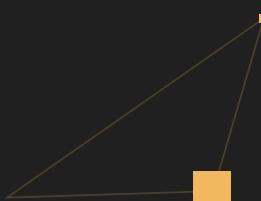
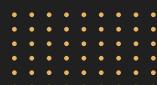


Portfolio Optimization With Crypto Assets

AN ARGUMENT FOR AN ALLOCATION OF CRYPTO TO A INVESTOR'S PORTFOLIO



This research report will show that the addition of a crypto asset such as Bitcoin (BTC) to an institutional investor's portfolio can drastically improve risk-adjusted returns. Within this report, we construct several portfolios with varying amounts of Bitcoin and backtest their performance since 2014. By all measures —Annualized Returns, Annualized Volatility, and Sharpe Ratio —portfolios which add amounts of between 2.5 – 10% of Bitcoin outperform more traditional portfolios. The reason for this, as this report shows, is the excellent performance of the crypto asset market over the last few years, coupled with the uncorrelated nature of crypto assets with traditional financial assets.



Introduction

When one considers investing in a given asset class – and subsequently a specific asset – there are two primary questions that should be asked:

1

What proportion of my portfolio should be allocated to this asset class given my current financial goals and constraints?

2

What is the investment case for this asset class?

This report will provide the answer to 2. At its core, the question is one of optimal portfolio construction and the risk management of said portfolio for a given set of constituents. For the sake of brevity, we will assume the reader has a good understanding of basic Modern Portfolio Theory, but perhaps is less familiar with crypto asset terminology and as such will define and expand on concepts where deemed necessary.

Our report's key argument is that – at the very least – adding a modest amount of crypto asset exposure (primarily Bitcoin) to one's portfolio will lead to superior risk-adjusted investment outcomes due to their unique property of having largely unrelated risks compared to all other asset classes. In the correlation visual (Fig. 1) we compare the correlation of returns¹ for several popular exchange-traded funds (ETFs), as well as Bitcoin (BTC). The ETFs chosen represent a variety of asset classes and risk profiles and are as follows:

- **EFA** – The iShares MSCI EAFE ETF seeks to track the investment results of an index composed of large-and mid-capitalization developed market equities, excluding the U.S. and Canada.
- **GLD** – The SPDR Gold Shares ETF seeks to track the investment results of an index tracking the price of gold bullion.
- **SPY** – The SPDR S&P 500 ETF seeks to track the investment results of an index tracking S&P 500.
- **TLT** – The iShares 20+Year Treasury ETF seeks to track the investment results of an index composed of U.S. Treasury bonds with remaining maturities greater than twenty years.
- **VNQ** – The Vanguard Real Estate ETF seeks to track the investment results of an index composed of stocks issued by REITs, and companies that purchase office buildings, hotels, and other real property.

FIGURE 1: ASSET CORRELATION MATRIX

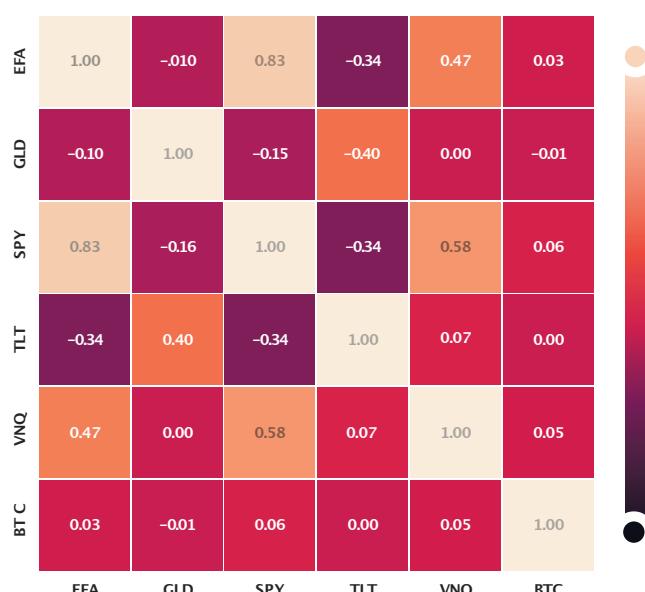


FIGURE 2: PORTFOLIO ALLOCATIONS

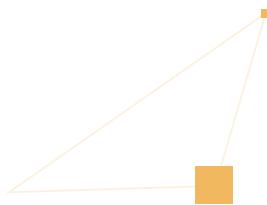
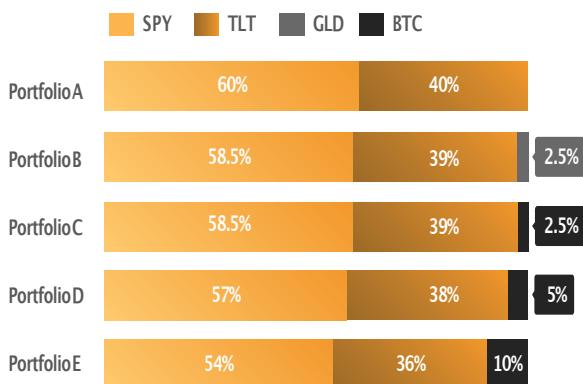
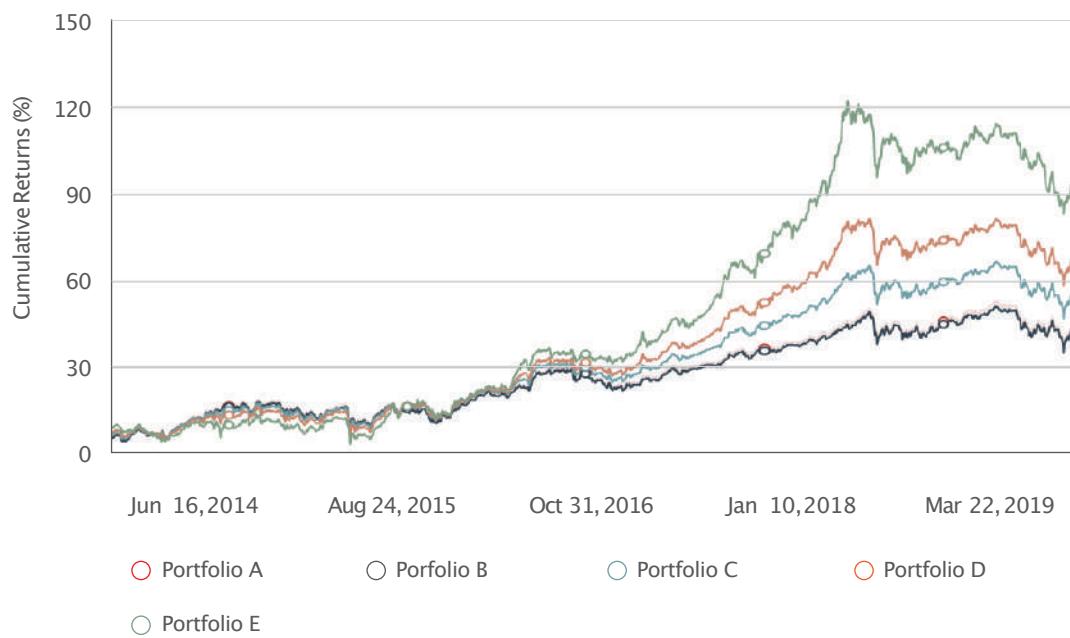


FIGURE 3: PORTFOLIO PERFORMANCE



Out of all the assets, Bitcoin is by far the most uncorrelated – even more so than gold (GLD). For example, Bitcoin's correlation with SPY is 0.06 compared to GLD's correlation with SPY of -0.16 and 0.00 for TLT compared to GLD's TLT correlation of 0.40.

This report will help explain the significance of this fact and elucidate what implication it has for investing. Moreover, aside from the extent to which Bitcoin is uncorrelated with most other asset classes, the results of adding it to a portfolio are phenomenal. The below chart (Fig. 3) plots the returns of five daily-rebalanced portfolios with the following compositions (Fig. 2) from 2014-06-16 to 2019-06-14.

Based on this example alone, adding a small amount of Bitcoin has a noticeable effect on the return profile of a given portfolio. However, the chart does not paint a complete picture of the risk profile of crypto assets nor does it completely explain the role crypto assets can play in portfolio optimization.

Modern Portfolio Theory

Overview

Modern Portfolio Theory (MPT) is an approach wherein asset allocators are able to quantify the best way to efficiently allocate assets by quantifying the amount of risk taken in achieving a given amount of return. We can summarize the three important aspects of MPT on which this report will focus:

- The integral role that covariance and diversification play and the general rule that uncorrelated assets produce greater risk-adjusted returns by reducing the overall variance of the portfolio's returns
- Standard deviation is used as a proxy of portfolio risk which allows for mathematical models to be developed for understanding the role of risk in a given portfolio
- The development of the Efficient Frontier which gives investors a systematic way to select portfolios based upon MPT's given assumptions and certain parameters

TABLE 1: PORTFOLIO TEARSHEET

	Portfolio A	Portfolio B	Portfolio C	Portfolio D	Portfolio E
Annualized Returns	9.2%	9.0%	11%	12.9%	16.6%
Cumulative Returns	54.9%	53.6%	68.7%	83.4%	115.7%
Annualized Volatility	7.8%	7.6%	7.8%	8.3%	10.1%
Sharpe Ratio	1.17	1.17	1.38	1.51	1.57
Daily Value at Risk	-0.9%	-0.9%	-0.9%	-1.0%	-1.2%
MaxDrawdown	-11.0%	-10.7%	-11.9%	-12.8%	-17.6%
Alpha	0.04	0.04	0.06	0.07	0.11
Beta	0.48	0.46	0.47	0.47	0.46
Omega Ratio	1.22	1.22	1.27	1.29	1.31
Sortino Ratio	1.66	1.66	1.96	2.17	2.32

Crypto assets have a unique profile compared to 'traditional' asset classes, which helps explain why their risk profile is also quite different. For example, unlike a stock which may trade on an exchange regulated by FINRA, such as NYSE, crypto assets can be bought in a variety of other ways often cut off from traditional financial infrastructures – like on a decentralized exchange, for example. Other differences include the relative recency of their creation (just over ten years ago) and the peculiarities of the inception of asset classes (the first was created by a pseudo-anonymous developer and they exist solely in the digital realm). These properties ensure things like use-case adoption, regulatory development, and technology improvements are the fundamental value-drivers for the

crypto asset industry. Let's consider several more tools within the arsenal of MPT to analyze several other portfolios with certain amounts of Bitcoin added. Here we compute tear sheets (Tab. 1) for the five aforementioned portfolios. These statistics^{2,3} give a clearer picture of the risks and benefits of an allocation of Bitcoin to one's portfolio with daily rebalancing.

However, there is a wider range of rebalancing strategies than a simple daily one; moreover, given the relatively limited liquidity of crypto asset markets (compared to other markets), daily rebalancing may be difficult to carry out and incur large amounts of fees and suboptimal spreads.

Rebalancing

We tested (**Tab. 2**) two types of rebalancing strategies for Portfolio D (SPY – 57%, TLT – 38%, BTC – 5%):

1

Time-Based Rebalancing – wherein the portfolio is rebalanced on a predetermined basis; for example, quarterly or annually. In the following example we rebalance once a month

2

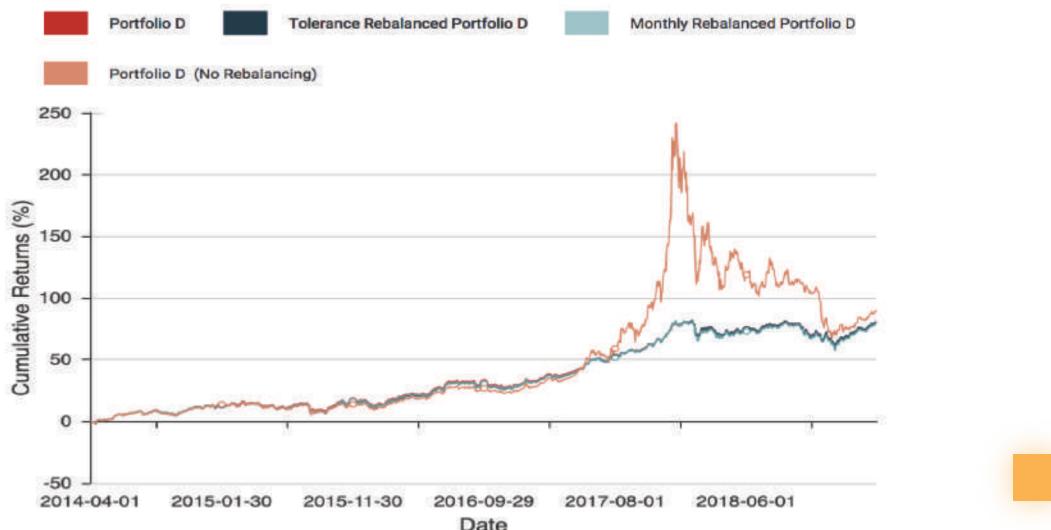
Tolerance Rebalancing – wherein the portfolio is rebalanced when a given allocation of a constituent moves away from a target by a predetermined amount. In the following example we rebalance when the weighted mean of the ratios for the constituents deviates by more than 5% from its predetermined value.

TABLE 2: PORTFOLIO TEARSHEET

	Daily Rebalance	Tolerance Rebalance	Monthly Rebalance	No Rebalance
Annualized Returns	12.9%	13%	12%	14%
Cumulative Returns	83.4%	81%	79%	90%
Annualized Volatility	8.3%	8%	8%	21%
Sharpe Ratio	1.51	1.48	1.45	0.72
Daily Value at Risk	-1%	-1%	-1%	-3%
MaxDrawdown	-12.8%	-12%	-13%	-52%
Alpha	0.07	0.07	0.07	0.10
Beta	0.47	0.47	0.46	0.47
Omega Ratio	1.29	1.28	1.28	1.18
Sortino Ratio	2.17	2.13	2.10	1.06

The benefits of rebalancing are obvious by looking at the portfolio with no rebalancing. Whilst the lack of a rebalancing strategy did mean that portfolio D (**Fig. 4**) gained considerable Bitcoin exposure at a favourable time (second half of 2017), the lack of risk management led to a subsequent drawdown period of around 50%. It can be argued that daily rebalancing is unrealistic, but even so, both Monthly and Tolerance-based rebalancing strategies offer considerable risk management benefits – as the tear sheet above shows.

FIGURE 4: PORTFOLIO PERFORMANCE



Asset Allocation Simulation

Overview

We can use the logic of MPT's Efficient Frontier to simulate (and also compute) the optimal portfolio from our available basket of constituents. Below we run a random walk (Fig. 5) on portfolio weightings 25,000times in order to discover portfolios which produce optimal values for Sharpe Ratio and Annualized Volatility. The colour coding represents the Sharpe Ratio of the given portfolio. Two portfolios are highlighted: MSI, the portfolio producing the Maximum Sharpe Ratio, & MVI, the portfolio producing the minimum amount of volatility. The constituent weightings of MSI and MVI are as follows (Tab. 3). It's interesting to note that both portfolios include noticeable amounts of Bitcoin – with the portfolio producing the best Sharpe Ratio containing around 14% Bitcoin. Even in the case of the minimum volatility portfolio, there is a small allocation to Bitcoin of 0.9% due to its abnormally uncorrelated returns when compared to the other constituents.

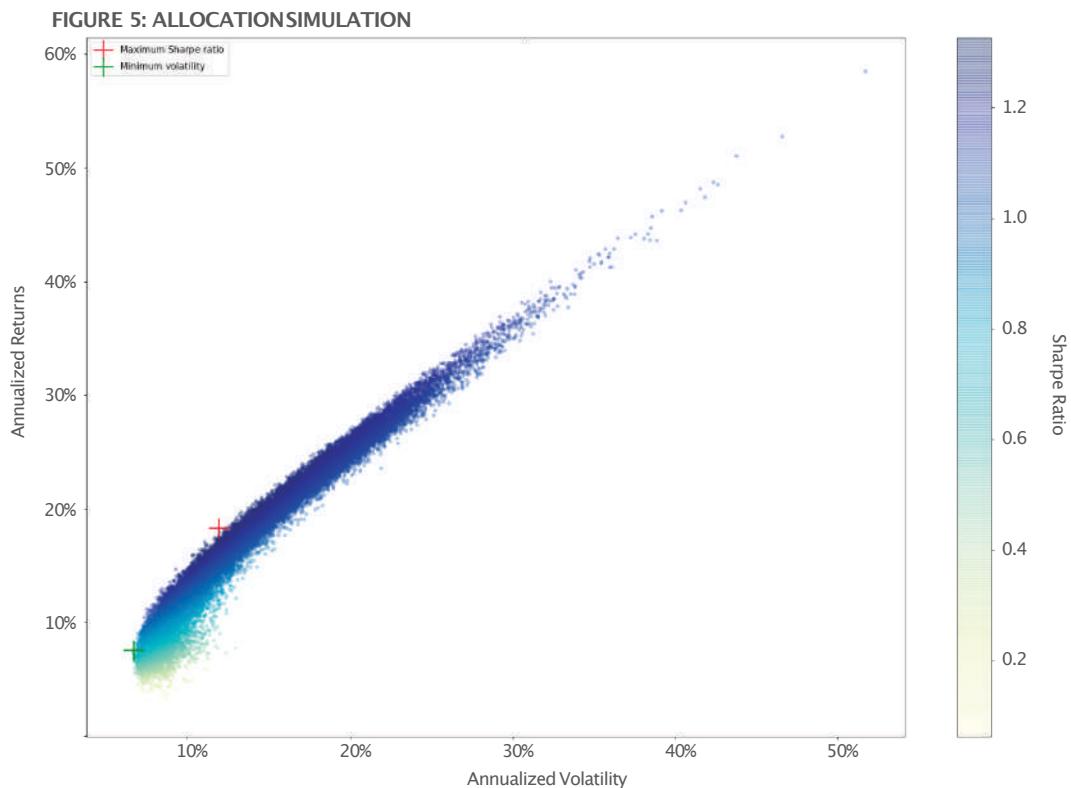
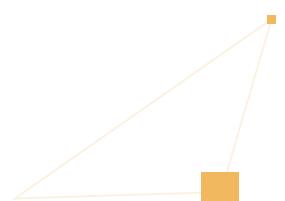


TABLE 3: PORTFOLIO ALLOCATIONS

	MSII	MVII
Annualized Returns	18%	7%
Annualized Volatility	12%	7%
EFA Allocation	0.43%	11.46%
GLD Allocation	1.6%	11.82%
SPY Allocation	36.17%	32.03%
TLT Allocation	43.22%	42.54%
VNQ Allocation	4.2%	1.26%
BTC Allocation	14.38%	0.9%



We can take this Efficient Frontier analysis a step further by calculating (**Fig. 6**) optimal portfolios given the constituent options (as opposed to finding the simulated best). Similarly, two portfolios are highlighted: MSII – the portfolio producing the Maximum Sharpe Ratio –, and MVII – the portfolio producing the minimum amount of volatility. The constituent weightings (**Tab. 4**) of MSII and MVII are as follows:

FIGURE 6: ALLOCATION SIMULATION

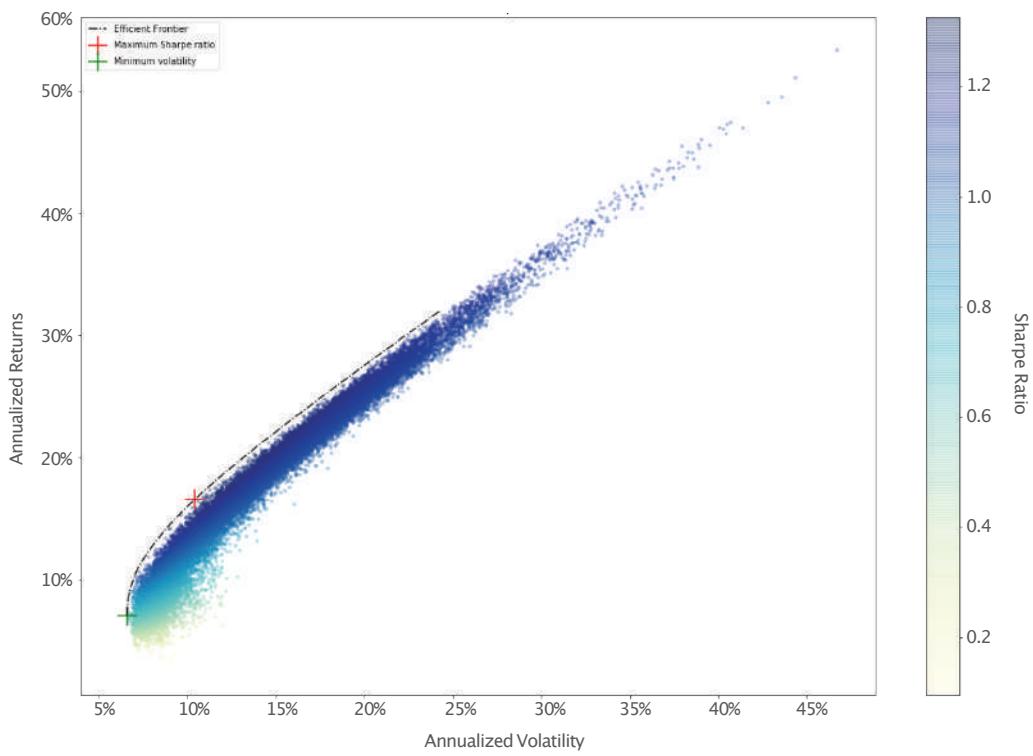


TABLE 4 : PORTFOLIO ALLOCATIONS

	MSII	MVII
Annualized Returns	17%	7%
Annualized Volatility	10%	7%
EFA Allocation	0%	9.54%
GLD Allocation	0%	18.68%
SPY Allocation	46.09%	30.75%
TLT Allocation	42.52%	40.28%
VNQ Allocation	0%	0%
BTC Allocation	11.39%	0.75%



It is possible that there are investors who may want to minimize their exposure to BTC as much as possible insofar as they benefit from some amount of the upside of a portfolio allocation to BTC. In the graph below (**Fig. 7**), we show a sliding scale of allocations of BTC to a portfolio from 0% to 100% – highlighting the various portfolios' Annualized Returns and Volatility, as well as their Sharpe Ratios. Here, the colour coding represents the given portfolio's allocation of BTC. The following simulation creates 25,000 portfolios with varying allocations of BTC but allocations of SPY and TLT which remain in a constant proportion of 60:40. Given the aforementioned constraints, we've highlighted (**Tab. 5**) the portfolios which produce the maximum Sharpe Ratio, MSIII, and the minimum volatility, MVIII.

The simulation suggests that the ideal allocation of BTC to a “traditional portfolio” when one wants to maximize the portfolio's Sharpe Ratio is around 9.34% and when one wants to minimize the portfolio's Annualized Volatility, the optimal allocation is around 0.79%.

FIGURE 7: ALLOCATION SIMULATION

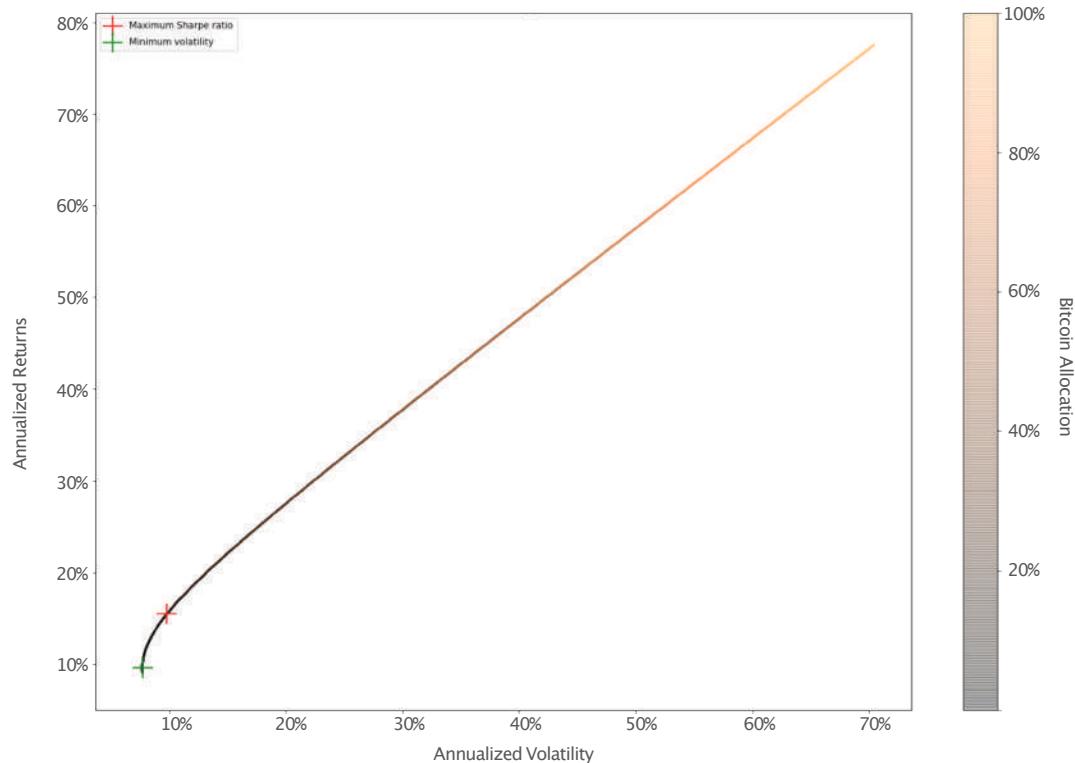


TABLE 5: PORTFOLIO TEARSHEET

	MSIII	MVIII
Annualized Returns	15%	10%
Annualized Volatility	10%	8%
SPY Allocation	54.39%	59.53%
TLT Allocation	36.26%	39.69%
BTC Allocation	9.34%	0.79%

Diversification within Crypto Assets

Overview

Thus far this report has focused solely on the diversification benefits of Bitcoin and ignored other crypto assets. However, there is evidence to suggest that other crypto assets – with slightly different value and risk drivers to that of Bitcoin – would offer further diversification benefits. Below we plot both a correlation matrix (**Fig. 7**) of Bitcoin (BTC), Ether (ETH), Ripple (XRP), & Litecoin (LTC) with the aforementioned ETFs over the period 2015–08–10to2019–06–14.

TABLE 6: PORTFOLIO ALLOCATIONS

	MSIV	MVIV
Annualized Returns	50%	14%
Annualized Volatility	23%	8%
EFA	6.98%	8.37%
GLD	14.39%	27.71%
SPY	23.85%	8.59%
TLT	16.52%	25.73%
VNQ	11.8%	25.04%
BTC	10.37%	2.6%
ETH	8.77%	1.39%
XRP	2.49%	0.49%
LTC	4.82%	0.09%

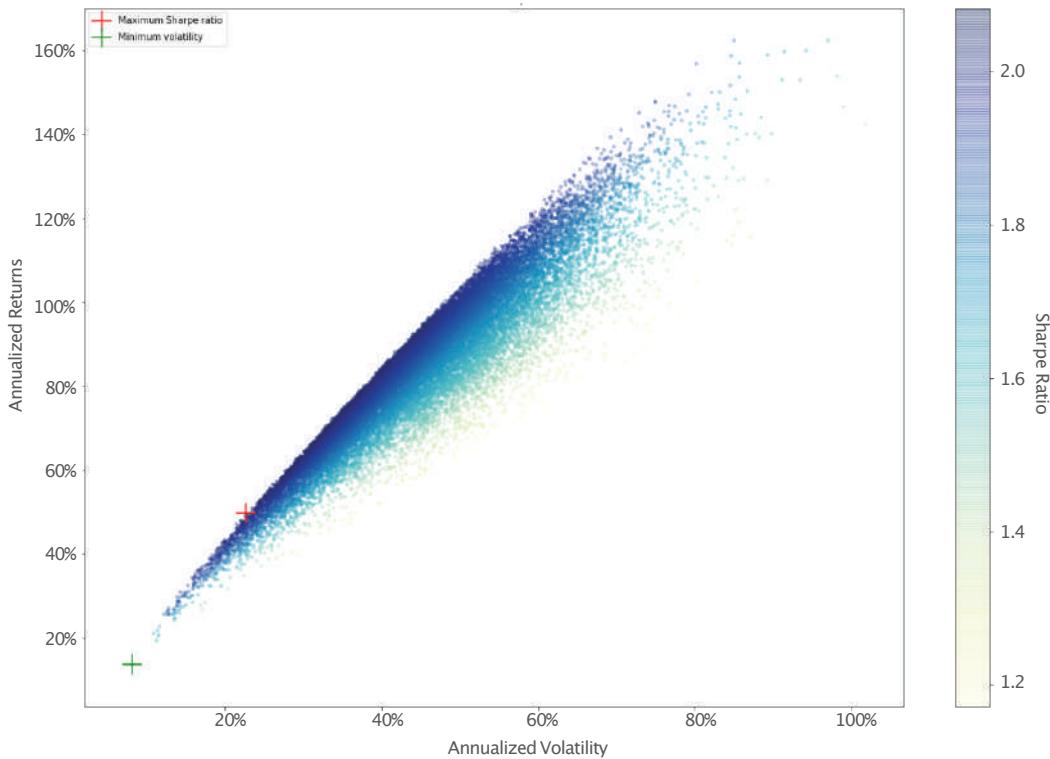
As we can see, the crypto assets BTC, ETH, XRP, and LTC all are equally as uncorrelated with the more traditional financial assets as each other. This demonstrates how crypto assets have fundamentally different value drivers from equities, bonds, and gold which means that a wide range of crypto assets have the potential to act as excellent ways for an investor to diversify their portfolio.

FIGURE 7: CORRELATION MATRIX



Crypto assets are exposed to a certain amount of systemic risk which, by definition, cannot be diversified away such as regulatory issues. However, all three additional crypto assets show similarly uncorrelated returns with each 'traditional' asset comparable to that of Bitcoin. Below, we run a simulation to estimate the optimal portfolio with the additional constituent options. Two portfolios are highlighted (Fig. 8) below: MSIV – the portfolio producing the maximum Sharpe Ratio – and MVIV – the portfolio producing the minimum amount of volatility. The constituent's weightings of MSIII and MVIII are shown on the previous page (Tab. 6).

FIGURE 8: ALLOCATION SIMULATION



Conclusion

This report has, through the lens of Modern Portfolio Theory, demonstrated the benefits of allocating a portion(2.5% to 10%) of one's portfolio to crypto assets such as Bitcoin.

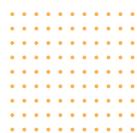
The core reason is historical evidence supporting the fact that crypto assets give investors a chance to further diversify their portfolio and maximize risk-adjusted returns. This is driven by the unique dynamics of the crypto asset industry which ensure that the key value drivers for a given crypto asset bear little relationship to the value drivers of stocks, fixed income, or alternative investments. When one considers an investment in an asset class it is essential that it is not done through a myopic lens.

What makes crypto asset investing extremely interesting is its potential to improve the risk profile of a traditional investor's portfolio by magnitudes. As such, the often-volatile risk profiles of crypto assets must be judged as just one part of an investor's whole portfolio. If an investor considers investing in crypto assets in this way the benefits are self-evident.

However, theoretical portfolio allocation is only one aspect of the investment process one must go through before making an investment; this report has purposely avoided associated topics such as trade timing, liquidity, and valuation as these will be covered in later reports. Nevertheless, this report has laid bare the evidence to support paying increased investment attention to crypto assets, especially for institutional investors looking to improve their portfolio's risk profiles.

Endnotes

- 01.** All data is sourced from Coin Metrics and Yahoo Finance unless stated otherwise.
- 02.** For metrics such as Alpha and Beta, our benchmark is the SPY exchange-tradedfund.
- 03.** Throughoutthis research report we assume the risk-freerate is 0%, in accordance with the calculation used withinthe Pyfolio library which was used to calculate all the metrics.



Disclaimer

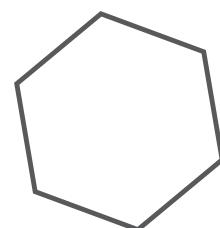


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