VOLATILITY AND THE PRISONER’S DILEMMA

CBOE Risk Management Conference Asia
Artemis Capital Management LP
Christopher Cole, CFA
December 1, 2015

98 San Jacinto, Suite 370
Austin, TX 78701
Phone (512) 467-4735
info@artemiscm.com
www.artemiscm.com
Volatility is an Instrument of Truth

Regardless of how it is measured volatility reflects the difference between the world as we imagine it to be and the world that actually exist.
“The only thing that will redeem mankind is cooperation”

Bertrand Russell

“Peace is not the absence of conflict”

Dorothy Thompson

Volatility and the Allegory of the Prisoner’s Dilemma

**Investors are trapped in a Prisoner’s Dilemma**

*Global central banking “arms race” to fight deflation has trapped investors in an equilibrium of excessive risk, debt, and false prosperity*

**Volatility is the only real asset class**

*Most active management strategies are short volatility in sheep's clothing*

**Volatility is your only escape from the Prisoner’s Dilemma**

*Hedge unknown unknowns and sell known unknowns*

*Global Macro Straddle + Asset Beta*
Cross-Asset Volatility

Rolling 12-month volatility adjusted by 30 year standard deviations / surface graph

Source: Artemis Capital Management LP, Bloomberg
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*

Illustration by Brendan Wuijf based on concept by Christopher Cole
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. The VIX index reached a 20+ year high of 80.86 on November 20th, 2008. 2008 was only “unprecedented” if you assume data from the inception of the VIX index in 1990. 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! VXO, precursor to VIX, hit 150.19 on Oct 19, 1987. 2008 was rare but not unprecedented!

Source: Artemis Capital Management LP, Global Financial Data
Volatility in Hellfire of Inflation
Extreme volatility can also occur in hyperinflation

Performance of German Stock Market during Weimar Republic Hyperinflation

- Adj. according to USD exchange rate
- Adj. according to wholesale index numbers
- In paper marks, Weimar

Weimar VIX?\(^{(1)}\)
Realized Volatility of German Stock Market during Weimar Republic Hyperinflation
(monthly volatility data annualized)

Source: “Economics of Inflation; A Study of Currency Depreciation in Post-War Germany” by Constantino Bresciani-Turroni Out of Print / 1968
(1) Based upon monthly realized variance from available stock price data.
Volatility in the Prisoner’s Dilemma

two purely rational entities may not cooperate, even if it is in their best interests to do so

Global central banks are in an arms race of devaluation resulting in suboptimal outcomes for all parties and greater systemic risk.
Volatility and Asset Prices in the Prisoner’s Dilemma

REGIMES OF GLOBAL CENTRAL BANK POLICY

GLOBAL CENTRAL BANK PUT VS. PRE-EMPTIVE STRIKES ON RISK

VIX INDEX (LHS) AND CFSI FINANCIAL STRESS INDEX (RHS) SINCE 2008

Classic Global Central Bank Put
Policy action occurs after the onset of financial stress and fundamental economic decline

Pre-Emptive Strikes Against Risk
Policy response at the first onset of financial stress but before full market and economic impact

Source: Artemis Capital Management LP, Global Financial Data
Volatility in the Prisoner’s Dilemma
Exchanges short term equilibrium for longer term tail risk

EFFECT OF GOVERNMENT INTERVENTION ON VOLATILITY

- Suppress Tail Risk
- Increase Peak of the Distribution
- Suppress Tail Risk

Source: Artemis Capital Management LP, Bloomberg
Volatility and Asset Prices in the Prisoner’s Dilemma

Best Risk Adjusted Performance for Equity Beta in 222 years

3 year Rolling Sharpe Ratio (LHS) vs. S&P 500 INDEX (RHS)

1793 to 2015

Source: Artemis Capital Management LP, Global Financial Data
Only two types of institutions in this world, those that are short convexity, and those that are massively short convexity

Source: Artemis Capital Management LP, Bloomberg
Active Long Volatility + Equity Index Exposure Significantly Outperforms the S&P 500 index and Major Hedge Fund Indices

LONG CONVEXITY + EQUITY BETA IS A POWERFUL COMBINATION

Source: CBOE Eurekahedge
Volatility by Holding Period

Source: CBOE Eurekahedge
We are all volatility traders
Most active management strategies produce alpha by being short volatility or correlation

Source: Hedge fund monthly returns from HFRX, volatility returns from Artemis Capital.
Volatility is the Only Real Asset Class
In the real world... there are two asset classes... long and short volatility

WHEN DOES PORTFOLIO #1 turn into PORTFOLIO #2?

1. **Deflationary collapse** followed by **financial repression** and **negative real rates** and/or;

2. **Historical correlation** (negative correlation) between equities and bonds **breaks down** rendering traditional diversification useless

Source: Special thanks to DROBNY Global Macro for original visual conceptualization of this idea
Volatility is the Only Real Asset Class
Changing Correlations Between Fixed Income and Equity Prices

Inconvenient Truth for Modern Portfolio Theory
Bonds do not always move opposite Stock Prices
Relationship between 10yr UST Yield and Domestic Equity Earnings Yield
3-year rolling correlation (monthly data) - 1885 to 2015

Source: Artemis Capital Management LP, Global Financial Data, Robert Schiller
Volatility is the Only Real Asset Class
Changing Correlations Between Fixed Income and Equity Prices

Source: Artemis Capital Management LP, Global Financial Data
The Next Volatility Regime

Three Possible Macro-VIX regimes for the next decade

I. Bull Market in Fear (2009 to 2012)
   - Post-2008 vol environment of steep term-structure
   - High Implied Correlations and Forward Volatility
   - Low to

II. Bear Market in Fear = Japanization of US Vol (2012 to Now)
   - 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 and high VOV

III. Deflationary or Inflationary Volatility Spiral
   - Runaway deflation/inflation drives higher volatility
   - Outperformance on the specific “tail” of the distribution
   - OTM puts/calls re-priced
Fear Regimes Explained by Portfolio Theory

Volatility Yields Should Rise (fall) when Real Interest Rates are negative (positive)
Diversification benefits of volatility become more valuable than extra yield (negative real) earned on fixed income

Volatility as a Portfolio Substitute for Fixed Income
Real Interest Rates (2yr UST - CPI) vs. Volatility Yield (SPX / 25% OTM Put)
1990 to Early 2014

- Real Interest Rate (2yr UST - CPI)
- 1-year SPX Volatility Yield (-25% OTM Put / Notional)
Volatility Yield vs. Fixed Income

Prisoner's Dilemma - Forced to Take Excessive Risk
Yields on UST Bonds, Investment Grade Corporate, High Yield, and Short Volatility

Source: Artemis Capital Mgmt LP, FRED, MarketDataExpress
**Bull Market in Fear and Modern Portfolio Theory**

**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%

<table>
<thead>
<tr>
<th>Nominal Expected Return on Stocks</th>
<th>Equity %</th>
<th>Fixed Income %</th>
<th>Cash %</th>
</tr>
</thead>
<tbody>
<tr>
<td>6%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Allocation for 3% Real Return

Source: Calculations executed by Artemis Capital Management LLC. Covariance matrix based on data between 1990-2013.

---

**Optimal Portfolio in Financial Repression**

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

- Inflation = 3%

<table>
<thead>
<tr>
<th>Long Volatility %</th>
<th>Cash %</th>
<th>Equity %</th>
<th>Fixed Income %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Allocation for 3% Real Return

---

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

**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%

<table>
<thead>
<tr>
<th>Nominal Expected Return on Stocks</th>
<th>Equity %</th>
<th>Fixed Income %</th>
<th>Cash %</th>
</tr>
</thead>
<tbody>
<tr>
<td>6%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Allocation for 3% Real Return

Source: Calculations executed by Artemis Capital Management LLC. Covariance matrix based on data between 1990-2013.
Volatility Yield vs. Fixed Income

Brothers in Risk
Relationship between Credit (rhs) and Volatility (lhs)

Correlation between Credit and Volatility
1997 to 2015

Source: Artemis Capital Mgmt LP, FRED, MarketDataExpress
Understanding VIX options

Dimensions of VIX optionality

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

VIX Volatility Surface

Vol of Vol

Moneyness (Sigma)

Maturity

VIX skew

Positively sloped

VOV Term Structure

VIX volatility increases into maturity

Mar-13
Apr-13
May-13
Jun-13
Jul-13
40%
60%
80%
100%
120%
140%
160%
-1.0σ
0.5σ
2.0σ
3.5σ
5.0σ
What Effects the Price of Volatility?
Structural imbalances in supply-demand dynamics of volatility

<table>
<thead>
<tr>
<th>Theme</th>
<th>Bull Market In Fear</th>
<th>Bear Market In Fear</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Emotional</td>
<td>▪ Post-traumatic Deflation Disorder</td>
<td>▪ Euphoria, Complacency, Greed</td>
</tr>
<tr>
<td>II. Monetary</td>
<td>▪ Forced participation in risk assets drives desire for hedging</td>
<td>▪ Low risk premiums drive volatility shorting for yield hunt</td>
</tr>
<tr>
<td>III. Macro</td>
<td>▪ Forced participation in risk assets drives desire for hedging</td>
<td>▪ Low risk premiums drive volatility shorting for yield hunt</td>
</tr>
<tr>
<td>IV. Regulatory</td>
<td>▪ Gov. regulation (Dodd-Frank) constrains risk appetite</td>
<td>▪ Dealers no longer able to inventory long volatility</td>
</tr>
</tbody>
</table>
Bull and Bear Markets in Fear

Low VIX index does not mean cheap volatility
You can’t trade the VIX – you can only trade the expectation of VIX

Lowest Volatility? Really?

VIX Futures Curve Comparison

August 17, 2012 vs. September 2008

Source: Artemis Capital Management LP, Bloomberg
Bull and Bear Markets in Fear
Forward volatility is a poor indicator for future movement of spot-vol

VIX Index and Forward Expectation of VIX Index

<table>
<thead>
<tr>
<th>Bear Market in Fear</th>
<th>Volatility Spikes</th>
<th>Volatility Falls and Bull Market in Fear</th>
<th>Bear Market in Fear</th>
<th>Moral Hazard Market</th>
</tr>
</thead>
</table>

Note:
Calculations based on monthly averages of VIX index and constant-maturity VIX futures

Historic Inversion shows expectation of central bank reaction function!
Volatility protects you from Shadow Short Convexity

Shadow Short Convexity
Immeasurable risk introduced when market participants reorganize portfolios in way that contributes to feedback loops

Source: Walt Disney, Fantasia
Short Interest in Volatility ETPs has exploded in the 2012-2014 period. Everyone is short volatility = dangerous. Yikes!

Source: Artemis Capital Management LP, Bloomberg
Nonlinear Rebalancing of Short VIX ETPs is disaster in making...

100% one day move in VIX could require $2 to $3 billion of vega buying pressure from short and leverage VIX ETPs alone (XIV, SXVY, TVIX & UVXY)

Source: Artemis Capital, Bloomberg
* Assumes month 1 and month 2 VIX futures move simultaneously. Ratio as % change in vega notional from start. Assumes 1 day move in vol and no inflow or outflow from starting ETP AUM.
Short Interest in Volatility ETPs has exploded in the 2012-2014 period. Everyone is short volatility = dangerous.

Source: Artemis Capital Management LP, Bloomberg

**VOLATILITY LIQUIDITY GAP**

Estimated Vega Notional Rebalance of Volatility ETPs as % of Liquidity (LHS) vs VIX Index (RHS)
August Volatility Event – Fastest Mean Reversion in History

Fastest Volatility Mean Reversion Ever

# of Consecutive Days for VXO (SPX 100 Vol) to Drop Below 15 After Spike to 30 or above

Source: Artemis Capital Management LP, Bloomberg
Left Tail of Volatility

**VIX TOP RANKED DRAWUPS**

1990 to Sep 2015 (Consecutive Days)

- Supernormal Vol Drawups & Violations of Power Law Dynamics
- Normal Vol Drawdowns Follow Power Laws

**VIX RANKED DRAWDOWNS**

1990 to Nov 2015 (Consecutive Days)

- Supernormal Vol Drawdowns & Violations of Power Law Dynamics
- Normal Vol Drawdowns Follow Power Laws

**VIX Index - Top Ranked Supernormal Vol Drawups**

<table>
<thead>
<tr>
<th>Rank</th>
<th>Date(T+)</th>
<th>Date(0)</th>
<th>Val(T+)</th>
<th>Val(0)</th>
<th>Drawup</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8/24/2015</td>
<td>8/14/2015</td>
<td>40.74</td>
<td>12.83</td>
<td>218%</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>5/7/2010</td>
<td>5/3/2010</td>
<td>40.95</td>
<td>20.19</td>
<td>103%</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>10/30/1997</td>
<td>10/21/1997</td>
<td>38.20</td>
<td>19.53</td>
<td>96%</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>2/27/2007</td>
<td>2/22/2007</td>
<td>18.31</td>
<td>10.18</td>
<td>80%</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>12/12/2014</td>
<td>12/5/2014</td>
<td>21.08</td>
<td>11.89</td>
<td>77%</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>8/6/1990</td>
<td>8/2/1990</td>
<td>35.91</td>
<td>20.43</td>
<td>76%</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>9/17/2001</td>
<td>8/31/2001</td>
<td>41.76</td>
<td>24.92</td>
<td>68%</td>
<td>6</td>
</tr>
<tr>
<td>10</td>
<td>10/13/2014</td>
<td>10/8/2014</td>
<td>24.64</td>
<td>15.11</td>
<td>63%</td>
<td>3</td>
</tr>
</tbody>
</table>

**VIX Index - Top Ranked and Supernormal Volatility Drawdowns**

<table>
<thead>
<tr>
<th>Rank</th>
<th>Date(T+)</th>
<th>Date(0)</th>
<th>Val(T+)</th>
<th>Val(0)</th>
<th>DrawDown</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10/12/2015</td>
<td>9/28/2015</td>
<td>16.17</td>
<td>27.63</td>
<td>-41.48%</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>7/17/2015</td>
<td>7/9/2015</td>
<td>11.95</td>
<td>19.97</td>
<td>-40.16%</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>3/25/2011</td>
<td>3/16/2011</td>
<td>17.91</td>
<td>29.4</td>
<td>-39.08%</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>12/24/2014</td>
<td>12/16/2014</td>
<td>14.37</td>
<td>23.57</td>
<td>-39.03%</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>10/14/2011</td>
<td>10/3/2011</td>
<td>28.24</td>
<td>45.45</td>
<td>-37.87%</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>5/12/2010</td>
<td>5/7/2010</td>
<td>25.52</td>
<td>40.95</td>
<td>-37.68%</td>
<td>9</td>
</tr>
<tr>
<td>8</td>
<td>10/21/2014</td>
<td>10/15/2014</td>
<td>16.08</td>
<td>25.27</td>
<td>-36.37%</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>8/28/2015</td>
<td>8/24/2015</td>
<td>26.05</td>
<td>40.74</td>
<td>-36.06%</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>11/20/1990</td>
<td>11/7/1990</td>
<td>20.09</td>
<td>30.87</td>
<td>-34.92%</td>
<td>9</td>
</tr>
</tbody>
</table>

August Volatility Event – High Volatility of VIX

VVIX (lhs) vs Realized Volatility of VIX (21d) (lhs) & 1-month SPX Drawdown (rhs) 2007 to 2015

Source: Artemis Capital Management LP, Bloomberg
**Conditions over Causation**

*Much easier to see conditions that increase the probability of a forest fire than to predict the exact spark that will ignite one*

---

**Volatility Wildfire Conditions**

- Financial Stress
- Correlation Breakdowns
- Volatility of Volatility
- Currency Flows
- Volatility Momentum
- Equity Turbulence
- High Leverage
- Low Hedging
- Autocorrelation
- Inter-bank Lending
- Credit Stress
- FX Turbulence
- Breakeven CPI
- Expected Inflation
- Liquidity Stress

---

*Note: Artemis proprietary model based on financial stress conditions. Machine learning model utilizes learned conditions to approximate state of volatility*
Volatility Regime Shift in the Prisoner’s Dilemma

Source: Artemis Capital Management LP, Bloomberg
Volatility Regime Shift in the Prisoner’s Dilemma

FINANCIAL STRESS (lhs) vs. VIX INDEX (rhs)

Source: Artemis Capital Management LP, Bloomberg
You would not drive cross-country using only your rear view mirror!!!

Financial markets do not always look like Nebraska!
So why does Wall Street mostly use past volatility to gauge future volatility?

**Historic Volatility** and **Forward Expectation of Volatility**
0.94 correlation!!!

Source: Artemis Capital Management LP, Bloomberg
1987 Black Monday Crash

Buy the FEAR and you will always be protected from the HORROR
Volatility is your Only Escape from the Prisoner’s Dilemma
GLOBAL MACRO STRADDLE + BETA

Note: Artemis created a model to simulate the behavior of the equity returns, volatility movement, and “greek” sensitivities of options. Volatility simulations are expected to represent real potential scenarios but there is no guarantee as to accuracy of the model.
Are we too complacent?

Source: Financial Times / September 2014
Christopher Cole, CFA
Managing Partner & Portfolio Manager / Artemis Capital Management LP

Christopher R. Cole, CFA is the founder of Artemis Capital Management LP and the portfolio manager of the Artemis Vega Fund LP and affiliated institutional managed accounts. Mr. Cole’s core focus is systematic, quantitative, and behavioral based trading of volatility managed derivatives. His decision to form a fund came after achieving proprietary returns during the 2008 financial crash trading volatility futures. Mr. Cole's research letters and volatility commentaries were influential in derivatives circles and thereafter widely referenced and quoted by the mainstream financial media, academic, and institutional asset management communities. He previously worked in capital markets and investment banking at Merrill Lynch. During his career in capital markets 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.