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Bitcoin: An Asset Allocator's Perspective

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INVESTMENTS & WEALTH INSTITUTE®

Bitcoin

AN ASSET ALLOCATOR'S PERSPECTIVE

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It's no secret that 2021 has started off well for bitcoin (BTC). The stock breached an all-time high of $61,788.45 on March 13, 2021, and it seems that each passing month brings new milestones, new players, and greater acceptance for the cryptocurrency. A Fidelity survey of 774 institutional clients based in the United States and Europe reported that 36 percent of respondents were investing in digital assets. Furthermore, 60 percent of those surveyed reported an interest in adding digital assets to their portfolios.[1] Looking out five years, 91 percent of respondents said they expect to have at least 0.5 percent of their portfolios allocated to digital assets.

Institutional adoption always has been recognized as a major hurdle for bitcoin, and although progress has been made, obstacles remain. Price volatility, possible market manipulation, lack of accepted fundamentals, and no established investing framework were all cited as areas of concern by participants in the Fidelity survey.

Bitcoin still vexes most investors. Part of the confusion is technological. Bitcoin (and cryptocurrencies in general) represents a paradigm shift in the structure of financial markets that investors have to learn and become comfortable with. The space has developed and matured, but investors have not kept pace. Investment frameworks and valuation criteria remain, by and large, inadequate. No pension fund manager is going to run the risk of defending a crypto allocation to the board without the empirical firepower to back it up.

Bitcoin (and cryptocurrencies in general) represents a paradigm shift in the structure of financial markets that investors have to learn and become comfortable with.

This article presents an asset allocator's view of bitcoin. It starts by focusing on the statistical properties of bitcoin and the state of its relationship with other major asset classes. It then addresses how the inclusion of bitcoin in a portfolio may impact risk, return, and expected outcomes.

MODELING BITCOIN

For this analysis, I collected 2,330 daily and 330 weekly observations of bitcoin's price and return series over the period beginning September 17, 2014, through February 1, 2021. I worked primarily with the weekly returns series because they provide the highest level of granularity for a portfolio setting (i.e., bitcoin trading occurs every day at all hours, but stocks and bonds trade only during set weekday hours).

One challenge encountered upfront with modeling bitcoin is what approach to take. The world of institutional risk management has four general approaches to model risk:

Fundamental models measure fundamental factors that drive risk and return. For stocks these factors include earnings, cash flow, sales, and growth. They also include variables in the Fama–French paradigm such as book-to-price, market capitalization (i.e., size), and momentum.

Macro models seek to measure a security's exposure to broad macro trends such as inflation, interest rates, credit spreads, valuations, etc.

Statistical models are based solely on the statistical properties of an asset discovered by analyzing time series data. Statistical models tend to focus on measuring volatility and the correlation among assets to infer the risk of a portfolio.

Hybrid models combine elements from some or all of the above approaches. For example, it is common to combine fundamental and macro factors into a single risk model that often are informed by theory (e.g., energy stocks are likely subject to both credit spreads and the price of oil).

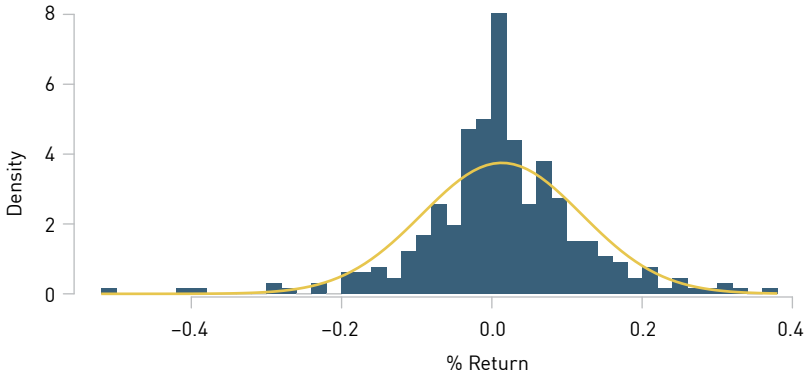
For this analysis, I adopted a purely statistical framework. Given that bitcoin has existed only in a post-Global Financial Crisis world, attempting to build a macro model is an ambitious endeavor.[2] The statistical framework is attractive because there is ample data and it allows the flexibility to pick the granularity of the analysis (i.e., daily, weekly, monthly, etc.).

BITCOIN RETURNS DISTRIBUTION

Figure 1 shows the distribution of weekly returns for bitcoin for the study period.

Figure 1

HISTOGRAM OF WEEKLY BITCOIN RETURNS



Note: Mean = 1.33%, Standard Deviation = 10.64%, Skew = −0.4293, Excess Kurtosis = 0.3065, Min = −50.23%, Max = 36.82%

Figure 2

120-DAY ROLLING VOLATILITY FOR BITCOIN AND MAJOR ASSET CLASSES

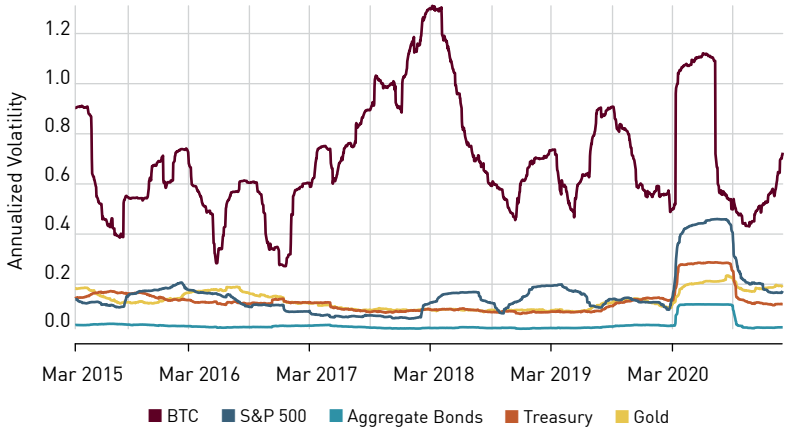


Figure 1 shows that the returns are not normally distributed. The empirical distribution appears leptokurtic with excessive peakedness around the mean and fat tails. This is confirmed by the summary statistics in the note to figure 1, which indicate a slight negative skew (a normal distribution has 0 skew) and excess kurtosis (a normal distribution has 0 excess kurtosis). However, the mean at 1.33 percent is distinctly positive; this is unsurprising given bitcoin's lifetime performance. The standard deviation (henceforth volatility) of about 10 percent is quite high for a weekly statistic and is more in line with what one might expect annually from a blue-chip stock.

From a purely statistical perspective, bitcoin is unquestionably high risk, high reward. Investors earn, on average, 1.33 percent weekly, but they also are exposed to large tail risks. The return distribution suggests that losses of more than 40 percent are substantially more common than a normal distribution would predict.

However, a one-dimensional analysis rarely tells the full story. Asset allocators and portfolio managers need to look beyond isolated metrics when constructing a portfolio. At a minimum, the following three criteria should be considered when evaluating an asset for inclusion in a portfolio:

- Volatility
- Correlation to other assets and potential diversification benefits
- Weight (the primary variable the portfolio manager has control over)

VOLATILITY

Volatility is the most basic measurement of dispersion. As shown in figure 1, bitcoin's weekly volatility is about 10.64 percent. On an annualized basis, bitcoin's volatility stands at about 76 percent, which should give any investor pause. Figure 2 presents a rolling 120-day calculation on an annualized basis and shows how bitcoin's volatility has developed over time.

The range of bitcoin's volatility is quite striking: a high of about 120 percent and a low of about 35 percent. Notice the most recent spike beginning in March 2020, where volatility topped out at more than 100 percent. Curiously, despite the emergence of the coronavirus and the ensuing meltdown across global financial markets, bitcoin's volatility topped out at a lower level than during the frenzy of 2017 and 2018. As of this writing, bitcoin's volatility is hovering right around the long-run average of about 75 percent.

For comparison, figure 2 also shows the rolling 120-day volatility for the S&P 500, Barclays Aggregate Bond Index (the Agg), Long Term Treasury Index (20+), and gold.

Among the major indexes, the S&P 500 is generally (but not always) the most volatile, followed by long-dated Treasuries, gold, and the Agg bond index. Again, as a consequence of the coronavirus, there is the prominent spike where the S&P's volatility surge to about 50 percent.

However, even amid the coronavirus pandemic, bitcoin's volatility is substantially higher than that of the four major asset classes.

As mentioned above and in the Fidelity survey, volatility is a primary barrier to institutional adoption of bitcoin. This volatility is considerable and notably more unstable than the volatility of other major asset classes, but it does not necessarily spell doom for bitcoin investment.

CORRELATION

Volatility is only one consideration when building portfolios. In fact, from the perspective of modern portfolio theory, it is primarily the correlation among assets that should be the principal concern. Correlation is a measure of how closely two variables move together (or "co-move"). Correlations range from (-1,1) with a correlation of 1 indicating two assets that move in perfect tandem and a correlation of -1 implying two assets that move in complete opposition.

One common measure of volatility is standard deviation, commonly denoted by the following equation:

where

$$\sigma = \sqrt{\frac{\Sigma_i^N = 1\ (r_i - \mu)^2}{N}}$$

r_i = return in period i
μ = mean
N = number of observations

In the extreme, consider the following example of two assets (A and B), each with a standard deviation (σ) of 100 percent, but they are perfectly negatively correlated. What is the volatility of this equally weighted portfolio?

$$\sigma_{Port} = \sqrt{w_A^2\sigma_A^2 + w_B^2\sigma_B^2 + \rho_{A,B}w_Aw_B\sigma_A\sigma_B}$$

$$\sigma_{Port} = \sqrt{0.5^2 1^2 + 0.5^2 1^2 + (-1)(0.5)(0.5)(1)(1)}$$
$$= 0.5 \text{ or } 50 \text{ percent}$$

This example shows that when combined, perfectly negatively correlated assets produce a portfolio with half the risk of either asset individually. This is essentially the situation we face with bitcoin.

Figure 3 shows the rolling 120-day correlation of bitcoin and the S&P 500. Over its lifetime, bitcoin generally has been uncorrelated with U.S. stocks. The correlation of returns has varied and, at times, has been slightly positive or slightly negative. The coronavirus spike presents itself once more, but more recently the correlation has been trending down toward a more normal range.

Figure 4 extends the correlation analysis to the other major assets: Agg bonds, long-dated Treasuries, and gold.

Against fixed income (Agg bonds and Treasuries) bitcoin is relatively uncorrelated; it usually hovered near zero with some periods of variability. Against gold, the correlation pattern is somewhat bifurcated. Between 2015 and 2018, the correlation is around zero, but recently the correlation has been more pronounced. On balance, bitcoin appears weakly correlated with gold.

Table 1 shows the correlation matrix over the full time period.

Figure 3

120-DAY ROLLING CORRELATION OF BITCOIN AND S&P 500

Figure 4

120-DAY ROLLING CORRELATION OF BITCOIN, AGG BONDS, TREASURIES, AND GOLD

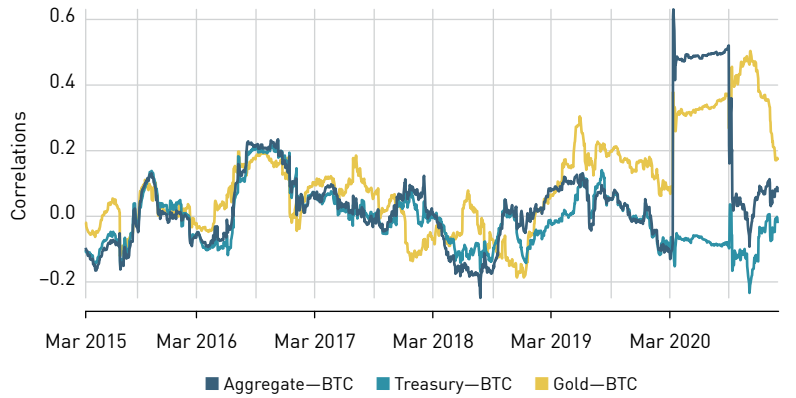


Table 1

CORRELATION MATRIX, OCTOBER 2, 2014–JANUARY 29, 2021

	S&P 500	Agg Bonds	Treasuries	Gold	BTC
S&P 500	1				
Agg Bonds	−0.0105	1			
Treasuries	−0.4007	0.75	1		
Gold	−0.0255	0.3441	0.3119	1	
BTC	0.1533	0.1358	−0.0252	0.0997	1

The correlation matrix in table 1 reinforces the information provided by the rolling plots shown in figures 3 and 4: Bitcoin is uncorrelated with Treasuries and weakly correlated with stocks, Agg bonds, and gold. The correlation coefficient for Agg bonds is of particular interest because it is a bit higher than figure 4 suggests. This may be an artifact of the coronavirus pandemic and not necessarily indicative of a long-term expectation; nonetheless, it must be considered.

The next step in the analysis calls for running formal tests. The claim of interest is: "Is bitcoin statistically uncorrelated with the other major asset classes?" Tests help to formalize the intuition gleaned so far and provide a range of plausible correlations that can be used for stress testing portfolios.

There are three basic tests of correlation: Pearson's product-moment, Kendall's rank, and Spearman's rank. Pearson's test calculates the correlation coefficients shown in table 1 using the following formula:

$$\rho_{i,j} = \frac{cov\,(r_i - r_j)}{\sigma_i \sigma_j}$$

where
r_i = returns of asset i
r_j = returns of asset j
σ_i = standard deviation of asset i
σ_j = standard deviation of asset j

The test statistic follows a Student's t-distribution with n – 2 degrees of freedom and is calculated as:

$$t = \rho\sqrt{\frac{n-2}{1-\rho^2}}$$

But a crucial assumption of Pearson's parametric test is that the data is normally distributed. This poses a problem because, as figure 1 shows, bitcoin's returns are not normally distributed. There is a way to adjust Pearson's test to account for non-normal random variables, but rather than address that here, let's use Pearson's test but keep in mind that it may be low power in this setting.

To supplement Pearson's test, I also calculated the Kendall and Spearman rank statistics. Rank statistics are attractive because they are non-parametric (i.e., they don't make assumptions about the underlying distribution) and only consider how well the data line up (i.e., on a given day that bitcoin's return is high [low], was the return for the S&P also high [low]). These tests together provide a well-rounded picture of how correlated the major asset classes are with bitcoin.

Table 2 shows the p-values or significance values for the three tests for each asset pair. The null hypothesis is that correlation equals 0, and a low p-value (0.05 or less being a traditional cut-off) indicates the null hypothesis is rejected (i.e., the pair is statistically correlated).

For bitcoin and the S&P, Pearson's test is highly statistically significant, which implies the two are, in fact, correlated. However, the Kendall and Spearman tests are more borderline with p-values close to but falling shy of the 0.05 threshold. Taken together, the results suggest that bitcoin and the S&P are correlated, but only weakly. In laymen's terms, they tend to co-move on average, but bitcoin having a good (bad) day when the S&P has a bad (good) day is not uncommon.

Table 2

SIGNIFICANCE VALUES

	Pearson Correlation Test	Kendall Correlation Test	Spearman Correlation Test
S&P 500-BTC	7.73E-10	0.0548	0.0558
Agg Bonds-BTC	5.28E-08	0.6021	0.5946
Treasury-BTC	0.3156	0.3709	0.3613
Gold-BTC	6.69E-05	0.0001	0.0002

The results for bitcoin and Agg bonds are probably the most interesting. Based on Pearson's test, bitcoin and Agg bonds appear statistically correlated. However, the null hypothesis of 0 correlation fails to be rejected under the Kendall and Spearman tests. This suggests that the argument above, that the apparent correlation of bitcoin and Agg bonds is really an artifact of the coronavirus pandemic, is true, and the correlation is not representative of a long-run expectation.

The tests for bitcoin and long-dated Treasuries are in resounding alignment, with all three indicating the two are uncorrelated. For gold and bitcoin, the tests all indicate a statistically significant degree of correlation, which has implications for the idea of bitcoin as "digital gold."

In summary, we can make the following observations about correlation:

- Bitcoin and the S&P 500 are weakly correlated
- Bitcoin and Agg bonds are uncorrelated
- Bitcoin and Treasuries are uncorrelated
- Bitcoin and gold are weakly correlated

Bitcoin exhibits relatively low correlation across asset classes, which is crucially important for the asset allocation analysis to follow. The diversification effect from even a small allocation to an uncorrelated asset can have a substantial impact in a portfolio. Bitcoin's volatility is likely to increase the absolute level of risk, but the added risk can be richly rewarded.

Another casual observation is that in periods of stress, bitcoin's correlation tends to increase. Over short periods of time the adage "all correlations go to 1" seems relevant. But a skilled manager knows that it is long-run expectations and not short-term dynamics that win the day. Indeed, the drivers of bitcoin's returns are quite different from those of

stocks and certainly different from those of fixed income and commodities. Thus, if history is any guide, we can expect bitcoin's price to continue to diverge, which we can use to our advantage.

ASSET ALLOCATION

What happens to a portfolio when a new asset is added? How does the overall risk profile change? How do the sources of risk change? Does the expected return justify the change in risk? These are the questions that a manager asks when considering the inclusion or exclusion of a particular asset in a portfolio.

The key question here becomes what role (if any) does bitcoin have to play in a portfolio?

To help answer this question, I looked at four possible allocations that easily can be employed in a real-world asset management context. The portfolios and asset allocations are shown in table 3.

The Base portfolio does not allocate to bitcoin and will (unsurprisingly) be used as the basis for comparison. The Pro-Rata portfolio allocates 5 percent to bitcoin taken proportionally from the weights of stocks, bonds, and gold. The No-Gold portfolio swaps the 5-percent allocation to gold in the Base portfolio for bitcoin; the idea being that if bitcoin is "digital gold," we want to see how the two differ when you remove physical gold entirely. Finally, the Risk portfolio allocates 5 percent to bitcoin by allocating away from stocks (the second most-risky asset).

The four defined portfolio variations are simple. Of course, you can imagine extending the analysis to include allocations to developed market equity, emerging markets, small caps, a broader cross section of commodities; real estate, hedge funds, private equity, and currency. However, before adding complexity, we first need to determine if bitcoin is at all useful in a portfolio context. For that to happen, the bitcoin portfolio needs to beat traditional allocations.

Table 3

PORTFOLIOS AND ASSET ALLOCATIONS

	Stocks (i.e., S&P 500)	Agg Bonds	Gold	Bitcoin
Base	60%	35%	5%	0%
Pro-Rata	57%	33%	5%	5%
No-Gold	60%	35%	0%	5%
Risk	55%	35%	5%	5%

Figure 5

VOLATILITY BY ALLOCATION

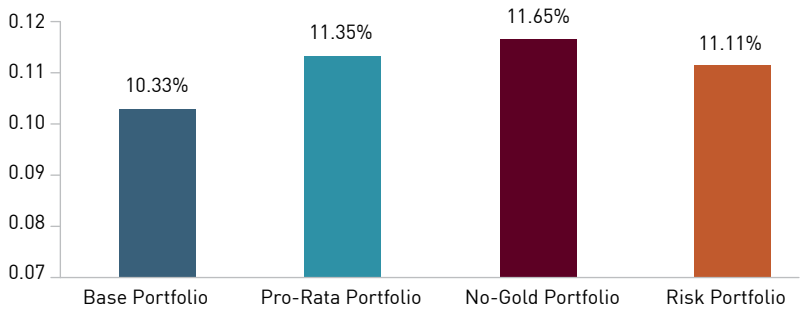


Figure 6

RISK CONTRIBUTION BY ASSET FOR BASE, PRO-RATA, NO-GOLD, AND RISK PORTFOLIOS

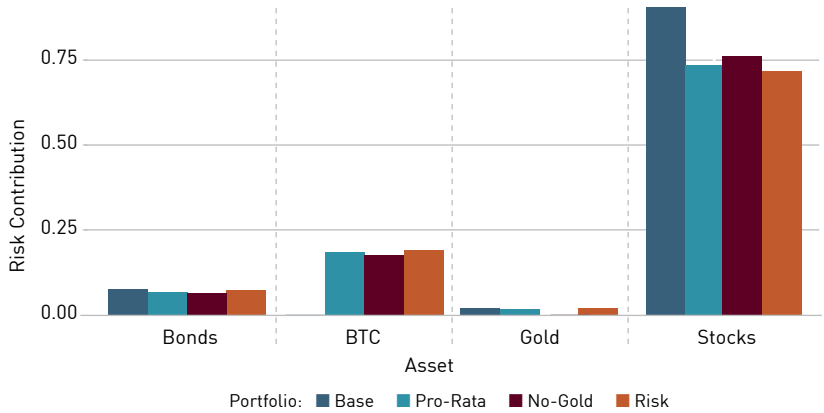


Table 4

RISK CONTRIBUTION TO PORTFOLIO VARIANTS BY ASSET

	Portfolio			
	Base	Pro-Rata	No-Gold	Risk
Stocks	90.59%	71.80%	73.36%	76.18%
Bonds	7.55%	7.33%	6.63%	6.43%
Gold	1.86%	1.90%	1.70%	0.00%
Bitcoin	0.00%	18.96%	18.30%	17.38%

Let's begin by looking at the estimated risk for each portfolio (see figure 5).

The Base portfolio has an annualized volatility of 10.33 percent. Among the portfolios that allocate to bitcoin (Pro-Rata, No-Gold, and Risk) the Risk portfolio has the lowest risk. This result makes intuitive sense because the Risk portfolio has the same bitcoin allocation but the lowest stock allocation of the three alternatives. With a volatility of 11.11 percent, the Risk portfolio is approximately

7.5 percent more volatile relative to the Base portfolio.

The No-Gold portfolio has the highest standard deviation at 11.65 percent; approximately 12.7 percent higher than the Base portfolio. This also makes sense because we have removed an entire asset class and therefore reduced the overall diversification benefit.

Next, let's examine the contribution of each asset to total portfolio risk. Risk contribution is another way to view portfolio diversification that enables us to decompose how an individual asset drives the total risk.

As figure 6 and table 4 demonstrate, even in the supposedly diversified Base portfolio, a full 90 percent of the total portfolio risk is attributable to stock. The implication is that in a situation where the market tumbles, but bonds hold up well, this portfolio still will be dragged down because stock is still the dominant source of risk. Contrast this with the Risk portfolio where the contribution from stock has been reduced to 76 percent and redistributed to bitcoin. In effect this creates a more balanced portfolio with risks more evenly distributed.

By now we have a good feel for how bitcoin impacts the risk profile of a portfolio. In general, a 5-percent allocation to bitcoin results in a modest increase in volatility compared with the Base portfolio. The portfolio is also less concentrated and less reliant on equity. Finally, bitcoin does better in a diversified setting. Having gold and bitcoin in a portfolio (like the Risk portfolio) dampens the overall volatility because we are broadening the portfolio's menu of uncorrelated assets.

If the inclusion of bitcoin in a portfolio results in slightly more risk, then investors need to be compensated for doing so. Figure 7 and table 5 show recent annual returns for each of the four alternative portfolios.

Figure 7 shows that a 5-percent allocation to bitcoin can impact a portfolio's annual returns. Historically the additional risk has been richly rewarded with the Pro-Rata, No-Gold, and Risk portfolios outperforming substantially in 2016, 2017, and 2020. In 2018, however, bitcoin shed more than 80 percent of its 2017 high, resulting in underperformance of the alternative portfolios relative to the Base portfolio.

Figure 8 shows cumulative returns for each portfolio.

Each alternative outperforms the Base portfolio by more than 30 percent. Interestingly, there is not much difference in cumulative return among the Pro-Rata, No-Gold, and Risk portfolios. The No-Gold portfolio does the best, and the Pro-Rata and Risk portfolios follow closely behind.

But is one of the alternative allocations superior? Risk-adjusted measures of return, namely, the Sharpe and Sortino ratios, quantify how well investors are compensated for taking a unit of risk.

The Sharpe ratio is defined as follows:

$$\text{Sharpe ratio} = \frac{E(r_p) - r_{rf}}{\sigma_p}$$

where:

- $E(r_p)$ is the expected return of the portfolio
- r_{rf} is the risk-free rate of return (which was near zero during the study period)
- σ_p is the portfolio volatility

A criticism of the Sharpe ratio is that it punishes volatility symmetrically. In other words, upside volatility is penalized the same as downside volatility, but investors are presumably content for an asset to be volatile if the price is rising.

Figure 7 ANNUAL RETURNS BY PORTFOLIO

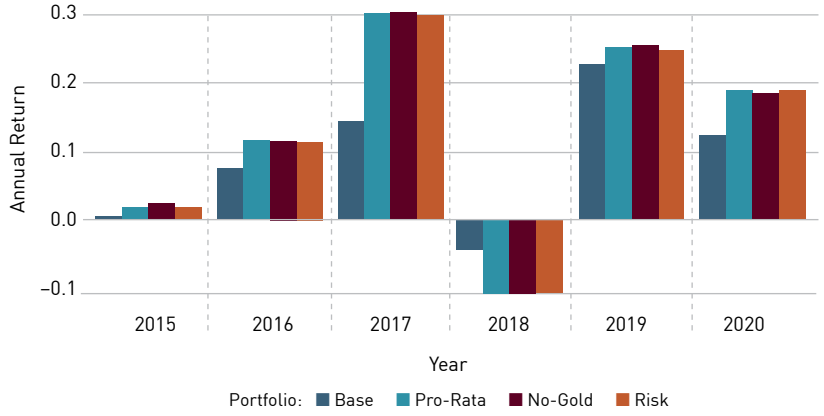


Table 5 ANNUAL RETURNS FOR PORTFOLIO VARIANTS BY YEAR

	2015	2016	2017	2018	2019	2020
Base	0.56%	7.55%	14.51%	−4.42%	22.90%	12.40%
Pro-Rata	1.89%	11.68%	30.51%	−10.84%	25.49%	19.16%
No-Gold	2.49%	11.68%	30.63%	−10.96%	25.72%	18.50%
Risk	1.84%	11.52%	30.14%	−10.71%	25.04%	19.08%

To address this shortcoming, we can employ the Sortino ratio, which is defined similarly to the Sharpe ratio, but instead has the downside deviation in the denominator. Downside deviation represents the volatility of returns but only below a threshold (usually zero). In this way the Sortino ratio accounts for asymmetric upside.

$$Sortino\ ratio = \frac{E(r_p) - r_{rf}}{\sigma_p^{Down}}$$

Where downside deviation in our context is calculated as

$$\sigma_p^{Down} = \sqrt{\frac{(min(r_i,0))^2}{n}}$$

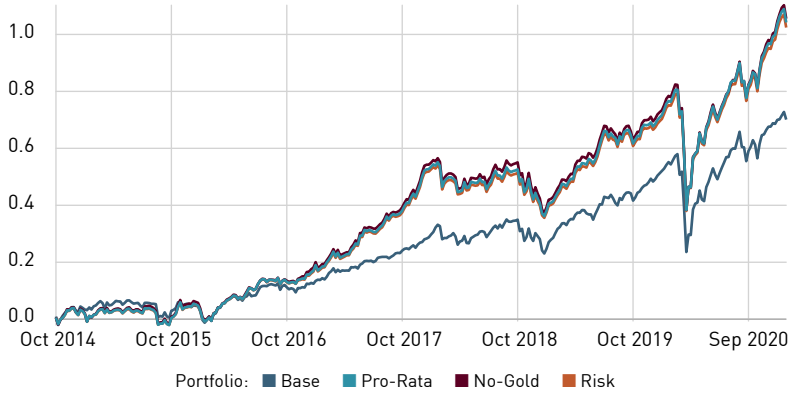
Table 6 shows that the Sharpe ratios for the alternatives are higher than for the Base portfolio, which implies that the additional risk that bitcoin adds to a portfolio is well compensated. The Risk portfolio has the highest Sharpe ratio, which indicates the best risk–reward trade–off.

With the Sortino ratio and downside deviation, an interesting picture emerges (see table 6). The Risk portfolio has the highest Sortino ratio. With respect to downside deviation, the difference between the four portfolios is remarkably small. The downside deviation of the Risk portfolio is only about 46 basis points higher than the Base (about 5.8 percent in a relative sense). This implies that even a 3 standard deviation move would imply a less than 1.5–percent underperformance of the Risk versus the Base portfolio, which seems tolerable for the opportunity to notch higher returns.

This shows that, on a risk–adjusted basis, an allocation to bitcoin is justifiable if not prudent. Bitcoin's returns are high and generally uncorrelated. Consequently, investors are able to reap substantial rewards while taking on only marginally higher risk. Among the alternative allocations, the Risk portfolio appears to be the superior choice. By incorporating four asset classes and allocating away from stock to bitcoin, the portfolio offers maximum diversification benefits and a better risk–return tradeoff.

Figure 8

CUMULATIVE RETURN BY PORTFOLIO



Note: Cumulative Return: Base = 70.09%, Pro–Rata = 104.21%, No–Gold = 105.54%; Risk = 102.42%

Table 6

SHARPE AND SORTINO RATIOS

	Base	Pro-Rata	No-Gold	Risk
Sharpe ratio	0.8445	1.0489	1.0313	1.0576
Sortino ratio	0.1565	0.1934	0.1899	0.1949
Downside deviation	7.90%	8.55%	8.80%	8.36%

By incorporating four asset classes and allocating away from stock to bitcoin, the portfolio offers maximum diversification benefits and a better risk–return tradeoff.

CONCLUSION

The key question that I sought to address in this article was: "What role does bitcoin have to play in an institutional caliber portfolio?" In short, bitcoin offers a highly attractive opportunity for managers who are long–term focused and willing to expand their investment universe. One key takeaway is that bitcoin's reputed volatility is very real and will necessarily require that portfolio managers and boards allocate in a way consistent with their risk tolerance. But managing that risk appropriately is more than achievable.

Allocating to crypto assets is going to become increasingly mainstream in coming years. Allocating to bitcoin provides managers with an opportunity to gain exposure to and become comfortable with this emerging technology, hedge portfolios against disruption, and get results for their clients.

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ENDNOTES

1. Fidelity Digital Assets, "The Institutional Investors Digital Asset Survey" (June 2020), https://www.fidelitydigitalassets.com/bin-public/060_www_fidelity_com/documents/FDAS/institutional-investors-digital-asset-survey.pdf.
2. See Aric Light, "Bitcoin Price Formation: An Empirical Investigation" (2019), https://search.proquest.com/openview/6454be44434dc166be63fb9dba18534d/1?pq-origsite=gscholar&cbl=18750&diss=y.

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