
Submergence risk: what it is and how to manage it

A unified framework for handling drawdowns and recoveries

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1. Introduction: going beyond drawdowns

Drawdowns are a prevalent feature of most financial markets.¹ Figure 1 depicts the extent of drawdowns in major U.S. markets over the past four decades.² Deep, protracted drawdowns are commonplace, and they're a serious threat for investors: they hinder liquidity management and rebalancing, cause missed targets and opportunities and generally have a pronounced negative impact on returns.

However, many popular risk metrics don't adequately reflect the hazards posed by drawdowns. For instance, volatility measures are typically ineffective at capturing drawdown risk. Sharpe ratios give an inaccurate view of "risk-adjusted" returns, and maximum drawdown metrics say nothing about a drawdown's speed or the nature of the recovery that (hopefully) follows.³ This last point is vital: the severity of a drawdown shouldn't be analyzed in isolation; it must be treated in tandem with its subsequent recovery.⁴

¹ We define drawdowns in the conventional way: as declines in the price of an asset or portfolio relative to some running high, also known as a peak. We deem any peak-to-trough decline as a drawdown, regardless of its size. Doing so is in line with established research literature.

² Figure 1 embeds a valuable reality: drawdown dynamics aren't uniform across markets, and at any given time a drawdown in one market may be more or less severe than that in another market. This is likewise true at the level of individual assets. This fact also holds for recoveries, and is what enables risk-mitigation strategies that diversify across the drawdown and recovery behavior of different markets and assets.

³ Another popular risk measure, value at risk (VaR) suffers from related deficiencies.

⁴ The S&P-500's performance in 2020 is an instructive example. The index experienced a drawdown (measured via total excess returns) of 19.9% during that year, which is one of the largest in the history of modern equity markets. Yet the index managed to deliver a 17.8% gain on the year—a feat that wouldn't have been possible without a drastic recovery. All else being equal, a drawdown with a slow recovery is clearly "riskier" than one with a quick recovery, and any analysis of drawdown risk should respect this reality.

Figure 1: Drawdowns and recoveries in major U.S. markets since 1979



Source: Addepar Research

Notes: Figures reflect monthly excess total returns, and depths indicate the degree to which the given market has fallen below its prior peak. Figures are based on the S&P 500 (U.S. stocks), the ICE BoA U.S. Corporate Index (U.S. corporate bonds), and the Bloomberg U.S. Treasury index (U.S. Treasuries).

Surprisingly, there's currently no term in the financial lexicon that refers to a joint episode of drawdown plus recovery. We refer to such an episode as a submergence, since the asset or portfolio remains submerged below its peak during the entirety of the episode. Submergence analysis has long been a missing instrument in investors' toolkits—an absence that may frequently have caused misrepresentation of the:

- Risk-adjusted performance of assets and external managers
- Protective benefits of diversification, when such diversification is based on covariances of returns

In our recent paper, [Submergence = Drawdown + Recovery](#), we perform detailed analysis on the extent of these problems. However, that piece is a lengthy read, so to accommodate your busy schedule, the following is a selective, condensed overview of its findings.

2. Key takeaways

The notable lessons from our primer are that:

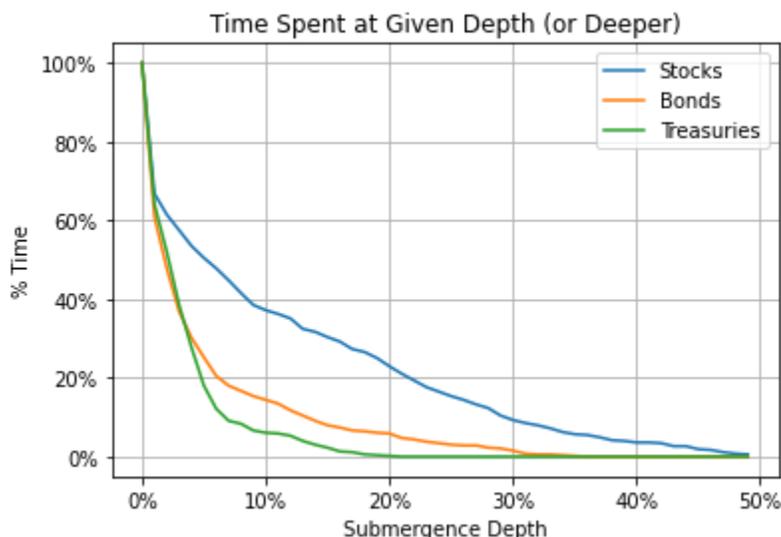
1. **In public markets, submergences may be both lengthy and deep.** In some situations, they may last for nearly a decade or even longer. They can also be deep—not just in terms of



maximum depth, but also average depth.⁵ For instance, since 1980, the S&P 500 has spent 37% of its time submerged by 10% or more, and 23% of its time submerged by 20% or more (see Figure 2).

2. **When risk-adjusting returns, it's best to factor in an investor's specific risk tolerance.** This is something that current methods (namely, Sharpe ratios) generally don't do. When one accounts for such tolerances, adjusting returns for submergence risk can lead to a far different picture of performance relative to what can be gleaned from unadjusted returns or Sharpe ratios.
3. **Typically, diversification is the most advisable approach for addressing submergence risk**, so long as it's based on diversifying across the submergence properties of different markets and asset classes rather than covariance in returns (which is what's commonly done). Optimal portfolio structures under submergence-based diversification can be substantially different from those under covariance-based diversification. That said, several methods exist for dealing with submergence risk, and these vary in their complexity and effectiveness.

Figure 2: Proportion of time spent at various submergence depths (1979 to present)



Source: Addepar Research

⁵ Our larger paper's analysis doesn't cover private markets, so we don't report on them here. However, in future work we aim to characterize submergence behavior in private equity, venture capital and other private asset classes.



Notes: Values exclude current (in-process) submergence episodes and are based on excess total returns for the following indices: S&P 500, the ICE BofA U.S. Corporate Index and the Bloomberg U.S. Treasury index.

Regardless of whether you dive into our larger paper, we encourage you to examine the submergence risk in your own portfolios. We're glad to speak with you should you need assistance in doing so.

2. Measuring submergence and its returns implications

To properly study and manage submergence risk, one must be able to measure it. Existing approaches to doing so have various flaws, which prompted us to create a new metric, *submergence density* (abbreviated as d in the formula below), which is calculated as:

$$d = \sqrt[\kappa]{T^{-1} \sum_t^T s_t^\kappa}$$

Here: T is the total number of measurement periods (e.g., 24 in a 2-year horizon of monthly returns); s_t is the degree of submergence in period t (this is measured as the percentage difference between an asset or portfolio's price in the period and its prior peak: $s_t = 20\%$ would mean the asset/portfolio's value was 20% below its highest observed value up until period t)⁶; and κ is a risk-tolerance parameter that's specific to the investor. (We elaborate on the interpretation of this parameter in our larger paper.) Inclusion of κ means that submergence density is "customizable" to any investor's risk preferences, which isn't the case with many other risk metrics.

We believe that it's best practice to include such preferences in the measurement of risk, as well as risk-adjusted performance, because failing to do so can lead an investor to adopt investment strategies that are badly aligned with their specific needs and goals (and unknowingly accept more risk or lower returns than they'd otherwise intend).

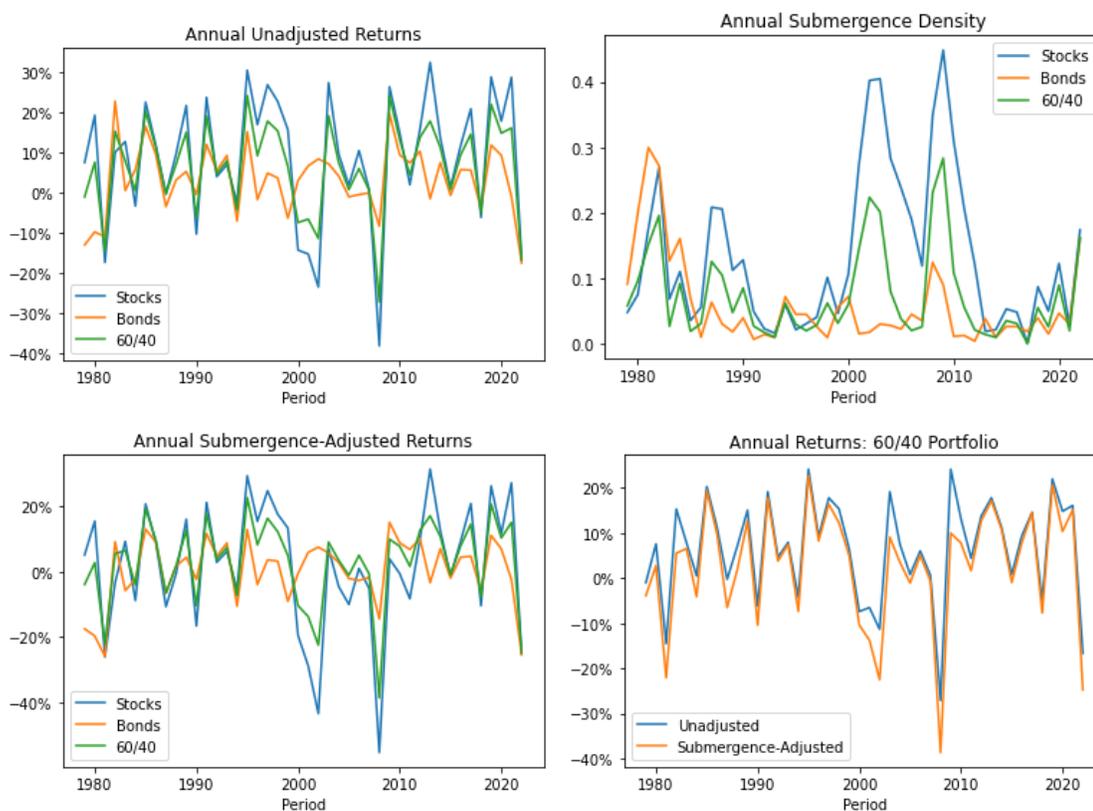
Submergence density is useful for measuring the submergence risk of an asset or portfolio over time, but it can also be employed in adjusting returns to reflect submergence risk. This is achieved by:

⁶ If the asset or portfolio reaches or exceeds its prior peak during period t , then this value is 0% for the period.

$$r_d = r - (d \times \theta)$$

Here: d is the submergence density for the asset/portfolio in question; r is the investment return for that asset, measured over the same horizon as d ; and θ is another risk-tolerance parameter, set by the investor. θ is essentially the threshold of return needed to offset a given level of submergence. For example, $d = 25\%$ is a fairly severe level of submergence, in most cases (it means that the asset or portfolio in question was 25% below its peak, on average, for the measurement horizon); setting $\theta = 0.5$ would require the investment to earn at least a 12.5% unadjusted return during the measurement horizon, in order for its adjusted return to be positive. (Please see our larger paper for a more detailed discussion of θ and its implications.⁷)

Figure 3: Returns and submergence risk in illustrative portfolios



Source: Addepar Research

⁷ This construction of risk-adjustment is novel, in that it allows positive unadjusted returns to be made negative if the degree of risk is sufficiently large (i.e., it allows a gain to be represented as a loss if the level of realized risk is too extreme). This property is useful for benchmarking the performance of external managers who might undertake risks that are unacceptable relative to an investor's particular tolerance or preferences. It's a property that's not exhibited by other common risk-adjustment methods.



Notes: Figures use $\kappa = 5$ and $\theta = 0.5$, and are based on excess total returns for the S&P 500 and the ICE BoA U.S. Corporate Index.

When one applies this method of risk-adjustment, the performance landscape that emerges is very often different from what one observes by looking at unadjusted returns or returns that are risk-adjusted by other methods. Figure 3 provides some sense of this. The top-left panel displays annual unadjusted returns for U.S. stocks (proxied by the S&P 500 index), U.S. bonds (proxied by the ICE BoA U.S. Corporate Index) and a 60/40 portfolio of stocks and bonds—while the top-right panel shows annual submergence densities for these three groups of assets.⁸ As can be seen, submergence density tends to spike in years in which there's pronounced market turmoil, namely: the dotcom bubble rupture of the early 2000s, the Global Financial Crisis of 2007–2009 and the early-1980s recession.

The bottom-left panel shows how the behavior of submergence density translates into adjusted returns: in years where realized submergence risk is minor, there's very little difference between adjusted and unadjusted returns. Yet for years stricken with deep submergence, adjusted and unadjusted returns can differ substantially. For example, for the 60/40 portfolios:

- In 2003, unadjusted returns were 19.1% versus 9.1% after submergence-adjustment
- In 2008, returns were -27.1% (unadjusted) and -38.7% (adjusted)
- In 2009, returns were 24.1% (unadjusted) and 10.0% (adjusted)
- In 2020, returns were 14.8% (unadjusted) and 10.4% (adjusted) (These calculations use $\kappa = 5$ and $\theta = 0.5$.)

We give special attention to the 60/40 portfolio because it highlights the helpful role diversification can play in handling submergence risk: median annual returns for stocks, bonds and the 60/40 portfolio over this horizon were 11.1%, 4.5% and 7.7%, respectively, on an unadjusted basis. After adjusting for submergence risk, median returns become 4.5%, 3.0% and 5.3%. These values indicate not only the protective power of (proper) diversification, but also the meaningful changes in asset performance rankings that can emerge after adjusting for submergence risk.

Other risk-adjustment methods don't yield the same ordering of performance. Sharpe ratios suggest that stocks are the top performer (relative to bonds and the 60/40 portfolio), while methods that emphasize drawdown risk (the Sterling ratio and Pain and Ulcer indices) all suggest

⁸ All analysis here uses total excess returns—i.e., returns inclusive of dividends, coupons, and so on, but net of a risk-free rate, which we take as the 1-month T-bill rate. The 60/40 portfolio assumes monthly rebalancing.



that bonds are the superior performer.⁹ These divergences underscore the need for investors to be very thoughtful about how they measure both performance and risk. Choosing the wrong approach can lead to questionable conclusions about what portfolio composition is best.¹⁰

Figure 4: Median annual performance ratios (1979 to present) for selected portfolios

	Sharpe	Calmar	Pain	Ulcer
Stocks	0.99	0.74	1.11	1.08
Bonds	0.86	0.89	2.46	1.74
60/40	0.99	0.87	1.84	1.37

Source: Addepar Research

Notes: Values are based on excess total returns for the S&P 500 and the ICE BoA U.S. Corporate Index. For all ratios, a higher value is construed as a higher-performing investment.

3. Managing submergence risk

Diversification is just one strategy for handling submergence risk (on which we'll have more to say shortly). Investors may also be able to use active management and hedging strategies to curb the impacts of submergence in their portfolios. As we discuss in our longer paper, active management can be useful not only in terms of downside protection, but also in accounting for how the upward price-swings of recoveries present substantial rewards for those able to time them. For example, from 1979–2022, holding the S&P 500 *only* when it was in recovery mode would've delivered an annualized return of 6.2% after adjusting for submergence risk, which is 490 bps higher than the annualized return for passively holding the index over the same horizon!¹¹

That said, many investors are unwilling to use active strategies that rely on market timing and are more likely concerned with guarding against submergences rather than trying to capitalize on them. These investors may be interested in techniques that make use of derivatives or other hedging instruments. Yet many of these techniques can significantly dampen returns, regardless of whether one looks at risk-adjusted or unadjusted returns.

⁹ We detail the flaws of these other methods for risk-adjustment in our long-form paper, and show how our approach avoids these deficiencies.

¹⁰ It's worth mentioning that the performance ordering for these asset groups is sensitive to parameter choices, which is sensible: the relative performance of an asset class *should* account for an investor's specific sensitivity to risk (which is not the case for Sharpe, Pain, Ulcer or Sterling ratios and indices).

¹¹ This calculation assumes a kappa value of 3 and theta value of 0.3. See our longer paper for a justification.



As an illustration, consider a hedging strategy that uses a one-month, 5% out-of-the-money put option (hereafter, “put”) on the S&P 500. From 1987–2022, the maximum submergence depth reached by the S&P 500 was 55.3% below its prior peak (measured using daily excess total returns data), whereas a position composed of holding the index as well as the put would’ve reached a maximum depth of only 42.0%: ostensibly a 24% reduction. However, if one translates this strategy into annualized risk-adjusted returns, the hedging defense meaningfully underperforms the index: holding the index alone yielded a mean annual adjusted return of 5.4% from 1987–2022, compared to a 2.8% return with hedging.¹²

Broadly, our investigations have found that diversification is often the best tool for mitigating submergence risk—and there are multiple forms that can provide protection, including sector-based and geographic diversification.

An example from our longer paper shows that a 30% allocation to Australian stocks can add 540 bps to an investor’s median annual submergence-adjusted return, as compared to holding the S&P 500 alone.

This degree of performance enhancement from proper diversification isn’t a rarity. We walk through multiple other examples in our long-form paper, such as how including non-obvious asset classes in a portfolio can sufficiently boost risk-adjusted returns by decreasing submergence risk. Across all examples, effective diversification is based not on covariance alone between asset returns. Instead, it’s based on the overlap in the timing and extent to which assets in a portfolio are collectively submerged.

6. Conclusion

Drawdowns and recoveries are inherent features of markets, and investors need the right perspectives and tools to understand and handle them. The submergence framework is a novel approach to doing so—and possibly the most comprehensive to date, in terms of its ability to fully measure drawdown risk across asset classes and adjust returns accordingly.

¹² This calculation uses $\kappa = 5$ and $\theta = 0.5$.



We believe that we've only begun to scratch the surface of this powerful new risk concept. We're excited to share our future findings and analytical tools with you. Please reach out to us with any questions, or for more information.



References

Rook, D., D. Golosovker, and A. Monk [2023] "Submergence = Drawdown + Recovery," *Social Science Research Network*, available at:

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