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# MANAGING NORMAL AND CATASTROPHIC RISK

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## Introduction

The management of portfolio risk is an important concern as a part of effective portfolio management. The management of risk is often separated into two principal concerns: management under 'normal' risk conditions, for which traditional methods such as principal component analysis are employed, and the management under catastrophic, or tail-risk conditions, for which typical statistical methods do not apply. This paper provides a critique of some methods for integrated management of normal risk and tail risk in futures markets and describes a multifaceted approach to portfolio management developed at Blackthorne Capital Management.

Our approach incorporates both statistically-based portfolio immunization techniques and scenario-based analysis in an integrated optimization process that is updated and executed on the Blackthorne portfolio daily.

## Risk Management

The issue of risk management in financial portfolios has a long history. Starting with Markowitz (1952), the use of statistical theories positing the joint normality of distributions of returns has been a mainstay of portfolio management decision making. Innovations such as the models proposed by Black and Litterman (1992), Tütüncü and Koenig, (2004); Qian, (2005), Maillard, Roncalli, and Teiletche, (2010), and Lopez de Prado (2016) address the issue of risk management through attempts to minimize overall portfolio variance by producing acceptable estimates of asset covariation and applying them to reduce overall portfolio variance. The issue of volatility management has become more prominent because of the often-expressed problems with accurate prediction of the magnitude of returns (Merton, 1980). Though many of these methods are subject to the difficulties associated with producing stable, unbiased measures of covariance matrices (Ledoit and Wolf, 2004), they advance the notion of portfolio management through addressing the coincident behavior of assets. There are further limits on these methods due to their assumptions regarding the nature of return distributions (Taleb, 2020).

Strategies such as those based in Markowitz portfolio theory (Markowitz, 1952) are appropriate for analyzing normal risk, but are often limited in their ability to address the issues associated with tail risk in financial markets, because they rely on assumptions of normality and independence in distributions of returns. As early as Mandelbrot (1963), theorists have taken positions that returns distributions are not normally distributed. The assumption that returns follow normal distributions has been another issue that has prompted alternative models of portfolio management that address skew (Ingersol, 1975; Kraus and Litzenberger, 1976; Chen, et al., 2001; Hu and Kercheval, 2008; Adcock, 2010) and fat tails (Taleb, 2020). Other efforts address the issue of unusual or catastrophic events (Taleb, 2010) that can radically influence the volatility of portfolios (Roy, 1952). Tail risk is a particularly important concern in practical portfolio management because of the prevalence of extreme market events (McRandal and Rozanov, 2012). It is, nevertheless, important to use both normal risk management and tail-risk management approaches. We first address some of the current approaches to tail risk management and their problems, and then describe Blackthorne's approach to portfolio risk management.

# *Approaches to Tail Risk Management*

There are a number of approaches that can be used to manage tail risk. Following is a summary of a number of these approaches, including some specific commentary concerning some of the challenges associated with each of those approaches. These provide an overview of the reasoning that led to the Blackthorne strategy for portfolio risk management.

1) ***Diversification:*** Diversifying positions across asset classes, geographies, and investment strategies can help to reduce the impact of tail risk events in individual markets in a portfolio, thus reducing the tail-risk for the portfolio. These approaches are more appropriate for normal risk scenarios than tail risk scenarios, however, because of the tendency for the correlation coefficients among assets to become more extreme under exigent or crisis circumstances (Engle and Sheppard, 2012; Ang and Chen, 2001).

2) ***Options Strategies:*** Put options can be used systematically to protect portfolios from extreme downward movements in asset prices. These options can act as insurance against market crashes. However, they can be expensive (Bondarenko, 2014b, McRandal and Rozanov, 2012). For example, Gearhart, Lyman, Trivedi and Vasilachi (2021) estimate an annual cost of 260 basis points to hedge equity portfolio risk against moves in the S&P 500 due to the COVID outbreak in 2020. Options markets also bear liquidity risk under market conditions in which the options must be exercised in response to extreme events. Finally, integrating put options into a complex portfolio can be complex, due to timing risk, and the need to dynamically readjust positions.

3) ***Volatility and Variance Swaps:*** Volatility and variance swaps address tail risk by providing for payoff in circumstances of extremely high volatility, thus providing some protection to extreme market events. They have drawbacks that are similar to those of Options strategies. They may be valued based on assumptions that do not reflect the nature of the underlying distributions of volatility, especially in the case of extreme market events. They can also be illiquid during periods of market stress, reducing their effectives due to increased transaction costs, wider bid-ask spreads, and distorted pricing (Bondarenko, 2014). Furthermore, because some of these instruments may be maintained on an over-the-counter basis, they may be subject to counterparty risk (Cont and Kokholm, 2014).

4) ***Tail Risk Hedge Funds:*** Some funds specialize in creation of strategies that address tail risk, providing a source of return under extreme market conditions. They often use collections of derivatives and/or other instruments designed to generate significant profit during extreme market events, effectively acting as providers of downside coverage to other market participants. These require that the fund be consistent with the stated goals of a portfolio manager, and the nature of the fund may not be consistent with those goals. Also, the returns on such funds, because they are typically positive only in specific conditions, may not be acceptable to investors.

5) ***Value at Risk:*** In the 1990s, the notion of Value at Risk (VaR) emerged as a popular approach to addressing tail risk in streams of returns (Jorian; 1996; J.P. Morgan Reuters, 1996) and has been adopted even in the regulatory realm. The VAR approach considers the tail risk for an asset or strategy by calculating the specific returns outcome associated with selected probability quantiles of a distribution of returns for a particular period. In other words, it is a loss such that there is a p probability of losses exceeding that value and a (1-p) probability of losses not exceeding the value. It was proposed as a means of comparing returns distributions that did not require strict adherence to assumptions of normality. Subsequent critiques (Artzner, et al., 1999, Yami and Yoshiba, 2004, Embrects, et al., 2015)) suggested that VaR was problematic for portfolio optimization because of the statistical properties of the estimates, including subadditivity (the VaR of a portfolio of multiple assets could be greater than the sum of the VaR values for the individual assets in the portfolio), convexity (there are problems due to the smoothness of the function of calculated values for VaR) and robustness (usefulness under a variety of distributional circumstances). Subsequently, much attention has shifted to Conditional Value at Risk (CVaR), sometimes called Expected Shortfall, which takes the expected value of losses exceeding the VaR value as the basis for decision making (Rockafellar and Uryasev, 2000; 2002). CVaR addresses many the problems with VaR (Artzner, et al, 1997, Yami and Yoshiba, 2004), but both measures are still subject to some common limitations (c.f., an introduction and overview of these issues in Danielsson, 2011). For example, many portfolios do not have a history of returns long enough to reflect the reaction of portfolio strategies to extreme events, limiting the degree to which historical methods (including estimates derived using Monte Carlo techniques), can be applied. Parametric methods, which calculate the expectations of tail-risk consequences using normal or t distributions, are problematic because many distributions of asset returns are not consistent with assumptions.

6) ***Hypothetical Stress Testing:*** Funds employing multiple strategies can conduct stress tests to assess how their portfolios would perform under pre-specified extreme market conditions (c.f., Čihák, 2007 for an introduction). This enables identification of vulnerabilities and the implementation of adjustments to limiting the tail risk under the specified hypothetical conditions. The use of such scenarios is only effective to the degree to which the pre-specified conditions reflect the extremity of actual market circumstances, however.

Given the challenges with the previously-described methods, and given the need to accommodate the characteristics of both normal and catastrophic risk, Blackthorne uses two distinct approaches for managing each of them. These are described in the following sections.

## *Blackthorne Approach to Management of Normal Risk*

The first goal of Blackthorne's normal risk analysis process is to define the risk of each asset in the portfolio, and then to calculate consistent risk-adjusted position sizes across all the assets. The concept of risk adjusted position size is simple and intuitive. If asset A is *twice* as risky as asset B then, its nominal position exposure should be *half* as much.

The second step in the normal risk calculation process is to consider the idiosyncratic behaviors of individual assets and asset classes. Similar to the risk-adjusted position size, the concept of asset and asset class caps is simple and intuitive. A balanced portfolio should be protected against the rogue behavior and influence of any individual market and the increased correlation of the assets in any specific market sector during times of macro-level stress.

The final step in the normal risk calculation is to include options information to add a forward-looking aspect to the portfolio construction process. Standard deviation and correlation calculations are by definition backward-looking. If there is an event shock that affects the markets, any statistical method that relies on historical relationships will be slow to respond to the new risk topography. On the other hand, options data can, in real-time, be used to incorporate the forward-looking information into assessments of the riskiness of different assets.

To incorporate these three levels of risk management, an optimization is run with the goal of minimizing the overall portfolio risk given the individual, asset class and portfolio level constraints.

Once this optimization is completed, the resulting portfolio is then stress tested against a list of catastrophic risk scenarios.

It should be noted that there are certain periods of extreme risk, such as during the outbreak of a war or a pandemic, where none of the standard measurements of risk can be trusted. In these situations, Blackthorne employs a consistent, nominal dollar exposure across all markets, and in some situations, the Blackthorne risk committee may use its discretion to exit certain markets or stop all trading activity temporarily if the uncertainty and/or volatility in those markets is considered to warrant these actions.

It should be further noted that while Blackthorne attempts to be systematic in all aspects of its portfolio construction process. There are other situations where, while rare, discretion must be employed to insure adequate protection of the portfolio.

## *Blackthorne Approach to Management of Catastrophic Risk*

The goal of a scenario-based catastrophic risk process is to protect the portfolio against the largest single day moves that have occurred in the past, and to theoretically "insure" that if similar events happen in the present the losses of the portfolio will be limited to an acceptable level. In the Blackthorne case, this is a 10% loss. Of course, this approach is not foolproof. No two catastrophic risk events are the same and losses could still exceed 10%, but the hope is that shielding the portfolio from the effects of an array of extreme events in the past will provide a good level of protection against similar extreme events in the future.

## *Identifying Catastrophic Risks*

The seven events currently used in the Blackthorne catastrophic risk analysis are summarized in Table 1, along with the daily returns on those days for selected markets to demonstrate the differences in effects that can occur across different markets.

Table 1: Days with Historic Market Moves and Sample Daily Returns

| | | in % | | | |
|---|---|---|---|---|---|
| **Event** | **Date** | **S&P 500** | **VIX** | **Crude Oil** | **Gold** |
| Black Monday | 1987-10-19 | (20.5) | 235.0 | (2.1) | 3.3 |
| Twin Towers Attack | 2001-09-11 | (4.9) | 31.2 | (2.4) | 2.3 |
| Lehman Collapse | 2008-09-15 | (4.7) | 23.5 | (5.4) | 2.9 |
| Greek Debt Crisis | 2011-08-08 | (2.4) | 18.1 | (4.0) | 0.8 |
| Market Correction | 2018-02-05 | (4.1) | 95.0 | (2.0) | (0.6) |
| Drone Strike on Saudi Oil | 2019-09-14 | (0.2) | 2.4 | 14.3 | (10.0) |
| Covid/OPEC Announcement | 2020-09-03 | (7.7) | 16.7 | (22.8) | 0.2 |

The returns identified on the selected days are then used as a basis for limiting position sizes through notional back testing of the potential effects on specific markets and on the portfolio if the returns on those days were to be manifest. After our normal position-sizing algorithm is executed, the proposed daily positions are checked against the extreme returns observed on the days identified. If the hypothetical losses for the portfolio exceed 10% in any one of these scenarios, the positions are revised to account for the implied risk.

This process is repeated until a solution that meets all the normal and catastrophic risk constraints is found.

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