





Volatility and the Allegory of the Prisoner's Dilemma

False Peace, Moral Hazard, and Shadow Convexity

TABLE OF CONTENTS

VOLATILITY AND THE ALLEGORY OF THE PRISONER'S DILEMMA.....	1
MORAL HAZARD IN THE PRISONER'S DILEMMA	3
COSMOLOGY IN THE PRISONER'S DILEMMA	5
RISK CONTROL IN THE PRISONER'S DILEMMA	6
CONVEXITY AND THE PRISONER'S DILEMMA.....	7
SHADOW SHORT CONVEXITY IN THE PRISONER'S DILEMMA	8
BLACK SWANS IN THE PRISONER'S DILEMMA	9
MODERN PORTFOLIO THEORY IN THE PRISONER'S DILEMMA	10
CONVEXITY EXPOSURE IN THE PRISONER'S DILEMMA.....	11
EQUITY VALUATIONS IN THE PRISONER'S DILEMMA.....	13
YIELDS IN THE PRISONER'S DILEMMA	14
STOCK AND BOND CORRELATIONS IN THE PRISONER'S DILEMMA.....	15
VIX IN THE PRISONER'S DILEMMA.....	19
SHORT VOLATILITY IN THE PRISONER'S DILEMMA.....	22
DEBT IN THE PRISONER'S DILEMMA.....	24
INCOME INEQUALITY IN THE PRISONER'S DILEMMA	25
DEMOCRACY IN THE PRISONER'S DILEMMA.....	26
ESCAPE FROM THE PRISONER'S DILEMMA.....	27
EPILOGUE TO THE PRISONER'S DILEMMA.....	30

APPENDIX

CINEMATIC CONVEXITY.....	34
ALLEGORY OF THE PRISONER'S DILEMMA TAPESTRY KEY AND ARTIST COMMENTARY	35
CITATIONS AND REFERENCES	48





Volatility and the Allegory of the Prisoner's Dilemma

False Peace, Moral Hazard, and Shadow Convexity

Dorothy Thompson once said “**peace is not the absence of conflict**”. Never forget there is a form of peace and stability reinforced by a foundation of underlying volatility. Game theorists call this the paradox of the **Prisoner’s Dilemma**, and it describes a dangerously fragile equilibrium achieved only through brutal competition. The **Prisoner’s Dilemma** is the most important paradigm for understanding shadow risk in modern financial markets at the pinnacle of a multi-generational debt cycle unparalleled in the history of finance.

In their masterwork tapestry entitled “**Allegory of the Prisoner’s Dilemma**” the artists Diaz Hope and Roth visually depict a great tower of civilization that rests upon a bedrock of human cooperation and competition across history. The artists force us to confront the fact that after 10,000 years of human civilization we are now at a cross-roads. Today we have the highest living standards in human history that co-exist with an ability to destroy our planet ecologically and ourselves through nuclear war. We are in the greatest period of stability with the largest probabilistic tail risk ever. The majority of Americans have lived their entire lives without ever experiencing a direct war and this is, by all accounts, rare in the history of humankind. Does this mean we are safe from the risk of devastating conflict on our own soil? In 1961, at the height of the Cold War, a B-52 bomber carrying two Mark 39 thermonuclear bombs accidentally crashed in rural North Carolina. A low technology voltage switch was the only thing that prevented a 4-megaton nuclear bomb with 250 times the yield of the bomb dropped on Hiroshima from detonating on American soil. In addition to killing everyone within the vicinity of the blast, the winds would have carried radioactive fallout over Washington D.C., Baltimore, Philadelphia, and New York City⁽¹⁾. It is not inconceivable to imagine that, at the height of cold war, a weapon of that magnitude exploding randomly on the eastern seaboard would have triggered immediate accidental retaliation against the Soviets resulting in full scale Armageddon and the end of humankind as we know it. This is just one of many nuclear accidents during the cold war. Peace has a dark side. Peace can exist due to hidden conflict in the Prisoner’s Dilemma.

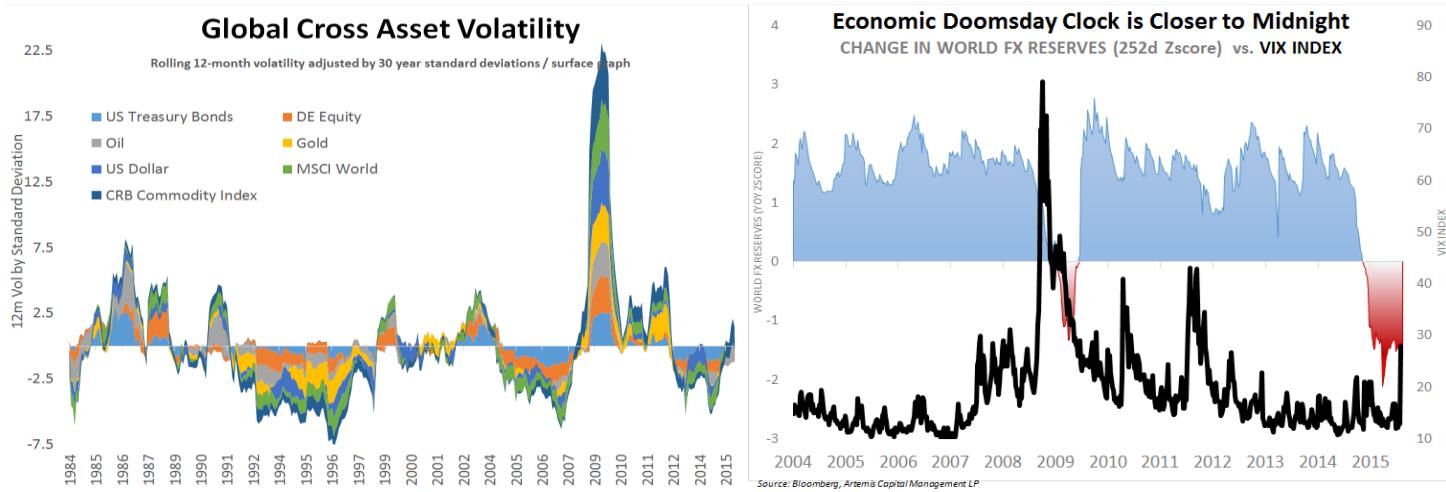
Global Capitalism is trapped in its own Prisoner’s Dilemma; fourty four years after the end of the Bretton Woods System global central banks have manipulated the cost of risk in a competition of devaluation leading to a dangerous build up in debt and leverage, lower risk premiums, income disparity, and greater probability of tail events on both sides of the return distribution. Truth is being suppressed by the tools of money. Market behavior has now fully adapted to the expectation of pre-emptive central bank action to crisis creating a dangerous self-reflexivity and moral hazard. Volatility markets are warped in this new reality routinely exhibiting schizophrenic behavior. The tremendous growth of the short volatility complex across all assets, combined with self-reflexive investment strategies, are creating a dangerous ‘shadow convexity’ that will fuel the next hyper-crash. Central banks in the US, Europe, Japan, and China now own substantial portions of their own bond or equity markets. We are nearing the end of a thirty year “monetary super-cycle” that created a “debt super-cycle”, a giant tower of babel in the capitalist system. As markets now fully price the expectation of central bank control we are now only one voltage switch away from the razors edge of risk. **Do not fool yourself - peace is not the absence of conflict – peace can exist on the very edge of volatility.**





Prisoner's Dilemma describes when two purely rational entities may not cooperate even if it is in their best interests to do so, thereby replacing known risks for unknown risks. In an arms race when two superpowers possess the ability to destroy each other, the optimal solution is disarmament and peace. If the superpowers do not trust one another completely, the natural course of action is proliferation of conflict through nuclear armament despite great peril to all. This non-cooperation, selfishness, and conflict, ironically results in an equilibrium of peace, but with massive risk.

Global central banks are engaged in an **arms race of devaluation** resulting in suboptimal outcomes for all parties and **greater systemic risk**. In this year alone 49 central banks have cut rates or devalued their currencies to gain a competitive edge and since 2008 there have been over 600 rate cuts worldwide⁽²⁾. Globally we have printed over 14 trillion dollars since the end of the financial crisis⁽³⁾. The global economy did not de-leverage from the 2008 crash but instead doubled down as global debt has increased a staggering 40% since 2007⁽⁴⁾. The pace of global growth is slowing with the World Bank lowering GDP projections from 3% to 2.5%, and emerging economies from China to Brazil are struggling⁽⁵⁾. Global currency reserves outside the US have declined over \$1 trillion USD from their peak in August 2014 as foreign central banks have sold dollars to offset the ill effects of capital flight and commodity declines⁽⁶⁾. The last time the world economy experienced declines in reserves of this magnitude was right before the crash of 2008. Cross-asset volatility is rising from the lowest levels in three decades yet markets remain complacent with the expectation that central banks will always support asset prices. **Volatility regime change** is happening now and is a bad omen for a global recession and bear market.



As global central banks compete in an endless cycle of fiat devaluation an **economic doomsday clock** ticks closer and closer to **midnight**. The flames of volatility regime change and an emerging markets crisis ignited on the mere expectation of a minor increase in the US federal funds rate that never came to be. The negative global market reaction to this token removal of liquidity was remarkable. Central banks are fearful and unwilling to normalize but artificially high valuations across asset classes cannot be sustained indefinitely absent fundamental global growth. Central banks are in a prison of their own design and we are trapped with them. The next great crash will occur when we collectively realize that the institutions that we trusted to remove risk are actually the source of it. The truth is that global central banks cannot remove extraordinary monetary accommodation without risking a complete collapse of the system, but the longer they wait the more they risk their own credibility, and the worse that inevitable collapse will be.

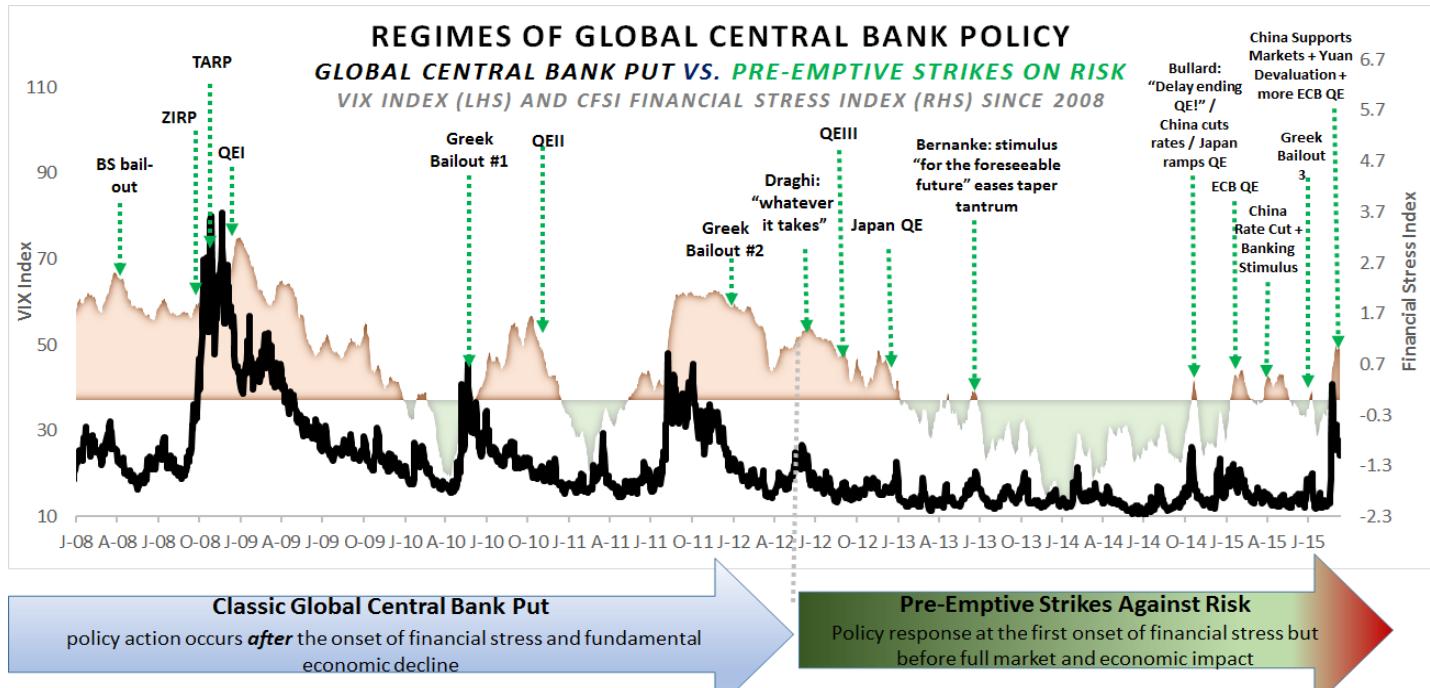
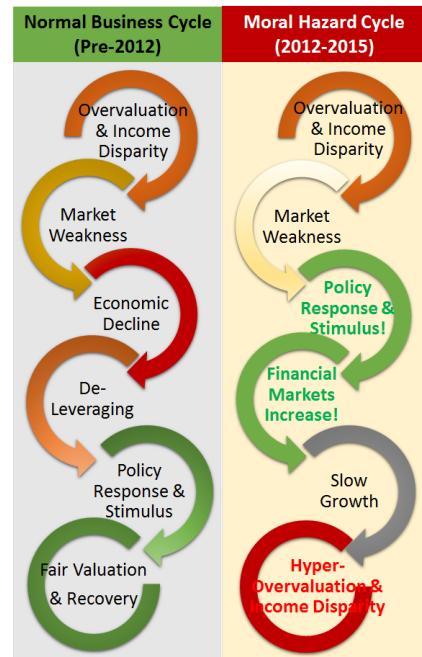
In the Prisoner's Dilemma, global central banks have set up the greatest volatility trade in history.



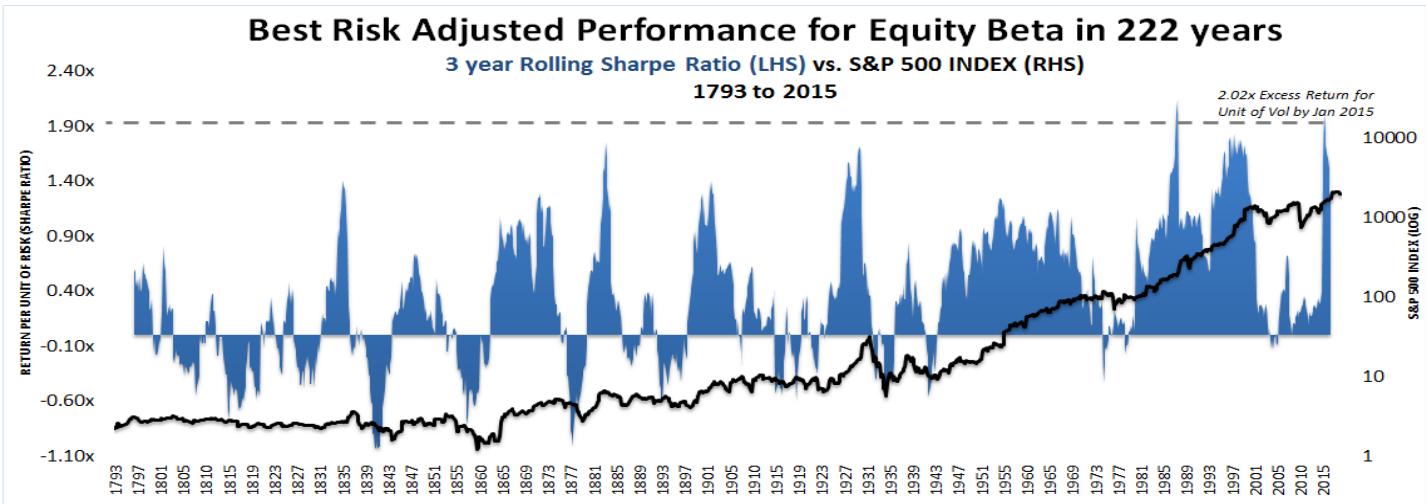
Moral Hazard in the Prisoner's Dilemma

A pre-emptive war describes a violent action designed to eliminate a perceived threat before it even materializes. Since 2012, the Federal Reserve have been engaged in a pre-emptive war against financial risk, and other central banks are forced to follow suit in a self-reinforcing cycle of devaluation and a mad game of Prisoner's Dilemma. This unofficial, but clearly observable policy has the unintended consequence of socializing risk for private gain and introduces deep 'shadow' risks in the global economy.

Pre-emptive central banking is a very different concept than the popular idea of the "central bank put". The classic "central bank put" refers to policy action employed in response to, but not prior to, the onset of a crisis. Rate cuts in 1987, 1998, 2007-2008, and Quantitative Easing I and II ("QE") programs were a response to weak economic data, elevated financial stress, and large drawdowns in credit and equity markets. To differentiate, pre-emptive central banking refers to monetary action *in anticipation* of future **financial stress** to avert a market crash **before** it starts, even if markets appear healthy and volatility is low. In executing a pre-emptive strike on risk, policymakers rely on changes in faster moving market data (e.g. 5yr-5yr breakeven inflation) rather than slower moving fundamental economic data (e.g. CPI and unemployment). Although well intentioned, their actions have created dangerous self-reflexivity in markets by artificially suppressing volatility and encouraging rampant moral hazard. Central banks have exchanged 'known unknowns' for 'unknown unknowns' creating the potential for dangerous feedback loops. A central bank reaction function is now fully embedded in risk premiums. Markets are pricing the supportive policy response before action is even taken. Bad news is good news and vice versa because the intervention is more important than fundamentals. Pre-emptive strikes on risk are contributing to the massive growth and popularity of any asset or strategy with a short convexity or mean reversion return profile. The unintended consequences of this massive short convexity complex will be born from phantom liquidity, shadow gamma, and self-reflexivity. In the past year alone, we have experienced 10+ sigma movements in the CBOE VIX index, US Treasury Yields, German Bunds, Oil, Chinese Equity Markets, and the Swiss Franc. Markets continue to exhibit bi-polar behavior as they struggle to gauge the level of anticipated forward invention by central banks against declining global growth.



The market has ceased to become an expression of the economy... it is the economy. The purpose of a pre-emptive strike on financial risk is to manipulate market psychology to affect fundamental reality. The global shift toward pre-emptive central banking occurred in the summer 2012: first with Mario Draghi's pledge to do "whatever it takes" to save the Euro on July 26th; and followed thereafter by Bernanke's QE3 speech at Jackson Hole on August 30th. At the time, risk assets had completely rebounded from the 2008 crisis and the VIX was in the mid-teens. Despite calm financial markets and falling financial stress, central banks on both sides of the pond added new doses of radical monetary policy. Since the summer of 2012, every period of rising financial stress has resulted in either direct monetary action by a major central bank or dovish commentary by a key official (see graphic on prior page). The result has been one of the best three-year volatility-adjusted performances for stocks in over 200 years of data!



Source: Global Financial Data, Artemis Capital Management LP

Moral hazard is institutionalized in the price of risk. A new generation of traders has learned to buy every stock market dip, short every volatility spike, and re-leverage at the mere hint of government intervention. Yield starved investors are forced to chase the expectation of government response rather than fundamental returns and good business models. If central banks are constantly reacting to market conditions rather than economic conditions the net effect is to crowd out value investors (please see Kaleidoscope Capital's excellent thought piece "The Fed is the New Value Investor" for more on this topic). It explains why great value investors like David Einhorn are experiencing their worst months since the 2008 crisis as value underperforms momentum; and why great contrarian investors like Hugh Hendry have been chasing leveraged beta in whichever market central banks are most actively propping up and making good returns doing it. Most importantly, it explains why the top 1% of income earning households that are most exposed to the **market economy** are dramatically outperforming the remaining 99% that are exposed to the **real economy**.

Pre-emptive central banking is analogous to Bush Doctrine foreign policy. The US foreign policy response to the 9/11 terror attacks involved a pre-emptive war against Iraq to prevent future terrorism. The Iraq war appeared successful at first, but soon after the fall of Baghdad dangerous 'unknown unknowns' emerged. In the aftermath of 2003 invasion, a rising insurgency and sectarian war led to a continuous and costly occupation and the deaths of 4.5k American soldiers⁽⁷⁾ and an estimated 500k Iraqi combatants and civilians⁽⁸⁾. The cost of the war ballooned to \$2 trillion and this limited our ability to respond fiscally to the 2008 recession⁽⁹⁾. President Obama, who started as an underdog candidate in the primaries, was victorious over Clinton and then McCain largely because he was credible in his opposition to the war. By 2011 Obama made good on a promise to withdraw US troops from Iraq. The chaos of a failed state led to the rise of ISIS, a terror group even more brutal than Al Qaida, which now operates with impunity over large portions of Iraq and Syria. As ISIS fights Assad and the Kurds in Syria the civil war has resulted in largest refugee crisis in Europe since World War II with an estimated 4 million Syrians fleeing violence in their country and another 12 million in need humanitarian assistance⁽¹⁰⁾. With no strategic buffer in the region and a shared enemy in ISIS, the US has controversially sought to strengthen diplomatic ties with Iran - an original member of Bush's "axis of evil". Whether you believe the Iraq war was just or not the point is that nobody predicted this extreme range of outcomes back in 2003. In similar fashion, global central banks are severely underestimating the unknown unknowns from their unprecedented policies today.



Cosmology in the Prisoner's Dilemma

"You have **meddled** with the **primal forces of nature**, Mr. Beale, and I won't have it, is that clear? You think you have merely stopped a business deal--- that is not the case! The Arabs have taken fifty billion dollars out of this country, and now they must put it back!

It is ebb and flow, tidal gravity, it is ecological balance!

You are an old man who thinks in terms of nations and peoples...

There are **no** nations!

There are **no** peoples!

There are **no** Russians!

There are **no** Arabs!

There are **no** third worlds!

There is **no** West!

There is only ONE holistic system of systems, one vast and immense, interwoven, interactive, multi-variate, multi-national dominion of dollars!

Petro-dollars, electro-dollars, multi-dollars! Reichmarks, rubles, rin, pounds and shekels!

It is the international system of currency that determines the totality of life on this planet!

That is the natural order of the things today!

That is the atomic, subatomic and galactic structure of things today! And **YOU** have meddled with the primal forces of nature, and **YOU WILL ATONE!!!!**

Am I getting through to you, Mr. Beale?

Now you get up on your little twenty-one inch screen, Mr. Beale, and **howl** about **America** and **democracy**.

There is no America.

There is no democracy.

There is only IBM, and ITT, and AT&T, and Dupont, Dow, Union Carbide, and Exxon.

Those are the nations of the world today.

What do you think the Russians talk about in their councils of state – Karl Marx? They pull out their linear programming charts, statistical decision theories and minimax solutions like the good little systems analysts they are and compute the price-cost probabilities of their transactions and investments just like we do.

We no longer live in a world of nations and ideologies, Mr. Beale.

The **world** is a **college of corporations**, inexorably determined by the **immutable** by-laws of business.

The world is a business, Mr Beale.

It has been that way since man crawled out of the slime, and our children, Mr. Beale, will live to see that perfect world without war and famine, oppression and brutality – one cast and ecumenical holding company, for whom all men will work to serve a common profit, in which all men will hold a share of stock, all necessities provided, all anxieties tranquilized, all boredom amused,

and I have chosen you to preach this evangel Mr. Beale....

why...Because you are on television."

Network, 1976

Written by Paddy Chayefsky

Directed by Sidney Lumet

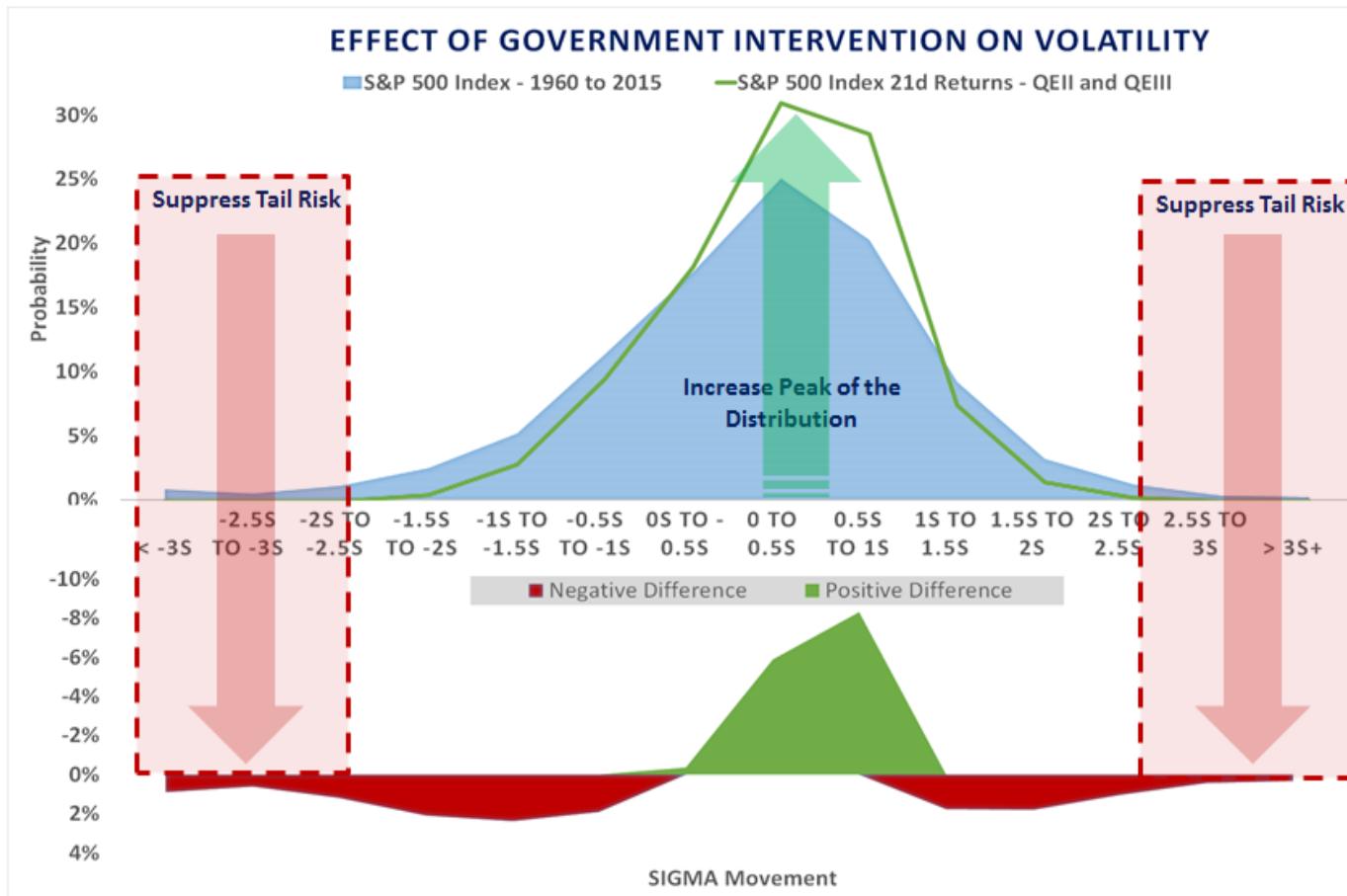


Risk Control in the Prisoner's Dilemma

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

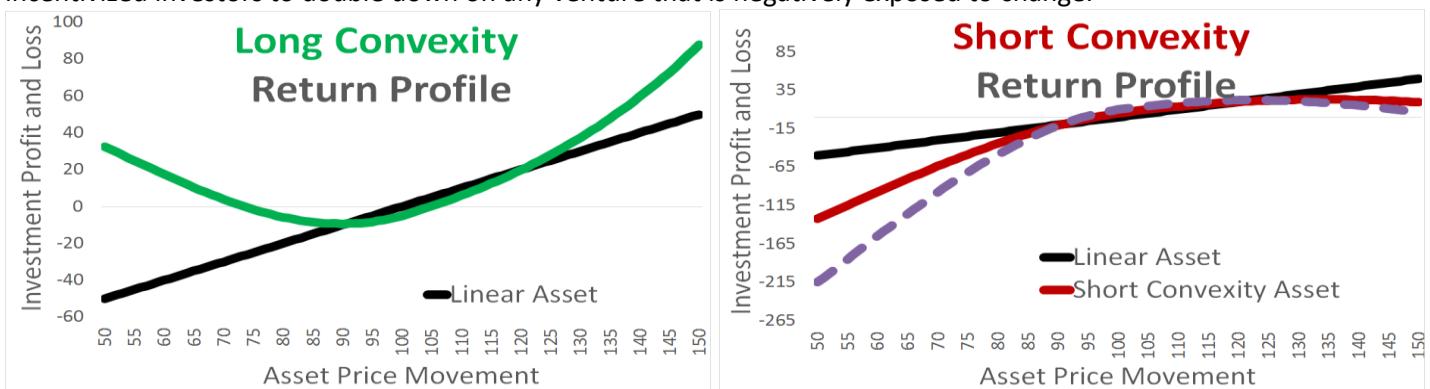
Vibrant life and rebirth comes from the acceptance of change and death in many complex systems. The forest service has long understood that controlled burns are a more effective tool for fighting forest fires than total suppression. The act of subduing forest fires results in a dangerous build up in dry foliage that counterintuitively causes larger and larger fires. Mother Nature will initiate controlled burns naturally via lightning strikes and this is essential to the rebirth of the forest. The trees of the great sequoia forests will not release seeds without first sensing heat from a wildfire. The art of avalanche prevention in backcountry snow terrain is based on a similar philosophy. Rangers use controlled blasts to reduce snow pressure rather than risk massive uncontrollable slides. Marriage therapists observe that couples that do not fight are at the greatest risk of a divorce. The couples that fight actively bring core issues to the forefront instead of suppressing their problems. Apathy is worse than anger. Treatment of cancer requires extensive chemotherapy to kill the cancerous agents from the body and allow healthy cells to multiply. Treatment of addiction requires brutal recognition of the reality of the problem, personal responsibility, and immediate withdrawal from the source despite painful short-term effects. The act of pruning a garden requires forcefully removing sick leaves to promote the vibrancy of the healthy plants. In management science the ability to address problematic or below average employees is an essential value in the culture of many successful organizations. The classic trading axiom of "cutting your losers and letting your winners ride" is an alternative form of the same idea. All of the aforementioned natural and social phenomena have great **positive exposure** to change but at the expense of a short-term loss. In other words, they are **long convexity**.

The mainstream view that central banks have suppressed tail risk is absurd and runs counter to common sense. Policy makers have done the opposite. Central banks have taken **asset returns from the future** and **brought them to the present**... they have taken **tail risk from the present** and shifted it into the **future**... that have turned **private risk** into **public risk**. The risk is not gone... do not fool yourself.



Convexity and the Prisoner's Dilemma

There are two types of institutions in this world: institutions that are **short convexity** and institutions that are **massively short convexity**. Portfolio management in the Prisoner's Dilemma is about recognizing that central banks have artificially incentivized investors to double down on any venture that is negatively exposed to change.



A **short convexity** choice derives small incremental gains on the assumption of stability in exchange for the risk of substantial loss in the event of change. A **long convexity** choice is the opposite, requiring a small upfront cost, in exchange for robust and significant positive exposure to change. Many investments and life choices reflect one form or the other⁽¹¹⁾.

Convexity is more than a financial concept and represents an entire cosmological construct for life. We are short convexity in our everyday lives without even being conscious of it and rationalize our exposure through cognitive dissonance. For example speeding, smoking, consumer debt, abusive relationships, not flossing, marrying for money and not love, obesity, or taking a job for a paycheck rather than for growth are all examples of short convexity behavior. Few individuals decisively pursue a course of long volatility that requires upfront cost or conflict in the short term for positive and nonlinear exposure to change. You are long convexity when you seek to improve yourself through self-study, exercise, healthy eating, networking, surrounding yourself with those who are smarter than you, traveling, and through meditation. As an institution gets increasingly larger and more complex it becomes more sensitive to change and falls into a short convexity trap. Small is beautiful because it is adaptable and defensive. This is one reason why hedgehogs, which have ancestors dating back 80 million years, managed to outlive dinosaurs⁽¹²⁾.



The human psyche has a very difficult time comprehending nonlinearity and convexity. While few people can even comprehend convexity exposure, what is even less transparent is the hidden convexity that exists in the way complex systems self-organize. I call this **shadow convexity** and it is much harder to understand and measure. In life shadow convexity exists when fragility or robustness is incentivized to such a degree that it becomes unknowingly institutionalized within a system of interactions. For example, when someone abuses drugs he or she is making an individual short convexity choice. Over time that individual may be ostracized by friends who do not wish to associate with that behavior and is drawn into a network of other abusers amplifying the original risk. Likewise shadow positive convexity can be a driving force for good. Many people seek out networks that share and reinforce positive values. When an organization achieves a positive culture this can exponentially magnify the results of a pre-existing positive process. The human mind often experiences a nonlinear reality via a linear construct. For example, time is nonlinear but we don't experience it that way. To this same effect your thoughts and the thought systems of those you surround yourself with have unforeseen power. Like attracts like, but more importantly like attracts like in an exponential fashion. In this cosmology of convexity look at your own life and try to understand where you are short and where you are long? What brings you a small amount of benefit at great risk of loss if the status quo is disrupted? Likewise, where have you taken a difficult road that in the end generates happiness from the vast complexity and randomness of life? Life is fragile. We are all born with something to lose... the ultimate short convexity is time and health. Warren Buffett is worth \$66.7bn but he is 85 years old. Would you switch places with him? No way. I own something called a "Tikker" which is essentially a watch that counts time backwards based on my life expectancy. I have 12933 days, 21 hours, 52 minutes, and 14 seconds left in my life as of right now. Every human life is a long option... bleeding linear time... with great exponential possibilities.

Where is your convexity?



Shadow Short Convexity in the Prisoner's Dilemma

“The world-in-itself is a paradoxical concept; the moment we think it and attempt to act on it, it ceases to be the world-in-itself”

Eugene Thacker, In the Dust of This Planet

Pre-emptive strikes on financial risk through unconventional monetary policy amplifies 'shadow' short convexity leading to tail risks that are near impossible to gauge. **Shadow short convexity** describes an immeasurable fragility to change introduced when participants are encouraged to behave in a way that contributes to feedback loops in a complex system. Shadow convexity reinforces the dominant trend in a hidden nonlinear way and effects all participants. The ultimate non-market example of shadow short convexity is the failure of communism and the fall of the Berlin Wall in 1989. Following decades of oppression, the wall literally and psychologically fell when crowds of East Germans gathered at checkpoints and border guards refused to use mass violence to suppress them. The wall collapsed organically and without violence after the suppressed desire for freedom became a self-reinforcing force of change that could no longer be denied. The ultimate market example of shadow convexity is the role of portfolio insurance in the 1987 Black Monday crash. The portfolio insurance strategy relied upon selling increasing amounts of financial futures to protect against drawdowns in equity markets. The greater the decline in the market the more financial futures were sold to offset the loss contributing to a nonlinear feedback loop and causing a **-20%** single day decline in the S&P 500 index.

Modern markets contain many new sources of shadow short convexity stimulated by extraordinary global monetary policy. Examples include **risk parity**, **volatility targeting**, **machine learning**, and **exchange traded products**. All of these structural devices contain a "shadow gamma" or "shadow liquidity" by reacting to market conditions that they themselves influence resulting in self-reflexivity. **Volatility targeting and risk parity strategies** create feedback loops by increasing and decreasing risk exposure based on volatility observed in the recent past. As these strategies dominate markets they can begin to influence the same realized volatility used to make their initial risk decision. **Risk parity** is an example of a strategy that adds shadow short convexity to the system by leveraging short correlations between stocks and bonds. A full discussion is presented in the section entitled "Stock and Bond Correlations in the Prisoner's Dilemma". **Machine learning technology** is a tool utilized by many high frequency and quantitative trading firms, including Artemis, and relies on advanced statistical methods to recognize nonlinear patterns in historical price data. There are many advanced algorithms with fancy names like "neural networks" and "random forests" but they all rely on the same limited history of financial data to make decisions. Quality data is always more important than the algorithm used. As machine learning gains widespread adoption the models may begin to recognize patterns in data that they themselves influence resulting in feedback loops. When a self-driving car uses visual pattern recognition algorithms to react to the road it does not adversely change the fundamental reality it was designed to respond to. Now imagine a fleet of self-driving cars that, upon first sign of any risk, avoid accidents by encouraging other drivers to collide with one another. Now you see the problem. **Exchange traded products ("ETPs")** introduce self-reflexivity by creating a highly liquid security (listed stock) that tracks a potentially illiquid underlying instrument (e.g. high yield bonds, commodity futures). **Exchange traded products with illiquid underlying assets remind me of a classic song from the Eagles because "you can check out anytime, but you can never leave"**. Leveraged ETPs also add to shadow short convexity by requiring nonlinear exposure adjustments to linear moves in asset prices. When combined with a liquidity mismatch any period of sustained buying and selling becomes self-reinforcing. We discuss nonlinear distortions in the VIX exchange traded products complex in the section entitled "Short Volatility in the Prisoner's Dilemma". All of the above structures and systems introduce shadow convexity to markets that reinforce the dominant price direction in a nonlinear way. This works very well when central banks are providing ample liquidity and reinforcing the status quo but it can and will cut in the other direction. Lower volatility drives lower volatility... and higher volatility drives higher volatility. Minsky once wrote that stability is the greatest source of instability. Shadow convexity is the reason.



Black Swans in the Prisoner's Dilemma

"The oldest and strongest emotion of mankind is fear, and the
 oldest and strongest kind of fear is the fear of the unknown"

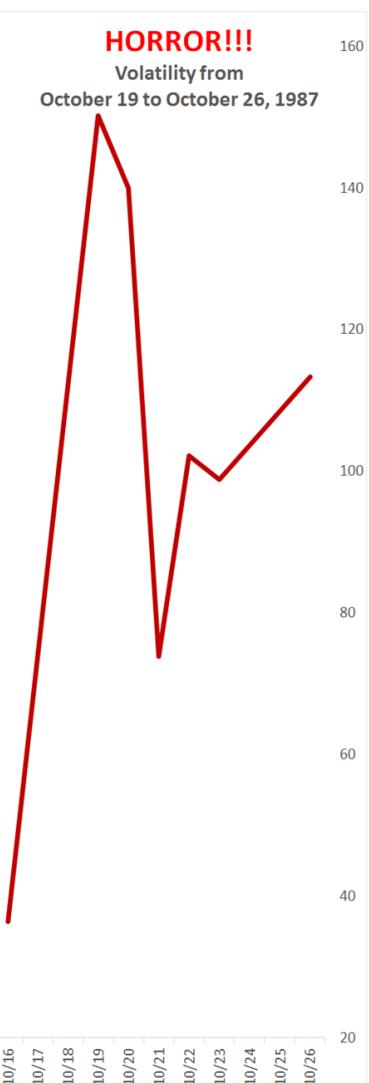
H.P. Lovecraft



"Horror is about the paradoxical thought of the unthinkable"
 Eugene Thacker, In the Dust of This Planet

The concept of a 'Black Swan', defined as an extreme or rare event, has never been more relevant to markets, but the idea is so frequently abused in financial commentary that it risks becoming a cliché. The absurd meme that central banks have eliminated extreme tail risks through accommodative monetary policy, recently repeated by the head of research at a major bank, is part of the institutionalized narrative of moral hazard. By Taleb's definition, Black Swan events are unpredictable, so how can a central bank prevent something they can't even identify in the first place? More to this point the investment community has no consistent definition of what tail risk or high volatility even means.

Volatility is about **fear**... but extreme tail risk is about **horror**. The **Black Swan**, as a negative **philosophical construct**, is when **fear** ends and **horror** begins. Fear is something that comes from within our scope of thought. True horror is not human fear in a definable world, but fear that comes from outside what is definable. Horror is about the limitations of our thinking⁽¹³⁾. In the novella, "The Call of Cthulhu", the horror author H.P. Lovecraft describes an ancient and malevolent entity hibernating deep within the earth the sight of which can drive a man to madness. The imprisoned Cthulhu will destroy the world upon its awakening and this is a source of subconscious anxiety for all humankind even if we are individually unaware of its existence⁽¹⁴⁾. Cthulhu is a **black swan**. I'm sorry but the 2007-2008 financial crash was not a **black swan**. That is a collective lie propagated by policy makers so they don't cry themselves to sleep at night. Many different people predicted and profited from the 2008 crisis including this author. A black swan is when things go from bad to uncontrollably bad, when a linear decline becomes an exponential decline. The black swan resembles what amateur screenwriters call the "all is lost moment". It is not the first act of the horror movie when people start turning into zombies... it is the end of the second act when the hero realizes he is the **only** person left who is **not** a zombie. 2008 was about the **fear** of failing banks and crashing markets... but the true **horror** was the impending collapse of the entire fiat money system that never came to be. That was the true black swan. The **unpredictable** horror of a black swan often occurs following a **predictable** period of fear. For example, the Black Monday 1987 crash was an **unpredictable event** that occurred within a **predictable crash**. In the late summer of 1987 the market was trending lower and financial stress conditions were rising rapidly. Volatility rose even before that fateful Monday increasing from 21.83 at the start of October to 36.37 the day prior to the big crash. By this point, the S&P 500 had already experienced a **-14%** peak-to-trough drawdown. Many investors ranging from global macro traders to systematic trend followers correctly predicted a crash. **Nobody** predicted the market would fall **-20%** in one day or that volatility would peak at 150. Ironically, if the same price movement occurred today most people would short volatility and buy equities the day prior to Black Monday in anticipation of policy support. Most crises occur slowly and then suddenly. A devastating earthquake is a tremor that just didn't stop... and Black Monday 1987 was a crash that just didn't stop. To this extent sizing long volatility positions into a crisis can yield life changing returns at the right point. Today, due to the actions of central banks, everyone is doing the exact opposite...

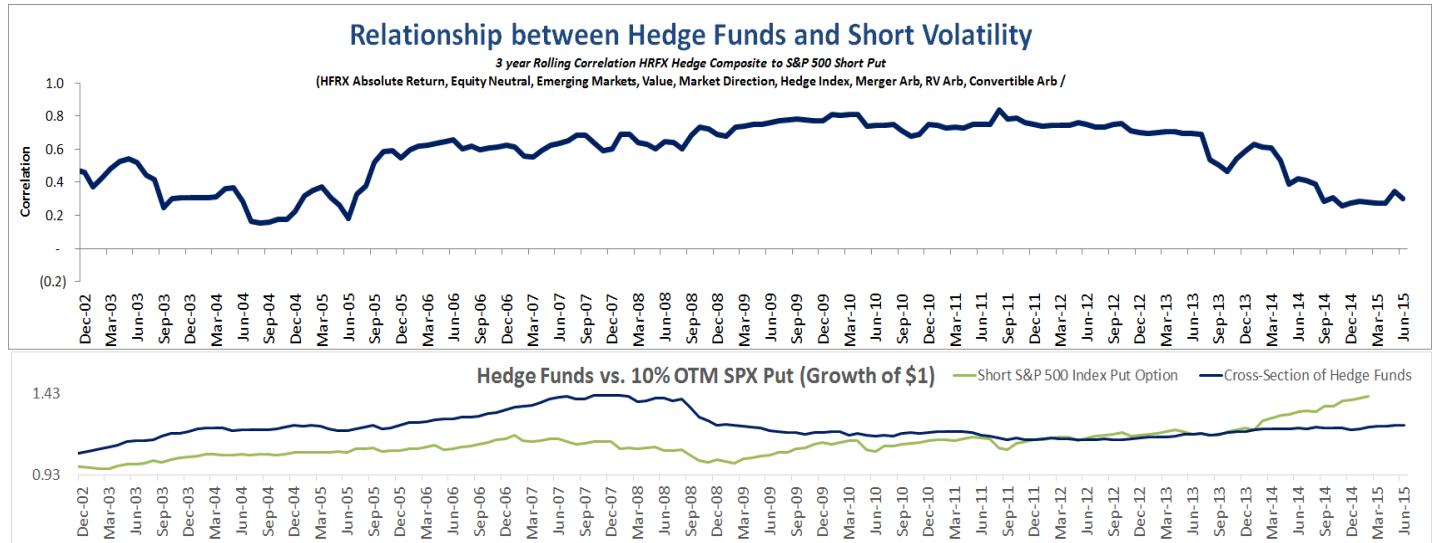


If you short **fear** you must be prepared for **horror**... in the Prisoner's dilemma we are one step closer to **HORROR**

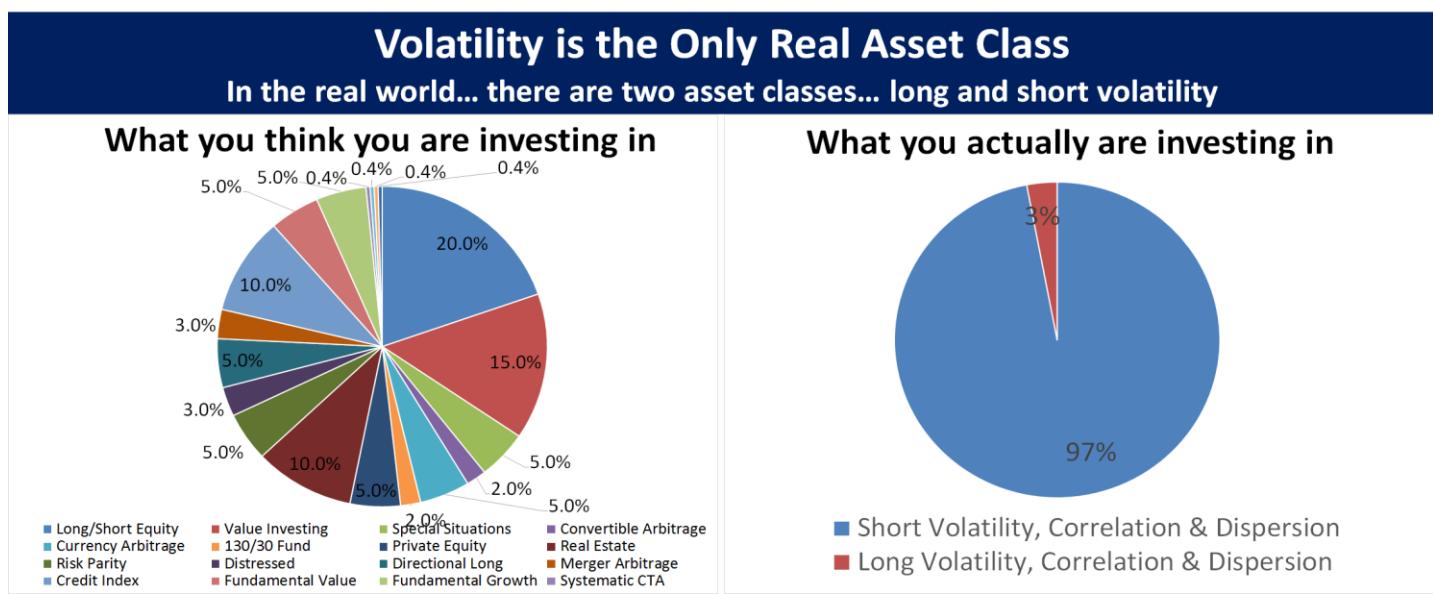


Modern Portfolio Theory in the Prisoner's Dilemma

There is a tiresome debate as to whether or not volatility is an asset class. Let me end that debate... Volatility is the ONLY asset class. We are all volatility traders and the only question is whether we realize it or not. If you disagree do me a favor and imagine you are an alien that just landed on earth and you know nothing about investing. Stocks, bonds, what are those? All you have to look at are numbers. Most investments will show upward growth in a steady and seductive line until they experience horrific drawdowns: classic value investing, credit, real estate, and carry trades all fit this profile and are akin to shorting volatility, correlation, and dispersion. Other investments exhibit negative to flat returns with huge profit jumps that occur infrequently. Examples include global macro funds, trend-following CTAs, and tail-risk funds. Most of what we think of as alpha is actually short volatility in sheep's clothing. To prove this point we took a cross section of popular hedge fund strategies and compared their returns against selling naked put options on the S&P 500 index. The results speak for themselves and the average hedge fund strongly resembles a simple short volatility position.



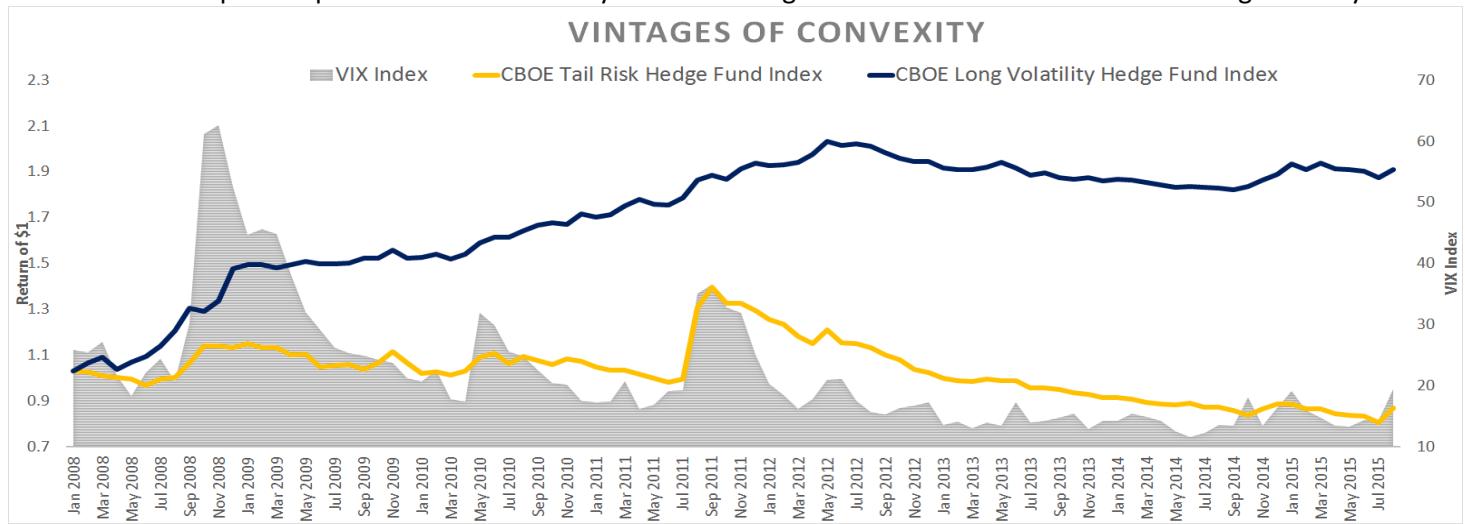
I find it puzzling why institutions focus on superficial asset buckets but fail to categorize investments by what really matters... return profile. This is akin to categorizing a blue and green parakeet as two entirely different species of animal, but putting an alligator and the green parakeet in the same bucket. Diversification is futile if you do not categorize by return style. Many investors assemble a varied portfolio of asset classes and hedge funds thinking there is safety in diversification... but all that is achieved is concentrated short convexity exposure. In a crisis the portfolio is revealed for what it really is – majority short volatility with no diversification at all (see “The Invisible Hands” by Steve Drobny)⁽¹⁵⁾.



Convexity Exposure in the Prisoner's Dilemma

Very few investments maintain a dedicated long convexity return profile. It can be hard to hang out with the designated driver when everyone else is getting drunk from the global monetary punchbowl. Many great investors understand that having a convex asset in their portfolio allows them to buy when everyone else is selling, stick with their investment plan in times of duress, or even apply a bit of leverage onto their beta to pay for any negative carry in the low turbulence years. It takes a very special breed of investor to allocate to a long volatility fund and be able to tolerate years of neutral performance to small losses when everything else is going up in value ... only to achieve remarkable gains when everything else crashes and burns. The key is to view a portfolio holistically, understanding that long volatility exposure provides tremendous flexibility and better risk adjusted returns over the entire business cycle.

The two classifications of positive convexity hedge funds are **long volatility funds** and **tail risk funds**. While long volatility and tail risk both provide exposure to crisis, they represent very different vintages. CBOE/Eurekahedge publishes indices that track the respective performance of each style. Artemis Vega Fund LP is a constituent of the long volatility index.

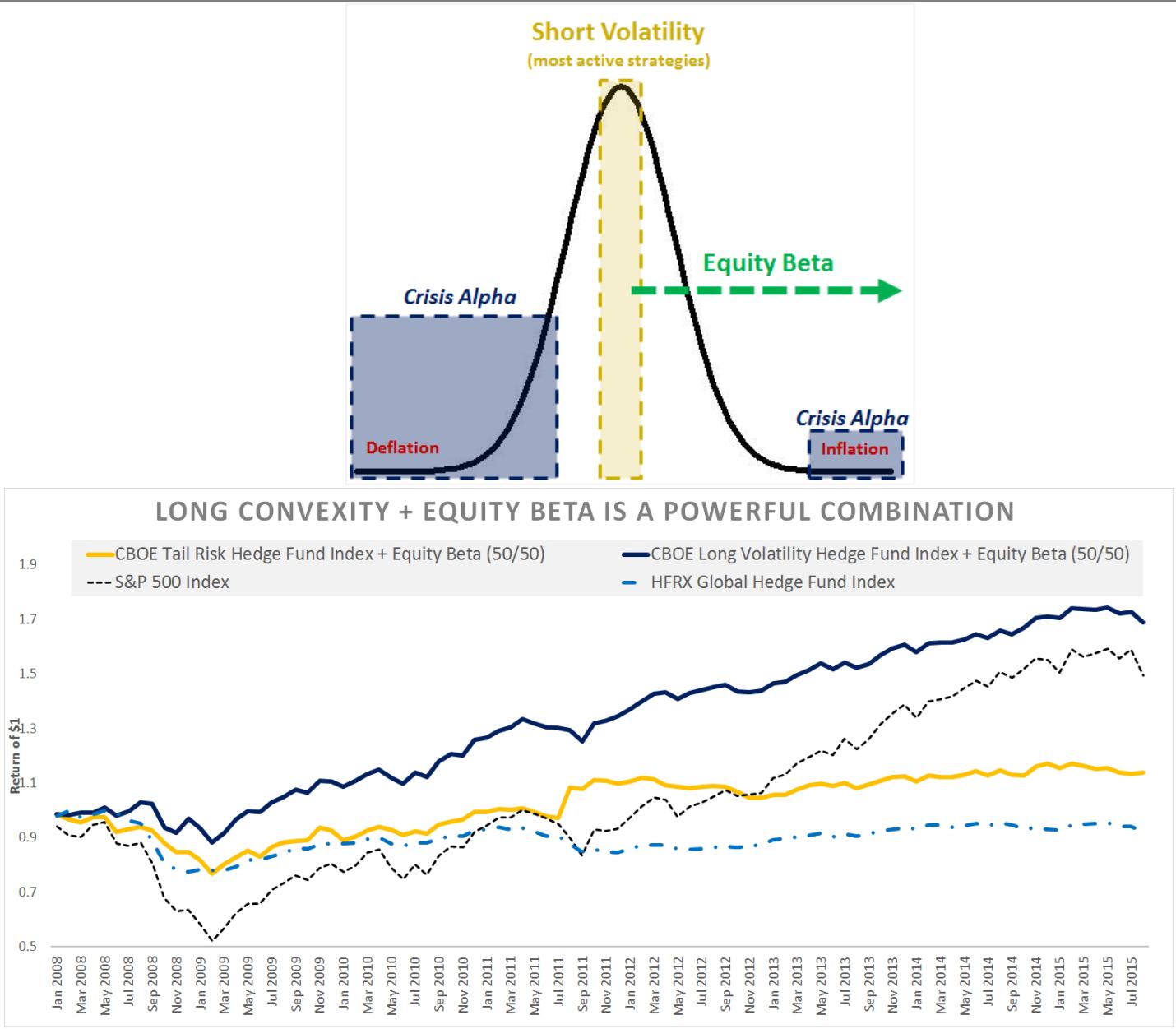


They say that being short volatility is like picking up pennies in front of a steamroller. If I had a penny every time somebody mischaracterized Artemis as a tail risk fund I could probably buy a steamroller.

Long volatility hedge funds are in search of **crisis alpha** defined as an uncorrelated return stream whereby the balance of risk and reward is skewed toward systemic crisis in markets without the constant negative carry associated with traditional hedging. This vintage of convexity should have a positive risk-to-reward ratio overall but with the best gains reserved for market crashes. To achieve this end such funds may balance long volatility exposure with strategic shorts or use tactical exposure to gain convexity. These funds are better at capturing **regime shifts in volatility associated with bear markets** as opposed to **one off volatility spikes that mean revert in a bull market**. That nuance is lost on many investors. Long volatility funds are designed to capture market endogenous forms of crisis (e.g. 2008 financial crash, 2011 debt ceiling crash) but may or may not capture market exogenous crises (e.g. market sell-off from 9/11 terror attack).

Tail risk funds are effectively a form of financial asset insurance that provides constant exposure to long convexity, with strong reactivity to crisis, but constant negative bleed. The tail risk fund has a negative expected return (absent a combination with equity beta) and is more of a pure hedge, as opposed to the long volatility fund, which is an alpha strategy that behaves like a hedge. Tail risk funds are positively exposed to both market endogenous and exogenous events, and do a better job capturing one-off volatility spikes. The CBOE tail risk index brings much needed transparency to tail risk funds, some of whom prefer to remain opaque to the disadvantage of investors. For example, one provider that is **not a member of the index**, reported recent returns to the financial media on a margin basis (effectively doubling or quadrupling returns) while reportedly excluding the fact that a portion of that performance was generated by buying equity futures the morning of a volatility spike. In actuality, this fund's performance was in line or likely below the CBOE tail risk hedge fund index on an equal comparison basis (non-margined). All the funds in the tail risk and long volatility indices have agreed to a level of performance transparency and fairness to the benefit of investors.





Long volatility and tail risk funds can be combined with basic equity exposure to create fantastic returns. A 50/50 combination of the CBOE long volatility hedge fund index and the S&P 500 index has significantly outperformed the market and the HFRX global hedge fund index since 2008 (see above). In many cases, institutions can layer the convex derivatives exposure directly on the equity beta so there is no lost opportunity cost. The difference is that investors are only paying for 'crisis alpha' and not generic beta or short convexity exposure.

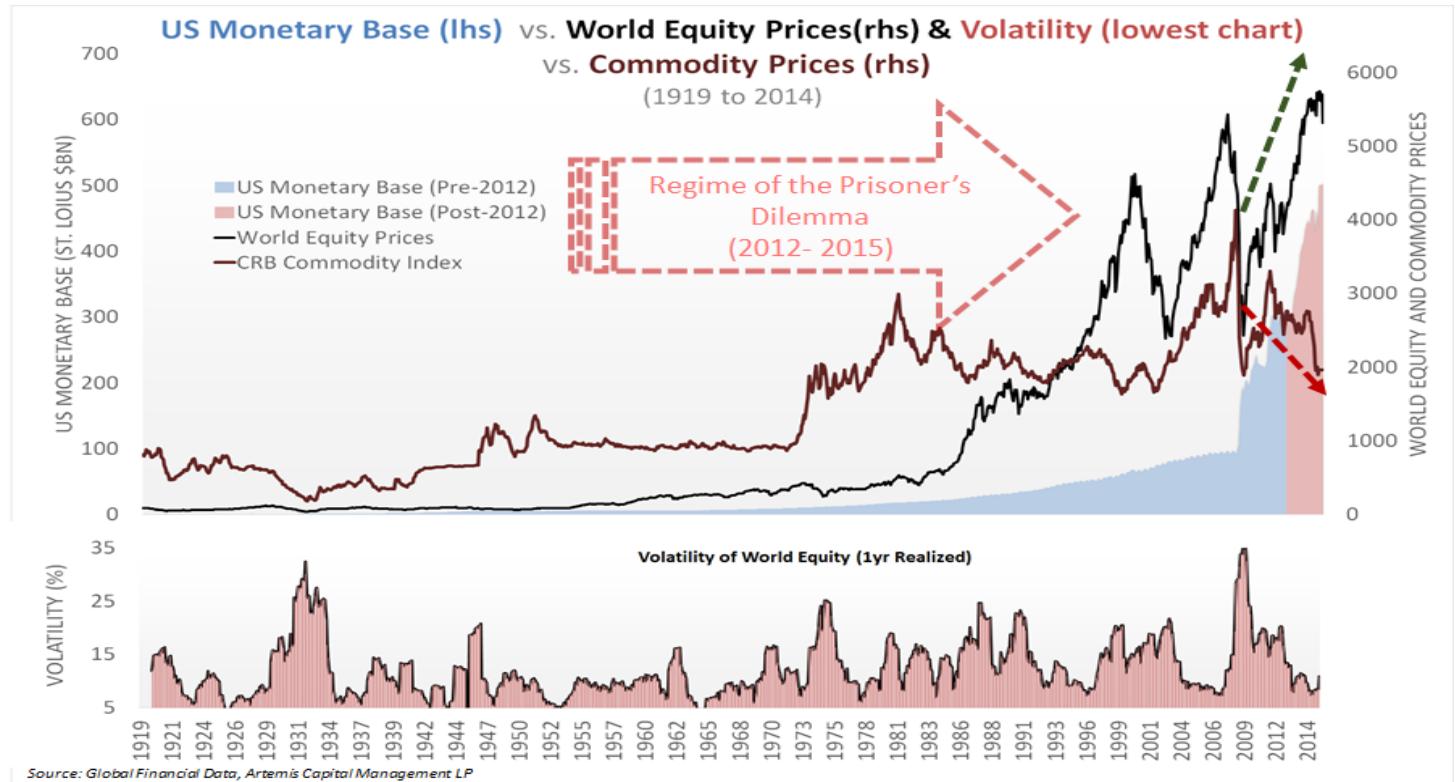
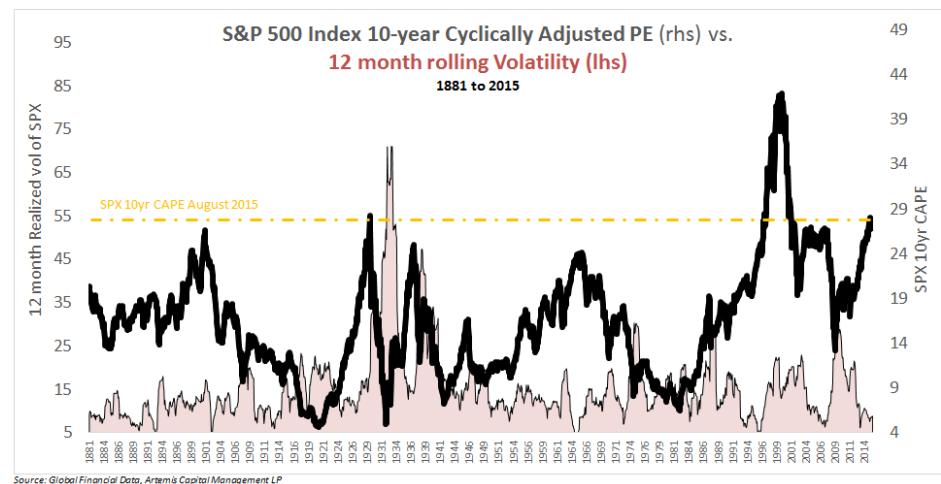
The best long volatility funds are **like guerilla freedom fighters** as opposed to a **standing army**. Small is better than large for long volatility because **convexity does not scale as easily as fragility**. Long volatility is a tough business model which is why it is so rare to find funds that offer true exposure. It is simple human nature to lose interest in an asset that has flat returns for years at a time with huge payouts only occasionally. Plain vanilla short convexity funds that make steady returns are a much easier sell and accrue incentive fees faster until they blow up. Somebody once said that he thought there would be a \$10+ billion volatility fund one day... that may be true... but at that point, it may cease to be a true volatility fund and risks becoming just an average hedge fund. Small is beautiful. Hedgehogs outlasted dinosaurs.



Equity Valuations in the Prisoner's Dilemma

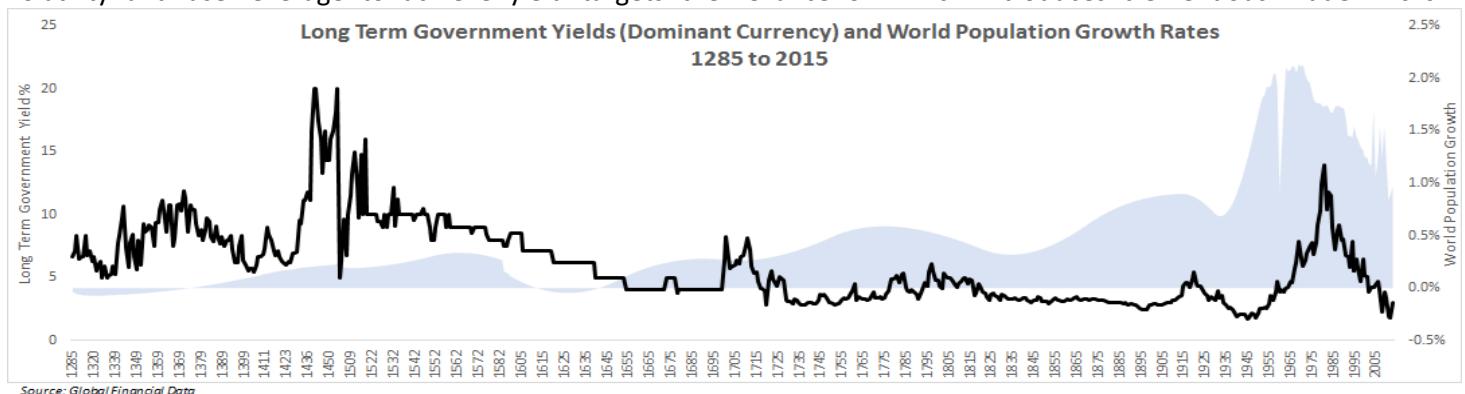
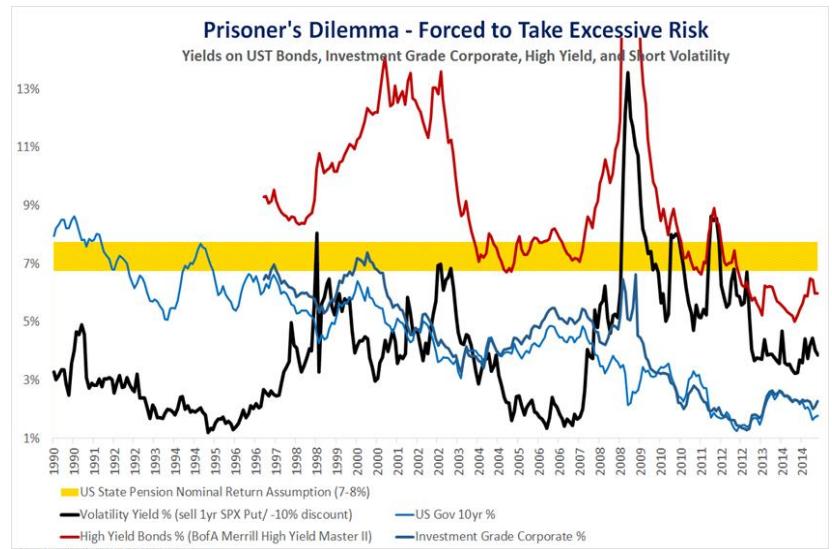
Global equities are dependent on monetary expansion to justify elevated valuations in the regime of the Prisoner's Dilemma. US stocks achieved the highest median price-to-earnings ratio in post-war history earlier this year and time-tested valuation metrics like 10-year cyclically adjusted PE ratios, enterprise value to EBITDA, market value to replacement value, and price-to-sales ratios are on par with pre-crash periods like 2000, 2007 and 1928 (see "Deep Value" and "Quantitative Value" by Carlisle for good overview). Last year

95% of corporate earnings were spent on share buybacks which increased stock prices but did nothing to encourage fundamental growth or create middle class jobs⁽¹⁶⁾. This is the only multi-year bull-market in history whereby trade volumes are declining rather than increasing. Some investors claim stocks are in a new paradigm, an age of central bank omnipotence, where long-term valuation metrics no longer matter. We have heard this fluff before, in 1928, in 1999, all the way back to 1716 with John Law in France⁽¹⁷⁾ – the original quantitative easing expert long before Bernanke, Yellen, Draghi, and Kuroda. It's different this time works very well if you need to rationalize how to beat your return benchmark next quarter or win an election. **Denial is not a trait you find in great investors.** Beginning in 2012 a sharp divergence emerged between the performance of commodities and global equity prices (see red vs. green arrow in graph). From the date of Bernanke's Jackson Hole speech the CRB Commodity index is down **-38.6%** while global equities are up **+28.6%**. The truth is that central banks cannot manipulate raw supply and demand the way they can financial assets. The global commodity super cycle is broken due to slower global growth, but risk assets continue to rise, showing an ominous divergence between the **real economy** and the **surreal economy**.



Yields in the Prisoner's Dilemma

If you are an investor or retiree, you are trapped in a prison of low returns and higher risk. With nearly every central bank devaluing and pushing rates to zero it is becoming harder and harder to escape from that prison. Today the average expected return for a US state pension system is about 7-8%. Back in the nineties, you could achieve 7-9% returns with investment grade debt. Today, you are forced out on the credit spectrum, the risk spectrum, forced to buy high yield, use leverage, or short volatility to meet that target. We have reached the zero bound and it is unprecedented in the history of finance. Long term and short term yields have never been lower in the history of civilization dating to 1285⁽¹⁸⁾. Earlier this year one fourth of the Bloomberg Eurozone sovereign bond index had negative yields, and some corporate bond yields even went into negative territory. Investors have no choice but to short volatility and use leverage to achieve yield targets the reliance on which introduces tremendous hidden risks.



A great example of using leverage and enhanced risk to meet an investment return target comes from my own experiences with the Government of Puerto Rico. A long time ago in a bull market far away, my job was to structure complex debt and derivative transactions for a major money center bank. It was a honor to work on socially relevant and challenging transactions early in my career, including optimizing debt and derivative issuance to finance the seismic retrofit of the Bay Bridge in San Francisco. Unfortunately not every deal went according to plan. For a year, I worked tirelessly on behalf of Puerto Rico to quantitatively structure an ambitious multi-bank plan to 'save' their struggling retirement system. At the time it was expected to be the largest public transaction in history and was monitored by the CEO of the firm – a man who turned out to be a questionable leader but excellent golfer under duress. Puerto Rico had a ridiculous 9.75% return expectation on employee retirement assets for a system that was 17% funded at the time. The brilliant plan was to issue bonds backed by retirement contributions and leverage the current asset base reinvesting debt proceeds into stock and bond markets. If they could earn above their then 6% borrowing cost the transaction would be huge success. It was a horrible idea, akin to using credit cards to fund your retirement, however my very own models predicted the entire system had a 99% probability of going bankrupt sometime between 2013 and 2022 absent radical action (right on schedule by the way). To the Puerto Rican bureaucrats this 'Hail Mary' pass seemed better than nothing in the face of horrific math. They issued \$3bn and the remaining \$10bn of the transaction fell apart when their borrowing costs rose and investment returns fell. Thank God it did - imagine leveraging your asset base by \$13bn to invest right before the 2008 crash. It is easy to make fun of Puerto Rico (and all involved in that escapade including myself) but with all due respect, this is just one extreme example of the same quandary all investors are facing in the Prisoner's Dilemma. Take more risk, leverage your returns, or face a slow, then fast, decent into insolvency.



Stock and Bond Correlations in the Prisoner's Dilemma

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 enchains 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 many different pieces but this only makes things worse. Now the pieces of the broom come alive and begin fetching water anew at multiple times 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.

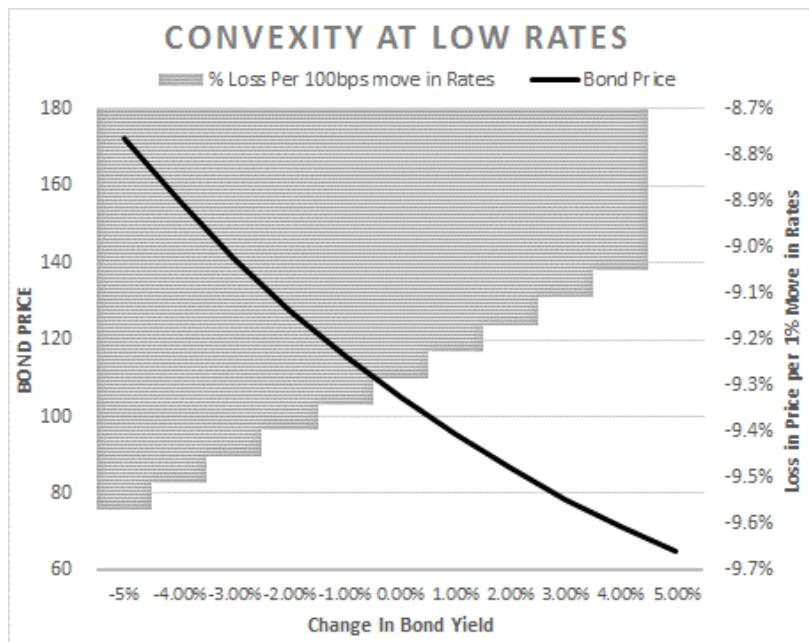


Do not call upon spirits you are not capable of controlling... risk in risk parity

The story of the sorcerer's apprentice is a tale about the dangers of nonlinearity and 'shadow' convexity. In the story, the apprentice became massively short "broom" convexity resulting in a dangerous overflow of liquidity. In fixed income terminology, the word 'convexity' describes the degree to which a bond is negatively exposed to rising interest rates in a nonlinear fashion. Central banks and regulators have decided to invoke their own sorcery by buying bonds through quantitative easing and requiring stringent capital requirements for 'too big to fail' banks. The unintended consequence is that systemically important institutions are now warehousing massive amounts of convexity risk in assets with negative real returns. What would happen if rates increased 300 basis points in a year the way they did between 1979 and 1980? The result would be a **-20%** mark-to-market loss on a portfolio of supposedly "safe haven" securities!

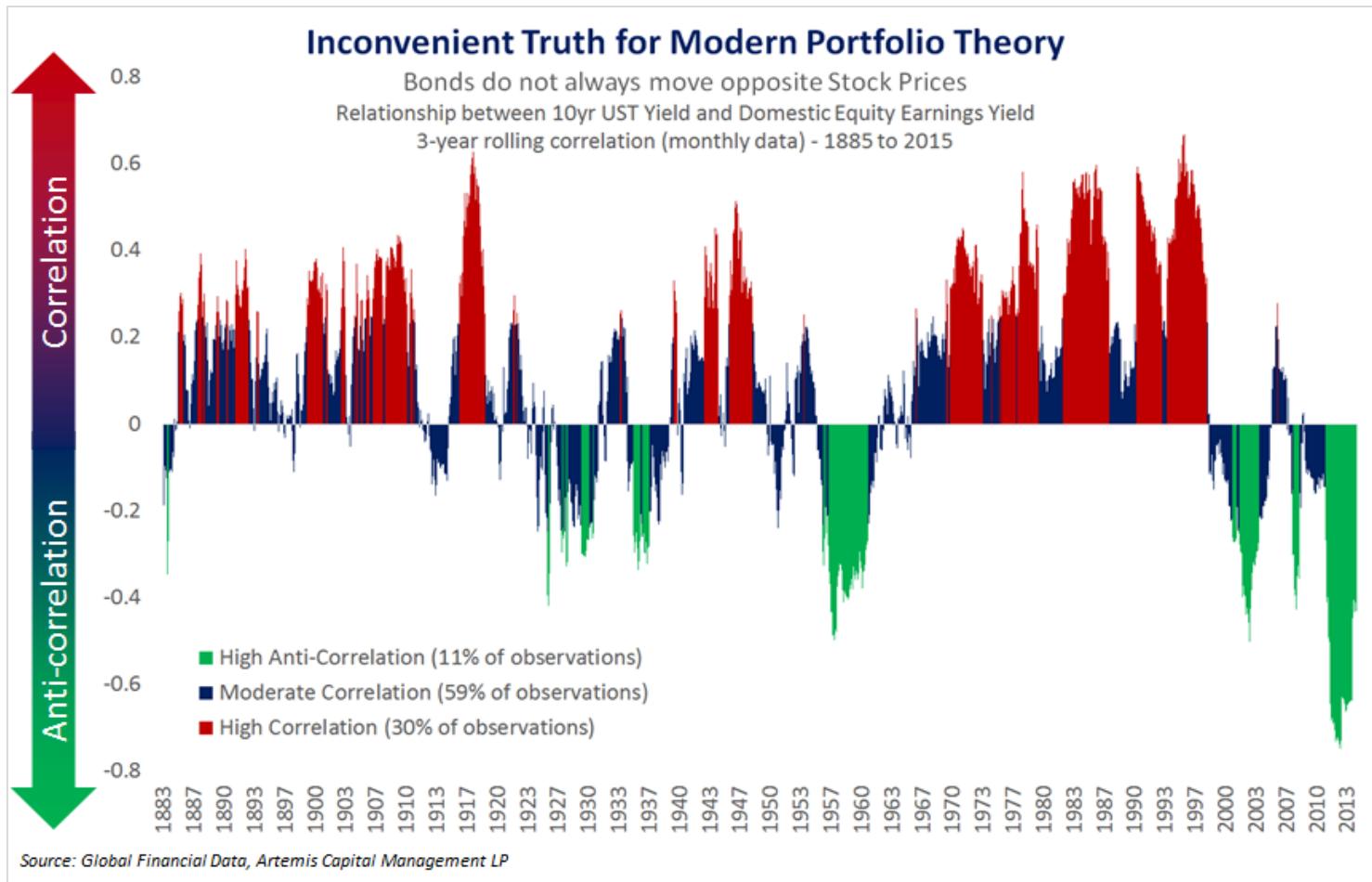
**Now imagine if that crash in 'safe haven' bonds occurs simultaneously with a decline in equity prices
... all of a sudden we have a big global problem.**

Modern portfolio theory ignores massive 'shadow' convexity from a potential correlation breakdown in the relationship between stocks and bonds. Let us assume I have a little money to invest and I go to a qualified financial advisor for advice on investing for retirement. The adviser would likely tell me to diversify those assets according to a 60/40 split between stocks and bonds. The theory is that when times are good stocks go up but bonds underperform and vice versa. Therefore, I put my money in a 60/40 split, supposedly, because there is anti-correlation between stocks and bonds. Now let us assume I run an institution with hundreds of millions to invest and I can afford a more expensive financial advisor. The expensive financial advisor agrees with the general principal of a 60/40 stock and bond split but feels that we can do much better by leveraging the bonds so they match the stock portfolio weighted by their respective volatilities. The theory is that bonds outperform stocks on risk-adjusted basis while exhibiting strong anti-correlation. The financial advisor calls this "risk-parity" and shows me an incredible 20-year record of returns including gains in 2008.



The entire global financial system is leveraged to the theory that stocks and bonds are always anti-correlated. Risk parity funds currently manage approximately \$1.4 trillion of notional exposure based on this theory (including leverage)⁽¹⁹⁾. It is impossible to estimate how many trillions of dollars are managed according to the simple 60/40 mantra... but let us just assume something north of \$1.4 trillion and something south of "more money than God". Given the unfathomable amount of assets leveraged to this simple relationship, I decided to test the anti-correlation between equity and fixed income, or positive correlation between yields and stock prices, based on over 132 years of price data. **The truth about the historical relationship between stocks and bonds is scary.** Between 1883 and 2015 stocks and bonds spent more time moving in tandem (30% of the time) than they spent moving opposite one another (11% of the time). It is only during the last two decades of falling rates, accommodative monetary policy, and globalization that we have seen an extraordinary period of anti-correlation emerge between stocks and bonds unmatched by any other regime in history. **Not only are stocks and bonds positively correlated most of the time but also there is a precedent for multi-year periods whereby both have declined.**

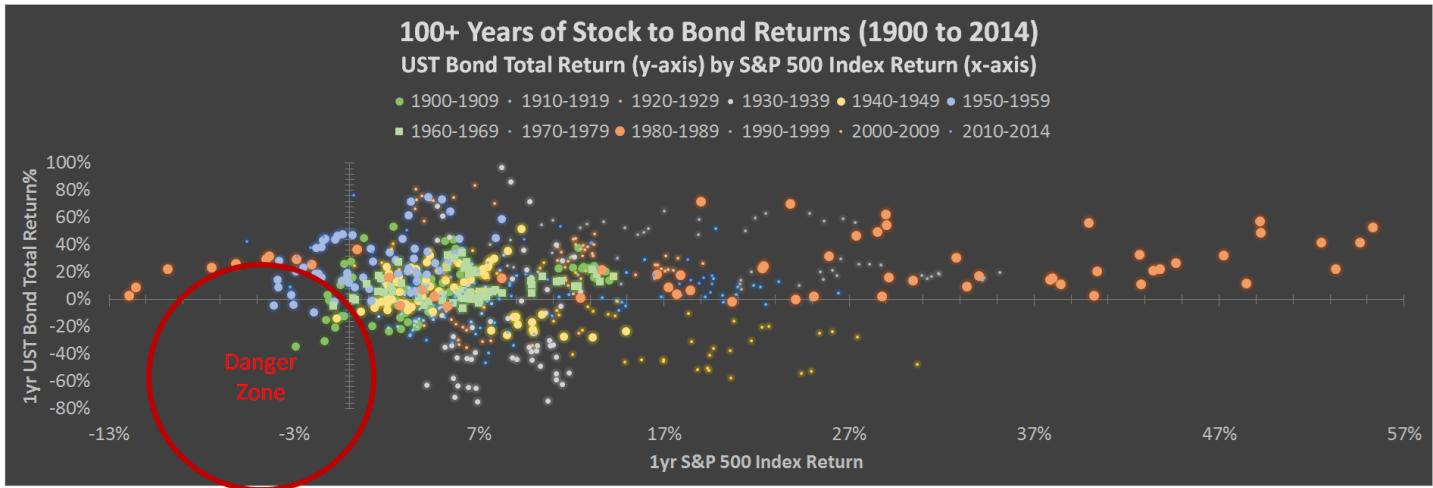
In the event stocks and bonds simultaneously lose value, the classic 60/40 portfolio will become a 100% loser and volatility will be the only asset class that is capable of protecting your portfolio.



Risk parity strategies are viewed as defensive in nature by the institutional investor community due to their outperformance during the 2008 financial crisis. While the strategy can be very effective the thirty year track record hides significant risks. Risk parity derives alpha through a form of 'shadow' short convexity that includes leveraged exposure to:

- 1) Short correlation between equity and fixed income;
- 2) Short portfolio gamma through volatility rebalancing.

To understand this risk we looked backward by estimating the performance of a classic 60/40 and a simple risk-parity portfolio across 100+ years of financial data. **Risk parity faces significant tail risk 1 out of every 50 years.** In the 20th and 21st century simultaneous positive returns occurred 63% of the time with negative stock and bond returns occurring in 2% of the years. The danger scenario whereby stocks and bonds decline in tandem (see lower left quadrant) occurred in the 1970s, late 1950s, 1940s, and between 1906 and 1909.



Although simultaneous negative returns in both equities and fixed income is rare, the impact on the classic 60/40 and risk parity portfolios is potentially devastating. The chart to the right shows the worst rolling years for each portfolio since 1800. We only include periods when stocks and bonds fell simultaneously. The nightmare period for negative correlation occurred between 1906 and 1909 when the 60/40 portfolio experienced a **-67%** peak-to-trough drawdown and a simple risk parity strategy would have gone bankrupt. This analysis is not taking into account the harder to measure second 'shadow' convexity exposure of risk parity described herein as portfolio gamma. What is portfolio gamma? During periods of rising volatility risk parity portfolios are forced to deleverage. If \$1.4 trillion of risk parity assets are deleveraging at the same time during a period of sustained stress in bonds and then stocks we would likely face a self-reflexive spiral of selling. The portfolio gamma is the hard to measure cost of reducing your risk exposure when everyone else is doing the exact same thing. Risk parity, like portfolio insurance in 1987, is self-reinforcing when widely adopted and arguably introduces fragility to markets. The size of the risk parity market questions whether the product may pose a systemic risk during a sustained period of negative stock and bond returns like 1906 to 1909, the late 1940s, or late 1970s.

Shadow Convexity when Diversification Fails						
Years When Bonds and Stocks Decline in Tandem -1900 to 2014						
Worst YOY% 60% Stock / 40% Bond Portfolio						
Rank (Worst to Better)	Year Ending	UST Bond TR YOY%	Stocks TR YOY%	60/40 Portfolio YOY%	Risk Parity (2.45x Bonds to 1 stock)	
1	1907-11-30	-2.9%	-34.4%	-21.8%	-42.6%	
2	1908-12-31	-1.3%	-14.9%	-9.5%	-18.6%	
3	1947-11-30	-0.7%	-13.8%	-8.6%	-15.8%	
4	1909-01-31	-0.4%	-12.1%	-7.4%	-13.3%	
5	1978-12-31	-0.2%	-11.0%	-6.7%	-11.7%	
6	1957-11-30	-2.0%	-9.0%	-6.2%	-14.5%	
7	1969-09-30	-0.9%	-4.9%	-3.3%	-7.3%	
8	1953-08-31	-0.8%	-1.2%	-1.0%	-3.5%	

Years When Bonds and Stocks Decline in Tandem -1798 to 1899						
Worst YOY% 60% Stock / 40% Bond Portfolio						
Rank (Worst to Better)	Year Ending	UST Bond TR YOY%	Stocks TR YOY%	60/40 Portfolio YOY%	Risk Parity (2.45x Bonds to 1 stock)	
1	1837-05-31	-13.7%	-39.4%	-29.1%	-72.9%	
2	1877-06-30	-3.5%	-39.5%	-25.1%	-48.0%	
3	1841-03-31	-13.8%	-20.1%	-17.5%	-53.8%	
4	1839-11-30	-14.3%	-15.3%	-14.9%	-50.3%	
5	1891-07-31	-2.8%	-11.4%	-7.9%	-18.1%	
6	1840-12-31	-5.1%	-8.3%	-7.0%	-20.8%	
7	1861-05-31	-7.7%	-5.2%	-6.2%	-24.0%	
8	1846-12-31	-1.6%	-8.8%	-5.9%	-12.6%	
9	1847-11-30	-0.1%	-9.1%	-5.5%	-9.2%	
10	1893-06-30	-2.7%	-6.0%	-4.7%	-12.7%	
11	1860-12-31	-6.1%	-0.4%	-2.7%	-15.4%	

Note: Data from Global Financial Data, Risk Parity assumes standardized sigma

The \$1.4 trillion dollar question is...

what would cause the relationship between stocks and bonds to completely melt down?

The **volatility of inflation** appears to be a core driver of higher correlation between stocks and bonds. When inflation, as gauged by the consumer price index, is more volatile we tend to experience higher levels of stock and bond correlation as evidenced by data from 1885 to 2015. The early part of the 20th century, which experienced the most debilitating periods of stock and bond underperformance, was a period of wild fluctuations between inflation and deflation. The last three decades of extraordinary anti-correlation has been an era of falling rates, globalization, accommodative monetary policy, and very low volatility of CPI. The global economy is now at the zero bound whereby the effectiveness of competitive devaluations is coming into question.



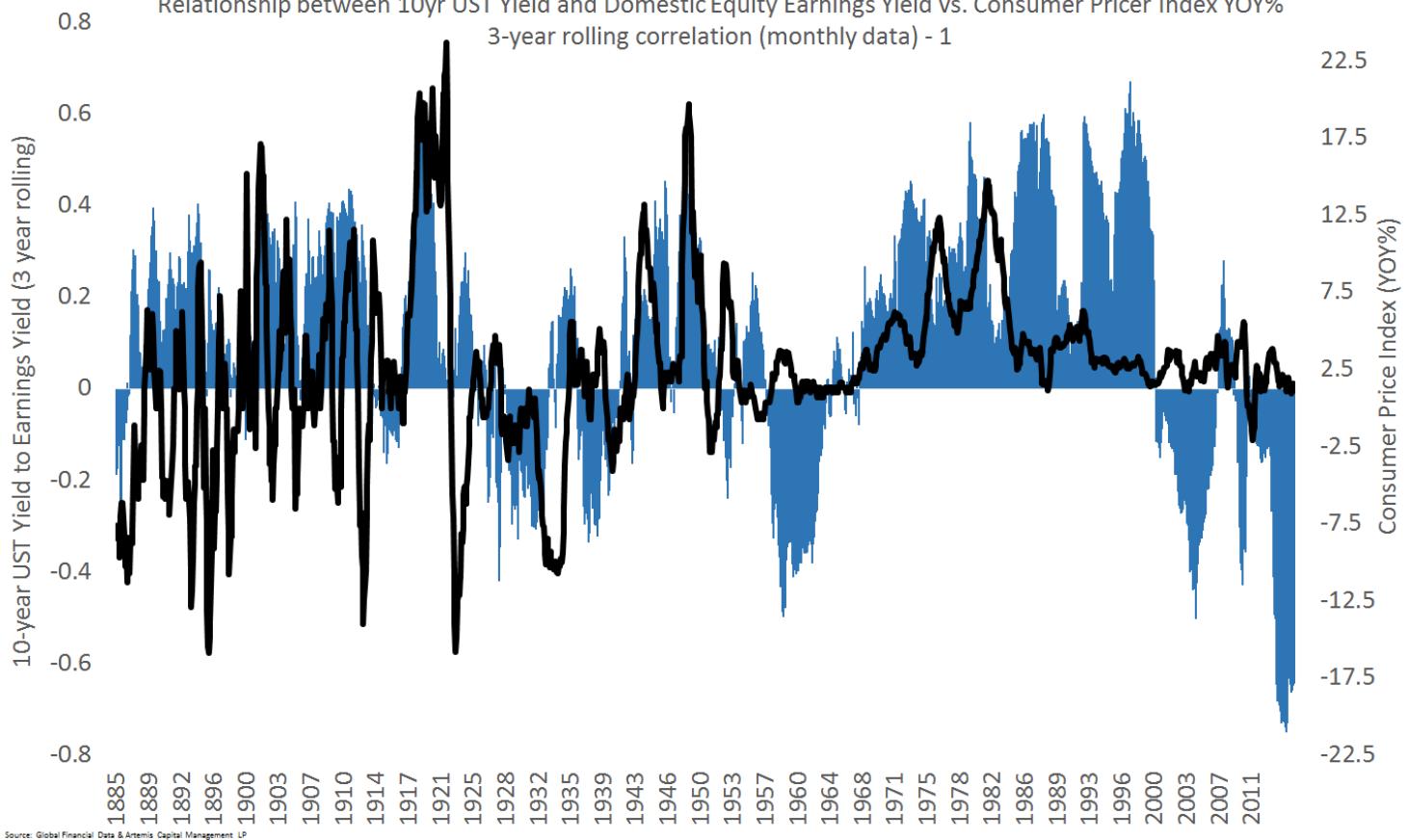
It is not hard to imagine a regime whereby central banks lose credibility or are not capable of moderating swings in inflation in a way consistent with the past three decades. Any period of sustained correlation failure will result in rising volatility and selling pressure across bonds and stocks in a self-reflexive cycle.

Fixed Income to Equity Relationship Driven by Volatility of CPI

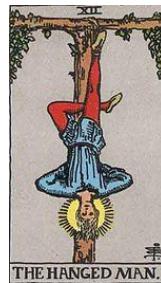
Bonds do not always move opposite Stock Prices

Relationship between 10yr UST Yield and Domestic Equity Earnings Yield vs. Consumer Price Index YOY%

3-year rolling correlation (monthly data) - 1



Modern portfolio theory relying on diversification and volatility targeting for alpha generation provides an illusion of safety but is simply exposing investors to alternative risks. In exchange for price risk, investors are exposed to short correlation risk. In exchange for lower portfolio volatility, investors are exposed negatively to portfolio gamma. Pure long convexity exposure is your only solution to this problem.

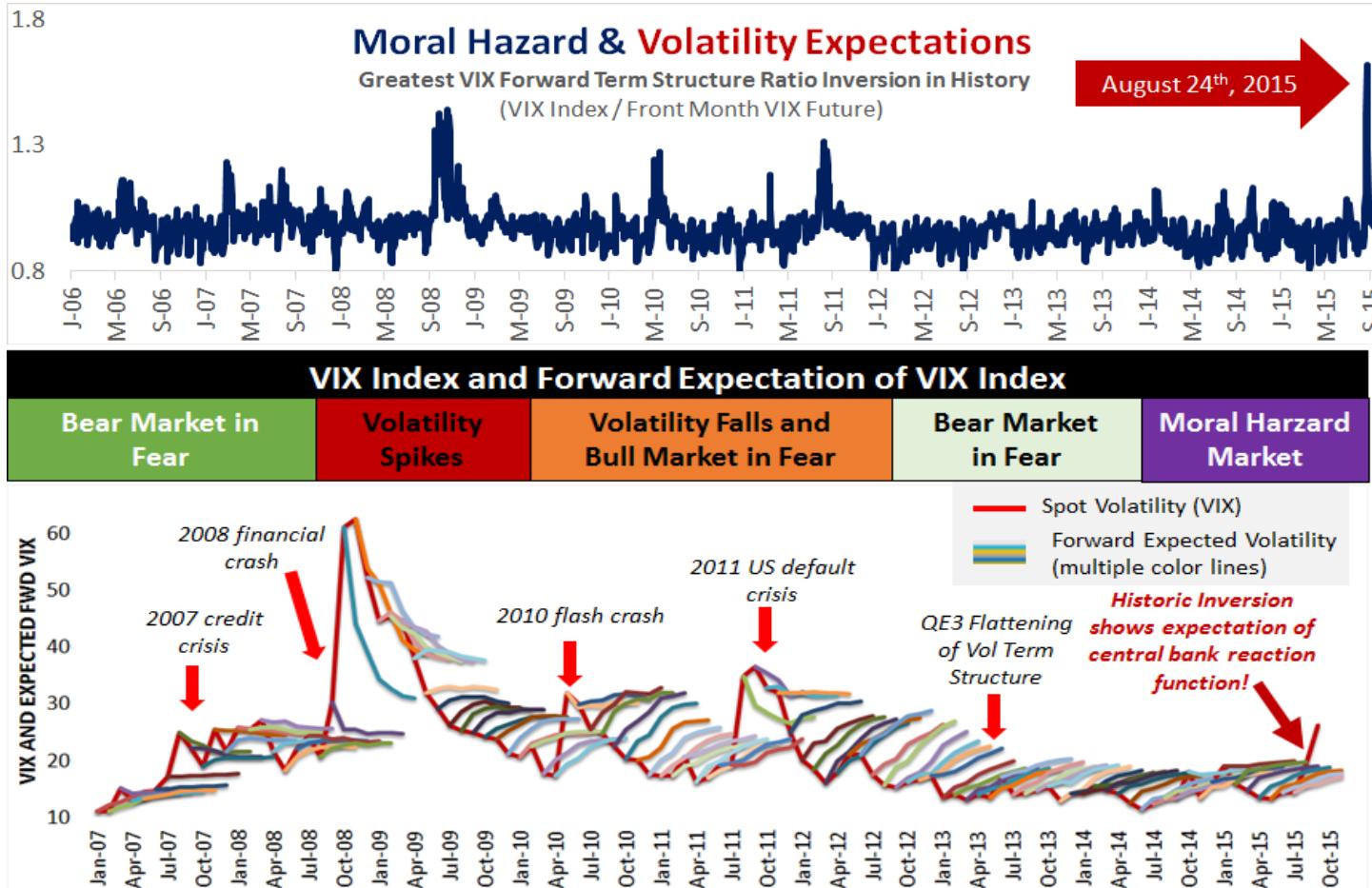


There can be significant risk in risk parity... many providers are established and smart investors and hopefully are aware of these risks. There is nothing wrong with owning a risk parity portfolio, which has performed admirably over the past two decades, but based on any longer view of financial history you are an irresponsible fiduciary if you are not hedging it with some form of long convexity exposure.

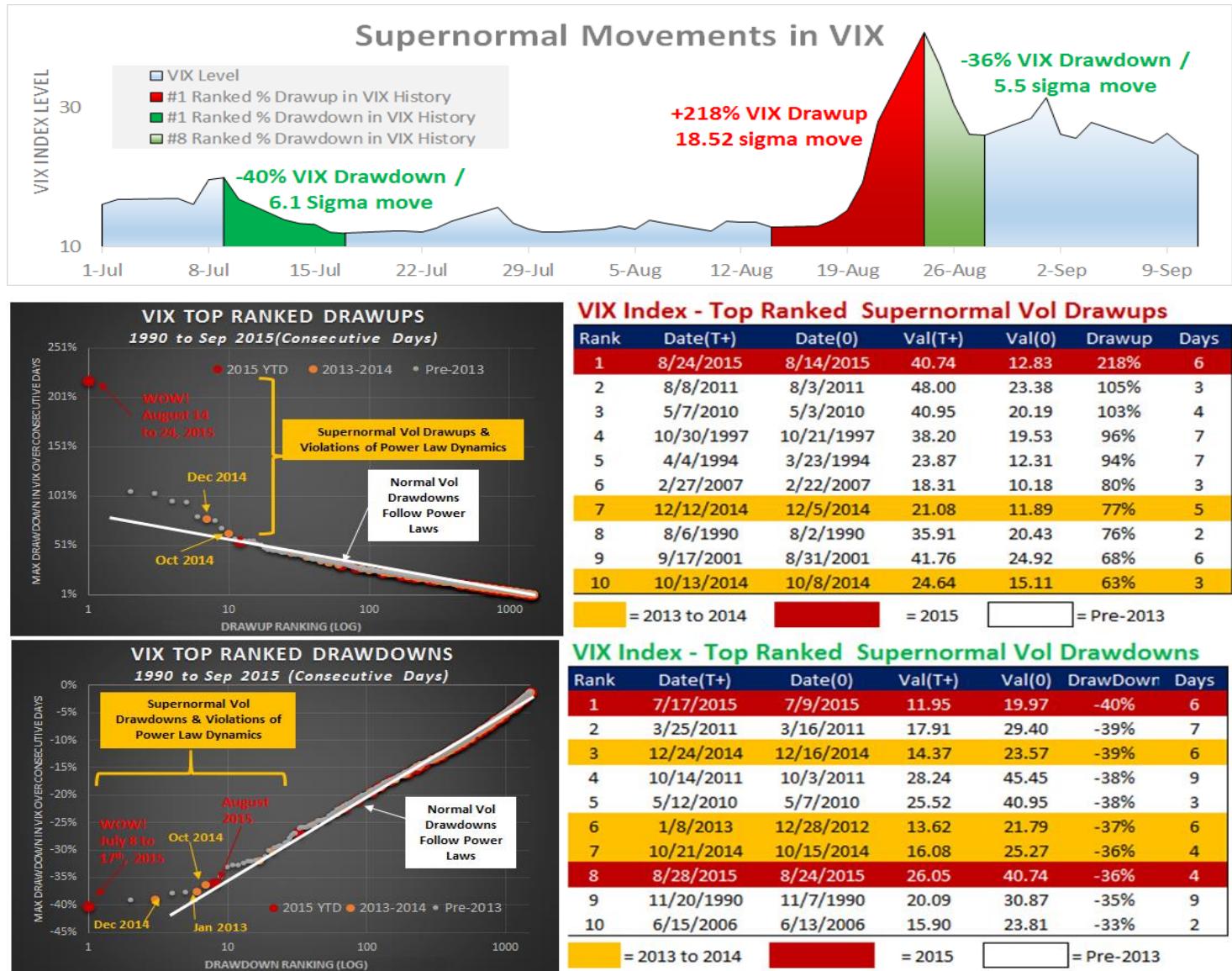


VIX in the Prisoner's Dilemma

True knowledge is not what you know but certainty in what you do not. Volatility is simply about putting a price on that. Drawing from the famous quote by Donald Rumsfeld, former US Secretary of Defense⁽²⁰⁾, the trader of volatility must be able to identify “known unknowns” and “unknown unknowns” while simultaneously making a market in both. Modern volatility markets know that the global economy is facing deflation... but they also know that global central banks will be right there to respond to any crisis. ***The single most important “unknown unknown” today is any random event that may unexpectedly cause global central banks to withdraw their stated support of markets.*** Moral hazard has contributed to a significant build up in short and leveraged volatility creating a shadow ‘volatility gamma’ that reinforces the current trend in volatility direction. Rising volatility is followed by more rising volatility and vice versa. Volatility is crushed whenever a central bank responds to crisis and thereafter leverage is re-applied in even greater amounts in a cycle of moral hazard. The pattern is creating a pro-cyclical monster of short volatility that, if left unchecked will contribute to a repeat of the May 2010 Flash Crash or 1987 Black Monday Crash. August 2015 was just an appetizer. In 2012 Artemis coined the term “Bull Market in Fear” to explain a regime of volatility defined by investor’s willingness to pay almost anything to shield their portfolios from the next deflationary crash. Between 2013 and October 2014 we experienced a “Bear Market in Fear” defined by a rising short volatility complex and low risk premiums for selling variance. Ever since last fall, we have entered into one last dangerous phase in the volatility cycle. Forward volatility markets no longer fade volatility out of denial; they fade volatility out of the prospect of central bank support. This is a new era of **hyper-moral hazard** whereby a central bank reaction function is fully priced into option markets. **Volatility markets do not believe central banks will let us fail.** For evidence, consider that the VIX futures markets faded the August VIX spike by the greatest margin in history. The graph below shows the ratio of the VIX to the market’s one-month forward expectation of the VIX. The higher the ratio the greater the market’s confidence in volatility mean reversion. August 2015 dwarfed all other crises in mean reversion expectation including October 2008, May 2010, and August 2011. The entire VIX market was essentially one large leveraged bet that central banks would respond to the crisis... and it paid off! What if it didn’t?

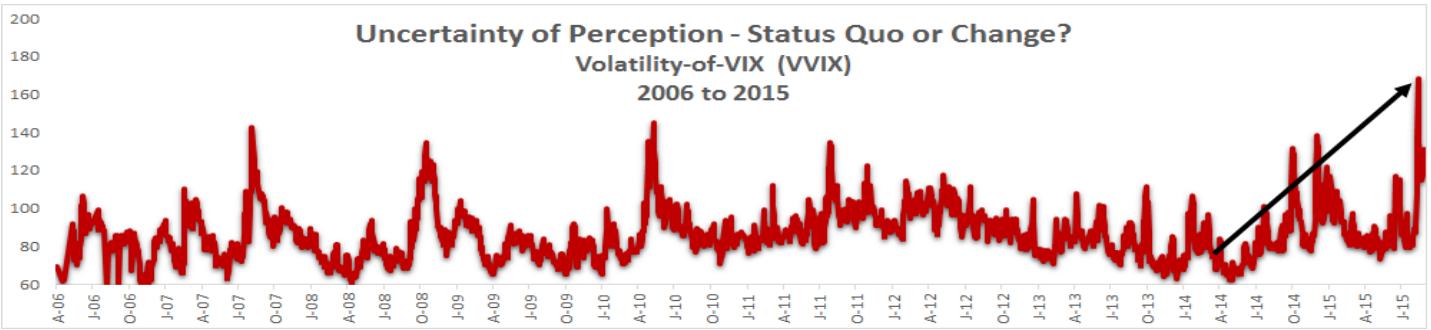


The VIX is experiencing **epileptic seizures** including **erratic and violent** outbursts up and down at the most frequent pace in history as new sources of structural short convexity interact with interventionist policy responses to crisis. **The VIX has registered a quantifiable 'supernormal' (five standard deviation +) move up or down every three months over the last two years.** In July-August 2015 alone, we experienced the single largest multi-day drawup and drawdown in the history of the VIX index. Artemis ranks consecutive drawups and drawdowns (trough-to-peak or peak-to-trough) in volatility and models them as a **power law distribution**. The distributions of a wide variety of physical, biological, and human phenomena closely follow this form. Examples include earthquakes, deaths in war and terrorism, populations of cities, solar flares, word frequencies in language, movie box office receipts, and asset price movements. When you logarithmically rank the event magnitude of these natural and human phenomena the majority of observations will align linearly along the x-axis as a power-law function (see white line below). Violations of the power-law function are supernormal events because their results contain a degree of reflexivity that exceeds the exponential growth function. Examples of supernormal violations in power laws across other phenomena include death counts in WWII ranked among all wars, box office receipts of the movie Titanic, the Titanic disaster itself, the 9.2 Magnitude 1960 Chilean Earthquake, the population of Tokyo, the 1987 Black Monday Crash, and the 9/11 terror attack in NYC. Three of the top ten supernormal VIX increases and four of the top eight supernormal VIX decreases have occurred in the last year alone! The top eight ranked drawdown collapses in VIX have all occurred during the post-2012 monetary regime. **Power-law violations in VIX to the downside and upside are now happening with regularity!**



Volatility markets are demonstrating deep uncertainty in the very nature of uncertainty itself. The schizophrenic behavior of volatility is a deep warning sign for policy makers that **something is not right**. Implied Volatility-of-the VIX ("CBOE VVIX") reached the highest levels in history on August 24th, 2015. The volatility-of-VIX rose higher than levels achieved even during the 2008 financial crisis, 2010 Flash Crash, and 2011-debt downgrade crisis. Many will point to structural considerations as a driver including the proliferation of VIX exchange traded products and the new spot-VIX calculation methodology. While these are important factors, they are only part of the story. To understand why the volatility of volatility reached new highs we have to engage in deep meta-thinking about our reaction to change.

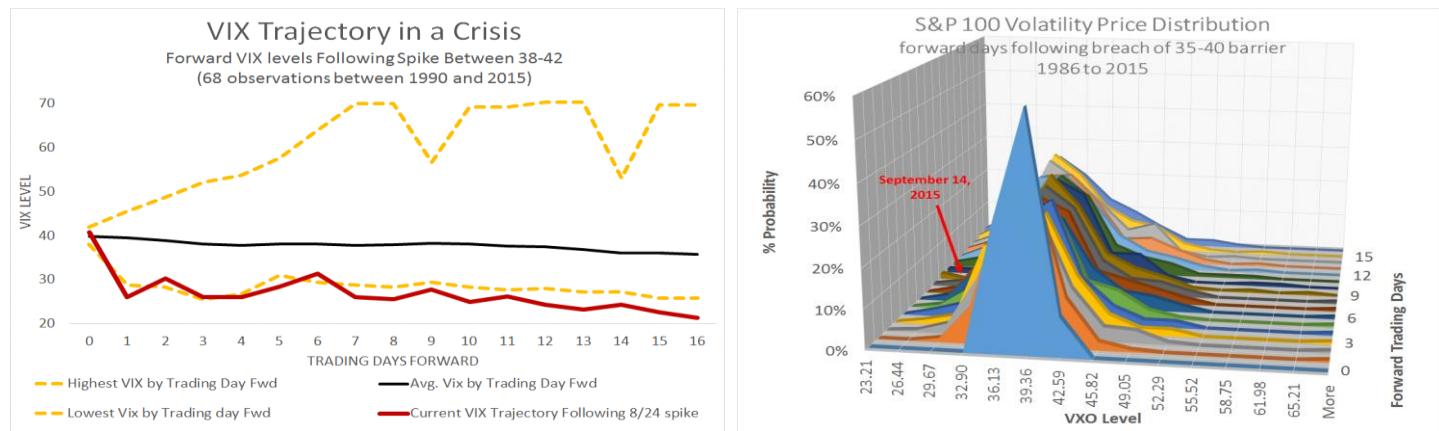
Volatility provides exposure to our collective insecurity towards an unknowable future. Likewise, to short volatility is to express personal confidence in the status quo of market affairs despite a broader fear of change. To go long volatility is to express fear that change is coming. Volatility-of-volatility is simply the war between these two different modes of perception... shifting perceptions in the nature of uncertainty itself. If uncertainty is rising so should the VIX... but there is a very different type of uncertainty to evaluate ... the uncertainty that central banks will intervene. When global central banks seek to defend the status quo and mean reversion it becomes increasingly difficult to accurately gauge the probability of change in markets. Volatility markets are now gaming central banks in addition to fundamental economic and technical conditions. If we are unclear from one moment to the next whether radical change or the status quo will prevail than volatility-of-volatility should logically rise.



Volatility mean reversion has been an abnormally profitable bet during the regime of pre-emptive strikes on financial risk.

Following each tail event in volatility, we are experiencing another tail event in the magnitude of volatility declines.

Central banks refuse to let volatility remain elevated and are quick to react to any crisis. Between August and September 2015 the VIX collapsed faster than ever before following a spike to 40 (see red line below) due to another massive stimulus response by central banks. China cuts rates, devalued the Yuan, and purchased an estimated \$263bn of equity (9.2% of freely traded shares) to artificially prop-up their stock market before a nationalistic military parade. Following China, the ECB expanded their QE program. The graph below demonstrates the historic decline in volatility by showing the average, high, and low trajectory paths of the VIX the ensuing fifteen days following every implied volatility spike to 40. Likewise, the area chart below and to the right graphs the forward probability distribution of S&P 100 implied volatility (VXO) following a breach of the 35 barrier in spot-vol. As expected, implied volatility exhibits an exceptionally positively skewed distribution following a 'risk-off' event, but notice how the current trajectory of VXO lies on the far left of the distribution. Central banks refuse to let volatility remain elevated but this is creating a new set of shadow risks.

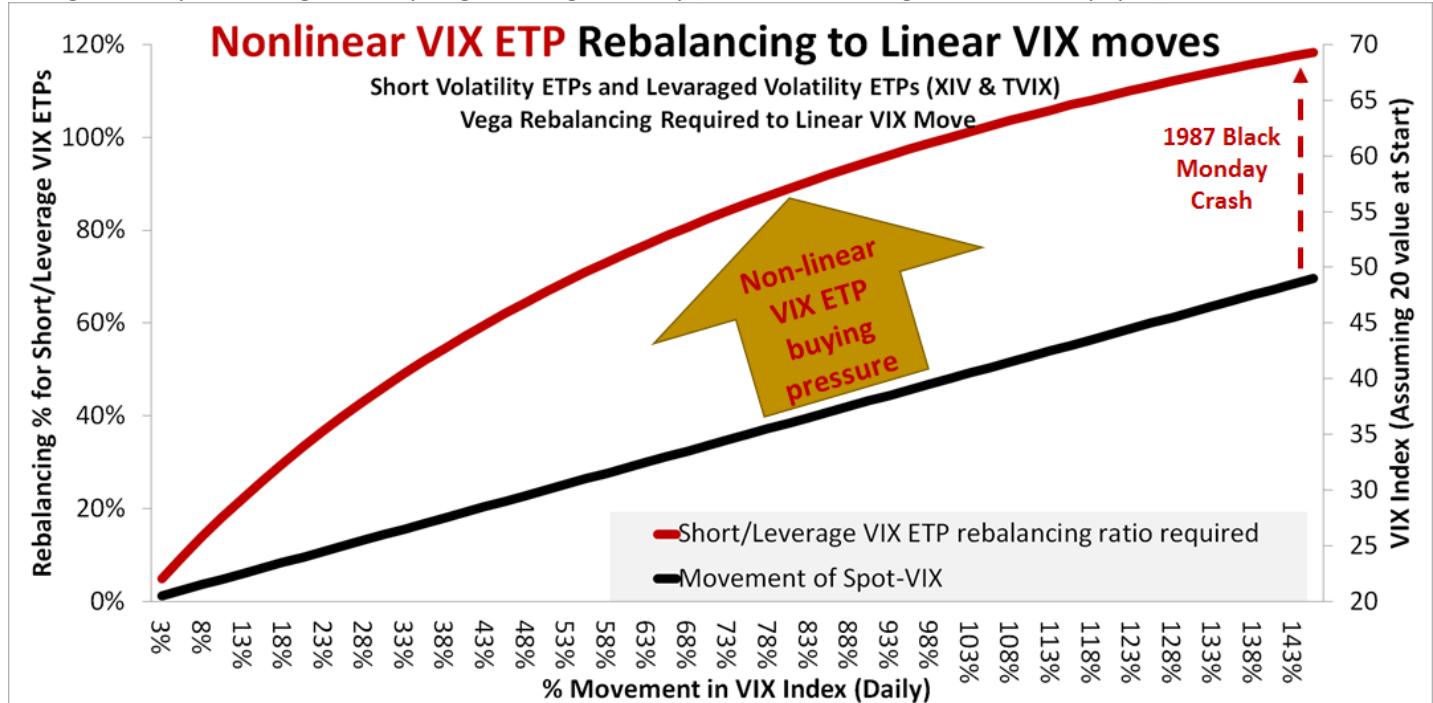


Short Volatility in the Prisoner's Dilemma

Global central banking has artificially incentivized bets on mean reversion resulting in tremendous demand to short volatility. The growth of short volatility exchange traded products ("ETPs") since 2012 is nothing short of extraordinary and at the end of August, total short volatility assets exceeded long for only the second time in history. The rise of this short complex is intrinsically linked to the recent schizophrenic behavior of the VIX and adds significant shadow convexity to markets. Velocity Shares Daily Inverse VIX ("XIV") is the largest of these short VIX ETPs and has a cult-like following among day traders. Although the product has gained **+111%** since 2012, when decomposed on a risk-adjusted basis, it basically resembles a 3x levered position in the S&P 500 index with more risk. As the short and leveraged volatility complex becomes more dominant it is contributing to dangerous self-reinforcing feedback loops with unknowable consequences.



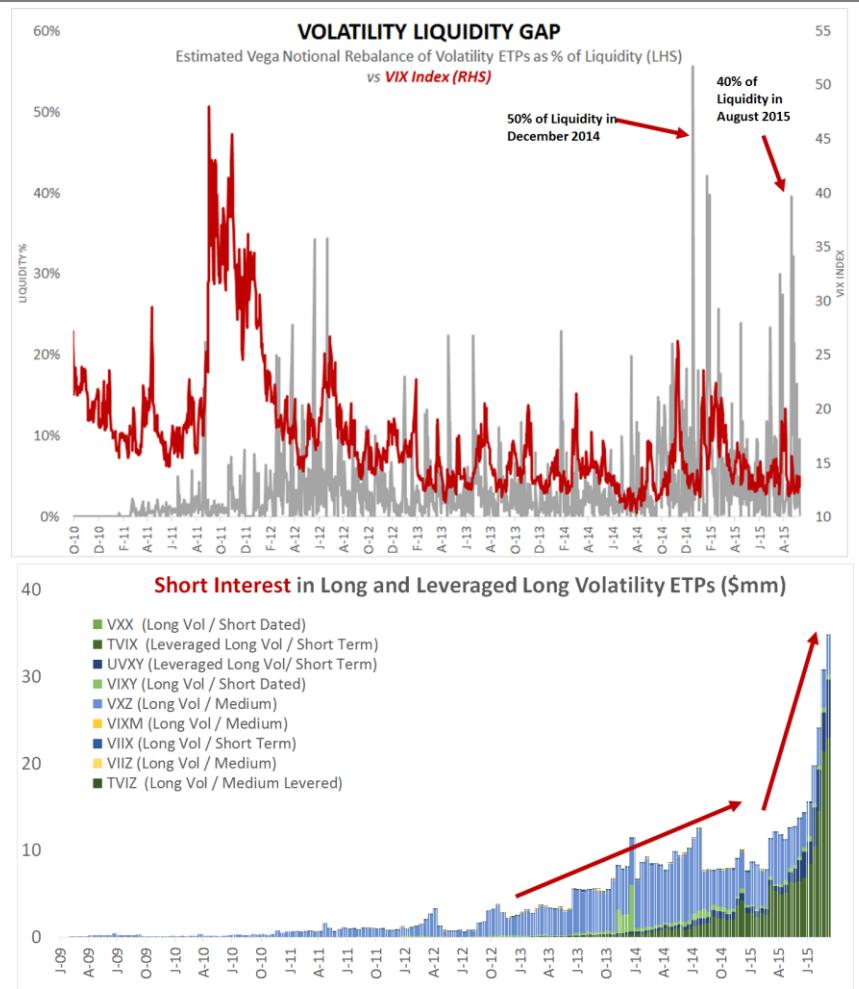
Many retail investors simply do not understand that short and leveraged volatility ETPs rebalance nonlinearly (see below). To the casual observer it may appear that short and long assets counterbalance one another but this is not the case. For example if the first two VIX futures move 20% higher the short volatility ETP providers must buy an estimated 33% more volatility (vs. 25% for long) to balance that exposure. **The first rule of derivatives hedging is that you never hedge a nonlinear risk with a linear tool.** The mismatch means a large move in spot-volatility in either direction requires excessive buying or selling pressure whenever short volatility assets are dominant. Therein lies the problem. Falling volatility begets falling volatility and rising volatility begets rising volatility (notice a recurring theme to this paper).



The great unknown is that this massive short volatility animal that appears **tame** given a regular diet of central bank liquidity may turn **wild** when that liquidity is removed. The wrong 'risk-off' event may expose a hidden liquidity gap in the short VIX complex that could unleash a monster. Artemis has attempted to quantify this theoretical liquidity gap by gauging the percentage of VIX open interest and volume required by exchange-traded products for rebalancing (only large dealers in VIX ETPs have the ability to fully quantify these relationships but have an obvious conflict of interest). During recent market stress points such as October 2014 and August 2015 we estimated the short and leveraged volatility ETP complex required upward of 40-50% of the total liquidity of VIX futures as measured by average trading volume and open interest. Consider that the largest one day VIX move in history was the **+64%** jump that occurred on February 27, 2007 when the VIX went from 11.15 to 18.31. This was not even a period of high financial stress! If a similar volatility spike occurred today, given the current size of the short VIX complex, the ETPs by themselves would require an estimated **95% of the liquidity for rebalancing!** This theoretically would drive the price of the VIX futures up further exacerbating the nonlinearity. The VIX futures market may struggle to absorb the demand for long volatility and dealers would be forced to rely on other sources for forward volatility. Dealers seeking to plug the liquidity gap would then purchase S&P 500 options and forward variance swaps. In a hypothetical disaster scenario, the excess buying pressure exerted from the short-volatility complex spilling over to S&P 500 options may push spot-VIX higher contributing to panic selling in the underlying S&P 500 index and a vicious and self-reinforcing cycle of fear followed by horror.

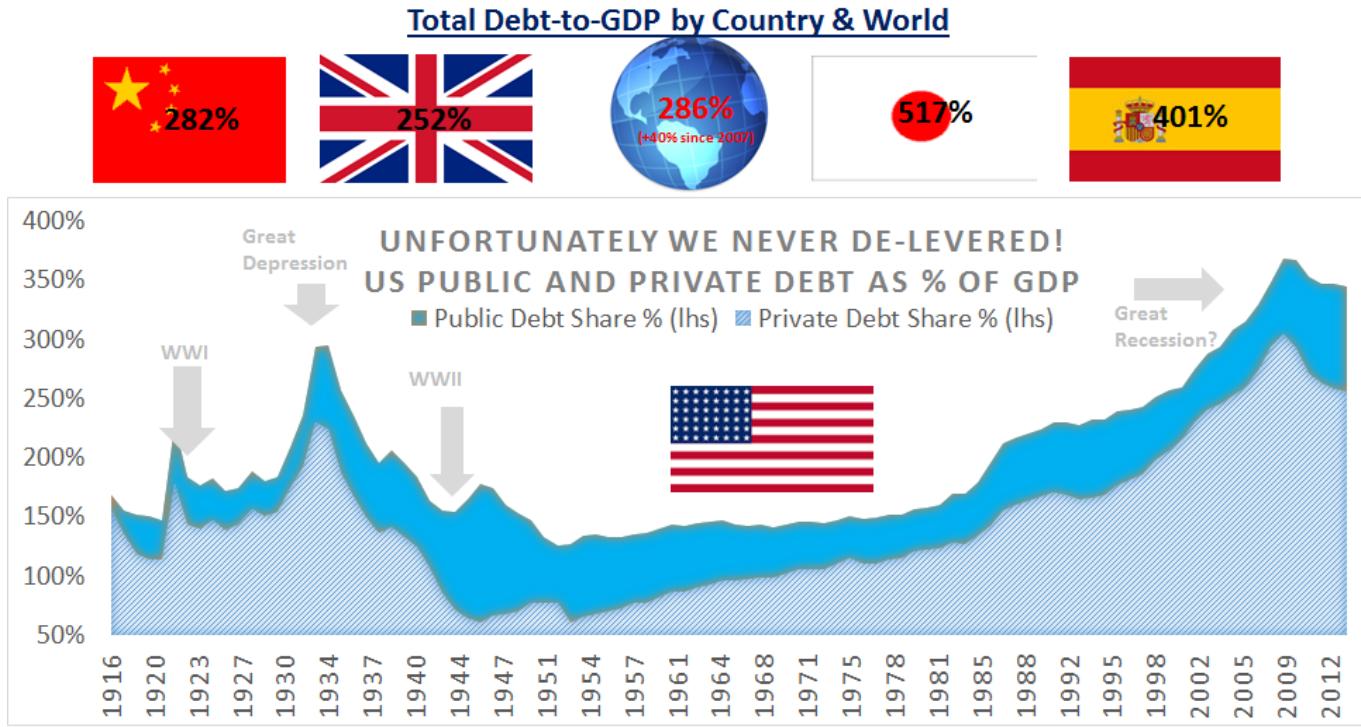
The bi-polar behavior in spot-VIX over the last year empirically supports the theory that a structural weakness now exists in this market by crowding of short volatility players. The shot across the bow for the short volatility complex came during the August 24th correction when SPX futures opened limit down and the CBOE struggled for 30 minutes to calculate the VIX. By the time the VIX level was finally calculated it opened 25 points higher at 53.29, before falling to 28 intra-day, then rebounding to 40.74 by the close, with the S&P 500 index down **-3.9%**. At the time of the crash, the assets in long VIX ETPs outnumbered shorts on a two to one basis however, the complex still required an estimated 25% to 46% of market liquidity between August 21 and 24th. Markets delivered historic volatility-of-volatility despite relatively mild historical declines in the S&P 500 index. It is important to understand that markets have experienced much more dramatic one-day losses across history than what occurred in August 2015. For example on August 8th 2011, the market suffered a one-day decline of **-6.7%**. September to December 2008 experienced ten declines of more than **-5%**, and on Black Monday 1987, the market fell an incredible **-20.5%** in one day. During the Black Monday 1987 crash implied volatility in the S&P 100 index more than tripled going from 36.37 to 150.19. **If markets experienced any of these historic crashes at current levels of short convexity the entire \$2bn+ short volatility ETP complex could potentially be wiped out overnight.**

Short volatility sellers ridicule the fact that the prospectus for the iPath Long Volatility ST Index (VXX) clearly states that the ETF has an expected long-term return of zero. They should ask themselves, is it better to know with certainty you are going to go bankrupt slowly, or be completely ignorant of the fact you will go bankrupt suddenly.



Debt in the Prisoner's Dilemma

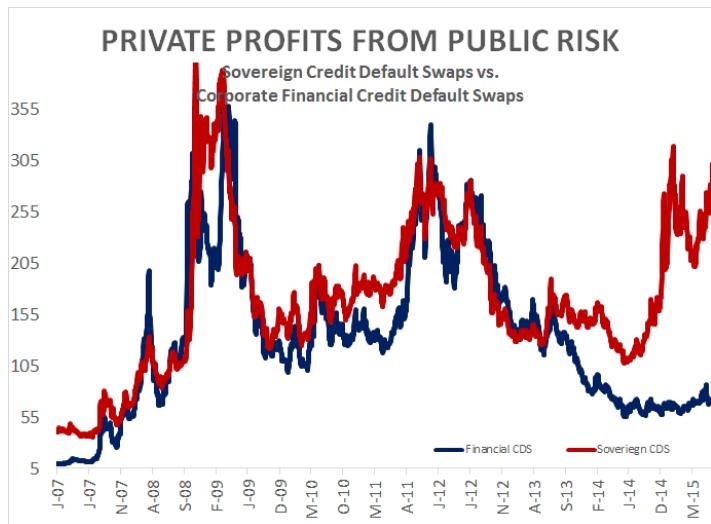
The arms race of devaluation is not free and has come at the cost of massive global debt expansion. There is no precedent in financial history for a robust economic recovery absent either debt reduction or rampant inflation. We never de-leveraged, in fact we just doubled down. According to a recent McKinsey study the world has reached \$200 trillion of debt in 2014 (286% of global GDP), which is a staggering 40% increase from 2007 levels (+\$57 trillion). In China, debt has grown four times faster than GDP since 2007, and half of that debt is linked to their property market⁽²¹⁾. The world has simply shifted private debt to the public balance sheet.



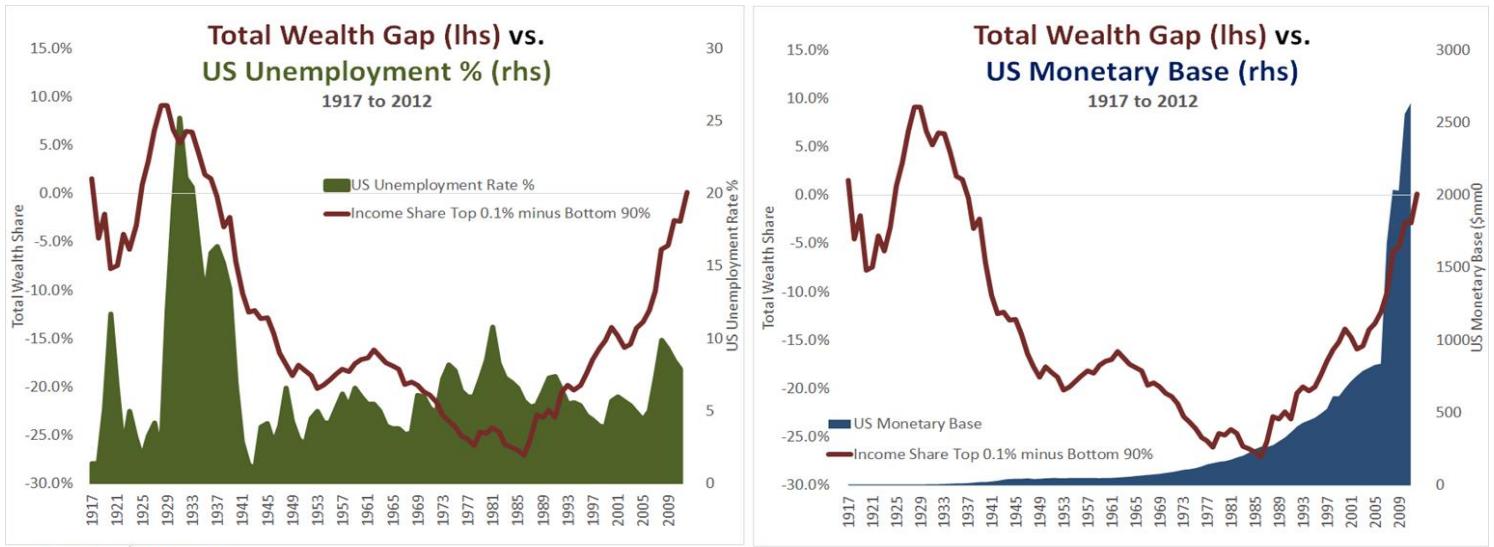
Source: Global Financial Data, Recent Debt-to-GDP data from McKinsey Global Institute

The private risk transfer to the public balance sheet can also be seen in the evolution of credit default swap pricing since 2007. Notice the sharp divergence between global sovereign CDS (red) and financial corporate CDS (blue) starting in 2013. The next major global crash will likely be driven by unhealthy sovereign credit rather than corporate credit. The next Lehman moment will be the financial collapse of a major developed country instead of a bank.

There are those who point to aggressive central banking of the late-1930s as the model for de-leveraging post-depression but this argument is highly flawed. We didn't financially engineer our way out of the Great Depression - we won a World War. It's extremely helpful in the de-leveraging process if you are the only capitalist industrial power left in the world untouched by utter and complete destruction. De-leveraging from the Great Depression had as much to do with the blood, sweat, and tears of American soldiers, the development of nuclear weapons, and the fact we were an ocean removed from the battlefield on both sides, as anything related to fiscal and monetary policy from the era. I don't think some investors are being *radically honest* when they omit this brutal truth in their analysis of late-1930s as model to argue for more quantitative easing. More quantitative easing is a great thing if you run a large risk parity fund but it will not help the American middle class.



Income Inequality in the Prisoner's Dilemma



Source: Saez and Zucman / Global Financial Data

The middle class is unknowingly trapped in the Prisoner's Dilemma and this is perhaps our greatest nonlinear risk as a nation. America is built on the promise of upward mobility but that promise is increasingly becoming a lie. Wealth inequality is at the highest level in 100 years and close to levels last achieved before the 1928 crash that led to the Great Depression. Today the top 0.1% of households now control an equivalent amount of the wealth as the bottom 90%. Since 1973, real family income for the top 1 percent has grown over 150% while incomes for the lowest 20% of earners has remained stagnant⁽²²⁾. The median household income adjusted for inflation in 2011 was just below its level from 1989 and \$4,000 lower than in the year 2000⁽²³⁾. The illusion of a middle class prosperity has been sustained via low interest rates, consumer debt, and globalization. Instead of helping the problem, accommodative monetary policy has accelerated this pace of income inequality in the US.

"Economic inequality has long been of interest within the Federal Reserve System"⁽²⁴⁾ said Janet Yellen during a April 2015 speech. Yellen has repeatedly argued that accommodative monetary policy reduces income inequality by lowering unemployment. While it is true that unemployment has declined, her conclusion assumes that lower wealth inequality and lower unemployment are correlated in some kind of linear fashion. In reality, the wealth gap peaked the year before the Great Depression started when the country was close to full employment and the joblessness rate was only 2.08%⁽²⁵⁾. The point is that full employment with extreme income disparity can and often does co-exist. If we measure the average income in a hypothetical village of 100 people, 99 of which have minimum wage jobs, the last of which is Warren Buffett, who employs the rest, you have income disparity and full employment. To this extent, Yellen's argument that lowering unemployment somehow decreases the wealth gap is illogical. During Yellen's September 17th, 2015 press conference she alludes to a mysterious academic paper that somehow proves otherwise, but I looked everywhere and couldn't find that paper. I do have a non-academic paper entitled "Common Sense" that takes a very different view.

Yellen's treatment of the wealth gap problem is an example of mistakenly **linearizing a nonlinear problem**. The Bernanke-Yellen Fed has achieved a **linear decline** in unemployment via **exponential growth** in the monetary base. When asset prices increase in a nonlinear fashion the top 1% of wealthy families that own real estate, stocks, bonds, and have access to low rates will benefit disproportionately. When the middle class earns a dollar, they spend that dollar on goods and services that reach the real economy. When the top 1% earns a dollar that money is likely to be reinvested in assets. As a result, we have seen nonlinear inflation in asset prices but no significant inflation in real wages or core CPI. With no wage inflation, global central banks are inclined to continue their rotation of devaluation further exacerbating this mad cycle and encouraging an even greater income gap and vast political risk. The policies of the Fed have simply exchanged nonlinear expansion of the wealth gap in exchange for a linear decline in the unemployment rate. What is clear is that Janet Yellen would make a terrible derivatives trader because she just does not seem to understand that you cannot hedge a nonlinear risk with the linear benefit. **The current monetary experiment, left unchecked, will inevitably threaten the very fabric of our democracy.**



Democracy in the Prisoner's Dilemma

"Last night, I got up here and asked you people to stand up and **fight for your heritage**, and you did and it was beautiful. Six million telegrams were received at the White House.

The Arab takeover of CC and A has been stopped; the **people** spoke, the **people** won.

It was a radiant **eruption of democracy!**

But I think **that was it** fellers.

That sort of thing isn't likely to happen again.

Because, in the bottom of all our terrified souls, we all know that....

Democracy is a dying giant, a sick, sick dying, decaying political concept, writhing in its final pain.

I don't mean the United States is finished as a world power.

The United States is the most powerful, the richest, the most advanced country in the world, light years ahead of any other country.

And I don't mean the Communists are going to take over the world.

The Communists are deader than we are.

What's finished is the idea that this great country is dedicated to the freedom and flourishing of every individual in it.

It's the **individual** that's finished.

It's the **single, solitary human being** who's finished.

It's **every single one of you** out there who's finished. "

Network, 1976

Written by Paddy Chayefsky

Directed by Sidney Lumet

"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."

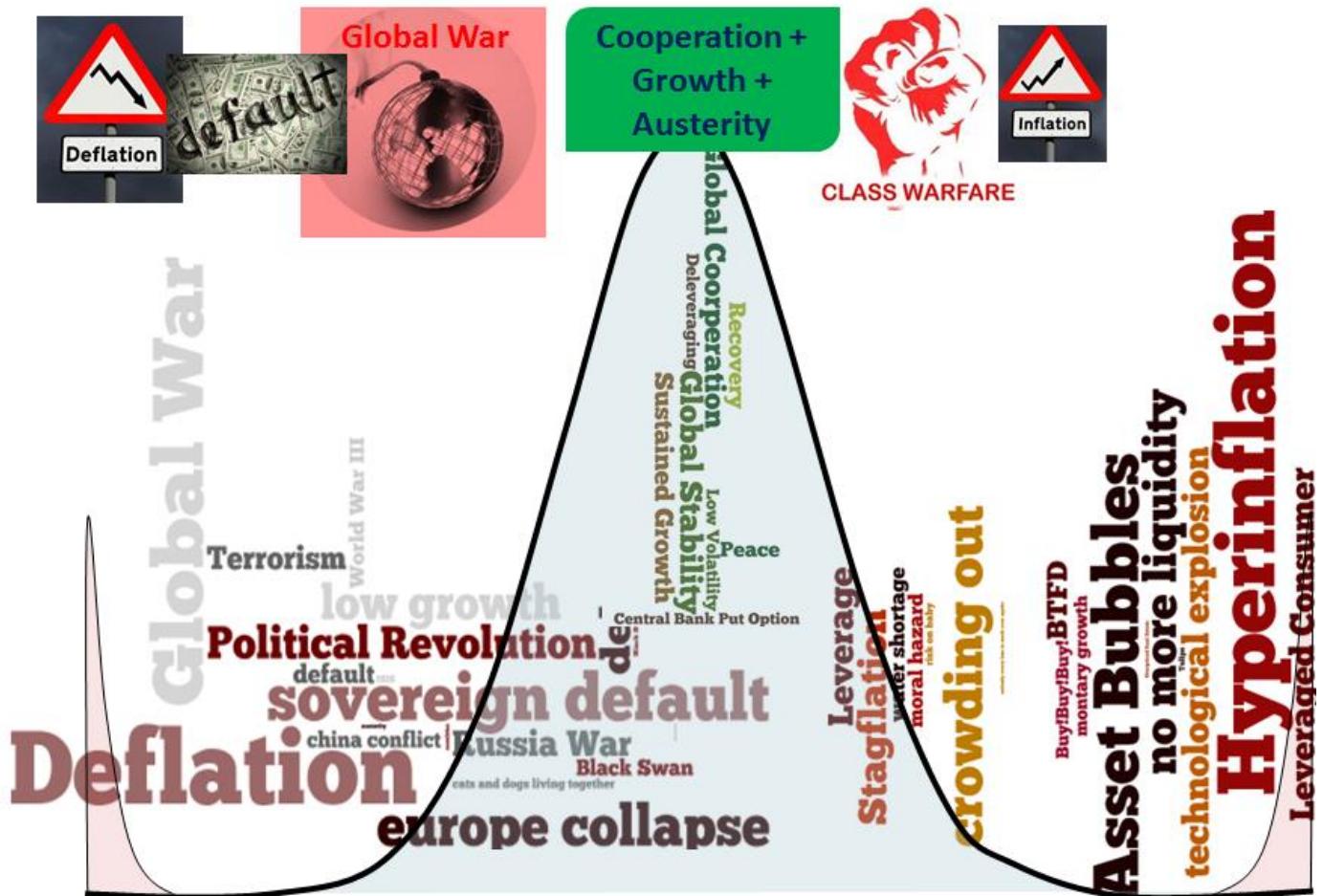
Benjamin Franklin

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

Mayer Amschel Bauer Rothschild



Escape from the Prisoner's Dilemma



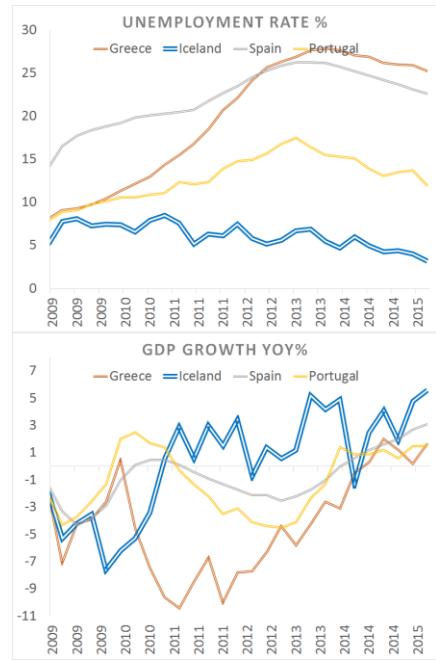
Source: istockphoto.com, worldy

The global economy is suffering from a cancer of debt-deflation, income inequality, and low growth. Instead of treating the root cause, policy makers have treated the symptom of asset price declines. Whenever the patient feels weak an increasing amount of policy drugs are required to maintain the illusion of stability to the point where the patient is addicted to the painkillers. The root cause of the cancer is never confronted and as a result, the fundamental health of the patient does not improve. Neither the doctors nor the patient wish to face the reality that difficult and painful therapy is needed to destroy the cancerous leverage in the system. The inevitable result of this denial will be the death of the patient.

In all instances, policy intervention has generated a short-term market fix at the expense of addressing the longer-term fundamental problems. The Federal Reserve has expanded its balance sheet \$4.5 trillion to create middle class jobs but instead has incentivized asset bubbles and the highest wealth concentration since before the Great Depression. The European Central Bank and Bank of Japan are pursuing quantitative easing to drive up asset prices rather than addressing the core issues of structural reform and weak demographics that are causing their deflation. European institutions rely on last minute 'bail-outs' and quantitative easing to avoid debt default while ignoring the necessary fiscal and philosophical integration required to make a unified Europe a success. China is struggling to shift from an export driven economy to a consumption driven economy despite decelerating growth, total debt growing four times faster than GDP, and the valuation of the Shanghai Composite at levels comparable to 2007. How does spending an estimated 10% of GDP⁽²⁶⁾, including \$263 billion in direct stock market intervention⁽²⁷⁾, coupled with cheap real estate loans to build ghost cities, fundamentally address any of China's real problems?

Is there another way? Iceland, a small Nordic island country, better known for glaciers than economic policy, has followed a very different path and their economic cancer of debt-deflation is in remission. Today the Icelandic economy is rapidly expanding with low unemployment, high growth, and declining debt even when Europe is printing money to avoid falling back into deflation. It is hard to believe that just 7 years ago Iceland faced arguably the direst conditions in the region. The banking system held assets at 10x the size of GDP after a decade of de-regulation in the lead up to the crash. In the aftermath of the bubble, GDP collapsed **-7.6%**, unemployment exploded above 8%, and inflation surged to above 12%. Banking liabilities, mainly denominated in foreign currencies, ballooned to 20x the budget of the State. Iceland accepted over \$5bn in bailouts from the IMF and neighboring countries following a run on the banking system.

What happened next goes against all contemporary economic thinking. Iceland did not re-leverage their financial system, bail out their banks, print money, or use public assets to support the stock market. Iceland refused to promote private risk with public money ... They did the exact opposite and let the private banks crash and prosecuted officials for negligence. Iceland then treated the disease and not the symptoms by undergoing a rigorous period of economic chemotherapy. Iceland devalued the Krona, introduced capital controls to stabilize local outflows and foreign inflow of assets, wrote down household debt, raised interest rates to 18%, and introduced more austerity than any European country other than Greece. The stock market fell 95% and interest payments on loans soared to over 300%. **Like medical chemotherapy, economic chemotherapy was horrible, but the cancer of debt-deflation was eradicated and the system made whole.** Today Iceland's economy has become one of the top performers in Europe with GDP growing **+5.6%** in the second quarter and unemployment falling to 4% versus 11% in the Eurozone. Tourism has grown **+100%** since 2006 and exports are up. Iceland began repaying IMF loans earlier than expected in 2012, and by the end of 2015, they will be eliminated. Icelandic debt-to-GDP is falling even as the rest of the developed world has seen debt levels balloon out of control. There are still challenges. Iceland is set to remove capital controls and businesses and residents lament that it is difficult to get loans at reasonable interest rates. The road forward will not be easy but Iceland has hope where there is little of it left in deflation ravaged Greece and Spain, where over one fifth of the citizens and over half of those under 25 years old are unemployed. **Iceland's cancer is in full remission and Europe's is getting worse.** ⁽²⁸⁾⁽²⁹⁾⁽³⁰⁾⁽³¹⁾



Risk cannot be destroyed, it can only be shifted through time and redistributed in form. Iceland has taken its risk head on, while the rest of the world has shifted its pain forward for our children to deal with. Every economy is different. Iceland is a small country with a largely homogenous population of only 300k. It may be difficult to fully adopt their methods in large countries that are less politically or culturally unified. While the Iceland model may not be the solution for every economy, the fact it is **not part of the policy debate represents a clear failure of our leadership.**

The rise of central banking is the death of empiricism.

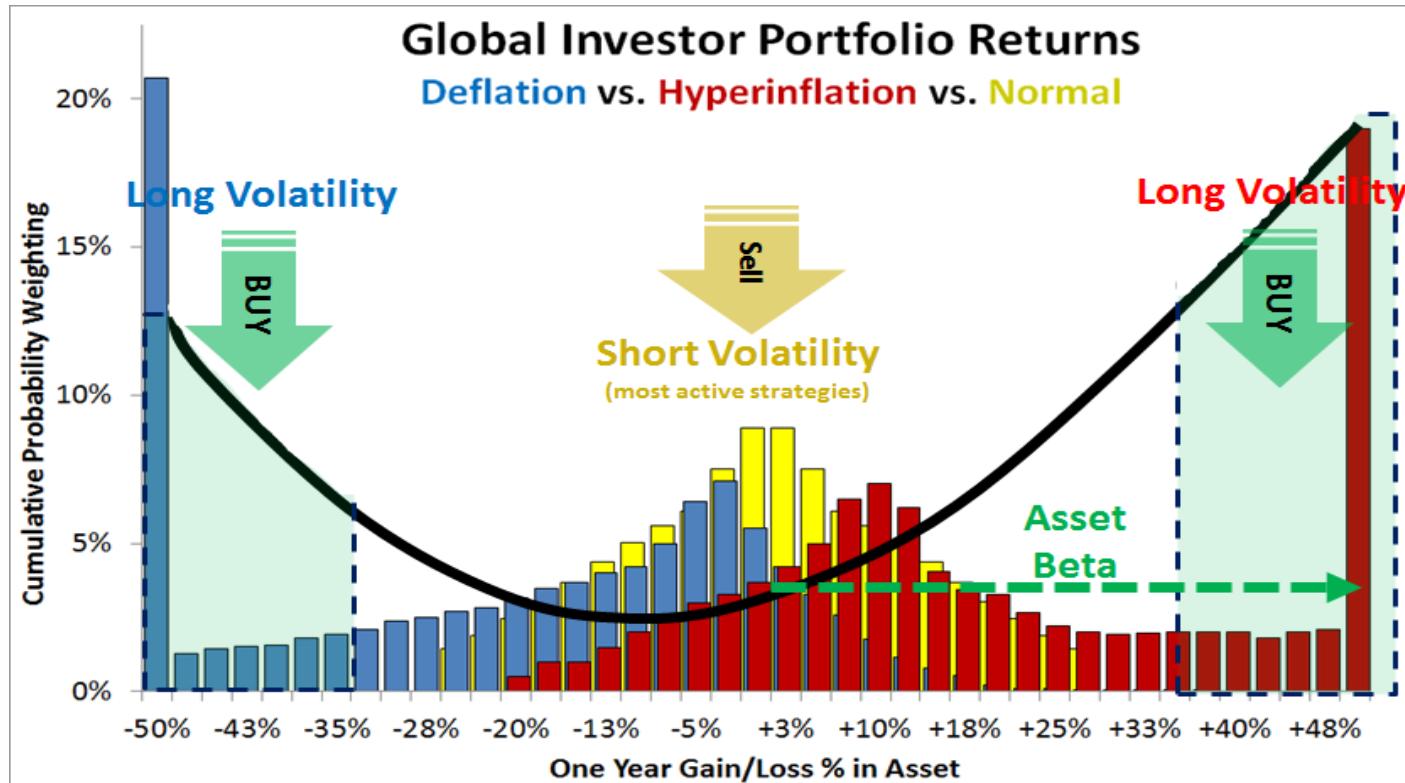
The Federal Reserve is arguably the most powerful organization on the planet and is the economic rudder of the global economy. The decisions made by its members effect anyone touched by capitalism from the garment worker in Bangladesh all the way to the investment banker in London. By design, board members are not democratically elected and independent from the oversight of the executive and legislative branches of the US government. The voting membership of the Federal Open Markets Committee is dominated by members with predominantly academic or policy backgrounds (Yellen, Evans, Fischer, Lacker, Williams, Brainard, Tarullo, and Powell) with the remaining deriving their experience as Wall Street economists (Dudley, Lockhart)⁽³²⁾. This means the most powerful economic body on earth has little diversity in its intellectual ranks. **No FOMC board member knows what it means to be an entrepreneur. No FOMC board member has a record of accomplishment as a great investor. No FOMC board member has started or run a successful global business. No FOMC member has led a corporation through a crisis. It may be time to consider whether economic leadership dominated by academic theory as opposed to empiricism is making things worse.** I don't claim to have the answers, but the empiricist knows what they do not know, and this is more than I can say for policymakers today.



Global central banks have made a **Faustian bargain** with our economic soul selling our future for a false stability today. At this stage, absent continuous intervention, a large deflationary crash in the global economy is inevitable. The greatest risk is that if central banks continue a policy of competitive devaluation and hyper-asset bubbles the end result will be an even more devastating crash, followed by sovereign defaults, and then class warfare. The next Lehman brothers will be a country. The real 'shadow convexity' will not come from markets but political unrest or war. Never forget that Hitler rose to power by harnessing the anger of a humiliated German middle class and abusing constitutional authority granted from a decade of economic devastation and money printing. The Federal Reserve is better off ending the Prisoner's Dilemma by engineering a painful but manageable global recession today rather than risk an uncontrollable tragedy tomorrow. Absent such drastic actions, volatility will manifest itself first through hyper-asset explosions on the right tail, followed by a deflationary crash and sovereign default on the left tail. It may already be too late. History shows us that economic recovery from a depression has never been successfully engineered without major debt reduction, devaluation, default, hyperinflation, political revolution, or world war. To this extent, it is very likely this Prisoner's Dilemma will end in one or more of these outcomes.

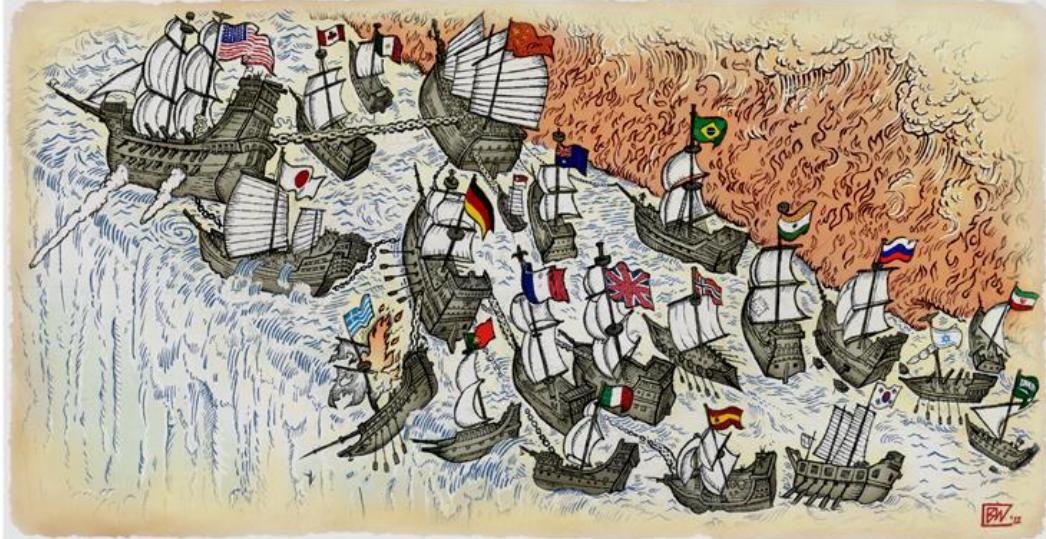
Peace is not the absence of conflict. *Global Central Banks have set up the greatest long volatility trade in history.* It is impossible to know with certainty when the volatility will fully manifest but the cost of holding the trade is far less than exponential pay-off. The longer the delay the bigger the payout will be. What is known is that at some point in the future a government or central bank will be asked to step up to a crisis and will either be unwilling or unable to do so, economically or by populist revolt. The markets will re-leverage in anticipation of policy support that will not materialize... the spell will be broken... and the collapse will be epic. You need to own volatility on both the right and left tail of the return distribution before that day happens. When markets are euphoric buy optionality to protect against deflation ... when markets are crashing buy optionality to protect against hyper-reflation. More important when volatility doubles... don't short it... keep buying it until it quadruples. Buy the **fear** and you will be protected from the **horror**. Do this consistently and dynamically and your portfolio will become a global macro straddle that, when combined with traditional asset classes, will result in a profile that is positively exposed to all forms of crisis. You do not know it yet... but your greatest asset are the risks the world is hiding from you. **You need to assemble a collection of the most dangerous outcomes in the global economy... and try to make them do some good.**

Volatility is your only escape from the Prisoner's Dilemma

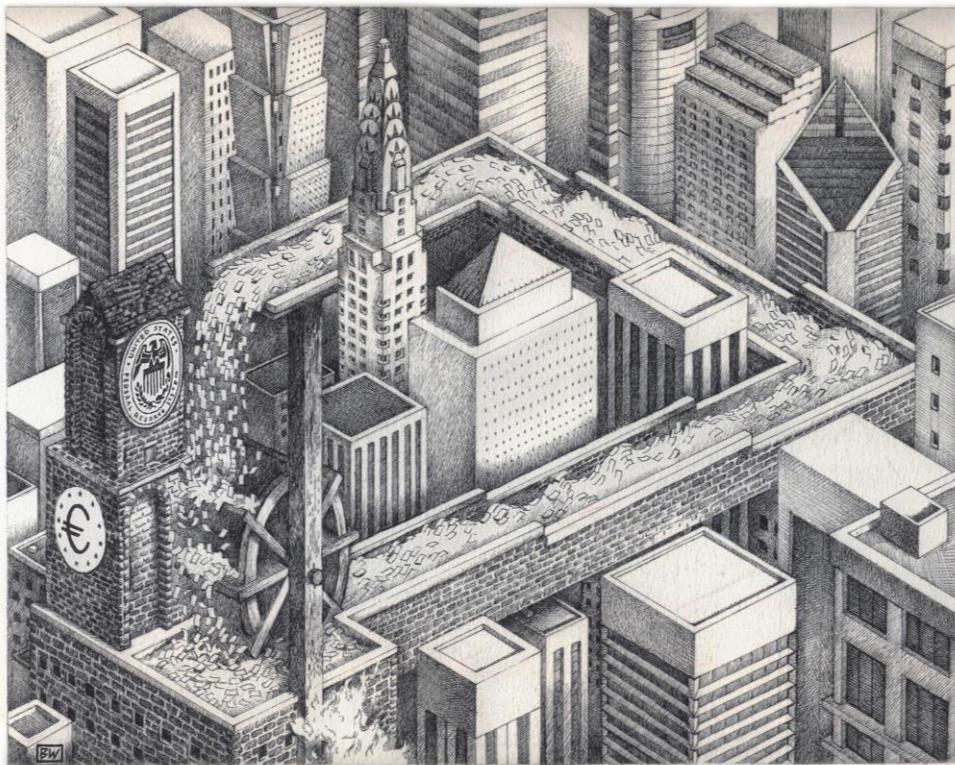


Epilogue to the Prisoner's Dilemma

Three years ago on April 30th, 2012 Artemis released a research paper entitled “Volatility at World’s End: Deflation, Hyperinflation and the Alchemy of Risk” introducing the concept of the “Bull Market in Fear” and arguing portfolio insurance was overpriced and that investors were focusing on the wrong tail of the returns distribution. The white paper made the case for purchasing long-dated and far out-of-the-money S&P 500 index calls. Immediately following publication, the paper had a definitive impact on re-pricing long dated skew for over-the-counter S&P 500 index options. The S&P 500 option trade recommended in the paper would have returned over 20x its initial cost of capital if held to today.



Later that same year Artemis published “Volatility of an Impossible Object: Risk, Fear, and Safety in Games of Perception”. The paper utilized the visual construct of an “Impossible Object” and work of Jean Baudrillard in his philosophical treatise “Simulacra and the Simulacrum” as a lens to understand central bank manipulation in markets.



“Volatility at World’s End” painting by Brendan Wiuff based on concept by Christopher Cole
“Volatility of an Impossible Object” sketch by Brendan Wiuff based on concept by Christopher Cole and inspired by art of M.C. Escher

Baudrillard re-told an old Borges fable about cartographers of a great Empire who drew a map of its territories so detailed it was as vast as the Empire itself. As the actual Empire collapses, the inhabitants begin to live their lives within the abstraction believing the map to be real. Artemis argued that in the postmodern economy market expectations were more important to fundamental growth than the reality of supply and demand the market was designed to mimic, the market was no longer an expression of the economy... it had become the economy. The conclusion held that in a world where up was down and down was up "*he who plays it safe may be assuming the greatest risk of all*". What followed was one of the greatest risk adjusted periods of asset returns in over 200 years.

There was a point in time... three years ago in the 'bull market in fear' whereby these ideas had edge. All you needed to do was follow the central banks and be rewarded. No longer. Today moral hazard is priced into markets. You are not a **contrarian** for following central banks. You are not a **contrarian** for buying into equity weakness. You are not a **contrarian** for shorting the volatility spike. You are not a **contrarian** for buying the dip. If you think you are a **contrarian**... the joke will be on you.

*"I started a joke... which started the whole world crying. But I didn't see...
that the joke was on me..."*

*"I started to cry, which started the whole world laughing, oh if I'd only
seen, that the joke was on me..."*

*"I finally died, which started the whole world living, oh if I'd only seen,
that the joke was on me."*

The Bee Gees, 1968

There is a time to live inside and embrace abstraction. That time is ending. The illusion is dying and truth is coming.

When you see the dark clouds on the horizon ... when you hear the clap of thunder in the distance...

when lightning bolts across the sky...do not seek shelter from the squall...

do not run from the winds of change...

Ride into the storm





VOLATILITY IS AN INSTRUMENT OF TRUTH

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

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

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

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

Christopher R. Cole, CFA

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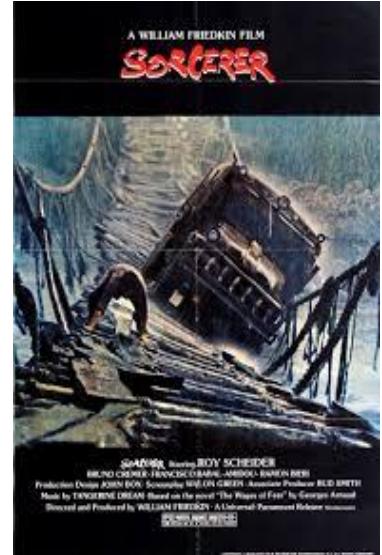
In early January 1831, Green DeWitt wrote to Ramón Músquiz, the top political official of Bexar, and requested armament for defense of the colony of Gonzales. This request was granted by delivery of a small used cannon. The small bronze cannon was received by the colony and signed for on March 10, 1831, by James Tumlinson, Jr. The swivel cannon was mounted to a blockhouse in Gonzales, Texas and later was the object of Texas pride. At the minor skirmish known as the Battle of Gonzales—the first battle of the Texas Revolution against Mexico—a small group of Texans successfully resisted the Mexican forces who had orders from Col. Domingo de Ugartechea to seize their cannon. As a symbol of defiance, the Texans had fashioned a flag containing the phrase "come and take it" along with a black star and an image of the cannon which they had received four years earlier from Mexican officials. This was the same message that was sent to the Mexican government when they told the Texans that they had to return their cannon; failure to comply with the Mexicans' original demands led to the failed attempt by the Mexican military to forcefully take back the cannon⁽³³⁾.

Appendix I - Cinematic Convexity

Cinema offers a powerful lens to explore the themes of convexity through a dramatic and visual medium. Below are my favorite long and short convexity films of all time.

Sorcerer – Damned to Short Convexity

The greatest **short convexity film** in history is the forgotten existential masterpiece “**Sorcerer**” (1977) directed by William Friedkin (Ingmar Bergman’s “**The Seventh Seal**” is a close second). In the jungles of an unnamed Latin country, four desperate outcasts agree to transport highly volatile nitroglycerin by truck across a dangerous rainforest to extinguish a remote oil well fire. Any turbulence will cause the cargo to explode. The oil company promises a small fortune if the job is successful setting up a high stakes game of survival for a group of lost souls desperate for money to start over again. This is the ultimate short nonlinearity plot device and each character embodies a life of short convexity. Jack is an ex-driver for an organized crime syndicate and the only survivor of a car crash and botched robbery. He flees to the US after a contract is put on his head. Kassem is a Lebanese terrorist that evaded capture following a bomb attack in Jerusalem. Victor is an elite French financier accused of fraud who decides to flee France and his loving wife following the suicide of his business partner and failed bailout attempt. Every character in Sorcerer is damned to a life of short convexity for money. They learn dark lessons about risk in an even darker jungle.



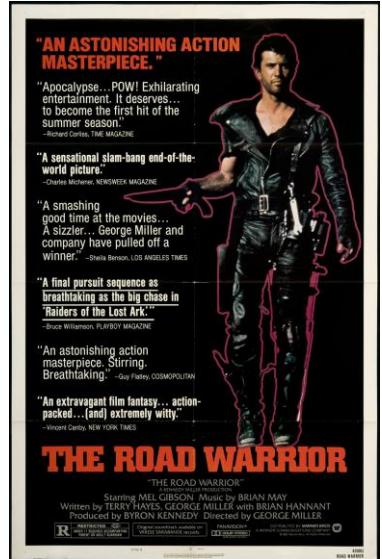
The Road Warrior – Long Convexity in a Short Convexity Wasteland

"I remember a time of chaos, ruined dreams, this wasted land. For reasons long forgotten two mighty warrior tribes went to war and touched off a blaze which engulfed them all. Without fuel they were nothing. They'd built a house of straw... Their world crumbled. Men began to feed on men... in this maelstrom of decay ordinary men were battered and smashed — men like Max... In the roar of an engine, he lost everything. And became a shell of a man, a burnt out, desolate man, a man haunted by the demons of his past, a man who wandered out into the wasteland. And it was here, in this blighted place, that he learned to live again..."

Mad Max 2: The Road Warrior, 1981

Written by Terry Hayes, George Miller, Brian Hannant / Directed by George Miller

The greatest long convexity film of all time is the Australian kinetic masterwork "**The Road Warrior**" (1981) directed by George Miller. This post-modern western brilliantly depicts an apocalyptic wasteland wrought from the short convexity of humanity and ravaged by the tail risks of thermonuclear war and reliance on fossil fuels. Mad Max, played by Mel Gibson, is an ex-Main force patrol officer who roams the desert wasteland scavenging on the remains of the old world after the brutal murder of his wife and child. His fate becomes entangled with a gasoline rich community of survivors in a remote desert compound threatened by a savage biker gang. The Road Warrior follows classic western and samurai mythology whereby a savage element threatens a vulnerable garden of civilization on a distant frontier. Members of the civilization are unable to confront the existential threat directly because they have too much to lose... they are fragile and short convexity. It is only the outsider, the "man with no name", that can save them. The archetypal frontier hero is part civilization and part savagery. Max is a loner with nothing left to lose after the death of his family except what is left of his own humanity. Not afraid to confront the savage elements of this lost world he literally drives into a storm of violence and convexity and saves the fragile civilization and his own soul.



**Appendix II
Allegory of the Prisoner's Dilemma Tapestry Key and Commentary by Artists**

By Andy Diaz Hope and Laurel Roth

References



And the whole earth was of one language, and of one speech.
And it came to pass, as they journeyed from the east, that they found a plain
in the land of Shinar; and they dwelt there.
And they said one to another, Go to, let us make brick, and burn them
thoroughly. And they had brick for stone, and slime had they for morter.
And they said, Go to, let us build us a city and a tower, whose top may reach
unto heaven; and let us make us a name, lest we be scattered abroad upon
the face of the whole earth.
And the Lord came down to see the city and the tower, which the children of
men builded.
And the Lord said, Behold, the people is one, and they have all one
language; and this they begin to do: and now nothing will be restrained from
them, which they have imagined to do.
Go to, let us go down, and there confound their language, that they may not
understand one another's speech.
So the Lord scattered them abroad from thence upon the face of all the earth:
and they left off to build the city.

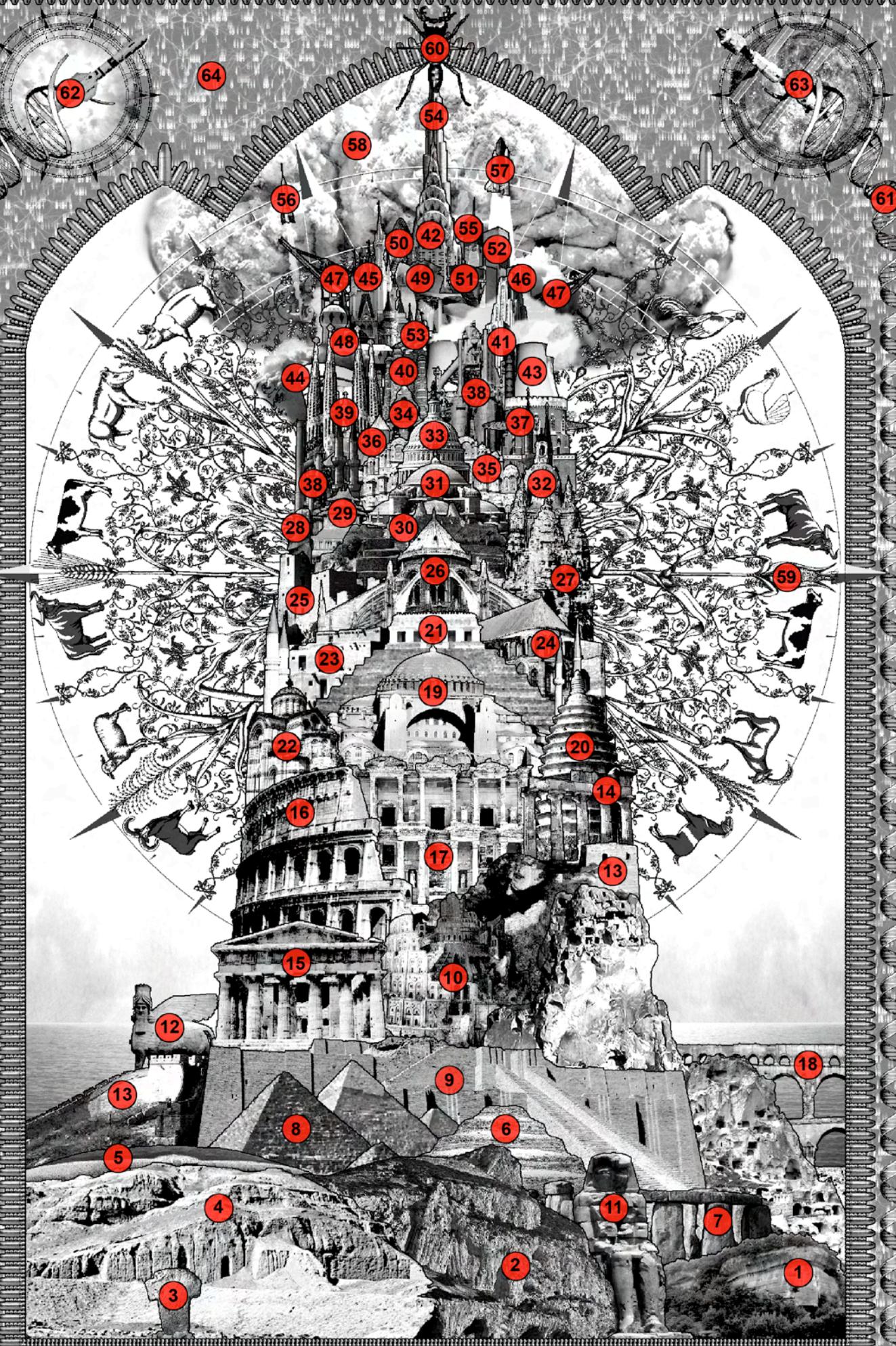
Genesis 11: 1-8 King James version

Allegory of the Prisoner's Dilemma is the third and final tapestry of *The Conflicts* triptych and addresses the theme of human cooperation vs. human conflict at a time when this arbitration may determine the survival of the human race. The original Prisoner's Dilemma is a game theory paradox that has inspired the creation of new evolutionary biology theory by showing that systems of cooperation regularly emerge in an environment where short term selfish action provides the highest potential individual reward.

Contrary to more dominant and savage interpretations of “survival of the fittest” and “might makes right,” cooperation has often been the path to success for individual organisms and societies. Genomes, cells, insects, animals, and human society are all heavily rooted in cooperation. Natural selection implies competition, yet as Harvard professor of mathematics and biology Martin A. Nowak says, “instead of opposing competition, cooperation has operated alongside it from the get-go to shape the evolution of life on earth, from the first cells to *Homo sapiens*.” From cooperative hunting and agriculture to urban planning and global trade, we work together to better insure our individual as well as collective success. At this point in history, it’s almost impossible for a human to survive without relying on those around them. Nowak calls humans “supercooperators” and attributes our cooperative power to language and information sharing. As we have increased circles of communication through technology, the ability to collaborate and cooperate has increased as well. As Nowak says, “As the human population expands and the climate changes, we will need to harness that adaptability and figure out ways to work together to save the planet and its inhabitants.”

Human evolution is now entering a new age of globalization that is deeply enmeshed with technology. Some technology experts theorize the near-future emergence of a global technological consciousness - sometimes referred to as the Singularity - at the rapidly approaching point that computers surpass human intelligence. At the same time, human populations continue to grow and expand their use of natural resources as well as affecting the very climate of the planet. We seem to be at a tipping point that could lead to global disaster or a new age of evolution, cooperation, and understanding.

This tapestry illustrates questions of how cooperation and competition have shaped and will continue to shape this trajectory. To convey this we focus our illustration on a massive Tower of Babel—a classic, though ultimately doomed, example of human cooperation based on global communication—against a backdrop of the history of agriculture. Compiled of a multicultural selection of iconic architecture, the tower represents a historical timeline rising vertically from the dawn of mankind to the present day, and ultimately disappearing into the uncertain and interdependent cloud of the future. Expanding on the theme of cooperation, we created this image in collaboration with visitors to the de young Museum of the San Francisco Fine Arts Museums, where we were Artists Fellows in 2012. We invited museum visitors to contribute their own ideas about what “Human versus Human” conflict means to them and buildings they thought we should include in our tower. In this way not only did we learn from a larger sampling of human experiences, but an element of public cooperation was incorporated into the creation of the piece.



1. 25000 BC **Font de Gaume**, France. This cave, containing prehistoric ice-age paintings, was forgotten until the nineteenth century when local people again began to visit the cave.
2. 24000BC **Gorham's Cave**, Gibraltar. Gorham's Cave is a natural sea cave in the Rock of Gibraltar, considered by some experts to be one of the last known habitations of the Neanderthals. Excavation has resulted in the discovery of four layers of stratification, with evidence for 8th to 3rd centuries BC use by Phoenicians, brief Neolithic use, at least 240 Upper Paleolithic artifacts of Magdalenian and Solutrean origin, and spear-points, knives and scraping devices identified as Mousterian (usually identified with Neanderthals).
3. 11600BC **Gobleki Tepe** Tiger, Turkey. This Neolithic hilltop sanctuary erected at the top of a mountain ridge in the Anatolia Region of Turkey is believed to be the oldest known human-made religious structure.
4. 3200BC **White Temple of Uruk**, Warka, Iraq (the ancient Sumerian city of Uruk and home of the legendary Gilgamesh). The White Temple, a shrine named in modern times for its whitewashed mud-brick walls, crowns the oldest surviving ziggurat. Unlike the Egyptians, the Sumerians had no “cult of the dead” and built temples solely for the worship of the gods.
5. 3200BC **Newgrange**, Ireland. The Megalithic Passage Tomb at Newgrange covers an area of over one acre and is surrounded by 97 kerbstones, some of which are richly decorated with megalithic art. The inner passage leads to a cruciform chamber that is illuminated by the Winter Solstice sunrise. It is estimated that the construction of the Passage Tomb at Newgrange would have taken a work force of 300 at least 20 years.
6. 3000BC **Pyramid of Djoser**, Egypt. This step pyramid is considered to be the earliest large-scale cut stone construction. The process of building such a structure would be far more labor intensive than previous monuments of mud-brick. This suggests that the state and the royal government had a new level of control of resources, both material and human.
7. 2600BC **Stonehenge**, England. One of the most famous prehistoric sites in the world, Stonehenge is composed of a circular setting of large standing stones set within earthworks. It is at the center of a complex of Neolithic and Bronze Age monuments in England, including several hundred burial mounds.
8. 2560BC **Pyramids of Giza**, Egypt. The people of ancient Egypt believed that death on Earth was the start of a journey to the next world. Each of the Giza

Pyramids formed part of a pyramid complex that included an adjoining mortuary temple where rituals for the dead king and Egyptian gods were carried out.

9. 2100BC **Ziggurat of Ur**, Iraq. This ziggurat was in a temple complex that served as an administrative center for the city and was a shrine of the moon god Nanna, the patron deity of Ur.
10. 1500BC (estimate of possible date of **Tower of Babel**), Mesopotamia (Iraq). According to the Book of Genesis, the Tower of Babel was an enormous tower built in the plain of Shinar by humankind united by purpose and a single language but thwarted by God, confounding their language so that they could no longer understand each other. Pieter Bruegel the Elder famously portrayed the tower in a painting in 1563 AD.
11. 1350BC **Colossi of Memnon**, Egypt. Pharaoh Amenhotep III built a mortuary temple in Thebes that was guarded by two gigantic statues of himself on the outer gates. All that remains are these 23 meter (75 ft) high one thousand ton statues of the pharaoh, who was worshipped as a god-on-earth during his lifetime.
12. 713BC **Sumerian Bull**, Mesopotamia (Iraq). During the Neo-Assyrian Empire, large monumental bulls, often with wings and always with human heads, were placed as gateway guardians at the entrances of royal palaces to ward off evil.
13. 700BC **Great Wall of China**, China. The Great Wall of China is a series of stone and earthen fortifications in China begun in the 7th century BC, and maintained between the 5th century BC and the 16th century AD to protect the northern borders of the Chinese Empire during the rule of successive dynasties.
14. 550BC **Temple of Hera**, Sicily. This Doric temple was built in the most westerly of the Greek colonies in Sicily for Hera, wife and sister of Zeus and goddess of women and marriage.
15. 400BC **Temple of Poseidon**, Greece. According to legend, this is the spot where Aegeus, king of Athens, leapt to his death when he believed his son had been killed by the Minotaur.
16. 80AD **Colosseum**, Rome, Italy. The Colosseum is an amphitheater in the center of Rome. It is considered one of the largest and greatest works of Roman architecture and engineering.
17. 135AD **Library of Celsus**, Ephesus, Anatolia (Turkey). This early library was built to store 12,000 scrolls and to serve as a monumental tomb for Celsus.
18. 312AD **Roman Aqueducts**, Spain. The Romans constructed aqueducts to bring water into cities, supplying public baths, latrines (public toilets), fountains and

private households. These aqueducts became a fundamental requirement for a civilized, Roman life and allowed expansion of their cities beyond local water source restrictions.

19. 360AD **Hagia Sophia**, Istanbul, Turkey. This former Orthodox patriarchal basilica became a mosque for almost 500 years after Constantinople was conquered by the Ottoman Empire. It is now a museum. It is considered the epitome of Byzantine architecture and was the largest church in the world for almost a thousand years.
20. 523AD **Songyue Temple Pagoda**, Henan Province, China. The earliest known Chinese brick pagoda, and one of the oldest surviving structures from that era (since the wooden ones did not survive.) Buddhism was spreading through China and influencing architecture, as seen by the merging of the Chinese style of straight edges with the circular style of Buddhism from the Indian subcontinent.
21. 675AD **Temple of the Inscriptions**, Chiapas, Mexico. This is the largest Mesoamerican stepped pyramid structure at the pre-Columbian Maya civilization site of Palenque. It was built as the funerary monument for K'inich Janaab' Pakal, ruler of Palenque in the 7th century, whose reign lasted almost 70 years.
22. 717AD **Church of Saint John Aliturgetos**, Bulgaria. According to legend this church was never consecrated due to the death of a builder on the site, but is thought to have been an especially beautiful medieval church.
23. 1000AD **Pueblo de Taos**, New Mexico, USA. Taos is an ancient pueblo made of adobe that belongs to a Native American tribe of Pueblo people.
24. 1005-1180AD **St Remi Abbey**, Reims, France. This abbey is the home of the relics of St Remi, Bishop of Reims, who led the conversion of the Frankish people to the Catholic Church.
25. 1190AD **Mesa Verde**, Colorado, USA, contains some of the best-preserved cliff dwellings in the world, built by the Ancestral Puebloan people, sometimes called the Anasazi.
26. 1200AD **Notre Dame de Paris**, France. Notre Dame is considered one of the finest examples of French Gothic architecture and among the first buildings in the world to use flying buttresses.
27. 1200AD **Angkor Wat**, Cambodia. This was the largest Hindu temple complex in the world. In the late 13th century, Angkor Wat gradually moved from Hindu to Theravada Buddhist use, which continues to the present day.
28. 1350AD **Easter Island Moai**, Chilean Polynesia. These monolithic human figures are carved from rock. In addition to representing deceased ancestors, the moai

may also have been regarded as the embodiment of powerful living or former chiefs.

29. 1420AD **Forbidden City**, Beijing, China, was the Chinese imperial palace from the Ming Dynasty to the end of the Qing Dynasty and now houses the Palace Museum. Construction lasted 15 years and required more than a million workers.
30. 1450AD **Machu Picchu**, Peru, is a pre-Columbian 15th-century Inca site that was unknown to the Spanish during their conquest, so it remained relatively intact. It is possible that most of its inhabitants died from smallpox introduced by travelers before the Spanish conquistadors arrived in the area.
31. 1616AD **The Sultan Ahmed Mosque**, Istanbul, Turkey, is popularly known as the **Blue Mosque** for the blue tiles adorning the walls of its interior. The design of the mosque is the culmination of two centuries of both Ottoman mosque and Byzantine church development and is considered to be the last great mosque of the classical period.
32. 1743AD **Frauenkirche**, Dresden, Germany, was destroyed in the firebombing of Dresden during World War II. This originally Lutheran church withstood two days of bombing during World War II before the dome collapsed. It was reconstructed as a landmark symbol of reconciliation between former warring enemies.
33. 1793AD **United States Capitol**, Washington, D.C., USA, is the meeting place of the United States Congress.
34. 1797AD **San Juan de Capistrano Mission Bell Tower**, California, USA. Mission Bells were rung at mealtimes, to call the Mission residents to work and to religious services, during births and funerals, to signal the approach of a ship or returning missionary, and at other times. San Juan de Capistrano was built in an area of Acagchemem villages. These and other resident indigenous peoples of the Americas were forcibly relocated from their traditional dwellings and villages to live and work at California Missions.
35. 1799AD **Palace of the Winds/Hawa Mahal**, Jaipur, India, is comprised of five stories of semi-octagonal, overhanging windows with perforated screens, domes and spires. The monument was originally conceived with the purpose of allowing the women of the royal household to watch the every day life and royal processions of the city without being seen.
36. 1815AD **Fort Ross**, California, USA, was the hub of the southernmost Russian settlements in North America from 1812 to 1842. San Francisco was then the northern reach of Spanish occupation, so it was a useful settlement for trade and an outpost for fur seal and otter hunting.

37. 1849AD **Cruquius Steam Pumping Station**, Cruquius, the Netherlands, is one of three steam driven pumping stations that pumped the Haarlem Lake dry in three years, allowing over 65 square miles of polder (low-lying land) to be settled.
38. 1857AD **Bethlehem Steel Factory**, Pennsylvania, USA. Bethlehem Steel was America's second-largest steel producer and largest shipbuilder. They made rails for the expanding railway system and armor plating for the US Navy, among other products. Its demise is often cited as one of the most prominent examples of the U.S. economy's shift away from industrial manufacturing, its inability to compete with cheap foreign labor, and management's penchant for short-term profits.
39. 1882AD **Sagrada Familia**, Barcelona, Catalonia, Spain, is an Antoni Gaudi designed church which has been under construction since 1882.
40. 1900AD **Lime Factory Kilns**, USA. A lime kiln is used to produce quicklime. As the Industrial Revolution unfolded, builders wanted a mortar that set fast with increased strength. These hydraulic properties were derived from lime and led to the creation of Portland cement.
41. 1930AD **Cathedral of Learning**, Pittsburgh, Pennsylvania, USA. Architecturally designed to be a combination of a modern skyscraper with Gothic architecture, it was built as the centerpiece of the University of Pittsburgh.
42. 1930AD **Chrysler Building**, New York, USA, is a classic example of Art Deco architecture and considered by many contemporary architects to be one of the finest buildings in New York City.
43. 1954AD **Nuclear Plants**. The first civilian nuclear power station started working in 1954 in Obninsk, Russia. There are 435 operating worldwide as of July 2012.
44. 1959AD **Guggenheim Museum New York**, USA. Designed by Frank Lloyd Wright, this cylindrical museum building is one of the 20th century's most important architectural landmarks.
45. 1970AD **Cinderella's Castle**, USA and Tokyo. Cinderella's Castle is the fairy tale castle at the center of two Disney theme parks. It was inspired by a variety of real and fictional castles including Fontainebleau and Versailles.
46. 1973AD **Twin Towers**, New York, USA. At the time of their completion, the original 1 World Trade Center (the North Tower) and 2 World Trade Center (the South Tower), known collectively as the Twin Towers, were the tallest buildings in the world. They were destroyed by terrorist attack via hijacked planes on September 11, 2001, killing an estimated 2,753 people.

47. 1980AD **Shipping Gantry Crane**, Oakland, California, USA. When containerization took hold in the 1960s Oakland invested \$1.4 billion in high-tech cranes, deeper berths, and integrated rail, truck and shipping facilities. The port moves more than 99 percent of the containerized goods that pass through Northern California.
48. 1986AD **Biosphere 2**, Arizona, USA, is a 3.14-acre science research facility owned by the University of Arizona. It was originally built to study the possible use of closed biospheres in space colonization, and allowed the study and manipulation of a biosphere without harming Earth's own.
49. 1997AD **Guggenheim Museum Bilbao**, Bilbao, Basque Country, Spain, is a museum of modern and contemporary art designed by Canadian-American architect Frank Gehry. It is often called one of the world's most spectacular buildings in the style of Deconstructivism.
50. 2003AD **30 St Mary Axe**, London, England. Informally known as the Gherkin, this is a skyscraper in London's financial district. It stands on the site of the former Baltic Exchange, which was extensively damaged in 1992 by the explosion of a bomb placed by the Provisional IRA. The building has become an iconic symbol of London and is one of the city's most widely recognized examples of modern architecture.
51. 2005AD **M. H. de Young Memorial Museum**, San Francisco, USA. Commonly called simply the de Young Museum, this fine arts museum located in San Francisco's Golden Gate Park showcases American art from the 17th through the 21st centuries, international contemporary art, textiles, and costumes, and art from the Americas, the Pacific and Africa. The museum has existed since 1895, but previous buildings were damaged in the 1906 and 1989 earthquakes. The new building has seismic engineering that allows it to move up to three feet due to a system of ball-bearing sliding plates and viscous fluid. This tapestry was made during the artists' Artist Fellowship at the de Young Museum.
52. 2006AD **Svalbard Seed Vault**, Spitzbogen, Norway, is an arctic complex that preserves a wide variety of plant seeds in an underground cavern. The seed vault is an attempt to provide insurance against the loss of seeds in gene banks, as well as a refuge for seeds in the case of large-scale regional or global crises.
53. 2008AD **Academy of Sciences**, San Francisco, USA. This LEED Platinum-rated natural history museum has a 2.5 acre green roof that mimics the surrounding geography and is planted with 1.7 million native plants. It retains 2 million gallons of rainwater and collects runoff in basement cisterns for reuse as irrigation.
54. 2010AD **Burj Khalifa**, Dubai, United Arab Emirates. The tallest man made structure in the world (as of July 2012), the Burj Khalifa has returned the title of

Earth's tallest freestanding structure to the Middle East, where the Great Pyramid of Giza had claimed this achievement for almost four millennia.

55. 2013AD **One World Trade Center**, New York, USA. Previously known as the Freedom Tower, the lead building of the new World Trade Center complex (at the time of its completion in 2013) will be the tallest building in the Western Hemisphere and the third-tallest building in the world, with its spire reaching a symbolic 1,776 feet in reference to the year of American independence.
56. **V-2 Rocket** - was a ballistic missile that was developed at the beginning of the Second World War in Germany, specifically targeted at London and later Antwerp. It was the world's first long-range combat-ballistic missile and first known human artifact to enter sub-orbital space.
57. **Space Shuttle** - was a partially reusable launch system and orbital spacecraft operated by the U.S. National Aeronautics and Space Administration (NASA) for human spaceflight missions from 1981 to 2011. The system combined rocket launch, orbital spacecraft, and re-entry space-plane with modular add-ons.
58. **Brain Cloud** - representing increasing global interconnectivity of human minds and the possibility of new awareness/singularity and/or environmental disaster that loom near. Some scientists see the world as entering a new “planetary phase of civilization” characterized by a shift away from independent nation states.
59. **Agricultural Mandala/Calendar**: Domestication is the process whereby a population of animals or plants is changed at the genetic level through a process of selection in order to accentuate traits that benefit humans. It differs from taming in that a change in the phenotypical expression and genotype of the animal occurs, whereas taming is simply the process by which animals become accustomed to human presence. The domestication of plants is one of the first steps in moving towards a full-fledged agricultural economy, although the process is by no means a one-directional movement. This Zodiac/calendar inspired mandala pairs the most commonly domesticated animals of agriculture with their prehistoric ancestors and illustrates some of the Neolithic founder crops as well as today's most commonly grown crops;
 - a. **Cow and Auroch** - Aurochs are the ancestor of today's cattle. They are a type of large wild cattle that inhabited Europe, Asia and North Africa, but are now extinct. In the course of the Neolithic Revolution, aurochs were domesticated in at least two events: one related to the Indian subspecies, leading to Zebu cattle; the other one related to the Eurasian subspecies, leading to Taurine cattle.
 - b. **Sheep and Mouflon** - Sheep were probably domesticated at least three separate times in the Fertile Crescent of western Iran and Turkey, Syria

and Iraq. This occurred approximately 10,500 years ago, and involved at least three different subspecies of the wild mouflon (*Ovis gmelini*).

- c. **Goat** - The wild goat (*Capra aegagrus*) is the ancestor of the domestic goat with a distribution ranging from Europe and Asia Minor to central Asia and the Middle East. Beginning about 10,000-11,000 years ago, Neolithic farmers in the Near East began keeping small herds of goats for their milk and meat, and their dung for fuel, as well as for materials for clothing and building: hair, bone, skin and sinew.
- d. **Chicken** - Chickens were first domesticated from the Red junglefowl (*Gallus gallus*), a bird that still runs wild in most of Southeast Asia. That seems to have occurred about 8,000 years ago. Recent research suggests there may have been multiple origins in distinct areas of South and Southeast Asia.
- e. **Pig** - The domestic pig originates from the Eurasian wild boar (*Sus scrofa*). They originally derive from central Asia, where they were domesticated perhaps as early as 11,000 BC, and were certainly present by 7000 BC.
- f. **Corn, Wheat, Rice, Potatoes, Sugar Cane and Sugar Beets** are the most commonly grown food crops of today.
- g. **Einkorn Wheat, Barley, and Peas** are among the eight Neolithic founder crops (or primary domesticates), along with Emmer wheat, bitter vetch, chickpea, lentils, and flax. They were domesticated by early Holocene farming communities in the Fertile Crescent region of southwest Asia, and formed the basis of systematic agriculture in the Middle East, North Africa, India, Persia and (later) Europe.

60. **Army Ant** - any of over 200 ant species that participate in aggressive predatory foraging groups, known as "raids", in which huge numbers of ants forage simultaneously and can consume up to 100,000 prey animals each day. An army ant colony moves almost incessantly. They build a living nest with their bodies, known as a bivouac. The members of the bivouac hold onto each other's legs and build a well-organized structure. The older female workers are located on the exterior; in the interior are the younger female workers. At the smallest disturbance, soldiers gather on the top surface of the bivouac, ready to defend the nest with powerful pincers and sometimes stingers. The interior of the nest is filled with numerous passages and contains many chambers with food, the queen, the larvae, and the eggs.

61. **DNA**- Deoxyribonucleic acid contains the genetic instructions used in the development and function of all known living organisms except RNA viruses.

62. **Tomahawk Missile** - is a long-range, all-weather, subsonic cruise missile introduced by General Dynamics in the 1970s. It has a modular design, allowing a wide variety of warhead, guidance and range capabilities.

63. **International Space Station** - is a habitable artificial satellite in low Earth orbit. The ISS represents a collaboration between several national space station projects: the Russian/Soviet Mir2, NASA's Freedom, the Japanese Kibo

laboratory, European Columbus space stations, and Canadian robotics. It serves as a microgravity and space environment research laboratory in which crewmembers conduct experiments in biology, physics, astronomy, meteorology and other fields.

64. **Background Texture:** digital rain of binary numbers superimposed on neurons, representing increasing global interconnectivity of human minds through digital means.

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 "The Misbehavior of Markets: A Fractal View of Financial Turbulence" by Benoit Mandelbrot
 "The Ascent of Money: A Financial History of the World" by Niall Ferguson
 "The Invisible Hands: Top Hedge Fund Traders on Bubbles, Crashes, and Real Money" by Steve Drobny
 "At the Mountain of Madness" & "Call of Cthulhu" by H.P. Lovecraft
 "Devil Take the Hindmost: a History of Financial Speculation" by Edward Chancellor

Notes & Data

- If not labeled data compiled or calculated by Artemis Capital Management LP based on raw sources below.
 Global Financial Data utilized for historical time series data going back as far as 1200.
 Security price data from Bloomberg and Yahoo Finance
 Options data from Market Data Express with calculations executed by Artemis Capital Management LP
 Wealth inequality data from Emmanuel Saez and Gabriel Zucman



Global Financial Data Notes:

www.globalfinancialdata.com

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

USA 10-year Bond Constant Maturity Yield: Richard E. Sylla, Jack Wilson and Robert E. Wright, *Price Quotations in Early U.S. Securities Markets, 1790-1860*, Hunt's Merchants Magazine (1843-1853), *The Economist* (1854-1861), *The Financial Review* (1862-1918), Federal Reserve Bank, *National Monetary Statistics*, New York: FRB, 1941, 1970 (annually thereafter); and Salomon Brothers, *Analytical Record of Yields and Yield Spreads*, New York: Salomon Brothers, 1995

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

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

The original 500 share indices included 90-95% of the capitalization of the New York Stock Exchange providing the most comprehensive index of stocks then available; however, the rapid expansion in Nasdaq and growth in the NYSE has meant that the S&P indices now represent a smaller proportion of total market capitalization than in the past. The Wilshire 5000, Russell 3000 and Investor's Business Daily 6000 all cover substantially more shares than the S&P 500. Nevertheless, the S&P 500 still represents about 75% of the stock market's capitalization. To update their index, S&P introduced a 400-share Mid-cap index (which was calculated back to 1981), in June 1991, and then introduced a Small Cap 600-share index in October 1994, which was calculated back to December 31, 1993. The 1500-share Supercomposite was introduced in July of 1995 and calculated back to December 31, 1993. In January 2002, S&P introduced the S&P 1000 which includes all the stocks in the S&P 400 Midcap and S&P 600 Small Cap Index. Beginning in March 2004, S&P began adjusting their indices so they would reflect the free float on their stock indices rather than the total capitalization. The free float method reduces the influence of stocks such as Wal-Mart for which 40% of the stock is privately held and not publicly traded. Volume data are for the stocks traded on the NYSE, not for the S&P 500 stocks.



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