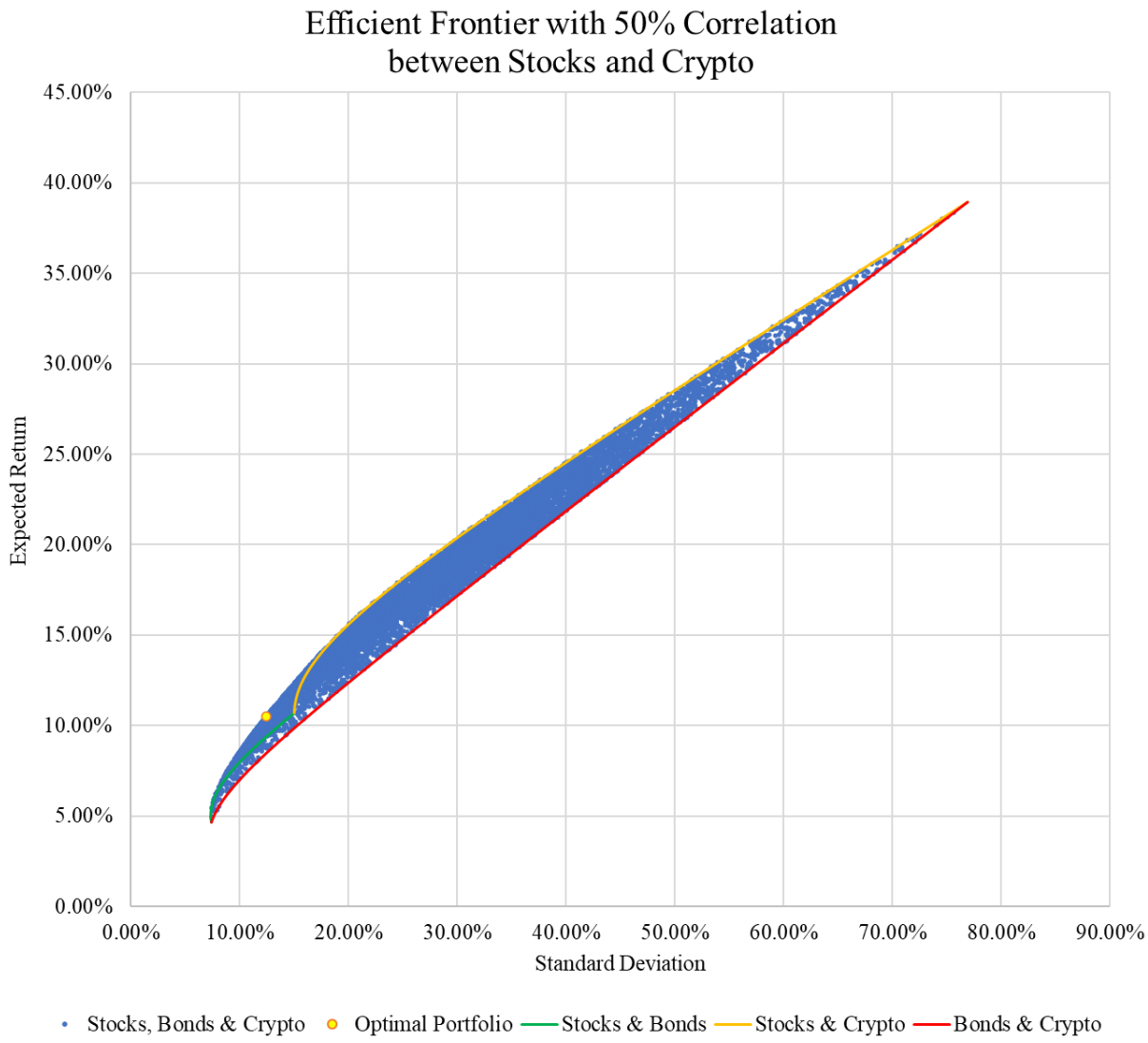

Figure 7: The optimal portfolio is invested 55.94% in stocks, 36.81% in bonds, and 7.24% in crypto. The portfolio produces a Sharpe ratio of 0.744581.

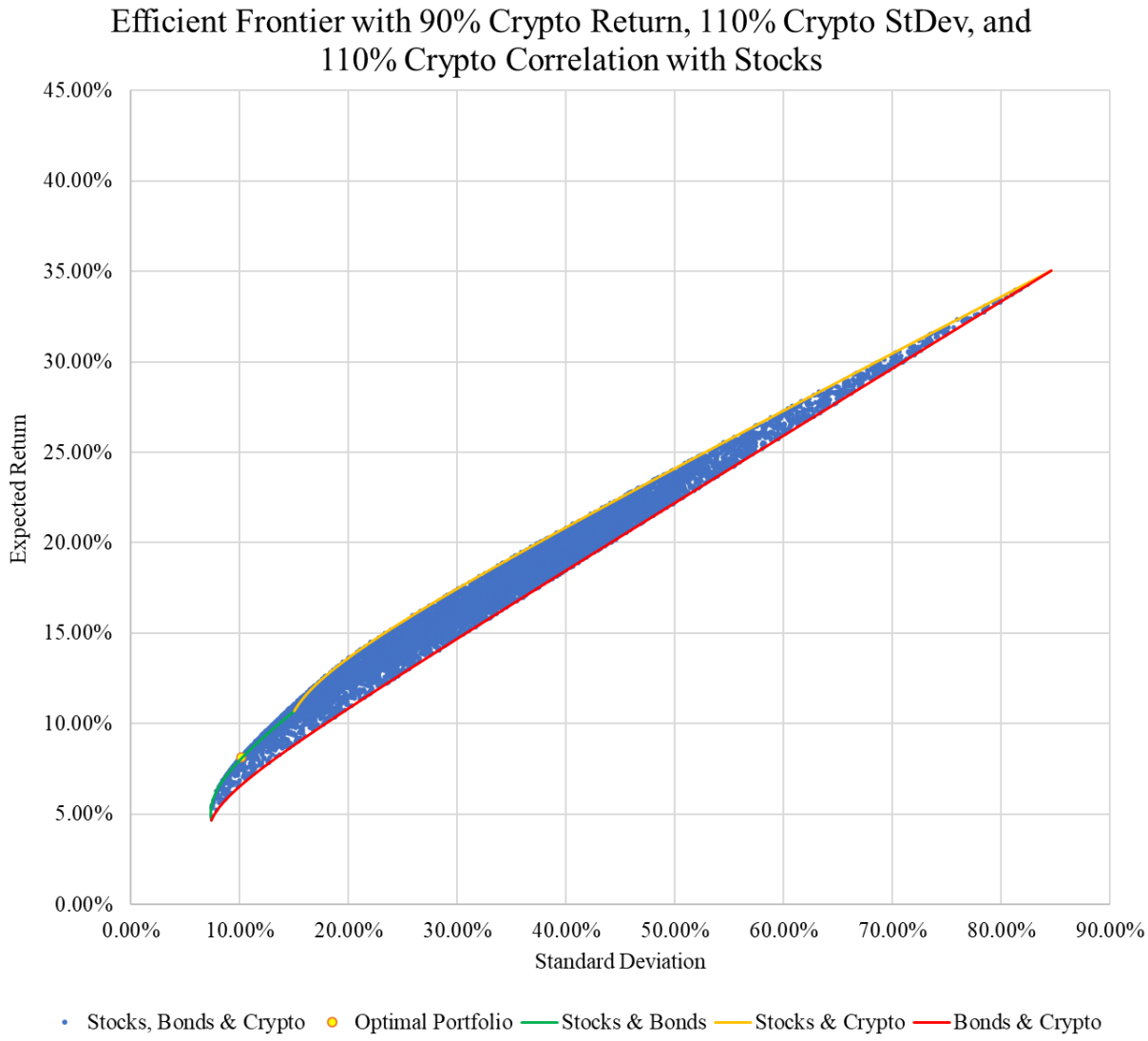

Figure 8: The optimal portfolio is invested 49.10% in stocks, 49.27% in bonds, and 1.63% in crypto. The portfolio produces a Sharpe ratio of 0.681054.

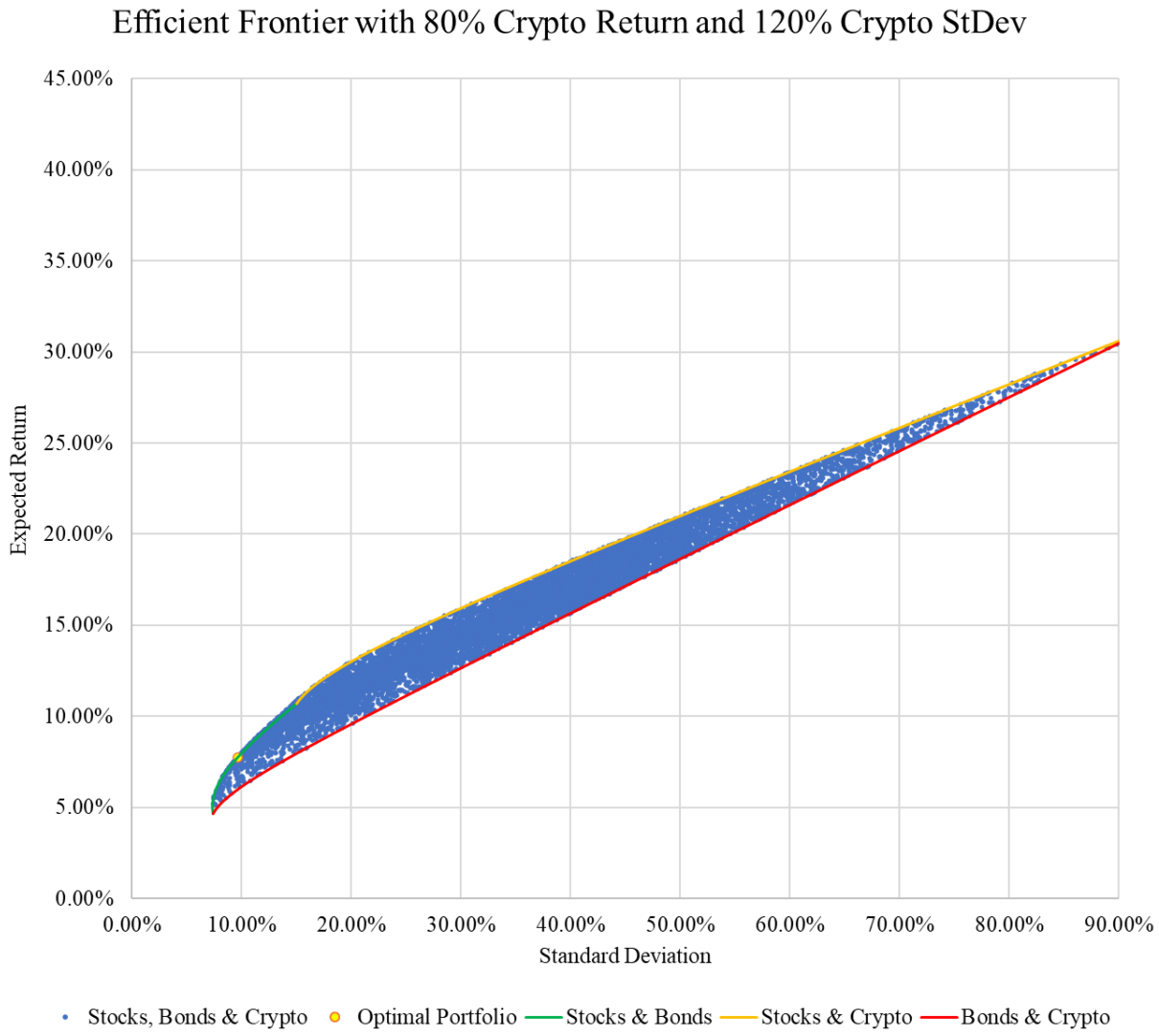

Figure 9: The optimal portfolio is invested 49.75% in stocks, 49.91% in bonds, and 0.34% in crypto. The portfolio produces a Sharpe ratio of 0.676464.

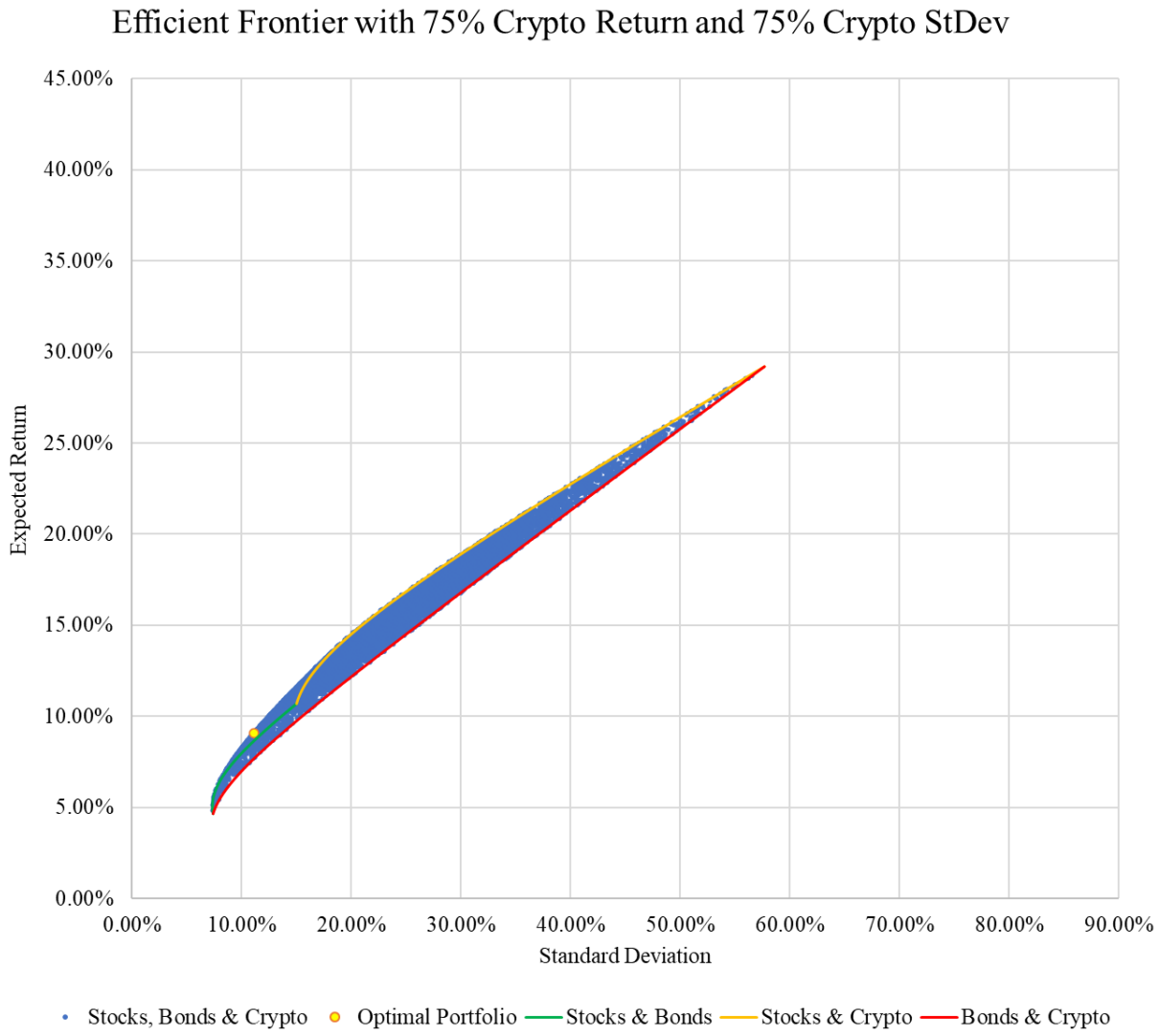

Figure 10: The optimal portfolio is invested 48.00% in stocks, 45.87% in bonds, and 6.13% in crypto. The portfolio produces a Sharpe ratio of 0.705128.

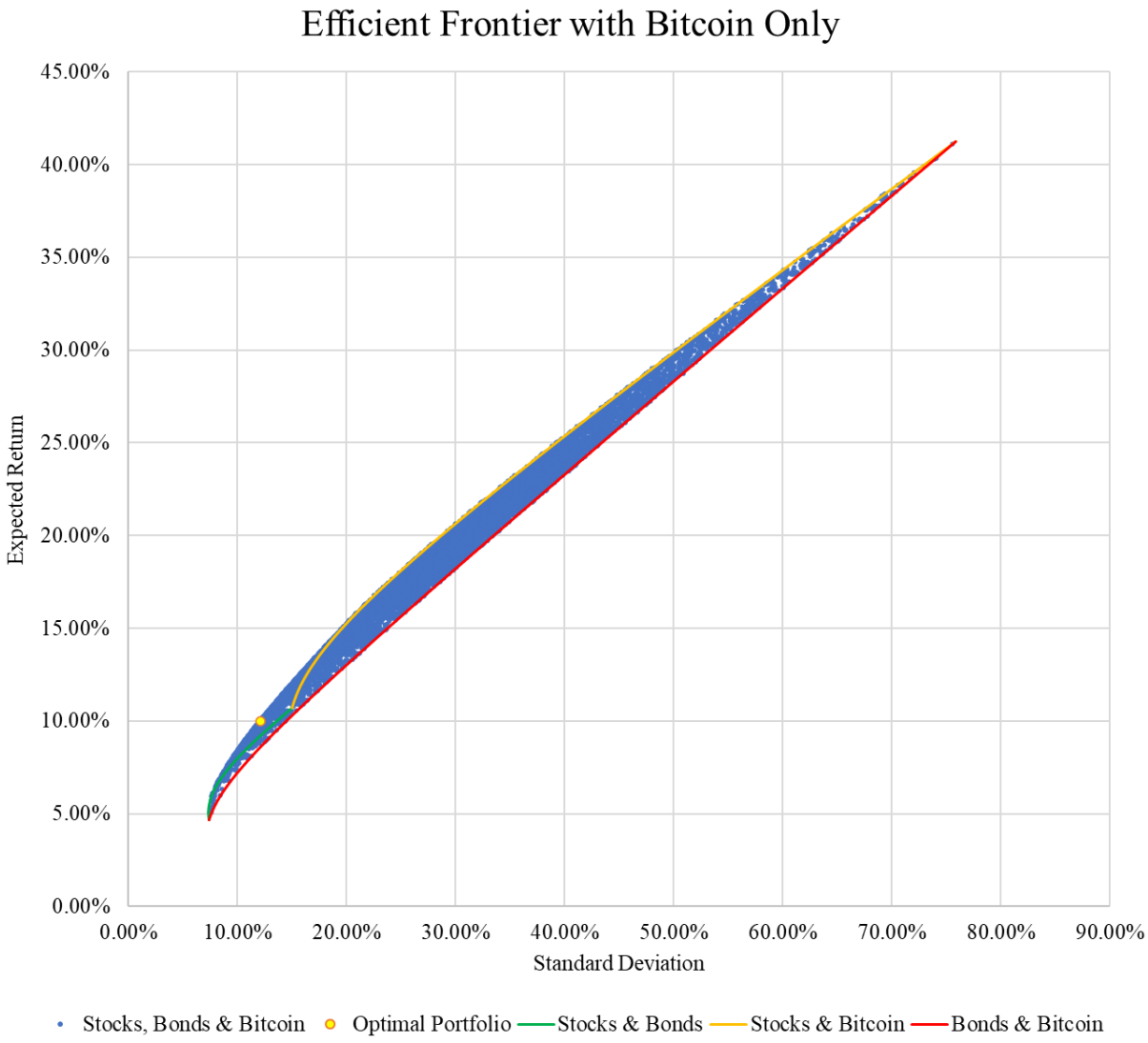

Figure 11: The optimal portfolio is invested 49.47% in stocks, 44.10% in bonds, and 6.43% in Bitcoin. The portfolio produces a Sharpe ratio of 0.726188.