



**Quest  
Partners** LLC

## **AlphaQuest CTA Research Series #2**

*The goal of this research series is to demystify specific black box CTA trend following strategies and to analyze their characteristics both as a stand-alone product as well as within a portfolio of typical financial instruments.*

---

# **Know Your Skew**

**Using Hedge Fund Return Volatility as a Predictor of Maximum Loss**

---

Nigol Koulajian and Paul Czekwianianc  
Quest Partners LLC  
[info@questpartnersllc.com](mailto:info@questpartnersllc.com)

***June 2011***

*The authors of this paper are principals of Quest Partners LLC. This paper does not constitute advice or recommendation to enter into any transaction. This work is intended for educational and informational purposes only.*

## Synopsis

The goal of this paper is to assist hedge fund investors evaluate the risk of disproportionate losses relative to volatility.

With the advent of modern portfolio theory, volatility of monthly returns has become accepted as the quintessential measure of risk. In order to increase returns while staying within the typical volatility constraints of portfolios, investment managers and investors are taking more tail (or event) risk. The returns that are earned from taking tail risk do not correlate to the stock market during stable periods and are therefore often confused with skill-based returns. Skill based returns are the *sine qua non* or essential ingredient for the hedge fund industry and the rationale for its high fees.

Tail risk, on the other hand, although difficult to differentiate from skill-based risk, is extremely harmful to portfolios during crisis periods and does not warrant high fees. Due to the lack of transparency of the hedge fund industry, this difference cannot be assessed through trading position analysis. This leaves investors the difficult but critical task of differentiating between skill and tail risk through numerical analysis of historical monthly returns.

We explain the benefits of using skew in assessing tail risk and compare it to more standard tools such as volatility and Sharpe ratio.

Specifically, we:

- 1) Analyze the relationship between skew and maximum drawdown.
- 2) Analyze the relationship between Sharpe ratio and maximum drawdown.
- 3) Explore the relationship between skew and the behavior of returns, volatility and correlation during market crises.
- 4) Discuss some of the trading strategies that generate positive skew.
- 5) Discuss the relationship of skew with investor psychology, hedge fund size, fees and recent Federal Reserve action.

Some of our findings are:

- 1) Negatively skewed strategies are only attractive during stable market regimes. During market shocks (*i.e.*, the three largest SP500 drawdowns in the past 17 years), low skew strategies display:
  - outsized losses of -41% (vs. gains of +39% for high skew strategies);
  - increases in correlation to the SP500; and
  - increases in correlation to each other.
- 2) During their three worst drawdowns, low skew strategies lose 4.2 times their ex-ante (preceding) volatility while high skew strategies lose 2.3 times their ex-ante volatility.
- 3) For low skew strategies, historical volatility is inadequate for estimating the risk of future loss.
- 4) During their three worst drawdowns, the strategies with high Sharpe ratios lose 4.3 times their ex-ante volatility, while the strategies with low Sharpe ratios lose only 2.2 times their preceding volatility.
- 5) Short-term and intermediate-term trend following strategies employed by CTAs exhibit inherently positive skew.
- 6) The accommodating and contagion-fearing Federal Reserve behavior of the last 20 years has emboldened investors and hedge fund managers to take more tail risk.

## I. Data and Methods

Our analysis was applied to 20 data series: 13 Dow Jones Credit Suisse Hedge Fund Indices (DJCSHFI), four stock market indices, one fixed income index and two systematic trend following strategies<sup>1</sup>:

- 1) DJCSHFI
- 2) DJCSHFI Convertible Arbitrage
- 3) DJCSHFI Dedicated Short Bias
- 4) DJCSHFI Emerging Markets
- 5) DJCSHFI Event Driven
- 6) DJCSHFI Event Driven - Distressed
- 7) DJCSHFI Event Driven - Multi Strategy
- 8) DJCSHFI Event Driven - Risk Arbitrage
- 9) DJCSHFI Fixed Income Arbitrage
- 10) DJCSHFI Global Macro
- 11) DJCSHFI Long/Short Equity
- 12) DJCSHFI Managed Futures
- 13) DJCSHFI Multi Strategy
- 14) S&P 500 Index (SP500)
- 15) MSCI - World Index
- 16) MSCI - Emerging Markets Index
- 17) MSCI - EAFE Index
- 18) WGBI - Citigroup World Government Bond Index USD Hedged
- 19) MA10x100 - 10x100 Simple Moving Average Crossover Strategy
- 20) CB50 - 50 Day Channel Breakout Strategy

The MA10x100 and CB50 strategies represent two trend following strategies that were introduced in our earlier paper: [Black Box Trend Following - Lifting the Veil \(September 2010\)](#).

The study covers the 17-year period starting on the inception of the DJCSHFI in January 1994 and ending in December 2010<sup>2</sup>. Monthly net returns are used for all calculations.

---

<sup>1</sup> In the study, the Dow Jones Credit Suisse Hedge Fund Index - Equity Market Neutral is purposely omitted. This is because of this index's large exposure to the fraud of Bernard Madoff; for reference see the Reuters article from February 18, 2009: [Madoff distortion makes some hedge funds look good](#).

<sup>2</sup> The only exception is the DJCSHFI Multi-Strategy, which begins in April 1994.

Skew is a measure of asymmetry of return distribution. The formula for skew is:

$$\text{Skew} = \frac{\sqrt{n(n-1)}}{n-2} * \frac{\frac{1}{n} \sum_{i=1}^n (x_i - x_{\text{avg}})^3}{(\frac{1}{n} \sum_{i=1}^n (x_i - x_{\text{avg}})^2)^{3/2}}$$

$x_i$  - monthly returns  
 $x_{\text{avg}}$  - average of monthly returns  
 $n$  - number of observations

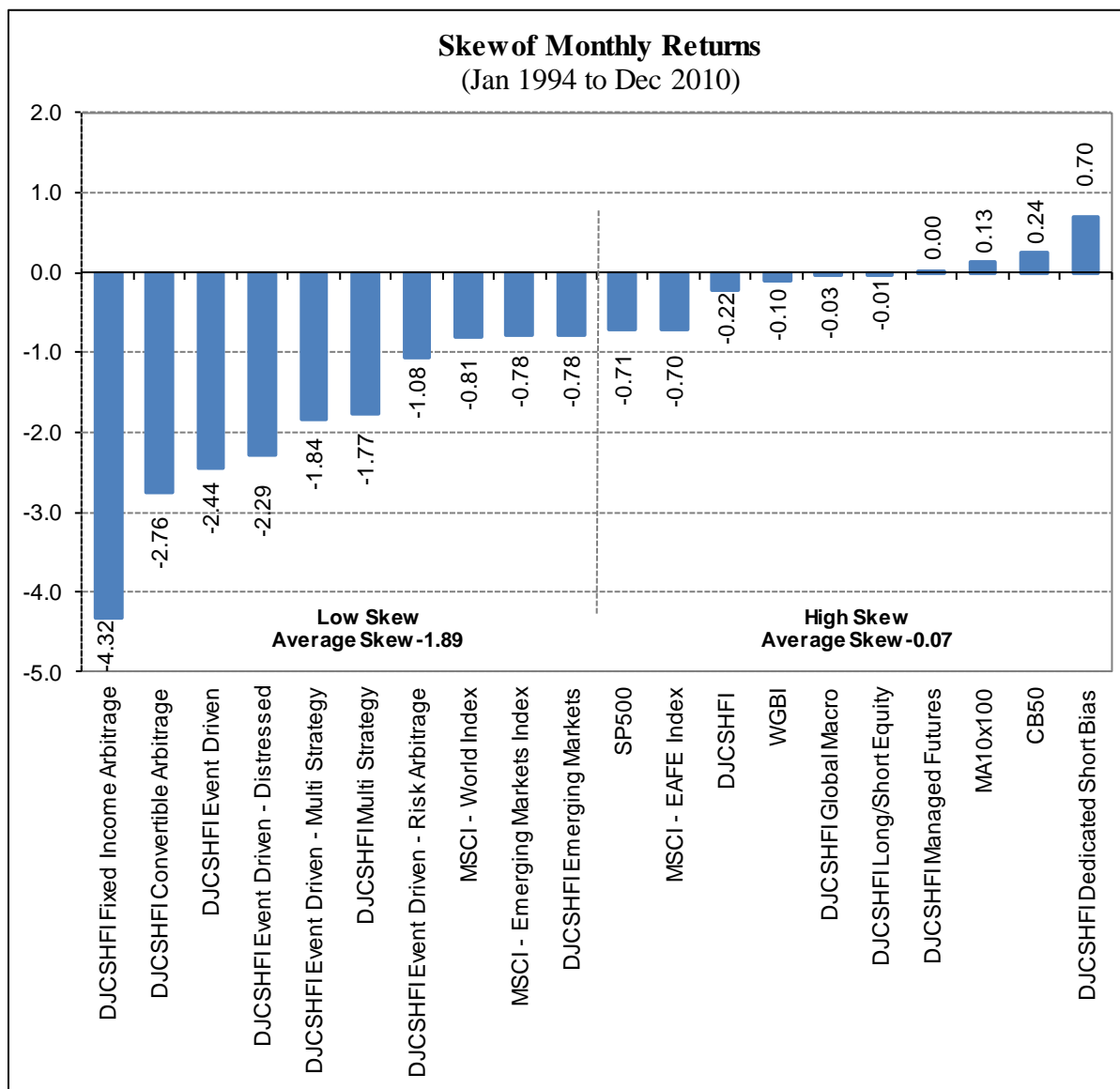
One can think of skew in relation to volatility in the same way one thinks of acceleration in relation to speed. It is not enough to know your speed when driving but also whether you are capable of decelerating when approaching an obstacle and accelerating when you need to.

Positive skew is the ability to have lower volatility than average when losing money and higher volatility when making money. Negative skew is the opposite; it is the characteristic of having higher volatility than average when losing money and lower volatility when making money.

A set of returns made up of frequent small, lower than average, returns and occasional large gains would be positively skewed. Conversely, a set of returns with frequent small, above average, returns and occasional large losses would be negatively skewed.

One additional characteristic of skew that must be mentioned is its invariance with respect to volatility, (*i.e.*, the value of skew for a set of returns stays unchanged if all the returns are multiplied by a constant.)

## II. Skew: Basic Statistics



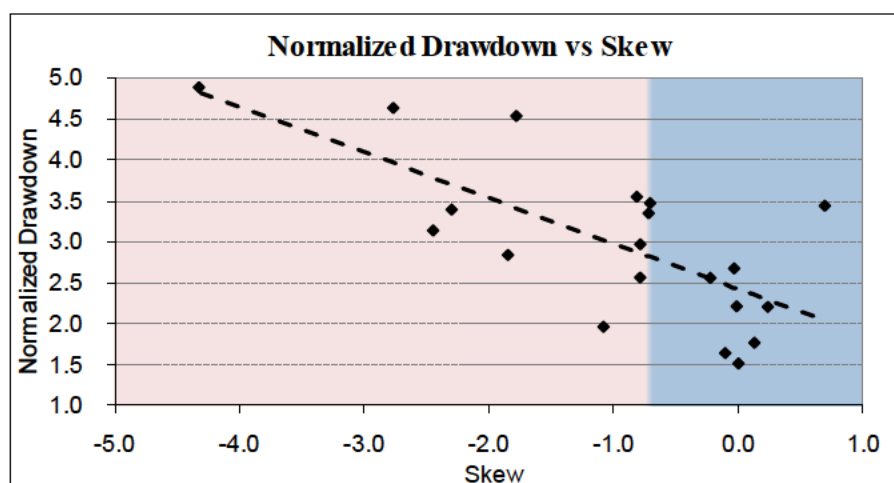
- 16 out of the 20 data series have negative values of skew.
- The median value of skew is -0.75.
- The index with the highest skew is the DJCSHFI Dedicated Short Bias, skew of 0.70.
- The index with the lowest skew is the DJCSHFI Fixed Income Arbitrage, skew of -4.32.
- Refer to Appendix I and II for a complete set of statistics.

### III. Estimating Maximum Loss

An important risk-related assumption in the hedge fund industry is that risk of maximum loss is proportional to volatility. This is a necessary assumption given that most funds do not have a track record that is long enough to have experienced a statistically significant number of drawdowns. Volatility on the other hand, can be estimated even by using a short track record.

The impracticality of using drawdown as a measure of risk has given volatility the role of the quintessential measure of risk. How accurate is the assumption that maximum loss is proportional to volatility?

In order to test this assumption, we look at the ratio of maximum loss to volatility and define this ratio as the normalized drawdown. In this analysis, we then compare the normalized drawdown to skew for each of our 20 data series.

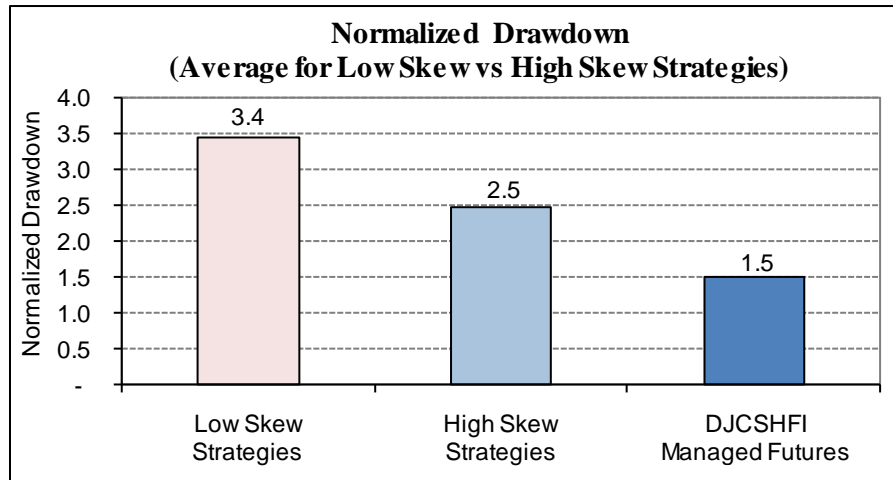


The relationship is very significant with a correlation of -71%. The more negative the skew, the larger the historical drawdown relative to volatility. **The regression line implies that for every point decrease in skew, one can expect an additional 0.56 times the volatility in drawdown.** The three data points with the highest ratio of drawdown to volatility are:

- 1) the DJCSHFI Fixed Income Arbitrage with drawdown of 4.9 times its volatility;
- 2) the DJCSHFI Convertible Arbitrage with drawdown of 4.6 times its volatility; and
- 3) the DJCSHFI Multi Strategy with drawdown of 4.5 times its volatility.

The DJCSHFI Fixed Income Arbitrage and the DJCSHFI Convertible Arbitrage have the two lowest values of skew in the entire data set.

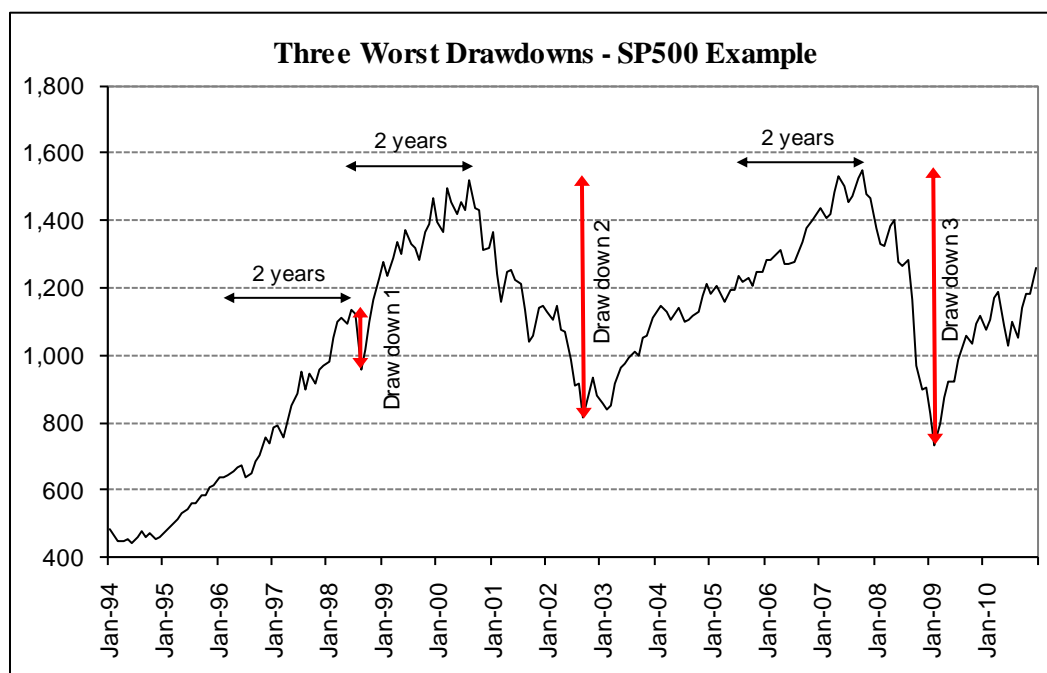
The low skew strategies (less than median skew, highlighted in pink) experienced drawdowns on average equal to 3.4 times their volatility while the high skew strategies (larger than median skew, highlighted in light blue) experienced drawdowns equal to 2.5 times their volatility. Among the 20 data series, the index with lowest ratio of drawdown to volatility was the DJCSHFI Managed Futures with value of 1.5.



#### IV. Ex-Ante Study: Estimating Maximum Loss using Skew

The same analysis ex-ante confirms the conclusions drawn in Section III about the relationship of drawdowns and skew. For each strategy, we analyze its worst three drawdowns. We compare each drawdown to the two-year skew and volatility at NAV high immediately preceding it. This approach is applied to each of the 20 data series individually.

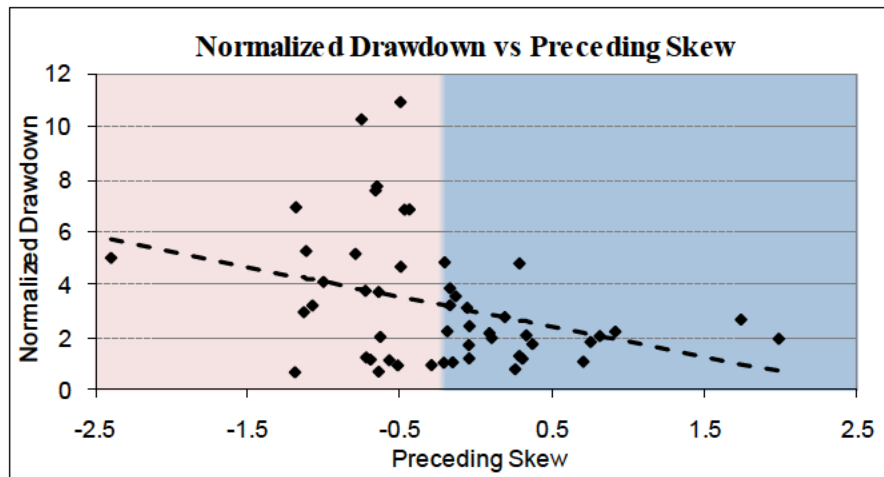
As an illustration, this process is shown below for the case of the SP500:



The three drawdowns are indicated in red. Each two-year time interval preceding its respective drawdown is indicated with a horizontal line. Data points where the first drawdown starts prior to January 1995 are omitted from the analysis.

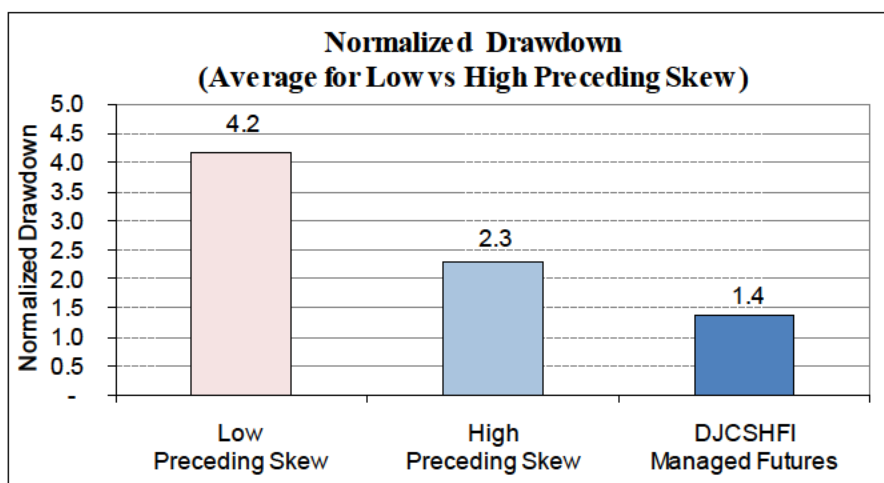


Each drawdown is normalized by dividing the drawdown by its preceding volatility and then plotted against the preceding skew:



In this ex-ante study, **the strategies with low values of skew experience drawdowns on average equal to 4.2 times their preceding volatility while the strategies with high values of skew have drawdowns equal to only 2.3 times their preceding volatility.** Strategies with low values of skew have normalized drawdowns almost twice as large as those with high values of skew.

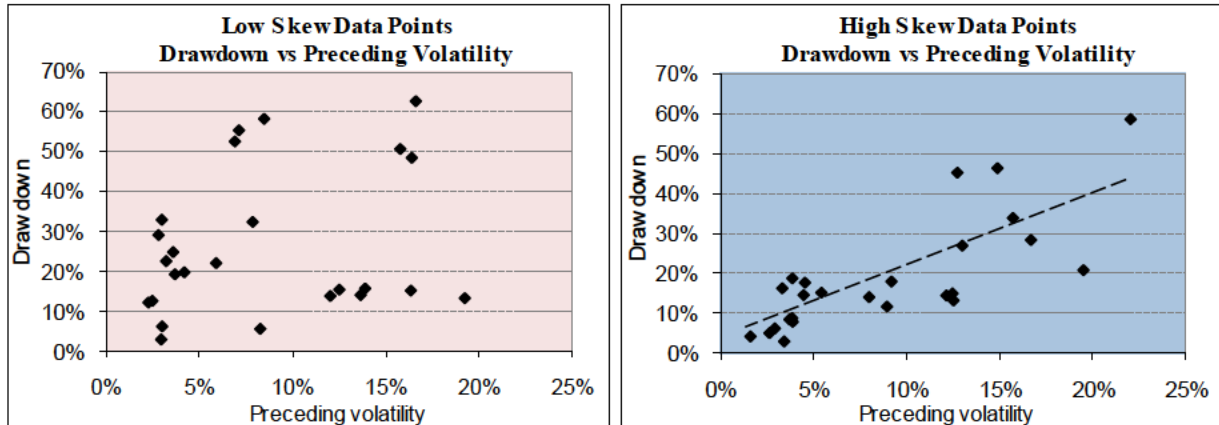
The two points furthest on the top are the DJCSHFI Convertible Arbitrage with a drawdown that begins in October 2007 and equals 11.0 times its preceding two-year volatility and the DJCSHFI Fixed Income Arbitrage with a drawdown that starts in January 2008 and equals 10.3 times its preceding two-year volatility. We note that the size of drawdown relative to preceding volatility is again lowest for the Managed Futures index and equal to 1.4.



Even if the two data points with the largest normalized drawdowns, both belonging to the low skew group, were removed from the data set, the strategies in the low skew group would still experience drawdowns on

average equal to 3.6 times their preceding volatility. These results are robust and are not crucially dependent on individual large outlier values.

As a further perspective on this study, we now separately plot drawdowns versus preceding volatility for the low and high values of preceding skew:

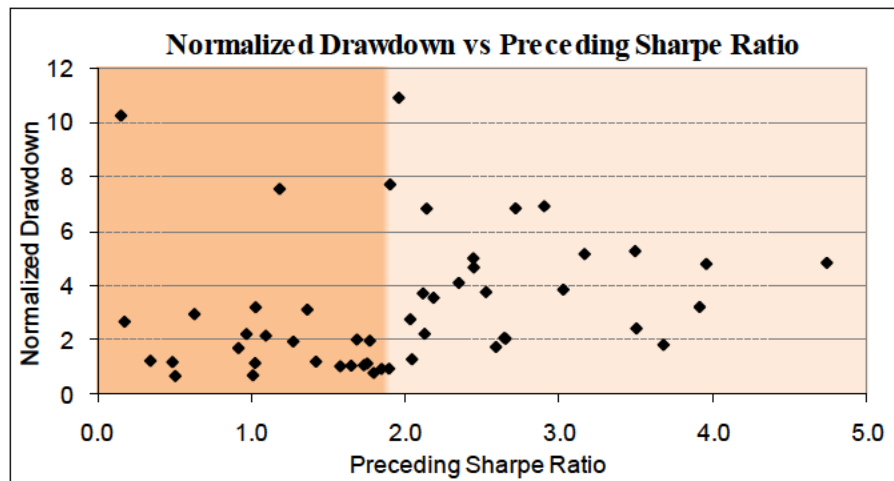


For the low values of skew, the correlation of drawdown to volatility is 24% and for the high values of skew, the correlation is 77%. **Effectively, this implies that volatility can be used to confidently predict drawdown for high skew strategies, but not for the low skew strategies. This is ironic as investors commonly invest in low skew strategies due to their low volatility and avoid high skew strategies due to their higher volatility.** For investors, this often results in large negative surprises due to the mistaken confidence in low risk that is implied by the low volatility strategies.

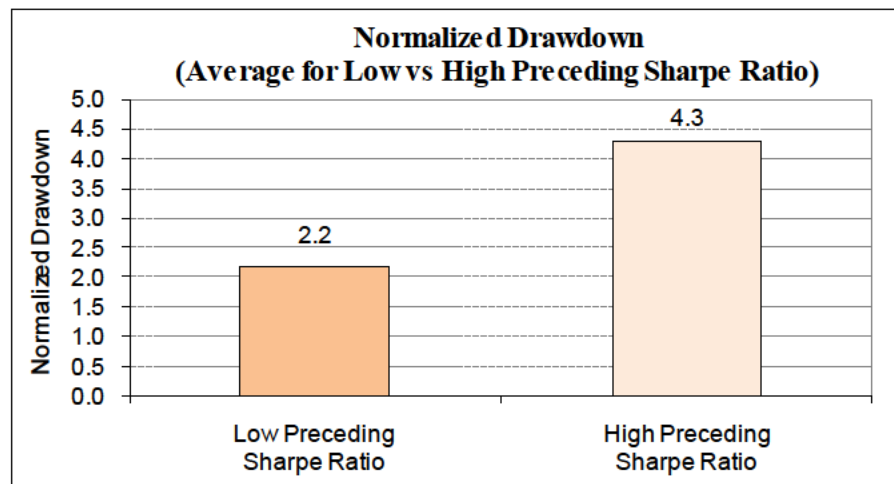


## V. Ex-Ante Study: Sharpe Ratio as a Predictor of Normalized Drawdowns

In this ex-ante study, for each data series, we compare the three largest drawdowns to the two-year Sharpe ratios and volatilities at preceding NAV peaks.



On average, data points with high Sharpe ratios (above median, light orange) experience drawdowns equal to 4.3 times their preceding volatility, while the data points with low Sharpe ratios (below median, dark orange) experience drawdowns equal to only 2.2 times their preceding volatility. High Sharpe ratio comes at the cost of increased chance of a disproportionately large drawdown. Again, this is highly ironic as one would assume exactly the opposite based on the common perspective. Notice that skew is not used in this study.

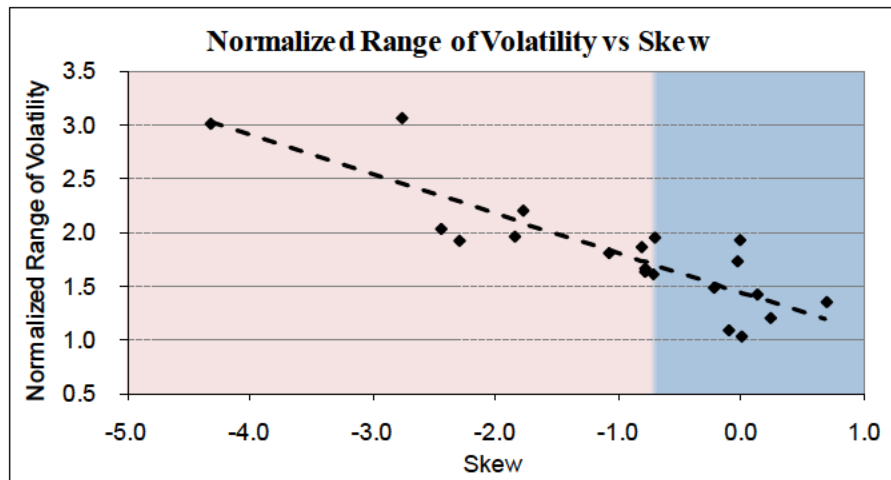


As a closing remark on this study, **if one selects only the high Sharpe ratio and low skew quartile of data points, the average drawdown is 5.9 times preceding volatility.**

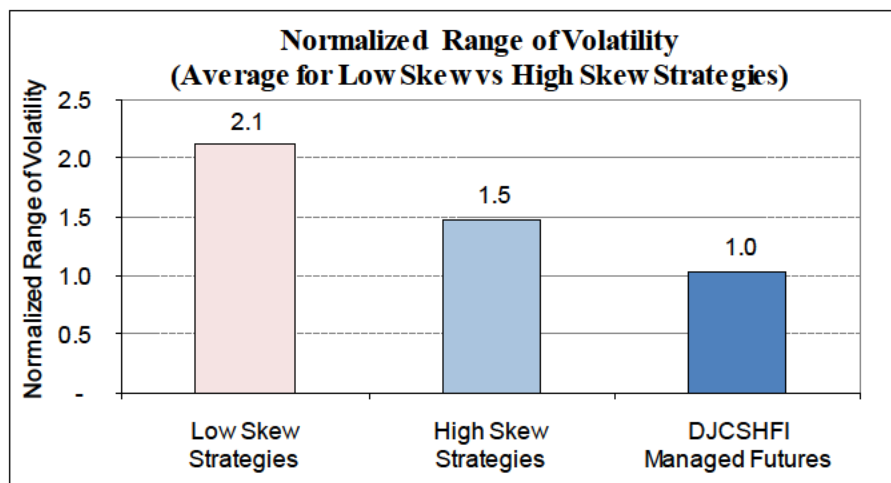


## VI. Stability of Volatility and Skew

The stability of an investment's risk profile is a highly attractive characteristic. In this section, we analyze the relationship of volatility to skew in order to explore using skew as a measure of risk stability. We graph the ratio of maximum 12-month volatility minus minimum 12-months volatility over average volatility in relation to skew.



The relationship is very strong with a correlation of -86%. For high skew strategies, the average normalized range of volatility is equal to 1.5 and for low skew strategies, it is 2.1. **Volatility is less stable for low skew strategies and large volatility increases are therefore more likely.** The value for the DJCSHFI Managed Futures is the lowest and equal to 1.0.

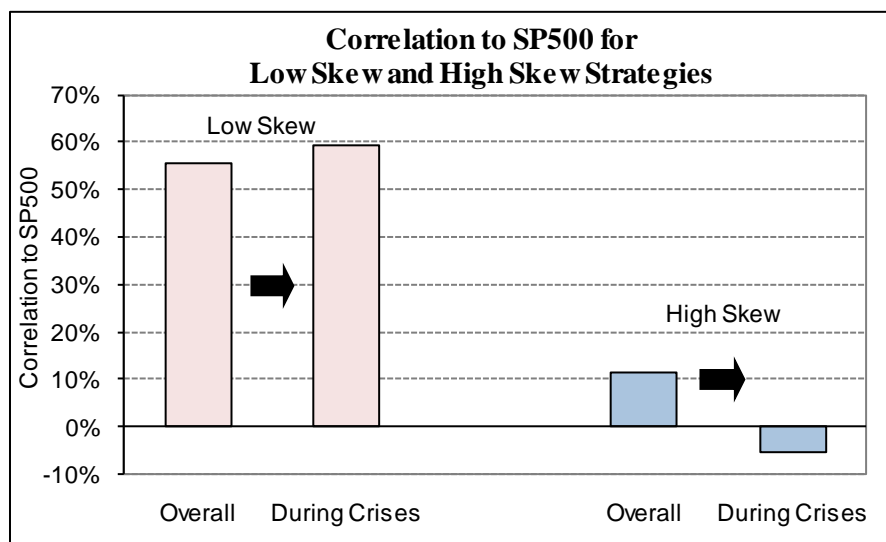


## VII. Building a Diversified Portfolio – Correlation to the SP500 and Skew

In this section, we compare strategy correlation to the SP500 and skew. We also study this relationship during the three largest stock market corrections.

The strategies with low values of skew have an average correlation to the SP500 of 56% while the strategies with high values of skew have average correlation to the SP500 of 12%.

During the three worst drawdowns for the SP500, the average correlation of low skew strategies to the SP500 increases to 59%, while the average correlation of the high skew strategies to the SP500 decreases to -5%.



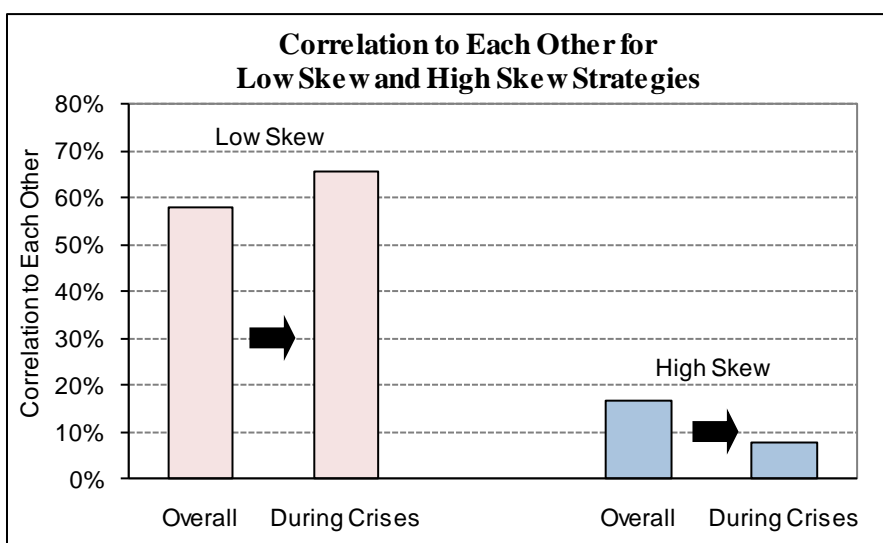
From a portfolio construction perspective, **high skew strategies seem to be more attractive as they have considerably less correlation to the stock market than low skew strategies. In addition, during market crises, the correlation of low skew strategies to the SP500 increases while the correlation of high skew strategies to the SP500 actually decreases.** Based on correlation, high skew strategies are of more value to a portfolio than low skew strategies because they maintain or increase diversification, particularly during equity crises. We note that **during these periods the correlation of DJCSHFI Managed Futures to SP500 was -54%.**

## VIII. Building a Diversified Portfolio – Cross-Correlation amongst Strategies

In this section, we compare strategy cross-correlation and skew. We also study this relationship during the three worst stock market drawdowns.

The strategies with low values of skew have an average cross-correlation of 58% while the strategies with high values of skew have an average cross-correlation of 17%.

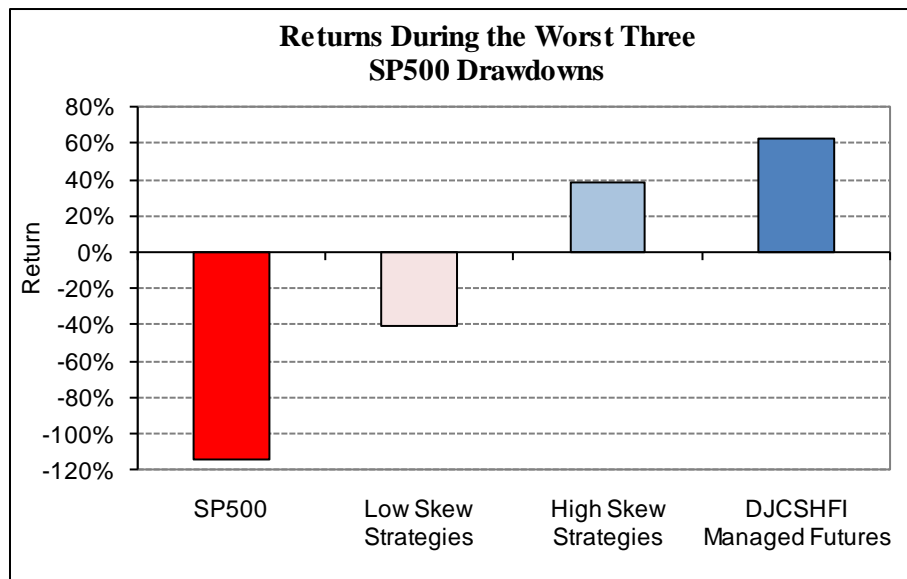
During the three worst stock market drawdowns, the average cross-correlation of low skew strategies increases to 66% while the average cross-correlation of the high skew strategies decreases to 8%.



**From a portfolio construction perspective, high skew strategies are more attractive as they have considerably less cross-correlation than low skew strategies. In addition, during market crises, the cross-correlation of low skew strategies increases while the cross-correlation of high skew strategies decreases.**

## IX. Building a Diversified Portfolio – Protection during Stock Market Downturns and Skew

In this section, we relate returns during the three worst SP500 drawdowns to skew.



**During the three largest SP500 drawdowns, the low skew strategies lost -41%, while the high skew strategies (SP500 excluded) made +39%. We also note that the DJCSHFI Managed Futures generated an over +63% return in this period.**

## X. Trading Styles and Skew

16 out of the 20 strategies analyzed actually have negative skew. The four strategies with positive skew are: DJCSHFI - Dedicated Short Bias index, CB50, MA10x100 and DJCSHFI - Managed Futures.

**As an important reminder, please note that increasing the leverage of a strategy increases its convexity and therefore further magnifies the effects of negative skew.**

### Short Sellers

Nominal and real interest rates are extremely low by historical standards. This has helped create more market bubbles and markets have become more negatively skewed as a result. The markets' negative skew naturally results in positive skew to the short sellers. **The positive skew of short sellers unfortunately comes at a heavy cost of -5.7% annual Alpha to the SP500.**

### Managed Futures

Out of the strategies analyzed, **DJCSHFI Managed Futures, MA10x100 and CB50 are the only positively skewed strategies that have achieved positive returns and positive Alpha to the SP500.** Traditionally, trend following managed futures strategies attempt to capture large market trends by establishing positions early on in a move. This may result in multiple small losses, but eventually a large gain is achieved once a trend is established. The positive skew is a by-product of this trading style of infrequent but large gains.

**As was shown in our “Lifting the Veil” paper on trend following, the main sources of positive skew within the managed futures industry are shorter term holding periods and trading on the short side of the market. Both long term trading and long trades actually have near zero skew. Ironically, both short term trading and short trades are difficult to execute for the transaction cost vulnerable and large managed futures managers. So even within the positively skewed managed futures industry, investors have been attracted to low skew managers.**

Since 2005 in particular, this investor preference has accelerated the style drift away from short term trading and short trades. **We estimate that these two optimizations cost the Managed Futures index about 60% in absolute return during the 2007-2009 market correction (page 15 of “Lifting the Veil”).**



## XI. What Drives Assets Towards Negative Skew Strategies?

With such obvious downsides to the negatively skewed strategies, why do both investors and managers pursue negatively skewed approaches?

### Behavioral Biases

Low skew strategies' steady return streams build extreme confidence during stable market environments. **Their lower month-to-month volatility gives the illusion of control and skill-based returns.** As such, investors prefer to make money for nine years and then lose most of it in year ten rather than invest in a strategy that loses money some years and ends up with the same outcome over the ten years. It is not the final result that drives allocations, but rather the perceived continuous comfort of positive results along the way. The perception that market risk has been conquered by an army of "Quants" or deep value investing is just too difficult to resist. In this regard, much "Black Swan" literature has been published recently.

From a crowd behavior perspective, in the absence of a clear fundamentally driven value picture, the crowds' self-reinforcing positive feedback loop dictates most price volatility. Trends slowly overshoot fair value and then retrace to fair value in dramatic corrections. **For investors, it is easier to digest losses at the same time as "the crowd" rather than in a separate period.**

### Fund Size

In the excellent paper relating hedge fund size to risk,<sup>3</sup> the authors note that **larger funds are less able to adapt to market and volatility shifts and are therefore more negatively skewed than smaller funds.** From an asset perspective, this creates a positive feedback loop. **As assets grow, managers are more likely to have to take tail risk to achieve returns due to their decreased ability to be agile in the markets. This comes with lower volatility during normal market regimes, which appears to be as a result of more skill. This is obviously an incorrect perception that was confirmed during the 2007 to 2009 crisis as many of the largest most sophisticated funds had substantial losses and had to suspend redemptions.**

### Fee Structures

**Most compensation structures within the financial industry award participation in gains, but not in losses.** Without an ethical overlay, this leads many investment managers to expose their investors to large amounts of negatively skewed risk. The consecutive periods of gains during which they are amply rewarded cloud their vision to see the potential of large losses to their investors. After these dramatic but rare events, it is relatively easy to raise new funds from new investors or change positions within the industry.

### Market Structure / "Bernanke Put"

The current central banking regime has been very keen on providing liquidity to the market especially in the form of bailouts during unstable financial market regimes. A clear example of this was the 2008 bailout and related anti-deflationary programs such as QE, QE2 and TARP. These liquidity actions encourage irresponsible risk taking as the potential gains now come without the typical accompanying potential losses. The general population's fear of financial contagion leads it to support these actions without clear awareness of the moral hazards that they create.

---

<sup>3</sup> The Relation Between Hedge Fund Size and Risk, Haim A. Mozes, Ph.D, Jason Orchard, CFA, (November 2010).

**These bailouts are effectively free but very valuable puts offered to investors well chosen for their inclination to invest in financial assets. This incentivizes leveraged risk taking in negatively skewed assets where this put is most valuable.**

## **XII. Conclusion**

**Investors must be aware that the intuitive appeal of smooth and consistent past returns may be misleading.**

**The current risk management framework is mainly based on volatility. It has pushed for lower volatility, increased the tail risk and has made the financial world a dangerous place. Under this framework, leverage of 60+ to 1 was possible and considered acceptable (Lehman, Bear Stearns, LTCM...).**

**The blind spot of this risk framework has also been exploited by the hedge fund industry that has reduced its volatility but increased its tail risk. For investors, this has resulted in an overestimation of skill based returns during stable market environments and an underestimation of potential losses during market crises.**

**With skew, we have offered a tool that substantially helps improve estimates of loss and return during market crises versus the volatility based framework. Manager skill is better understood as a result.**

*“When you argue with reality, you lose - but only 100% of the time.”*  
-Byron Katie



## Return and Risk Statistics

	CB50	M A 10x100	WGBI	M SCI - EAFE Index	M SCI - Emerging Markets Index	M SCI - World Index	SP 500	DJCSHFI Multi Strategy	DJCSHFI Managed Futures	DJCSHFI Long/Short Equity	DJCSHFI Global Macro	DJCSHFI Fixed Income Arbitrage	DJCSHFI Event Driven - Risk Arbitrage	DJCSHFI Event Driven - Multi Strategy	DJCSHFI Event Driven - Distressed	DJCSHFI Event Driven	DJCSHFI Emerging Markets	DJCSHFI Dedicated Short Bias	DJCSHFI Convertible Arbitrage	DJCSHFI
1. Annual Compounded Return	9.4%	14.1%	6.1%	3.2%	4.6%	4.6%	6.0%	8.2%	6.6%	10.2%	12.5%	5.3%	7.1%	10.0%	11.1%	10.4%	8.2%	-3.8%	7.3%	9.4%
2. Annual Volatility	7.7%	16.1%	3.1%	16.8%	24.5%	15.6%	15.7%	5.4%	11.8%	10.0%	10.0%	5.3%	4.2%	6.5%	6.6%	6.1%	15.2%	17.1%	7.1%	7.7%
3. Worst Peak-to-Trough Drawdown	19.7%	28.2%	5.1%	58.2%	62.7%	55.4%	52.6%	24.7%	17.7%	22.0%	26.8%	29.0%	8.2%	18.5%	22.5%	19.1%	45.1%	58.6%	32.9%	19.7%
4. Worst Peak-to-Trough Drawdown / Annual Volatility	2.55	1.76	1.63	3.47	2.56	3.55	3.35	4.54	1.50	2.20	2.67	4.63	1.95	2.84	3.33	3.14	2.97	3.44	4.64	2.55
5. Annual Compounded Return / Worst P-to-T Drawdown	0.48	0.50	1.19	0.05	0.07	0.08	0.11	0.33	0.37	0.47	0.47	0.18	0.87	0.54	0.50	0.54	0.18	-0.06	0.24	0.48
6. Annual Compounded Return / Annual Volatility	1.22	0.86	1.35	0.19	0.19	0.29	0.38	1.51	0.56	1.03	1.24	0.83	1.63	1.54	1.68	1.70	0.54	-0.22	1.11	1.22
7. Sharpe Ratio (Avg RFR=3.85%)	0.72	0.64	0.71	-0.04	0.03	0.05	0.14	0.80	0.24	0.64	0.86	0.24	0.78	0.95	1.10	1.07	0.29	-0.45	0.57	0.72
8. Skew	-0.22	0.13	-0.10	-0.70	-0.76	-0.81	-0.71	-1.77	0.00	-0.01	-0.03	-4.32	-1.08	-1.64	-2.23	-2.44	-0.76	0.70	-2.76	-0.22
9. Volatility Range: Max 1 Year Volatility - Min 1 Year Volatility	11.4%	22.8%	3.4%	32.7%	40.0%	29.1%	25.3%	12.0%	12.1%	19.2%	17.4%	17.9%	7.6%	12.8%	12.7%	12.4%	25.3%	23.0%	21.7%	11.4%
10. Volatility Range / Annual Volatility	1.49	1.42	1.03	1.95	1.63	1.86	1.61	2.20	1.03	1.93	1.73	3.02	1.81	1.96	1.92	2.03	1.66	1.35	3.07	1.49
11. Average Correlation Others*	46.8%	4.9%	-1.8%	38.0%	38.7%	38.5%	34.8%	30.4%	9.2%	42.1%	32.1%	30.4%	32.5%	43.7%	40.6%	45.0%	37.3%	-36.9%	34.1%	46.8%
12. Alpha to SP500	4.8%	10.3%	2.2%	-2.5%	-1.7%	-1.3%	0.0%	4.0%	2.8%	5.3%	8.0%	1.1%	2.3%	5.5%	6.5%	5.8%	3.1%	-5.7%	3.5%	4.8%
13. Beta to SP500	0.27	-0.18	-0.02	0.87	1.14	0.94	1.00	0.12	-0.07	0.41	0.16	0.13	0.13	0.24	0.26	0.24	0.51	-0.81	0.16	0.27
14. Correlation to SP500	56.0%	-17.7%	-8.8%	82.3%	73.4%	95.1%	100%	35.8%	-3.7%	64.3%	24.8%	34.0%	49.3%	56.3%	61.1%	62.6%	53.2%	-74.3%	36.2%	56.0%
15. Correlation to SP500 During Worst Three SP500 Drawdowns**	59.6%	-59.4%	-36.2%	87.6%	83.1%	97.1%	100%	33.5%	-54.4%	64.3%	23.3%	45.0%	52.8%	57.4%	59.1%	59.3%	67.9%	-73.9%	37.1%	59.6%
16. Return During Worst Three SP500 Drawdowns**	-21.3%	15%	30.3%	-115%	-127%	-116%	-114%	-11.4%	63.1%	-42.3%	40.2%	-10.4%	-6.3%	-23.1%	-21.3%	-22.7%	-57.5%	118%	-15.2%	-21.3%

Footnotes

\* For each data series, correlation is measured to the each of the remaining 19 data series, then the average is taken.



### Statistics for Low Skew vs High Skew Strategies

	Average Low Skew Strategies	Average High Skew Strategies	Average All
1. Annual Compounded Return	7.7%	7.5%	7.6%
2. Annual Volatility	9.7%	12.4%	11.0%
3. Worst Peak-to-Trough Drawdown	31.8%	32.3%	32.0%
4. Worst Peak-to-Trough Drawdown / Annual Volatility	3.45	2.48	2.96
5. Annual Compounded Return / Worst P-to-T Drawdown	0.35	0.39	0.37
6. Annual Compounded Return / Annual Volatility	1.11	0.79	0.95
7. Sharpe Ratio (Avg RFR=3.85%)	0.59	0.39	0.49
8. Skew	-1.89	-0.07	-0.98
9. Volatility Range: Max 1 Year Volatility - Min 1 Year Volatility	19.2%	18.6%	18.9%
10. Volatility Range / Annual Volatility	2.12	1.48	1.80
11. Average Correlation Others*	37.1%	17.6%	27.3%
12. Alpha to SP500***	2.9%	3.6%	3.2%
13. Beta to SP500***	0.39	0.06	0.23
14. Correlation to SP500***	55.8%	11.5%	34.8%
15. Correlation to SP500 During Worst Three SP500 Drawdowns**	59.2%	-5.2%	28.7%
16. Return During Worst Three SP500 Drawdowns **	-41.1%	38.8%	-3.3%

### Statistics Sorted by Strength of Relationship to Skew

	Correlation to Skew	Intercept	Slope
8. Skew	100%	0.00	1.00
10. Volatility Range / Annual Volatility	-85.7%	1.44	-0.37
4. Worst Peak-to-Trough Drawdown / Annual Volatility	-70.9%	2.42	-0.56
11. Average Correlation Others*	-48.6%	19.4%	-0.08
2. Annual Volatility	47.0%	13.1%	0.02
15. Correlation to SP500 During Worst Three SP500 Drawdowns**	-46.9%	8.5%	-0.20
14. Correlation to SP500***	-41.9%	21.0%	-0.14
16. Return During Worst Three SP500 Drawdowns **	36.4%	18.7%	0.22
6. Annual Compounded Return / Annual Volatility	-35.5%	0.78	-0.18
7. Sharpe Ratio (Avg RFR=3.85%)	-29.7%	0.39	-0.10
13. Beta to SP500***	-19.7%	0.16	-0.07
3. Worst Peak-to-Trough Drawdown	15.9%	34.2%	0.02
9. Volatility Range: Max 1 Year Volatility - Min 1 Year Volatility	11.4%	19.7%	0.01
1. Annual Compounded Return	-9.2%	7.3%	0.00
5. Annual Compounded Return / Worst P-to-T Drawdown	4.6%	0.38	0.01
12. Alpha to SP500***	-4.0%	3.1%	0.00

#### Footnotes

\* For each data series, correlation is measured to the each of the remaining 19 data series, then the average is taken.

\*\* The periods of the worst three SP500 drawdowns between Jan 1994 and Dec 2010 are the following:

Jul98 -> Aug98, Sep00 -> Sep02, Nov07 -> Feb09, SP500 not included in these statistics.

\*\*\* SP500 not included in these statistics.