VOLATILITY PARADIGM AND PARADOX

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What is Volatility?

Volatility at World’s End Deflation
Imagine the world economy as an armada of ships passing through a narrow and dangerous strait between the *waterfall of deflation* and *hellfire of inflation*

*Our resolution to avoid one fate may damn us to the other*
Volatility in World’s End Deflation

Volatility shocks are rightfully associated with deflationary crashes

Volatility at World’s End Deflation

Dow Jones Industrial Index (RHS) vs. 1-month Realized Volatility of DJIA (LHS)

Volatility shocks are rightfully associated with deflationary crashes. Financial media pundits called the 2008 crash an "unprecedented" period of volatility, as the VIX index reached a 20+ year high of 80.86 on November 20th, 2008. However, historical DJIA realized volatility data going back to 1929 shows volatility climbed to similar levels or higher a total of 6 times in the past 80 years. The VXO, precursor to VIX, hit 150.19 on Oct 19, 1987. 2008 was rare but not unprecedented!
Weimar Germany would have experienced over 2000% monthly realized volatility.

- $1mm variance swap struck in 1919 at 17.5% (average vol for period) would payoff $417 billion by 1923 (hypothetical).
- Germany in 1920-21 had no surface inflation, a booming stock market, and briefly the strongest currency in the world.

**Volatility in Hellfire of Inflation**

**Extreme volatility can also occur in hyperinflation**

**Performance of German Stock Market during Weimar Republic Hyperinflation**

- Red line: Adj. according to USD exchange rate
- Green line: Adj. according to wholesale index numbers
- Blue line: In paper marks, Weimar

**Weimar VIX?**

Realized Volatility of German Stock Market during Weimar Republic Hyperinflation (monthly volatility data annualized)

Source: “Economics of Inflation; A Study of Currency Devaluation in Post-War Germany” by Constantino Bresciani-Turroni Out of Print / 1968

(1) Based upon monthly realized variance from available stock price data.
Volatility of an Impossible Object

Modern financial markets are an impossible object
Volatility of an impossible object is our changing perception of risk

Illustration by Brendan Wiuff based on concept by Christopher Cole
Volatility of an Impossible Object

Volatility itself is now a paradox (both in time and space)

Temporal Paradox
- Low Spot-VIX but steep VIX Futures term structure
- Power law distortions in daily volatility moves
- Steep Volatility-of-Volatility term structure & Skew but low-spot VOV

Spatial Paradox
- Low volatility-of-volatility (realized) but higher potential for volatility-of-volatility (implied)
- Historically expensive gamma on tails of probability distribution
- Steeper volatility-of-volatility skew
- Volatility is Global Macro

Common sense says do not trust your common sense
Volatility itself is now a paradox (both in time and space)
Predictable (in retrospect)
Unpredictable (even In retrospect)

Volatility is Global Macro

Bull Market in Fear is Defined by
1. Volatility Kindling / Higher Potential Vol of VIX
2. VIX Futures are less effective hedging tools
3. Unbalanced VIX Option Shadow Gamma
4. Shadow VIX Theta
5. Skew shift
6. Volatility of VIX futures increasingly driven by short squeeze rather than VIX itself
“There are known knowns; there are things we know that we know. There are known unknowns; that is to say there are things that, we now know we don't know. But there are also unknown unknowns – there are things we do not know, we don't know.”

Donald Rumsfeld, United States Secretary of Defense

### Known Unknowns
- Debt Ceiling Crisis
- China hard landing
- War with Iran
- European Crisis
- Global Recession
- Fiscal Austerity

### Unknown Unknowns

### Volatility
- Vanilla Options
- VIX Index
- Implied Volatility
- Vol Term Structure

### Volatility of Volatility
- Forward Volatility
- Convexity
- Tail Risk Hedging
- Vol Curve Trades

### Risks
- Risks that you know and can quantity
- Risks that you know but can’t quantify
- Risks that you don’t know but could quantify
- Risks that you don’t know and can’t quantify
**Bull Market in Fear**

What is the “Bull Market in Fear”?  
*New paradigm for pricing risk that emerged after the 2008 financial crisis as related to our collective fear of the next deflationary crash*

**Bull Market in Fear is Defined by**

1. Abnormally Steep Volatility Term-Structure
2. Distortions in Volatility from Monetary Policy
3. Expensive Portfolio Insurance
4. Violent Volatility Spikes and Hyper-Correlation

*Bull Market in Fear is not about where volatility is today as so much as it is about where markets think volatility will be tomorrow*
Bull Market in Fear

Structural imbalances in supply-demand dynamics of volatility markets

I. Emotional
   - Post-traumatic Deflation Disorder
   - Desire for safety and security at any cost

II. Monetary
   - Forced participation in risk assets drives desire for hedging
   - Unspoken feeling that gains in financial assets are “artificial”

III. Macro-Risks
   - Debtor-developed economies face structural headwinds
   - Unrest in Middle East, Iran, Japan & China Tensions

IV. Regulatory
   - Government regulation (Dodd-Frank, Volcker rule) has constrained risk appetite for banks to supply volatility
   - Lower demand for structured products by investors
TEMPORAL PARADOX - Abnormally Steep VIX Futures Term Structure

BULL MARKET IN FEAR
"There is no terror in the bang, only in the anticipation of it." Alfred Hitchcock

Bull Market in Fear / VIX Futures Curve
2004 to Present

(VIX Futures/Spot Vix)
Low VIX index does not mean cheap volatility

Low Volatility? Really?

VIX Futures Curve Comparison
August 2012 vs. September 2008

- August 17, 2012 / Lowest VIX in 5 years at time
- September 15, 2008 / Day after Lehman Bros. Bankruptcy
- February 19, 2013

Volatility is more than the VIX index!

Overt focus on VIX is analytical equivalent using the 1yr UST to explain the entire bond market!
Since 2008 global central banks have expanded their balance sheets by $9 trillion - enough fiat money to buy every person on earth a 55'' wide-screen 3D television
Fat Left Tails have Dominated the Distribution of S&P 500 index Variance
You are not smart for hedging what everyone else already knows!

Note: Artemis calculates the implied probability distribution using interpolated weights from variance swap pricing. This methodology may occasionally give higher weightings to tails in down markets than other methods like taking the second derivative of call prices, fitting mixture of normal PDFs to recover prices, or fitting vol models (SVI, SABR).
For the first time in history the annualized short volatility yield (OTM SPX Put) is competitive with the yield on long dated UST Bonds!

Volatility Yield (%) vs UST Bond Yields (%)
1990 - 2013

-25% from SPX Strike Rate Breached
Volatility Yield (sell 1yr SPX put / -25% discount)
10yr UST Yield
30yr UST Yield

WOW!

For the first time in history the annualized short volatility yield (OTM SPX Put) is competitive with the yield on long dated UST Bonds!
When the “Bull Market in Fear” meets a “Bubble in Safety” a short equity option position and “risk-free’ UST bond have similar risk-to-reward payoffs!

Efficient Frontier / Risk to Reward Comparison

Long Dated UST Bond vs. 1yr OTM Short Puts (collateralized)

SPX Short Put (Strike @-25% OTM)

30yr UST Bond

10yr UST Bond

Risk / Unrealized Loss in Stress Test Scenario

SPX Put Stress Test
SPX ↓ -9% to -14%
68% to 33% probability
SPX ↓ -25%
13% chance
SPX ↓ -50%
2% probability

UST Bond Stress Test
Rates ↑ 100bps to 200bps
68% to 33% probability
Rates ↑ 320bps to 600bps
13% to 2% probability

Note: All data as of February 17, 2013. Estimated unrealized loss on position given stress test scenario. Historic probability data based on period of 1960 - 2012 for the UST bonds and 1950 to 2012 for the S&P 500 index. Option pricing based on estimated local volatility shifts, however actual shifts may differ from estimates during a real crash depending. All stress tests are assumed to occur close to the purchase period of the instrument. Unrealized losses may differ closer to maturity.
The more people fear the LEFT TAIL the more you should buy the RIGHT...

Maybe it is correct to buy tail risk insurance ... but is everyone just hedging the wrong tail?

Mirror Reflection: Deflation vs. Hyperinflation
S&P 500 Probability Distributions in different Regimes of Risk
1-year Gain-Loss%

- Implied from March 2012 SPX options
- Simulated from in 2013-2022 Hyperinflationary Model (1 scenario of 10k)

Note: 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%.
PARADOX IS FUNDAMENTAL

Effects of Volatility Paradox

I. VIX index
   - Fire danger (VOV) is higher despite low spot-Vol
   - Higher potential for Volatility-of-Volatility (kindling)
   - Skew Realization

II. VIX Futures & Options
    - Inconsistent hedging ratios
    - Loss of hedging effectiveness
    - Roll-Yield Deception
    - Inconsistent Deltas
    - Shadow Gamma
    - Shadow Theta

III. VIX Structured Products & ETNs
    - To many players shorting the front of the curve
    - Shadow Risk in “dynamic” VIX structured products
    - Roll Yield Short Squeeze?
Volatility of Volatility WILDFIRE - Correlations

*Fire Risk can be high when the forest is calm*

Higher correlations are *kindling* for violent VIX fires (spike)

**HIGHER CORRELATIONS** lead to...

* S&P 500 Sector Correlation (60 day) 2000 to 2012

**More VIOLENT VOLATILITY SPIKES**

*Volatility of VIX index (60 day) 2000 to 2012*
Today the difference between high implied and falling realized correlations makes hedging single stock names cheaper than buying index vol.
Understanding VIX Options

**VIX options widely misunderstood**

**VIX options are priced off VIX Futures, NOT the VIX Index**

**BSM Put-Call Parity Relationship is consistent when VIX options are priced using VIX futures as the underlying**

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**Violation of BSM put-call parity when vol calculated on spot VIX index**

**BSM Put-Call parity holds when vol is calculated based on the VIX futures (accurate method)**

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- When the VIX futures curve is in contango deep in-the-money VIX puts will trade at a discount to intrinsic value when evaluated against spot VIX
  - Likewise deep in-the-money calls will trade at a discount during backwardization
- Most commercial options programs do not make this adjustment, erroneously pricing implied vol from the spot VIX
Understanding VIX options

Dimensions of VIX optionality
VOV Term Structure (z-axis) & VIX Skew (x-axis)

VIX Volatility Surface

- VIX skew positively sloped
- VOV Term Structure VIX volatility increases into maturity
SPATIAL PARADOX – Volatility of Volatility Skew

Vol of VIX skew has built in a higher probability of volatility spikes to account for this “wildfire” effect

New Regimes of Fear
VIX index vs. Vol of VIX / SKew of the VIX (Smoothed)

VIX index vs. Vol of VIX / SKew of the VIX (Smoothed)

Volatility of the VIX (1m Options)

VIX index

Volatility of Volatility Skew

Vol of VIX skew has built in a higher probability of volatility spikes to account for this “wildfire” effect

New Regimes of Fear
VIX index vs. Vol of VIX / SKew of the VIX (Smoothed)

Increasingly expensive Vol of Vix post-2008 at all levels

Steepening VIX skew

Bull Market (Jan 2006 to Jul 2007)
Credit Crisis Onset (Aug 2007 to Aug 2008)
Market Crash (Sep 2008 to Feb 2009)
Recovery to Flash Crash (Mar 2009 to May 2010)
Post-Flash Crash Steepening (May 10 to Sep 11)
LTRO Steepening Regime (Nov 11 to Mar 12)
QEIII Regime (Sep 12 to Feb 13)
Temporal PARADOX – Volatility of Volatility Term Structure

Volatility of VIX Term Structure has steepened in the “bull market for fear” implying greater futures delta sensitivity to spot-VIX movement

New Regimes of Fear

Volatility of VIX Futures Term Structure / 2006 to 2013

Steepening VIX VOL Term Structure

Volatility of VIX Futures (%)}

Expiration / Terms

- Bull Market Jan 2007 to July 2007
- Credit Crisis Onset (Aug 2007 to Aug 2008)
- Market Crash (Sep 2008 to Feb 2009)
- Recovery to Flash Crash (Mar 2009 to May 2010)
- Post-Flash Crash Steepening (May 2010 to Oct 2011)
- LTRO Steepening (Nov 2011 to Aug 2012)
- QEIII (Sep 2012-Feb 2013)
Nonetheless VVIX has continued to drift lower tempered by the bull market in equities and QEIII – volatility can’t fight the Fed.
VIX Exchange Traded Products vs. Traditional Volatility Strategies

VIX ETPs gain in popularity despite muddled performance in comparison to classic volatility strategies

VIX ETPs vs. Traditional SPX Volatility Trades
Dec 2010 to July 2012

<table>
<thead>
<tr>
<th>Vol Bias</th>
<th>Traditional Volatility Trading</th>
<th>Volatility ETNs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ATM Long Straddle</td>
<td>ATM Short Straddle</td>
</tr>
<tr>
<td></td>
<td>-28.62%</td>
<td>31.31%</td>
</tr>
<tr>
<td>Sortino Ratio</td>
<td>-1.77x</td>
<td>0.79x</td>
</tr>
<tr>
<td>Sharpe Ratio</td>
<td>-1.20x</td>
<td>0.85x</td>
</tr>
<tr>
<td>Return to Drawdown</td>
<td>-0.57x</td>
<td>1.10x</td>
</tr>
<tr>
<td>Max Drawdown</td>
<td>-50.16%</td>
<td>-28.39%</td>
</tr>
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</table>
Prior to 1990 there was not VIX index. We have substituted the CBOE VXO index, the precursor to the VIX, which was available starting in 1986.

When the ‘shoeshine boy’ is shorting VIX ETNs maybe it is time to be cautious. Front-month VIX futures are increasingly influenced by short squeezes due to rising popularity of short selling strategies.

Note: Prior to 1990 there was not VIX index. We have substituted the CBOE VXO index, the precursor to the VIX, which was available starting in 1986.
Shorting the front of the Vol Curve

Volatility-of-VIX futures in the last 15 minutes is substantially higher than that of the VIX index itself demonstrating the power of structural flows

Volatility of VIX Index vs 1m Vix Future (2012) by Trading Minute
Averages by Year (annualized)

Volatility of VIX by Minute (% annualized)

Source: Calculations executed by Artemis Capital Management LLC with data from CQG data factory. Average executed trades by minute.
Great Vega Short could work if these conditions are always met:

1. Asset prices do not crash too far again and;
2. Other debtor-developed nations do not copy the strategy;
3. Taxpayer funded margin or government borrowing is unlimited.

If these conditions are not met before self-sustaining growth is revived, the asymmetrical return distribution of the strategy will result in ruin. Traders call this a Martingale process, similar to constantly doubling down your bet while gambling… It works only if your bankroll is unlimited… so the real question is whether the debtor-developed world has unlimited borrowing capability?

Despite higher asset prices, little evidence of experimental monetary policy is helping the middle and lower class who do not own stocks and do not have access to credit.

### Flash Crash
- **Black Monday 1987, Flash Crash**
- **2008 Crash, Great Depression**
  - Slowly building crash with slow recovery
  - End of leveraging cycle
  - High volatility, but relatively muted VOV
  - Great Depression
  - Global Recession
  - Flash Crash
- **Hyper-speed crash with fast recovery**
  - Market fragmentation and self-reflexity
  - Extreme volatility of volatility

### Artificially Low Vol from Monetary Expansion
- + Higher potential for Volatility-of-Volatility
- + Dangerous Global Macro catalysts
- + VIX Derivatives Short Squeeze

\[ \text{Short Roll Yield} \quad \text{Vol-of-Vol Timing Timing} \quad \text{Leverage} \]

\[ \text{Short Vol Squeeze} \quad \text{Hyper Vol-of-Vol} \quad \text{Self-Reflexivity} \]
Shorting the front of the Vol Curve

February 25\textsuperscript{th} 2013 - Volatility Killer Rabbit

Minute by Minute Performance of VIX and Front Month Future
VIX Jumps 29\% (log) on February 25th, 2013

VIX Futures Curve following Largest VIX \% Spikes (VIX < 20 to start)
2004-2013

10\% of future volume in last minute of trading!

Source: Calculations executed by Artemis Capital Management LLC with data from CQG data factory. Average executed trades by minute.
The Next Volatility Regime

Three Possible Macro-VIX regimes for the next decade

I. Bull Market in Fear = New Normal
   - Post-2008 vol environment of steep term-structure is here to stay
   - Traders short the front and buy the back but with violent corrections
   - High Implied Correlations, Volatility of Volatility, but low spot-vol

II. Bear Market in Fear = Japanization of US Volatility
   - Positive real rates lead to volatility as fixed income alternative
   - Long-term volatility and skew collapse as investors short rich vol
   - Rise of volatility short sellers builds systemic risk

III. Inflationary Volatility Spiral (Japan moving to this regime)
   - Runaway inflation actually drives higher volatility
   - Options skew “flips” to compensate (OTM Calls ↑ Vol)
   - OTM calls re-priced as we all have been hedging the wrong tail
Bull Market in Fear is Explained by Markowitz Portfolio Theory

- Long volatility exposure extremely valuable to portfolio optimization in financial repression despite substantial negative carry because it hedges forced over-allocation to equity
- *5-12% is optimal volatility portfolio exposure in negative real interest rate environment!*

**Optimal Portfolio with Positive Real Rates**

(Stocks, Bonds, Cash & Vol) / Portfolio Target = 3% real return
Inflation = 3%

**Optimal Portfolio in Financial Repression**

(Stocks, Bonds, Cash & Vol) / Portfolio Target = 3% real return
Inflation = 3%

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### Volatility Paradigm and Paradox

- Long Volatility exposure extremely valuable to portfolio optimization in financial repression despite substantial negative carry because it hedges forced over-allocation to equity.
- *5-12% is optimal volatility portfolio exposure in negative real interest rate environment!*

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**Volatility of VIX microstructure is calmer in 2012 however the last 30 minutes of the trading day have become increasingly more violent than previous periods.**

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**Bull Market in Fear and Modern Portfolio Theory**

- *Bull Market in Fear is Explained by Markowitz Portfolio Theory*
Post-Modern Volatility can be more than just FEAR

Volatility is the ultimate post-modern asset for our existential economic future because it protects you from the fracture of the abstraction.
**Visualizing Volatility**

*Volatility at World’s End: Two Decades of Movement in Markets* is a depiction of real stock market variance using trading data from 1990 to 2011. The visuals are designed from S&P 500 index option data replicating the implied volatility wave (or variance swap curve) extending to an expiration of one year. The front of the volatility wave contains the same data used to calculate the CBOE VIX index. The movement of this wave demonstrates changing trader expectations of future stock market volatility. As the wave moves through time the expected (or implied) volatility surface transforms into a realized volatility surface derived from historical S&P 500 index movement. The transition represents what professional traders call ‘volatility arbitrage’. The color variation in the volatility waves show the volatility-of-volatility or internal movement of the wave. The track underneath the volatility wave represents underlying S&P 500 index prices.
Reference Material & Acknowledgements

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"Penrose Triangle, Devil’s Turning Fork & Necker’s Cube" Derrick Coetzee / Public Domain

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Managing Partner & Portfolio Manager

Christopher R. Cole, CFA is the founder of Artemis Capital Management LLC and the portfolio manager of the Artemis Vega Fund LP. Mr. Cole’s core focus is systematic, quantitative, and behavioral based trading of exchange-traded volatility futures and options. His decision to form a fund came after achieving significant proprietary returns during the 2008 financial crash trading volatility futures. His research letters and volatility commentaries have been widely quoted including by publications such as the Financial Times, Bloomberg, International Financing Review, CFA Magazine, and Forbes. He previously worked in capital markets and investment banking at Merrill Lynch. During his career in investment banking and pension consulting he structured over $10 billion in derivatives and debt transactions for many high profile issuers. Mr. Cole holds the Chartered Financial Analyst designation, is an associate member of the NFA, and graduated Magna Cum Laude from the University of Southern California.
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