ABSTRACT

Since the height of the Global Financial Crisis in 2008, institutional investors have spent considerable time investigating ways to limit the downside risk in their portfolios. The term "Black Swan" has been used extensively to classify hard-to-identify, but impactful, events that cause "tail risks" in investors' portfolios. Investor timeframes and constraints differ and, thus, the decision of whether and how to hedge these risks will vary for investors.

In this paper, we discuss the nature of tail risks and evaluate at a high level the options available to institutional investors. We determine that managing tail risk can be done strategically or tactically, primarily through asset allocation, derivative overlay strategies, or through tail risk hedge funds. Importantly, each approach will have an associated cost, either explicit or implicit, and we discuss the trade-offs for each approach.

BACKGROUND

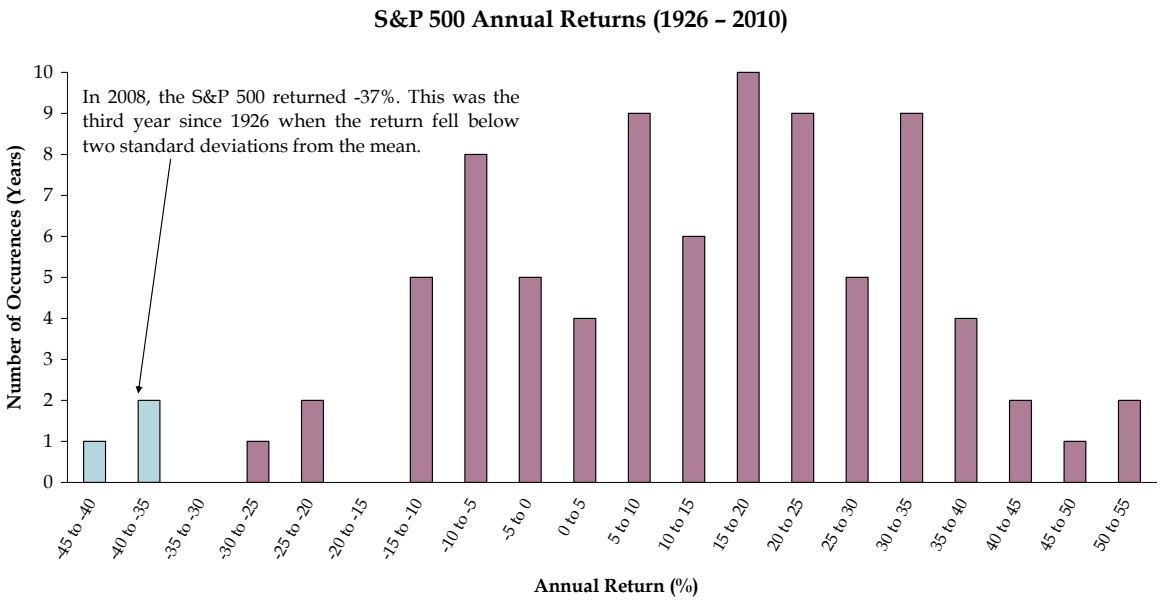
The Global Financial Crisis and accompanying market crash from late 2007 to early 2009 resulted in a peak to trough decline of 56.8% in the S&P 500 index. The severity and swiftness of the decline, as well as the associated volatility and high correlation of the global stock markets at that time, took many investors by surprise. This is perhaps because the last time the market experienced a decline of that magnitude was 1937, well beyond the living memory of most investors.

What is Tail Risk?

Tail risks are events that cause negative (or positive) returns on the far ends (or "tails") of the "normal" distribution of returns in the capital markets. These are risks that are improbable by definition and have an outsized impact on financial markets. They also happen with greater frequency than would be predicted by the "normal" distribution. The Global Financial Crisis of 2008 to 2009 represented one of these tail risks, as traditional statistical models would have estimated that returns experienced during that period (or during the Great Depression) should occur only once every 3,000 years.

Nassim Taleb popularized the concept of tail risks in his book *The Black Swan*. In it, he argues that outlier events are virtually impossible to anticipate in advance, their impact is extreme and broad, and that they occur more frequently than traditional financial modeling suggests. Moreover, he argues that it is human nature to underestimate the severity and likelihood of negative outlier events.

The largest source of tail risk in an investment portfolio has historically been the equity allocation, as illustrated in the following chart depicting annual returns for the S&P 500 index. Since 1926, the index has lost at least 35% three times.



A related challenge for investors is that when market volatility increases dramatically, the correlation among risky asset classes increases towards one (i.e., the anticipated diversification benefit becomes non-existent). The result is that during times of extreme stress and volatility in the markets, most portfolios hold very few diversifying assets.

IS HEDGING NECESSARY?

Tail risks are the most damaging investment risks, as they are unpredictable and difficult to model. Any approach to managing tail risk will have an associated cost, either explicit or implicit, because an investor who hedges tail risk is essentially purchasing insurance. Insurance policies cost money (i.e., a premium), and usually the seller, not the buyer, of insurance wins in the long run. In fact, it could be argued that investors with a long-term time horizon, as is the case with most institutional investors, would be better served by providing such insurance and collecting the associated premium.

However, there are many reasons why a plan sponsor or endowment would consider tail risk management including, but not limited to: maintaining a minimum asset level or funding ratio, funding issues, upholding debt covenants, or some combination of these issues. For example, the Pension Protection Act of 2006 requires that private pension funds that fall below certain funding levels take actions that may include: making disclosures to participants, developing a funding improvement plan, paying penalties, or foregoing future benefit increases. Thus, the penalty for plans experiencing short-term performance shocks can be quite severe. Another example would be an institution that relies heavily on its endowed assets and whose budget cannot afford a significant reduction, even if it is only for a year or two.

A significant investment loss can adversely affect a plan sponsor both in the short-term and long-term. Overall, institutions should have a specific reason to hedge, given the long-term cost associated with hedging. The goal of hedging tail risk in a portfolio is to reduce the possibility that a large negative return adversely impacts the institution's ability to meet its financial obligations.

MANAGING TAIL RISK

An investor has two approaches available to address tail risk in a portfolio: *reduce* their exposure to risk, or *hedge* their exposure to risk (specifically tail risk). These approaches may be implemented either strategically or tactically. A strategic risk management approach alters the long-term policy asset allocation of the portfolio in order to reduce market risk. Tactical tail risk management approaches include derivative overlay strategies that change the expected return profile of the portfolio, hedge funds that use a broad array of derivative instruments, and tactical strategies that dynamically adjust the asset allocation on shorter-term basis.

Long-Term Policy Asset Allocation

A strategic approach to managing tail risk changes the long-term policy asset allocation to reduce exposure to volatile asset classes, such as equities, and replace it with a less volatile asset class or an asset with hedging characteristics. An asset with hedging characteristics is expected to be negatively correlated with equities. Meketa Investment Group studied the effects of several groups of assets that are presumed by many investors to possess hedging properties. The four assets include:

Core Bonds -- Investment grade bonds are a staple in many institutional portfolios and they have exhibited one-fourth the volatility of equities, thus making them a good candidate to replace equities as a way to reduce tail risk.[1]

Intermediate-Term Treasury Bonds -- Treasuries typically exhibit positive performance in a stock market downturn as investors make a "flight to quality." They also benefit when interest rates decline, which often results when the economy slows.

Long-Term Treasury Bonds -- Longer term Treasuries are assumed to benefit even more so from a flight to quality. Long-duration Treasuries are highly sensitive to changes in interest rates, which makes them much more volatile than intermediate-term bonds.

Long-Term TIPS -- Because TIPS are a Treasury obligation, they should likewise benefit from investors seeking government bonds. Their hedge against inflation that investors usually find attractive will provide no benefit, however, in a deflation environment (when stocks are often declining).

Gold -- Considered a safe haven from inflation and currency debasement, gold often performs well in times of economic and political uncertainty.

[1] This presumes that the portfolio closely resembles a core bond benchmark, such as the Barclays Aggregate index. However, active bond managers often exhibit significantly more credit risk in their portfolios than is in the benchmark.

Return Characteristics of Presumed Hedges[2]

(1992 through 2010)

	Core Bonds	Intermed.-Term Treasuries	Long-Term Treasuries	Long-Term TIPS[3]	Gold	*S&P 500*
Annualized Return	6.4%	6.1%	7.8%	5.3%	7.6%	*8.1%*
Annualized Std. Deviation	3.8%	4.6%	11.0%	11.7%	15.2%	*15.0%*
Skewness[4]	-0.31	-0.18	0.00	-0.22	0.21	*-0.73*
Max Drawdown	-5.2%	-6.9%	-21.4%	-17.3%	-37.5%	*-50.9%*
Best 12 months	18.5%	16.8%	33.7%	23.8%	54.9%	*53.6%*
Worst 12 months	-3.7%	-5.5%	-21.4%	-10.6%	-21.5%	*-43.3%*
Correlation with S&P 500	0.08	-0.14	-0.09	0.19	-0.01	*1.00*
Correlation when S&P 500 was negative	-0.01	-0.26	-0.11	0.41	0.05	*1.00*
Average Monthly Return when S&P 500 declined at least 5%	1.4%	1.6%	0.7%	1.6%	-0.4%	*-8.1%*

As the bottom row of the above table indicates, each of these assets serves as a reasonable hedge, generally producing flat or positive returns during periods when the stock market declined by at least 5%. Of note, intermediate-term Treasuries provided the most downside protection. We further investigate these strategies via scenario analysis and look at their impact in a diversified portfolio later in this paper.

In the long term, shifting the mix of "risky" (e.g., equities) and "riskless" (e.g., bonds) assets is a very effective way to manage risk.

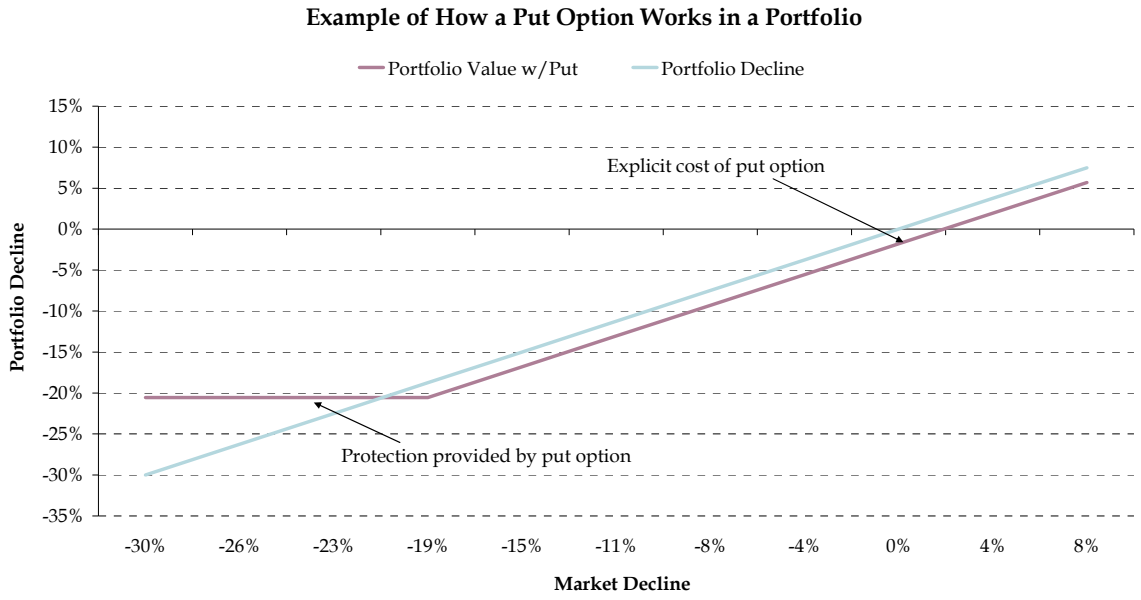
Derivative Overlay Strategies

A derivative overlay strategy uses derivatives (e.g., options, futures, swaps) to hedge a portfolio against a market downturn. An overlay strategy makes no changes to the underlying portfolio, as it uses derivatives (usually index-based options) to provide insurance in the event of a downturn. In its simplest form, an overlay purchases a put option based on an equity index that will increase in value when the equity market falls below a specified level. A put option effectively sets a floor to the market value of the portfolio (see the following chart).

[2] Sources: Core Bonds are proxied by the Barclays Aggregate index. Long Term Treasuries are proxied by the Barclays 20+ Year Treasury index. Long Term TIPS are proxied by the BofA ML 15+ Year US Inflation-Linked Treasury index. Gold is proxied by the Gold spot price. Intermediate Term Treasuries are proxied by the Ibbotson US Intermediate term Government Bond index.

[3] The Long Term TIPS series begins in April 2004.

[4] Skewness is a measure of a distribution's lack of symmetry around its mean. Negative skew indicates a long left tail but generally the distribution is shifted to the right. For equity investors negative skew, with a long left tail, means there are likely a few large negative returns in the data. Positive skew indicates the right tail is longer.



A derivative overlay strategy allows an investor to customize a hedge in a manner that meets their portfolio's unique exposures. Accordingly, it requires the investor to make several key decisions, including:

- At what level of return should protection be triggered (e.g., -15%, -20%, -25%)?
- How much of the portfolio should be protected?
- For how long should the protection be in place?
- How will the program be implemented?

The advantage of a derivatives overlay strategy is that it provides a simple way to access a broad, customized level of hedging without changing the underlying holdings of the portfolio. Overlays can be customized to the risk exposures and level of protection desired by the investor. For example, put options are available on the S&P 500, Russell 3000, and MSCI EAFE indices. A further benefit to put options is that the maximum loss an investor can incur when buying an option is known when initiating the position, since an investor can lose no more than the up-front price that was paid for the option.

The primary disadvantages of a derivatives overlay strategy include the costs and complexity of implementation. Put options are often expensive and their pricing can be highly variable. From 2005 through mid-2011, the average annual cost to limit the loss of a downturn in the S&P 500 to 25% was 2.4%, based on the notional protected amount. However, costs have ranged from a meager 0.1% to 7.7% in the depths of the 2008 Financial Crisis (see the following chart). In other words, the cost of protection is dearest when it is most desired.

Historical Cost of Put Buying[5]

The range in option prices presents a challenge for an investor who wants to use this strategy perpetually, since the costs vary dramatically. A further challenge with the overlay method is determining whether or when to sell the options as they increase in value during a market downturn. It is usually during these periods that investors most crave protection and hence may be hesitant to sell. To mitigate against indecision in this scenario, investors will often establish a rules-based approach to liquidating appreciated options.

Because put options are usually the most expensive form of protection, they are often combined with other options to offset the cost. For example, a "collar" involves selling a call option in addition to buying the put option. This defrays some of the cost, but also limits the investor's upside, while increasing the complexity of the strategy.

Finally, the use of derivatives for hedging introduces "basis" risk, or the risk that the strategy hedges the wrong risk. Derivatives do not exist to hedge perfectly all types of risk in a diversified institutional portfolio.

Hedge Funds

Most hedge fund strategies are expected to produce a positive return in most market environments, while providing a moderate hedge during a downturn. Yet, certain types of hedge funds can be used to explicitly address tail risk. For example, short-biased hedge funds should produce gains during a market downturn. There is a small and growing universe of hedge funds with dedicated tail risk strategies.

[5] Source: Rampart Investment Management. The chart represents the annual cost of a one-year put option on the S&P 500 index that is 25% "out of the money" from January 2005 through June 2011.

Tail risk hedge funds employ a variety of strategies, but most funds can be categorized as global macro, managed futures, or volatility arbitrage. These funds often invest (typically through derivatives) in a range of asset classes, including equities, interest rates, currencies, and commodities. Investment instruments used in these funds are numerous and complex, including options, swaptions, futures, forwards, variance swaps, credit default swaps (CDS), and other derivatives. Below is a description of the three different categories of hedge funds and how they approach tail risk:

Global Macro -- These funds focus on big picture, or "macro," decisions and use their global views to purchase securities in diverse markets across the globe. A key assumption in this strategy is that the securities purchased will be either uncorrelated or negatively correlated to the risks in the investor's portfolio.

Managed Futures -- These funds typically use momentum-based strategies that profit from market trends, both in the short-term and long-term. These funds also can span markets, seeking to identify price trends in equity, commodity, and currency markets.

Volatility Arbitrage -- These funds use derivatives to focus on the volatility levels of underlying assets and benefit from a change in the volatility, rather than an increase or decrease in the price of the asset. The strategy usually benefits when volatility rises, which often happens when markets decline.

Most institutional investment portfolios are "short volatility." This means that when market volatility increases (and stock markets decline), portfolio values fall. On the contrary, being "long volatility" means an investor has an exposure that profits when volatility increases. The hedge fund strategies above address tail risk by positioning portfolios to benefit when market volatility increases (i.e., they are long volatility strategies).

The primary advantage of a tail risk hedge fund is that it is a "packaged" solution. The key hedging decisions of how much to hedge and how to structure those hedges are delegated to external investment professionals. This is in contrast to an asset allocation or derivative overlay solution, both of which require the Plan Sponsor to make these decisions. Tail risk hedge fund strategies will often use complex strategies as they seek the most cost efficient hedging structures. If structured properly, these funds should provide asymmetric (i.e., highly positive) returns in a market decline.

Meketa Investment Group developed a composite of hedge funds that exhibited negative correlation to the S&P 500 index in order to approximate the exposure gained by using one or more tail risk hedge funds. The composite had a -.81 correlation to the S&P 500 index, as the following chart indicates. The composite had a modestly positive return over the full time period (+0.7%), while returning a monthly average of 5.3% when the S&P 500 declined.

Tail Risk Hedge Fund Analysis[6]
(1992 through 2010)

	Tail Risk Hedge Fund Composite	*S&P 500*
Annualized Return	0.7%	*8.1%*
Annualized Standard Deviation	18.9%	*15.0%*
Skewness[7]	1.13	*-0.73*
Max Drawdown	-32.3%	*-29.6%*
Best 12 months/*Corresponding S&P 500 Return*	52.8%	*-26.6%*
Worst 12 months/*Corresponding S&P 500 Return*	-29.8%	*39.8%*
Correlation with S&P 500	-0.81	*1.00*
Correlation when S&P 500 was negative	-0.62	*1.00*
Average Monthly Return when S&P was negative	5.3%	*-3.8%*

There are several trade-offs when using tail risk hedge funds. First, many expect to produce a negative return in most environments, except for when a negative market event occurs. The reason for this is they purchase hedges that cost money and expire worthless in the absence of a market decline. This "carrying cost" can be significant, as the costs range from one percent to over twenty percent per annum[8]. A further challenge is that hedge funds introduce new risks. For example, a number of the investment instruments used are not exchange-traded, which introduces counterparty risk. Further, the covariance relationships that held in the past may change during the next crisis, which would result in the strategy not providing the anticipated hedge. On a related note, because these funds often are not customized to hedge against the investor's specific portfolio, some basis risk should be expected. Finally, like most hedge funds, they will typically charge high fees (e.g., "2 and 20") and provide limited transparency.

Tactical Asset Allocation Strategies

A dynamic or tactical approach to managing tail risk makes temporary changes to the asset allocation over a relatively short period of time. One such rules-based approach, popularized in the 1980's, is called Constant Protection Portfolio Insurance (CPPI). CPPI caps a Plan's losses by setting a floor on the value of the portfolio. CPPI is guided by a

[6] For this analysis, Meketa Investment Group constructed a composite of hedge funds that serves as a rough proxy for the exposure gained from using one or more tail risk hedge funds. For inclusion in the composite, each component was required to exhibit a correlation to the S&P 500 of -0.50 or lower for the full life of the fund and an operating history beginning prior to April 2008 with data through March of 2011. The most common strategies included in the composite are short only/short biased funds and global macro funds. The constituents were equal weighted based upon their inception date, meaning that during the early periods the composite is comprised of very few components while later periods offer a more robust depiction of the opportunity set.

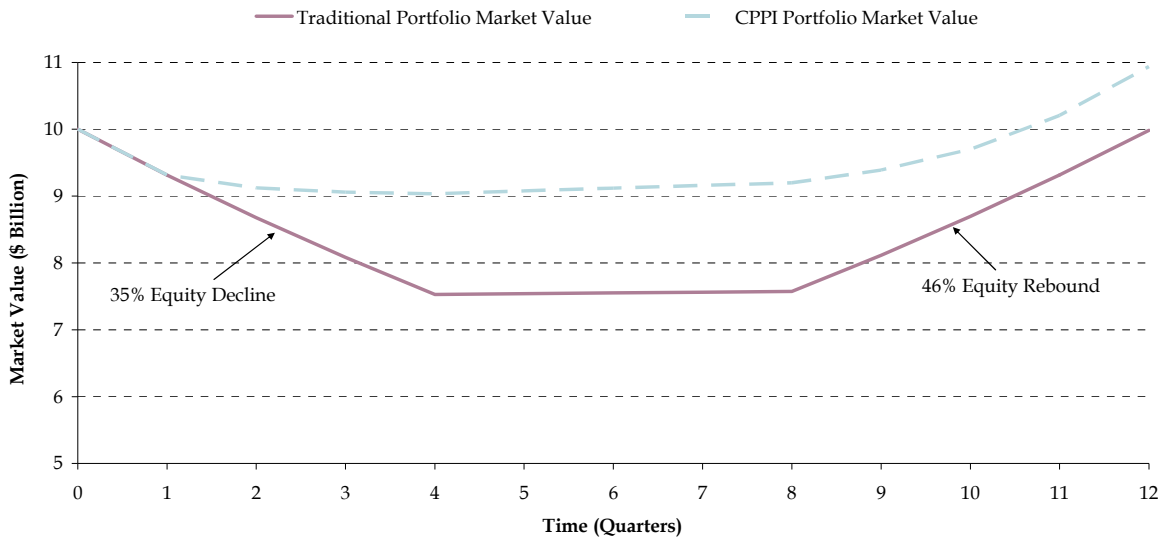
[7] Skewness is a measure of a distribution's lack of symmetry around its mean. Negative skew indicates a long left tail but generally the distributions is shifted to the right. For equity investors negative skew, with a long left tail, means there are likely a few large negative returns in the data. Positive skew indicates the right tail is longer.

[8] Carrying costs are based on estimates provided by various tail risk hedge funds interviewed by Meketa Investment Group.

predetermined metric such as the Plan's funding status or the amount of a market decline. As the portfolio value approaches the floor, CPPI automatically reduces exposure to risky assets and shifts to low-risk assets, effectively limiting losses. There is a related mechanism to increase equity exposure as the Plan's assets increase.

This approach works well in a downward trending market, as risk is quickly reduced (see the following chart). However, CPPI will produce highly sub-optimal outcomes in mean-reverting markets, as it is selling when the market has already decreased and buying after the market has already increased (i.e., selling low and buying high). The strategy will also lag during extreme short-term market stress, like when markets gapped down in 1987 and during the flash crash of 2010.

CPPI Strategy in a Trending Market



Other rules-based models exist for making tactical allocation changes, but most of them are not focused on hedging tail risks. Further, as with all quantitative approaches, there remains a distinct possibility that a model that worked in the past will not work in the future.

IMPACT ON PERFORMANCE

There is a trade-off to having downside protection in a portfolio, whether through a strategic allocation or through a tactical asset allocation strategy. In this section, we examine the historical performance of these strategies and estimate the impact on expected returns in an institutional portfolio.

Historical Impact

To analyze how the different approaches performed as a hedge, each asset was added to a well-diversified "model" pension portfolio by allocating 10% to the asset, replacing 5%

domestic equity, 3% international equity, and 2% of the core bond allocation. The table below reviews the annualized historical return and risk (standard deviation) over a 19-year period for the six different hedged portfolios.

Portfolio Performance (1992 – 2010) [9]

	Historical Return (%)	Standard Deviation (%)	Sharpe Ratio
Pension Model Portfolio[10]	6.5	10.7	0.17
Pension Model + L-T Treasuries	6.6	8.9	0.22
Pension Model + Gold	6.6	9.6	0.21
Pension Model + I-T Treasuries	6.4	9.1	0.19
Pension Model + Core Bonds	6.4	9.3	0.19
Pension Model + Tail Risk HFs[11]	6.1	8.0	0.18
Pension Model + CPPI Floor[12]	5.7	9.0	0.12

Each hedge reduces the risk of the portfolio, but to varying degrees. Gold provided the least risk reduction, while tail risk hedge funds provided the most, in terms of standard deviation. Two of the six hedges improved the historical return, though it was by a modest ten basis points per annum. Investment grade bonds and intermediate-term Treasuries reduced the return by just ten basis points, while the addition of tail risk hedge funds reduced the return by forty basis points. The Sharpe ratio for each of the hedging strategies falls within a fairly tight range, with the exception of the CPPI Floor. In short, each of the hedges considered have different performance characteristics, without a clear distinction for a superior portfolio hedge.

The traditional mean variance characteristics of return and standard deviation are limited when it comes to analyzing portfolio hedges, primarily due to the assumptions that are made when using it (e.g., a "normal" return distribution, stable volatility, and co-variance). A scenario analysis can be more instructive to understanding how the hedges benefit a portfolio, and the following table reviews asset performance and portfolio performance over several market stress scenarios that occurred during the past two decades.

[9] Historical Return represents the annualized geometric mean return. Standard Deviation represents the standard deviation of annual returns. Sharpe Ratio uses the average intermediate-term interest rate during the period of 4.7% as the risk-free rate.

[10] Pension Model Portfolio: 25% Russell 3000, 20% MSCI ACWI ex. U.S., 10% Barclays Aggregate, 10% TIPS, 5% Barclays High Yield, 10% NCREIF Property Index, 5% DJ UBS Commodity Price Index, 5% HFRI Fund of Funds Composite, 10% Venture Economic PE Composite Median.

[11] This analysis uses the Tail Risk Hedge Fund Composite introduced on page 8.

[12] Meketa Investment Group used the pension model portfolio as the base portfolio and reduced risk when the funded status dropped below 85%, with an intended floor of 65%.

	Rate Spike	Asian Debt Crisis	LTCM/ Russian Debt Crisis	Dot-Com Bubble	Global Financial Crisis	Flash Crash Jitters
	Feb-Nov 1994	Aug-Nov 1997	May-Aug 1998	Apr '00 - Mar '03	Nov '07 - Feb '09	May-Jun 2010
Asset Performance						
S&P 500	*-3.1%*	*1.2%*	*-13.2%*	*-47.7%*	*-67.1%*	*-13.2%*
Long-Term Treasuries	-12.3%	5.1%	9.1%	32.4%	21.2%	10.7%
Gold	0.5%	-9.2%	-9.7%	20.3%	22.2%	5.5%
Intermediate-Term Treasuries	-7.1%	2.0%	4.5%	30.4%	14.9%	2.8%
Barclays Aggregate	-4.9%	2.5%	3.6%	28.3%	6.1%	2.4%
Tail Risk HF Composite[13]	29.0%	9.4%	42.5%	73.0%	50.7%	10.3%
Portfolio Performance						
Pension Model Portfolio	-2.1%	-1.1%	-7.7%	-16.8%	-37.9%	-5.8%
Pension Model + LT Treasuries	-2.9%	-0.3%	-5.6%	-10.0%	-30.0%	-3.7%
Pension Model + Gold	-1.6%	-1.7%	-7.4%	-11.2%	-29.9%	-4.2%
Pension Model + IT Treasuries	-2.4%	-0.6%	-6.0%	-10.2%	-30.7%	-4.5%
Pension Model + Core Bonds	-2.1%	-0.6%	-6.1%	-10.4%	-31.5%	-4.5%
Pension Model + Tail Risk HF	1.2%	0.1%	-2.2%	-6.0%	-27.1%	-3.7%
Pension Model + CPPI Floor	-2.1%	-1.1%	-7.7%	-12.6%	-26.1%	-1.1%

Core bonds did not provide as good a hedge as Treasuries during the most significant declines in the stock market. Gold served as a good hedge during the Global Financial Crisis, but it produced negative returns during Asian and Russian Debt crises. The CPPI Floor did not provide much of a hedge during brief downturns, but it did prove a useful hedge during extended downturns. The Tail Risk Hedge Fund composite served as the best hedge during most of these crises, though this should be expected given the extreme negative correlation that defined the universe.

Unfortunately, any historical analysis has certain limitations and will be subject to time-period bias. For example, bonds have been in a secular bull market for most of the time period shown above, a result of a long-term decline in interest rates. Similarly, the past decade was a very favorable period to invest in gold. Another limitation to the above analysis is that the performance of the CPPI Floor approach was partly dependent on the assumed financial position of the pension fund when it entered the period of stress.

Impact on Long-Term Expected Returns

Another way to consider the performance of tail risk hedges is to look at the expected returns when they are used in a typical pension plan portfolio. The following table below considers dedicated allocations to long-term Treasuries and gold, derivative overlays (put options triggered at a 15% and 25% market fall), and tail risk hedge funds.

[13] The returns of the Tail Risk Hedge Fund Composite are likely upwardly biased as it includes self-reported hedge fund performance statistics.

	Model Pension Plan	Model Pension + 10% LT Treasuries	Model Pension + 10% Gold	Model Pension + 15% OTM Put	Model Pension + 25% OTM Put	Model Pension + 10% Tail Risk HF
Expected Return[14]	7.4	7.1	7.2	5.0	5.7	6.7
Expected Std. Dev.	11.8	10.7	11.3	11.8	11.8	10.0
Allocation						
% Equity	55	47	47	55	55	47
% Hedge Funds	5	5	5	5	5	15
% Real Assets	15	15	25	15	15	15
% Bonds	25	33	23	23	23	23
% Cash/Derivatives	0	0	0	2	2	0

The analysis of expected returns shows how simple put options can be expensive as their costs directly reduce expected return. A 25% out-of-the-money put option reduces the expected return from 7.4% to 5.7%, based on the average historical purchase price of 2.4% per year. Adding a 10% allocation to tail risk hedge funds (primarily from equities) reduces the expected return by 0.7% but also lowers the standard deviation by 1.8%. A dedicated allocation to long-term Treasuries appears to have the best risk-reward trade-off, as the expected return is lowered by only 0.3% while the standard deviation declines to 10.7%. Clearly, each hedging strategy has a cost.

Considering the expected returns of tail risk strategies relative to a typical pension fund is instructive; however, traditional mean variance analysis is not well suited for analyzing the benefits of a tail risk strategy, especially for put options. To better analyze these allocations, we also constructed a prospective scenario analysis that tests the impact, over a 12-month period, of rising interest rates and declining equity markets. The table below shows the one-year returns of the pension plan portfolios under different market scenarios.

	Model Pension Plan	Model Pension + 10% LT Treasuries	Model Pension + 10% Gold	Model Pension + 15% OTM Put	Model Pension + 25% OTM Put	Model Pension + 10% Tail Risk HF
10-Year T-Bond Yield Rises 100 bp	9.8%	7.4%	8.7%	9.8%	9.8%	8.7%
10-Year T-Bond Yield Rises 300 bp	2.5%	-2.4%	2.3%	2.8%	2.7%	2.3%
Equities Decline 10%[15]	-6.4%	-5.6%	-5.9%	-8.7%	-8.0%	-4.4%
Equities Decline 25%	-16.0%	-14.0%	-14.8%	-11.9%	-17.6%	-11.0%
Equities Decline 40%	-25.6%	-22.4%	-23.6%	-11.9%	-17.6%	-17.6%

[14] Expected returns and standard deviations are based on Meketa Investment Group's 2011 Asset Study. Assumptions: 3.4% cost of protecting against 15% decline in the S&P 500 for 12 months; 2.4% cost of protecting against 25% decline in the S&P 500 for 12 months; hedging roughly 65% of the Plan's value with overlay (implies correlation between equities and other asset classes during a downturn). For modeling purposes, the put option exhibits characteristics of cash collateral, while in reality a put option would have a skewed distribution that is difficult to model with traditional mean variance optimization techniques.

[15] Credit, real assets, and traditional hedge funds are all expected to participate (to varying degrees) in an equity market decline.

As we would expect, the portfolio that includes the 10% allocation to long-term Treasuries performs worst during a rising interest rate environment, declining 2.4% if rates were to rise by 300 basis points. The put strategies set a clear floor on the portfolio as the market declines, but only past the trigger point of the put option. The tail risk hedge fund approach mitigates losses in equity downturns much better than the dedicated allocations to long-term Treasuries or gold. While this provides a clearer picture of the different characteristics and risk-reward profiles of each approach, it does not lead to a conclusive answer regarding which approach is best.

RISKS

There are a number of risks to consider with tail risk management strategies, and the extensive use of derivatives by some of these strategies introduces unique risks that an investor might not otherwise encounter. The primary risks that exist with tail risk management strategies include counterparty risk, liquidity risk, basis risk, operational risk, execution risk, and the risk of opportunity cost. Each risk is described briefly below.

Counterparty Risk -- Any over-the-counter transaction (i.e., non-exchange traded derivatives) requires two parties to agree upon the transaction. Both parties assume the other (i.e., the counterparty) will be able to pay the contracted amount when required. The risk of a counterparty breaching a contract will be highest during a period of market stress, especially if it is caused by a systemic (i.e., widespread) crisis.

Counterparty risk can be mitigated in a number of ways. First, an investor should ensure that sufficient collateral is in place to cover any mark-to-market losses, and that such settlements are made on a regular basis. An investor can diversify their counterparty risk by using multiple counterparties. An investor can hedge counterparty exposure, though this adds another layer of cost. Finally, investors should determine what jurisdiction retains the derivative as capital regulations, rehypothecation requirements, and bankruptcy procedures vary from country to country.

Liquidity Risk -- A derivative instrument or structured product may become relatively illiquid (i.e., difficult to exit the position) during times of market stress. Similarly, many hedge funds have explicit liquidity constraints that would prevent an investor from exiting the fund regularly or during a down market. Obviously, this risk can also have important implications for funds that have to meet obligations no matter the market environment.

Liquidity risk can be reduced by understanding and trading in highly trafficked derivative instruments and investing in securities that have a natural buyer. Also, having a systematic process to harvest gains can reduce the risk of selling at a market extreme, when liquidity is most likely to be limited.

Basis Risk -- In a portfolio context, basis risk is the degree to which a derivative's intended exposure does not exactly match the portfolio holdings. Given the broad array of markets in which most plan sponsors invest, there is a high probability that the hedges used (especially in a commingled fund) will not perfectly hedge the exposures in an investor's portfolio.

Basis risk can be mitigated by customizing a hedging strategy to reflect the unique risks in the investor's portfolio. Some investors may only want to hedge if it can be customized to the portfolio and minimize basis risk.

Operational Risk -- Derivative transactions require that a pre-specified amount of capital, or collateral, be set aside to cover mark-to-market settlements (e.g., margin calls). In a futures or swap transaction, if there is insufficient collateral, additional capital must be raised, which could force an investor to liquidate assets during what is likely a market decline.

A Plan with sufficient in-house resources can consider whether to run a derivatives overlay program in-house, to outsource the operational aspects to a third-party like a Qualified Professional Asset Manager (QPAM), or to use a solution of solely external managers. Executing a derivatives program in-house introduces other operational complexities such as establishing a legal entity to hold the derivatives, vetting counterparties, and executing International Swaps and Derivatives Association (ISDA) agreements with said counterparties.

Execution Risk -- A flawed approach to managing a hedging program may result in derivatives being monetized at inopportune times, hedges not being implemented in a timely or cost effective manner, or a flawed belief in what exposures are being hedged. Accordingly, a hedging policy and process should be defined before a tail risk hedging program is implemented.

Opportunity Cost -- When allocating capital to a hedging strategy, regardless of the approach, that capital could be deployed in another asset class with the potential for higher returns. This opportunity cost increases as larger allocations to tail risk hedging strategies are implemented. When allocating to a tail risk strategy, a full understanding of the risks, opportunity costs, and potential benefits should be weighed, including the scenario if no tail risk event occurs.

CONCLUSION

Tail risks are the most damaging investment risks, as they are large, unpredictable, and difficult to model. There are many ways to manage tail risk in a portfolio context. The tools available vary in complexity, risk level, and cost. This paper reviewed four approaches, and the advantages and disadvantages of each are summarized in the following table.

Summary of Tail Risk Hedging Approaches

Strategy	Advantages	Disadvantages
Strategic Asset Allocation	• Easy to implement, may not require additional investments or complexity • No explicit cost	• Does not handle tail risk effectively (asymmetric payoffs not as high) • Some opportunity cost
Derivatives Overlay	• Conceptually straightforward and transparent, presuming a basic put option structure • Provides a proven hedge • Leaves portfolio allocations in-tact • Customizable to the cost, level of protection, and timing	• High opportunity cost, as put options are often the most expensive form of protection • Option costs can vary dramatically and are highest when insurance is most needed • A more complex approach is needed to reduce basis risk
Tail Risk Hedge Funds	• Tail risk decisions are delegated to an outside manager • Offer the most diversified and efficient hedging solutions • On average, have performed quite well during market declines	• May introduce basis risk, counterparty risk, complexity, lack of transparency, and illiquidity • Hedges may not be as reliable as their models indicate • High fees
Tactical Asset Allocation	• Predetermined rules make it easy to implement • Can reduce losses in a downward trending market	• Potentially large indirect opportunity cost • Does not work well in a volatile, mean reverting market

All risk mitigation tools have an implicit or explicit cost and, therefore, lower an investor's long-term expected return. Given these long-term costs, institutional investors should have a specific reason to hedge. In the absence of accounting regulations (for pension plans) or budget constraints (for endowments), we believe that the costs of tactical risk management strategies outweigh the long-term benefits to most institutional investors.

We believe that risk is most efficiently managed through changes to an investor's long-term strategic asset allocation. However, there are many reasons why a plan sponsor or endowment would consider tail risk management. In these situations, using one or more of the approach(es) we have reviewed may be appropriate. We believe that the most effective risk mitigation tools are those that are simple, low cost, and involve limited basis risk.

APPENDIX A

TAIL RISK-ORIENTED HEDGE FUND STRATEGIES

Managed Futures

Managed futures funds generally employ systems driven trading systems to identify and follow trends in fixed income, foreign exchange, commodity, and stock index markets. Modern managed futures trading systems are highly complex and quantitatively generated. They seek to follow trends up or down across large number of markets (they typically trade around 100 markets simultaneously) and a variety of time horizons. However, some Managed futures strategies employ discretionary approaches while others focus on trend reversal, contrarian (countertrend), mean reversion and spread trading techniques. These funds trade derivative instruments such as futures contracts, options, forward contracts, swap contracts and leverage contracts. Returns vary according to the system and degree of leverage employed.

Global Macro

Macro hedge funds employ a variety of hedge strategies, but are best known for their highly leveraged trades in bond, currency and other markets. Macro fund managers study global macro economic and political developments and form views as to whether likely developments are reflected in financial markets. Should they see a compelling opportunity, they will invest accordingly. The performance of these funds varies enormously according to the investment process and predicative skills of the manager and the amount of leverage employed.

Short-Biased Equities

The managers of these funds are generally stock pickers who employ both fundamental and technical analysis to invest on both the long and short side of the market. Most short-biased hedge funds will have some long positions, but will be net short (i.e., they have a larger short position than their long position). Being short means that the manager will profit when the security goes down in price.

APPENDIX B

DERIVATIVE INSTRUMENTS COMMONLY USED FOR HEDGING

Options

Definition: The right to buy or sell an underlying asset at a specified price in the future.

Description: A put option gives the owner the right, but not the obligation, to sell an underlying asset at a specified price. While a call option, gives the owner the right, but not the obligation, to buy an underlying asset at a specified price. Put and call options can be used on the major asset classes: equities, commodities, and currencies.

Counterparty: Exchange traded and Over-the-counter (OTC)

Futures

Definition: A contract between two parties that agrees to exchange an asset at a future date and specified price.

Description: The futures market is one of the most liquid markets in the world and exists across many asset classes including equities, commodities, interest rates, and currencies.

Counterparty: Exchange traded

Swap

Definition: An agreement between two entities to exchange one party's financial interest for the other's financial interest.

Description: The swap market contains five major asset classes including interest rates, currencies, credit (bonds), commodities, and equities. A swap often exchanges a fixed financial return, like an interest rate, for a variable financial return, like an equity index.

Counterparty: Primarily Over-the-counter (OTC)

Swaptions

Definition: The right to enter into a swap on a specific date in the future. An option on a swap.

Description: There are put swaptions and call swaptions. The buyer of a call swaption has the right to enter a swap at specified future date and price.

Swaptions typically refer to an option on an interest rate swap, but options can be traded on a variety of swaps. Swaptions allow investors to take a position where a swap is the underlying arrangement.

Counterparty: Over-the-counter (OTC)

Volatility Swap

Definition: A swap contract based on the volatility of a given asset.

Description: A volatility swap allows an investor take a position on the volatility of an underlying asset, irrespective of the underlying asset's price.

Counterparty: Over-the-counter (OTC)

Variance Swap

Definition: A type of volatility swap that is based on the variance of the underlying asset rather than the volatility.

Description: Since variance is the square of volatility (standard deviation), variance will have larger payout that is convex, as opposed to a linear payout from a volatility swap.

Counterparty: Over-the-counter (OTC)

Credit Default Swap

Definition: A contract that guarantees the credit worthiness of an underlying bond security.

Description: The buyer of the default swap is buying protection from default while the seller of the protection is liable for the credit worthiness of the underlying security. A bondholder can buy protection on a bond owned to transfer the risk of default to the seller of the credit default swap. A speculator may buy a credit default swap if they believe default is possible and will benefit as the security falls in value.

Counterparty: Over-the-counter (OTC)