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Volatility and the Alchemy of Risk

Reflexivity in the Shadows of Black Monday 1987

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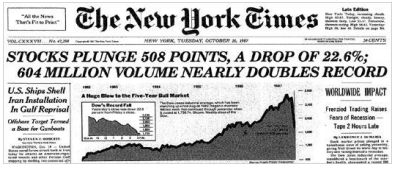
The Ouroboros, a Greek word meaning 'tail devourer', is the ancient symbol of a snake consuming its own body in perfect symmetry. The imagery of the Ouroboros evokes the infinite nature of creation from destruction. The sign appears across cultures and is an important icon in the esoteric tradition of Alchemy. Egyptian mystics first derived the symbol from a real phenomenon in nature. In extreme heat a snake, unable to self-regulate its body temperature, will experience an out-of-control spike in its metabolism. In a state of mania, the snake is unable to differentiate its own tail from its prey, and will attack itself, self-cannibalizing until it perishes. In nature and markets, when randomness self-organizes into too perfect symmetry, order becomes the source of chaos [(1)].

The Ouroboros is a metaphor for the financial alchemy driving the modern Bear Market in Fear. Volatility across asset classes is at multi-generational lows. A dangerous feedback loop now exists between ultra-low interest rates, debt expansion, asset volatility, and financial engineering that allocates risk based on that volatility. In this self-reflexive loop volatility can reinforce itself both lower and higher. In a market where stocks and bonds are both overvalued, financial alchemy is the only way to feed our global hunger for yield, until it kills the very system it is nourishing.

The Global Short Volatility trade now represents an estimated $2+ trillion in financial engineering strategies that simultaneously exert influence over, and are influenced by, stock market volatility[(2)]. We broadly define the short volatility trade as any financial strategy that relies on the assumption of market stability to generate returns, while using volatility itself as an input for risk taking. Many popular institutional investment strategies, even if they are not explicitly shorting derivatives, generate excess returns from the same implicit risk factors as a portfolio of short optionality, and contain hidden fragility.

Volatility is now an input for risk taking and the source of excess returns in the absence of value. Lower volatility is feeding into even lower volatility, in a self-perpetuating cycle, pushing variance to the zero bound. To the uninitiated this appears to be a magical formula to transmute ether into gold… volatility into riches… however financial alchemy is deceptive. Like a snake blind to the fact it is devouring its own body, the same factors that appear stabilizing can reverse into chaos. The danger is that the multi-trillion-dollar short volatility trade, in all its forms, will contribute to a violent feedback loop of higher volatility resulting in a hyper-crash. At that point the snake will die and there is no theoretical limit to how high volatility could go.


The New York Times
STOCKS PLUNGE 508 POINTS, A DROP OF 22.6%; 604 MILLION VOLUME NEARLY DOUBLES RECORD
WORLDWIDE IMPACT

Thirty years ago to the day we experienced that moment. On October 19th, 1987 markets around the world crashed at record speed, including a **-20%** loss in the S&P 500 Index, and a spike to over **150%** in volatility. Many forget that Black Monday occurred during a booming stock market, economic expansion, and rising interest rates. In retrospect, we blame portfolio insurance for creating a feedback loop that amplified losses. In this paper we will argue that **rising inflation** was the spark that ignited 1987 fire, while computer trading served as explosive nitroglycerin that amplified a normal fire into a cataclysmic conflagration. ***The multi-trillion-dollar short volatility trade, broadly defined in all its forms, can play a similar role today if inflation forces central banks to raise rates into any financial stress.*** Black Monday was the first modern crash driven by machine feedback loops, and it will not be the last.

A reflexivity demon is now stalking modern markets in the shadows of a false peace… and could emerge violently given a rise in interest rates. Non-linearity and feedback loops are difficult for the human mind to conceptualize and price. The markets are not correctly assessing the probability that volatility reaches new all-time lows in the short term (VIX<9), and new all-time highs in the long-term (VIX>80). Risk alone does not define consequences. A person can engage in highly risky behavior and survive, and alternatively a low risk activity can result in horrible outcomes. Those who defend and profit from the short volatility trade in its various forms ignore this fact. Do not mistake outcomes for control… remember,

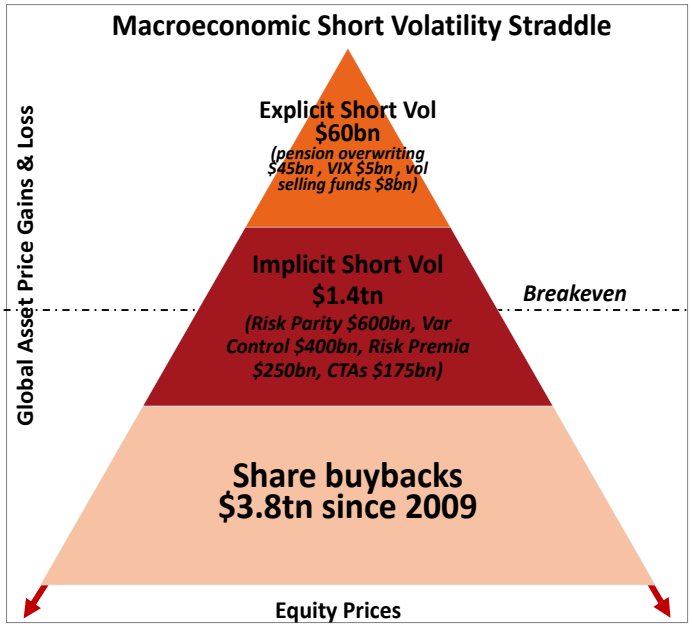
There is no such thing as control… there are only probabilities [(3)]

The Great Snake of Risk

A short volatility risk derives small incremental gains on the assumption of stability in exchange for a substantial loss in the event of change. When volatility itself serves as a proxy to size this risk, stability reinforces itself until it becomes a source of instability. The investment ecosystem has effectively self-organized into one giant short volatility trade, a snake eating its own tail, nourishing itself from its own destruction. It may only take a rapid and unexpected increase in rates, or geopolitical shock, for the cycle to unwind violently. It is not wise to expect that central banks will save financial markets if inflation begins to rise.

At the head of the Great Snake of Risk is unprecedented monetary policy. Since 2009 Global Central Banks have pumped in $15 trillion in stimulus creating an imbalance in the investment demand for and supply of quality assets[4]. Long term government bond yields are now the lowest levels in the history of human civilization dating back to 1285[5]. As of this summer there was $9.5 trillion worth of negative yielding debt globally. Last month Austria issued a 100-year bond with a coupon of only 2.1%[6] that will lose close to half its value if interest rates rise 1% or more. The global demand for yield is now unmatched in human history. None of this makes sense outside a framework of financial repression.

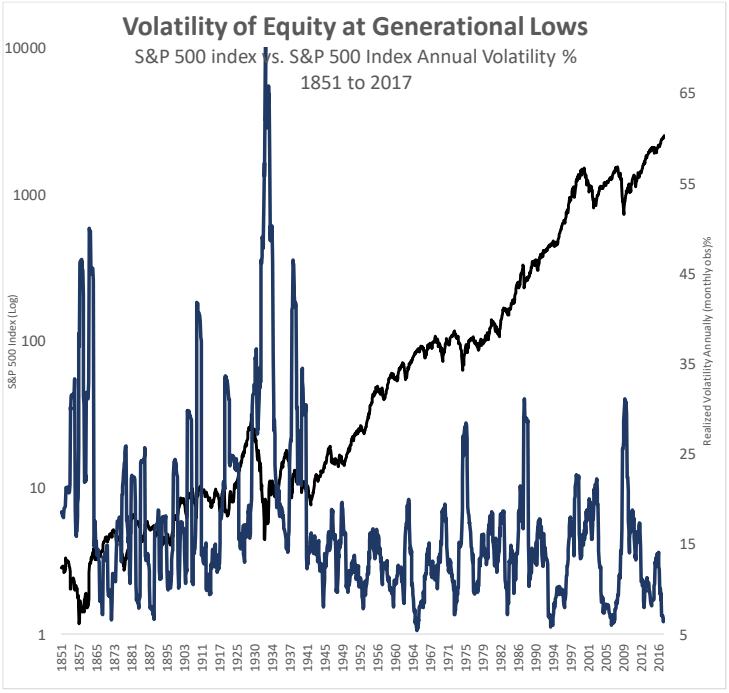
Amid this mania for investment, the stock market has begun self-cannibalizing… literally. Since 2009, US companies have spent a record $3.8 trillion on share buy-backs[7] financed by historic levels of debt issuance. Share buybacks are a form of financial alchemy that uses balance sheet leverage to reduce liquidity generating the illusion of growth. A shocking +40% of the earning-per-share growth and +30% of the stock market gains since 2009 are from share buy-backs. Absent this financial engineering we would already be in an earnings recession. Any strategy that systematically buys declines in markets is mathematically shorting volatility. To this effect, the trillions of dollars spent on share buybacks are equivalent to a giant short volatility position that enhances mean reversion. Every decline in markets is aggressively bought by the market itself, further lowing volatility. Stock price valuations are now at levels which in the past have preceded depressions including 1928, 1999, and 2007. The role of active investors is to find value, but when all asset classes are overvalued, the only way to survive is by using financial engineering to short volatility in some form.

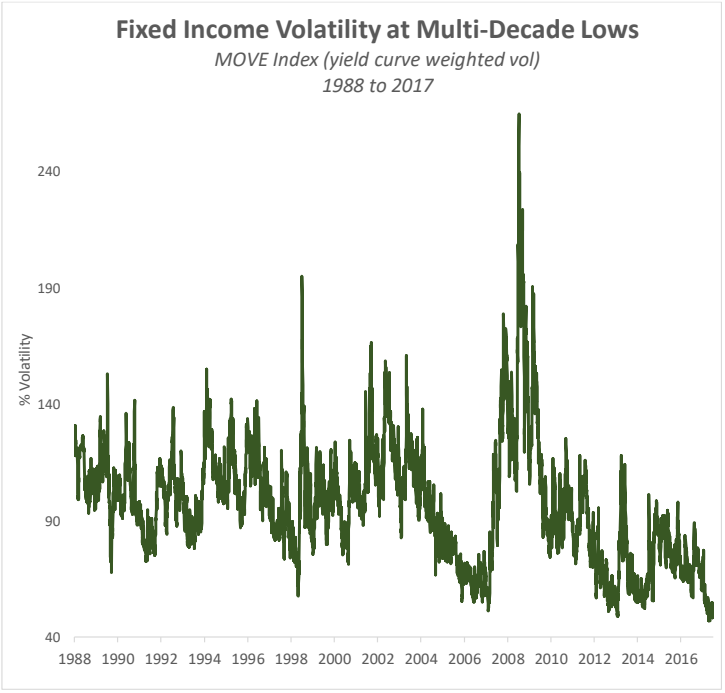


Volatility as an asset class, both explicitly and implicitly, has been commoditized via financial engineering as an **alternative form of yield**. Most people think volatility is just about options, however many investment strategies create the profile of a short option via financial engineering. A long dated short option position receives an upfront yield for exposure to being short volatility, gamma, interest rates, and correlations. Many popular institutional investment strategies bear many, if not all, of these risks even if they are not explicitly shorting options. The short volatility trade, broadly defined in all its forms, includes up to $60 billion in strategies that are **Explicitly short volatility**[(2efg)] by directly selling optionality, and a much larger $1.42 trillion of strategies that are **Implicitly short volatility**[(2abcd)] by replicating the exposures of a portfolio that is short optionality. Lower volatility begets lower volatility, rewarding strategies that systematically bet on market stability so they can make even bigger bets on that stability. Investors assume increasingly higher levels of risk betting on the status quo for yields that look attractive only in comparison to bad alternatives. The active investor that does his or her job by hedging risks underperforms the market. Responsible investors are driven out of business by reckless actors. In effect, the entire market converges to what professional option traders call a 'naked short straddle'… a structure dangerously exposed to fragility.

Volatility is now at multi-generational lows…

Volatility is now the only undervalued asset class in the world. Equity and fixed income volatility are now at the lowest levels in financial history. The realized volatility of the S&P 500 Index collapsed to all-time lows in October 2017. The VIX index also touched new lows around the same time. Fixed income implied volatility fell to the lowest level in its 30-year history this past summer. The forward variance swap on the S&P 500 index is now priced lower than the long-term average volatility of the market. In theory, volatility has nowhere to go but up, but lacks a catalyst given the easy credit conditions, low rates, and excess supply of investment capital.

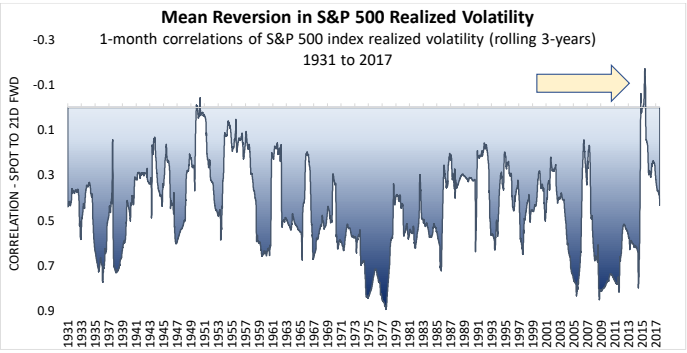


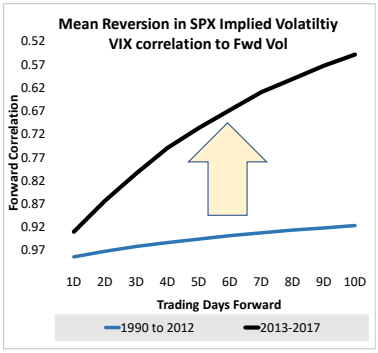


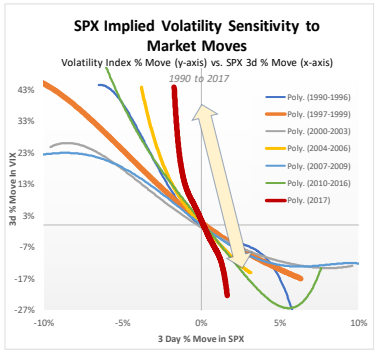
Source: Global Financial Data, Artemis Capital Management LP

Whenever volatility reaches a new low the financial media runs the same cliched story over and over with the following narrative 1) Volatility is low; 2) Investors are complacent; 3) Insert manager quote saying "this is the calm before the storm" [8]. Low volatility does not predict higher volatility over shorter periods, in fact empirically the opposite has been true. Volatility tends to cluster in high and low regimes.

Volatility isn't broken, the market is… the real story of this market is not the level of volatility, but rather its highly unusual behavior. Volatility, both implied and realized, is mean reverting at the greatest level in the history of equity markets. Any short term jump in volatility mean reverts lower at unusual speed, as evidenced by volatility collapses after the June 2016 Brexit vote and November 2016 Trump US election victory. Volatility clustering month-to-month reached 90-year lows in the three years ending in 2015. Implied volatility has also been usually reactive to the upside and downside. In 2017, the VIX index has been 3-4x more sensitive to movements in the market compared to the similar low-volatility regime of the mid-2000s and the mid-1990s (see **red** line in right chart).







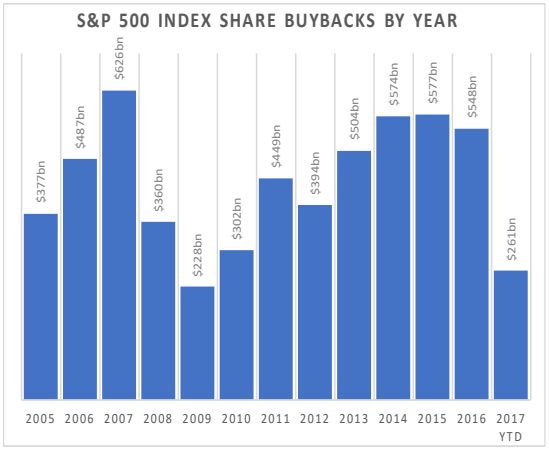
Source: Bloomberg, Artemis Capital Management

What is causing this bizarre behavior? To find the truth we must challenge our perception of the problem... ***What we think we know about volatility is all wrong.*** Modern portfolio theory conceives volatility as an external measurement of the intrinsic risk of an asset. This highly flawed concept, widely taught in MBA and financial engineering programs, perceives volatility as an exogenous measurement of risk, ignoring its role as both a source of excess returns, and a direct influencer on risk itself. To this extent, portfolio theory evaluates volatility the same way a sports commentator sees hits, strikeouts, or shots on goal. Namely, a statistic measuring the past outcomes of a game to keep score, but existing externally from the game. **The problem is volatility isn't just keeping score, but is massively affecting the outcome of the game itself in real time. Volatility is now a player on the field.** This critical mis-understanding of the role of volatility modern markets is a source of great self-reflexive risk.

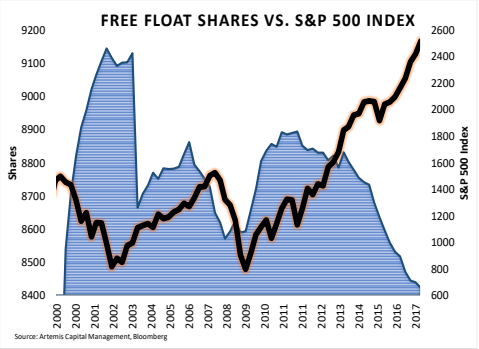
Today trillions of dollars in central bank stimulus, share buybacks, and systematic strategies are based on market volatility as a key decision metric for leverage. Central banks are now actively using volatility as an input for their decisions, and market algorithms are then self-organizing around the expectation of that input. The majority of active management strategies rely on some form of volatility for excess returns and to make leverage decisions. When volatility is no longer a measurement of risk, but rather the key input for risk taking, we enter a self-reflexive feedback loop. Low volatility reinforces lower volatility… but any shock to the system will cause high volatility to reinforce higher volatility.

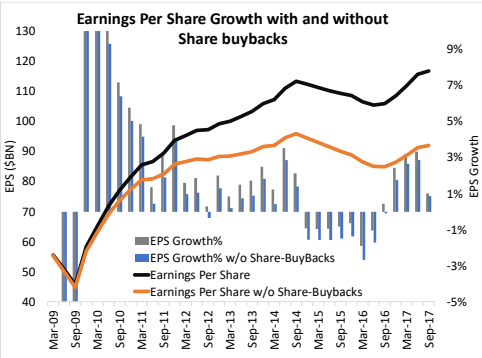
Self-Canibalization of the Market via Share buybacks

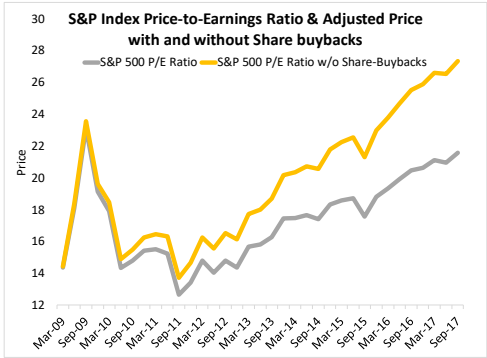
The stock market is consuming itself…literally. Since 2009, US companies have spent over $3.8 trillion on what is effectively one giant leveraged short volatility position. Share buybacks in the current market have already surpassed previous highs reached before the 2008. Rather than investing to increase earnings, managers simply issue debt at low rates to reduce the shares outstanding, artificially boosting earnings-per-share by increasing balance sheet risk, thereby increasing stock prices. In 2015 and 2016 companies spent more than their entire annual operating earnings on share buybacks and dividends. Artemis isolated the impact of the share buyback phenomenon on earnings, asset prices, and valuations since 2009 and the numbers are staggering.

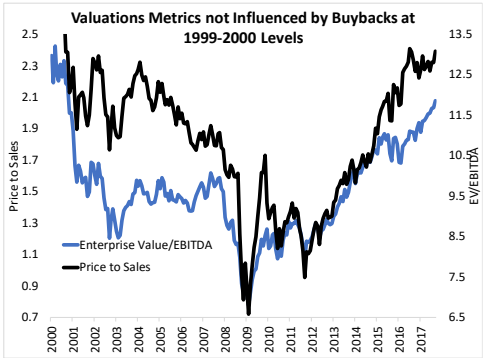


The later stages of the 2009-2017 bull market are a valuation illusion built on share buyback alchemy. Absent this accounting trick the S&P 500 index would already be in an earnings recession. Share buybacks have accounted for +40% of the total earning-per-share growth since 2009, and an astounding +72% of the earnings growth since 2012. Without share buybacks earnings-per-share would have grown just +7% since 2012, compared to +24%. Since 2009, an estimated +30% of the stock market gains are attributable to share buybacks. Without share buybacks the S&P 500 index would currently trade at an expensive 27x earnings. Not surprisingly, a recent study found a positive relationship between insider equity sales and share repurchases, supporting the idea that buybacks are more about managerial self-interest than shareholder value[9].



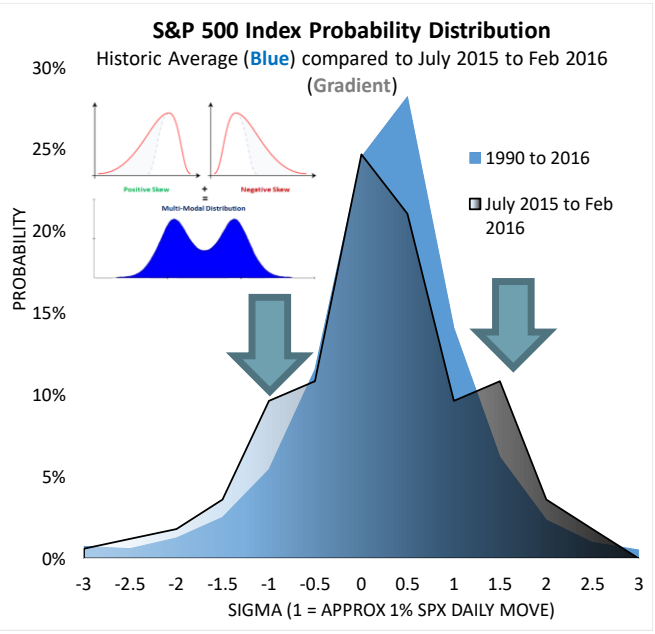






Share buybacks financed by debt issuance are a valuation magic trick. The technique optically reduces the price-to-earnings multiple (Market Value per Share/Earnings per Share) because the denominator doesn't adjust for the reduced share count. The buyback phenomenon explains why the stock market can look fairly valued by the popular price-to-earnings ratio, while appearing dramatically overvalued by other metrics. Valuation metrics less manipulated by share buybacks (EV/EBITDA, P/S, P/B, Cyclically Adjusted P/E) are at highs achieved before market crashes in 1928, 2000, and 2007. Buybacks also remove liquidity. Free float shares and trading volume in the S&P 500 index have collapsed to levels last seen in the late-1990s, despite stock prices more than doubling.

Share buybacks are a major contributor to the low volatility regime because a large price insensitive buyer is always ready to purchase the market on weakness. The key periods are the two to three weeks during and after earnings announcements, when the SEC mandated share buyback blackout period officially ends. The largest equity drawdowns of the past few years (August 2015 and January-Feb 2016) both occurred during the share buyback blackout period. Both times the market rallied to make back all losses when the buyback restriction period expired. The S&P 500 index demonstrates an unusual multi-modal probability distribution during years with high buyback activity. The market flips between a positively or negatively skewed return distribution based on whether the regulatory share repurchase blackout period is in effect. In addition, 6 of the top 10 multi-day VIX declines in history, all 4+ sigma events, have occurred during heavy share buyback periods between 2015 and 2016. Share buybacks result in lower volatility, lower liquidity, which in turn incentivizes more share buybacks, further incentivizing passive and systematic strategies that are short volatility in all their forms.

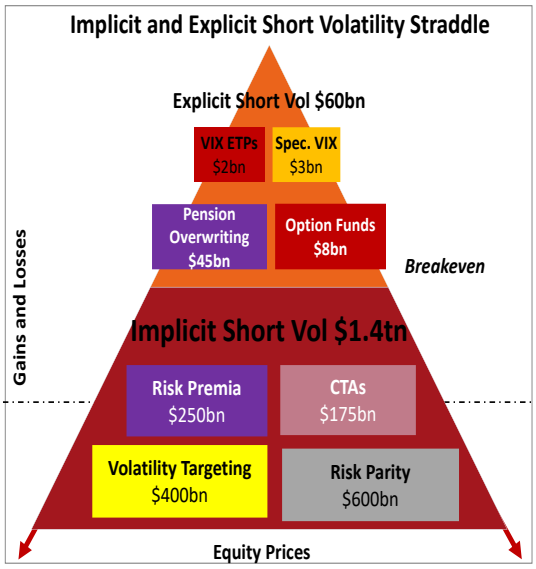


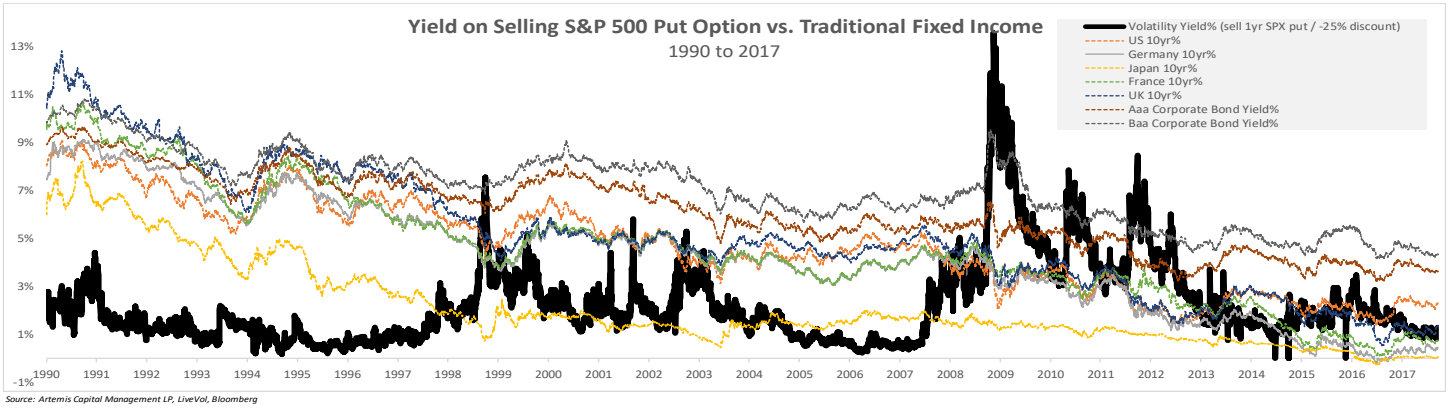
Source: Artemis Capital Management LP, Bloomberg

Like a snake eating its own tail, the market cannot rely on share buybacks indefinitely to nourish the illusion of growth. Rising corporate debt levels (see page 11) and higher interest rates are a catalyst for slowing down the $500-800 billion in annual share buybacks artificially supporting markets and suppressing volatility[2j].

Global Short Volatility Trade

The short volatility trade is any strategy that derives small incremental gains on the assumption of stability in exchange for substantial loss in the event of change, whereby volatility is a critical input to the allocation of risk. Short volatility can be executed explicitly with options, or implicitly via financial engineering. To understand this concept, it is helpful to decompose the key risks. The investor holding a portfolio of hedged short options receives an upfront premium, or yield, in exchange for a non-linear risk profile to four key exposures 1) Rising Volatility; 2) Gamma or Jump Risk; 3) Rising Interest Rates; 4) Unstable Cross-Asset Correlations. Many institutional strategies derive excess returns by implicitly shorting those exact same risk factors despite never trading an option or VIX future. ***As of 2017, there is an estimated $1.12 to 1.5 trillion USD[2] of active short volatility exposure in domestic equity markets.*** In this paper we will focus on short volatility in US equity markets, however the short volatility trade, in all its forms, is widely practiced across all major asset classes. In world of ultra-low interest rates shorting volatility has become an alternative to fixed income. For the first time in history the yield earned on an explicit short volatility position is competitive with a wide array of sovereign and corporate debt (see below).





Explicit Short Volatility are strategies that literally sell options to generate yield from asset price stability or falling stock market variance. The category includes everything from popular short volatility exchange-traded-products to call and put writing programs employed by pension funds. Despite the headlines, this is the smallest portion of the short volatility trade. Explicit short volatility contains upward of only $60 billion in assets, including $45 billion in short volatility pension put and call writing strategies[2g], $8 billion in short volatility overwriting funds[2f], $2 billion in short volatility exchange traded products[2e], and another $3 billion in speculative VIX shorts[2e]. Explicit short volatility strategies are active in the short term, fading short and intermediate volatility spikes. Volatility spikes that mean revert quickly help the performance of these strategies (August 2015). Explicit short volatility is most harmed by an extended period of high volatility that fails to mean revert, such as in 1928 or 2008, or a super-normal volatility spikes such as the Black Monday 1987 crash.

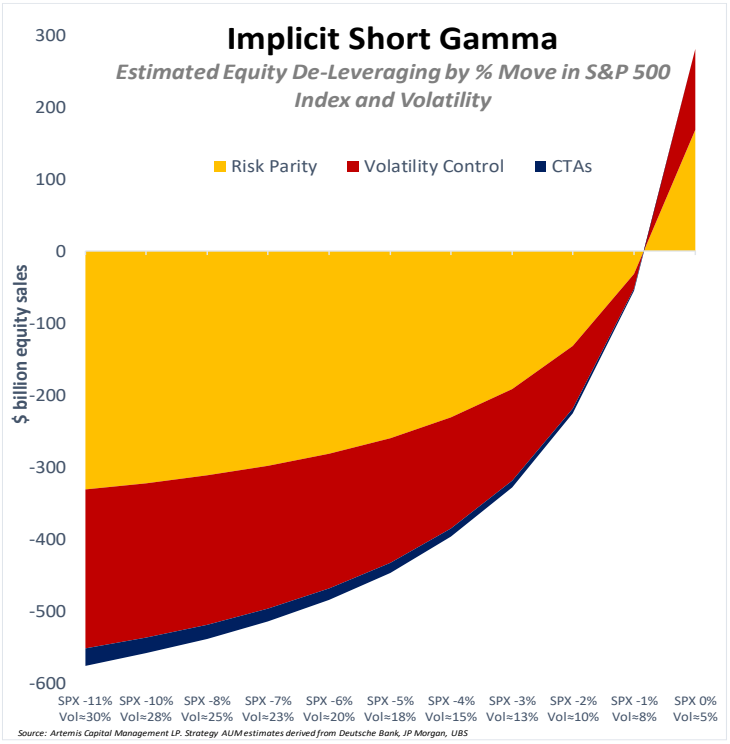
Implicit Short Volatility are strategies that, although not directly selling options, use financial engineering to generate excess returns by exposure to the same risk factors as a short option portfolio. Many investors, and even practitioners, are ignorant or in denial that they are holding a synthetic short option in their portfolio. In current markets, there is an estimated $1.12 to $1.42 trillion in implicit short volatility exposure, including between $400 billion in volatility control funds [2b], $400 to $600 billion in risk parity[2a], $70-175 billion from long equity trend following strategies[2c], and $250 billion in risk premia strategies[2d]. These strategies are similar to a short option position because they produce efficient gains most of the time, but are subject to non-linear losses based on variance, gamma, rates, or correlation change. The strategies tend to have longer time horizons for rebalancing than explicit short volatility. In practice, exposure to equities is reduced based on the accumulation of variance over one to three months.

The next few pages will focus on some of the hidden risks in the short volatility trade, both explicitly and implicitly.

Gamma Risk

Imagine you are balancing a tall ruler vertically on your palm. As the ruler tilts in any one direction, you must to overcompensate in the same direction to keep to the ruler balanced. This is conceptually very similar to a trader hedging an option with high gamma risk. The trader must incrementally sell (or buy) more of the underlying at a non-linear pace to re-hedge price fluctuations.

A short gamma risk profile is not unique to option selling, and is a hidden component of many institutional asset management products. The portfolio insurance strategy credited with causing the 1987 Black Monday Crash is a classic example of a short gamma profile gone awry. When large numbers of market participants are short gamma, implicitly or explicitly, the effect can reinforce price direction into periods of high turbulence. Risk parity, volatility targeting funds, and long equity trend following funds are all forced to de-leverage non-linearly into periods of rising volatility, hence they have synthetic gamma risk. At current risk levels, we estimate as much as $600 billion in selling pressure would emerge from implicit short gamma exposure if the market declined just **-10%** with higher vol [(10)]. Many of these strategies rely on accumulation of one to three month realized variance to trigger that de-leveraging process. Hence the short gamma buying and selling pressure operates on a time lag to the market. During the drawdowns in the fall of 2015 and early-2016, share buybacks helped the market rebound quickly minimizing the effect of 'short-gamma'' de-leveraging. This further emboldened explicit short volatility traders to continue to fade any volatility spikes. If the first leg of a crisis is strong enough to sustain a market loss beyond -10%, short-gamma de-leveraging will likely kick-start a second leg down, causing cascading losses for anyone that buys the dip.

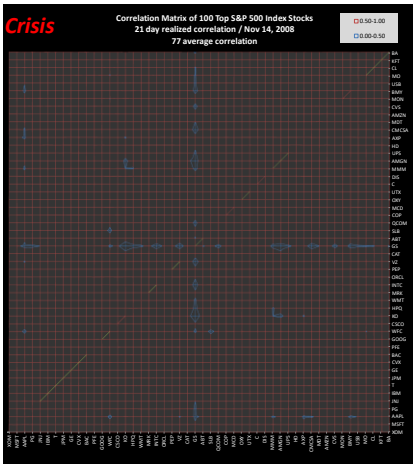


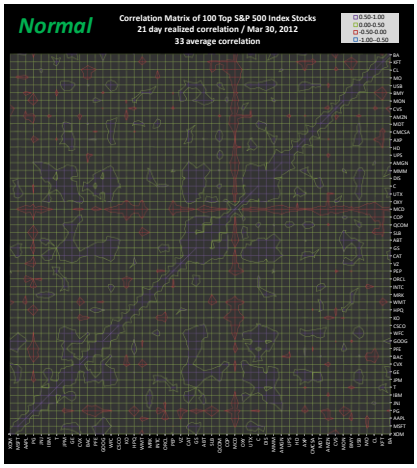
Correlation and Interest Rate Risk

The concept of diversification is the foundation of modern portfolio theory. Like a wizard, the financial engineer is somehow able to magically reduce the risk of a portfolio by combining anti-correlated assets. The theory failed spectacularly in the 2008 crash when correlations converged. You can never destroy risk, only transmute it. All modern portfolio theory does is transfer price risk into hidden short correlation risk. There is nothing wrong with that, except for the fact it is not what many investors were told, or signed up for.

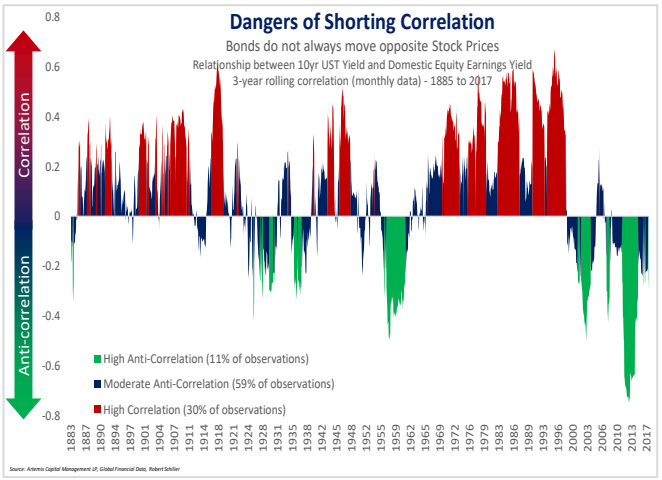
Correlation risk can be isolated and actively traded via options as source of excess returns. Volatility traders on a dispersion desk will explicitly short correlations by selling the variance of an index and going long the weighted variance of its constituents. When correlations are stable or decreasing, the strategy is very effective, but when correlations behave erratically large losses will occur. The graph to the right shows the collapse of correlations between normal and stressed markets.

Many popular institutional investment strategies derive excess returns via implicit leveraged short correlation trades with hidden fragility





Risk parity is a popular institutional investment strategy with close to half a trillion dollars in exposure[2a]. The strategy allocates risk and leverage based on variance assuming stable correlations. To a volatility trader, risk parity looks like one big dispersion trading desk. The risk parity strategy, decomposed, is actually a portfolio of leveraged short correlation trades (alpha) layered on top of linear price exposure to the underlying assets (beta). The most important correlation relationship is between stocks and bonds. A levered short correlation trade between stocks and bonds has performed exceptionally well over the last two decades including in the last financial crisis. From 2008 to 2009 gains on bonds offset losses in the stock market as yields fell. To achieve a similar benefit in a crisis today, the 10-year Treasury Note would need to collapse to from 2.32% to -0.91%. This is not impossible, but historically there is a much higher probability that bonds and stocks rise or fall together when rates are this low.



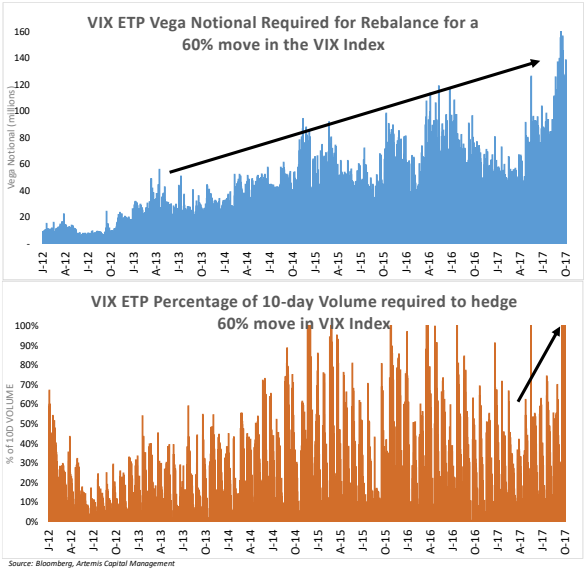
The truth about the historical relationship between stocks and bonds over 100+ years is illuminating (please see our 2015 paper "Volatility and the Allegory of the Prisoner's Dilemma" for more detail). Between 1883 and 2015 stocks and bonds spent more time moving in tandem (30% of the time) than they spent moving opposite one another (11% of the time)[11]. Stocks and bonds experienced extended periods of dual losses every 50 years. It is only during the last two decades of falling rates, accommodative monetary policy, and globalization that we have seen an extraordinary period of anti-correlation emerge. At best the anti-correlation between stocks and bonds may cease to be a source of alpha, and at worst it may the driver of significant reflexive losses.

Volatility Risk

With interest rates at all-time lows shorting volatility has become an alternative to fixed income for yield starved investors. The phenomenon is not new to Japan. For nearly two decades banks packaged and sold hidden short volatility exposure to Japanese retirees via wealth products called Uridashi. Uridashi notes pay a coupon well above the yield earned on Japanese debt based on knock-out and knock-in levels to the Nikkei index. In 2016 there was an estimated $13.2 billion USD in Uridashi issuance[12]. Now that low rates are global the short volatility trade is expanding to retail investors beyond Japan.

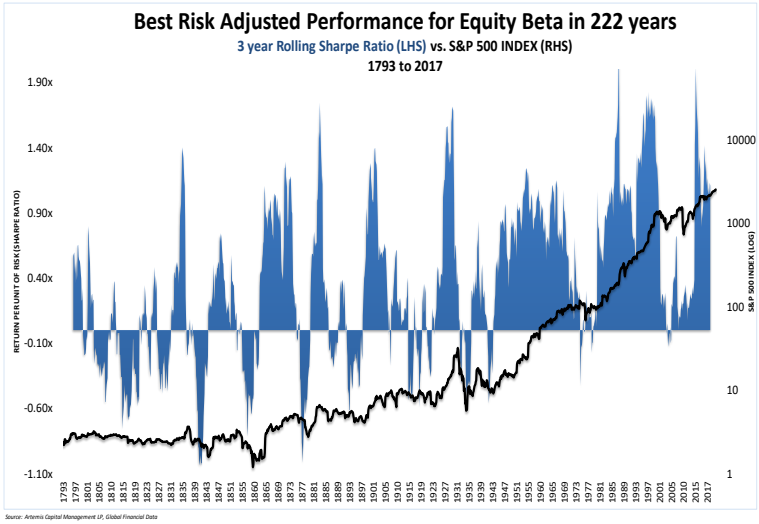
In the US short volatility has emerged as a get-rich-quick scheme for many of these smaller investors. The short VIX exchange traded complex, at approximately $2 billion in listed assets, is the smallest but most wild segment of the global short volatility trade. In the past you had to be a big Wall Street trading desk ('Bear Stearns') or hedge fund ("LTCM") to blow yourself up shorting volatility. Not anymore. The emergence of listed VIX products democratized the trade. A story in the New York Times details the exploits of an ex-Target manager who made millions shorting a 2x leveraged VIX ETP[13]. Such stories harken back to the dotcom bubble of the late 1990s when day-traders quit their jobs to flip internet stocks before the crash.

When everyone is on one side of the volatility boat, it is much more likely to tip over. Short and leveraged volatility ETNs contain implied **short gamma** requiring them to buy (sell) a non-linear amount of VIX futures the more volatility rises (falls). The risk of a complete wipe out in the inverse-VIX complex in a single day is a very real possibility given the wrong shock (as Artemis first warned in 2015). The largest one day move in the VIX index was the **+64%** jump on February 27, 2007. If a similar move occurred today a liquidity gap would likely emerge. The chart to the right estimates the volatility notional required for a **+60%** shock in the VIX given supply-demand dynamic over the past five years. For a **+60%** move in VIX we estimate ETPs would be required to buy $138 million in vega notional in the front two contracts alone, equivalent to 142k VIX contracts[12]. This is over 100% of the average daily trading volume. In this event, inverse-VIX products will experience an "unwind event" resulting in major losses for scores of retail investor. Those shorting leveraged VIX products will have unmeasurable losses. The products are a class-action lawsuit waiting to happen.

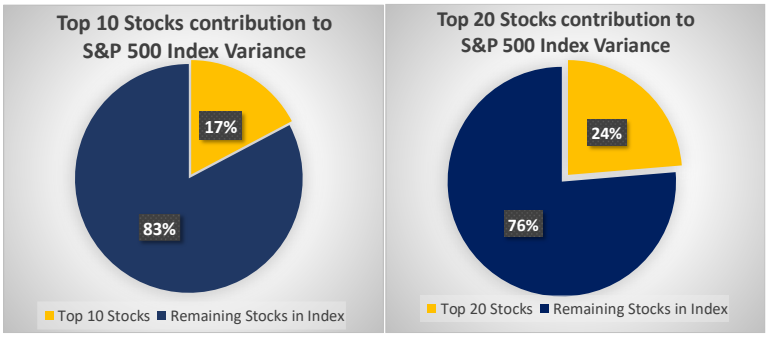


Shadow Risk in Passive Investing

Peter Diamandis, the entrepreneur and founder of the X prize, said it best, "If you want to become a billionaire, find a way to help a billion people". The purpose of efficient markets is to allocate capital to institutions that add the most value. In a market without value, the only thing left to do is to allocate based on liquidity. The massive stimulus provided by central banks resulted in the best risk-adjusted returns for passive investing in over 200 years between 2012 and 2015. Today investors are chasing that historical performance. By the start of 2018, 50% of the assets under management in the US will be passively managed according to Bernstein Research. Since the recession $2 trillion is assets have migrated from active to passive and momentum strategies according to JP Morgan.



Passive investing is now just a momentum play on liquidity. Large capital flows into stocks occur for no reason other than the fact that they are highly liquid members of an index. All stocks in the index go up and down together, regardless of fundamentals. In effect, the volatility of the entire stock market can become dominated by a small number of companies and correlation relationships. For example, the top 10 stocks in the S&P 500 index, comprising only 2% of index membership, now control upward of 17% of the variance of the entire market. The largest 20 companies, or 4% of companies, are responsible for 24% of the variance.



Source: Bloomberg, Artemis Capital Management

The shift from active to passive investing is a significant amplifier of future volatility. Active managers serve as a volatility buffer, willing to step in and buy undervalued stocks when the market is falling, and sell overvalued stocks when the market is rising too much. Remove that buffer, and there is no incremental seller to control overvaluation on the way up, and no incremental buyer to stop a crash on the way down.

Shadow Risk in Machine Learning

Let's pretend you are programmer using artificial intelligence ("AI") to develop a self-driving car. You "train" the AI algorithm by driving the car thousands of miles through the desert. AI learns much faster than any human, so after a short period, the car able to drive at 120 miles per hour with perfect precision and safety. Now the car is ready for a cross-country trip. The self-driving car works flawlessly, driving with record speed through the city, desert, and flatlands. However, when it reaches the steep and twisting roads of the mountain the car drives right off a cliff and explodes. The fatal flaw is that your driving algorithm has never seen a mountain road. AI is always driving by looking in the rear-view mirror.

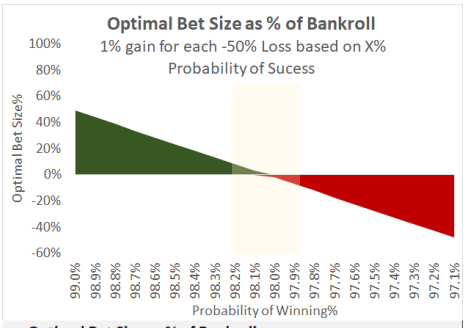
Markets are not a closed system. The rules change. As machines trade against machines, self-reflexivity risk is amplified. 90% of the world's data across history has been generated over the last two years. It is very hard to find quality financial data at actionable time increments going back past 20 or even 10 years. Now what if we give all the available data, most of it extremely recent, to a machine to manage money? The AI machine will optimize to what has worked over that short data set, namely a massively ***leveraged short volatility trade***. For this reason alone, expect at-least one major massive machine learning fund with excellent historical returns to fail spectacularly when the volatility regime shifts… This will be a canary in the coal mine.

Conceptual Mistakes in Shorting Volatility

"I can't wait for the next crisis because I can sell volatility at even higher levels!" said one institutional asset manager at a conference. This is a commonly held but very dangerous assumption. Many investors compare shorting volatility to selling insurance. The option seller collects an upfront premium with frequent gains but large negative exposure to uncommon events. It is typical to erroneously conclude that selling volatility can never lose money if you keep systematically rolling the trade forward. The flaw in this logic is the assumption risk events are independent and probabilities consistent. In markets this is never the case.

Let's play a game. You get to bet on a rigged coin with a 99% probability of landing on heads in your favor. If the coin lands on heads, you win **+1%** of your bankroll, but if it lands on tails, you lose **-50%**. Do you play? Yes, the game has a positive expected return, and given the law of large numbers you will always succeed if you keep playing. Consider that if the probabilities decrease to a 98% success rate, the game becomes a net loser. Remarkably, a 1% change in probability is the only thing that separates a highly profitable strategy from cataclysmic loss (see the statistics below). Small changes in probabilities have an outsized effect on the profitability of any strategy with small frequent gains and large infrequent losses.

The coin game is similar to a systematic short volatility strategy, except in life you never know which coin, positive or negative, you are betting on at any given time. Worse yet, in self-reflexive markets the probabilities between coin flips become correlated based on outcomes. For each loosing coin flip, the likelihood for another loss increases and vice versa! You start with 99% odds and a positive expected strategy, but after the first loss, the odds reduce to 90%. After two losses in ten, the odds fall to 50%. It is not the first loss, or leg down in markets that hurts you, but rather the second and third. Systematic short volatility without accounting for shifting probabilities is akin to doubling down at a casino into bad odds. Don't fool yourself… this is exactly how financial crises develop.



Optimal Bet Size as % of Bankroll

Probability of Gain (%) \ % Loss of Capital for 1% gain	-10%	-20%	-30%	-40%	-50%	-60%	-70%	-80%	-90%
99.5%	95%	90%	85%	80%	75%	70%	65%	60%	55%
99.00%	89%	79%	69%	59%	49%	39%	29%	19%	9%
98.50%	84%	69%	54%	38%	23%	8%	-7%	-22%	-37%
98.00%	78%	58%	38%	18%	-2%	-22%	-42%	-62%	-82%
97.50%	73%	47%	22%	-3%	-28%	-53%	-78%	-103%	-128%
97.00%	67%	37%	7%	-23%	-53%	-83%	-113%	-143%	-173%
96.50%	62%	26%	-9%	-44%	-79%	-114%	-149%	-184%	-219%
96.00%	56%	16%	-24%	-64%	-104%	-144%	-184%	-224%	-264%
95.50%	51%	5%	-40%	-85%	-130%	-175%	-220%	-265%	-310%
95.00%	45%	-5%	-55%	-105%	-155%	-205%	-255%	-305%	-355%

Source: Artemis Capital Management

Shorting volatility, in of itself, is not necessarily a bad thing if executed thoughtfully at the right margin of safety. In our 2012 paper "Volatility at World's End" we correctly argued, against our self-interest, for the overvaluation of portfolio insurance in what we coined a "Bull Market in Fear' between 2009 and 2012. At the time tail risk hedging was very popular and investors shorting volatility had a high margin of safety. For the reasons detailed in this paper, we believe the exact opposite today.

Intrinsic Value and Volatility

This past summer the ever-wise Jim Grant of Grant's Interest Rate Observer asked for my thoughts on the low volatility regime. In the middle of my explanation on the short volatility trade, out of nowhere, Jim says, "What does any of this have to do with intrinsic value?" I was floored… I honestly didn't know how to answer his question. The truth… the short volatility trade is about the absence of value. In a bull market, when investors can't find value in traditional assets, they must manufacture yield through financial engineering. In a mania the system begins to devour its own tail.

The difference between risk and outcomes…

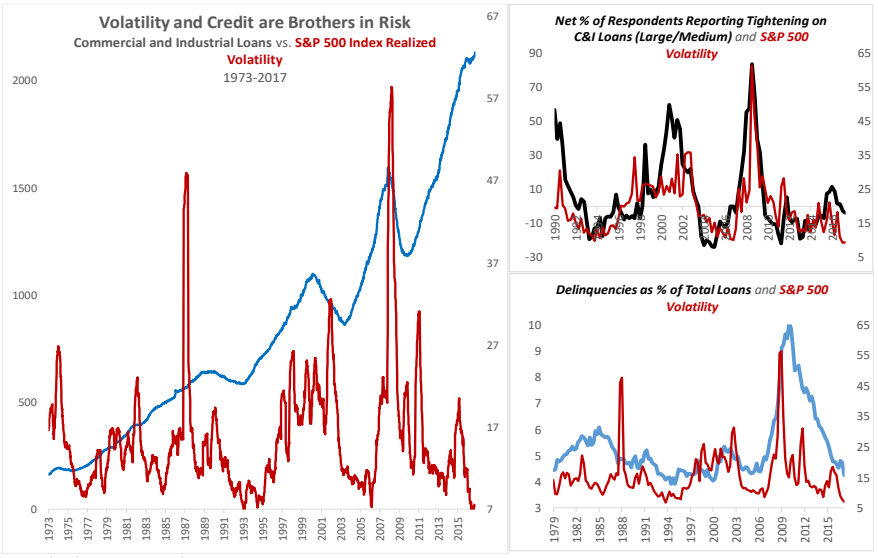
Imagine your friend invites you over for dinner. In his dining room is a barrel of **highly explosive nitroglycerin.**

You: *"What is that barrel of explosive nitroglycerin doing in your living room!"*
Friend: *"Oh that, no big deal."*
You: *"It's DANGEROUS! That could blow up the entire block!!! Where did you even get that?"*
Friend: *"Calm down, the bank pays me good money to store it here, it's the only way I can afford the mortgage."*
You: *"WHAT! ARE YOU CRAZY? All it takes is a small fire to set that thing off!"*
Friend *"What fire? There is no fire. Look, it's been here for five years without a problem."*

Risk alone does not guarantee any outcome, it only effects probabilities. The global short volatility trade, in all of its forms, is like a barrel of nitroglycerin sitting in the market portfolio. It may or may not explode. What we do know is that it can potentially amplify a routine fire into an explosion. The real question is what causes the fire?

The death of the snake....

Volatility fires almost always begin in the debt markets. Let's start with what volatility really is. ***Volatility is the brother of credit...*** and volatility regime shifts are driven by the **credit cycle**. Volatility is derived from an option on shareholder equity, but equity itself can be thought of as a perpetual option on the future success of a company. When times are good and credit is easy, a company can rely on the extension of cheap debt to support its operations. Cheap credit makes the value of equity **less volatile**, hence a tightening of **credit conditions** will lead to higher equity volatility. When credit is easily available and rates are low, volatility remains suppressed, but as credit contracts, volatility rises.



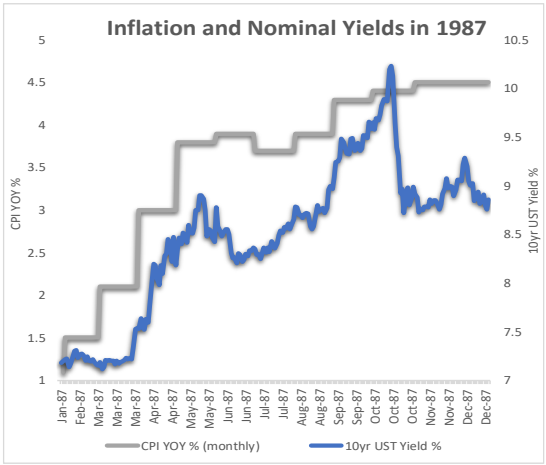
Source: Bloomberg, Artemis Capital Management LP

In the short term we ***do not*** see the credit stress required for a sustained expansion of volatility, but this can change very quickly. Storm clouds are gathering around 2018-2020, as rising interest rates, rich valuations, and corporate debt roll-overs all converge as potential triggers for higher stress and volatility. The IMF warned that 22% of U.S. corporations are at risk of default if interest rates rise. Median net debt across S&P 500 firms is close to a historic high at over 1.5x earnings, and interest coverage ratios have fallen sharply(15). Between 2018-2019 an estimated $134 billion of high yield debt(16) must to be rolled-over, presenting a catalyst for higher volatility in the form of credit stress.

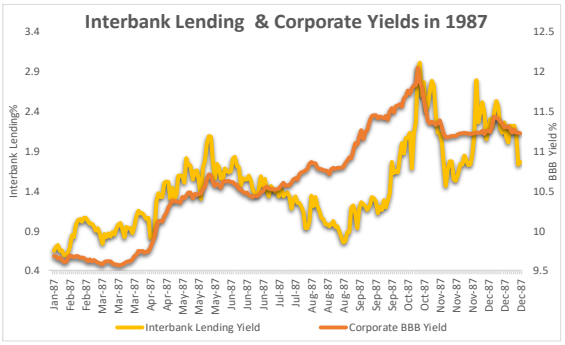
Reflexivity in the Shadow of Black Monday 1987

Thirty years ago, to the day, financial markets around the world crashed with volatility never seen before or equaled again in history. On October 19th, 1987 the Dow Jones Industrial Average fell more than **-22%**, doubling the worst day from the 1929 crash. $500 billion in market share vaporized overnight. Entire brokerage firms went bankrupt on margin calls as liquidity vanished. It was not a matter of prices falling, there were no prices. You couldn't exit a position. Trading desks refused to pick up the phone. Black Monday appeared to come out of nowhere as it occurred in the middle of a multi-year bull market. There was no rational reason for the crash. In retrospect, financial historians blame portfolio insurance, ignoring the role of interest rates, inflation, and the Federal Reserve. The demon of that day still haunts markets, and 30 years later the crash is still not well understood. Black Monday 1987 was the first post-modern hyper-crash driven by machine feedback loops, but it all started in a very traditional way.(17)

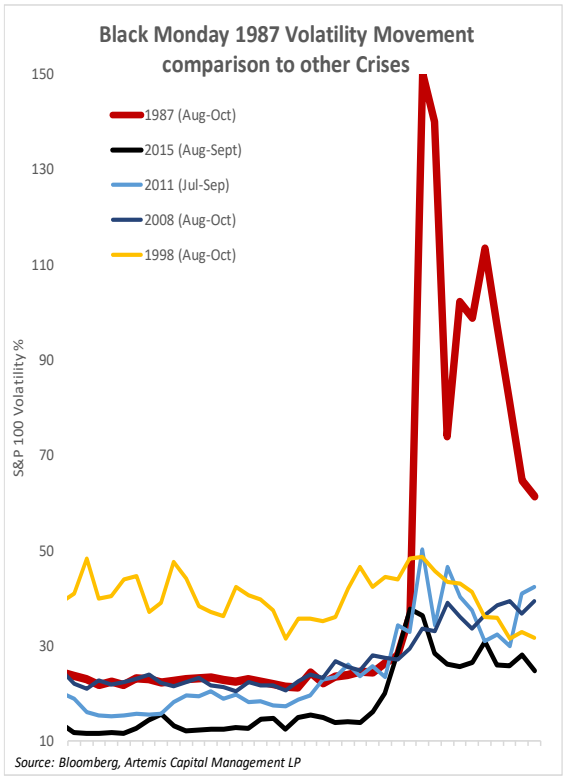
Be careful what you wish for... Today every central bank in the world is trying to engineer inflation, but inflation was the hidden source of the 1987 financial crash. ***At the start of 1987 inflation was at 1.5%, which is lower than it is today!*** From 1985 and 1986 the Federal Reserve cut interest rates over 300 basis points to off-set a slowdown in growth. That didn't last for long. Between January and October 1987 inflation violently rose 300 basis points. Nominal rates jumped even higher, as the 10-year US treasury rose 325 basis points from 6.98% in January 1987 to 10.23% by October 2014. The Fed tried to keep pace by raising rates throughout the year but it was not fast enough. The quick increase in inflation was blamed on the weak dollar, falling current account balance, and rising US debt-to-GDP levels. None of this hurt equity markets, as the stock market rose **+37%** through August 25th, 1987. Then the wheels fell off.



First the fire, then the blast…In 1987 portfolio insurance was a popular strategy ($60 billion in assets) that involved selling incrementally greater amounts of index futures based on how far the markets fell (see short gamma risk, see page 7). The WSJ ran an article on October 12th that warned portfolio insurance "could snowball into a stunning rout for stocks" [17,18]. Nobody paid attention.



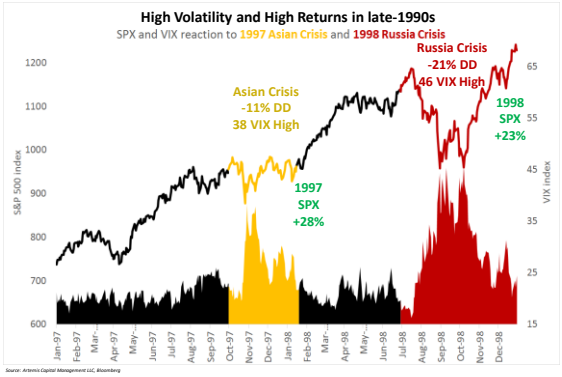
Although equity markets continued to rise into the summer, the credit markets began to suffer from a liquidity squeeze. The spread between interbank loans and Treasury Bills spiked 100 basis points in the month of September alone, and then rose another 50 basis points in October leading up to the crash. Corporate yields exploded 100 basis points the month leading up to the Black Monday crash, increasing of over 200 basis points since earlier in the year. By the late summer the equity markets got the memo. Between August 25th and October 16th, the S&P 500 index fell **-16.05%**. S&P 100 volatility moved from 15 in August to 36.37 on October 16th. That was just the beginning.



Source: Bloomberg, Artemis Capital Management LP

On Black Monday the market lost one fifth of its value and volatility jumped to all-time highs of 150 (based on VXO index, predecessor to the VIX index). In total, from August to October 1987 the market lost **-33%** and volatility exploded an incredible **+585%**. Black Monday is best understood as a massive explosion that occurred within a traditional fire. Rising inflation started a liquidity fire in credit, that spread to equities, and reached the nitroglycerin of computerized trading before exploding massively. Central bankers were not able to cut rates at the onset of the crisis to stop the fire due to rising inflation. The same set of drivers exist today, but on steroids. Higher rates combined with $1.5 trillion in self-reflexive investment strategies are a combustable mix. It is important to realize that the 1987 Black Monday crash was comparable to any other market sell-off until it wasn't. The only difference… in 1987 volatility just kept going higher and markets lower. The chart to the right shows the movement in volatility leading up to crises in 1987, 1998, 2008, 2011, 2015. The point is that if you are a volatility short seller, how do you know whether you will get a 2015 outcome, when markets rallied, or a 1987 outcome? You don't! In 1987 inflation started the volatility fire, but program trading amplified that fire into a cataclysmic conflagration. The $1.5 trillion short volatility trade, in all its forms, can play a very similar role now if rising inflation causes tighter credit conditions, but also limits central banks from reacting.

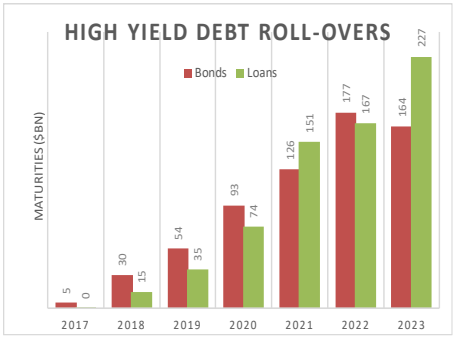
Melt-up Risk. Never underestimate the will of global central banks to risk overvaluation in asset prices to achieve inflation. For this reason, a speculative **melt-up** in prices on par with the late 1990s dot-com bubble is possible if policy makers support markets perpetually amid low inflation and growth. In fact, one legitimate argument for raising rates is simply so they can lower them before the business cycle turns. High volatility and high equity returns often coincide in the final phases of a speculative market. Very few investors realize that between 1997 and 1999 the stock market experienced both rising volatility and returns at the same time. For example, during this period the S&P 500 index was up close to **+100%** but with over five times the volatility we are experiencing today. The recent stock market bubble in China also was an example of high volatility and high returns. Yes, stocks are overvalued, but if rates stay low coupled with dovish monetary policy and supply-side tax reform it could touch a frenzy in speculation. For this reason alone, sitting on the sidelines presents business risk for professional managers.



How does an investor survive the Ouroboros?

The markets are not correctly assessing the probability that volatility reaches new all-time lows in short term (VIX <9 in 2017), and new all-time highs in the long term (VIX > 80 in 2018-2020)

Reflexivity in both directions is very hard to conceive. Volatility is low and can go lower this year absent any catalyst. Rising interest rates, wage inflation, and credit issuance are very real catalysts in the long-term. Between 2018 and 2020 high yield issuers will re-test markets by rolling over $300 billion in expiring debt[16]. U.S. average hourly earnings are rising at fastest pace since pre-recession putting pressure on inflation. If these debt-roll overs occur into rising inflation and higher rates this could easily be the fire that sets off the global short volatility explosion.



Source: Bank of America

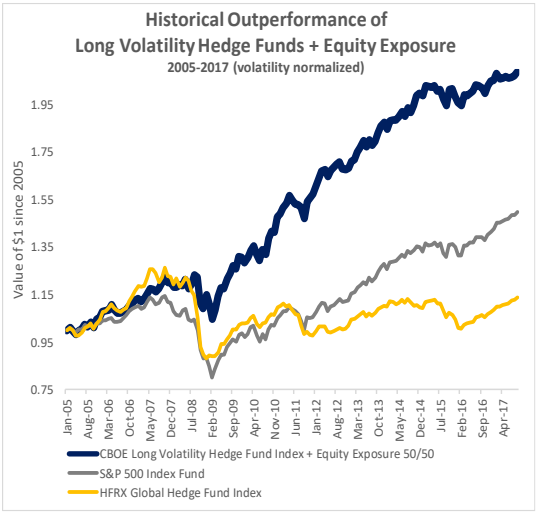
If you are going to short volatility, do it with a long-volatility mindset, namely a limited loss profile. Short-dated VIX put options that payoff with the VIX below 10 are currently 5-10 cents. Forward variance out one year is cheap and should be bought into any period of rising interest rates, inflation, or credit stress.

Fixed income volatility is at all-time lows at a time when the Federal Reserve is raising rates

Something must give, inflation or deflation, but you don't have to be smart enough to know what if you bet on the volatility of fixed income.

Active Long Volatility and Stocks will outperform over the next five years

Long volatility is a bet on change, as opposed to direction. At a time when central banks are removing stimulus, the world has never been more leveraged to the status quo. For this reason, long volatility combined with traditional equity exposure is an effective portfolio for the new regime. Historically a 50/50 combination of the CBOE Long Volatility Hedge Fund Index and the S&P 500 Index outperformed the average hedge fund by **+97%** since 2005. The inclusion of long volatility reduced equity drawdowns from **-52%** to **-15%** in 2008 while improving risk-adjusted returns.



Source: Bloomberg, Artemis Capital Management LP

The value-add of active long volatility management is to minimize losses in stable markets while making portfolio changing returns in the event of a market crash. The smart long volatility fund can offer protection at a limited or even positive cost of carry. The combination of active long volatility and equity has historically protected a portfolio from a deflationary crash like 2008, but can also profit if high volatility and high equity returns co-exist in melt-up like 1997-1999. Long volatility may be your only line of defense if stock and bonds decline together. At this stage in the cycle, you want to position yourself on the other side of the global short volatility trade.

Risk cannot be destroyed, it can only be shifted through time and redistributed in form.

If you seek total control over risk, you will become its servant.

There is no such thing as control… there are only probabilities.

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ARTEMIS
CAPITAL MANAGEMENT

VOLATILITY IS AN INSTRUMENT OF TRUTH

Volatility as a concept is widely misunderstood. Volatility is not fear. Volatility is not the VIX index. Volatility is not a statistic or a standard deviation, or any other number derived by abstract formula.

Volatility is no different in markets than it is to life.

Regardless of how it is measured, volatility reflects the difference between the world as we imagine it to be and the world that actually exists.

We will only prosper if we relentlessly search for nothing but the truth, otherwise the truth will find us through volatility.

Artemis Capital Management L.P. is an investment management firm that employs systematic, quantitative, and behavioral based trading models to generate returns from long volatility exposure.

The philosophy of Artemis is to profit from turbulence in markets and regime shifts without the substantial negative bleed associated with traditional hedging products. Artemis seeks to provide long volatility exposure that, when combined with traditional assets like stocks and bonds, can improve the risk adjusted performance of an institutional portfolio. The flagship Artemis Vega Fund L.P. was established in 2012 and is a founding member of the CBOE Long Volatility Hedge Fund Index.

Artemis Capital Management L.P. and Artemis Capital Advisers L.P. were founded and associated portfolios managed by Christopher Cole, CFA. His decision to form a fund came after achieving proprietary returns during the 2008 financial crash trading volatility futures and options (as verified by independent auditor).

Artemis Capital Management is registered with the Commodity Futures Trading Commission (“CFTC”) as a commodity pool operator (“CPO”), with the Securities and Exchange Commission (“SEC”), and is a member of the National Futures Association (“NFA”). For more information please contact info@artemiscm.

Additional Material

ARTEMIS
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Research

http://www.artemiscm.com/welcome#research

Volatility and the Allegory of the Prisoner's Dilemma: False Peace, Moral Hazard, and Shadow Convexity – Q3 2015
Dorothy Thompson once said "peace is not the absence of conflict". Never forget there is a form of peace and stability reinforced by a foundation of underlying volatility. Game theorists call this the paradox of the Prisoner's Dilemma, and it describes a dangerously fragile equilibrium achieved only through brutal competition. The Prisoner's Dilemma is the most important paradigm for understanding shadow risk in modern financial markets at the pinnacle of a multi-generational debt cycle unparalleled in the history of finance. The paper argues that institutions should utilize a barbell approach to targeting the return distribution going forward
http://www.artemiscm.com/s/Artemis_Q32015_Volatility-and-Prisoners-Dilemma-x71i.pdf

Volatility at World's End: Deflation, Hyperinflation, and the Alchemy of Risk – Q1 2012
This thought piece launched Artemis in the institutional derivatives community and was credited for shifting the pricing of long-dated skew in S&P 500 index options. The premise argued that the left tail of the equity return distribution was dramatically overvalued, while the right tail remained inexpensive when compared to the potential of reflation, particularly far out on the volatility term structure.
http://www.artemiscm.com/s/Artemis-Capital-Q12012_Volatility-at-Worlds-End-4aim.pdf

Volatility: The Market Price of Uncertainty – CFA Journal January 2014
Artemis publication in the Chartered Financial Analyst journal that outlined the philosophy for 'crisis alpha' and volatility trading.
https://www.cfainstitute.org/learning/products/publications/cp/Pages/cp.v31.n1.1.aspx

Market Views

http://www.artemiscm.com/ market-views

Star Wars Convexity – January 2017
The directing and writing deal that George Lucas negotiated for Star Wars in 1976 is an excellent case study for how a long convexity position can be held at neutral to positive carry.
http://www.artemiscm.com/s/Artemis_Star-Wars-Volatility.pdf

Dennis Rodman and the Art of Portfolio Management – April 2016
Dennis Rodman's ability to rebound a basketball made him, statistically, one of the most valuable players in NBA history. Even though he couldn't score, his six sigma rebounding dramatically improved the offensive efficiency of the players around him helping his teams win five championships. Long volatility exposure offers a similar benefit to the institutional portfolio.
http://www.artemiscm.com/s/Artemis-Research_Dennis-Rodman-and-Portfolio-Optimization_April2016-efr3.pdf

References

Special thanks to Akshobhya Mann for her illuminating ideas on control, probability, and quantum physics which greatly informed the ideas presented in this paper.

Artwork

1. *"Volatility and Alchemy of Risk" artwork by Bredan Wiuff based on concept created by Brendan Wiuff and Christopher Cole*
2. *Early alchemical ouroboros illustration with the words "ἓν τό πᾶν" ("one is the all") from the work of Cleopatra the Alchemist (c. third century, Egypt). | Wikipedia | "Ouroboros"*
3. *New York Times on October 19th, 1987*
4. *Roman Coin from Wikipedia*
5. *A copy of a 1478 drawing by Theodoros Pelecanos, of an alchemical tract[1] attributed to Synesius | Wikipedia | "Ouroboros"*

Footnotes & Citations

1. *"Ouroboros" Wikipedia |* https://en.wikipedia.org/wiki/Ouroboros
   "Ouroboros" Token Rock | https://www.tokenrock.com/explain-ouroboros-70.html
2. *Artemis Capital Management LP gathered estimates for exposure to the "short volatility trade" from a variety of different sources deemed reliable including money center banks, research, and data services. The exact numbers are extremely difficult to discern given the breadth of participants and required knowledge of the operations for thousands of private institutions. To that effect, the results provided are a best efforts compilation based on reputable sources.*
   Implicit Short Volatility Exposures
   a. *Risk Parity exposure estimated at $500 billion by J.P. Morgan Cross Asset Derivatives Research Teams between 2015 and 2016 based on research notes by Marko Kolanovic. $400-600 billion estimate is provided by the Financial Times as of 2016. "Little Known Trading Strategy Exacerbates Market Turmoil" Financial Times October 14, 2016 / Wigglesworth.*
   b. *Volatility Control Funds/Variable Annuity Funds exposure estimated at $400 billion in 2015 by Equity UBS AG Equity Derivatives Research Notes as distributed by Davide Montoni. J.P. Morgan Cross Asset Derivatives Research Teams estimated this exposure at $200-$300 billion in 2015-2016 based on research notes by Marko Kolanovic.*
   c. *Managed Futures equity exposure estimated at $70-175 billion based on May 2017 research note by Bank of America. "If Vol-Nuetrals are Finally Liquidating, Could They Crash the Market? Here is the Math" http://www.zerohedge.com/news/2017-05-17/if-vol-neutrals-are-finally-liquidating-could-they-crash-market-here-math*
   d. *Low Vol Risk Premia strategies exposure estimated at $250 billion by Rob Arnott of Research Affiliates based on 2017 interview in Grant's Interest Rate Observer.*
   Explicit Short Volatility Exposures
   e. *$2 billion in VIX exchange-traded-product AUM, $2 billion in VIX short interest, and $3-4 billion in speculative VIX shorts based on data compiled from the CFTC, Bloomberg, and calculations by Artemis Capital Management.*
   f. *$8 billion in exposure from option writing funds estimated by Macro Risk Advisers in April 7, 2017 derivatives research by Pravit Chintawongvanich.*
   g. *$45 billion in pension short volatility overwriting programs estimated as of 2017 from Deutsche Bank as distributed in 2017 Tail Risk Monitor. $32 billion estimated as of 2012 from Financial Times (via Deutsche Bank) "Search for yield leads to derivatives funds" Financial Times September 24, 2012 / Wigglesworth and Makan.*
   Share buybacks
   h. *Data provided by Bloomberg.*
   i. *$780 billion in 2017 share buybacks estimated by David Kostin of Goldman Sachs, http://www.marketwatch.com/story/share-buybacks-will-return-with-a-vengeance-next-year-2016-11-21*

3. *Special thanks to Akshobhya Mann for her illuminating ideas on this concept.*
4. *"Major central banks to turn up policy heat despite low-burn inflation" Reuters, July 20 2017 / Karunakar https://www.reuters.com/article/us-global-economy-poll/major-central-banks-to-turn-up-policy-heat-despite-low-burn-inflation-reuters-poll-idUSKBN1A50FQ*
5. *Global Financial Data*
6. *"The world is awash in $9 trillion of bonds that are guaranteed to lose money" Quartz June 14, 2017 https://qz.com/1005720/negative-interest-rates-the-world-is-awash-in-9-trillion-of-bonds-that-are-guaranteed-to-lose-money/*
7. *Bloomberg*
8. *The author has been made this mistake, probably more than once.*
9. *"Managerial Self-Interest and Strategic Repurchases: Evidence from Equity Vesting Schedules" by David Moore / University of Kentucky 2017*
10. *Gamma estimated are best efforts based on analysis of rebalancing strategies employed by Risk Parity, CTAs, and volatility control funds. Author referenced the following papers for guidance "Leverage Aversion and Risk Parity" by Asness, Frazzini, and Pederson Financial Analysts Journal 2012, "Portfolio Rebalancing Common Misconceptions" by Huss and Maloney AQR Capital Management LLC*
11. *Global Financial Data / Robert Shiller*
12. *"High-Risk Investments Make a Comeback in Japan" by Kim and Vaghela, Bloomberg March 28, 2017*
13. *"Day Trading in Wall Street's Complex 'Fear Gauge' Proliferates by Landon Thomas Jr. / New York Times August 28th, 2017*
14. *Based on models derived by Artemis Capital Management LP from Bloomberg Data.*
15. *International Monetary Fund Global Stability Report "Getting the Policy Mix Right" April 2017*
16. *Estimated by Bank of America*
17. *"A Brief History of the 1987 Stock Market Crash with Discussion of Federal Reserve Response" by Carlson / Finance and Economics Discussion Series 2007-2013*
18. *"A Demon of Our Own Design" by Richard Bookstaber / Wiley and Sons 2007*

Notes & Data

Global Financial Data utilized for historical time series data going back as far as 1200.
Security price data from Bloomberg
Options data from Market Data Express with calculations executed by Artemis Capital Management LP

Global Financial Data Notes:

www.globalfinancialdata.com

Long term government rate index: Data on government bond yields from several different sources. Data from 1285 to 1303 and from 1408 to 1500 uses the Prestiti of Venice. Data from 1304 to 1407 uses the Consolidated Bonds from Genoa; data from 1504 to 1515 uses the Juros of Spain; data from 1520 to 1598 uses the Juros of Italy; data from 1606 to 1699 uses General Government bonds from Netherlands; data from 1700 to 1728 uses the yield on Million Bank stock; data from 1729 to 1918 uses the yield on the British Consol and data from 1919 to date uses the 10-year US Government Bond.

USA 10-year Bond Constant Maturity Yield: Richard E. Sylla, Jack Wilson and Robert E. Wright, Price Quotations in Early U.S. Securities Markets, 1790-1860, Hunt's Merchants Magazine (1843-1853), The Economist (1854-1861), The Financial Review (1862-1918), Federal Reserve Bank, National Monetary Statistics, New York: FRB, 1941, 1970 (annually thereafter); and Salomon Brothers, Analytical Record of Yields and Yield Spreads, New York: Salomon Brothers, 1995
Notes: Current yields on the 6s of 1790 are used from 1800 through August 1820, and the 5s of 1821-1835 are used from September 1820 to 1834. The Federal government completely paid off its debt in the 1830s, so New York State Canal 5% bonds are used from 1835 to June 1843. US Government 5% bonds are again used from July 1843 to 1852 and 6% bonds are used from 1853 to 1865. From 1866 to June 1877, the 5/20s are used and from July 1877 to January 1895, the 4% U.S. Government Bonds of 1907 are used, and from February 1895 until September 1918, the 4% U.S. Government Bonds of 1925 are used. Where no trades were recorded during a given month, the previous month's yield was used. The source for this data is William B. Dana Co., The Financial Review, New York: William B. Dana Co. (1872-1921) which reprinted data published by The Commercial and Financial Chronicle. Beginning in 1919, the Federal Reserve Board's 10-15 year Treasury Bond index is used. 10 year bonds are used beginning in 1941. Data for 1872 through 1918 are taken from the Financial Review. The interest rate series dating back to 1919 are taken from the Federal Reserve, National Monetary Statistics, New York: Federal Reserve Board which was published in 1941, 1970 and annually since then. The Commercial Paper data for 1835 through 1871 are taken from Walter B. Smith and Arthur H. Cole, Fluctuations in American Business, Cambridge: Harvard Univ. Press, 1935, and the Broker Call money data are taken from F. R. Macaulay, The Movements of Interest Rates, Bond Yield, and Stock Prices in the United States since 1856, New York: National Bureau of Economic Research, 1938. Yields on Treasury nominal securities at 'constant maturity' are interpolated by the U.S. Treasury from the daily yield curve for non-inflation-indexed Treasury securities. This curve, which relates the yield on a security to its time to maturity, is based on the closing market bid yields on actively traded Treasury securities in the over-the-counter market. These market yields are calculated from composites of quotations obtained by the Federal Reserve Bank of New York. The constant maturity yield values are read from the yield curve at fixed maturities, currently 1, 3 and 6 months and 1, 2, 3, 5, 7, 10 and 20 years. This method provides a yield for a 10-year maturity, for example, even if no outstanding security has exactly 10 years remaining to maturity. Similarly, yields on inflation-indexed securities at 'constant maturity' are interpolated from the daily yield curve for Treasury inflation protected securities in the over-the-counter market. The inflation-indexed constant maturity yields are read from this yield curve at fixed maturities, currently 5, 7, 10, and 20 years. Yields on treasury securities at constant, fixed maturity are constructed by the treasury department, based on the most actively traded marketable Treasury securities. Yields on these issues are based on composite quotes reported by U.S. government securities dealers to the Federal Reserve Bank of New York. To obtain the constant maturity yields, personnel at treasury construct a yield curve each business day and yield values are then read from the curve at fixed maturities.Although the bond yield calculated by the Fed uses a constant maturity bond which is always exactly ten years from maturity, because the Fed does not provide the coupon on the underlying securities for their constant maturity yield, it is not possible to provide the duration.

S&P 500 Composite Price Index: The Standard and Poor's Composite combines a number of different indices. From 1791 to 1801, GFD has calculated an equal-weighted index using data from 7 banks (Union National Bank of Boston, Massachusetts National Bank of Boston, the First Bank of the United States, Bank of the State of New York, Bank of Pennsylvania, Bank of South Carolina, and the Bank of America), 3 insurance companies (New York Insurance Company, Insurance Co. of Pennsylvania, Insurance Co. of North America) and two transport companies (Philadelphia and Lancaster Turnpike Company and Schuylkill Permanent Bridge Company). Using Walter B. Smith and Arthur H. Cole, Fluctuations in American Business, 1790-1860, Cambridge: Harvard Univ. Press, 1935, the index combines the monthly price indexes of Bank stocks (1802-1815, Bank and Insurance Stocks (February 1815-December 1845), and Rails (1834-1862) from Smith and Cole, ibid.: and Railroads (1863-1870) from Frederick R. Macaulay, The Movements of Interest Rates, Bond Yields and Stock Prices in the United States Since 1856, New York: National Bureau of Economic Research, 1938. Where these indices overlap, the indices have been weighted according to the number of stocks included in the indices. Beginning in 1871, the Cowles/Standard and Poor's Composite index of stocks is used. The Standard and Poor's indices were first calculated in 1918, and the Cowles Commission back-calculated the series to 1871 using the Commercial and Financial Chronicle. For more information, see Standard and Poor's, Security Price Index Record, New York: Standard and Poor's, 2000 and Cowles Commission for Research in Economics, Common-Stock Indexes, 2nd ed., Bloomington: Principia Press, 1939. The 90-stock Composite was calculated from 1926 through February 1957 when S&P introduced the S&P 500 stock average including 425 industrials, 25 rails and 50 utilities, weighting the index substantially in favor of the industrials. S&P did not calculate the 500-stock index prior to March 1957, but used the old 90-share index (as well as the old 50 industrials, 20 rails and 20 utilities indices) to extend the data back to 1928. The daily closes listed in the Security Price Index Record consist of the 90 stock averages adjusted to the new 1941/43 base from 1926 through February 1957, and the 500 stock averages starting in March 1957. Similarly, the weekly/monthly data for these indices uses the 90 stock average, rather than the more extensive indices of industrials that included 400 stocks, and were calculated on a weekly rather than a daily basis.High-low-close are available since January 1930 except for 1/2/41-7/30/46, 2/28/47-3/5/47, 10/24/47-10/28/47, 3/5/48-3/10/48, 5/6/49-5/11/49, 12/23/49-1/23/52, 6/27,30/1952, 9/5,8,9/1952. The indices were revised again in July 1976 when the rail index was dropped, and was replaced by the Transportation index, and a Financial Index was added. Until that time, financial shares had been excluded from the S&P 500 because many were over-the-counter stocks making it difficult to calculate exact prices for the averages. The components were changed from 425 industrials, 60 utilities and 15 rails to 400 industrials, 40 utilities, 20 transportation and 40 financial stocks in 1976. On April 6, 1988, exact numerical allocations were abandoned allowing the sectoral composition of the S&P 500 index to change as new stocks were removed and added to the S&P 500. Data for the S&P 500 index is theoretical through 1983 and actual, real-time data from January 3, 1984 on. Where possible, we have included high-low-close data for the indices, which meant readjusting the data for the period prior to March 1957 to the old indices. High-low-close are currently available for 1930-1941, September 1946-December 1949, and beginning in January 1956. Other dates have the close only. The primary sources for these data are Standard Statistics Corp., Base Book, New York: Standard Statistics Corp., 1931, Standard and Poor's Security Price Index Record, New York: Standard and Poor's (1940, 1941, 1948, 1955, 1957, 1962, and biannually since then), Standard and Poor's, Outlook, New York: Standard and Poor's (published weekly) and Standard and Poor's, Statistical Service, New York: S&P. For a detailed history of the components of both the 90 and the 500 stock averages see the current and past issues of the biannual Security Price Index Record published by Standard and Poor's. S&P has recently introduced two new versions of the S&P 500. The S&P Equal Weight index gives equal weight to each index rather than weighting the indices by capitalization. The O-Strip index is an index of all the stocks in the S&P 500 that are listed on the NASDAQ.
The original 500 share indices included 90-95% of the capitalization of the New York Stock Exchange providing the most comprehensive index of stocks then available; however, the rapid expansion in Nasdaq and growth in the NYSE has meant that the S&P indices now represent a smaller proportion of total market capitalization than in the past. The Wilshire 5000, Russell 3000 and Investor's Business Daily 6000 all cover substantially more shares than the S&P 500. Nevertheless, the S&P 500 still represents about 75% of the stock market's capitalization. To update their index, S&P introduced a 400-share Mid-cap index (which was calculated back to 1981), in June 1991, and then introduced a Small Cap 600-share index in October 1994, which was calculated back to December 31, 1993. The 1500-share Supercomposite was introduced in July of 1995 and calculated back to December 31, 1993. In January 2002, S&P introduced the S&P 1000 which includes all the stocks in the S&P 400 Midcap and S&P 600 Small Cap Index. Beginning in March 2004, S&P began adjusting their indices so they would reflect the free float on their stock indices rather than the total capitalization. The free float method reduces the influence of stocks such as Wal-Mart for which 40% of the stock is privately held and not publicly traded. Volume data are for the stocks traded on the NYSE, not for the S&P 500 stocks.

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