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ASSET MANAGEMENT

Trend Following and Volatility

THE INTERPLAY BETWEEN TREND FOLLOWING AND VOLATILITY IN AN EVOLVING "CRISIS ALPHA" INDUSTRY

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Table of Contents

Executive Summary

Institutional investors increasingly invest in trend following ("Trend") strategies based on the notion that they can deliver positive performance during both normal market conditions as well as during bear markets (selloffs of more than -20%) in risk-assets. The concept of Trend "Crisis Alpha" has been well received because such diversifying strategies with positive expected excess return can widen the efficient frontier available to investors.

Trend strategies can share option-like, convex characteristics, similar to owning certain long volatility positions. This was researched by Fung and Hsieh who published these findings in 2001.[1] Their ideas gained in popularity after Trend strategies generated outsized returns during the 2008 crisis. Since then, we observe that some investors view Trend strategies as a synthetic long volatility position rather than strong diversifiers that may profit during certain risk-asset selloff environments. The path and speed of the selloff will be an important factor in determining the ability of Trend signals to be effective in providing Crisis Alpha. In some risk-asset selloffs, Trend strategies may generate negative returns. This is rarely quantified and analyzed for investors so at best, they have an imprecise understanding of the issue and at worst, they are unaware of the issue. As a result, they may be overexposed to a risk-asset selloff.

Compounding the issue, we observe several changes occurring within Trend strategies that may hinder their ability to deliver Crisis Alpha going forward. Some CTA firms ("CTAs") are now using strategies that are considerably slower to react to sudden market reversals. Furthermore, the volatility that the Trend industry has delivered has been declining which may indicate that Trend strategies offer less upside volatility in a crisis than in the past. We believe it is important for investors in Trend strategies to understand these changes to evaluate how and when there may be a risk of generating underwhelming or even negative alpha in times of crisis.

In Section 1, we first identify how the time horizon and volatility profile of the Trend industry has changed. We then study how these changes impact the industry's ability to generate returns in several simulated and historical market crisis paths (most notably the Black Monday 1987 and 2008 scenarios). This section concludes that the industry is considerably slower in aggregate to respond to market reversals, and is thus exposed to abrupt risk-asset selloffs.

In Section 2, we evaluate some of the portfolio construction tools ("Building Blocks") that investors consider to mitigate the potential for standard Trend models to generate losses in a sudden risk-asset reversal. We first discuss Trend strategies with caps on equity exposure ("Equity Capped Trend"). We demonstrate that the cost of this strategy relative to standard (uncapped) Trend is high, with less benefit than may be generally assumed. We go on to consider another Crisis Alpha focused Trend approach, "Binary Execution on Signal" Trend (BES Trend). This approach is either fully in a position or not at all (for example, if a position has been stopped out). This is a Crisis Alpha focused approach because it can be flat risk-assets much faster than Trend approaches that scale into and out of positions gradually. We conclude that BES Trend is superior to Equity Capped Trend.

Long volatility strategies perform well in the types of sudden shocks that Trend following strategies are exposed to and can complement Trend allocations well. We model standard Tail Hedging/Passive Volatility strategies and conclude that they are costly and only effective if they are well timed. We consider an alternative, Active Value Volatility ("AV Volatility")

1 William Fung and David A. Hsieh (2001). The Risk in Hedge Fund Strategies: Theory and Evidence from Trend Followers. The Review of Financial Studies, 14(2): 313-341.

exposure and conclude that this approach does not require precise timing and can be highly effective in delivering Crisis Alpha.

We conclude by comparing the stand-alone building blocks above to a combined BES Trend strategy and AV Volatility portfolio. This combination has the attractive properties of providing Crisis Alpha even in instantaneous risk-asset reversals while also delivering positive expected value when levels of implied volatility are low.

SECTION 1 - TREND:

Changes Beneath the Surface

The SG Trend Index (the "Trend Index", an index of the largest 10 Trend funds representing 23% of the CTA industry) returned +20.9% in 2008, providing a meaningful offset to other alternatives strategies as well as traditional risk-assets during a period of market stress. The CTA industry has since grown by 67% to USD 344 billion. Although CTAs typically trade liquid instruments, some Trend funds have grown to individually manage tens of billions of dollars and therefore have to manage market impact and capacity. A way to do this is to use longer term trading signals and/or scale into and out of positions more gradually. Both capacity management techniques make the strategy slower to react to the market environment. In this section we investigate whether Trend has undergone material changes post 2008 and consider the likely impact on the ability of the Trend industry (generically as defined by the Trend Index) to generate Crisis Alpha going forward.

To study how the Trend industry has changed, we built 15 Trend strategies for research purposes (collectively, "Trend Research Strategies"), spanning the short, medium and long term signal horizons to observe whether the Trend Index has become increasingly correlated to less reactive, longer term strategies and less correlated to the shorter term strategies. The Trend Research Strategies were evaluated from January 2000 – December 2016 on a universe of 60 instruments, balanced across 14 equity futures, 12 fixed income futures, 18 commodity futures and 16 FX forwards. The same moving average based entry and exit signal was applied to all instruments. For example, to generate the return stream for the "10x30" Trend strategy, the 10 and 30 day moving averages were calculated for each instrument in the universe. A buy signal was generated when an instrument's 10 day moving average was above its 30 day moving average and a sell signal was generated when the shorter term moving average was below the longer term moving average. Once a buy or sell signal was assigned to each of the 60 instruments, the portfolio was constructed by applying an inverse volatility weight to each position (in other words, equal risk in each position, volatility adjusted). The positions were then scaled so that the portfolio's ex-ante volatility reached a 10% volatility target. We then calculated the returns for the portfolio from 2000-2016. We split the returns into two 8 year periods, pre and post 2008. In each period we studied the 15 strategies' correlations to the Trend Index and applied a Fisher transformation to run a Z-test at a 97.5% level to consider the statistical significance of these correlations. The results are found in the two tables below.

We observe that pre-2008, the Trend Index was significantly correlated to relatively short/medium term signals, specifically the Trend strategies that use 10x40 moving averages and 10x50 moving averages. We'll refer to these collectively as the "Pre-08 Trend Models". Post-2008, the Trend Index correlated to moving averages ranging from the 20x100 – 75x375, with the most significant of these being the 50x250. We'll refer to these collectively as the "Current Trend Industry Models". In other words, in a relatively short period of time, the Trend Index has become correlated to signals that are approximately 5x longer than the pre-2008 signals. This does not necessarily mean that CTAs have changed their signal length. The authors do not have transparency into which factors are responsible for the slower behavior, but this result is consistent with the implementation of techniques described above (the use of longer term signals and scaling into and out of positions). These changes in Current Trend Industry Models have implications for their ability to adapt to a sudden change in market environment. We discuss these implications in the following section.

Significant Correlations to the Trend Index 2000-2008:

Moving Average Pairs	10x30	10x40	10x50	20x60	20x80	20x100	50x150	50x200	50x250	75x225	75x300	75x375	100x300	100x400	200x400
Sample Correlation	0.53	0.64	0.68	0.63	0.63	0.63	0.63	0.56	0.55	0.50	0.58	0.59	0.57	0.54	0.56
Z-Test	0.41	2.07	2.81	1.87	1.96	1.84	1.96	0.83	0.75	0.04	1.08	1.21	0.99	0.56	0.88
Significant?	No	Yes	Yes	No	No	No	No	No	No	No	No	No	No	No	No

Significant Correlations to the Trend Index 2008-2016:

Moving Average Pairs	10x30	10x40	10x50	20x60	20x80	20x100	50x150	50x200	50x250	75x225	75x300	75x375	100x300	100x400	200x400
Sample Correlation	0.44	0.46	0.55	0.57	0.63	0.68	0.73	0.71	0.74	0.68	0.68	0.66	0.64	0.62	0.47
Z-Test	-0.75	-0.55	0.69	0.93	1.86	2.79	3.71	3.40	4.09	2.71	2.72	2.35	2.03	1.70	-0.34
Significant?	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No

SLOWER TREND: IMPLICATIONS FOR CRISIS ALPHA – QUANTIFYING THE IMPORTANCE OF SPEED

The fact that Trend signals have evolved to mimic longer term models hampers their ability to generate Crisis Alpha because, all else equal, they will take longer to react when an uptrend in risk-assets changes direction. Shorter Trend signals have the ability to profit from market moves over shorter periods whilst longer signals are better suited to profit from market moves over longer periods. This result is not new and existing literature already makes this link. Our contribution to the existing literature is to present how the speed of a Trend reversal will impact the expected return of the Current Trend Industry Models.

To study this, we simulated 2,500 market paths, each with an upward drift of 13% and volatility of 13% to match the S&P 500 equity market conditions over the past 5 years. We then applied a -20% simulated reversal of each of these market paths (modelled using a Brownian Bridge at 35% volatility) running 2,500 market selloff simulations occurring over 1 day, 1 month, 1 quarter, 6 months and 1 year (12,500 simulations in total). We then studied the performance of each Trend signal across these paths to observe a median, expected performance. We also combined the Current Trend Industry Model signals (the signals driving the Trend Index described in the previous section) to form a "Combined Current Trend Industry Model" which allocates to each of the signals equally and accounts for any diversification benefit from using a range of signals. The results are found in the table below and show a relationship between the time horizons of market reversals and the signal speed needed to produce Crisis Alpha.

Most large selloffs take time to unfold. In such cases Trend strategies should be expected to provide diversification benefit. The Current Trend Industry Model signals will need a selloff to occur over at least 3 months – 1 year to start delivering Crisis Alpha on this simulated underlying. However, the current signals are effectively "short volatility" for reversals occurring over any horizon of a month or less, with a substantial exposure to one day equity market selloffs (e.g. "Black Monday", 1987).

This observation is true for the industry as defined by the Trend Index but not for every, individual CTA. Investors looking to Trend for Crisis Alpha will have to be discerning in selecting funds with aligned Crisis Alpha goals as demonstrated by having sufficiently reactive signals. We discuss this in greater detail in Section 2.

The results indicate how the Current Trend Model signals are likely to perform on a single, hypothetical, underlying asset, designed to reflect the characteristics of the S&P 500. We limited our study to a single asset in this analysis to minimize the number of inputs and assumptions needed in our simulation model. Other assets with their own volatility, drift, skew characteristics and evolving correlations will also impact overall Trend performance. We study this in the case studies that follow.

Median Performance of Current Trend Model Signals for a Single, Simulated Asset over 12,500 Paths:

-20% Crash Speed	20x100	50x150	50x200	50x250	75x225	75x300	75x375	Combined Current Industry Model
1 Day	-14.22%	-14.32%	-14.43%	-14.54%	-14.48%	-14.63%	-14.71%	-14.60%
1 Month	-0.14%	-0.08%	0.01%	-0.05%	-0.08%	-0.13%	-0.17%	-0.29%
3 Months	0.61%	1.01%	1.12%	1.25%	1.22%	1.27%	1.39%	0.60%
6 Months	0.97%	1.98%	2.31%	2.69%	2.72%	3.04%	3.40%	2.07%
1 Year	2.53%	3.87%	4.79%	5.46%	5.28%	6.00%	7.07%	5.19%

SLOWER TREND: IMPLICATIONS FOR CRISIS ALPHA – 2008 CASE STUDY

In addition to the previous analysis, we can also use 2008 as a case study to quantify the impact of today's slower Trend signals. The previous analysis is helpful in understanding Trend behavior across many paths but a drawback is that those paths are built using model assumptions. Studying specific periods of history only allows us to study one market path which opens the potential for certain signals to have just been "unlucky" that time around, but has the advantage that it does not depend on any modelling assumptions. Furthermore it has the advantage that we can run the signals on multiple asset classes to understand how the speed of a market move can impact a Trend strategy at the portfolio level (which builds upon the previous analysis that was based on a single, hypothetical asset).

We evaluated our Trend Research Strategies' 2008 performance. Below we compare the Pre-2008 strategies to the Current Trend Industry Model strategies. This way we can estimate the expected change in alpha should a 2008 crisis repeat itself. The 2008 performance for both the Pre-2008 Models and today's Current Trend Industry Models across the universe of instruments is summarized below. The performance of the Combined Pre-2008 model generated an attractive performance of +26.6% gross of fees (+20.1% net estimate using 1.5%,15%). This is of similar magnitude to the actual Trend Index which generated +20.9% net of fees. The Current Trend Industry Models performed much less favorably. If the 2008 crisis were to repeat exactly, the Current Trend Industry Models driving the Trend Index today, would deliver +8.2% gross of fees (+5.4% net estimate).

Given that most CTAs do not offer transparency into how their models evolve, it is natural that most investors return expectations will be guided by past performance. If this is the case, the Trend industry is likely to underdeliver on expectations by -15.5% all else equal (+5.4% net expected performance from today's models minus Trend Index 2008 performance of +20.9%).

2008 Performance:

	Pre 2008 Signals			Current Trend Industry Model Signals										
Moving Average Pairs	10x30	10x40	10x50	20x60	20x80	20x100	50x150	50x200	50x250	75x225	75x300	75x375	100x300	100x400	200x400
2008 Return	26.8%	23.6%	26.6%	25.3%	20.8%	20.9%	7.3%	11.3%	8.2%	7.9%	5.2%	0.9%	6.0%	0.7%	-8.7%
Combined Signals 2008 Return		**26.8%**			**8.2%**										

SLOWER TREND: IMPLICATIONS FOR CRISIS ALPHA – 1987 CASE STUDY

We performed the same exercise for 1987 to study a faster risk-asset selloff event. In October 1987 the S&P 500 declined by -20.47% on "Black Monday" and ended the month down -21.76%. Consistent with our analysis over multiple simulated paths, longer Trend signals are more likely to generate negative returns in a fast reversal. The fast nature of the selloff during October 1987 would have generated losses of -24.8% for the Current Trend Industry Model signals. As we will present later, of that -24.8% gross monthly return, -19.8% was generated on Black Monday alone.

October 1987 Performance:

	Pre 2008 Signals			Current Trend Industry Model Signals										
Moving Average Pairs	10x30	10x40	10x50	20x60	20x80	20x100	50x150	50x200	50x250	75x225	75x300	75x375	100x300	100x400	200x400
October 1987 Return	5.7%	9.7%	6.6%	6.8%	2.8%	-8.4	-25.9%	-26.7%	-21.4%	-21.5%	-20.1%	-21.4	-18.8%	-20.1%	0.0%
Combined Signals October 1987 Return		**9.6%**							**-24.8%**						

TREND VOLATILITY COMPRESSION

The analysis above suggests that some CTAs have made changes that ultimately make their strategies slower to react to market reversals. This would benefit the management company because it reduces either the amount of times they have to transact and/or the daily transaction size in the market which increases capacity. However, a more direct way to increase a strategy's capacity is to simply lower the volatility by either reducing the notional trading size in the market or (more likely) diversify away from pure Trend and add other non-Trend strategies. To the extent that these non-Trend strategies' returns exhibit negative skew (as is usually the case with mean-reversion, counter-trend, carry and short volatility strategies for example) their addition would likely dilute Trend Crisis Alpha.

The volatility of the Trend Index from 2000-2008 was 16.9%. The volatility from 2008-2016 was 11.1%. The average pairwise correlation of the index constituents was higher in the post-2008 period (0.75 correlation) vs the pre-2008 period (0.7) so the fall in volatility was not driven by dispersion (a higher correlation would have increased the Trend Index's volatility). Therefore the fall in volatility was either a function of the environment or alternatively it was driven by changes to the strategies employed by the funds in the Trend Index (beyond the changes in the reactivity of the models that we have already discussed).

To investigate this, we combined the returns of our Pre-2008 and Current Trend Industry Models to create a return stream that was significantly correlated to the Trend Index over the whole period 2000-2016. This return stream serves as a control group that is run at a constant 10% volatility target. It also already accounts for the changes in the reactivity of Trend strategies. This allows us to quantify how much of the volatility suppression has been due to changes in the environment vs. other changes to models used by the CTAs in the Trend Index.

While the delivered volatility of the Trend Index fell by -34% post-2008, the volatility for the control group increased. This is a statistically significant drop in volatility relative to the control group, suggesting that the active changes that Trend firms have made to their models are responsible for the fall in volatility, rather than it being a function of the environment.

While the authors do not have transparency into which changes have driven the fall in volatility, possible factors that would be consistent with this result include either reducing notional deployed in the market, diluting Trend exposure with other strategies, etc. Whatever the driver, the Trend Index is delivering meaningfully less volatility and should be expected to deliver less upside volatility in a crisis on a going forward basis.

	Trend Index	Control Group
2000-2008	16.9%	10.1%
2008-2016	11.1%	10.7%
Vol Point Change	-5.7%	0.6%
% Change	-34.0%	5.7%

TREND CHANGES BENEATH THE SURFACE - SUMMARY

Investors who rely on Trend to generate an offset to risk-assets in times of crisis now have to be especially discerning in sourcing their Crisis Alpha exposure. Post 2008, the Trend industry's signals have become correlated to longer term strategies, effectively slowing the reactivity of Trend to market reversals. Compounding the issue is a lack of leverage to market movement as the Trend industry's volatility has fallen (more than would be suggested by the market environment). The fall in volatility is likely driven by *some* Trend firms deciding to dilute their pure Trend strategies with other strategies to lower volatility and simultaneously increase capacity. Less Crisis Alpha should be expected from the Current Trend Industry Models during risk-asset selloffs that unfold over a medium term horizon (for example 2008). Furthermore, investors are not protected and will likely generate negative returns in rapid risk-asset reversals (for example 1987). We demonstrated how investors in standard (non-Crisis Alpha focused) Trend are flat or even short volatility in market reversals that occur over time frames shorter than a month.

These observations are based on data for the Trend Index. However, not all Trend funds are created with the same goals in mind. Investors are starting to demand customized strategies and Trend funds focused more on Crisis Alpha. Due to the inherent tradeoff between capacity and reactivity, Trend based Crisis Alpha solutions are more likely to be delivered by firms more focused on aligning with their investors' portfolio construction goals rather than AUM maximization.

In Section 2 we consider the relative merits of Crisis Alpha focused solutions in greater detail, both for Trend and long volatility strategies.

SECTION 2 -

Crisis Alpha Building Blocks

The potential for the Current Trend Industry Models to generate significant losses in a sudden crisis impairs the robustness of using standard (non-Crisis Alpha focused) Trend as a portfolio construction tool. This has led some investors to consider either (1) investing in Trend strategies that are explicitly Crisis Alpha focused by design, or (2) supplementing Trend strategies with long volatility exposure.

CRISIS ALPHA FOCUSED TREND BUILDING BLOCKS

Investors are increasingly aware of the incongruence of holding Crisis Alpha strategies that are long equities and have begun to demand Trend strategies that cap equity beta to address this. Below we demonstrate that this approach comes at a material cost and with less benefit/more risk than may generally be assumed. We also demonstrate that there is another approach that is superior, namely, BES Trend. BES Trend models are either fully in a position or not at all, exiting positions in full size without scaling out of positions. This is a Crisis Alpha focused approach because it can be flat equities much faster than Trend approaches that tend to scale into and out of positions gradually. BES Trend can enjoy the benefits of having exposure to equities during an uptrend but can provide the same benefits as Equity Capped Trend (in all but an instantaneous, one day shock) by stopping out of positions quickly.

VOLATILITY BUILDING BLOCKS

Adding exposure to long volatility strategies can be a powerful complement to CTA portfolios intended to generate Crisis Alpha for investors. However, we conclude below that most standard tail hedging/passive volatility portfolio building blocks are costly and only effective if they are well timed. We also demonstrate that an Active Value Volatility ("AV Volatility") exposure does not require precise timing and can be highly effective in delivering Crisis Alpha, particularly when implied volatility levels across asset classes are in their lowest deciles.

A COMBINED TREND AND ACTIVE, VALUE VOLATILITY SOLUTION

We compare the stand-alone building blocks above, to a more complete solution of combining a BES Trend Portfolio with a AV Volatility portfolio. We demonstrate that the combination has the attractive property of providing Crisis Alpha irrespective of market path (i.e. even in instantaneous shocks) while also delivering positive expected value.

Crisis Alpha Focused Trend Building Blocks

Below we consider the costs and benefits of Equity Capped Trend and BES Trend strategies.

1. TREND WITH CAPS ON EQUITY EXPOSURE ("EQUITY CAPPED TREND")

The potential for standard Trend strategies to generate negative returns in a sudden market reversal is at odds with their role as portfolio diversifiers to risky assets. Trend strategies that are built with Equity Caps are increasingly considered as a potential solution. These strategies are often bespoke without any "standard" implementation. However, anecdotally, popular strategies cap the net equity exposure at the asset class level to be flat or short ("Equity Capped Trend"). In addition, they may include a portfolio optimization that takes into account the equity beta of other, non-equity assets, and caps the overall portfolio beta at zero ("Beta Capped Trend").

Below we estimate the historical return and opportunity cost of a strategy that caps equity exposure. We also consider some of the risks of using Equity and Beta Caps at the portfolio level and quantify the potential benefits relative to the Current Trend Industry Model signals.

Equity Caps on Trend - Return and Opportunity Cost

To study the historical returns and opportunity cost of capping equity exposure we simulated the industry returns using (A) the Current Trend Industry Model signals, and (B) using the same models with the constraint that they can only be flat or short equities ("Equity Capped Trend Model"). Apart from the Equity Cap, the portfolio construction methodology is identical for each of these models. The Equity Capped Trend Model returned an annualized 6.4% from 2000-2016. The Current Trend Industry Model annualized 8.7%. On the surface, the opportunity cost of implementing the Equity Cap is -2.3%. However, this period coincided with two major bear markets (in 2000-2002 the S&P 500 fell -49.1% peak to trough and in 2007-2009 the S&P 500 fell -56.9%) which would have provided a tail wind to Equity Capped strategies. Given there is uncertainty about how long it may take for the next bear market to occur, there is value in analyzing the returns of these strategies in (1) benign market conditions, and (2) during equity selloffs. We calculated the average annual returns of each strategy during positive or flat years for the S&P 500 to understand expected returns in benign market conditions. To analyze strategy performance during bear markets, we forecasted returns during a -20% market selloff over different time horizons by regressing each strategy's returns against S&P 500 monthly, quarterly, semi-annual and annual returns, conditional on the S&P 500 returns being negative. For one day -20% equity market selloffs we calculated each strategy's returns for the Black Monday crash of 1987.

Some managers overlay a beta control on other non-equity assets in the portfolio. In this paper we only consider the milder implementation of just capping explicit equity exposure because otherwise results would greatly depend on portfolio optimization techniques.

The results below show the cost of capping beta during benign markets has been high at -5.5% annualized (2.4%-7.9%). This is expensive because an investor in an Equity Capped strategy is only expected to significantly outperform standard Trend in very rapid selloffs (which are historically rare). Furthermore, the Equity Capped strategy generates -1.8% of negative Crisis Alpha in a 1 day -20% equity market selloff (whereas an AV Volatility

strategy would not only avoid losses but also generate significant profits as later discussed in the Active, Value Volatility Exposure section).

Forecast Returns in -20% Equity Market Selloff and Benign Equity Markets

-20% Speed	1 Day	1 Month	1 Quarter	6 Month	1 Year	Average Crisis Return	Average Return Benign
Current Industry Models (10% Vol)	-19.8%	7.6%	6.0%	15.7%	10.7%	4.1%	7.9%
Equity CapTrend (10% Vol)	-1.8%	6.2%	7.3%	18.9%	14.1%	8.9%	2.4%

Equity Caps on Trend - Risk

The cap on equity exposure is not only expensive, but also unable to provide Crisis Alpha during Black Monday, 1987 (generating a negative -1.8% simulated return). In addition to the lack of Crisis Alpha in a sudden reversal, Equity Capped strategies may also carry other risks.

Equity Capped and Beta Capped Trend Strategies typically depend on correlation assumptions (more so than standard Trend strategies). The correlation assumptions themselves become sources of considerable risk.

For example, today's inverse correlation between bond and equity returns would allow significant fixed income exposure in an Equity Capped Trend strategy. The fixed income exposure would likely be levered to reach a given volatility target. The leverage would likely have to be greater than in a standard Trend strategy because the volatility associated with equity risk would need to be replaced with something else. In this example, the risk that would have been deployed to equity beta in a standard Trend strategy would now be redeployed to levered fixed income assets. Therefore, if bonds sell off in a crisis (similar to the "Taper Tantrum"), Equity Capped strategies should be expected to generate negative Crisis Alpha both in absolute terms and also potentially relative to standard Trend strategies because the Equity Capped version is likely more levered. This result is likely more acute in Beta Capped strategies as risk-assets in other asset classes (for example emerging market FX) will also have to be replaced with levered exposures. In recent decades, such correlation shocks have not persisted for prolonged periods. However, the chance of such an environment persisting would likely be greater in a world of lower expected growth and rising inflation.

2. BINARY EXECUTION ON SIGNAL TREND ("BES TREND")

Current Trend Industry Models have become slower and less reactive to fast market reversals. Equity Capped Trend strategies are expensive relative to the benefits they may offer (depending on the correlation environment). We demonstrate below that a BES Trend strategy is a better Crisis Alpha focused alternative. We define a BES Trend strategy as any Trend strategy that is either fully in a position or not at all (hence the "Binary" term). This is in contrast to most Trend strategies that modulate positions, for example, by gradually scaling into and out of positions. A BES Trend strategy that exits positions fully as soon as a stop loss signal is received, can flatten exposure to equities quickly. Therefore BES Trend strategies may provide more Crisis Alpha than standard Trend strategies and a similar amount of alpha to Equity Capped Strategies in most crises (with the exception of the rare instance of an instantaneous selloff). This may be achieved without the prohibitive -5.5% opportunity cost of Equity Capped strategies in benign market conditions.

We test this by building a BES Trend strategy to study its performance in bear markets and also during benign market conditions. BES Trend models can be constructed using any length of signals, fast or slow. The key for a BES Trend strategy is that once a signal is received, it is acted upon immediately, in full size. For example, the BES Trend research model was built with substantially similar parameters as One River's Systematic Trend strategy. This strategy uses a combination of longer term moving averages and breakouts to enter positions and trailing stop losses to exit positions. Importantly, the strategy executes on its stop loss in full size, without scaling out gradually. For more information on the model construction please refer to our Risk Premia: Behind the Curtain whitepaper (available upon request).

Such a strategy is designed this way to combine the benefits of longer term signals (less "whipsaw") while still allowing investors to flatten exposure to equities quickly in a crisis (due to the binary, full exit of equity positions once a stop loss signal is triggered). When uptrends reverse, a BES Trend strategy can flatten risk-asset positions in a day after receiving a stop loss signal. Conversely, Trend strategies that gradually scale into and out of risk-asset positions during a crisis will leave investors exposed to a selloff for longer.

Below (see next page) we compare the return and diversification characteristics of BES Trend to standard Current Trend Industry Models as well as the Equity Capped implementation (using the methodology described in the Equity Capped section).

In our simulations and historical backtests, BES Trend outperformed both standard Trend and Equity Capped Trend in benign markets by +0.3% and +5.8% annualized, respectively. Although the Equity Capped strategy did outperform in an instantaneous equity market selloff as expected, BES outperformed both Current Trend Industry Model and Equity Capped strategies, on average during times of crisis. In such times, BES Trend on average outperformed by +5.2% and 0.4% respectively. We include the results for an 18% volatility strategy for completeness to illustrate the benefits of utilizing capital efficient strategies in the construction of crisis alpha portfolios. We believe 18% is indicative of higher volatility stand-alone Trend funds.

Forecast Returns in -20% Equity Market Selloff and Benign Equity Markets*

-20% Speed	1 Day	1 Month	1 Quarter	6 Month	1 Year	Average Crisis Return	Average Return Benign
Current Industry Models (10% Vol)	-19.8%	7.6%	6.0%	15.7%	10.7%	4.1%	7.9%
Equity CapTrend (10% Vol)	-1.8%	6.2%	7.3%	18.9%	14.1%	8.9%	2.4%
BES Trend 10% Vol Target	-4.4%	7.7%	7.7%	19.5%	15.9%	9.3%	8.2%
BES Trend 18% Vol Target	-7.9%	13.8%	13.9%	35.2%	28.7%	16.7%	14.8%

**See disclaimer for limitations of hypothetical returns.*

CRISIS ALPHA FOCUSED TREND BUILDING BLOCKS – SUMMARY

In our simulations and historical backtests, capping the exposure of equities relative to a standard Trend strategy costs -5.5% annualized in benign market periods and generates flat to negative returns in sudden 1 day equity market reversals. BES Trend in contrast, has attractive Crisis Alpha characteristics in addition to being able to outperform standard Trend strategies in benign markets. Financial theory suggests that more Crisis Alpha would normally come at a cost during normal market conditions. The lack of tradeoff in this case suggests there is a structural edge in BES Trend. Due to the tradeoff between capacity and the ability to implement binary execution, it is likely that this edge will remain as long as some CTAs focus on maximizing AUM instead of their ability to deliver Crisis Alpha.

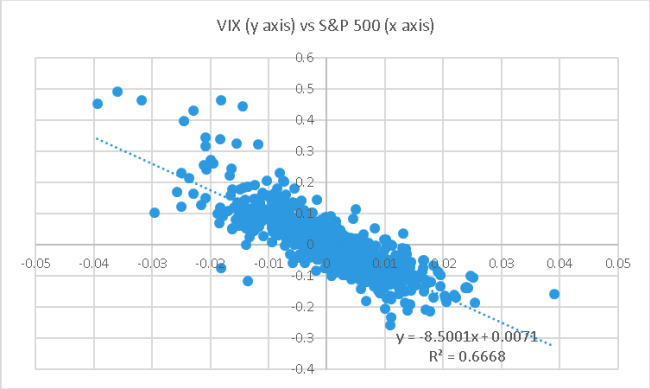
Volatility Building Blocks

The Crisis Alpha that Current Industry Trend Models are able to provide, is inversely proportional to the speed of a reversal in risk-assets. Conversely, increases in volatility are larger for fast market moves. Therefore long volatility exposure may be considered by investors looking for a complement to their traditional portfolios during fast risk-asset selloffs. Below we consider the cost and expected returns of standard long volatility instruments (VIX ETFs). We later compare these passive strategies (akin to the standard "tail hedging" strategies that are insensitive to the price of protection, for example, systematically rolling far out of the money equity puts, buying VIX futures etc.) to an AV Volatility strategy.

1. PASSIVE LONG VOLATILITY/TAIL EXPOSURE

Long volatility exposure has strong diversification benefits for risk-asset portfolios (see VIX vs. S&P 500 chart of daily returns over the past 5 years).

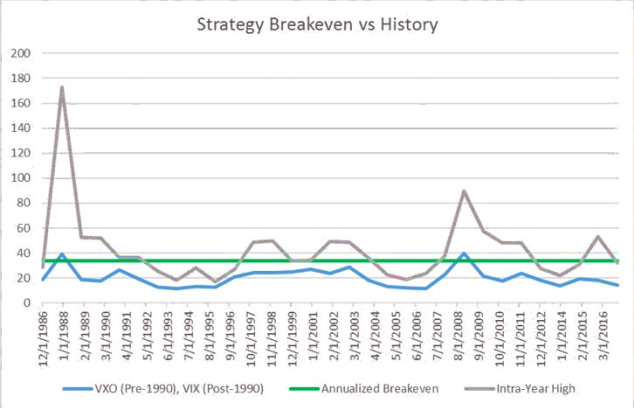
However, unlike Trend, long volatility exposure over long periods of time is associated with negative expected returns, driven by negative carry (roll-down cost and theta decay). As a result, despite the strong diversification benefits for risk-asset portfolios, most investors have been reluctant to embrace long volatility as a portfolio construction tool.



VIX ETFs

The most popular long volatility ETFs are based on the S&P 500 VIX Short-Term Futures Index (we will refer to this strategy by a popular ETF ticker "VXX"). This strategy buys the front two VIX futures to maintain exposure to a constant maturity, one month VIX forward position. It is a value-insensitive strategy and buys these futures irrespective of carry and/or level of volatility. This strategy has the advantage of offering significant upside in a crisis, but it historically has been expensive to implement due to a steep roll-down cost. Roll-down is the carry cost incurred when the VIX futures curve is in contango, as high priced VIX futures settle into a lower VIX spot price. The VIX curve is typically in contango during benign market conditions. Flows exacerbate the steepness of this roll-down as ETF investors are typically net buyers of the front futures and VIX spot is typically artificially compressed by systematic volatility sellers who sell variance swaps (which pushes the spot VIX lower). At the time of writing (December 2017), the roll-down is -2 volatility points per month.

We consider the breakeven of a similar strategy that buys the front futures and rolls at expiry, paying the current roll-down of -2 volatility points per month. At the time of writing, the annual breakeven of such a strategy is the current VIX level of 9.67+2x12 = 33.67. To avoid the hindsight bias of assuming an investor would be able to time the intra-year high in the VIX we assume the investor enters the strategy at the beginning of the year and may only elect to liquidate the strategy at year end. Over the past 30 years, such a strategy would have made a positive return on only two occasions. It would have made approximately 5 volatility points above this breakeven in 1987 and 6 volatility points in 2008.

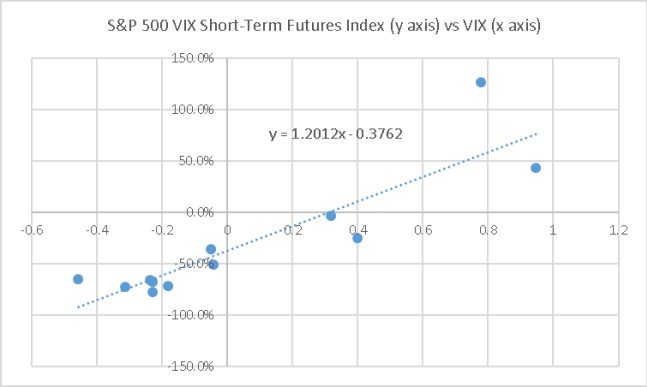


This profit is approximately 3 months roll-down cost which is small compared to how infrequently such events tend to occur. Even if investors in this strategy knew that an 1987 or 2008-like crisis was to occur in 15 months from now, using history as a guide, they would still not be expected to make money. Historically of course, events of such magnitudes are much less frequent than once every 15 months.

While not the focus of this paper, it is worth noting that not only do VIX ETFs and similar passive strategies offer poor risk/reward ratios for hedgers (absent of market timing), but they also offer poor risk/reward ratios for volatility sellers. As we discuss in our Risk Premia: Behind the Curtain whitepaper (available on request), a similar passive volatility selling strategy run at 5% volatility is likely to lose -100% of capital if an event similar to the 1987 crash occurs again.

Both passive volatility buying and selling strategies offer poor risk/reward ratios because there is a substantial path dependency for mean reverting strategies whose returns exhibit large negative skew. During October 1987 a volatility buyer, would have enjoyed large mark-to-market gains but assuming no market timing, the mean reversion of volatility ultimately led to only modest gains being crystalized by year end. A volatility seller would have lost -100% on Black Monday and so would not have survived to benefit from the mean reversion that ultimately occurred.

From Jan 2006 to today the VXX strategy has annualized -47.2%. The adjacent chart plots the S&P 500 VIX Short-Term Futures Index vs the VIX. The regression alpha (i.e. the roll-down carry cost for the VXX strategy when VIX is unchanged) is -37.6%. This indicates that most of the negative return (-37.6%/-47.2%) has been driven by the roll-down carry cost. Over the same period the volatility of the VXX has been 60.9%, implying the implied Sharpe ratio from paying the carry component of the VXX has been -0.6.



Even at low levels of volatility, consistently owning passive long volatility strategies, often rendered expensive by flows affecting the volatility surface, offer negative expected value and poor annualized risk/reward ratios, irrespective of the level of volatility.

2. AN ACTIVE, VALUE VOLATILITY ("AV VOLATILITY") EXPOSURE

Investors are accustomed to paying a premium to own exposure that offsets their portfolio risk. This premium may be in the form of an implied-realized volatility premium or in the form of the roll-down described in the passive long volatility approach above. Hedging flows exacerbate these premiums. For example, the aforementioned VXX strategy is expensive because VIX futures are bid up by hedging demand. In volatility markets there are also volatility selling flows that can offer a source of value for investors in volatility. The example below illustrates how applying a value approach to volatility can improve the expected cost and the risk/reward ratio of owning volatility vs. a passive approach.

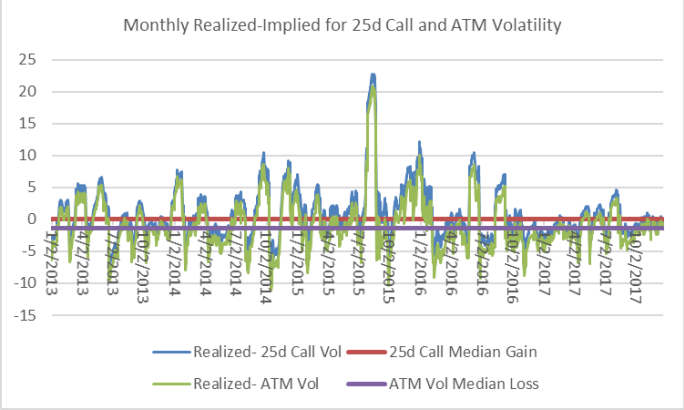
AV Volatility Case Study - Low Delta Call Volatility

Covered call, "buy-write" strategies involve selling (writing) call options on underlying securities (or indices) that the writer already owns. Buy-write strategies generate a flow in the market that systematically sells out-of-the-money ("OTM") call options on the US market, artificially suppressing the implied volatility of OTM call options on the S&P 500. A value investor in volatility markets could own the call and delta hedge daily to eliminate any directional exposure to the S&P 500. This would leave the investor with a combination of long gamma exposure to profit when realized volatility rises (for example, in a large, instantaneous selloff in the S&P 500) and long vega exposure to profit in an environment of rising implied S&P 500 volatility.

At the time of writing, the at-the-money ("ATM"), 1 month volatility on the S&P 500 is 7.4 whereas the 25 delta call implied volatility is 6.5. A 25 delta call is an OTM call, indicative of the call volatility typically impacted by overwriters. One month volatility had just realized 6.5. Excluding for the moment, any mean reversion of volatility, the implied-realized premium (carry cost) of owning ATM volatility is 0.9 (7.4-6.5) volatility points whereas the 25 delta call implied-realized spreads carry cost is 0 volatility points. However, volatility exhibits mean reversion,

which should be factored into a forward looking expectation of realized volatility. Using a GARCH model to forecast the most likely path for realized volatility we can see that the current expected realized volatility is 8.3. The expected profit from owning implied volatility and delta hedging is approximately 8.3-6.5 = +1.8 volatility points.

We can study the persistence of such a value strategy historically. To do this we compare implied volatility of the 25 delta call to subsequent (i.e. 1 month lagged) realized volatility. We observe that historically this strategy was valuable as the median realized volatility (lagged 1 month) was 0.01 volatility points above the 25 delta call implied level. The median realized minus ATM volatility spread was -1.4 volatility points, meaning that owning the 25 delta call volatility was approximately flat (slightly positive) whilst owning the ATM volatility would have lost approximately -1.4 volatility points per month.



Moreover, as expected, the realized volatility expanded in market dislocations, offering Crisis Alpha for investors (for example, in August 2015 the spread rose above 20).

The Risk/Reward Ratio of an AV Volatility Portfolio

The example above is one of numerous strategies that may be included in an AV Volatility portfolio. However to be effective, this approach will need to rotate across positions and strategies wherever there is perceived value. As there is no long running benchmark for AV Volatility strategies it is not possible to easily assess expected cost and payoff of such an approach using historical analysis. In lieu of such analysis, we used RiskMetrics' risk reports for a hypothetical cross-asset, long volatility strategy (informed by our experience in running such a strategy) to understand how an AV Volatility portfolio at the time of writing is expected to behave during -20% equity market selloffs. The drawback of such analysis is that we have no way of knowing how representative this expected behavior is across other AV Volatility approaches. However, it does provide a starting point for analysis in the absence of standardized data.

In a status quo environment, the cost of carry (excluding mean reversion in volatility levels) was estimated by calculating the annualized time decay minus gamma rent (i.e. gains from gamma trading) assuming realized volatility stays at low levels. The carry cost was -5.0% annualized. If implied and realized volatility fall further (at the time of writing implied and realized volatilities are in their lowest deciles over the past 50 years) the loss would be greater. The table below describes the expected behavior of the portfolio at an aggregate level during a -20% equity shock that unfolds over different time horizons. To generate these results, we first forecasted the VIX rise for a -20% fall in equities over different time horizons. To do this we ran regressions between the S&P 500 and VIX using monthly, quarterly, semi-annual and annual data since 1990. To study a one day -20% selloff in the S&P 500

we needed an index that covered Black Monday so we used the VXO index (a statistically similar relative of the VIX that is constructed with only minor differences to the VIX) to generate an estimate for how the VIX is likely to behave. We then used RiskMetrics to predict a portfolio profit for each forecast increase in the VIX. RiskMetrics' results are generated by shocking a static portfolio. Furthermore, some positions (particularly in the Rates part of the hypothetical portfolio) cannot be modelled in RiskMetrics. Despite these limitations, to maintain a level of objectivity, we have not edited RiskMetrics' generated results. Overall, our opinion is that the RiskMetrics' results are broadly indicative of the type of returns an AV Volatility strategy may achieve. Please refer to the disclaimer on page 22 for more limitations of such hypothetical returns.

The stress tests show that the faster the selloff occurs, the greater the volatility, and so the greater the expected gain at the portfolio level. This return profile is complementary to the slower selloff speeds needed for Trend to make attractive positive returns, and fills the sudden-gap risk that Trend strategies are exposed to.

Forecast Returns in -20% Equity Market Selloff and Benign Equity Markets*

-20% Speed	1 day	1 month	1 quarter	6 month	1 year
VIX Shock	**VIX +140**	**VIX +49**	**VIX +33**	**VIX +23**	**VIX +19**
Commodity	2.2%	1.3%	1.0%	0.7%	0.6%
Credit	0.3%	0.1%	0.0%	0.0%	0.0%
Equity	100.0%	48.9%	37.0%	28.1%	24.0%
Foreign Exchange	16.5%	10.0%	7.9%	6.1%	5.3%
Rates	0.2%	0.2%	0.1%	0.1%	0.1%
AV Volatiltiy	**119.2%**	**60.5%**	**46.0%**	**35.0%**	**30.0%**

**See disclaimer for limitations of hypothetical returns.*

Volatility Building Blocks-Summary

Even at low levels of volatility, consistently owning passive long volatility strategies offers negative expected value and poor annualized risk/reward ratios, irrespective of the level of volatility. In contrast, an AV Volatility exposure may reduce carry and theta cost and therefore improve the risk/reward ratio. From the low levels of implied volatility observed at the time of writing, an AV Volatility approach only needs minor reversion higher in volatility to offset its carry and theta cost. Once such reversion is factored in, the expected value of such a strategy is positive. Furthermore, unlike Trend strategies (including Equity Capped strategies), Crisis Alpha is provided in the case of a sudden reversal in risk-assets. A long volatility strategy therefore, may be highly complementary to Trend strategies. We consider the value of a combined Trend and AV Volatility solution next.

A Combined BES Trend and AV Volatility Solution

In the Trend sections above, we concluded that BES Trend has attractive Crisis Alpha characteristics because it can flatten exposure to equities more quickly than standard Trend strategies in a selloff, and historically this risk management feature would not have cost the strategy relative to the Current Industry Trend Models. This should put BES Trend in a better position to produce Crisis Alpha relative to standard Trend strategies. However BES Trend, like a standard Trend model, is exposed to an instantaneous shock lower in equities. An AV Volatility exposure could fill this gap. At the same time, the long term expected value of Trend returns has a good chance of offsetting the negative carry of a long volatility position while waiting for volatility to mean revert to more normal levels. Furthermore, the analysis above shows that in certain paths (selloff speeds), long volatility positions and BES Trend positions may both generate substantial, positive returns.

We use the results in the Trend and AV Volatility sections above to compare a portfolio of 70% BES Trend and 30% AV Volatility ("70:30 Portfolio") to the stand-alone Crisis Alpha strategies explored earlier in this paper. The results are presented in the table below which compares the expected cost of owning these strategies in benign equity markets and the predicted payoffs during selloffs. The 70:30 Portfolio offers attractive average returns in a benign market environment and also offers Crisis Alpha in sudden market reversals.

Forecast Returns in -20% Equity Market Selloff and Benign Equity Markets*

-20% Speed	1 day	1 month	1 quarter	6 month	1 year	Average Crisis Return	Average Return Benign
VIX Shock	**VIX +140**	**VIX +49**	**VIX +33**	**VIX +23**	**VIX +19**	**VIX +52**	**VIX +0**
AV Volatiltiy	119.2%	60.5%	46.0%	35.0%	30.0%	58.2%	-5.0%
Current Industry Models (10% Vol)	-19.8%	7.6%	6.0%	15.7%	10.7%	4.1%	7.9%
Equity CapTrend (10% Vol)	-1.8%	6.2%	7.3%	18.9%	14.1%	8.9%	2.4%
BES Trend 10% Vol Target	-4.4%	7.7%	7.7%	19.5%	15.9%	9.3%	8.2%
BES Trend 18% Vol Target	-7.9%	13.8%	13.9%	35.2%	28.7%	16.7%	14.8%
70:30 (BES at 10% Vol)	32.7%	23.5%	19.2%	24.2%	20.1%	24.0%	4.2%
70:30 (BES at 18% Vol)	30.3%	27.8%	23.5%	35.1%	29.1%	29.2%	8.8%

**See disclaimer for limitations of hypothetical returns.*

On the following page, we summarize which of these strategies have dominant expected return characteristics. To do this we a simplify the analysis by stating that there can only be two states of the world, (1) a benign market state, and (2) a -20% equity market selloff state. Considering the probability of smaller market selloffs in addition to these two states of the world would add granularity but also complexity and would not change the broad conclusions (because the return predictions were largely based on linear analysis).

For each Crisis Alpha strategy, we calculated probability weighted crisis returns (the forecast strategy crisis return multiplied by a crisis probability) across a range of crisis probabilities. We also calculated probability weighted benign market returns (the average benign market return multiplied by 1 minus the probability of a crisis). We then calculated the expected return for each strategy by taking the sum of these weighted returns. The results in the first

table are for -20% equity reversals that play out over "an average" amount of time. The results in the second table are for -20% equity reversals based on the Black Monday analysis.

For example, if an investor assigned a probability of 10% to a -20% selloff occurring over the next year but did not have a sense of whether it was to unfold quickly or gradually, the investor would consider the first table and see that the probability weighted return for the Equity Capped Trend strategy is +3.1% whereas the 70:30 Portfolio has a probability weighted predicted return of +6.2%. Investors more interested in performance during a 1 day shock, would consider the results in the second table.

We observe that BES Trend (at both 10% and 18% volatility targets) is expected to outperform Equity Capped and Current Industry Trend Models in all cases unless an investor places a high probability on an instantaneous selloff. In the extreme case where an instantaneous selloff was a certainty, Equity Capped Trend would only outperform BES Trend by +2.6% (second table; 4.4%-1.8%). However, in that case the 70:30 Portfolio would outperform a Equity Capped Trend Strategy and a standard Trend strategy by +34.5% and +52.5% respectively. We can summarize that in all cases, either a BES Trend Strategy or a 70:30 Portfolio (the choice between which would depend on the expected speed and probability an investor assigned to a selloff) are more optimal than both the Current Industry Models and Equity Capped Trend.

Probability Weighted Strategy Returns – Average of 1 Day, 1,3,6,12 Month Selloff Speeds*

-20% Speed	Average Crisis Scenario	Average Benign Return	Return Expectation for an X% Probability of -20% Crisis Occuring						
Scenarios and Probabilities	**VIX+52**	**VIX+0**	**5%**	**10%**	**20%**	**30%**	**40%**	**50%**	**Scenario Specific**
AV Volatiltiy	58.2%	-5.0%	-1.8%	1.3%	7.6%	13.9%	20.3%	26.6%	
Current Industry Models (10% Vol)	4.1%	7.9%	7.7%	7.5%	7.1%	6.7%	6.4%	6.0%	**Lower Expected Return Portfolios**
Equity CapTrend (10% Vol)	8.9%	2.4%	2.7%	3.1%	3.7%	4.4%	5.0%	5.7%	
BES Trend 10% Vol Target	9.3%	8.2%	8.3%	8.3%	8.4%	8.5%	8.6%	8.8%	**Dominant Portfolios**
BES Trend 18% Vol Target	16.7%	14.8%	14.9%	15.0%	15.2%	15.4%	15.6%	15.8%	
70:30 (BES at 10% Vol)	24.0%	4.2%	5.2%	6.2%	8.2%	10.2%	12.1%	14.1%	
70:30 (BES at 18% Vol)	29.2%	8.8%	9.8%	10.9%	12.9%	14.9%	17.0%	19.0%	

Probability Weighted Strategy Returns – Based on Black Monday, 1987*

-20% Speed	Sudden Crisis Scenario	Average Benign Return	Return Expectation for an X% Probability of -20% Crisis Occuring						
Scenarios and Probabilities	**VIX+140**	**VIX+0**	**5%**	**10%**	**20%**	**30%**	**40%**	**50%**	**Dominant Portfolio**
AV Volatiltiy	119.2%	-5.0%	1.2%	7.4%	19.8%	32.3%	44.7%	57.1%	
Current Industry Models (10% Vol)	-19.8%	7.9%	6.5%	5.1%	2.4%	-0.4%	-3.2%	-5.9%	**Lower Expected Return Portfolios**
Equity CapTrend (10% Vol)	-1.8%	2.4%	2.2%	2.0%	1.6%	1.1%	0.7%	0.3%	
BES Trend 10% Vol Target	-4.4%	8.2%	7.6%	6.9%	5.7%	4.4%	3.2%	1.9%	**Dominant Portfolios**
BES Trend 18% Vol Target	-7.9%	14.8%	13.6%	12.5%	10.2%	8.0%	5.7%	3.5%	
70:30 (BES at 10% Vol)	32.7%	4.2%	5.7%	7.1%	9.9%	12.8%	15.6%	18.5%	
70:30 (BES at 18% Vol)	30.3%	8.8%	9.9%	11.0%	13.1%	15.3%	17.4%	19.6%	

**See disclaimer for limitations of hypothetical returns.*

A Combined BES Trend and AV Volatility Solution - Summary

Combining two well-constructed building blocks, BES Trend and an AV Volatility exposure, allows an investor to construct a dominant portfolio solution that offers a higher expected return per unit of Crisis Alpha across a broad range of market crisis probabilities. Whereas the individual portfolio building blocks typically embed a tradeoff between path dependency and cost, the combined 70:30 Portfolio may offer both positive expected returns (from low levels of volatility available at the time of writing) in benign markets while also providing significant Crisis Alpha that is robust across varying market shock speeds.

Conclusion

The Trend industry has undergone significant changes post the 2008 crisis. Current Industry Trend Models may be slower to react to market reversals and will likely deliver less upside volatility than in the past. These results are consistent with some CTAs increasing capacity at the cost of providing less Crisis Alpha for investors. As a result there is an increasing need for investors to be selective as to where to source their Crisis Alpha. Aligned strategies will be pure Trend solutions (not diluted by mean reversion, short volatility, etc.) that have been built with the ability to react to sudden reversals in risk-assets. These strategies should also be run at a volatility target consistent with delivering meaningful payoffs when needed. The trade-off between capacity and reactivity means that small and mid-size CTAs are in a strong position to offer an optimal Crisis Alpha strategy.

Trend strategies should be expected to generate meaningful losses in a sudden reversal of an uptrend in risk-assets. By quantifying the magnitude of such losses, we hope this whitepaper will help any investors who rely on Trend to generate Crisis Alpha, to address this gap in their portfolio construction. A long volatility exposure may fill this gap. A long volatility strategy that is actively managed with a value approach and the ability to monetize gains by rotating exposure across asset classes may offer positive expected returns from the low levels of volatility prevalent across markets at the time of writing. A combined BES Trend and AV Volatility portfolio may outperform both Equity Capped Trend strategies and the Trend strategies represented in the Trend Index, during market selloffs irrespective of the speed of a market selloff. This may be achieved while delivering positive expected returns in benign market conditions. These characteristics make a combined BES Trend and AV Volatility portfolio a robust Crisis Alpha solution with an attractive risk/reward ratio.

Please contact Stefan Pollmann, Head of Business Development, for any questions on this whitepaper or One River's strategies.

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