



Volatility at World's End
Deflation, Hyperinflation and the Alchemy of Risk



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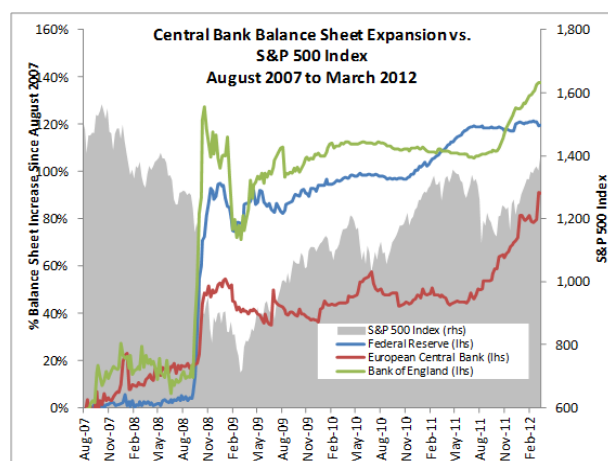
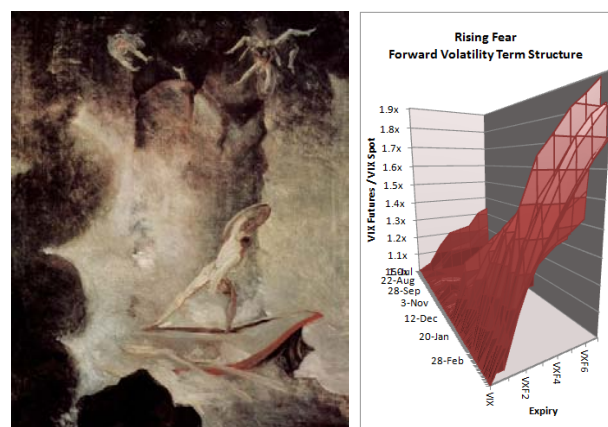
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Volatility at World's End: Deflation, Hyperinflation and the Alchemy of Risk

Imagine the world economy as an armada of ships passing through a narrow and dangerous strait leading to the sea of prosperity. Navigating the channel is treacherous for to err too far to one side and your ship plunges off the **waterfall of deflation** but too close to the other and it burns in the **hellfire of inflation**. The global fleet is tethered by chains of trade and investment so if one ship veers perilously off course it pulls the others with it. Our only salvation is to hoist our economic sails and harness the winds of innovation and productivity. It is said that de-leveraging is a perilous journey and beneath these dark waters are many a sunken economy of lore. Print too little money and we cascade off the waterfall like the Great Depression of the 1930s... print too much and we burn like the Weimar Republic Germany in the 1920s... fail to harness the trade winds and we sink like Japan in the 1990s. On cold nights when the moon is full you can watch these ghost ships making their journey back to hell... they appear to warn us that our resolution to avoid one fate may damn us to the other.

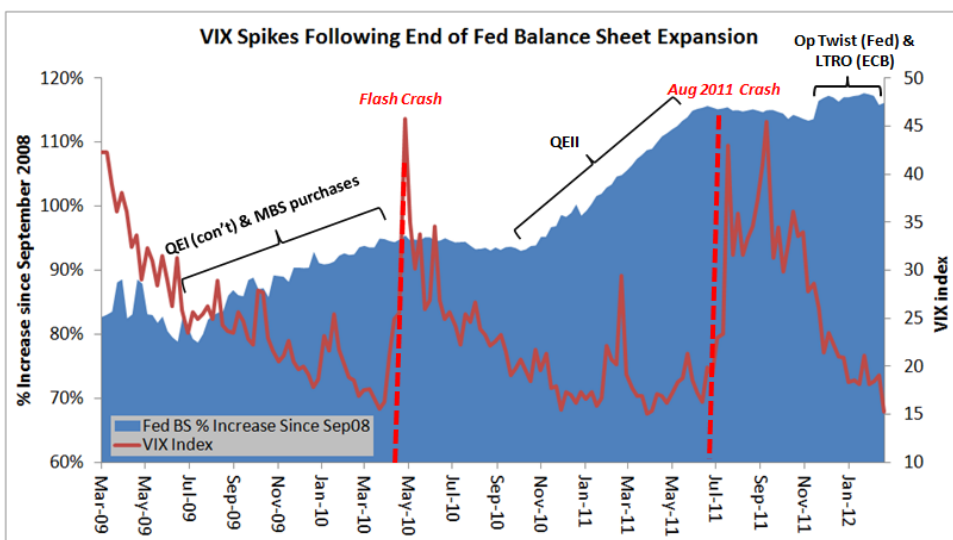
Volatility at World's End symbolizes a new paradigm for pricing risk that emerged after the 2008 financial crash and is related to our collective fear of deflation. The metaphor encapsulates the unyielding sense of dread that the global economy will plunge into the dark abyss and is the source of major changes in volatility markets. Today the existential fear of world's end deflation is so powerful investors are willing to pay the highest prices for portfolio insurance in nearly two decades. The market for forward volatility has become unhinged as the SPX variance and VIX futures curves sustain historically high premiums over low spot vol. My argument is not that this extreme fear is misplaced but that it is mispriced. Like Odysseus in the epic poem the global economy is trapped between the monsters of Scylla and Charybdis. We risk one to avoid the other. From one world's end to the next sometimes I wonder if decades from now we will look back with the hindsight that we were all hedging the **wrong tail**.

In the face of foreboding undercurrents our US-economic ship seems to have turned course toward calmer waters. The S&P 500 index had its best first quarter in 14 years, volatility fell to a 5 year low, and bond yields rose sharply on the trade winds of better than expected economic and jobs data. Risk assets were buoyed by an orderly Greek default with the ECB's three year bank lending program (LTRO) succeeding in reducing dangerously high sovereign yields in the Euro-zone. While I admit I don't understand why further leveraging the Euro-banking system to the same sovereign debt that caused the crisis will fix anything in the long-run it definitely has succeeded in calming markets in the short-term. Unfortunately this has been a recurring theme and once again there is no shortage of eager financial and political middlemen cheering that the worst is now over. The conventional wisdom says "do not fight the Fed" so by extension of that logic it is madness to fight every central bank in the world by fading this rally. The pace of global monetary stimulus has been astounding reaching almost \$9 trillion in total expansion over the past three and a half years in the greatest period of fiat money creation in human history⁽¹⁾. Let me put these numbers into perspective. **Collectively global central banks have created enough fiat money to buy every person on earth a 55" wide-screen 3D television (do the math).**



Central Bank Defined Regimes of Risk

The effect of coordinated global monetary easing on the performance of risk assets and volatility cannot be underestimated. A total of 16 central banks have eased since the fourth quarter of last year alone providing ample support for risk markets⁽²⁾. The ECB has allocated more than €1 trillion in Euros (\$1.34 trillion in USD) since December as part of its three year lending program. The total ECB balance sheet is now an astounding 30% of euro-zone GDP. In addition the Fed has left the door open to a third round of quantitative easing and currently carries a \$2.9 trillion dollar balance sheet that represents 19% of US GDP. Emerging economies continue to add stimulus too with China lowering its bank reserve requirement ratio 100 basis points since last November and Brazil easing rates into the high single digits⁽³⁾.

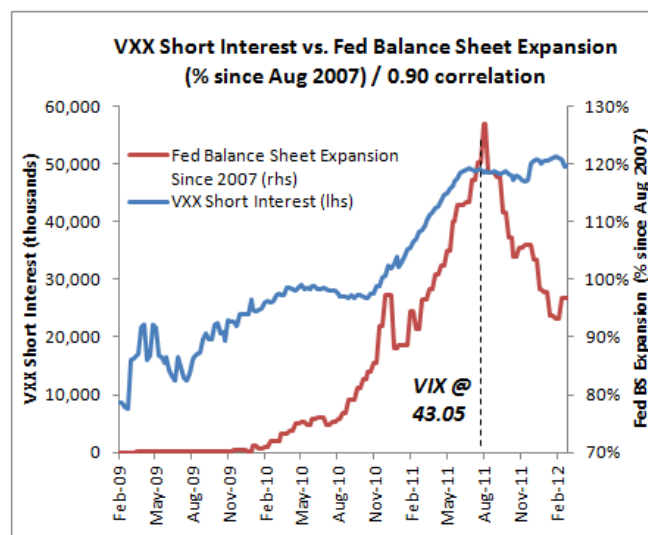


Risk and Vol Performance during Fed BS Regimes				
Crisis and Recovery (September 2008 to March 2012)				
Period	Average Weekly Change			
	SPX	VIX	21d SV	Fed BS
Fed Balance Sheet ↑	0.6%	-2.3%	-1.4%	1.6%
Fed Balance Sheet > +1σ ↑	1.6%	0.2%	-9.3%	5.3%
Fed Balance Sheet ↓	0.0%	1.5%	0.0%	-1.1%
Fed Balance Sheet < -1σ ↓	-0.8%	-0.5%	-4.1%	-3.0%
Post-Crisis Recovery Period (March 2009 to March 2012)				
Period	Average Weekly Change			
	SPX	VIX	21d SV	Fed BS
QEI con't (March09-Jun 09)	1.4%	-2.6%	-2.5%	0.5%
Post QEI (Jun09-Oct10)	0.2%	-0.2%	-0.8%	0.1%
QEII (Sep10-June11) ⁽¹⁾	0.5%	-1.0%	0.0%	0.4%
Post-QEII (July11-Nov11)	-0.2%	2.2%	2.3%	0.3%
LTRO (Dec11 to March12)	0.7%	-3.7%	-9.7%	0.6%

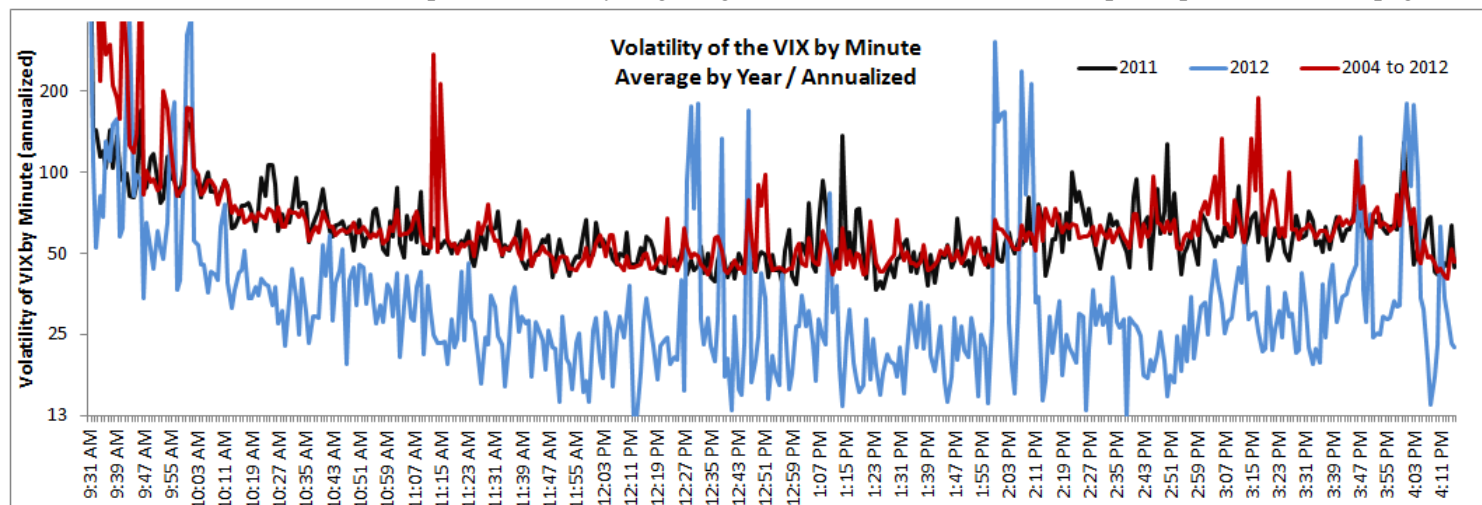
In our postmodern economy it is very difficult to separate the reality of fundamental economic growth from the illusion of central bank backed-prosperity. Today's markets are trapped in an Orwellian world of financial repression whereby equity and bond markets are not up, not down, but merely where ever central banks want them to be. When the monetary gods want you to buy risk assets, like it or not, you will be punished for not doing so in the form of ZIRP and lagging performance. What concerns me most is not how markets perform during monetary expansion but what occurs immediately thereafter. For the investor the equation is simple: when central banks are printing money volatility declines and risk assets increase, but when the printing stops... get the hell out of the way (see above for evidence).

Since the recovery began in early 2009 volatility spikes have consistently occurred shortly after the end of central bank balance sheet expansion. A comparison of the performance of the S&P 500 and VIX during different Fed balance sheet regimes shows a clear relationship. The greater the level of monetary expansion the calmer the VIX and the higher the gains in the S&P 500 index (and vice versa). Volatility markets know this and that game theory expectation has contributed to the steepest SPX volatility curves in over two decades (see graph on page 5).

To understand how easily this pattern can fool the average retail investor notice how short interest on the iPath S&P 500 VIX Short Term Futures ETN (VXX) exhibits a very high correlation to monetary expansion. The ETN provides small investors a crude vehicle to go long or short volatility via a note that tracks-short term rolling VIX futures. Short interest levels on VXX typically climb during Fed balance sheet expansion and continue to do so well after the printing ends until the inevitable VIX spike causes rapid short covering. The dynamic was most evident during the 2011 summer correction when VXX short interest tracked with Fed balance sheet expansion through April and continued to climb all the way until the VIX hit 43 in August. During VIX spikes in both May 2010 and August 2011 traders shorting the VXX overstayed their welcome at the stimulus punchbowl failing to recognize the Fed had left the party and the reality police were knocking on the door.

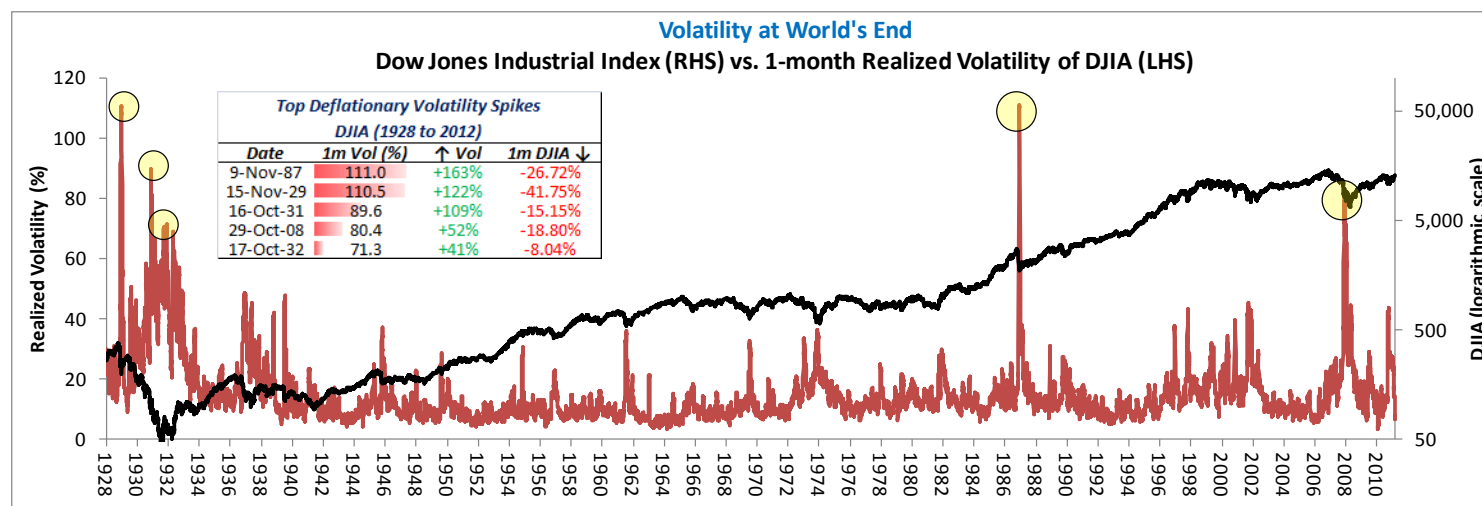


The calm in volatility markets (realized and implied) since implementation of the recent wave of global stimulus has been nothing short of incredible. The microstructure of daily VIX movement (defined as minute-by-minute vol-of-vol annualized) has fallen dramatically since implementation of the ECB's LTRO program. Volatility-of-volatility microstructure is now calmer than at any point over the past six years of data. The VIX index registered the lowest intra-day movement in history on January 11 with a daily high-low range of only 1.14%. The S&P 500 index has gained or lost only 0.46% a day in 2012 compared to 1.04% in 2011 representing the biggest reduction in eight decades going back to 1934 (shortly after Roosevelt devalued the dollar to end the Great Depression)⁽⁴⁾. The low realized VOV has been countered by extreme levels of implied VOV reflected in VIX futures and options driven by large vega inflows from retail VIX ETN participation (more on page 16).



Volatility at World's End: Deflation

The volatility market continues to push new boundaries of fear as traders distrust the sustainability of these calm waters. This is not entirely irrational as our economic ship is still within a stone's throw from the deflationary waterfall. It is hard to predict when a systemic build up of leverage on any level can turn a routine decline into a self-reinforcing nightmare. Fortunately the behavior of volatility in a deflationary spiral is widely anticipated and very well documented. In addition to recent experiences with deflation we can benefit from studying a wealth of historical data going back to the Great Depression. In a deflationary collapse market participants often severely underestimate the potential for volatility spikes but more importantly the length of time vol can remain elevated. The realized volatility of the DJIA going back to 1929 shows volatility climbed to 2008 extremes or higher a total of six times in the past eighty years. This included levels of volatility over 100 in 1929 and 1987 (2008 only reached 80+).



The table to the right demonstrates the duration over which volatility remained elevated during prior deflationary crisis throughout history. Before 2008 it was common for traders to sell vol when the VIX hit the magic mark of 30 due to an anchoring bias. The anchoring bias was reflected in the pricing of VIX futures prior to the crash which exhibited heavy backwardization whenever the magic VIX 30 number was breached. Many traders following this simple heuristic were rewarded between 2002 and 2007 however they ignored data from the crashes of 1987 and 1929 at their own peril. During the 2008 deflationary shock volatility remained at elevated levels for the longest period in recorded history including the crash that initiated the Great Depression. In 2008 it was both tragic and comedic to see market pundits call a top in vol every time the VIX broke to a new high. One well read blogger called a top in the VIX multiple times before he just stopped writing for awhile. The predictive ability of implied volatility in extreme deflationary spirals is historically weak. Ironically today we face the exact opposite bias whereby traders bid up implied and forward volatility to irrational levels whenever the VIX reaches a new low. Many day traders recommended buying VIX ETNs during the quarter on the logic that the "VIX was low" but this ignored the fact that implied vol was already extremely expensive compared to realized (as high as 2.4x in February). In addition the VIX futures roll premium was concurrently at the most expensive levels in the history of that market. The VIX is not a value stock. A low VIX is not necessarily "cheap" and the retail market's inability to recognize this fact shows that decisions are being driven mostly by irrational psychological anchors.

Post-Traumatic-Deflation-Disorder (PTDD)

Many of us have painful emotional memories of the deflationary collapse and that suffering is now embedded in the post-crash volatility surface. Our generation experienced volatility at world's end and now we have a visceral and primitive connection to that particular risk. We should not take lightly the impact of that emotional memory on all levels of our society as it will play a huge role in our judgment of probability for the foreseeable future. The human mind is terrible at evaluating extreme risks. Highly unlikely events are either entirely ignored or vastly over weighted based on whether we can visualize them clearly. In terms of survival we assign an absurdly high probability to miniscule but vivid narratives of loss or death⁽⁵⁾. This explains our irrational fear of terrorism following the 9/11 attacks. Researchers at Cornell estimated there were an additional 725 fatalities from car crashes the three months after 9/11 due to the greater number of people driving for fear of flying⁽⁶⁾. In reality you have a 1 in 25 million chance of dying in an airplane related terrorist attack over your life compared to a 1 in 88 chance of dying in car accident⁽⁷⁾. You are far more likely to die from lightning, floods, falls, fireworks discharge, or from bee-stings than you are from a terrorist attack. There is no comparison. The volatility markets are subject to similar biases in an assessment of emotional risks like a deflationary collapse.

New Regime for Volatility

We are in the middle of the bull market for fear. The new regime of volatility is defined by investor's willingness to pay almost anything to shield their portfolios from the next deflationary apocalypse. The emotional scars of 2008 are quantified via abnormally steep volatility curves, overpriced tail risk, high implied volatility of volatility, and underperformance of portfolio insurance. The expensive price of volatility is a reflection of investor neurosis driven by forced participation in risk assets from artificially low interest rates and financial oppression. The dynamics of the new volatility regime have only become more pronounced as markets have rallied in 2012. For example during the first quarter the term-structure of SPX volatility steepened to the most extreme levels in two decades of data.

Max Consecutive Trading Days Volatility Closed Above Specific Level

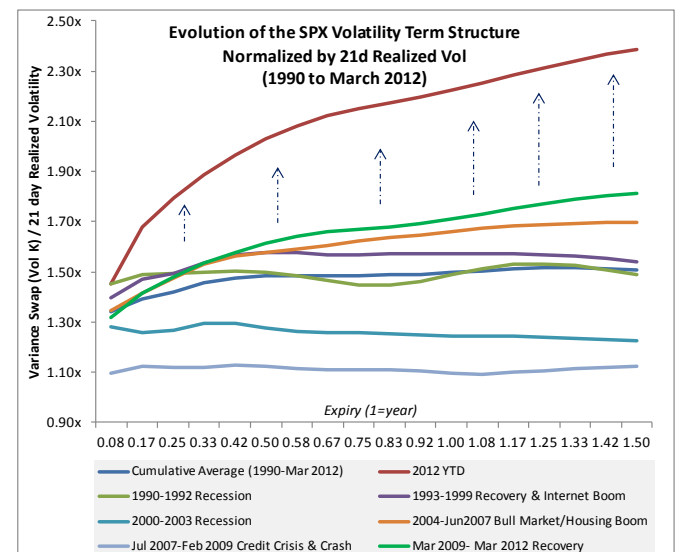
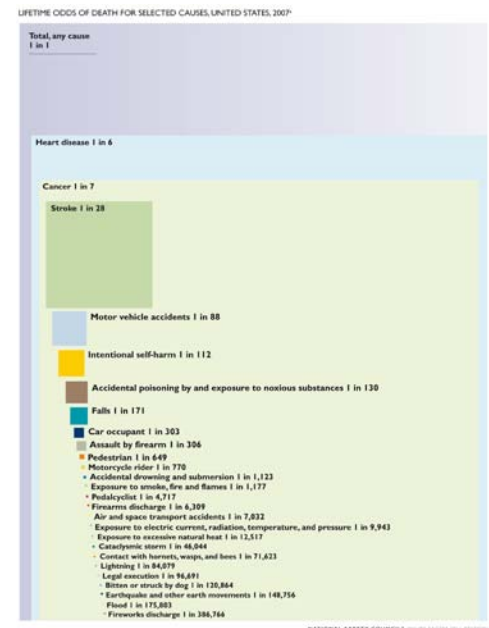
Market Event/Crisis	Vol > 30	Vol > 40	Vol > 50
Great Depression Crash of 1929 ⁽¹⁾	65 days	32 days	26 days
Black Monday 1987 Market Crash ⁽²⁾	86 days	26 days	18 days
1998 Russian Default / LTCM Crisis	48 days	10 days	n/a
9/11 Terrorist Attack	30 days	3 days	n/a
2008 Credit Crisis / Lehman Bankruptcy	170 days	63 days	29 days
2010 Flash Crash	9 days	2 days	n/a
2011 US Credit Downgrade	50 days	3 days	n/a
Historical VIX Index since 1990	12 days	7 days	8 days
21 day Realized SPX Vol Since 1950 ⁽³⁾	14 days	15 days	43 days

Note: VIX was not established until 1990 and S&P 500 not until 1950

(1) Measured by the 21-day statistical volatility of DJIA, due to fact S&P 500 and VIX were not yet established

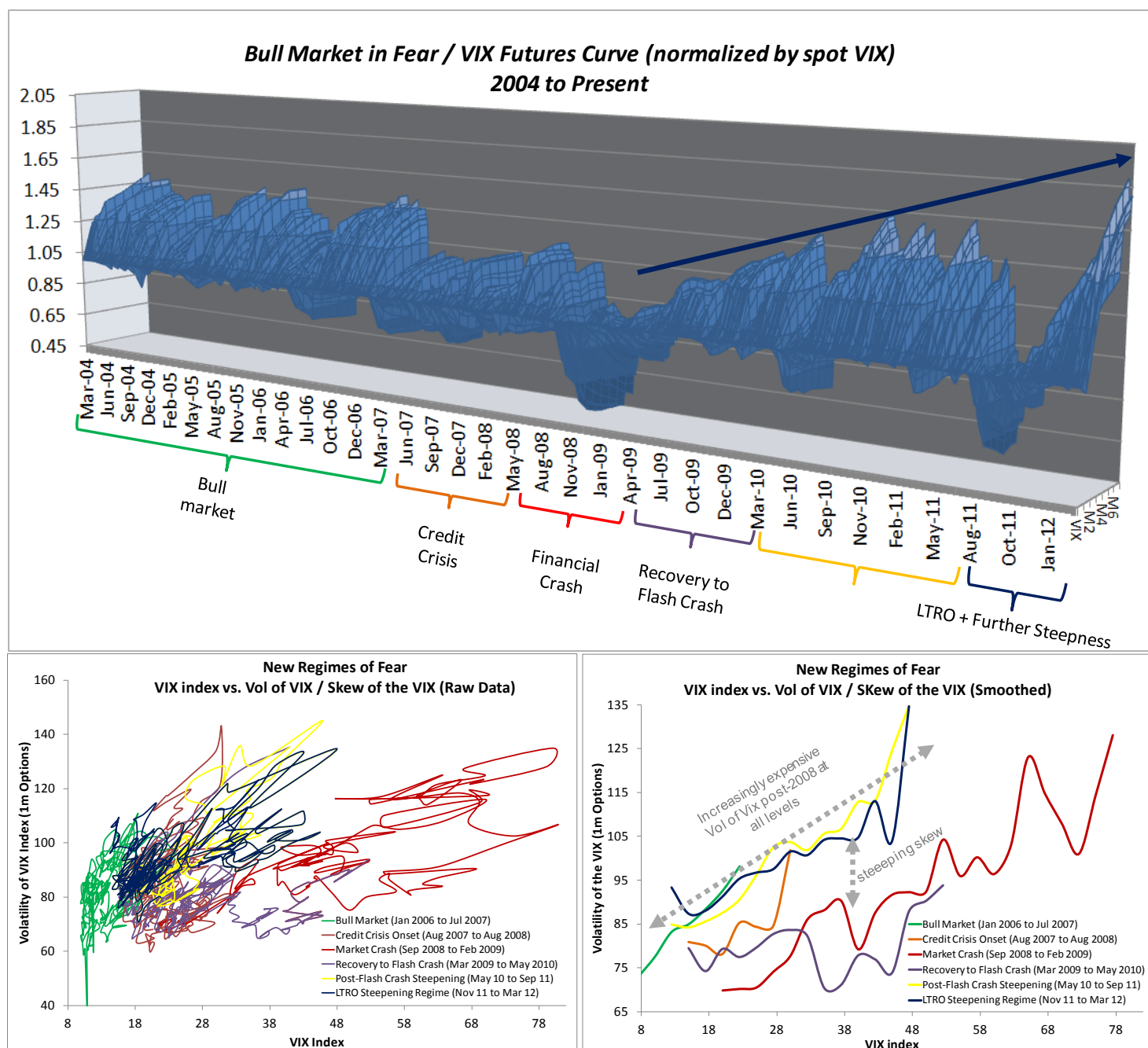
(2) As measured by the VIX Index, the precursor to the VIX Index

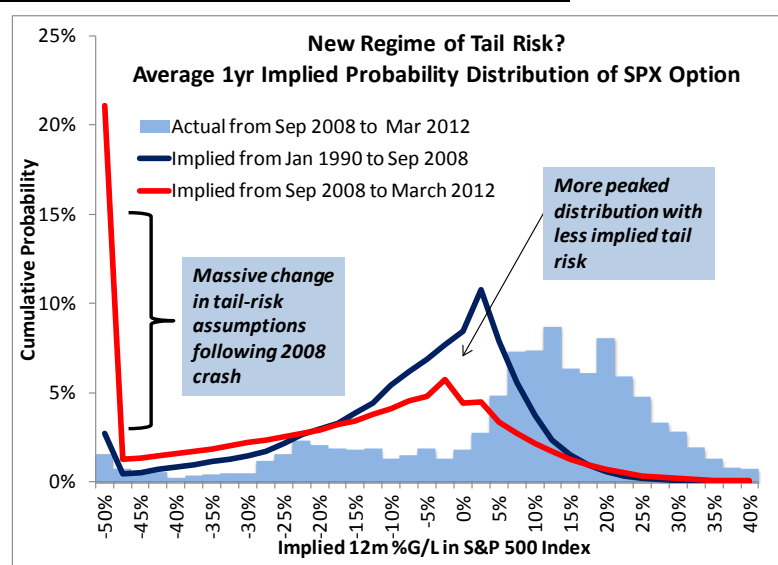
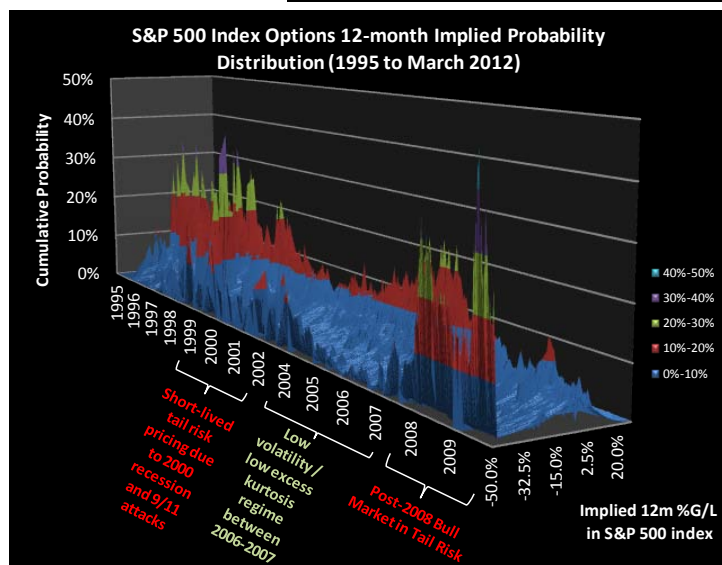
(3) Measured by the 21 day realized volatility on S&P 500 index since 1950



Today traders are irrationally exuberant for fear.

The VIX futures curve (a rough proxy for SPX forward volatility markets) has become unhinged breaking new boundaries in the price of fear. The cynicism of retail investors burned by a decade of phony bull-markets is driving the popularity of VIX exchange traded notes and introducing retail demand for vega on the front of the term structure. The largely retail buyer base of VIX ETNs seems to follow a one-dimensional playbook for purchasing vol based on anchoring biases with little regard for the intricacies of the asset class (e.g. "buy VXX when the VIX is low"). Farther out on the curve institutional investors are driving up the price of forward volatility by purchasing tail risk insurance even as investment banks have pulled back the supply of short vega due to reduced demand for structured products. Below is visual breakdown of different regimes in VIX futures and options from 2004 to 2012. The steepening of the VIX futures curve and higher volatility-of-volatility ("VOV") skew for VIX options demonstrates the rise of investor fear in the post-crash environment. VIX skew measures the volatility-of-volatility (VOV on y-axis) investors are willing to pay per given level of spot-VIX (on x-axis). The steeper the VIX skew the more premium it costs to hedge against a crash using VIX options. The chart that looks like it was drawn by a first grader (bottom left) shows raw VIX skew data and is hard to interpret. The chart to the bottom right uses a smoothing technique to show the rise in fear and sharply steeper VIX skews whether volatility is at 14 or 40.

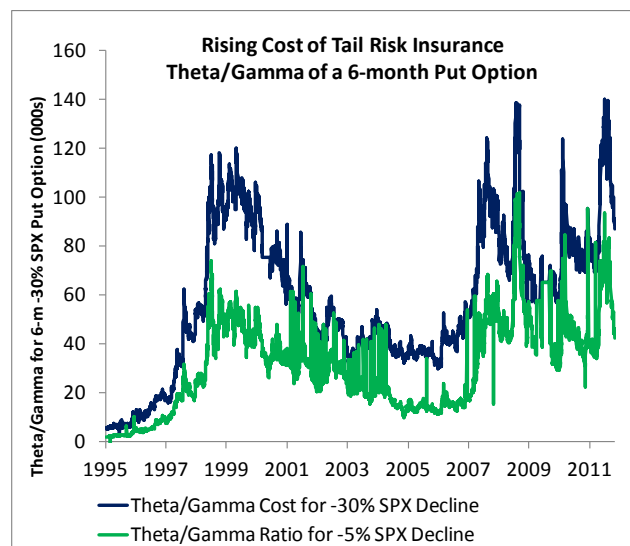
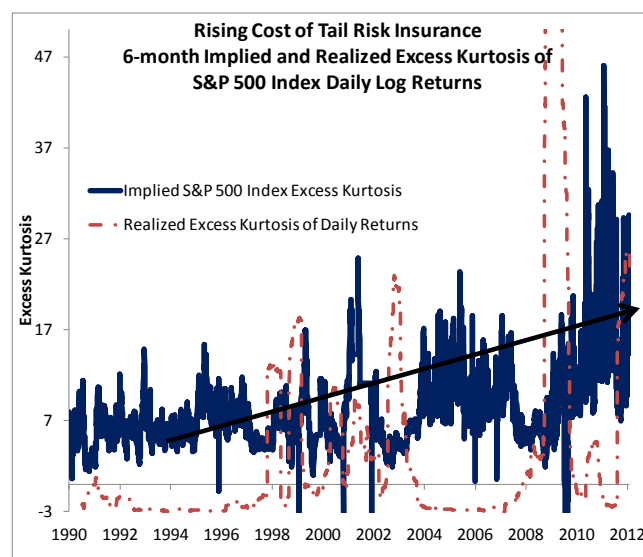


Irrational Exuberance for Fear*"There is no terror in the bang, only in the anticipation of it." Alfred Hitchcock*

Tail risk insurance is at the most expensive relative levels in over two decades of data reflecting a profound emotional fear of deflationary collapse. Tail risk bets protecting against extreme declines in equity markets are now priced at multiple times the eight decade historical probability of those declines being realized (we can never know for certain true future probability). The evolution of portfolio insurance premium is observable via the implied probability distributions for returns backed-out from S&P 500 index options. Artemis used strips of out-of-the-money SPX put and call options to model these distributions over the past two decades (see above). Since the 2008-crash the SPX options market has consistently assigned a 21% probability of a **-50%** or more crash in the S&P 500 index for any given year (logarithmic price changes). The realized historical probability of a **-50%** or greater crash is only 2.93% (using DJIA data to extend samples to 1928).

Artemis used two other methods to price the cost of tail risk and both showed similar extremes in valuation. The second method involves backing-out implied excess kurtosis from strip of SPX options (model-free movement cubic spline interpolation technique per Jiang and Tian [2005]). Excess kurtosis is a statistical measure used to assess how "fat" the tails of a probability distribution are compared to the "normal" distribution (which has an excess kurtosis of zero). We can compare the implied excess kurtosis from the options market to the realized excess kurtosis from actual SPX daily movements to understand if those "tails" are being realized. Implied excess kurtosis is at the highest levels in over a decade. The third tail-risk valuation metric involves graphing the theta to gamma ratio of a 30% OTM SPX put option. This is a fascinating and objective way to gauge how much "time decay" you are paying for each unit of "hedge" you are getting back. Once again the metric validates the highest cost of tail-risk protection for the past few decades.

What should be clear is that tail-events are now being priced as if they were standard risks. Ironically you get much better pricing today hedging smaller declines of higher probability (e.g. **-5%) rather than very rare but extreme crashes.**



The Great Volatility Short

Our irrational exuberance for fear extends from markets to policy and by now it should be apparent the Fed will do whatever it takes to prevent deflation. No politician or central banker wants their legacy shattered by the deflationary collapse that everyone already fears. In his now (in)famous 2002 speech Bernanke outlines the entire Fed play-book for combating deflation at the zero-bound. This includes existing and soon-to-exist experimental strategies such as direct purchases of private securities and foreign government debt, low-interest loans to banks, government debt purchases, time commitments to hold rates at zero, forced caps on yields, and intervening directly to affect the foreign exchange value of the dollar. Bernanke defends these ideas by stating that Roosevelt's 40% devaluation of the dollar vs. gold from 1933-1934 ended deflation and resulted in the best year in the history of the stock market⁽⁸⁾. Ironically he fails to mention Executive Order 6102 of 1933 "forbidding the Hoarding of Gold Coin, Gold Bullion, and Gold Certificates within the continental United States" with violations resulting in \$10,000 in fines (\$165,000 today) and 10 years in prison⁽⁹⁾. It is hard to imagine that form of extreme financial repression working today. Fed research on deflation almost always concludes that central banks should respond by aggressively printing more money than needed. The logic is that once you go over the deflation waterfall there is no turning back but you can always reign in excess monetary stimulus later (a scary assumption). Consider the following quotes:

"... monetary policy should respond not only to baseline forecasts ...but also to special downside risks... such stimulus should go beyond the levels conventionally implied... Too much stimulus can be taken back later through a corrective tightening of policies. However, if too little stimulus is provided and the economy moves into deflation, the future ability of monetary policy to pull the economy out of its slump can be substantially undermined."

Ahearne et al, Preventing Deflation: Lesson's from Japan's experience in the 1990s (2002)

"...the US government has a technology, called a printing press (or, today, its electronic equivalent), that allows it to produce as many U.S. dollars as it wishes at essentially no cost... under a paper-money system, a determined government can always generate higher spending and hence positive inflation."

Ben Bernanke, Deflation - Making sure "it" doesn't happen here (2002)

The Fed must be taken very seriously in its quest to end deflation at all costs. If deflation were a physical thing (like a waterfall) I have no doubt the Fed would finance the military to shoot missiles at it (see picture). More to the point what is the Fed's anti-deflation crusade worth in terms of optionality? Don't we "sort of" own portfolio insurance in the form of an implicit Fed guarantee to stop deflation paid for by your children (and children's children). Based on this logic the hedge premium in the market is only rational if it reflects the expectation that austerity will eventually prevent the Fed from printing money (very possible). Nonetheless your tax-payer funded "Bernanke Put" is worth something (see Artemis Q4 2010 "The Great Vega Short" research paper).



Nassim Taleb's definition of a "black swan" is a risk event that is wholly unpredictable and immeasurable⁽¹⁰⁾. ***It is not dying because your parachute didn't open while skydiving... it is dying because the guy whose parachute didn't open landed on you while you were golfing.*** You are not smart for hedging what everyone already knows (including policy makers). Can we really call a deflationary crash a "black swan" if the market assigns a 1 in 5 chance of it happening every year? That is like saying the average American dying of heart disease is a black swan event. More accurately (based on current pricing for a crash) it is like saying the *combined* probability of dying from heart disease, car accident, stroke, falling, and firearms is a black swan event.

Like terrorism we've gone from ignoring the left tail to obsessing over it. I'm not saying the world is suddenly a safe place and deflation should be ignored. It is not that I find the fear of deflation misplaced but rather mispriced. Those who defend this cost of insurance will tell you the probability doesn't matter as much as the extremity of the outcome. While there is truth in this rebuttal it still doesn't address what happens to volatility when all these buyers look to cash in on their expensive tail risk insurance all at the same time. The jackpot is a lot smaller when everyone owns a winning lotto ticket. All that expensive protection will likely underperform expectations and in the end you would have done better hedging closer to the odds. **It is hard to make money knowing what everyone else already knows.**

I'd rather spend my time imagining what unforeseen risks are not priced into the market. Is there something that will be as obvious tomorrow as it is laughable today? I sincerely hope the future vindicates current monetary policy but it is unwise to have blind trust. If global central banks are willing to protect us at all costs against deflation then who will protect us against the central banks?

Maybe the market is correct in buying tail risk insurance ... but everyone is just hedging the wrong tail.



"Imagine a group of people all staring at writing on the wall, everyone congratulating one another on reading the words correctly. But behind that group is a mirror whose image shows the writing's true message. No one looks in the mirror. No one thinks it is necessary."

Max Brooks, World War Z⁽¹¹⁾

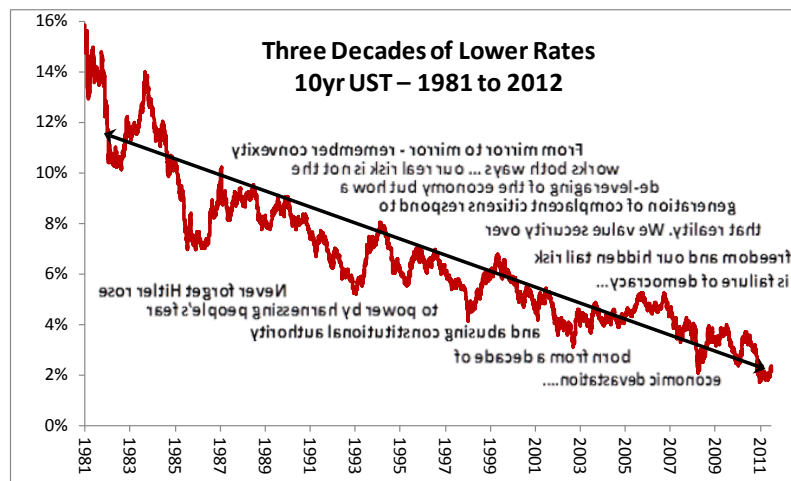
Volatility in Hell: Hyperinflation

Note: For the purposes of this paper I define hyperinflation as price increases of $\pm 26\%$ a year or $+100\%$ cumulative for three years (International Accounting Standards Board). This is more moderate than the commonly referenced definition of $+50\%$ price appreciations every month as realized in Weimar Germany and Zimbabwe. I find the IASB definition much more applicable to what could occur in a modern developed economy with a global reserve currency.

Our fear of deflation may damn us to hyperinflation. Even if we fall over the waterfall of deflation first at the very bottom of that abyss may be the fire. It is not currently fashionable to talk about the risks of hyperinflation in modern developed economies. If you merely mention the concept you are quickly relegated to being an apocalypse junkie, gold bug, or someone who spends too much time looking at the Mayan calendar. The Fed and financial establishment seem to be on a public relations campaign to debunk the risks of inflation (I presume as a precursor to QEIII). Remember that psychological bias whereby our minds either completely ignore or exaggerate the probability of rare events based on an emotional connection? **It works both ways.** We have 100+ years of deflationary fear imprinting. The last Americans to experience hyperinflation on our soil were in the Confederate South during the Civil War. Very few investors or policy makers today have any direct professional and more importantly emotional experience in a hyperinflationary reality.

The **financial and monetary establishment** currently ridicules those concerned with **hyperinflation as being naive ... ironically that is exactly why we should be afraid.** During this period of unprecedented fiat money creation a devastating period of long-term inflation is worth serious reflection. The role of a successful trader is not so much to *predict the future* but to find *mispricings in risk*. To be clear I am not predicting hyperinflation will occur today, tomorrow, or even in the next ten years... but what I am saying is that the risk in the right tail is not priced into the options market and this is remarkable given a careful study of economic world history.

For a generation of traders (including the author of this paper) the intellectual implausibility of rampant inflation is compounded by spending our entire lives in a cycle of declining interest rates. I remember that while in training at an investment bank they ran us through an incredibly stupid trading simulation using actual market data between 1980 and 2000 condensed into one hour. The team with the most profits by the end earned a \$300 bounty. The winning team (wink wink) leveraged their portfolio to the max with long-duration zero coupon bonds and then took an hour long happy hour before coming back to claim their well-deserved prize. If only real trading were that easy! So goes the power of decades of declining rates condensed into one hour. To understand what rampant inflation would mean to our world look at the last few decades in the mirror.



The conventional thinking is that hyperinflation in the developed world is impossible because the velocity of money is close to zero. I find this argument flawed because #1) it ignores economic history and #2) it forgets velocity of money is a psychological concept first and an economic concept second. In other words money velocity is volatile and can reappear just as quickly as it vanishes in a crash. The Fed's thesis that *"too much stimulus can be taken back later through a corrective tightening of policies"* (Ahearne et al, 2002) is a classic cognitive bias that is at best arrogant and at worst dangerous. Many hyperinflationary episodes in history began with a period of very low velocity of money. In Weimar Germany there was **no** surface inflation and prices were remarkably stable between 1920 and 1921 as the government doubled the money supply. In that same period Germany had one of the healthiest economies in post-WWI Europe (on the surface) with a booming stock market and for a brief time the mark was even the **strongest currency in the world**⁽¹²⁾.



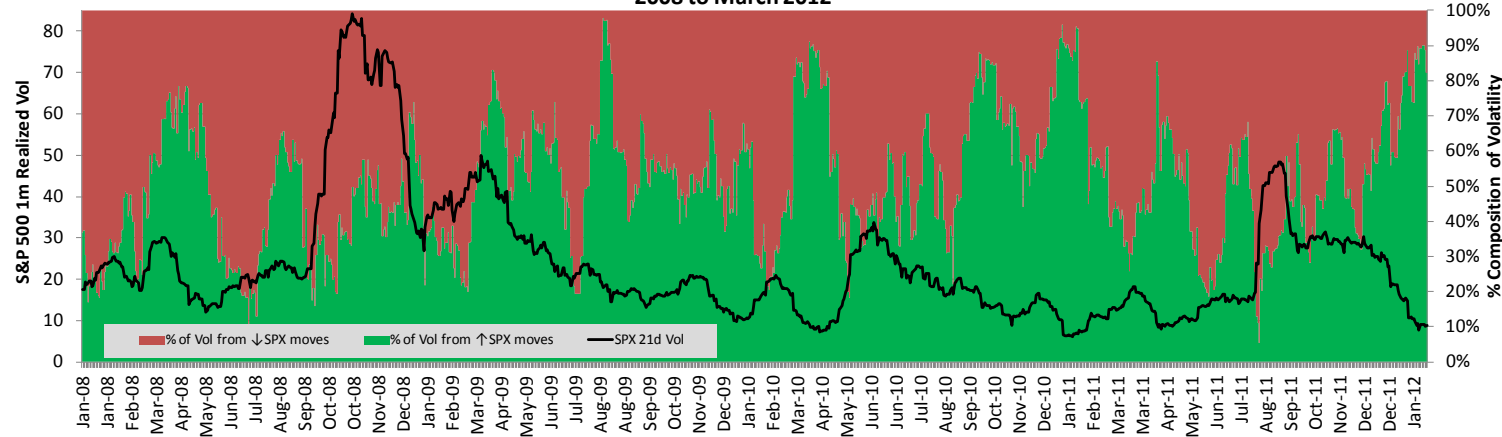
"Monetary inflation invariably makes itself felt first in the capital markets, most conspicuously as a stock market boom. Prices of national product remain temporarily steady while stock prices rise and interest rates fall. This (is what) happened at the commencement of the German inflationary boom of the 1920... (then) velocity took an almost right-angle turn upward in the summer of 1922, and that signaled the beginning of the end. An explosive rise in velocity thus accurately marks the point of obliteration of an inflated currency, but it does not cause itself. People cause velocity, and they only cause hypervelocity after prolonged abuse of their trust"

Jens O. Parsson, Dying of Money: Lessons of the Great German and American Inflations (1974)

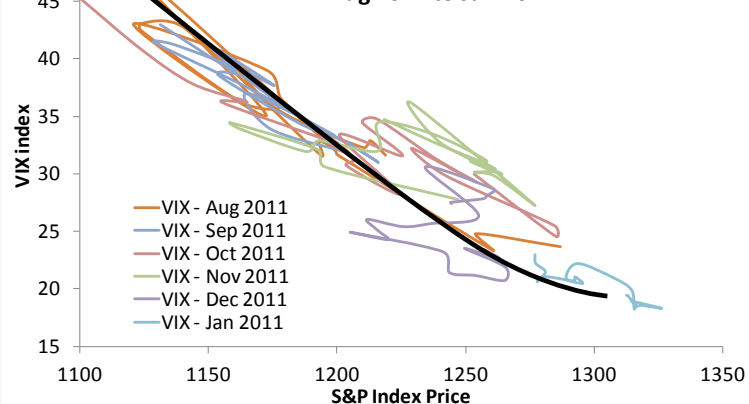
There is no historical precedent to understand how modern derivatives market would perform in the hell of destructive inflation. Weimar Republic Germany did not have a market for options, CDS, or variance swaps for us to study. For me it is valuable to theorize how that reality may unfold in volatility markets and to do so we need to think creatively.

In hyperinflation everything we think we know about volatility will be backwards... literally it will be like watching options markets through the *mirror*. The traditional rule is that volatility will spike when the market crashes and vice versa. This is a rule of markets but *not* a law. In reality volatility is only a statistic indifferent to the direction of price movement. Volatility increases when an asset declines only because prices fall faster than they rise (the old adage that markets take the stairs up and the elevator down). To illustrate this concept the graphic below shows the 1-month realized volatility of the S&P 500 index deconstructed according to the percentage of variance derived from increases or decreases in the index price. On average 54% of SPX 1-month volatility comes from increases in stock prices but during crashes downside movements may comprise up to 99% of variance (thus far in 2012 increases in the SPX contributed between 80-90% of variance). The market for implied volatility anticipates the fat downside tails associated with market crashes. Since 1987 out-of-the-money put options have traded at a higher volatility level than out-of-the-money call options, a phenomenon otherwise known as negative volatility skew. The VIX index moves up and down the SPX volatility skew on the assumption that higher local volatility will result from a decline in the underlying index (see charts). The negative skew for SPX options became even more pronounced after the 2008 crash as tail risk hedging became fashionable. The problem is that this volatility paradigm, entirely valid in today's deflation fearing market, is **completely wrong** in a world where prices rise faster than they fall... like in hyperinflation.

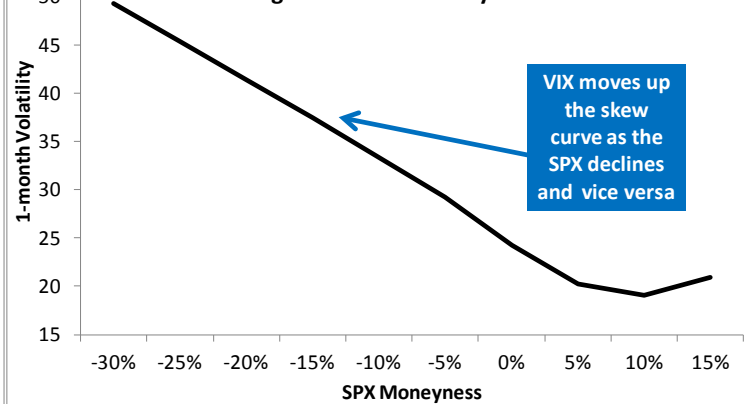
**S&P 500 1m Volatility & Up/Down Composition of Variance
2008 to March 2012**



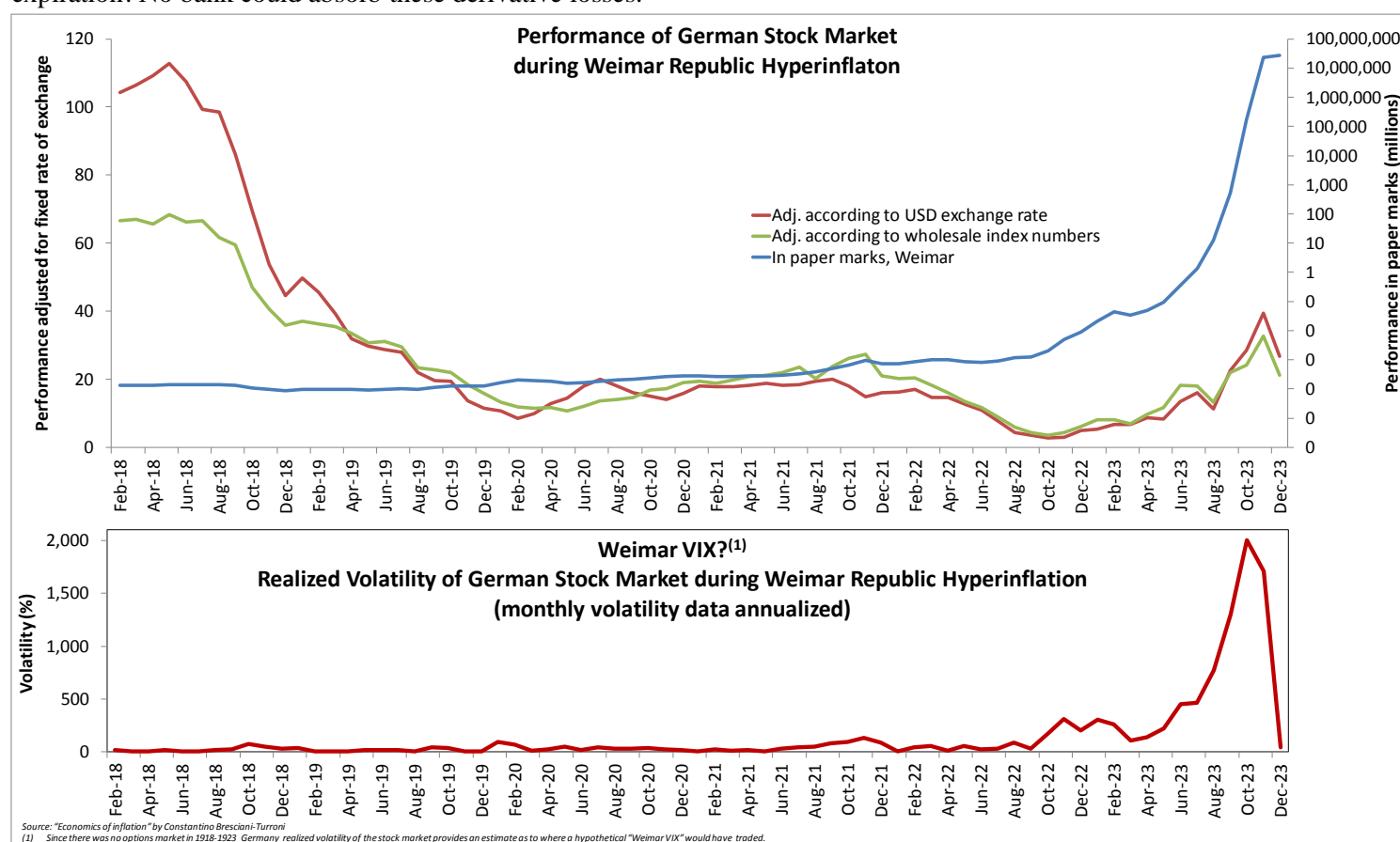
**Volatility "Smile" as a Function of VIX to SPX Levels
Aug 2011 to Jan 2012**



**S&P 500 Volatility Smile
August 2011 to January 2012**



Volatility as a measurement is agnostic to inflation except as transmuted through stock price movement. The quandary is that in a hyperinflationary environment the inverse relationship between equity prices and volatility will be flipped. The SPX volatility skew should technically reverse itself from negative to positive. For evidence we can look at historical monthly stock prices from the 1918 to 1923 hyperinflationary years of Weimar Republic Germany⁽¹³⁾. While there was no market for listed options in the 1920s I was able to calculate realized volatility using stock prices from the period. The realized volatility recorded during the 1918-1923 hyperinflation provides an *extremely rough* estimate as to where a hypothetical "Weimar VIX" may have traded⁽¹⁴⁾ and the results are staggering. The theoretical Weimar VIX would have averaged close to 17.5% between January 1918 and December of 1919 before exploding to over 2000% by October 1923 (monthly annualized). Realized volatility would have averaged an annualized 647% in the explosive period between 1922 and 1923 alone. The dramatic increase in volatility was directly correlated with the 2,581% nominal gain in the German stock market over the same period (91% adjusted for USD / humorously Weimar Germany had excellent equity return to risk ratios excluding the impact of interest rates). Imagine a world of 2000% volatility driven almost entirely by *increases* in stock prices. The volatility highs of a hyperinflationary collapse would dwarf the 80% peak in SPX volatility at the lows of the 2008 crash. That kind of volatility spike today would wipe out the balance sheet of any institution that is short convexity (e.g. probably every investment bank). To put this into perspective an imaginary uncapped four year variance swap at \$1 million notional written on the German stock market in 1919 (17.5% strike) before the onset hyperinflation would have paid-off an estimated \$417 billion at expiration! No bank could absorb these derivative losses.



For many (including the author) the concept of 50% inflation a month in a developed economy with a world reserve currency is outlandish. What about 26%+ a year for multiple years (the IASB definition)? Is that feasible? Why not? The consumer-price-index averaged above 12% between March 1979 and October 1981 (reaching a multi-decade high of nearly 15% in 1980) with nowhere near the global monetary stimulus overhang we see today. Shadow Government Statistics estimates that current CPI adjusted for methodological changes to match the way it was calculated in 1980 would be over 10% today (*feels* right given changes in rents, energy, and food prices)⁽¹⁵⁾. History is full of examples of countries printing money to combat hyperdeflation only to face frightful episodes of inflation later on. The argument that hyperinflation in a developed country and debasement of the global reserve currency is impossible strikes me as similar to the same logic that concluded a nationwide housing collapse was not a believable risk.

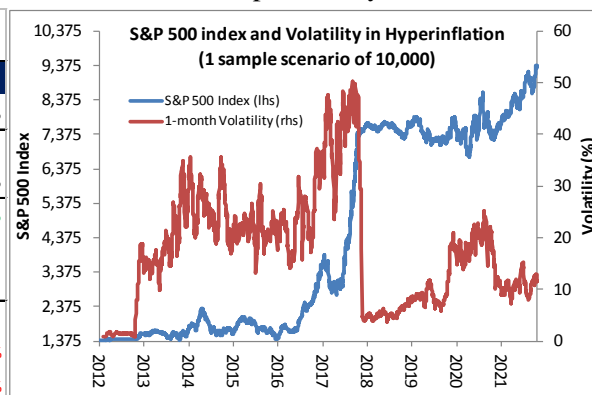


We have a very good sense of what a deflationary collapse looks like since we just lived through one. It is much harder to imagine how hyperinflation may unfold and this is where a little stochastic tinkering can be very helpful. To better understand the dynamics of a modern inflationary collapse Artemis created a model to simulate the behavior of the S&P 500 index and volatility during an inflationary shock. The model is **not** intended to be a prediction of the future but is merely a rudimentary stochastic-based method to understand what modern markets may look like in rampant inflation. The simulation runs 10,000 price scenarios for the S&P 500 index over 10 years modeling daily stock price behavior using a generalized Wiener process (Wiener.. not Weimar) and a drift rate that assumes linkages between annual CPI and equity performance. We assume inflation rises sharply from current levels of 2.87% in 2012 to 26% by 2015 and stays elevated at that level until 2017 (20% a year overall). The average volatility shifts are based upon assumptions regarding equity return to variance parameters observed in prior inflationary episodes (1970s US & 1920s Germany). The simulation shows annualized SPX returns for the decade at **+9.94%** but adjusted for inflation this drops to **-9.8%**. What should be clear is that a hyperinflationary event will lead to volatility shocks but with the *right tail* becoming the dominant source of variance in the probability distribution.

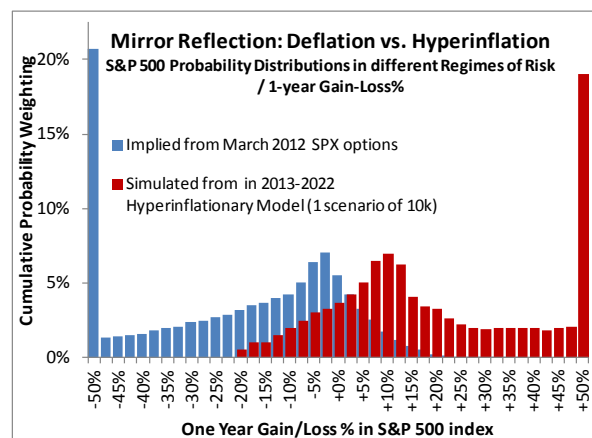
S&P 500 in Hyperinflation

10,000 Simulations via Monte Carlo / 2012 to 2021 Mean Values

Mean Value (10k simulations) EOY	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Consumer Price Index	3.0%	12.5%	20.0%	26.0%	26.0%	26.0%	19.0%	17.0%	15.0%	12.0%
S&P 500 Value (Mean)	1,409	1,553	1,787	2,148	2,594	3,126	3,543	3,956	4,354	4,694
10yr UST	4.6%	8.6%	13.8%	18.0%	26.1%	26.1%	19.1%	17.1%	15.1%	12.0%
Nominal SPX Return % (Mean)	0.01%	8.28%	10.70%	12.91%	13.02%	12.77%	9.52%	8.72%	7.72%	6.54%
Inflation Adj. SPX Return % (Mean)	-3.0%	-4.2%	-9.3%	-13.1%	-13.0%	-13.2%	-9.5%	-8.3%	-7.3%	-5.5%
21d Average Vol (Mean)	10.25	11.54	18.65	24.26	24.49	24.62	18.04	16.15	14.30	11.39
OTM SPX Call @ 10k Strike (2022 Expiry)	0.6	13.0	58.2	153.0	499.0	449.1	96.5	22.0	0.7	0.0
Nominal Ret on OTM Call (20c entry)	+112%	+418%	+567%	+664%	+782%	+772%	+618%	+470%	+129%	-100%
Inflation Adj. Ret on OTM Call (20c entry)	+109%	+402%	+532%	+603%	+695%	+658%	+485%	+320%	-36%	-100%



In volatility markets hyperinflation would literally turn everything backwards. The negative volatility skew that has existed since the 1987 crash would be flipped 180 degrees (see graphic to right). Following a painful period of adjustment OTM SPX call options would eventually trade at steep premiums to OTM put options. The term structure for volatility would also be caught off guard. As equity prices raced forward realized volatility would initially trade at a steep premium to the VIX index weighed down by an expectation for reversion to the mean. The front of the term structure would invert as traders, playing by the old rules, would be caught off guard by the sight of equity prices and realized volatility rising rapidly in tandem. When traders recognized what was happening they would start bidding up call options shifting the skew and sending the VIX up rapidly. Model-free variance would become exceptionally valuable but for counterintuitive reasons. Many volatility arbitrage and gamma short sellers would go bankrupt (unless they focus entirely on puts). Covered call and buy-write strategies would dramatically underperform during the initial stages of the inflationary shock only to outperform at a later stage when richly priced call options fell after the inflation and price volatility subsided. As interest rates increased the volatility term structure would begin to be seriously impacted by movements in the yield curve. If the yield curve went parabolic so would the volatility curve given high enough yields. Once again many traders would be caught off guard because they would assume non-parallel shifts in interest rates in calibration of "rho". The volatility curve would steepen dramatically and violently higher equity prices would result in a steep positive skew. In OTM and long-dated call options would be continuously undervalued based on the changing dynamics of steep positive skew, rising rates, and higher vol.

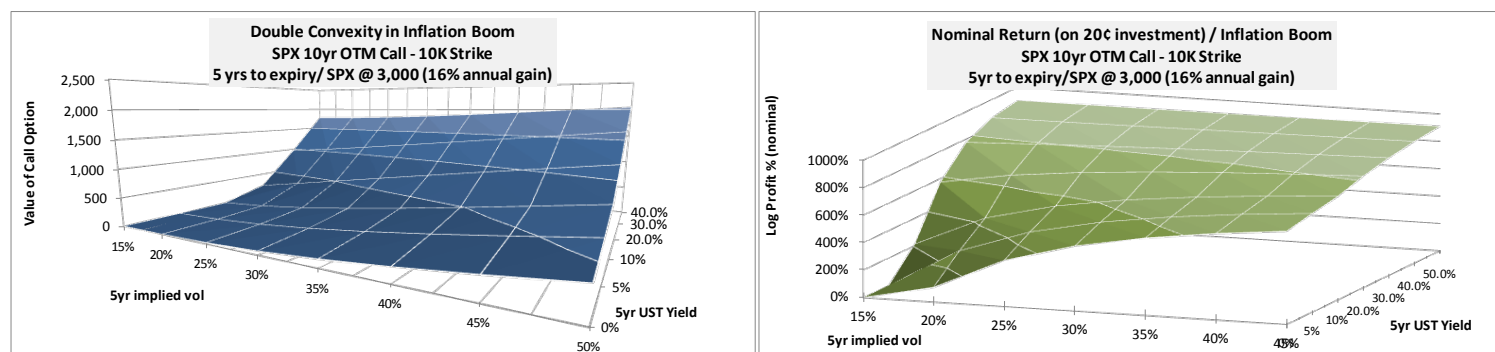


I can't tell you if hyperinflation will ever occur but what I do know is that the single most undervalued asset class to hedge against this rare event is *volatility itself*. As institutional and retail investors herd into commodities, farmland, and gold they ignore the powerful leverage afforded to them using extremely long-dated call options and model-free variance. One thing that is consistent in historical hyperinflations is that markets, bankers, and investors are slow to recognize that rising prices are being caused by currency debasement. During the German inflationary-boom bankers severely underestimated the potential for increases in rates while offering soon to be worthless loans to industrialists that made a fortune buying hard assets for nothing. It may be realistic to assume that derivatives markets would exhibit similar denial if an inflationary shock came to

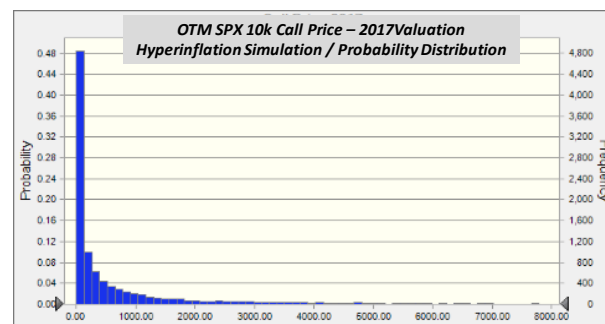


pass providing ample opportunity to purchase OTM call options or variance at bargain basement prices.

Today most investors purchase tail risk insurance on the premise that long-term deflation is the primary risk. With the complete opposite idea in mind I asked several dealers to quote me a price for an over-the-counter 10-year out-of-the-money European call option on the SPX with a strike rate of 10k (spot is at 1,400 so 700% OTM). The price of the call option ranged from a low of "are you insane" to a high of 20 cents. The median price was about 10 cents. What many fail to realize is that a far-OTM call option will exhibit powerful **double convexity** during an inflationary shock. The premium will be heavily influenced by both rising volatility and interest rates and these two variables are self-reinforcing in hyperinflation. The key point is that during the rare inflationary event large payoffs would accrue for sufficiently long-dated OTM calls even if the SPX is nowhere near the strike. The convex payoff is astronomical in consideration of the small upfront premium demanded.



The graphs above visualize the payoff structure of the OTM 10-year call option with 5-years to expiry under different volatility and interest rate regimes. What is shocking is that the price of the option increases exponentially even if interest rates approach 10-15%. The estimated price of the call option is also tracked in my hyperinflation stock market simulation and the results are equally staggering. When the hyperinflation simulation reaches the peak of 26% annual inflation in 2017 the mean SPX index will be 3,126 and the OTM call option could be worth an estimated \$449. That is a **+772%** nominal return from our 20 cent purchase price and a **+658%** real return after inflation assuming long-term volatility at only 20%. The key point is that you do not need the S&P 500 to surpass 10,000 to realize a significant gain if interest rates and volatility are sufficiently high. Ideally you would sell your OTM call option at the height of the hyperinflationary episode and then reinvest the money into physical assets. You could also ladder in OTM call options during initial stages of the hyperinflation while markets are in denial. Of course this assumes that financial institutions and major exchanges remain solvent but it is not hard to see government intervention being used to prevent widespread bank runs. These tactics could be very valuable in providing cheap leverage to stock prices if capital controls prevent you from re-allocating financial assets outside domestic banking centers.



What do we fear more... the evil that we know or the evil that we don't know? The market is clearly fearful of the phantom of our recent economic past and rightfully so. It is not the fear that is the problem but how we respond to it. We fear deflation so much that we have complete faith in the same institutions that failed to foresee it and their judgment in scaling back an unprecedented monetary experiment before we veer into hell. The truth is that pure intellect, even with the best of intentions, can lead us to tragedy if not tempered by common sense. Our real peril is that we value willful ignorance over knowledge and stability over free will. It is not farfetched that one day we will knowingly give up our freedoms to stop an economic terror. In fact many European sovereigns are doing this today. Whether we plunge off the **waterfall of deflation** or burn in the **hell of inflation** may matter less than if we recognize ourselves in the **mirror** when it is all finished.

"Give me control of a nation's money and I care not who makes it's laws"

Mayer Amschel Bauer Rothschild

"I believe that banking institutions are more dangerous to our liberties than standing armies."

Thomas Jefferson

"Those who would give up essential liberty to purchase a little temporary safety deserve neither liberty nor safety."

Benjamin Franklin





The Sorcerer's Apprentice

Die Deister, die ich rief the spirits that I called...

The Sorcerer's Apprentice by Goethe (1797) is a classic German poem that begins when a powerful sorcerer retires from his workshop tasking his young apprentice with the chore of filling a large vat with water. The lazy apprentice, tired of fetching water with a bucket, uses his master's magic and enchants a broom to complete the task for him. When the broom comes alive and begins fetching the water the apprentice is delighted! Alas the boy is not fully trained in the magic he is attempting to yield and the broom will not cease filling the vat with water even after it is full. Before long the workshop is flooded and apprentice is unable to control the spell he has cast. In desperation he takes an axe and splits the broom in two but this only makes things worse. Now the two pieces of the broom come alive and begin fetching water anew at twice the speed. The workshop is now overflowing and the apprentice has no choice but to call his master for help. When all seems lost the Sorcerer reappears ... he calls off the magic spell and the brooms fall lifeless to the floor. The Sorcerer's final warning to the boy is that those untrained in the art of black magic risk great danger by calling upon spirits they are not capable of controlling.

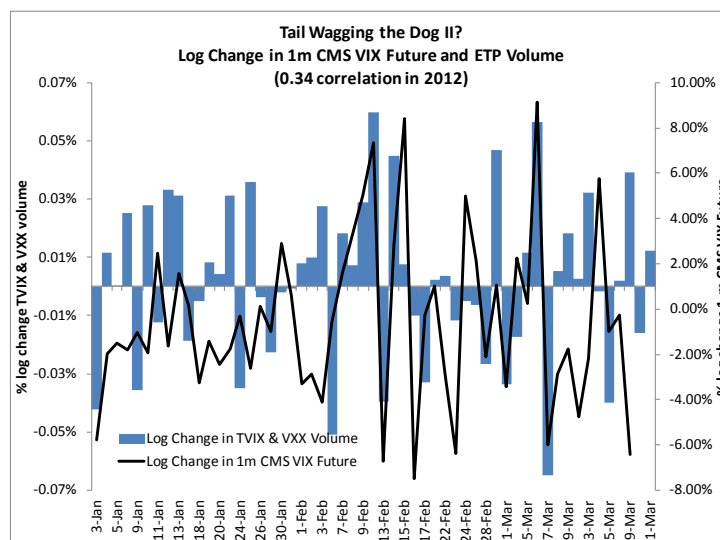
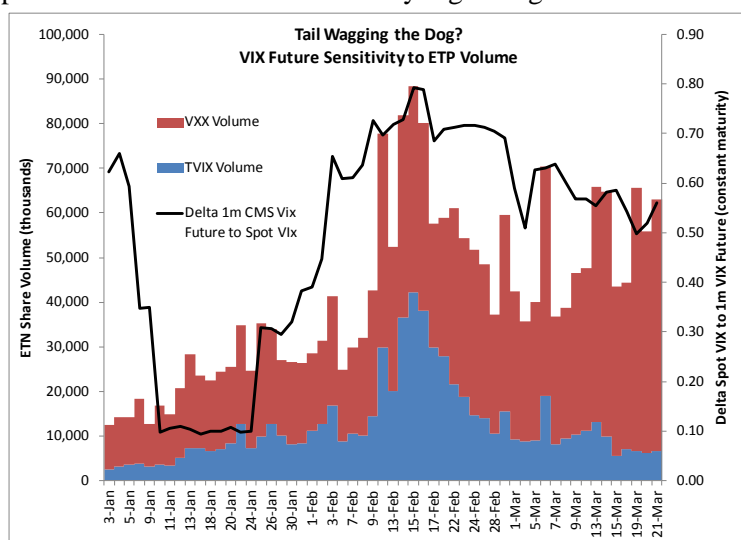
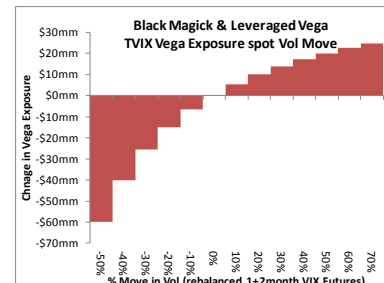
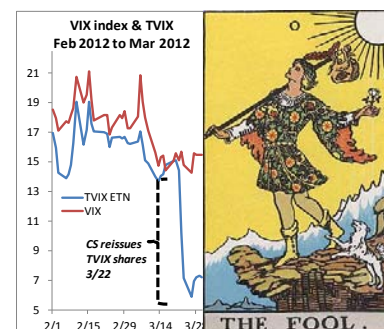


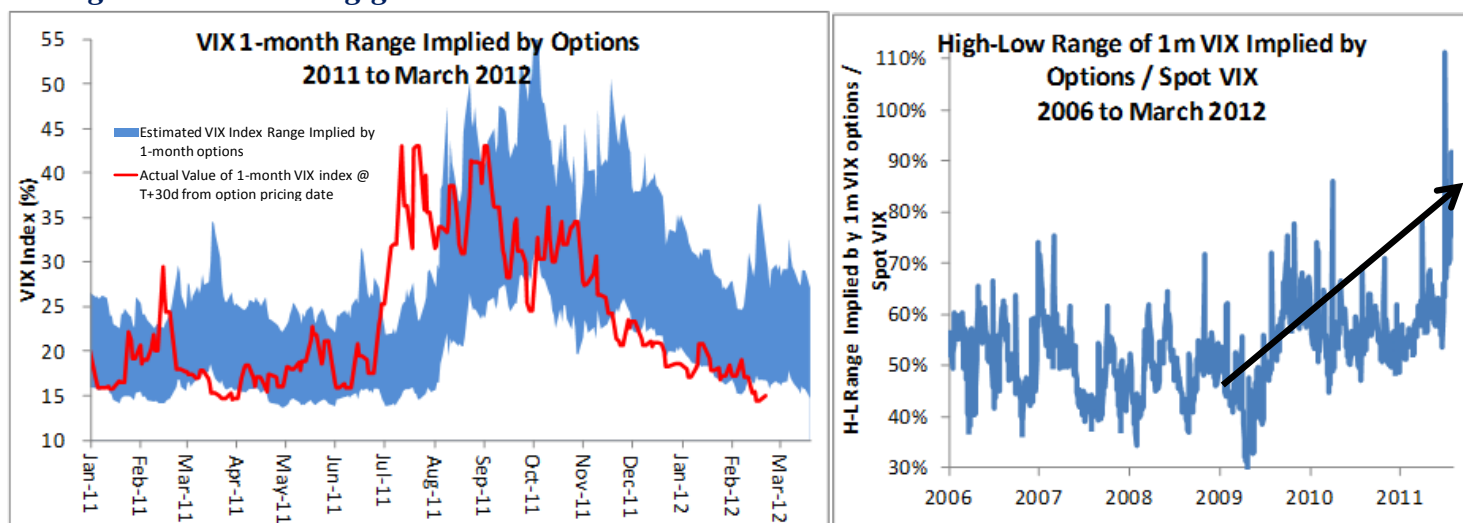
The Sorcerer's Apprentice and TVIX

In volatility markets many retail investors and institutions alike are calling upon spirits they cannot fully control. The explosion of volatility based exchange traded notes reflects the kind of sorcery that can be incredibly powerful but also destructive in the wrong hands. To be clear Artemis has directly benefitted from the liquidity these products have brought to volatility futures and options. Nonetheless I can honestly say that many retail investors and financial advisers seem ignorant of what they are buying. My feeling is that if a person does not understand underlying VIX futures and options they should not be trading VIX ETNs. The exchange traded product does not simplify the process of volatility trading any more than CDOs enhance the credit quality of their components.

The cautionary tale of TVIX is a perfect example of well-intentioned financial magic gone awry. The sorcerer's apprentice here is both the issuer (Credit Suisse) and the retail investor. On February 21 Credit Suisse announced it had suspended issuance of the Velocity Shares 2x Short-Term VIX ETN due to "internal limits on the size of the ETNs". The product was wildly popular with day traders who drove volumes to a market-moving \$60 million in total vega exposure⁽¹⁶⁾. Many retail investors do not understand that an ETN is a credit obligation of the issuer that is effectively short the exposure outlined in the prospectus. They often are unwittingly providing the issuer free credit and sometimes a synthetic "put option" at no additional charge. In the case of a VIX ETN the issuer is forced to hedge the short vega exposure directly in the VIX futures market or via alternatives like SPX options or variance swaps. When the product is leveraged a self-reflexivity is introduced whereby the issuer's vega exposure is amplified in the direction of spot vol movement (see graph). This increasing (or decreasing vega) exposure is tantamount to the apprentice splitting the broom in half only to see the intensity of his problem double... and double it did as TVIX rapidly became the market for short-term VIX futures. As in Goethe's poem Credit Suisse had created an army of magical brooms (TVIX shares) that risked flooding their workshop with overflowing vega exposure. They took the easy way out of this mess. With no ability to control their own magic spell Credit Suisse simply instructed the brooms to carry the overflow to their customers by suspending issuance. Unbeknownst many retail investors wishing to dabble in the black arts continued to buy TVIX bidding it up to an 89% premium to NAV. When Credit Suisse announced it would begin issuing new shares TVIX's price collapsed by 50% in just two days. The TVIX debacle has given the entire exchange traded product industry a black eye.

In my opinion anyone who claims that VIX ETNs are not having a major impact on the VIX futures market either doesn't trade or know what the hell they are talking about. VIX ETNs have *always* been the elephant in the room. Following their introduction it was not uncommon to see bulky and not-so-mysterious vega flows suddenly materialize at key roll-months during the close. In a more positive light they have been instrumental in adding much needed liquidity to an important new market. Notwithstanding their weight was clearly amplified beyond reason during the TVIX saga. For evidence consider the delta sensitivity of the weighted combination of 1 month and 2 month VIX futures as compared to trading volume in the two largest VIX ETNs (VXX and TVIX). The delta-sensitivity of the futures is highly correlated with the ETN volume. The same pattern can be observed in the daily log-changes between ETN volume and VIX futures....



Through the VIX looking glass...

Volatility trading is financial alchemy but this does not mean it ceases to be grounded in any fundamental reality. The market for forward volatility must eventually converge to real movements in equity prices with temporal deviations representing a window into the psyche of traders. The VIX futures market should mirror the multi-billion dollar market for forward variance derived from out-of-the-money SPX index options (minus convexity premium)⁽¹⁷⁾. These markets can be arbitrated against one another in the event of dislocations but only very sophisticated institutions are capable of this. Notwithstanding VIX futures have recently traded at a premium to both forward variance and SPX skew reflecting the steady inflow of ETN Vega. The excess vega exposure from ETNs has resulted in rich volatility-of-volatility premiums shown above by the fact VIX options are reflecting the widest anticipated range of future spot VIX movement in their history (derived from a synthetic variance swap constructed with VIX options). While the everyday investor raced to "buy the VIX because it is low" they failed to see that implied vol traded as much as two times realized vol during the quarter. The future that forward volatility markets saw at the beginning of the year has rarely been so radically different from the reality that came to be.

The post-modern volatility regime poses the question whether VIX ETNs and futures are large enough to influence the much deeper SPX options market. The existence of this dynamic would represent a self-reinforcing feedback loop with potentially dangerous repercussions. For example large flows into VIX ETNs could influence the price of SPX options which in turn would cause the VIX to increase in a potentially vicious cycle. Volatility practitioners have wildly different opinions as to whether this is even feasible. The institutional dogma is that the new supply of ETN vega is too small to feedback into the larger market for SPX options. There is evidence to support this view as open interest in options does not appear to be directly correlated with VIX ETN flows indicating that excess vega demand is being absorbed without disruption. Despite this fact the data only shows aggregate vega and a more convincing analysis would be matching flows to the points most impacted by VIX ETNs (month 1-2 roll). Unfortunately these flows remain hard to quantify.

In the end this debate misses the larger point... even if VIX self-reflexivity is *not* happening today it *will* happen in the future given the explosive growth and democratization of model-free volatility as an asset class. If self-reflexivity is introduced the VIX could become prone to periods of hyper-volatility-of-volatility. To be absolutely clear we are a very long way off from that reality. One market researcher I highly respect argued that there has *always* been self-reflexivity between S&P futures and that index without harm. Ironically I think he forgot that many attributed the 1987 Black Monday crash to S&P futures based portfolio hedging that fed back into the index. The concept that model-free VIX products may pose systemic risks given current vega levels is tantamount to saying the canary is going to blow up the coal mine. It is impossible today and these products currently hedge risk rather than being a source of it. Far enough down-the-road... who knows? Nonetheless the end game for VIX need not be so apocalyptic. Oddly I see a day when buyer-segmentation for aggregate vega may resemble something similar to the dull municipal bond market whereby institutions dominate the back of the curve and retail investors hold equal influence on the front. While some may downplay uncertainties the intensity of this debate demonstrates just how important model-free volatility has become as an emerging asset class.

Through the volatility looking glass is the TVIX debacle an omen for something much darker? ...you can go down that rabbit hole as far as you desire. On a simple level the calamity with this leveraged volatility note should be a warning to the broader exchange-traded-product universe. On a much deeper level it is a fitting allegory for our global monetary experiment...

... we should fear the spirits we have called....



Volatility and the Alchemy of Risk

To harness true power is to know that you will never know... and for this reason volatility is the ultimate post-modern asset for our existential economic future. Today there are still some who question whether vol is even an asset class and they lack both vision and common sense. Fear driven by self-deception is fundamental to the human condition... hence volatility is fundamental to markets. Not only is volatility an asset class but it will be the most important one for the next few decades because it alone can protect you from both the fire and the waterfall.

The alchemy of trading volatility is not magic for the fool. You must be the sorcerer and not his apprentice ... you must control the spirits that you have called and to do so means a deep understanding of one mystical truth that encompasses the whole of global banking and modern capital markets. It is the profound knowledge that on all levels life is about hedging risks we fully understand and in doing so assuming risks we cannot possibly fathom.

Vive la vérité



Vive le volatilité



Artemis Vega Fund, L.P.

Handwritten signature of Christopher R. Cole.

Christopher R. Cole, CFA
Managing Partner and Portfolio Manager
Artemis Capital Management, L.L.C.



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Rider-Waite Tarot Deck artwork by Pamela Coleman Smith from the instructions of academic and mystic A.E. White / copyright expired in US

"Liberty Leading the People" by Eugène Delacroix 1830 / public domain

Notes & Data

- Unless otherwise noted all % differences are taken on a logarithmic basis. Price changes and volatility measurements are calculated according to the following formula $\% \text{ Change} = \text{LN}(\text{Current Price} / \text{Previous Price})$
- Security price data from Bloomberg and Yahoo Finance
- Options data from Market Data Express with calculations executed by Artemis Capital Management LLC
- Central bank balance sheet data obtained directly from the Federal Reserve, Bank of England, Bank of Japan, European Central Bank, and the Bank of International Settlements

Footnotes & Citations

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Personal Note: Although part of the 'zombie apocalypse' genre of literature and film what this novel is truly about is the institutional response and denial of incomprehensible and exponentially growing risks. Max Brooks' zombie vision is one-half Romero the other-half the Economist and he does a masterful job theorizing cross-cultural global, local, and personal responses to the unfathomable. World War Z is a fitting metaphor for financial or ecological contagion and a wholly appropriate if not peculiar addition to the library of any finance professional.
12. "Dying of Money: Lessons of the Great German and American Inflation" by Jens O. Parsson / Wellspring Press 1974
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14. The term "Weimar Vix" is shamelessly used but the calculation reflects realized and not implied vol. The actual calculation was executed with monthly log changes in German stock market prices annualized to reflect estimated realized volatility during the period. True implied vol would trade at some unknowable discount or premium to the realized vol observed during the period.
15. Adjusted CPI is from John Williams and Shadow Statistics and is net of methodological changes -- including the shift to geometric weighting and the shift to owner's equivalent rent -- since the early 1980s that were introduced so as to depress reported CPI inflation. For more information please see www.shadowstats.com
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