FINANCIAL TIMES

2-28-2018

An abridged, illustrated history of volatility

By: Robin Wigglesworth

Volatility has evolved from an academic idea into a risk management tool and now something investors can trade, just like a stock or bond. It now even has its own world-famous index, the Vix, which has lent its name to a fictional homicidal supercomputer.

Its winding history features multiple Nobel Prize winners, Mark Cuban, a vineyard owner, a plethora of investment bankers and one Greek snake eating its own tail.

But to understand why and how this evolution happened – and what it might mean -- we first need to go back more than six decades, to the intellectual ferment of the University of Chicago's famous economics department.

For a long time, fund managers were judged largely by their performance. But that changed in 1952, when a young economic graduate at the University of Chicago named Harry Markowitz published a groundbreaking paper titled " Portfolio Selection" that argued fund performance should be judged compared to the amount of risk it takes.

Since "risk" can be a vague concept, Markowitz used volatility as a handy proxy (though he called it "variance"). For example, stocks are more volatile than bonds, so investors should expect better returns as a result. Similarly, the shares of smaller companies tend to trade in choppier ways than bigger companies' shares, so they should (and do) offer investors higher returns over time.

Together with other related insights – such as the importance of diversification, famously the only "free lunch" in markets – this became known as the " modern portfolio theory" that underpins much of how the modern investing world functions. Eventually it won Markowitz a Nobel prize in 1990. In the words of the Royal Swedish Academy of Sciences:

> On a general level, of course, investment managers and academic economists have long been aware of the necessity of taking returns as well as risk into account: "all the eggs should not be placed in the same basket". Markowitz's primary contribution consisted of developing a rigorously formulated, operational theory for portfolio selection under uncertainty - a theory which evolved into a foundation for further research in financial economics.

And:

> Markowitz showed that under certain given conditions, an investor's portfolio choice can be reduced to balancing two dimensions, i.e., the expected return on the portfolio and its variance. Due to the possibility of reducing risk through diversification, the risk of the portfolio, measured

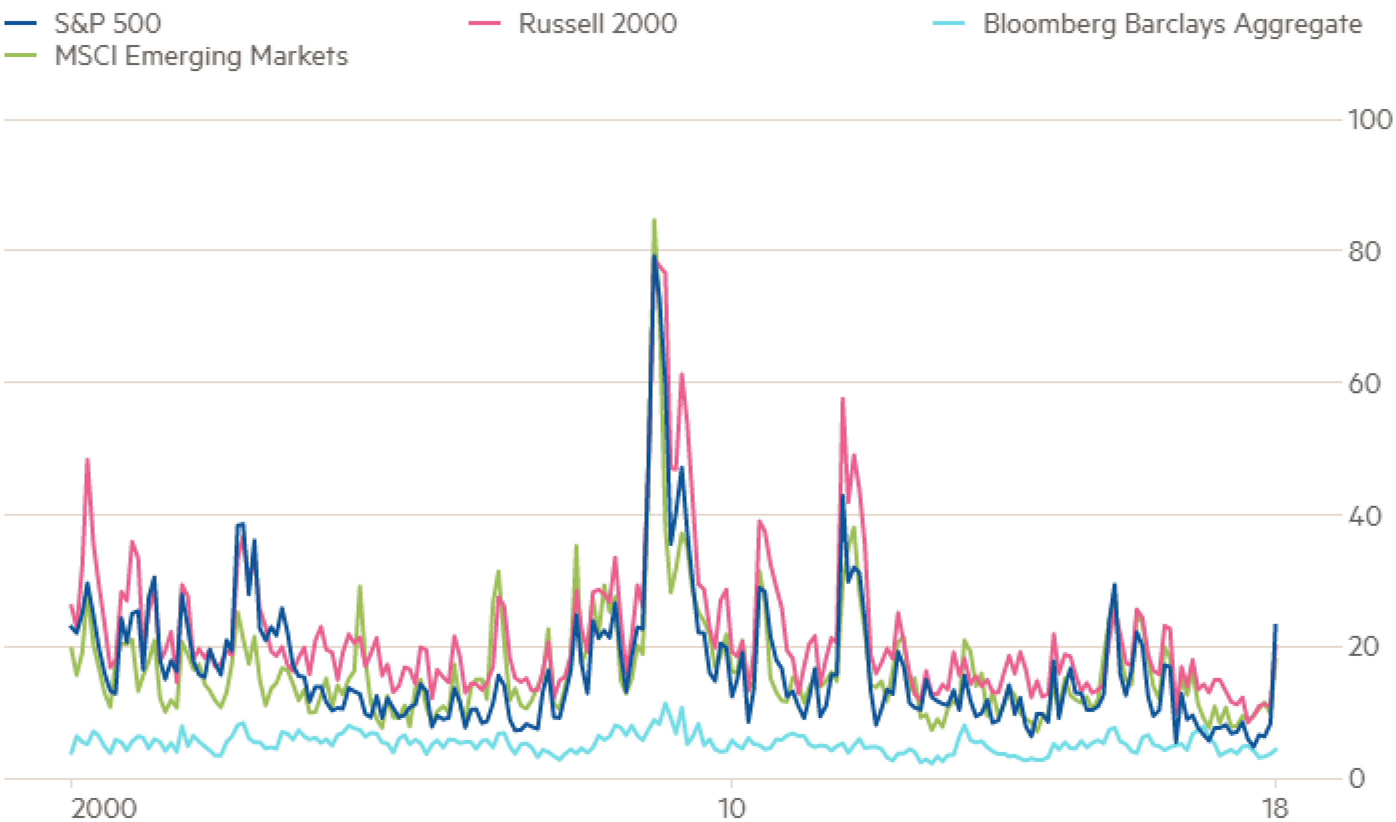
as its variance, will depend not only on the individual variances of the return on different assets, but also on the pairwise covariances of all assets.

In other words, Markowitz developed an academic model with which investors could measure the trade-offs they faced between risk and return.

And in the process, he ensured volatility would be the reigning proxy for risk.

To gauge an asset's volatility, investors often look at price moves over the past 30 days. For the US stock market, this averages about 15 per cent, and bond-market volatility averages just under 4 per cent. The chart below shows the relative volatility of the S&P 500, the small-cap Russell 2000, the Bloomberg Barclays Aggregate bond index and the MSCI Emerging Markets Index:

Variances in volatility



Source: Bloomberg

Over time, the entire financial industry started using volatility to measure risk. Most famously, in the wake of the Black Monday crash of 1987, JPMorgan's then-chairman Sir Dennis Weatherstone ordered staff to start a new daily report that would as briefly and succinctly as possible show how much money the bank could lose on its trading positions on any given day, a tool that ultimately became known as " value-at-risk".

JPMorgan's daily VaR report was first designed by a banker called Till Guldimann, who used the historical volatility of markets to calculate the maximum the bank could lose on any given day, with 95-per-cent certainty. Guldimann later worked at Sungard and has now retired to a vineyard in Saratoga, California, called Chateau Hetsakais. Here he is with some of his grapes.

While banks and investment groups developed proprietary risk-management systems, also often based on volatility, JPMorgan's VaR model spread across the finance industry after it decided to make its methodology freely available in 1993.

Of course, the model has been fine-tuned significantly since the early 1990s and received plenty of criticism in the wake of the financial crisis.

But to this day, many banks publish VaR numbers to show how much risk they are running, and now the investing industry uses the framework to manage risk as well. As Fincad, an analytics software provider, said in a blog post in late January (with their emphasis):

While there are varying opinions about the significance of **value at risk (VaR) in risk management, it remains one of the most fundamental methods for the critical measurement of market risk exposures.** Data gathered during VaR modeling helps risk managers determine whether they have adequate capital available to cover potential losses.

They continue:

Typically asset management houses will have mandates that dictate acceptable levels of VaR depending on the instrument being traded. For example, an internal mandate on investing in a particular asset class or derivative might include an 85% VaR confidence level, while for another investment type it might be lower or higher depending on various risk factors.

As volatility became the dominant way to measure financial risk, others started laying the groundwork for banks and investors to eventually trade volatility itself.

In practice, trading any derivatives involves an implicit bet on volatility. For example, writing a put option – agreeing to ~~sell~~ **buy** an asset at a pre-agreed price at some point in the future – is a bit like writing insurance against price declines. Buying a call option, which gives the right but not obligation to buy at a prearranged price, is like betting a stock will rise. When combined, they're known as a straddle trade, and function as a bet on market turbulence.

Options trading -- for insurance and speculation alike -- owes its popularity to three academics called Fisher Black, Robert Merton and Myron Scholes. In 1973, they published a model to efficiently calculate the value of these options, which was partly based on volatility. This became popularly known as the Black Scholes Model and won Merton and Scholes the Nobel prize for economics in 1997. (Black was ineligible as he had passed away a few years before the prize was awarded.)

But this wasn't quite enough to truly turn volatility into an asset class like equities or bonds in its own right. Calls and puts are sensitive to volatility, but not *only* volatility, which makes it more difficult to use them for bets on market turbulence.

In the 1980s, two academics called Menachem Brenner and Dan Galai published a series of papers that used the prices of these options to create an actual index of stock-market volatility, which they called " Sigma". They pitched the idea to various exchanges, but at the time no one wanted to turn their model into a live volatility benchmark.

Technical Notes

New Financial Instruments for Hedging Changes in Volatility

*by Menachem Brenner, Hebrew University and New York University, and Dan Galai, Hebrew University**

With the introduction of stock index futures and options as well as bond futures and options, investors can hedge against market volatility and interest rate volatility. But investors are still exposed to the risk of *changes* in volatilities. Market volatility can change in response to changes in macroeconomic factors such as inflation, unemployment or economic policy, or in response to changes in the volatility of equity of specific firms, due to shifts in capital structure or news about performance.

The history of U.S. stock indexes since the beginning of the century shows that volatility has exhibited substantial instability.[1] During the 1970s, for example, the annualized standard deviation of stock returns ranged from 10 to 40 per cent. In the '80s, before October 1987, volatility decreased to the 10 to 20 per cent range.

According to a report from BARRA, the 1973–75 period could be characterized as volatile, the 1976–79 period as quiet, the 1980–82 period as more volatile, the 1983–84 period as quiet and the 1985–86 period as more volatile.[2] From January 1973 to September 1987, daily average volatility was 1.15 per cent (18 per cent annually, using 250 trading days). In October 1987, daily volatility jumped to 5.87 per cent (90 per cent annualized). Even if October 19th is excluded, daily volatility was still 3.51 per cent, compared with the second-highest volatility, in October 1974, of 2.02 per cent.

A similar picture is obtained from the time series of volatility implied by option prices. In September 1986, for example, the implied volatility of the stock market jumped from about 15 per cent in the first week to 25 per cent in the second.[3] This amounts to a 60 per cent change within a few days. During October 1987, implied volatility increased from 20 to over 100 per cent on October 20 and declined to 30 to 40 per cent thereafter.[4]

Volatility changes are also apparent in the bond and foreign currency markets. From August 1986 to January 1987, for example, the implied volatility of options on the Swiss franc moved between 10.5 and 16 per cent. The historical (12-week rolling) volatility of 10-year Treasury notes moved in the range of 5 to 30 per cent in the 1982–87 period.[5]

Following the market crash, volatility increased, and the volume of trading in futures and options shrank considerably. Exchanges and institutions have expressed fears that the public may shy away from investing in risky assets because of the perception of enhanced riskiness.

While there are efficient tools for hedging against general changes in overall market directions, so far there are no effective tools available for hedging against *changes* in volatility. It should be noted that the percentage change in *volatility* is much greater than the change in the *level* of stock indexes. We therefore propose the construction of three volatility indexes on which cash-settled options and futures can be traded. One index would depict volatility in the equity market, the second volatility in the bond market and the third volatility in the foreign exchange market. "Volatility options" and "volatility futures" would expand the investment opportunities available to investors and provide efficient means to hedge against changes in volatilities.

Constructing a Volatility Index

Our volatility index, to be named Sigma Index (SI), would be updated frequently and used as the underlying asset for futures and options. There are many ways to construct such an index. It could be based on the standard deviation obtained from historical observations (with more weight given to recent observations). It could be based on implied volatilities from options that have just traded. Or we could use a combination of historical and implied volatilities to provide some balance between long and short-run trends.

Admittedly, no volatility index can represent the volatility exposures of all market participants. Therefore, no volatility option or futures can provide a perfect hedge for all. But, because various volatility measures are highly correlated, we believe that most potential users would find the instruments on a volatility index useful, even if the index does not perfectly match their needs.

A volatility index would play the same role as the market index plays for options and futures on the index. In line with conventional stock indexes, each percentage point of standard deviation would be equivalent to 10 index points. For example, a standard deviation of 15 per cent (on an annual basis) would translate into an index level of 150 points. (Equivalently, each percentage point of standard deviation would equal $100.)

1. Footnotes appear at end of article.

* The authors thank Howard Baker, Bill Silber and Marti Subrahmanyam for their helpful comments.

The idea languished until 1992, when the Chicago Board Options Exchange hired Robert Whaley (another academic, natch) to turn the idea of an options-based volatility index into reality. So he and his family decamped to a village in France for six months, and by 1993, the CBOE Volatility Index – popularly called Vix, after its ticker – was born.

Although the exact methodology for calculating Vix has shifted over the years, it aims to measure the expected volatility of the US stock market over the next 30 days, as implied by option prices.

Here's how the index is structured: If investors expect the S&P 500 to fluctuate by an average 1 per cent each day for the next month, the Vix will be about 20 — roughly its long-run average — while 40 implies 2 per cent moves. But because it is only a number based on complicated calculations from thousands of underlying derivatives, investors can't buy or sell the Vix itself.

So even after the Vix's invention, there were no "pure" volatility contracts that investors could trade. But where there is a need (and fees to be made) investment banks invariably find a way.

The first "pure" volatility derivative appears to have been a deal structured by a UBS banker called Michael Weber, in 1993. He built a transaction that became known as a "variance swap", based on the UK stock market's volatility, to protect the Swiss bank's trading book from losses.

More details can be found in a 2009 paper from Peter Carr and Roger Lee – two prominent academics and practitioners – about the evolution of volatility:

> According to Michael Weber, now with J.P. Morgan, the first volatility derivative appears to have been a variance swap dealt in 1993 by him at the Union Bank of Switzerland (UBS). As both an at-the-money-forward (ATMF) straddle and a variance swap are thought by practitioners to have sizeable vega but little delta, UBS initially quoted the variance swap rate at the ATMF implied volatility, less one volatility point for safety. They later valued the variance swap using the method of Neuberger (1990a). Weber recalls that UBS bought one million pounds per volatility point on the FTSE 100. The variance swap rate was quoted at a volatility of 15%, with a cap quoted at a volatility of 23% (so UBS also dealt the first option on realized variance as well). The motivation for the trade was that the UBS book was short many millions of vega at the five-year time horizon and thus the trade lessened this exposure.

Variance swaps started to gain ground on Wall Street, especially in the late 1990s when markets were roiled by the Asian Financial Crisis and the collapse of hedge fund LTCM (which ironically had Scholes and Merton on its board).

This naturally sparked interest in whether volatility itself could be traded – rather than just protected against -- and first gave rise to a popular arbitrage between "realised volatility" (how choppy markets actually are) and "implied volatility" (how choppy options prices indicate that they will be).

Traders expected that *someone* would eventually develop a clean, centrally cleared and widely-available way to bet on volatility. As Emanuel Derman, a pioneering "quantitative" analyst – the term used for the army of computer scientists, physicists and mathematicians that have invaded the finance industry– put in a 1996 paper while he worked at Goldman Sachs:

If you are interested in volatility as an asset, it may be simplest to buy a realized volatility contract from a trading desk that can synthesize it. At present, dealers can provide forwards on volatility in the form of realized volatility contracts. Over time, as both the analytical and trading technology mature, we expect to see the evolution of volatility options and realted *[sic]* volatility derivatives.

As the dot-com bust echoed through markets years later, the Vix index was widely followed but couldn’t be traded, and variance swaps were used primarily by banks, hedge funds and other institutional investors.

Enter Mark Cuban.

As the WSJ wrote in a piece last year:

In the summer of 2002, newly minted billionaire Mark Cuban called Goldman Sachs Group Inc. looking for a way to protect his fortune from a crash. Because the VIX typically rises when stocks fall, he wanted to use it as insurance. But there was no way to trade it.

Devesh Shah, the Goldman trader who fielded the call, says he instead offered him an arcane derivative called a “variance swap,” but Mr. Cuban wasn’t interested.

Lamenting the lost opportunity, Mr. Shah met up with Sandy Rattray, a Goldman colleague and erstwhile indexing buff with a knack for packaging investment products. What if, the pair speculated, they could tap the VIX brand and reformulate the index based on their esoteric swaps?

“The world wanted to drink Coca-Cola, ” says Mr. Shah, who retired from Goldman as a partner in 2011. “They didn’t want the white label.”

Rattray, now CIO of Man Group, and Shah approached CBOE about overhauling the Vix’s methodology to make it possible to create tradeable futures contracts based on its level.

By 2004 the work was complete, and the CBOE launched Vix futures, and introduced options two years later. Initially, interest was respectable but muted. Even by 2006, the total volume of Vix futures contracts traded totaled only 434,000, about 1730 contracts a day.

But when the global financial crisis erupted, it turned the Vix into a rock star of the index world. In 2008, more than 1m of Vix futures contracts traded, or 4,300 per day.

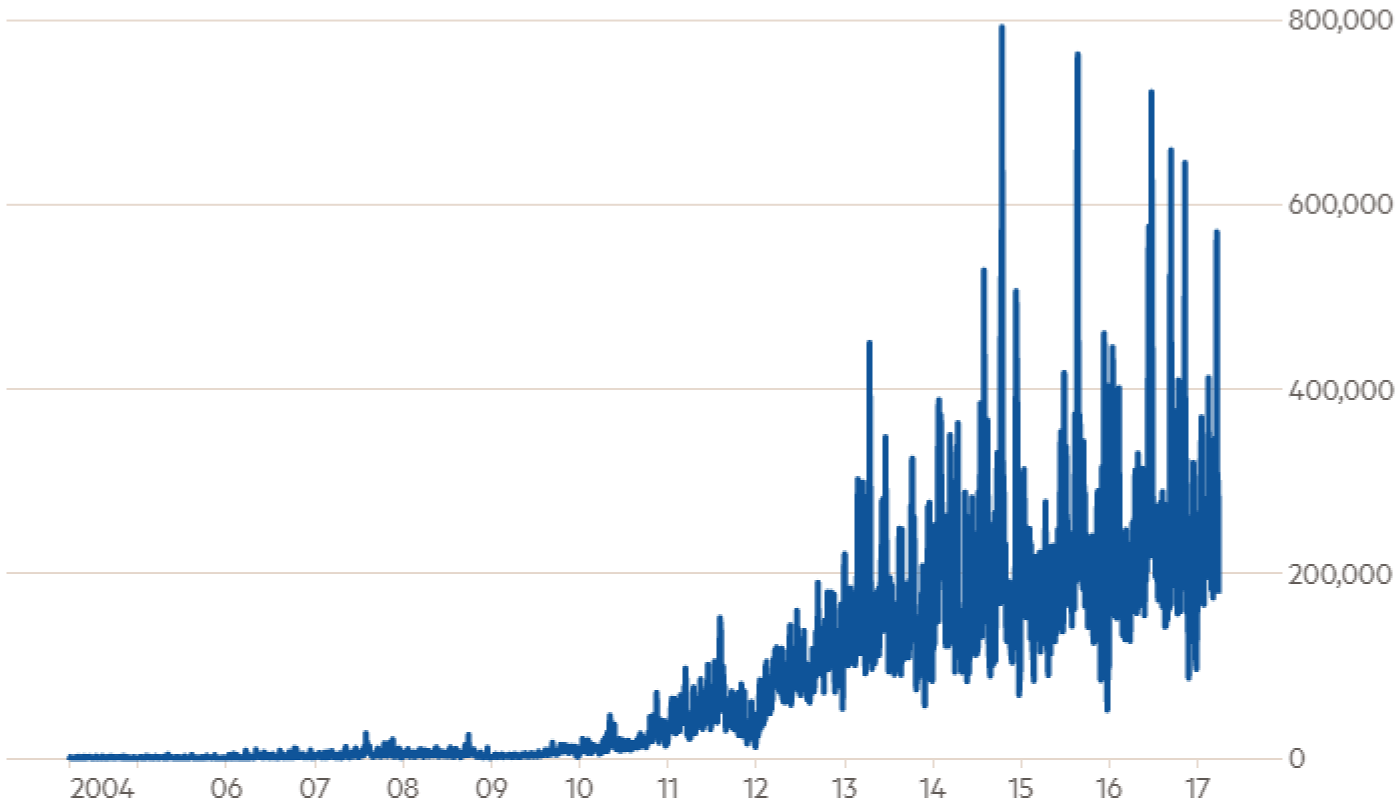
Its rising popularity reawakened the interest of financial engineers, who smelled an opportunity to “democratise“ access to the Vix by constructing exchange-traded products based on the index.

In 2009 Barclays built the first-ever Vix-linked ETP using volatility futures. By early 2017 there were over 40 Vix-linked ETPs, with an aggregate daily trading volume of $2.6bn. Some of them rise when volatility climbs, and others benefit when it falls. (The latter group includes the “inverse” products that went bust during last month's rout.)

With that we reach the current stage of volatility's evolution.

The current era features high volumes of Vix futures trading, driven in part by the boom in exchange-traded products:

Vix futures volumes explode

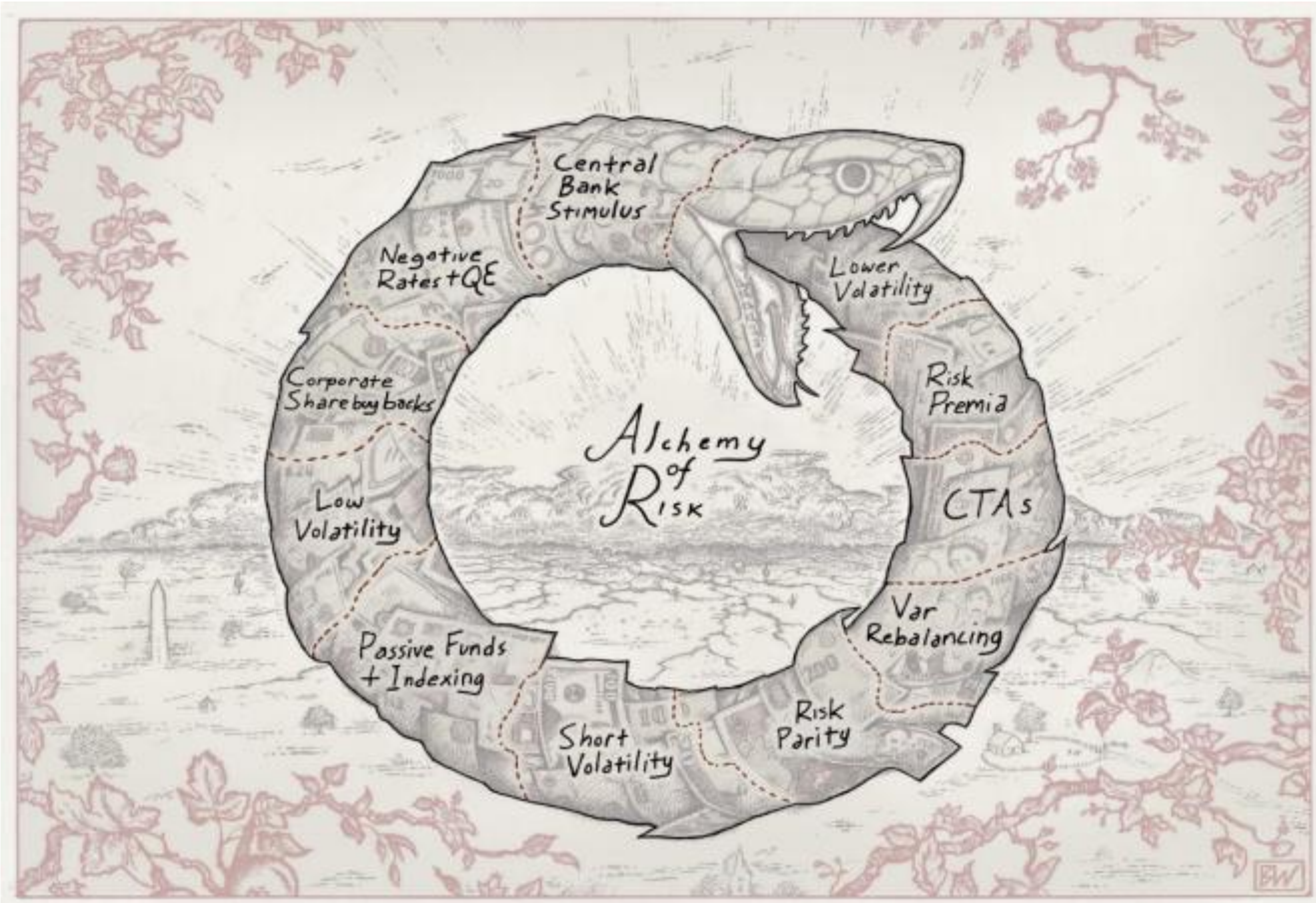


Source: CBOE

Like any popular technological advance, the latest innovation in Vix trading comes with its own set of concerns.

Some analysts and investors worry about feedback loop, saying there are risks inherent in having a major input into risk-management models that is *also* a popular trading tool.

As Christopher Cole, the head of Artemis Capital Management, argued in a paper last year: ”a dangerous feedback loop now exists between ultra-low interest rates, debt expansion, asset volatility, and financial engineering that allocates risk based on that volatility”, comparing it to the Ouroboros snake eating its own tail.



He estimated that there was over $2tn in strategies that both exert influence over and are influenced by stock market volatility. He warned of the consequences in dire terms.

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

This was roughly, if less apocalyptically, what happened in early February. A sudden volatility spike caused the collapse of several inverse Vix ETPs, which exacerbated the turbulence and triggered automatic selling by volatility-targeting strategies.

However, markets have snapped back almost as quickly as they tumbled, two of the inverse Vix ETPs have been killed off and others are taking measures to limit the damage they can do. Most analysts say that while markets will not be as tranquil as they were last year, they doubt that the Armageddon-like scenarios painted by the likes of Cole will come to fruition.

Nonetheless, the linkages between volatility as a tradable asset and a risk-management tool remain in place, and are likely to continue to stir concerns.

As Rattray told the FT in the wake of the February carnage:

“If the tail was wagging the dog before, you didn’t notice very it much. What happened on Monday was the tail grabbed the dog and gave it a swing around the room... The Vix has moved from being a measure of something to being something that influences this thing it is trying to observe... You have an incredibly active market now in Vix futures, and now the market is clearly moving Vix itself. You have potential for a circular system. Something changed on Monday. If anybody doubted that . . I don’t think they will doubt it now”.