# The Lucid Guide to Cryptocurrency Risk Management

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**Abstract**

This guide documents how modern risk-management, tailored to cryptocurrencies' unique risk-reward profile, can significantly improve the experience of principled crypto-investors. There are 5 main takeaways for principled investors and the professionals who advise them.

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# 1 Summary

1. *For volatile assets, risk management can help you compound faster.* If you are looking to compound, losses end up weighing more than gains. For instance, if you start with USD 100, gain 20%, then lose 20%, you're left with USD 96.[1]

   This means that risk-management can improve the speed at which you compound. Over the medium run, an 80/20 regularly rebalanced portfolios of cryptocurrencies and cash can deliver higher compounded returns than holding the cryptocurrency alone.

2. *The relationship between volatility and returns has been different for equities and crypto.* For equities, high volatility periods tend to be associated with low returns. This has made strategies that reduce exposure in volatile years popular. In contrast, for crypto, there has been no strong negative relationship between volatility and returns. Hence, crypto risk-management cannot focus on volatility alone.

3. *The main risky scenarios are large instantaneous price drops and persistent small losses.* News events, especially about regulatory oversight, can cause large instantaneous losses, but the data shows that persistent small losses are surprisingly frequent, and cause large losses.

4. *Those risks can be addressed through a mix of regular rebalancing and drawdown control.* Regular rebalancing addresses large instant losses but you should insulate against persistent declines. Balanced drawdown control efficiently takes care of persistent declines.

5. *Risk management always disappoints in the short run, even if it pays-off in the medium run.* Over the short run, fully allocating to either cash or the market always beats a balanced portfolio. This is why managing risk on your own is hard and delegating makes sense.

[1] Indeed, $100 \times \frac{120}{100} \times \frac{80}{100} = 96$.

# 2 Why a risk management approach to crypto?

Crypto tends to polarize people. The loudest voices either love it or hate it. This guide is for the cautiously curious: those who don't claim to predict the future of crypto, but weigh the pros and cons, and like the potential. We believe that with thoughtful risk-management it's a story principled investors can responsibly be part of.

While there are concrete fundamental reasons for optimism, such as Ethereum's successful transition to Proof of Stake, reducing energy costs by 99.99%, higher standards of conduct for key actors, or the approval of Bitcoin ETFs, it remains true that like any new technology, the success of crypto will depend on the ingenuity of entrepreneurs and their ability to develop value-added applications.

Our key investment thesis is that uncertainty regarding the business model of crypto is not in and of itself a challenge for investors. It it is not dissimilar to the uncertainty investors in new and risky business models have always faced. With some adjustments, thoughtful risk-management that works for more familiar assets, will also improve the experience of owning crypto.

We develop this thesis in detail in the remainder of this guide. Whenever possible we illustrate how fundamental risk-management techniques – the core expertise of investment professionals – can be applied to both standard assets and cryptocurrencies.

# 3 How risk-management improves compounding

## 3.1 Compounding and volatility

**The miracle of compounding.** Compounding is one of the miracles of investing. If you invest USD 100K and your portfolio returns 8% every year after 10 years, you'll have USD 216K, after 20 years, USD 466K, and after 30 years, USD 1M. It grow exponentially. Practically the reason for this is that in the second year, you earn interest on your interest.

In the third year, you earn interest on the interest on your interest, and so on...

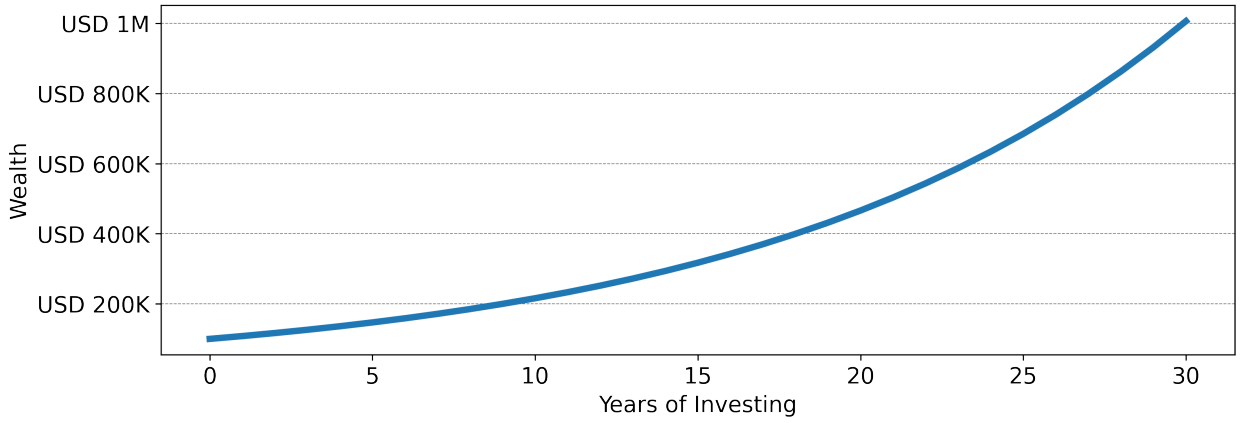



Figure 1: The miracle of compounding

**Why volatility is bad for compounding.** Variation in returns turns out to be your enemy. Imagine that you invest USD 1 for two years. The first year you gain 20%, and the second year you lose 20%. Your average return is 0, but how much money do you have at the end? For any return $r$

$$(1+r)\times(1-r) = 1+r-r-r^2 = 1-r^2.$$

If $r = 20\%$, at the end of two years, instead of a dollar, you only have 96 cents. This doesn't look like much, but over time variation in returns makes a portfolio compound a lot slower.

Imagine that your portfolio alternates good and bad years. In bad years you lose 8%, and in good years, you gain 24%. Your average return is still $8\% = (-8\% + 24\%)/2$. But your portfolio compounds much more slowly. At the end of 30 years, you'll have USD 663K instead of USD 1M.

The variation of returns around their mean is called the volatility of the returns. Formally, if you have a sequence of returns $r_1, r_2, \cdots, r_n$, with mean $\overline{r} = \frac{1}{n}(r_1 + r_2 + \cdots r_n)$ the volatility

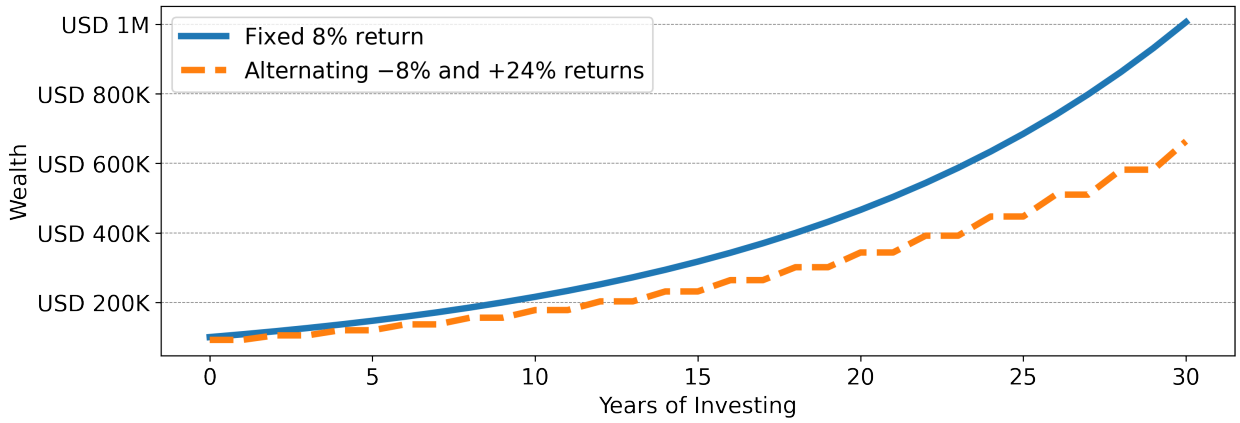



Figure 2: Volatility depresses the rate of compounding

of those returns is

$$\mathrm{v} = \sqrt{\frac{1}{n}\sum_{k=1}^{n}(r_k - \overline{r})^2}.$$

When you look at returns over short time intervals (say daily returns) so that returns are small, a portfolio with returns $r_1, r_2, \cdots, r_n$, compounds approximately at the same speed as a portfolio with fixed return equal to

$$\underline{r} = \overline{r} - v^2/2, \tag{1}$$

where $v^2/2$ is the volatility penalty. In other terms, volatility makes portfolios compound slower.

For instance, over the last 90 years, the yearly returns of the S&P 500 are approximately 8%, with a yearly volatility of about 20%. This means that a portfolio invested into the S&P 500 will compound like a portfolio with a fixed return of 6%:

$$6\% = 8\% - 20\% \times 20\%/2.$$

Over many years, the difference becomes important: over 20 years USD 100K can become

USD 321K if it compounds at a 6% rate, versus USD 466K if it compounds at an 8% rate.

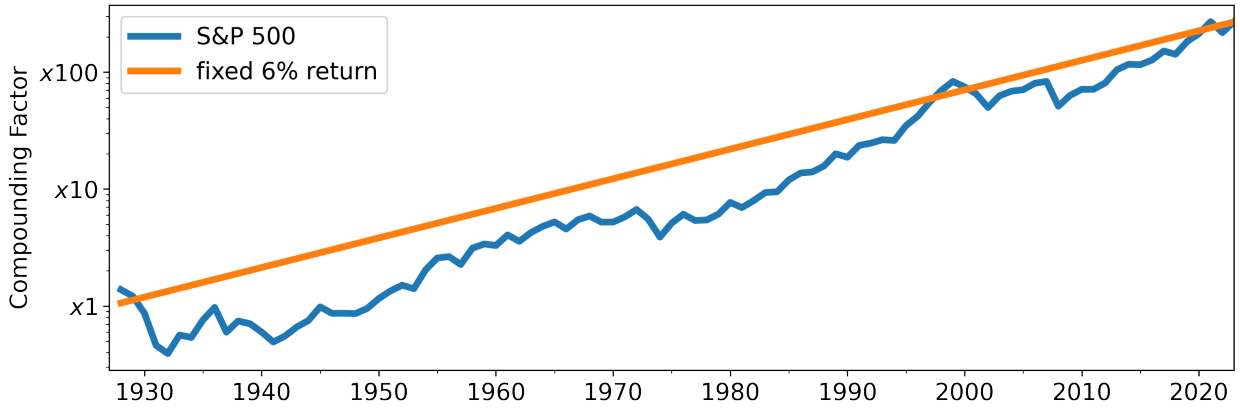



Figure 3: The S&P 500 has an average return of 8% but a compounding rate of only 6%.

**Controlling risk is especially important for crypto.** As formula (1) shows, an asset with average return $\overline{r}$ and volatility $v$ compounds at a rate approximately equal to

$$\underline{r} = \overline{r} - \frac{1}{2}v^2.$$

This means that the volatility penalty grows like the square of the volatility. As a result, when volatility increases, the penalty increases even more. For instance, if the volatility doubles, the penalty is multiplied by four!

This is an important concern for crypto because it exhibits massive volatility. For reference, over its history the S&P 500% has a mean yearly return of roughly 8% and a volatility of roughly 20%. Since 2015, Bitcoin has had an average *monthly* return of 7.3% and a monthly volatility of 22%. This is what makes crypto an eye grabbing asset class: it's a little bit like watching the market on 12X fast forward. At the same time, this means that volatility really slows down compounding for crypto investors. As Figure 4 shows, this means that since 2015, Bitcoin has compounded at an actual monthly rate of 4.7%, rather than 7.3%. This gap in the compounding rate makes a big difference over 8 years, roughly a factor of

10. This is not to say that Bitcoin did not offer amazing returns: USD 1 invested in 2015 would have become roughly USD 200 in 2023, but without the penalty due to volatility it would have become USD 2000. This gives risk-management a lot of room to contribute.

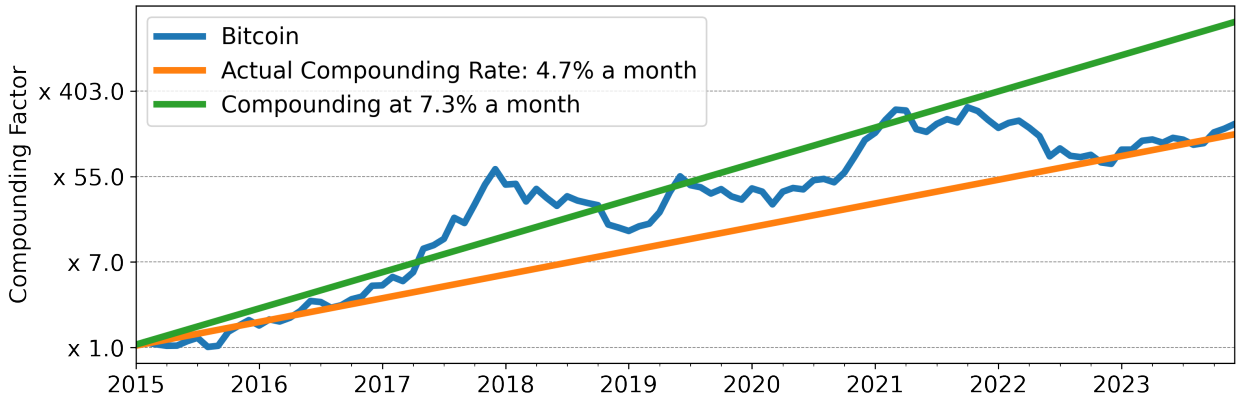



Figure 4: The volatility penalty for Bitcoin is very large (log scale)

## 3.2 Risk-adjusted performance metrics

The impact of volatility on compounding is one of many reasons why investors care about more than just average returns. A number of metrics seek to capture aspects of returns that investors care about. Here are three that we pay special attention to.

**The long-term growth rate.** This is basic, but important. Because average returns are not sufficient to identify the rate at which you are compounding, we don't pay much attention to them. Instead, we do the obvious, and pay attention to the effective growth rate of portfolios including the volatility penalty.[2] In our backtests we always report the effective compounding rate.

Since 2015, Bitcoin has been compounding at the rate of 73% a year. For comparison, over the same period, Nasdaq compounded at the rate of 17% a year, and the S&P 500 at

[2]This turns out to correspond to the average of log returns. This is why our performance graphs are systematically in log scale: the performance graph of an asset compounding at a fixed rate becomes a line.

12% a year.

**The Sharpe ratio.** The Sharpe ratio is the ratio of average returns (net of the risk-free rate) to volatility. Importantly, your Sharpe ratio doesn't change if you leverage into the asset, or dilute the asset with cash. It's a signature for the asset, capturing the rewards you get *per unit of risk*.

The Sharpe ratio of Bitcoin since 2015 has been 1.04, while that of Nasdaq has been 0.73 and that of the S&P 500 0.6. The attractiveness of Bitcoin comes from the fact that it's a high volatility asset with a high Sharpe ratio.

**Drawdowns.** We now come to drawdowns, or more precisely (and this will matter later) drawdowns vs the safe asset. The drawdown of a portfolio against a safe asset like cash, is the loss in value between the historical peak of the portfolio, and the current value. Formally, the drawdown at time $t$ is

$$\text{Drawdown}_t = 1 - \frac{\text{Porftolio Value}_t}{\text{Peak Historical Value}_t}.$$

The maximum drawdown of a portfolio over a time-period corresponds to the biggest Peak-to-Trough loss experienced by the portfolio. The maximum drawdown for the Nasdaq is remarkable. From March 2000 to September 2002, the Nasdaq lost 81% of its value.

As Figure 6, the magnitude of Bitcoin's drawdowns has been similar. Between the end on 2017 and the beginning of 2019, Bitcoin lost 83% of its value.

These are remarkable numbers. In both cases, if you had invested USD 1000 at the peak, in one or two years, you'd be left with USD 200.

This is not something that an investor can ignore, even if you are hoping to stay invested for the long run. First, it's an incredible amount of stress to deal with. Instead of riding the storm out, most people who plan to buy-and-hold end up getting cold feet and sell


Figure 5: It took 14 years for the Nasdaq to recover from its 2000–2002 drawdown (log scale)

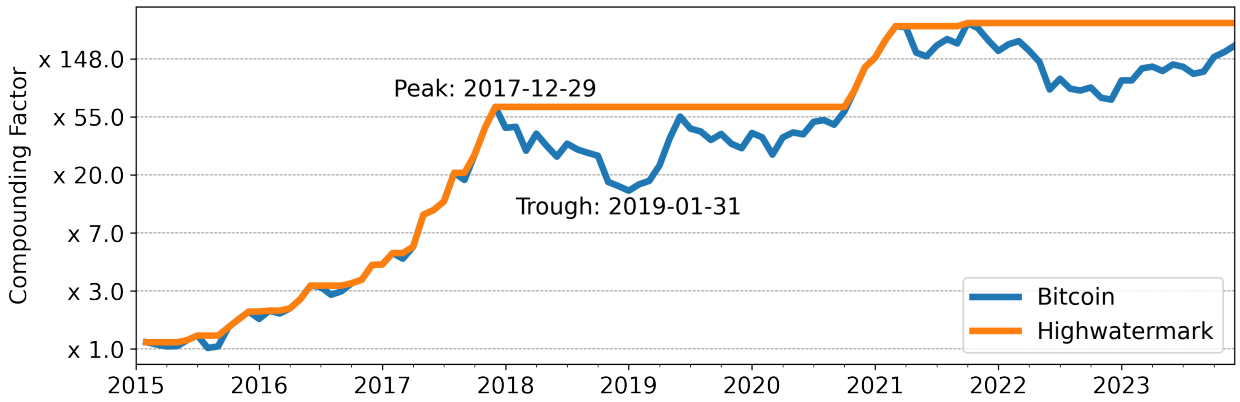



Figure 6: Bitcoin experiences drawdowns of similar magnitude (log scale)

somewhere close to the trough. Second, such drawdowns are really problematic if you need liquidity. Imagine you need to deal with a large expense somewhere close to the trough...

## 3.3 Regular rebalancing and the diversification free lunch

Take two assets A and B. Asset A has returns $r_1^A, r_2^A, \cdots, r_n^A$, while asset B has returns $r_1^B, r_2^B, \cdots, r_n^B$. Imagine that both assets have the same expected yearly returns and volatility as the S&P 500: an 8% return, and 20% volatility. As we've just seen, each asset compounds roughly at a 6% rate.

Now imagine that you diversify. You follow a regular rebalancing strategy in which each

January 1st, you rebalance your assets so that 50% of your wealth is in asset A, and 50% of your wealth is in asset B. This means that each year your portfolio will have returns

$$r_1^{50/50} = \frac{1}{2}r_1^A + \frac{1}{2}r_1^B \quad , \quad r_2 = \frac{1}{2}r_2^A + \frac{1}{2}r_2^B \quad , \quad \cdots \quad , \quad r_n = \frac{1}{2}r_n^A + \frac{1}{2}r_n^B.$$

This means that the 50/50 portfolio also has an average return of 8%. The beauty of diversification is that the volatility of the 50/50 portfolio is not 20%. Frequently, the negative shocks experienced by one asset will be compensated by the shocks to an other asset. In particular, if the two assets have *independent returns*, then the 50/50 portfolio has a variance $20\%/\sqrt{2} \simeq 14\%$!

This means that the 50/50 portfolio will compound faster than each of the underlying assets.

**An example.** Consider a regular rebalancing strategy assigning 50% weights to the S&P 500 and to 20 Year US Treasury Bonds. Over the 50 years from 1970 to 2020, the S&P 500 and 20Y Bonds have similar yearly returns and volatility: roughly 9% returns and 17% volatility, although 20Y Bonds end up performing better. Over 50 years, the S&P500 multiplies wealth by 40, and 20Y Bonds by 50. A 50/50 Rebalancing strategy multiplies wealth by 60.

A really surprising fact is that even though the S&P 500 performs less well than 20Y Bonds over this period, combining the two together yields an asset that performs better than both. There are two caveats to this.

**Caveat 1: you need to rebalance.** For a diversified portfolio to perform better than any of the underlying assets, you need to rebalance regularly. If you invest 50% of your assets in a bond fund, 50% in an equity fund and never rebalance across stocks and bonds, ten years later, your wealth will be 50% of the value of the bond fund plus 50% of the value of the

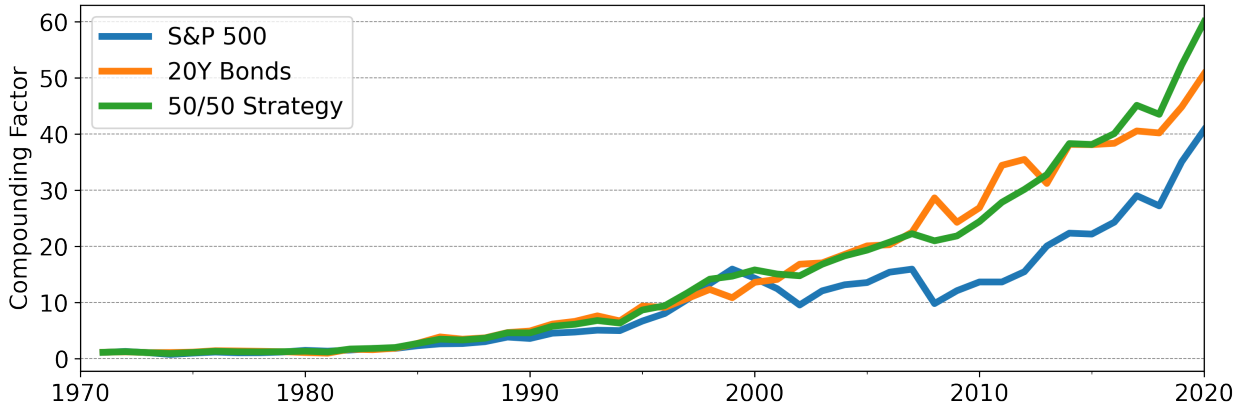



Figure 7: A regularly rebalanced strategy can compound faster than all of the underlying assets.

equity fund.

**Caveat 2: correlations matter.** Allocating your portfolio to multiple assets only reduces volatility if the assets don't move the same way. If the assets always move in the same direction they do not diversify each other very well. Correlation is a measure of how well two assets diversify one another. It takes values between 1 and -1. When correlation is 1, the shocks to the two assets are always in the same direction. When correlation is -1, the shocks to the two assets always compensate one another.

For instance the S&P 500's correlation with the Nasdaq is 90% while its correlation with 20Y Bonds is $-30\%$. This means that on average, 20Y Bonds have offered better diversification benefits than Nasdaq to equity holders.

**How this translates to crypto.** The correlation between different crypto assets is high because they are affected by similar factors: interest rates, animal spirits, regulatory risk, headline risk.... For instance, as Figure 9 illustrates, the correlation between Bitcoin and Ethereum is between 60% and 70%. This means that cryptocurrencies diversify one another only to a limited extend.

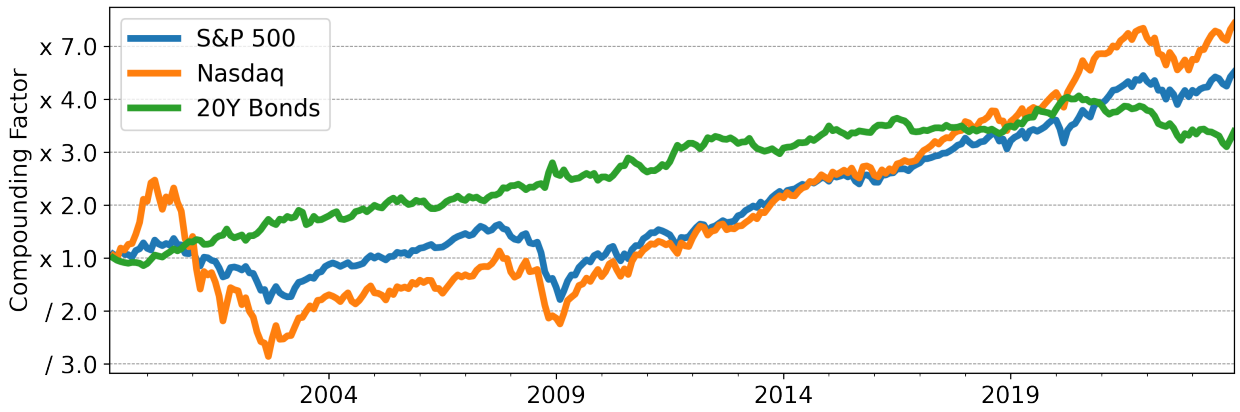



Figure 8: The Nasdaq and the S&P 500 are very correlated

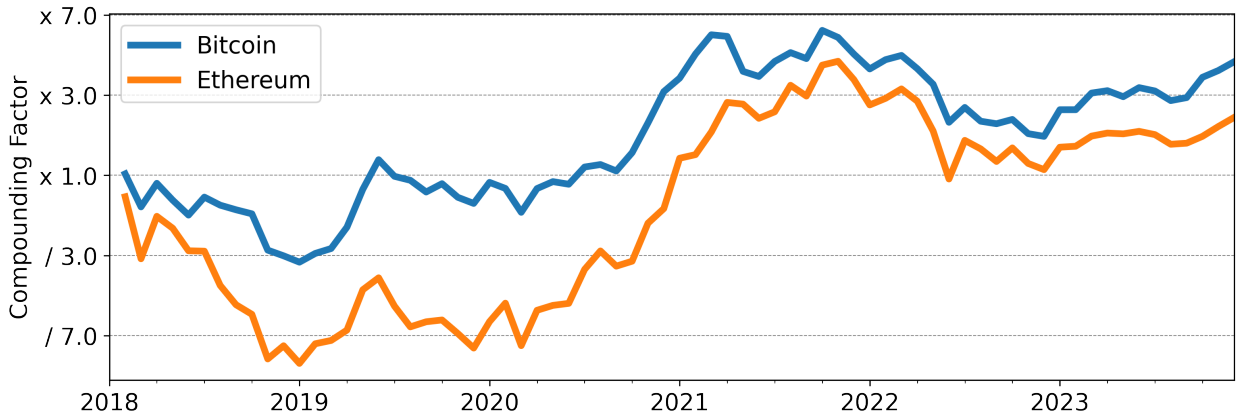



Figure 9: Bitcoin and Ethereum are highly correlated.

The simplest approach to diversification is simply to hold a safe asset, like cash, or a well designed stablecoin. In fact, even if cash does not provide a return, it turns out that a regularly rebalanced portfolio with 80% invested in a cryptocurrency, and 20% invested in cash, can outperform both cash and the underlying crypto. As Figure 10 shows, this is the case over the period from 2018 to 2024. In principle, one could think of using other safe assets such as tokenized gold, but empirically, this does not meaningfully improve the performance of regular rebalancing.

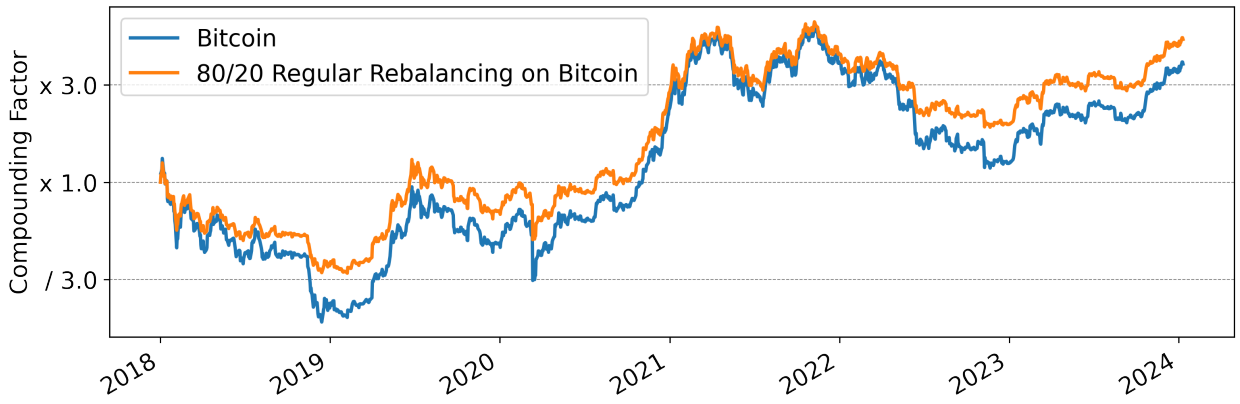



Figure 10: A regularly rebalanced 80/20 portfolio between Bitcoin and cash has reduced risk and improved performance since 2018 (log scale).

# 4 The relationship between volatility and returns

## 4.1 Volatility control

Volatility targeting, or volatility control seeks to keep the volatility of a portfolio close to a target level by appropriately scaling the portfolio's exposure to the underlying risky asset of interest.

For instance, if the Nasdaq has volatility 25% and you want a portfolio with 15% volatility, you could invest $60\% = \frac{15}{25}$ of your assets in the Nasdaq and 40% in cash, or treasury bills. The resulting portfolio will have volatility 15%.

This risk-management strategy is especially useful when the underlying asset of interest has time-varying volatility, so that relatively quiet times alternate with more agitated times. Then, volatility control lets an investor with a fixed risk-appetite to keep a stable risk exposure. Figure 11 plots the annualized rolling volatility of the Nasdaq, and of a Volatility Controlled version of the Nasdaq, targeting an annual volatility of 20%. Because the Nasdaq has an average yearly volatility of 27% over the 25 years from 1994 to 2019, the Volatility Controlled Nasdaq has a reduced exposure to risk, but in quiet periods where the Nasdaq has a volatility less than 20%, Volatility Control may actually use some leverage (i.e., borrow

to buy more) to increase its risk exposure. It's common to limit the maximum leverage, for instance, to 25%.

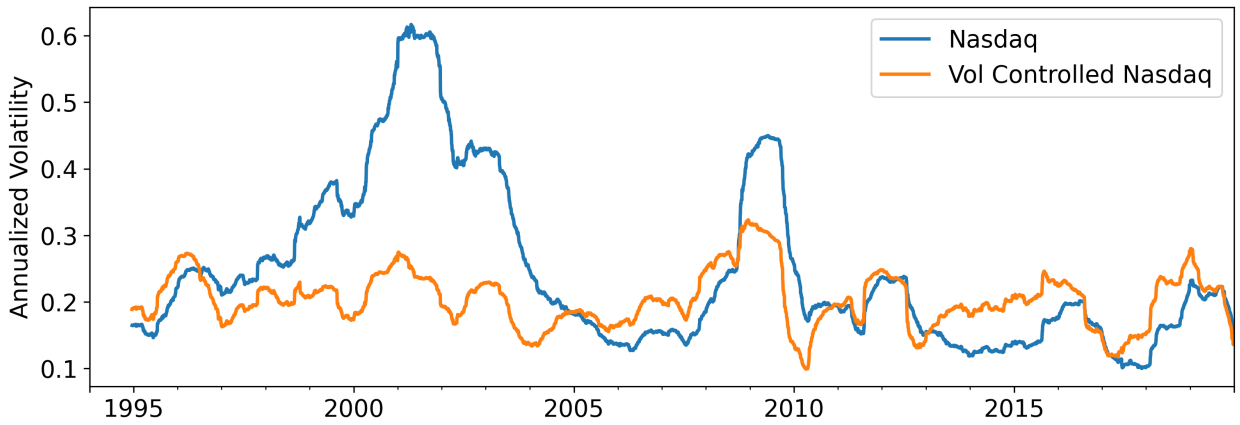



Figure 11: Volatility varies a lot over time, and volatility control reduces the variation

A surprising finding is that volatility control can increase the risk-reward ratio (and potentially the performance) of a particular asset class. Figure 12 shows that this was the case for Nasdaq during the 25 years from 1994 to 2019.

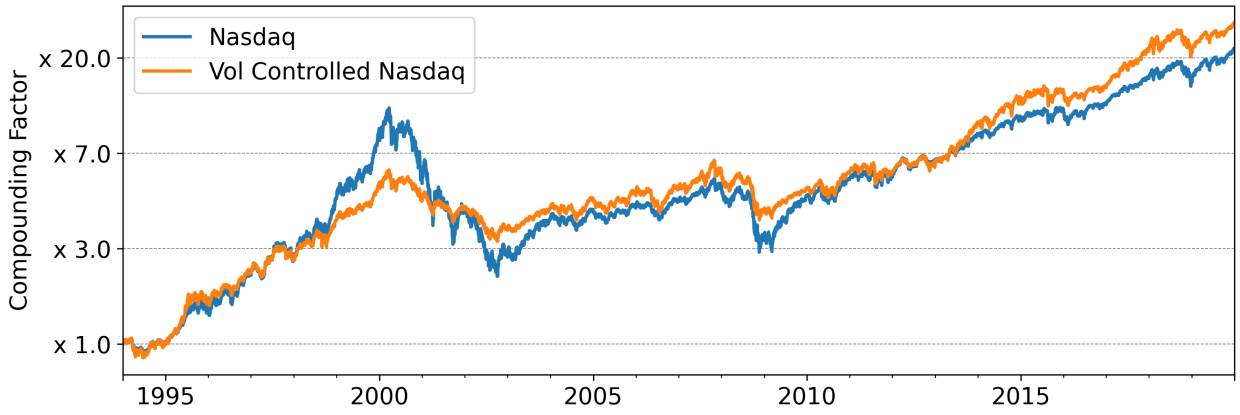



Figure 12: Volatility control can improve returns (log scale)

This is surprising, because simple economic theory suggests that expected returns should increase during agitated times to compensate for the increased risk, but in many markets, it's just not the case. In fact, for equity, it's the opposite. Periods of high volatility tend

to be periods with low returns. The figure below shows the relationship between the yearly volatility and returns of the S&P 500, the Nasdaq, and the Russell 2000. Volatility and returns tend to be negatively correlated.[3] This means that investors tend to be poorly rewarded in high volatility periods. This makes a strategy like volatility control attractive. This is especially true for outliers: years with very high volatility (i.e. above 40%) have been years with low returns.

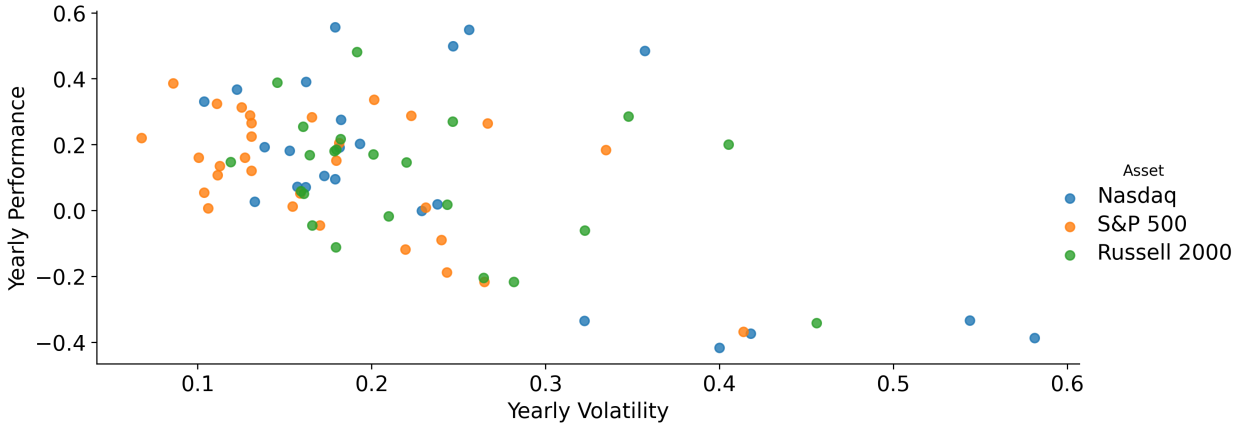



Figure 13: High volatility is bad news for equity investors

## 4.2 Volatility and crypto

With crypto, volatility is par for the course. Between 2017 and 2023, the volatilities of the S&P 500 and Nasdaq were respectively 19% and 24%. The volatilities of Bitcoin and Ethereum were 74% and 92%.

However, with crypto, volatility is kind of the point. Over 2017–2023, all four assets have similar risk-reward ratios. The Sharpe ratio of the S&P 500 is .63, Nasdaq's is .8, Bitcoin's is .84, and Ethereum's is .74. However, as an investor, you don't get to spend risk-reward ratios, you only get to spend the compounded returns. This means that *keeping risk-reward ratios the same*, volatility can sometimes be your friend.

[3]For comparison purposes, volatility and returns are also negatively correlated in the subperiod from 2015 to 2023.

Recall that

$$\text{Sharpe} = \frac{\text{Average Return}}{\text{Volatility}}.$$

This means that

$$\text{Average Return} = \text{Sharpe} \times \text{Volatility}.$$

Keeping the Sharpe ratio fixed, the way you enjoy greater returns is by increasing volatility. That is the attraction of crypto for investors: It has offered a fairly high Sharpe ratio, and a very large volatility.

Volatility control is still valuable, but only makes sense if an appropriate volatility target is chosen. Figure 14 plots the returns of a volatility control strategy targeting a 50% volatility applied to both Bitcoin. Volatility control reduces drawdowns and volatility without noticeably reducing returns.

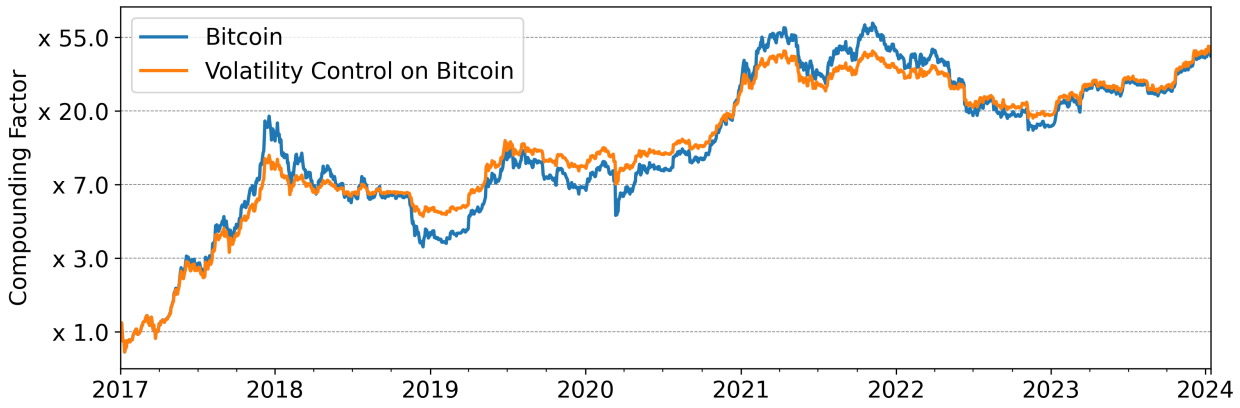
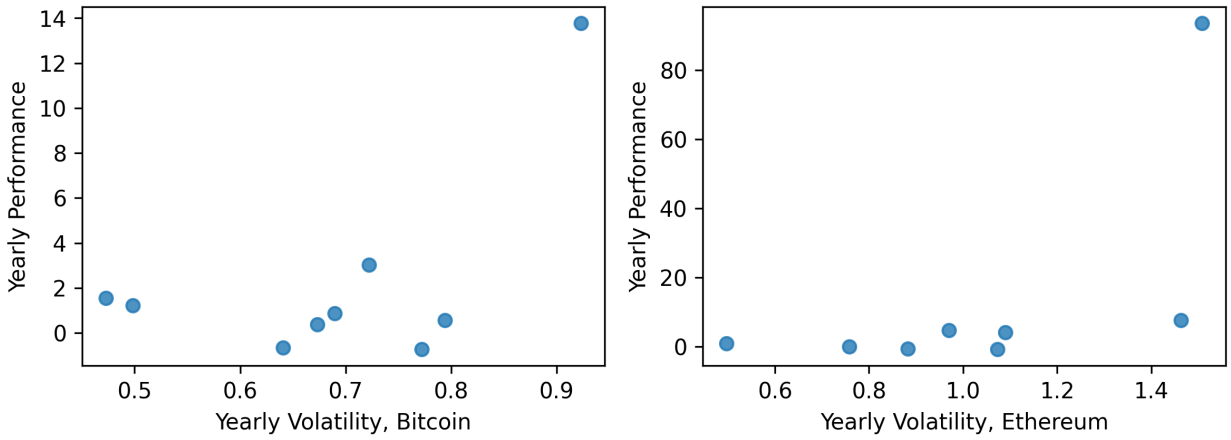



Figure 14: Volatility Control for Bitcoin

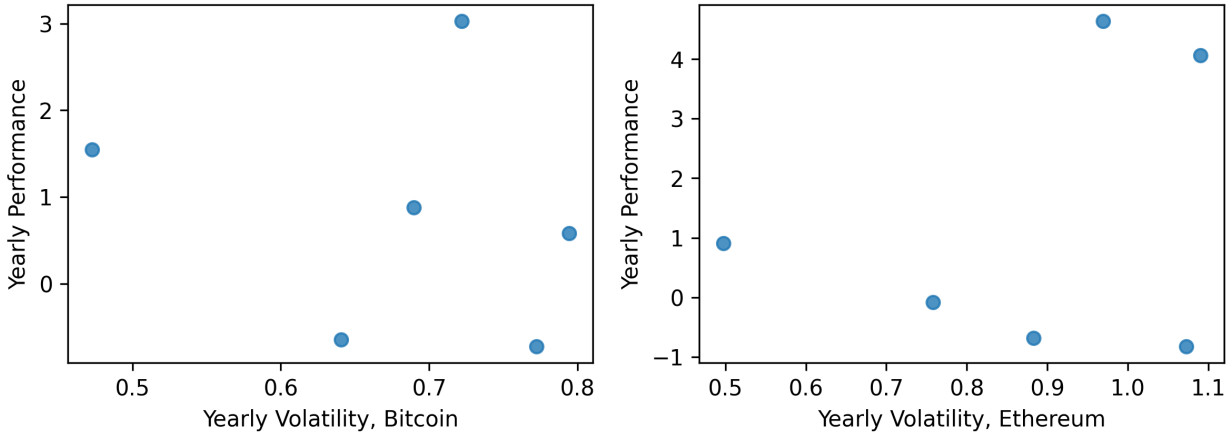
However, one fact suggests that it may be possible to improve on volatility Control. Figure 15a plots the relationship between the yearly volatility and performance of Bitcoin, and Ethereum. Unlike equity indices, there doesn't appear to be a strong negative relationship between volatility and performance. Even ignoring outliers, Figure 15b shows that many of crypto's best years correspond to high volatility years.[4] This is why our preferred

[4]One might also argue that outliers are part of the point of crypto.

risk-management approach treats risk in a bull market differently from risk in a bear market.




(a) Including outliers




(b) Excluding outliers

Figure 15: High volatility is not always bad news for crypto investors

# 5 Sudden crashes and persistent slides

It is useful to break-down the downward risks an investor might face in two categories:

- sudden crashes, i.e. losses at a time scale where the investor cannot trade effectively on the market – in our examples, we will focus on daily losses;

- persistent slides, i.e. surprisingly persistent sequences of losses, at a time scale where it is possible for the investor to trade effectively.

This section quantifies those risks. The next section discusses how they can be dealt with.

## 5.1 Sudden crashes

Sudden crashes are a real thing, especially for crypto. Black Monday, the worst single-day return of the S&P 500 took place on October $19^{th}$, 1987. The S&P 500 lost 20% of its value.

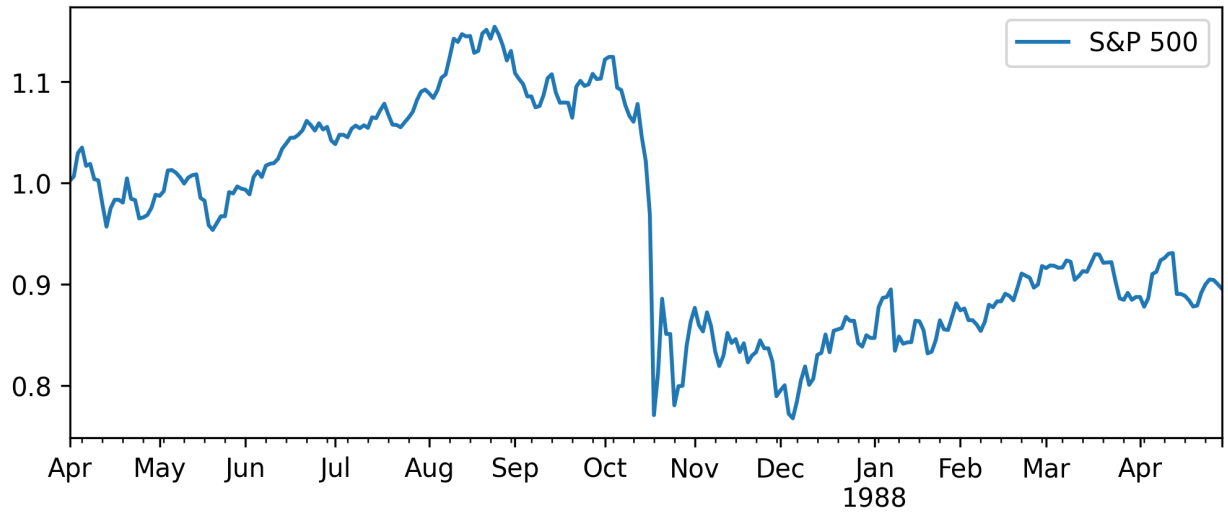



Figure 16: Not a good day (S&P 500 values, indexed to 1 on April $1^{st}$ 1987).

The worst single day returns of the Nasdaq, Bitcoin, and Ethereum are respectively $-12\%$, $-37\%$, and $-45\%$.

A well known fact is that, although rare, these large losses are much more frequent than one would expect if returns followed a Gaussian distribution. For a Gaussian distribution, a daily loss that's 4 times the volatility (a $4\sigma$ loss) should happen once every 100 years. Depending on the asset, the empirical frequency of $4\sigma$ daily losses is between once every year to once every three years.

Because losses loom larger than gains when you are trying to compound, these large losses impact the rate at which investors compound. The only solution is to buy reasonably priced insurance. The simplest way to do so, which we study in greater depth in the next section, is to use a regularly rebalanced strategy holding adequate proportions of both cash, and risky assets. Cash holdings allow you to weather large sudden crashes and get back into the market as you rebalance.

## 5.2 Persistent slides, and excess drawdowns

Large drawdowns (i.e. peak-to-trough losses) can be caused by sudden crashes, but also by persistent slides, i.e. moderate losses repeating themselves over many days. In principle, long sequences of small losses should be rare in equilibrium: if continued losses can be anticipated, investors should reduce their exposure, causing a sudden price adjustment. However, large persistent slides occur surprisingly frequently. One interpretation is that markets are not in equilibrium, and many investors hold inaccurate beliefs. Another is that investors are reluctant to cut their losses, because losses don't feel real until the asset is actually sold.

**Large drawdowns are surprisingly frequent.** Consider the following sequences of returns: Over 6 months, the two assets experience the same returns but in different orders.

| | Jan | Feb | Mar | May | Jun | Jul |
|---|---|---|---|---|---|---|
| Asset A | +5% | −7% | −2% | +3% | +2% | −3% |
| Asset A' | +3% | +5% | +2% | −2% | −7% | −3% |

This means that overall, Assets A and A' have the same aggregate performance (both assets lost 2.5%), and have the save monthly volatility (4%). However both assets have different maximum drawdowns. For Asset A, the maximum drawdown is 9% and takes place from February to March. For Asset A', the maximum drawdown is 12% and takes place from May to July.

What we've done here is reshuffle returns. You can think of reshuffling as follows: write a return on each card of a 52 card deck, one for each week of the year, and shuffle the cards. Regardless of the way you shuffle, the set of returns is going to be the same, so both the performance, and the volatility of the return sequence is going to be the same. However the order in which the returns show up will be different. One reshuffling may start with many gains, followed by many losses. Another reshuffling may alternate gains and losses more evenly.

This leads us to two observations:

- Reshuffled sequences of returns have the same performance, the same volatility, but different drawdowns. Large drawdowns can happen even if volatility is low if small losses are persistent.

- If returns are unpredictable, then all reshufflings of the order of returns are equally probable. This gives us a test of how surprising real-life drawdowns are: compare the actual worst case drawdowns of the real-life asset to the distribution of worst case drawdowns you generate when reshuffling the sequence of returns.

**Example: Reshuffling the Nasdaq.** Figure 17 illustrates a typical reshuffling of the weekly returns of the Nasdaq. In the 25 years from 1994 to 2019, both the actual Nasdaq and the Reshuffled Nasdaq have a mean yearly return of 11.5% and a volatility of 25%.

However, they have very different drawdowns. While the Nasdaq experiences Peak-to-Trough losses of 81%, the Reshuffled Nasdaq only experiences a Peak-to-Trough loss of 38%. The reason for this is that the reshuffling breaks down persistent patterns in actual Nasdaq returns.

The contrast between drawdowns in the actual Nasdaq and the Reshuffled Nasdaq is not due to the fact that we picked a very specific reshuffling. Figure illustrates the distribution of Peak-to-Trough drawdowns obtained from 1,000 independent reshufflings of the Nasdaq.

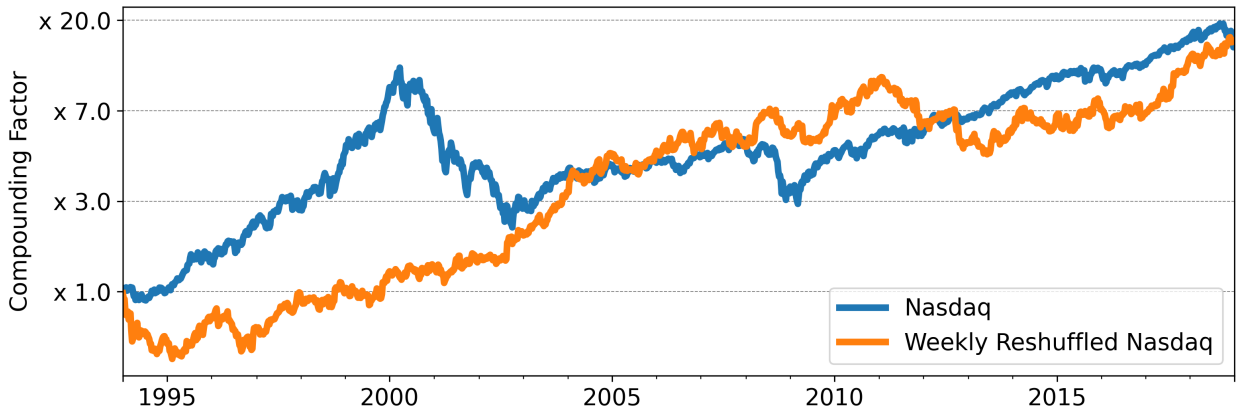



Figure 17: The Nasdaq has exhibited large drawdowns

In 99.58% of simulations, the maximum drawdown of the reshuffled Nasdaq is less than the maximum drawdown of the real Nasdaq. In an efficient market where patterns of returns are not predictable, actual drawdowns should not be so far to the right in the distribution of reshuffled drawdowns.

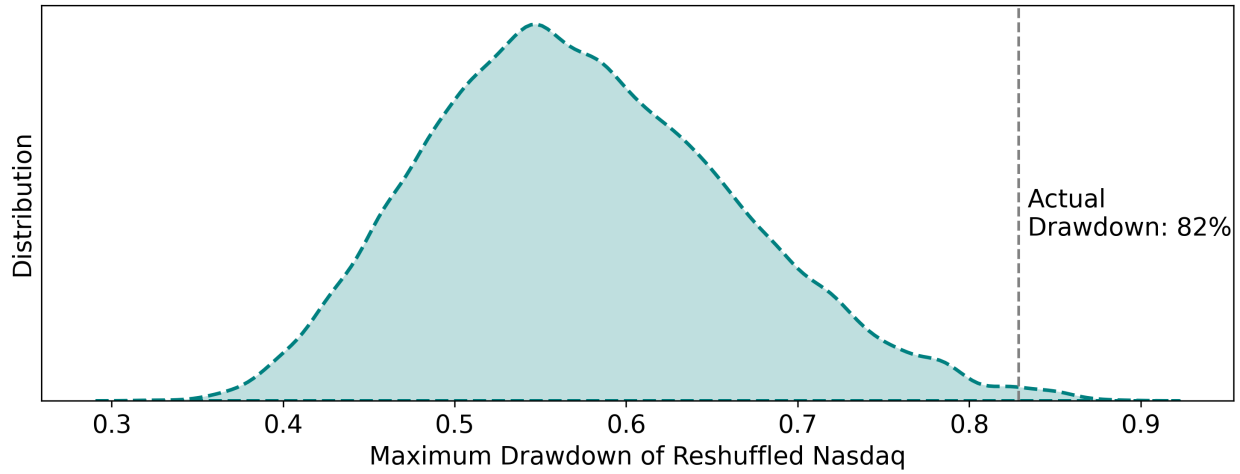



Figure 18: Large drawdowns should be rare in an efficient market

**Why investors should care.** It should be clear to most investors that investing in the reshuffled Nasdaq is a lot less stressful than investing in the actual Nasdaq, even though they start and end at the same point.

What's less obvious is that if you draw on your savings for consumption, then large drawdowns can reduce your long run wealth. For instance, imagine that in 1994 you invested USD 150,000 in the Nasdaq. Starting in 1994, every month, you sell some of your assets to fund USD 1000 of expenses, growing at 5% a year. If you invested in the actual Nasdaq, then in 2019, your wealth would be USD 258,000. If you invested in the reshuffled Nasdaq, your wealth in 2019 would be USD 411,000.

The reason for this is that after a large drawdown, your expenses make up a larger part of your savings. This reduces the basis on which you compound going forward, potentially resulting in significantly lower wealth.

**This is not specific to Nasdaq.** This phenomenon is not specific to Nasdaq. Figure 19 illustrates the distribution of drawdowns for the reshuffled S&P 500, the reshuffled Bitcoin and the reshuffled Ethereum. In all three cases, actual worst case drawdowns fall into the right tail of the distribution, indicating that actual drawdowns are unusually large. Repectively, actual drawdowns of the S&P 500, Bitcoin, and Ethereum fall in the $98^{th}$, $82^{nd}$ and $92^{nd}$ percentiles of the distribution of reshuffled drawdowns.

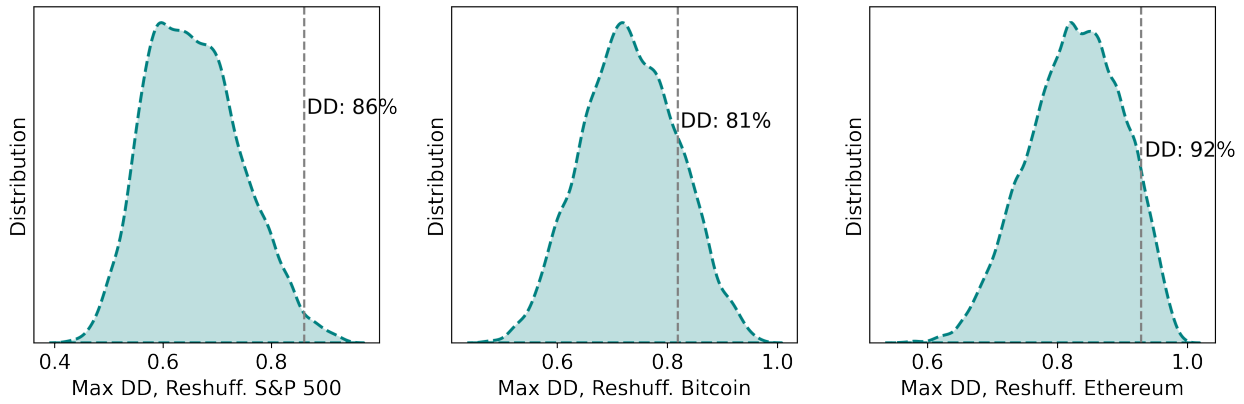



Figure 19: Large drawdowns are unusually frequent across assets (dotted grey line indicates actual maximum drawdowns)

# 6 Regular rebalancing and drawdown control

Different types of risk can be addressed through different preventative measures. We highlight two: regular rebalancing, and drawdown control.

## 6.1 Regular rebalancing

Regular rebalancing consists in setting target portfolio weights across different assets, and regularly selling over-performing assets and buying underperforming assets to restore initial allocation targets.

Typically, some share of the portfolio will be assigned to relatively safe assets, and the remainder to risky assets. This helps portfolios deal with sudden shocks: the relatively safe asset reduces the impact of shocks, and lets investors reinvest at improved valuations after a crash.

A common combination is to rebalance over equities and bonds, with 60/40 being popular weights. With crypto, the simplest approach is to rebalance over a combination of cash or stablecoins, and more risky cryptocurrencies. Since the volatility of risky cryptocurrencies is very large, which safer asset is used typically doesn't make a huge difference. For instance, in the analysis that follows, using cash, a stablecoin or tokenized versions of gold makes a negligible difference in the performance of regularly-rebalanced portfolios. For this reason we always use cash as the reference safe asset.

**Finding a good balance.** Let's first focus on the case where a single risky asset is used. In that case, the main question when designing a regularly-rebalanced portfolio is how much of the safe asset to hold.

In general portfolio weights should depend of investors' risk tolerance. But a good initial benchmark is the allocation maximizing the growth rate of the resulting portfolio.

Table 1 shows that since 2016, setting a target weight for the safe asset to 20% has done

| safe asset weight | Bitcoin | Ethereum | Ripple | Cardano | EOS |
|---|---|---|---|---|---|
| 0% | 79% | 165% | 77% | 65% | -21% |
| 10% | 79% | 170% | 86% | 89% | -16% |
| 20% | 77% | 170% | 91% | 101% | -12% |
| 30% | 74% | 165% | 94% | 105% | -9% |

Table 1: Compounding rate of regularly rebalanced portfolios for different safe asset weights and different risky assets (2016/17-2023).

well across a range of cryptocurrencies. It is eye opening to realize that even given the remarkable performance of Ethereum, Ripple and Cardano over the time period, returns are enhanced by using a regularly rebalanced portfolio with a safe asset weight between 20 and 30%. Rebalancing can enhance growth while reducing risk.

Table 1 also illustrates a key pitfall of risk-management backtesting: survivorship bias. Assets that turn out to have performed particularly well, like Bitcoin or Ethereum, tend to be top of mind for investors studying past performance. For such assets, because they have performed well, lighter risk-management tends to be optimal. In contrast, more conservative risk-management tends to add more value to assets that have performed poorly. As a result, paying attention only to assets that have done well (survivorship bias) can lead investors to use excessively permissive risk-management.

**Preparing for persistent declines.** We now come to regularly rebalanced strategies involving multiple risky assets. To steer clear of survivorship bias, we consider Bitcoin, Ethereum and EOS as reference risky assets. As Figure 20 shows, Bitcoin and Ethereum have performed reasonably well over the last 5 years, while the value of EOS has been divided by roughly 10.

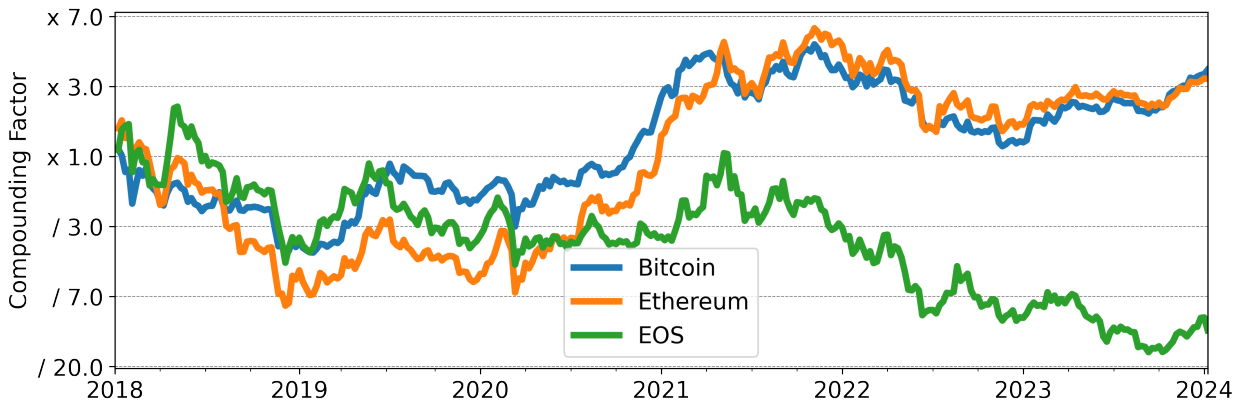


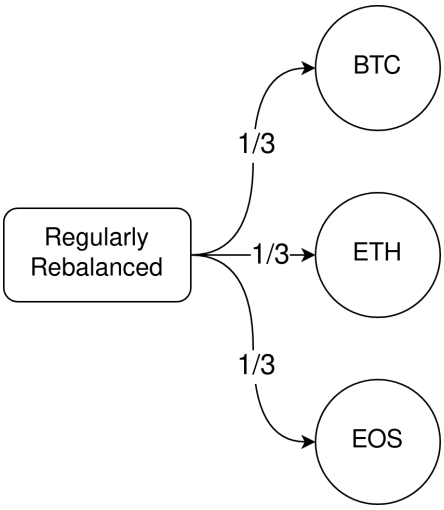

Figure 20: EOS has persistently under performed (2018-2023)

Figure 21 describe three possible architectures for a regularly rebalanced strategy:

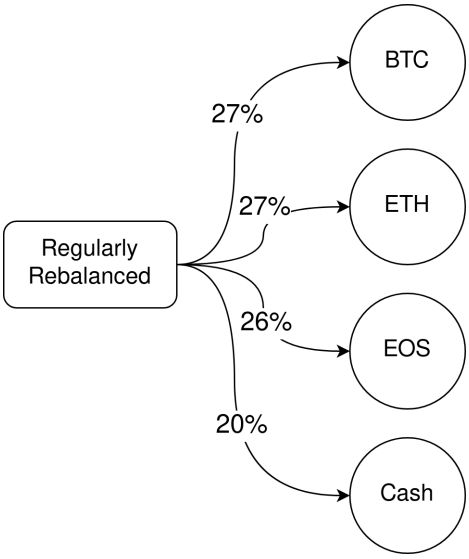
- Architecture RR1 (Figure 21a) is a regular rebalancing strategy with equal target weights applied to risky assets Bitcoin, Ethereum, and EOS.
- Architecture RR2 (Figure 21b) is a regular rebalancing strategy with a target weight of 20% for cash, the remainder of the weight being allocated to Bitcoin, Ethereum, and EOS.
- Architecture RR3 (Figure 21c) is a two-layered architecture. The first stage consists of a non-rebalanced (or at least rarely rebalanced) allocation node, allocating resources to a second layer, consisting of three regularly rebalanced nodes with 80/20 weight targets across individual cryptocurrencies and cash.

The annualized growth, volatility and drawdowns achieved by these three architectures is summarized in Table 2.

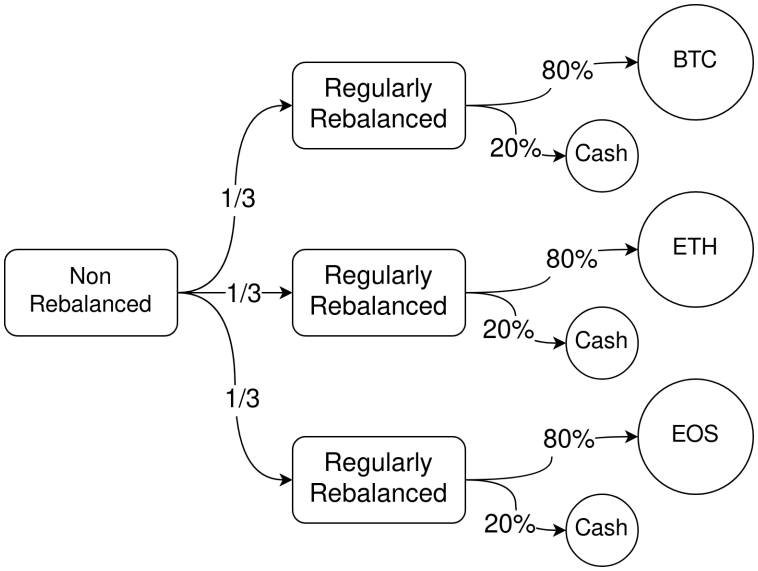
The increase in performance from RR1 to RR2 comes from the fact that RR1 only rebalances across highly correlated risky assets. In contrast, RR2 can rely on cash (which is mechanically uncorrelated to risky assets) to smooth the impact of bull and bear markets.




(a) RR1: Single layer rebalancing across risky assets




(b) RR2: Single layer rebalancing across risky and safe assets




(c) RR3: Two layer rebalancing across risky and safe assets

Figure 21: Three different rebalancing architectures

The increase in performance from RR2 to RR3 comes from the fact that one of the underlying risky assets, EOS, performs consistently badly over the time period. In that case, rebalancing effectively keeps reallocating from well performing assets to this poorly performing asset. If EOS performs worse than Bitcoin and Ethereum, then over time its

| | RR1 | RR2 | RR3 |
|---|---|---|---|
| annualized growth rate | 9% | 17% | 27% |
| volatility | 85% | 65% | 58% |
| drawdowns | 80% | 72% | 66% |

Table 2: Performance of different rebalancing architectures, (2018–2023)

allocation share will diminish, say to 15%. When rebalancing time comes, this means that the strategy will sell Bitcoin and Ethereum to buy EOS. If EOS performs consistently poorly, this is effectively throwing good money after bad.

Because there is still a lot of uncertainty about which cryptos will develop rich value-added ecosystems, it is plausible that some of today's leaders will turn out to be tomorrow's duds. Design RR3 is better designed to deal with the possibility of persistently poor performance by some risky assets.

The second layer of allocation nodes rebalances regularly between cash and risky assets, offering the compounding benefits of diversification to individual cryptocurrencies. The first allocation node either does not rebalance (or at least rebalances at a much lower frequency). This ensures that if one asset is a persistently poor performer, it does not keep claiming resources that will then be wasted. Its allocation weight will drop to 15% then 10%, then 5% ... until it effectively exits the portfolio.

**An implication for overall portfolio allocation.** The real possibility of consistently poor performance has some significance for overall portfolio construction. While regular rebalancing is a good idea within the portion of one's portfolio allocated to crypto, it is less clear that regular rebalancing between crypto and more traditional parts of your portfolio is such a good idea. Crypto as an industry still faces some existential challenges, and it is not impossible that it experiences persistent losses as a whole.

Instead we think it is healthy to assign some initial proportion of assets to crypto (say between 1% and 10%), implement some healthy risk-management within the crypto pocket

of your portfolio, and let it grow on its own until it's time to spend it.

## 6.2 Drawdown Control

Regular rebalancing's main strength is to soften the impact of sudden losses. It turns out that better approaches exist to deal with persistent slides. An approach we like is balanced drawdown control. The key idea is to allocate portfolio weights to safe and risky assets to reduce two different peak-to-trough losses: losses relative to the safe asset, and losses relative to the risky asset. Let us first define those formally.

**Drawdowns against the safe asset.** We have already defined the drawdowns of a strategy against cash. It corresponds to the raw peak-to-trough losses of the asset against cash:

$$\text{Current Drawdown vs Safe} = 1 - \left( \frac{\text{Current Portfolio Value}}{\text{Peak Historical Value}} \right).$$

By convention, whenever we refer to drawdowns without specifying drawdowns versus the safe or the risky asset, we mean drawdowns versus the safe asset.

Figure 22 illustrates the performance and drawdowns against the safe asset of a volatility controlled Bitcoin fund targeting a 50% volatility from 2018 to 2024. The risk-managed strategy performs relatively well: it generates an annual return of 27% (Sharpe .7) against a return of 17% for Bitcoin (Sharpe .3). However, it still exhibits a drawdown of 59% against the safe asset.

Everything else equal, investors dislike drawdowns against the safe asset. However, drawdowns against the safe asset provide a partial picture of what investors care about. Investors dislike losing money if markets tumble, but investors also dislike missing out on a growing market. A good risk-management strategy needs to balance these two objectives.

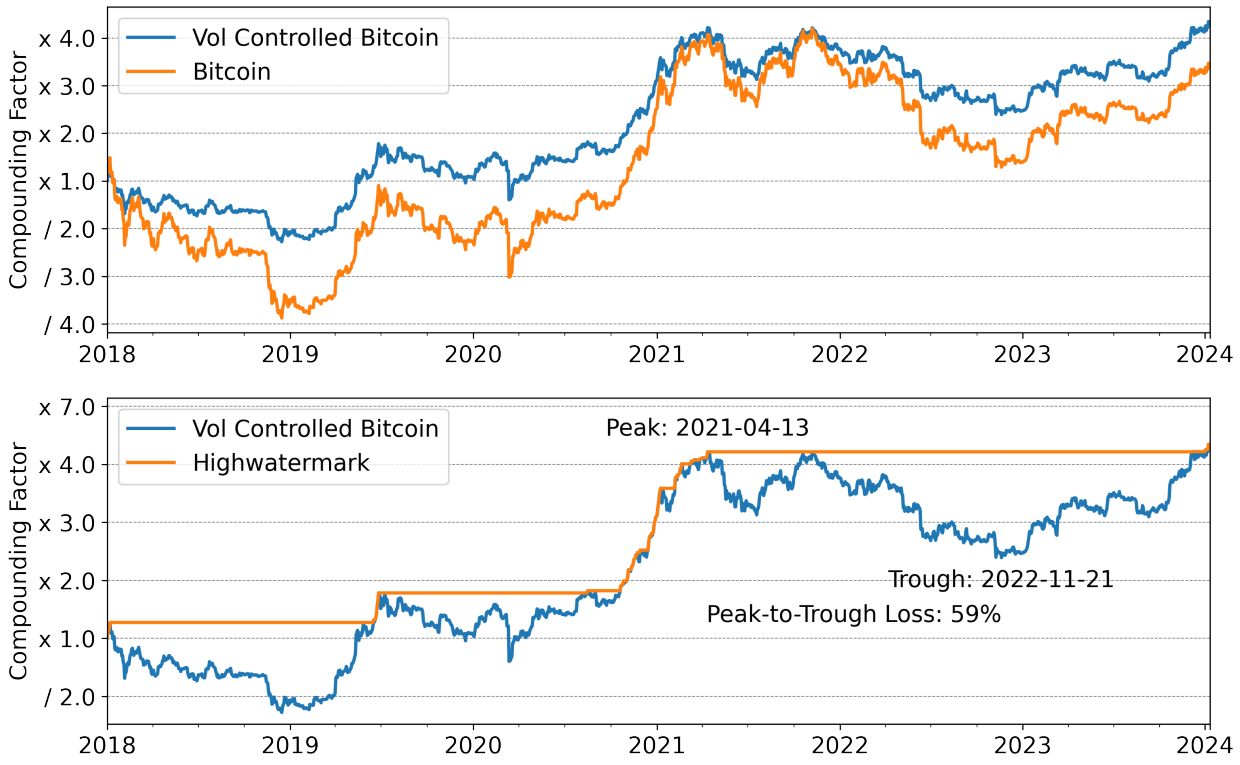



Figure 22: Volatility controlled Bitcoin, performance and drawdowns vs. cash

**Drawdowns against the risky asset.** Taking into account drawdowns against risky assets offers a more complete picture of investors' objectives. The drawdown of a portfolio against a risky asset is the worst underperformance of the portfolio compared to the risky asset of interest. It is formally defined as follows.

We first introduce a portfolio's relative value compared to what the investor's wealth would have been if they had been fully invested in the risky asset (say Bitcoin).

$$\text{Current Value Relative to Risky} = \frac{\text{Current Portfolio Value}}{\text{Value of the Risky Asset}}.$$

The drawdown of a portfolio versus a risky asset corresponds to peak-to-trough losses in the relative value of the portfolio.

$$\text{Current Drawdown vs Risky} = 1 - \left( \frac{\text{Current Value Relative to Risky}}{\text{Peak Historical Value Relative to Risky}} \right).$$

For instance, imagine that an investor sells 1 Bitcoin, and invests it in some fund. After 1 year, the fund is worth 1.2 Bitcoins, but after 2 years, the fund is only worth 0.8 Bitcoins. At the end of year 2, the fund's drawdown with respect to Bitcoin is $1 - \frac{0.8}{1.2} = 33\%$. From peak-to-trough, the fund has lost 33% of its value relative to bitcoin.

Figure 23 illustrates the performance of volatility controlled Bitcoin, and its drawdown relative to Bitcoin itself. From peak-to-trough, Vol Controlled Bitcoin loses the advantage it had accumulated over Bitcoin: in relative terms, it underperforms Bitcoin during this period.

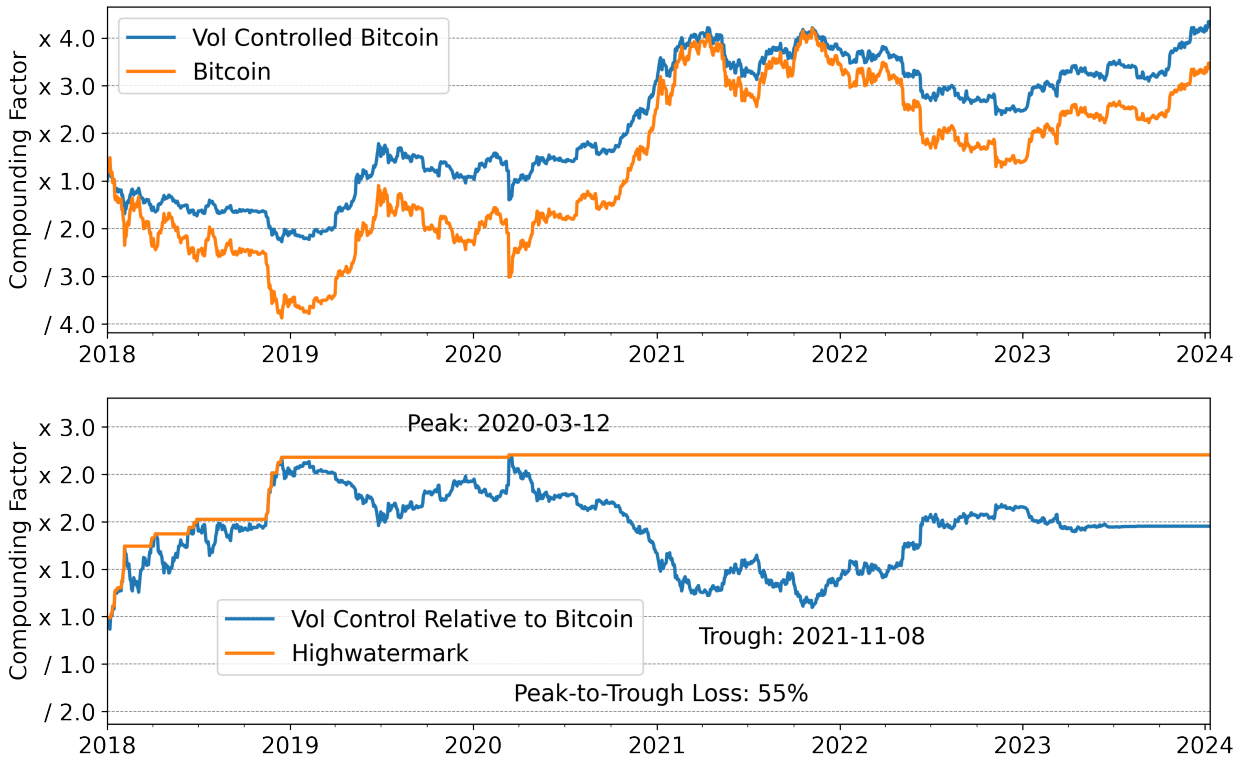



Figure 23: Volatility controlled Bitcoin, performance and drawdowns vs. Bitcoin

**Balanced Drawdown Control.** Good risk-management should limit both hard losses – drawdowns against the safe asset – and foregone returns – drawdowns against the reference risky asset of interest.

Chassang (2018, 2019) establishes that:

1. The optimal portfolio chosen by an investor that has correct anticipations about market risk will experience low drawdowns against both safe and risky assets with large probability.

2. There exist balanced drawdown controlled strategies that achieve low drawdowns with respect to both safe and risky assets for most market configurations *provided there are no large sudden crashes*.

Figure 24 illustrates the performance and drawdowns of balanced drawdown control applied to Bitcoin from 2018 to 2024. Balanced drawdown control reduces maximum drawdowns to 53% while increasing annual returns to 47% (Sharpe 1.1).

**Complementarities between regular rebalancing and drawdown control.** Drawdown control cannot be fully relied on to provide protection against sudden crashes. If you are fully invested in an asset, and public news makes the asset suddenly worthless, drawdown control cannot help you manage this catastrophic loss. Drawdown control helps you deal with persistent progressive changes in markets. In contrast, regular rebalancing across safe and risky assets can help you deal with sudden crashes, but can turn out to be expensive in the event of a persistent decline.

Regular rebalancing and drawdown control can potentially work well together as complementary risk-management strategies. Figure 25 illustrates outcomes from applying drawdown control to a regularly rebalanced 90/10 portfolio of Bitcoin and cash. Compared to applying drawdown control alone, it keeps the rate of compounding roughly the same, but

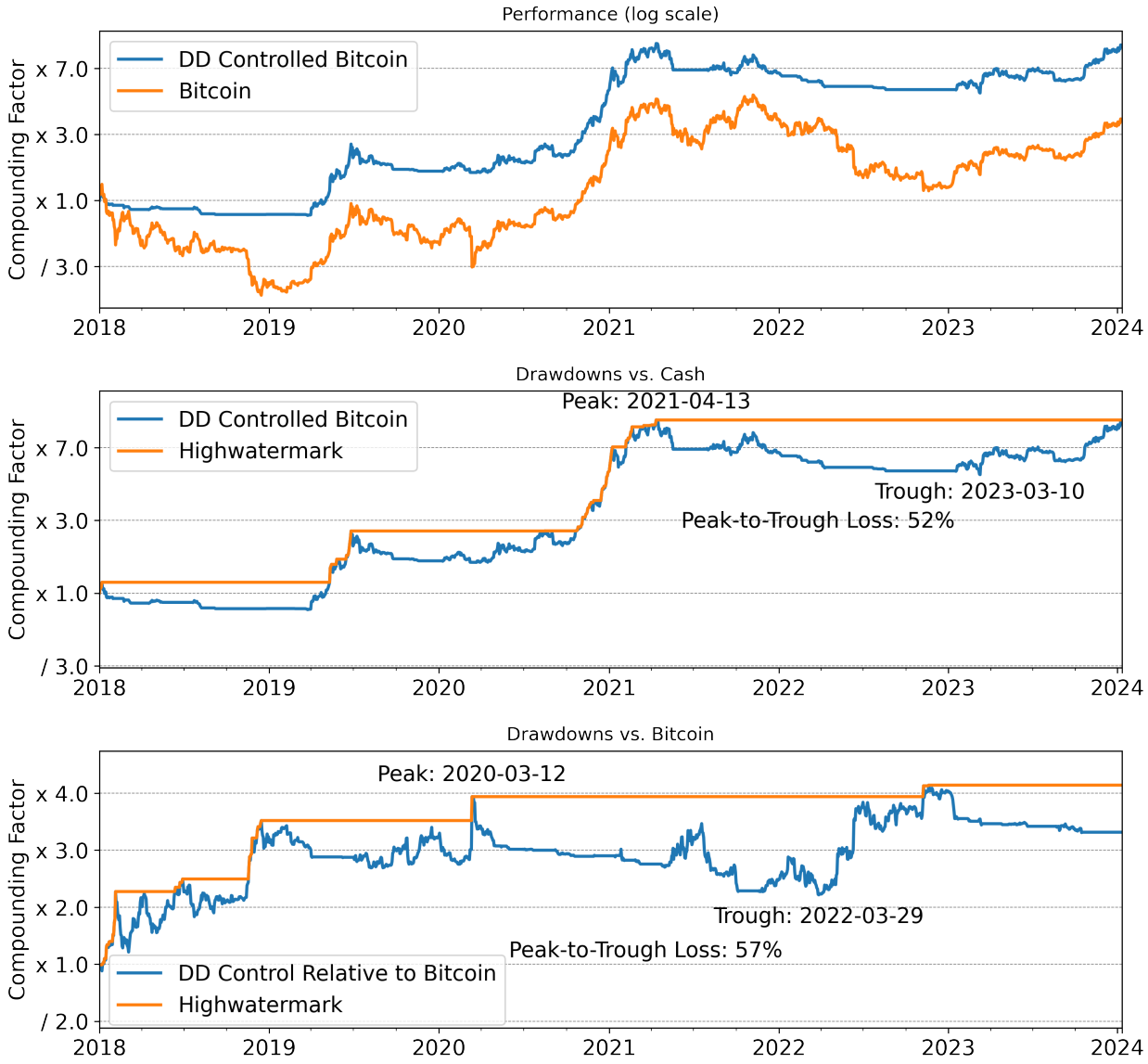



Figure 24: Balanced drawdown control, applied to Bitcoin

it reduces drawdowns against cash from 53% to 45%.

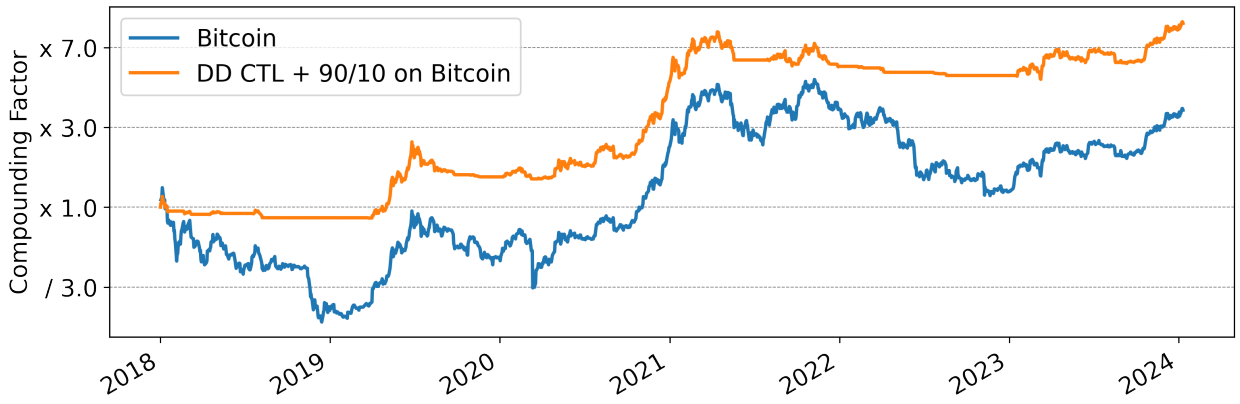



Figure 25: Balanced drawdown control meets a 90/10 regularly rebalanced portfolio applied to Bitcoin

# 7 Risk-management always disappoints in the short-run

The previous sections make the case that risk management can potentially contribute a lot to crypto investors. This section explains why even in circumstances where risk management is a good idea, it is psychologically difficult for investors to follow through.

The reason is simple. Because risk management is a compromise between no risk and full risk, short-run performance always leads to regrets: if markets boom, full risk looks better; if markets crash, zero risk looks better. A principled investor must anticipate these feelings of regret to stay the course over the market's bull and bear cycle.

One useful way to prepare emotionally is to go over how using a drawdown control strategy on Bitcoin would have felt over the 2021-2023 cycle.

**Overall, drawdown control adds value.** Figure 26 illustrates that a drawdown control strategy significantly improves the risk-reward profile of Bitcoin from 2021 to 2023.

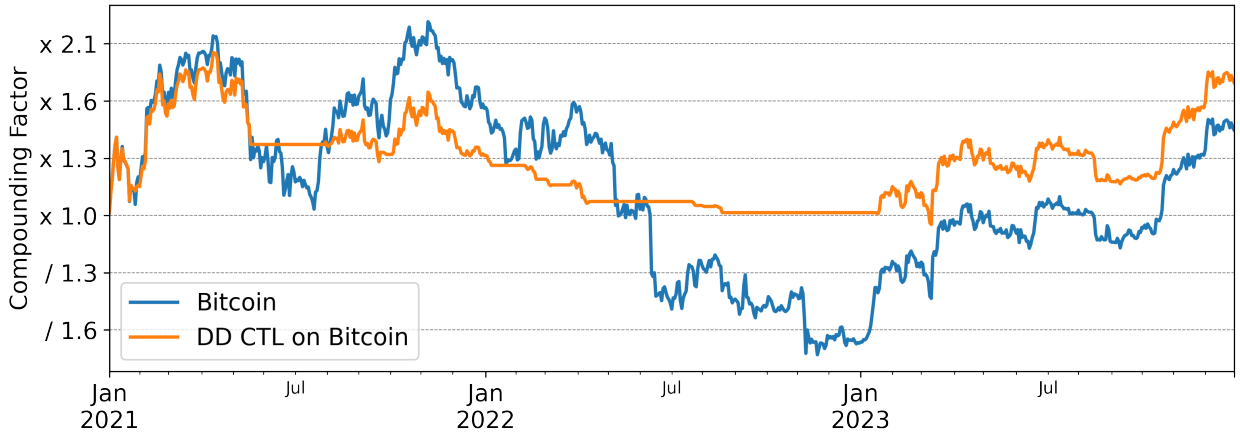



Figure 26: Balanced drawdown control on Bitcoin, 2021–2023

Indeed, over 2021-2023, Bitcoin yielded an average return of 14% for a worst-case drawdown of 77%. In contrast, balanced drawdown control applied to Bitcoin yielded an average return of 22% for a worst-case drawdown of 53%. So overall, using balanced drawdown control is a good idea over this period. It beats Bitcoin alone, and it beats the safe asset.

Let's now look at how the strategy performed over one-year periods.

**Year 1: sideways market.** Figure 27 illustrates that 2021 was a sideways market for crypto. In such a market, it is difficult for drawdown control to improve on the underlying asset, and whether it comes ahead or behind is essentially a toss-up. In this case, it came out behind. Specifically, in 2021, Bitcoin generated a return of 60% for a worst drawdown of 53%, while drawdown controlled Bitcoin generated a return of 30% for a worst drawdown of 38%.

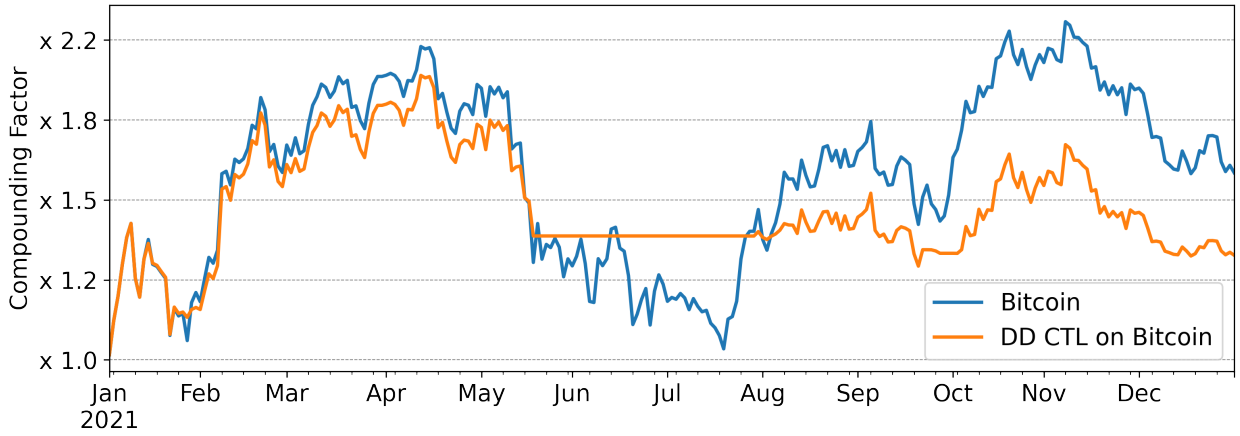



Figure 27: Drawdown controlled Bitcoin in 2021

After year 1, an investor would feel regret with respect to Bitcoin.

**Year 2: crash.** In 2022 the market crashed. This is where drawdown control helps. Bitcoin lost 64% of its value, while drawdown controlled Bitcoin lost only 22%.

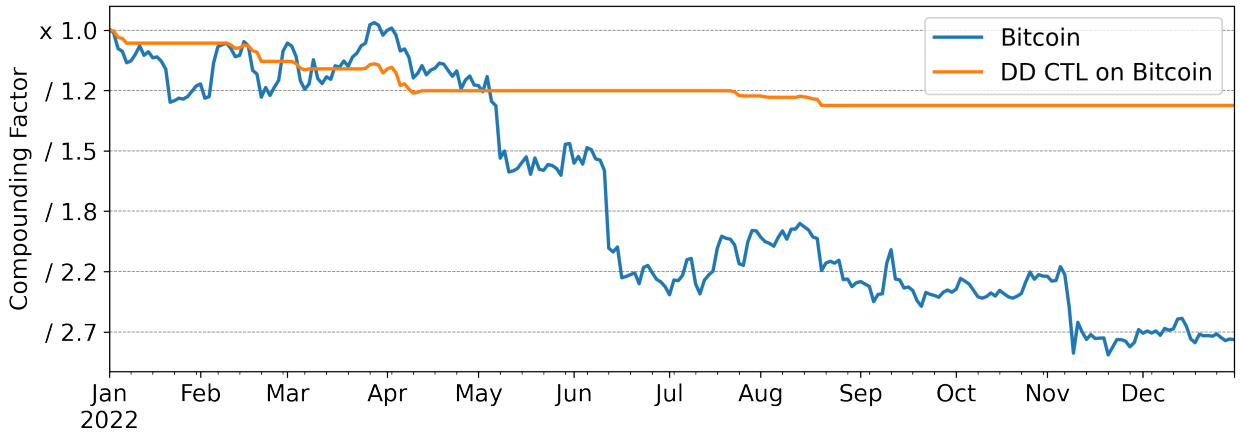



Figure 28: Drawdown controlled Bitcoin in 2022

In this case, an investor would feel regret for cash.

**Year 3: boom.** In 2023, the market boomed. The drawdown controlled Bitcoin strategy was able to get back into the market, but it's a progressive process, resulting in foregone re-

turns compared to Bitcoin. Specifically, Bitcoin generated a return of 155%, while Drawdown Control generated a return of 78%.

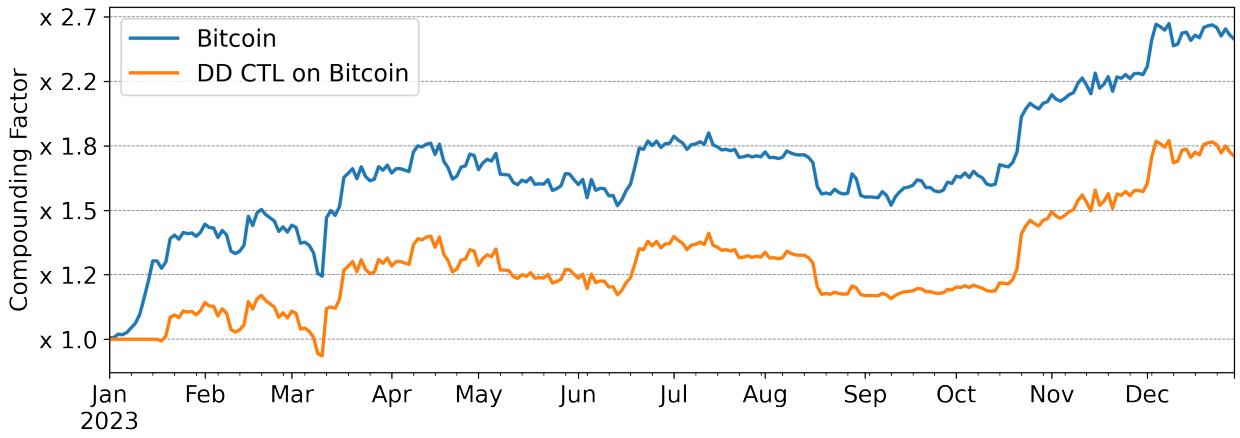



Figure 29: Drawdown controlled Bitcoin in 2023

Once again, this is a case where an investor would feel intense regret for Bitcoin.

**Back to compounding.** How can it be that drawdown control improves on Bitcoin overall, and yet performs significantly more poorly 2 out of 3 years? The answer is compounding. As we saw earlier on, losses weigh larger than gains when you are compounding.

Remember, if you invest 1 dollar, gain 10% and lose 10% you are not back to 1 dollar, you now have 99 cents ($0.9 \times 1.1 = 0.99$). Things get worse as the losses get bigger.

In this case, a dollar invested in Bitcoin in 2021 becomes

$$(1 + 0.60) \times (1 - 0.64) \times (1 + 1.55) = 1.47 \text{ dollars}$$

While a dollar invested in Drawdown control in 2021 becomes

$$(1 + 0.3) \times (1 - 0.22) \times (1 + 0.78) = 1.80 \text{ dollars.}$$

For medium-run investors, who seek to compound, asset protection is more important than chasing gains.

**Don't look too often.** A possible take-away from this analysis is that compounding just isn't intuitive, and that risk-management will be difficult to commit to. For this reason, it is possible that investors could be better served by outsourcing their risk-management strategy, and checking in on their portfolios infrequently.

# 8 Final thoughts

## 8.1 Who is on the other side of risk-management trades?

If risk management adds value to investors, then why are traders on the other side willing to trade? Does the fact that they are willing to trade suggest that in fact, it is beneficial to "buy-the-dip"?

The availability of liquidity reflects the heterogeneity of both needs, risk aversion, and beliefs among investors. For investors seeking to build a position, dips may be natural entry points: one man's loss is another's tempting opportunity. Indeed, the perception of losses will be different depending on the market history of the investor. An investor that's already enjoyed triple digit returns will not be scared by a 30% loss. The same loss could be daunting to an investor who has just entered the market.

Importantly, casual exploration does not suggest that buy-the-dip strategies capture systematic returns. Figure 30 illustrates the performance of a strategy that goes long Bitcoin for two weeks after it loses 15% or more in one week. The strategy (and nearby variants) do not seem to deliver any systematic premium.

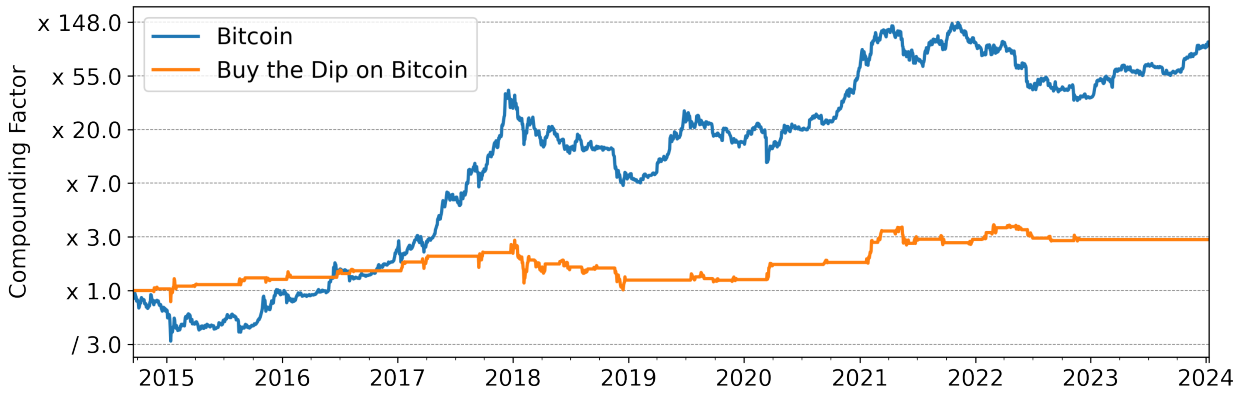



Figure 30: Buying the dip does not appear to deliver a systematic premium.

## 8.2 What about taxes?

There is unfortunately no way around it: risk-management can be costly to investors exposed to capital gains taxes.[5] Indeed, risk-management operates by selling risky assets to buy safe assets when risk-metrics worsen. This can trigger taxable events.

In a large share of jurisdictions (say France, Canada or the UK), investors are not taxed for movements taking place within properly structured investment vehicles. Instead, investors are only taxed when they receive dividends, or sell shares in the investment vehicle. In these jurisdictions, there will be strong incentives to package risk management strategies within a fund structure to avoid capital gains taxes on risk-management movements.

In the US however, investment funds are considered pass-through entities, and investors are, in principle, taxed on capital gains internal to the fund. In that scenario, the additional trading due to risk-management will cause some tax inefficiencies.

One solution is to hold the riskiest part of one's portfolio in accounts or investment vehicles that are exempt from capital gains tax. This is not difficult for investors operating self-managed IRAs.

But push comes to shove, even if risk-management trades trigger capital gains taxes,

[5] If you are taxed in New Zealand, Singapore, or Switzerland, there are no capital gains taxes in your jurisdiction, and you don't need to read any further.

the benefits from risk management are probably big enough to justify the expense. Table 3 reports the annualized growth rate of different investment approaches in a tax-free scenario, and in a scenario with a 37% capital gains tax. The impact of taxes on returns is particularly high for drawdown controlled strategies, but in the period from 2018 to 2022, even with high taxes, drawdown control still out performs other investment approaches.

| | Annualized Growth Rate (Tax Free) | Annualized Growth Rate (37% Capital Gains Tax) | Drawdowns |
|---|---|---|---|
| 100% Bitcoin | 22% | 22% | 81% |
| 80/20 Bitcoin/Cash | 27.6% | 25.9% | 68% |
| DD CTL Bitcoin | 45.8% | 34.1% | 54% |

Table 3: Capital gains taxes reduce the benefits of risk-management (2018-2024)

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