A Comparison of Tail Risk Protection Strategies in the U.S. Market

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1. Introduction

The global financial crisis (GFC) of 2007-08 was remarkably severe not only in the magnitude of drawdowns suffered by individual asset classes, but also the drawdowns of portfolios thought to be well diversified. The risk of such an outcome has come to be labeled tail risk in reference to the extreme left tail of an asset's or portfolio's return distribution. Since the GFC, many investment organizations have launched tail risk protection strategies designed to address such periods of severe market distress. Likewise, flows into managed futures strategies (commonly thought to profit during periods of elevated volatility) increased dramatically .[1]

Tail risk represents the loss at the most negative part of an asset or portfolio's return distribution, or the left tail. Many studies show that equity market returns do not follow a normal distribution, with tails fatter than predicted (Fama (1965)). Extreme losses occur during times of crisis or financial market distress. In these times, we observe a contagion effect marked by a pronounced rise in many asset class correlations to equities. Since it stands out as the dominant explanatory risk factor in multi-asset class portfolios, equity return is used as a proxy for financial market risk in our study. While protection against tail risk has generated considerable attention and asset flows, there is significant disagreement regarding the efficacy of such strategies and their cost/benefit tradeoffs. Theoretically, a tail risk strategy should have a low required rate of return because it pays off at times of market distress.

This paper measures the benefits and costs of several candidate tail risk protection strategies empirically using more than 20 years of monthly data from U.S. markets. We analyze four methods for controlling tail risk: (1) long volatility, (2) low volatility equity, (3) trend following, and (4) equity exposure management.

We consider an investment strategy to offer tail risk protection if it consistently outperforms equities when equity returns are most negative. We define portfolio tail risk as the conditional mean portfolio return in months where equity returns exceed a loss of five percent. For each tail risk strategy, we estimate the fixed allocation, that when combined with an equity portfolio, reduces tail risk by a constant proportion. In this way each tail risk strategy is compared on an equal footing based on its contribution to tail risk reduction.

This paper also introduces two new measures of tail risk protection efficacy. First, we measure the cost of the protection in terms of annual performance drag when added to an equity portfolio. Then, we measure the certainty, or consistency, of the tail risk protection. The ideal tail risk strategy combines a low performance drag with a high certainty of protection. We identify a number of tail risk strategies that perform well along these two measures.

2. The Benefits of Tail Protection

Good tail risk protection may benefit portfolios in several ways. Bhansali and Davis (2010) show that tail risk hedging can boost total portfolio profitability since a hedged portfolio allows for a more growth-oriented asset allocation. In addition, Fama and French (1989) demonstrate that expected returns are time-varying. Expected returns are likely to rise during periods of market distress, in order to compensate those investors willing to bear

market risk. In fact, Kelly (2011) showed that tail risk has a significant, positive relationship with forward expected returns.

Time-varying expected returns that are correlated to business conditions and recent market volatility increase the benefits to an efficiently run tail risk hedging program. Presumably, if an investor can truncate losses during a significant market drawdown, saving their "dry powder," the investor can then re-allocate toward riskier assets after the drawdown in order to benefit from rising return premiums.

Exhibit 1 provides supportive evidence of time-varying expected returns. Using capitalization-weighted U.S. equity returns from 1926, the table shows that the market often rebounds significantly in the quarter following a sharp decline. Both the average return and the probability of a positive return rises as the magnitude of the prior market decline increases.

3. Diversification

An investment manager's first tool to curtail tail risk is typically to diversify among asset classes with low correlation. However, simply diversifying global equity with fixed income, for example, does not do enough to limit tail risk. A portfolio with a traditional 60% equity, 40% fixed income allocation derives over 90% of portfolio risk from the equity component (Qian (2011)).

One limitation to the diversification approach is that asset class return correlations rise in times of crisis, as shown

Exhibit 1 Forward Equity Returns Increase Following a Crisis, June 1926 - June 2011, S&P 500 Index

Quarterly Returns since 1926	Occurances	% Followed by Positive Return	Following Quarters Average Return
Market Fall > 5%	54	61%	3.34
Market Fall > 10%	29	69%	9.23
Market Fall > 15%	16	75%	9.75
All Quarters	340	68%	3.04

Source: Factset, Standard & Poor's. Past performance is not a guarantee of future results.

Exhibit 2 Asset Correlations in Normal and Crisis States, January 1990 – September 2011

Normal

	S&P500
S&P500	1.00
Russell2000	0.70
MSCI World x US	0.61
MSCI EM	0.54
US Aggregate	0.18
High Yield	0.51
S&P GSCI	0.02
FTSE NAREIT	0.42
HFRI Fund Weighted	0.60

Crisis

	S&P500
S&P500	1.00
Russell2000	0.75
MSCI World x US	0.77
MSCI EM	0.73
US Aggregate	0.34
High Yield	0.75
S&P GSCI	0.46
FTSE NAREIT	0.66
HFRI Fund Weighted	0.71

Crisis - Normal

	S&P500
S&P500	1.00
Russell2000	0.05
MSCI World x US	0.16
MSCI EM	0.19
US Aggregate	0.15
High Yield	0.23
S&P GSCI	0.43
FTSE NAREIT	0.25
HFRI Fund Weighted	0.11

Source: Fact Set, Standard & Poor's, Russell, MSCI, Barclays, FTSE, HFRI

in Exhibit 2. We define a normal state as any month when the S&P 500 returned greater (more positive) than -5%, and a crisis state as any month when the S&P 500 fell -5% or worse. There were 261 total months in this test. Of those months, 234 were normal and 27 were crisis months.

The left panel shows asset correlations for the normal months versus the S&P 500, while the middle panel summarizes the correlations for the crisis months. The right panel simply shows the difference between a crisis state and a normal state correlation of each asset class versus the S&P 500. Notice that in each case, asset class correlations rise when moving from a normal to a crisis state.

The correlation coefficient measures the degree to which the movements of two variables are related. For example, a correlation of 1.00 would indicate that the two asset classes monthly returns move in the same direction (positive or negative) for the stated time period. In contrast, a correlation coefficient of -1.00 would mean that the two indices move in opposite direction. A correlation of zero indicates that the two exhibit no discernible relationship.

The analysis from Exhibit 2 underscores some of the challenges when only using diversification as the tail risk hedging tool. First, finding truly uncorrelated asset returns is difficult. Many non-equity asset classes are positively correlated to equities, suggesting they carry significant equity "beta" exposure. Second, correlations rise just when they are needed most. For example hedge fund indices, high yield debt, and REITS all correlate between 0.66 and 0.75 with the equity market during crisis periods.

4. Measuring Tail Risk: Equity Exposure

The foregoing hints at the pervasive nature of equity risk that affects even well-diversified multi-asset class portfolios. Indeed, Bhansali (2011) finds an equity market risk factor explains the largest portion of cross-sectional asset class return variance. One may think of this risk factor as shifts in economic growth expectations or investor risk aversion that afflict many assets simultaneously. Given the above reasoning, along with a heavy equity bias in most institutional allocations, we use equity index losses as a proxy measure for portfolio tail risk exposure in our study.

Exhibit 3 graphically shows the magnitude and frequency of tail events illustrated by the peak-to-trough drawdown losses of the U.S. market since 1926. The data series is constructed by Ibbotson Associates and represents a back-casted S&P 500 return. Every time the line hits the top axis, the equity market has reached or exceeded its previous peak. The S&P 500 has experienced 24 drawdown events of 20% or more since 1926, averaging one event every 3.54 years. Exhibit 4 documents these events. We calculate the beginning of a new drawdown event either once a new peak has been hit or once there has been a previous 20% drawdown event. For example, if there were two consecutive monthly returns of -20%, we would consider this to be two distinct 20% drawdown events.

Although some might consider prolonged drawdowns during recessionary markets as one event, we believe our methodology more accurately reflects the risk to an investor from entering the market at any time during that period. Excluding depression-era stock market performance, we find that a drawdown event of 20% or greater occurred every 7.08 years since 1940. More recently, the S&P 500 drawdown of -49.84% during the 2007-08 global financial crisis eclipsed the -44.73% drawdown in September 2002 after the bursting of the technology bubble began in early 2001 and is the largest peak to trough drawdown since the end of the Great Depression.

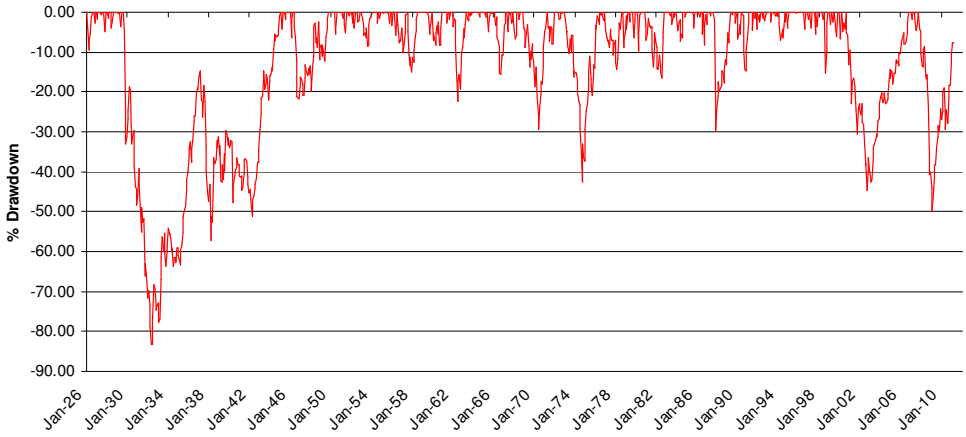

Exhibit 3 Equity Market Drawdown in the S&P 500 (January 1926 – March 2011)

Source: Standard and Poor's, Fact Set

Exhibit 4 S&P 500 Periods of Drawdown January 1926 – March 2011

Periods of Drawdowns (January 1926 -March 2011)		
Periods	*Breaks 20% Drawdown*	*Max Drawdown**
Sept 1929 - Dec 1944		83.41%
Oct-1929	-23.55%	
Sep-1930	-24.45%	
May-1931	-27.00%	
Sep-1931	-33.62%	
Jan-1932	-23.01%	
Apr-1932	-29.24%	
May-1932	-21.96%	
Feb-1933	-29.82%	
Jul-1934	-20.71%	
Sep-1937	-21.92%	
Dec-1937	-21.40%	
Mar-1938	-24.87%	
May-1940	-25.72%	
Apr-1942	-23.08%	
Jun 1946 - Sep 1949		-21.76%
Sep-1946	-21.08%	
Jan 1962 -Mar 1963		-22.28%
Jun-1962	-22.28%	
Dec 1968 - Feb 1971		-29.33%
Apr-1970	-21.33%	
Jan 1973 - Jun 1976		-42.65%
Apr-1974	-20.07%	
Sep-1974	-28.25%	
Sept 1987 - Apr 1989		-29.58%
Oct-1987	-23.26%	
Sept 2000 - Sept 2006		-44.37%
Mar-2001	-23.04%	
Jul-2002	-26.22%	
Nov 2007 - ?		-49.84%
Sep-2008	-23.19%	
Nov-2008	-22.76%	

Note: Past performance is not a guarantee of future results.
Source: Standard and Poor's, Fact Set

5. Tail Risk Strategy Analysis

In this section we examine a number of tail risk strategies, grouping them into four categories: (1) long volatility, (2) low volatility equity investing (stock selection), (3) trend following, and (4) equity exposure management. The calculations and indices used for strategy performance are detailed in the Appendix.

Strategies in the long volatility category are VIX futures (*VIX1m* and *VIX5m*) and variance swaps (*VARSWP1m* and *VARSWP3m6m*). *VIX1m* and *VIX5m* hold a combination of VIX futures contracts to maintain a constant 1-month

Exhibit 5 Tail Risk Strategies Stand Alone Performance March 1990 – March 2011

Strategy Type	Strategy	Annual Return	Annual Std Dev	IR	Correlation S&P 500	Beta S&P500	Correlation VIX
	S&P 500	9.08	15.11	0.60	1.00	1.00	-0.63
Cash	TBILL	3.59	0.59	6.04	0.06	0.00	0.07
Volatility Based	VIX1m	-45.55	52.86	-0.86	-0.59	-2.07	0.75
Volatility Based	VIX5m	-5.57	29.93	-0.19	-0.54	-1.07	0.68
Volatility Based	VARSWP1m	-4.03	7.24	-0.56	-0.34	-0.16	0.41
Volatility Based	VARSWP3m6m	-0.54	15.96	-0.03	-0.61	-0.64	0.58
Low Vol Equity	LBMHB	-0.82	24.26	-0.03	-0.69	-1.10	0.42
Low Vol Equity	DSB	-0.53	19.23	-0.03	-0.71	-0.90	0.47
Trend Following	MGDFUT	6.34	8.32	0.76	-0.10	-0.06	0.08
Exposure Mgmnt	PUT	-2.75	4.27	-0.64	-0.55	-0.16	0.44
Exposure Mgmnt	TACT	8.62	15.13	0.57	-0.05	-0.05	-0.01

Source: Factset, Standard & Poor's, Bloomberg, Ibbotson Associates, Commodity Systems Inc., Barclays, Hedge Fund Research, Inc.

(30-day) and 5-month time to maturity. They are tracked by the highly liquid ETNs (NYSE Tickers: VXX and VXZ). *VARSWP1m* is a rolling investment in 1-month to maturity variance swaps, struck at prevailing S&P 500 implied variance, and receives realized variance. *VARSWP3m6m* invests in a forward start variance swap struck at the S&P 500 implied variance at three months' time, and receives the six month realized variance over the period starting at three months' time. Long volatility strategies are a natural equity hedge because equity market declines are often accompanied by jumps in volatility.

The low volatility equity investing (stock selection) strategies are negative beta stock portfolios that benefit from return anomalies or stock picking ability. The negative beta of these portfolios make them an obvious equity hedge, meanwhile the portfolios are designed to provide an alpha component beyond their systematic risk exposure. The low beta minus high beta strategy (LBMHB) is 100% long the low-beta quintile and 100% short the high-beta quintile of liquid US stocks within the Russell 3000 Index. Prior to portfolio formation, betas are estimated for each stock by regressing its daily returns on the daily market returns over the prior two years. This decile spread represents the active return from a low volatility or minimum variance equity portfolio when compared to the S&P 500 Index. The dedicated short bias (DSB) strategy is represented by the HFRI Short Bias Index. Managers comprising this index rely on their skill in shorting overvalued companies.

The trend following strategy (MGDFUT) is represented by the Barclay's CTA Index, a composite of managed futures funds. Commodity trading advisors primarily rely on a trend-following approach to add value. Fung and Hsieh (2001) showed that trend-following strategies have the payoff profile of a lookback straddle with higher performance in pronounced market uptrends and downtrends.

The fourth and final category, equity exposure management, comprises strategies that limit equity exposure. The put option (PUT) strategy purchases one-month to maturity 8.5% out-of-the-money puts on the S&P 500 index and liquidates one day prior to expiration. The tactical equity strategy (TACT) invests in the S&P 500 index when it lies above its ten-month moving average and shorts the index when it falls below its moving average.[2] Put options, by design, and a tactical equity strategy with skill at timing when to short, will both pay off during equity

downturns.

Exhibit 5 summarizes the stand-alone performance of our collection of tail risk strategies along with the S&P 500 and cash (one-month Treasury Bill) over our sample from March 1990 – March 2011. S&P 500 returns averaged 9.08%per year with 15.11% annual risk during this time period. Since the annual return and risk figures are close to or even above their long term average, the period of analysis will not bias our study toward making tail risk solutions look effective. From Exhibit 5, we see that monthly returns to the S&P 500 are very negatively correlated (-0.63) to monthly percent changes in the CBOE VIX index. Most tail risk strategies exhibit negative correlation with equity returns and positive correlations to changes in VIX.

At first glance, the collection of tail risk strategies may not elicit any optimism because of their low or negative stand-alone annualized returns. However, it is precisely their ability to have a positive payoff in bad times that drives down the expected risk premia for tail risk solutions.[3]

6. Tail Risk Hedging Power – Performance in Crisis

Before combining each tail risk hedging strategy with an equity portfolio, we examine historically how each strategy performs during a tail risk event, defined as a month where the S&P 500 declines by 5% or more.[4] Column 3 of Exhibit 6 reports the average return of the tail risk strategies as well as the S&P 500 during such crisis months between March 1990 and March 2011. In these months, the average return for the S&P 500 is -8.10% while average return to all of the tail risk strategies is positive. Column 4 of the table shows excess return to the S&P 500 during crisis months for each strategy and represents hedging power. The two VIX futures strategies have the greatest hedging power, outperforming the S&P 500 by 24.7% and 19.2%. All strategies have stronger tail risk hedging power than a Cash allocation (*TBILL*) which outperforms by 8.3%.

7. Adopting a Tail Risk Strategy

We now evaluate the effects on portfolio performance of allocating to different tail risk strategies. To make a fair comparison, we estimate the fixed allocation between the S&P 500 and each strategy that achieves a targeted reduction in tail risk. First, we define portfolio tail risk for portfolio j which we abbreviate PTR_j:

$$PTR_j = E[R_j \mid R_{SP500} < -5\%] \quad (1)$$

Exhibit 6 Tail Risk Hedging Power

Strategy Type	Strategy	Average Rtn (S&P < -5%)	Excess Rtn (S&P < -5%)
	S&P 500	-8.10	0.00
Cash	TBILL	0.24	8.34
Volatility Based	VIX1m	16.57	24.67
Volatility Based	VIX5m	11.09	19.19
Volatility Based	VARSWP1m	1.59	9.69
Volatility Based	VARSWP3m6m	6.87	14.97
Low Vol Equity	LBMHB	10.78	18.88
Low Vol Equity	DSB	7.01	15.11
Trend Following	MGDFUT	1.73	9.83
Exposure Mgmnt	PUT	1.57	9.67
Exposure Mgmnt	TACT	3.65	11.75

Source: Factset, Standard & Poor's, Bloomberg, Ibbotson Associates, Commodity Systems Inc., Barclays, Hedge Fund Research, Inc.
Note: see appendix for description of indices used and construction of tail risk strategy performance.

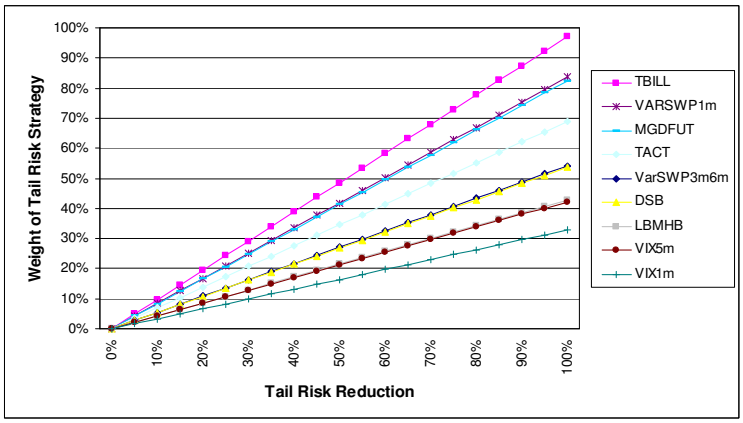

Exhibit 7 Tail Risk Strategy Allocation Frontier

Note: See appendix for description of indices used and construction of tail risk strategy performance.
Source: Factset, Standard & Poor's, Bloomberg, Ibbotson Associates, Commodity Systems Inc., Barclays, Hedge Fund Research, Inc.

Portfolio tail risk is defined as the conditional mean monthly portfolio return during months the S&P 500 loses in excess of 5%. In essence, we measure how fat is the left tail of the portfolio's return distribution. From Exhibit 6, we can see PTR_{SP500} = -8.10%. By our measure, a portfolio with 10% lower tail risk would have PTR = -7.29% (-8.10% x 0.90). Since each strategy has an excess return to the S&P 500 at its left tail (see Exhibit 6), we expect a combined S&P 500 and tail risk solution portfolio to have portfolio tail risk measure less than PTR_{SP500}.

Because each strategy has varying sensitivity to the equity market during a crisis, a different allocation to each strategy is necessary to achieve the same tail risk reduction. This is illustrated in Exhibit 7 which is a "frontier" of the required allocation to each tail risk strategy (y-axis) to achieve a certain amount of portfolio tail risk reduction (x-axis).

As expected, to gain more tail risk reduction, further investment is needed into the tail risk strategies and away from the S&P 500. The two extremes in hedging power are represented in the top and bottom lines in Exhibit 7: *TBILL* requires the largest and VIX1m the smallest allocation to reduce portfolio tail risk by a given amount. A higher required weight signifies a higher opportunity cost to the total portfolio, since less weight can be devoted to growth-seeking asset classes. Using this metric, cash (*TBILL*) is an expensive tail-risk hedge.

8. Performance Drag Measure

For the remainder of our analysis we use the allocation to each tail risk strategy that achieves a 20% reduction in portfolio tail risk. Each combined portfolio has the same portfolio tail risk (PTR_j = -6.48%, which is 80% of -8.10%); in this way we compare tail risk strategies on an equal tail risk adjusted basis.

The allocation that reduces portfolio tail risk by 20% when combined with the S&P 500 is given in the first column of Exhibit 8.[5] Some tail risk strategies require a larger allocation than others. For the put option strategy, we chose the 8.5% out of the money options as the strike that exactly achieves 20% portfolio tail risk reduction and so the allocation is given as 100%.

We introduce our first measure of tail risk efficiency which we term performance drag. Performance drag is the reduction in annual return when adopting a tail risk strategy and is shown in Exhibit 8. As an example, allocating the required 19.4% to Cash and the remaining 81.6% to the S&P 500 reduces annualized return from 9.08% to 8.19%, resulting in a performance drag of 89 basis points. The combined S&P 500/Cash portfolio achieves 80%

Exhibit 8 Performance Drag when Adopting Tail Risk Strategy

				portfolio performance			reduction in risk measures		
Strategy Type	Strategy	Allocation	Performance Drag	Annual Return	Annual Std Dev	IR	Annual Std Dev	Maximum Drawdown	PTR: Avg Rtn (S&P < -5%)
	S&P 500		0.00	9.08	15.11	0.60	100%	100%	100%
Cash	TBILL	19.4%	0.89	8.19	12.18	0.67	81%	84%	80%
Volatility Based	VIX1m	6.6%	3.55	5.52	12.39	0.45	82%	84%	80%
Volatility Based	VIX5m	8.4%	0.65	8.43	12.65	0.67	84%	84%	80%
Volatility Based	VARSWP1m	16.7%	2.03	7.04	12.22	0.58	81%	82%	80%
Volatility Based	VARSWP3m6m	10.8%	0.68	8.40	12.50	0.67	83%	85%	80%
Low Vol Equity	LBMHB	8.6%	0.32	8.76	12.47	0.70	83%	88%	80%
Low Vol Equity	DSB	10.7%	0.55	8.53	12.12	0.70	80%	87%	80%
Trend Following	MGDFUT	16.5%	0.21	8.87	12.55	0.71	83%	84%	80%
Exposure Mgmnt	PUT	100.0%	2.68	6.40	13.18	0.49	87%	87%	80%
Exposure Mgmnt	TACT	13.8%	-0.25	9.33	13.08	0.71	87%	79%	80%

Source: Factset, Standard & Poor's, Bloomberg, Ibbotson Associates, Commodity Systems Inc., Barclays, Hedge Fund Research, Inc.
Note: See appendix for description of indices used and construction of tail risk strategy performance.

portfolio tail risk (by design) and 81% of portfolio standard deviation as compared to an S&P 500 only portfolio, and risk-adjusted performance given by an information ratio of 0.67.

The performance drag from cash serves as a useful benchmark; to be viable, tail risk strategies should do better. However, several candidate tail risk strategies fail to meet this standard. The long volatility strategies with allocations to VIX1m and VARSWP1m have performance drags of 355 and 203 basis points respectively, both worse than Cash. The strategy allocating to put options (PUT) also has a large performance drag of 268 basis points per year.

Poor performance for the strategies allocating to VARSWP1m and PUT is explained by the volatility risk premium. The cost of put options and variance swaps depends on implied volatility of equity index options, which usually trade at a premium to realized volatility.[6] The sizeable drag of the VIX1m strategy is due to the historical contango relationship in VIX futures; short term VIX futures usually trade at a premium to spot VIX. We estimate the average roll cost to maintain a one month to maturity VIX futures at 3.62% per month (more detail in the Appendix).

On the brighter side, the majority of strategies included in our study feature lower performance drag than cash, making them historically viable solutions for managing tail risk. All of the following strategies improved tail risk adjusted return as well. The VIX5m long volatility strategy (8.4% Vix5m/91.6% S&P 500) had a performance drag of 65 basis points per year. The VIX futures term structure flattens at longer maturities, reducing estimated roll cost for VIX5m. For similar reasons, the forward start variance swap strategy VARSWP3m6m had a performance drag of 68 basis points.

Both strategies allocating to low volatility equity (stock selection) fared well while reducing tail risk. The portfolio allocating a portion to low beta minus high beta (LBMHB) underperformed a pure S&P 500 investment by only 32 basis points. The portfolio allocating a portion to dedicated short bias (DSB) underperformed a pure S&P 500 investment by 55 basis points. The strategy allocating 16.5% to managed futures (MGDFUT) did well as it had an annual performance drag of only 21 basis points.

The best tail risk strategy on our performance drag measure was tactical equity (TACT) which actually outperformed the S&P 500 by 25 basis points per year while still reducing tail risk by 20%. We combined this timing

strategy with the S&P 500 as we did the other strategies (in this case the S&P 500 was 86.2% of the portfolio). As a reminder, our tactical equity strategy uses a simple trading rule and is long the S&P 500 index when above its 10 month moving average and short the index when below. Remarkably, of the 24 months with greater than 5% loss in the S&P 500 between March 1990 and March 2011, 17 of them (or 71%) occurred with the S&P 500 below its 10-month moving average.[7]

9. Certainty Measure

A second way to evaluate the effectiveness of a tail risk strategy is to look at the consistency with which it outperforms during a crisis. We introduce a measure we call certainty of tail risk protection, abbreviated Cj which we define as the conditional information ratio of tail risk strategy k's excess return to S&P 500 during a tail risk event (months where the S&P 500 falls more than 5%):

$$Ck = IR\left[Rk - R_{SP500} \mid R_{SP500} < -5\% \right] \text{ or} \qquad (2)$$
$$Ck = E\left[Rk - R_{SP500} \mid R_{SP500} < -5\% \right] / SD\left[Rk - R_{SP500} \mid R_{SP500} < -5\% \right]$$

Certainty of tail risk protection is summarized in Exhibit 9 where we also show the mean and standard deviation of excess return used to calculate the conditional IR. The final column in Exhibit 9 shows the frequency with which each strategy had a positive return in a tail risk event. The high frequency of positive performance, often approaching 100% of the time, validates the inclusion of these strategies in our study. Because tail risk events are by definition infrequent, we want some degree of confidence that a tail risk strategy will pay off when needed and in a predictable fashion.

We consider a certainty measure of 1.0 as a reasonable minimum threshold from a tail risk strategy. All strategies in our study have a certainty measure above 1.0 with the exception of VIX1m (0.87). Cash (TBILL) is the most consistent tail risk hedge with a 2.94 certainty measure, due to low variation in T-Bill returns. The VIX-based strategies have the largest variability in excess return and the long volatility strategies fare the worst as a group

Exhibit 9 Certainty of Tail Risk Strategy Protection

Strategy Type	Strategy	Certainty Measure	Average Excess Return	Std Dev Excess Return	% Positive Return
Cash	TBILL	2.94	8.34	2.84	100%
Volatility Based	VIX1m	0.87	24.67	28.39	83%
Volatility Based	VIX5m	1.50	19.19	12.75	100%
Volatility Based	VARSWP1m	1.34	9.69	7.25	54%
Volatility Based	VARSWP3m6m	1.50	14.97	9.95	100%
Low Vol Equity	LBMHB	2.25	18.88	8.38	88%
Low Vol Equity	DSB	2.42	15.11	6.24	96%
Trend Following	MGDFUT	2.19	9.83	4.49	67%
Exposure Mgmnt	PUT	1.96	9.67	4.94	79%
Exposure Mgmnt	TACT	1.32	11.75	8.92	71%

Source: Factset, Standard & Poor's, Bloomberg, Ibbotson Associates, Commodity Systems Inc., Barclays, Hedge Fund Research, Inc.
Note: see appendix for description of indices used and construction of tail risk strategy performance.

on our certainty measure. Strategies that provide highly consistent protection are the two low volatility equity (stock selection) strategies and managed futures, all of which feature certainty measures above 2.0.

The ideal tail risk strategy has low performance drag and high certainty of protection. Exhibit 10 displays each tail risk strategy along these two dimensions where strategies to the upper left are preferred.

It is clear from Exhibit 10 that three tail risk strategies are dominated by the others. These inferior strategies are put options, VIX one month futures, and one month variance swaps. Furthermore, VIX five month futures, and 3 month variance swaps are both dominated by Short bias, Low minus High Beta and Managed Futures. Several strategies remain that are not dominated and meet our two criteria of a certainty measure above 1.0 and a performance drag lower than Cash – namely Short bias, Low minus High Beta, Managed Futures and Tactical Equity. Depending upon our willingness to trade off return (performance drag) for risk (certainty of protection) the strategies contained in the shaded region appear to be historically viable choices for managing tail risk.

10. Conclusion

Modest allocations to a handful of tail risk protection strategies may significantly improve portfolio performance in times of tail risk events. Protecting against tail events can help improve long-term performance for even well diversified investors seeking to capture premia from risky assets. Protection during periods of market distress allows managers to reallocate to riskier assets in the aftermath of the event, just when expected returns are the highest.

A number of tail risk solutions showcased in this study feature low performance drag and offer high certainty of protection. In addition, skilled active management holds the potential to improve each tail risk strategy we identify in this study. For example, dedicated short bias and managed futures are represented by industry composites;

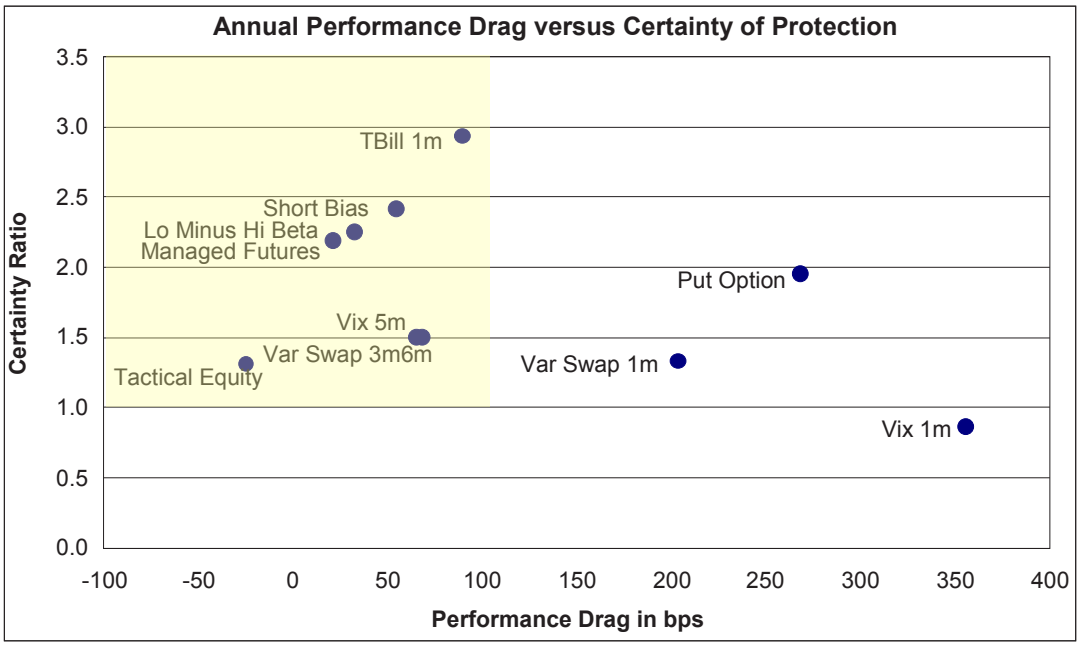

Exhibit 10 Tradeoff of Annual Performance Drag versus Certainty of Protection
Source: Factset, Standard & Poor's, Bloomberg, Ibbotson Associates, Commodity Systems Inc., Barclays, Hedge Fund Research, Inc.

high performing managers beat average peer performance. Low volatility or minimum variance portfolios are composed differently by each manager and variations can lead to better performance. Skilled volatility regime forecasts can lead to a more robust dynamic allocation of VIX futures contracts. Similarly, sophisticated tactical asset allocation models can potentially outperform the simple moving average crossover model used in the tactical equity strategy. Ultimately, the choice of tail risk strategy will depend on a prospective evaluation of strategy performance, in conjunction with an investor's asset allocation preference. The framework used in this analysis can serve as a starting point for investors interested in tail risk hedging.

Appendix

Sources of Indices Used and Construction of Tail Risk Strategy Performance

TBILL is the U.S. 30 Day Treasury Bill Total Return from Ibbotson Associates' Stocks, Bonds, Bills and Inflation.

VIX1m and VIX5m represent an investment in a synthetic one-month and five-month constant maturity VIX futures as calculated by Chicago Board of Options Exchange (CBOE) indices SPVXSTR and SPVXMTR available from Bloomberg January 2006 to March 2011.

Prior to 2006, VIX futures index data are unavailable. We backfill VIX futures index using CBOE VIX index returns (also sourced from Bloomberg) which are available throughout our sample period with the following methodology. For January 2006 to March 2011, we estimate the relationship between monthly VIX futures index return and the spot VIX index return in a regression.

As expected the return to the VIX futures contracts are very significantly positively related to VIX return with the VIX 1m Future having a lot higher sensitivity, +0.70, than the VIX 5m Future, +0.31. The regression for the VIX 1m Future has a large negative constant, -3.62 percent per month, that reflects the negative roll yield associated with owning VIX short term futures contracts in this time period. The VIX futures term structure has typically been upward sloping, or in contango, at short maturities. In contrast, the VIX 5m Future has very little monthly roll cost as estimated by the above regression, -0.16%per month, as the VIX futures term structure has been relatively flat at five months.

We backfill VIX1m and VIX5m by simulation using (1) coefficients from the above regression, (2) the actual levels of VIX available from 1990-2005, and (3) a simulated error term that reflects the unexplained error from above regression and the observed error correlation across VIX1m and VIX5m futures. A slightly more sophisticated

Exhibit A1 Regression of Monthly VIX Futures Index versus VIX return

Dep. Variable	Intercept	Beta VIX	R-SQ
	(t-stat)	(t-stat)	
VIX1m Future	-3.62	0.70	0.55
	(-1.99)	(8.56)	
VIX5m Future	-0.16	0.31	0.47
	(-0.17)	(7.32)	

regression model incorporating a two term intercept reflecting a different term structure slope depending on whether VIX was above or below average was also estimated. Performance results from this second model are nearly identical to those achieved with the model presented which is chosen for its ease of exposition.

VARSWP1m uses the S&P 500 Volatility Arbitrage Index SPARBV available from Bloomberg. Since SPARBV represents a one-month swap that pays realized variance and receives implied variance, we use the negative of this index to represent a swap paying realized variance and receiving implied variance. To make it a total return index we also add on the interest component, or the difference between SPARBVT and SPARBV, the total and excess return versions of this index.

VARSWP3m6m uses the Deutsche Bank Equity Long Volatility Investment Strategy Index DBVELVIS available from Bloomberg.

LBMHB uses the most liquid 2,300 stocks, or roughly 75%, of the Russell 3000 universe where liquidity is estimated using trailing six month median daily dollar trading volume. For each stock we estimate a historical beta to the Russell 1000 index using two years of trailing daily returns. Performance is calculated as a quintile spread buying the 20% of stocks with lowest beta and selling the 20% of stocks with the highest beta each month. The strategy represents an equal weight portfolio long 460 low beta and short 460 high beta liquid U.S. stocks rebalanced monthly.

A long short portfolio replicating the LBMHB strategy would also have its performance supplemented by its cash holdings. Detracting from performance would be trading costs from turnover and additional interest costs for harder to borrow securities. Using estimates of all of these costs from trading similar strategies along with historical interest rates, we expect performance for the LBMHB strategy that includes cash and net of transaction costs to be higher than those presented.

DSB uses the HFRI Short Bias Index HFRISHSE as calculated by Hedge Fund Research, Inc. and available from Bloomberg.
MGDFUT uses the Barclay CTA Index BARCCTA available from Bloomberg.
PUT uses S&P 500 index option data available from Commodity Systems Inc.
TACT uses monthly levels of the Standard & Poor's 500 Index available from Facstet and we calculate its ten-month moving average. At each month end, if the S&P 500 lies above its ten-month moving average, the next month's strategy performance equals a long S&P 500 investment. When the S&P 500 lies below its ten-month moving average, the subsequent month's strategy performance equals a short S&P 500 investment.

The model portfolio performance shown was created by Alternatives Team. The model portfolio performance does not reflect actual trading and does not reflect the impact that material economic and market factors may have had on SSgA decision-making. The results shown were achieved by means of a mathematical formula. The model performance shown is not indicative of actual future performance, which could differ substantially.

[1]According to Barclay Hedge, managed futures strategies experienced $114 (B) in asset growth, representing a 55% increase, since the end of 2008. During that period, the Barclays CTA Index had a 3.54% return, signaling most of this growth is due asset inflows, not appreciation.
[2]We could just as easily construct the tactical equity strategy to be asymmetric so that it shorts the S&P 500 index when below its moving average and otherwise invests in cash.
[3]The required risk premium for any asset reflects its covariation with bad times. (Ilmanen 2011 p. 69)
[4]In our study period March 1990 – March 2011, a decline in the S&P 500 exceeding 5% occurs in 24 months or 9.5% of the time.
[5]A 20% reduction in tail risk is chosen to guide the analysis. Required allocations scale linearly to the chosen level of tail risk reduction (see Exhibit 7) because we use mean returns in our calculations. For example, a 40% reduction in tail risk requires twice the allocations given in Exhibit 8.
[6]Between March 1990 and March 2011, we estimate that realized forward one-month S&P 500 volatility exceeds implied volatility, given by VIX, in only 15.0% of the months. S&P 500 realized volatility is measured using daily returns.
[7]The ten-month or 200-day moving average is a popular technical indicator among market participants; its effectiveness in asset class timing is documented by Faber (2005).

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