

"It is better to be feared than loved, if you cannot be both." – Niccolò Machiavelli

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US Volatility Research

Volatility Strategy Effects on the US Implied Volatility Surface

What has been the effect of various volatility carry strategies on the volatility surface? What are the implications?

Positive Feedback Loop

Positive feedback loops are said to amplify change. One way to look at this is through the lens of investment performance returns and "performance chasing". In other words, success leads to more chasing success leads to more chasing success and so on. This is the reason why markets tend to trend, asset value increases lead to further increases and asset value declines lead to further declines. As extreme examples, this type of behavior could lead to an asset market bubble or market crash.

Negative Feedback Loop

Negative feedback loops are said to buffer change. In other words, a system may find more equilibrium. Equilibrium could lead to more stability. For example, portfolio rebalancing, buying undervalued or underweight assets and selling overvalued or overweight assets – could foster a negative feedback loop.

Growth in Volatility Strategies

Post the Global Financial Crisis ("GFC") of 2008, investors have sought low volatility equity solutions and income solutions as volatility dampening for equity heavy portfolios. They have also sought yield seeking as substitute for the low yielding fixed income environment. Short volatility strategies of various types have addressed these issues. Additionally, various structural changes, including regulatory issues and central bank activity has indirectly opened the door for investors to volatility investing.

We believe there are more informed ways of providing volatility exposure relative to traditional benchmark and overcrowded spaces.

Return opportunities could be enhanced through seeking the unloved and feared while being cautious with overcrowded and loved spaces. Let's look at the following outline to address the growth and implications:

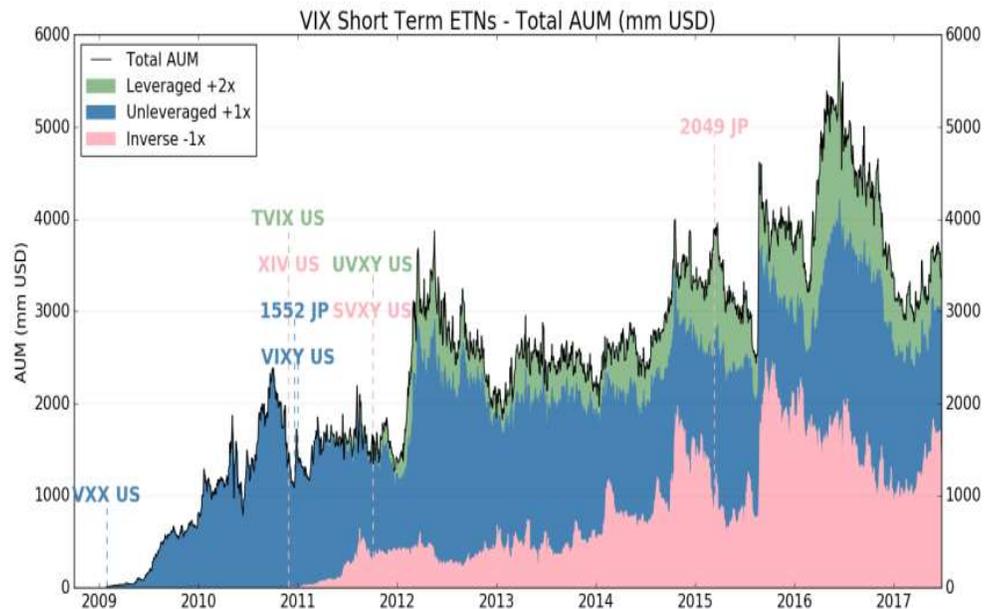
- Growth of VIX Exchange Traded Products (“ETPs”).
- Growth of short volatility index option strategies including: call overwriting and put writing funds/separate accounts.
- Impact of volatility strategies on volatility metrics: Skew, Term Structure and Volatility of Volatility.

VIX Futures: Rolling, Rolling, Rolling...

Exhibit 1 shows VIX exchange-traded note (“ETN”) growth and marks dates where the most successful of these VIX ETNs have been introduced. The growth of VIX ETNs was started by ticker VXX, the iPath S&P 500 VIX short-term futures ETN post the GFC. Sometime later, various short volatility ETNs were introduced. Start of year 2012 saw the sharpest growth in AUM.

The growth of VIX ETNs was led by ticker VXX, the iPath S&P 500 VIX short term futures ETN post the Global Financial Crisis.

Exhibit 1: VIX ETN AUM growth

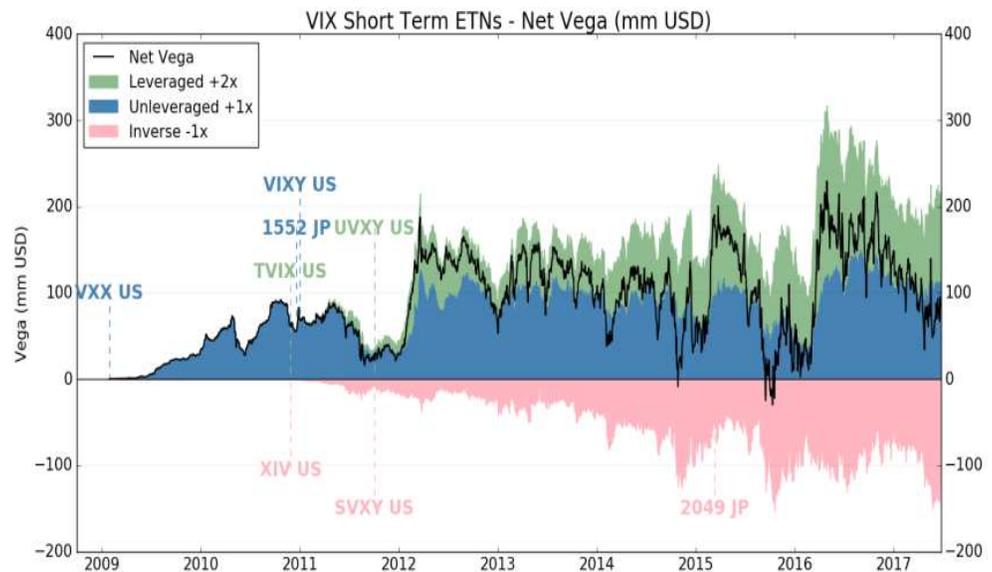


Source: Bloomberg, Gladius. As of June 2017. Notes: This information is not intended as a recommendation to invest in any particular asset class or strategy or as a promise of future performance. Indexes are unmanaged and used for illustrative purposes only. They are not intended to be indicative of any fund or strategy's performance.

Exhibit 2 quantifies the net long or short exposure of these VIX ETNs. The aggregate short-term vega has remained net positive besides a brief period in 2015. We can clearly see the consistent growth of short volatility ETNs through the 2013-2014 period. Monitoring the total and component volatility exposure is useful as strong net historical positive or negative readings represent one-sidedness and overcrowding. A closer look at the index methodology of the IPath S&P 500 VIX short-term futures Index, the largest of the VIX ETNs, shows a daily rolling characteristic: selling near-dated 1st month futures to buy the 2nd month futures, maintaining a constant 1M maturity. The most important implication to note, since the reading is net long vega, is the consistent supply of short-dated volatility through the selling of the 1st month futures.

The most important implication to note, is the consistent selling of short-dated volatility through selling 1st month futures, driven by the ETNs following the S&P 500 VIX short-term futures index.

Exhibit 2: Aggregate Volatility Exposure ('Vega'), 1-Month VIX ETPs

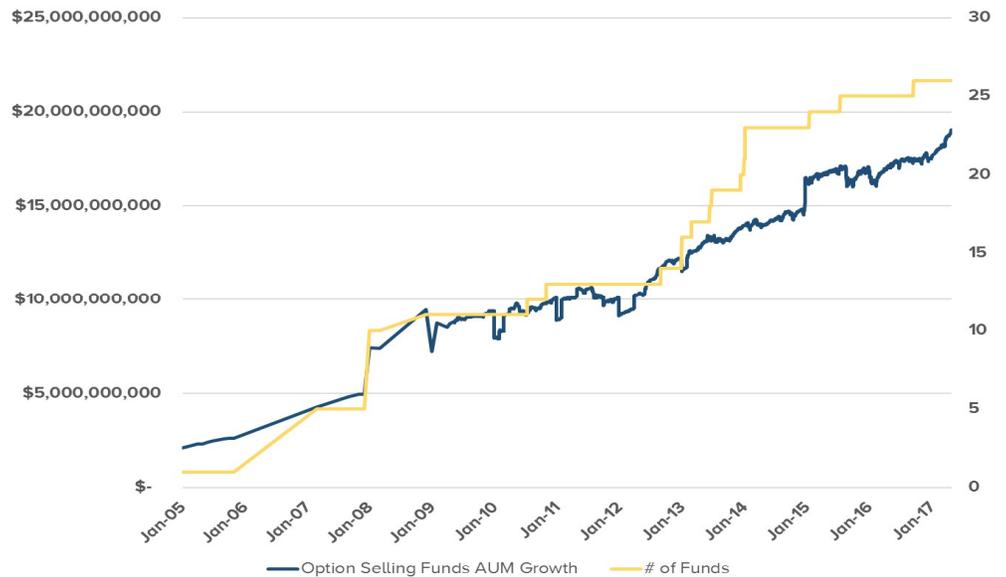


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Index Options: The Rise of Option Writing...

The most striking fact is the growth of U.S. listed mutual funds and exchange traded funds ("ETF's") utilizing equity index option strategies in recent years. It is very difficult to quantify just how much AUM is running in short volatility strategies due to separate accounts. However, based on U.S. listed mutual funds and ETF pooled vehicles that use index options, the growth was staggering in 2013—ironically, this was accompanied by the worst relative performance (to the SP500) in the history of the CBOE BXM Index due to a highly trending upside market and low levels of implied volatility. The below chart does not account for non-U.S. nor separately managed accounts ("SMA's") for high net worth or institutional investors.

Exhibit 3: Growth of U.S. Listed Mutual Funds and ETF Vehicles using Index Options



Source: Bloomberg. Notes: This information is not intended as a recommendation to invest in any particular asset class or strategy or as a promise of future performance. Indexes are unmanaged and used for illustrative purposes only. They are not intended to be indicative of any fund or strategy's performance. The above chart does not account for non-U.S. nor separately managed accounts ("SMA's") for high net worth or institutional investors.

Impact of Volatility Strategies

Skew has increased as out-of-the-money puts trade at a higher level of implied volatility than at-the-money options and out-of-the-money call options.

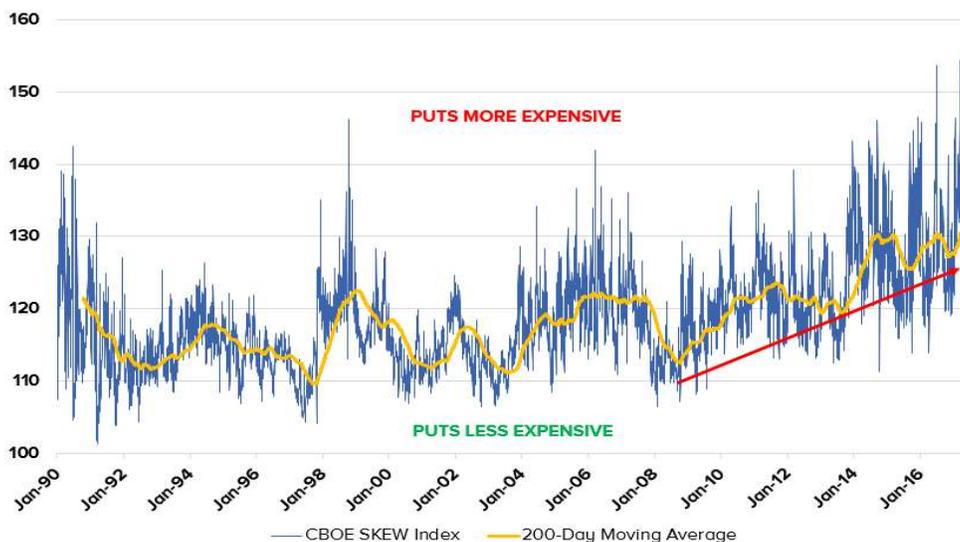
VOLATILITY SKEW

The CBOE SKEW Index ("SKEW") is an index derived from the price of S&P 500 tail risk. Similar to the CBOE VIX Index, the price of S&P 500 tail risk is calculated from the prices of S&P 500 out-of-the-money options. A SKEW value of 100 means that the perceived distribution of S&P 500 log-returns is normal, and the probability of outlier returns (positive or negative) is therefore negligible. As SKEW rises above 100, the left tail (put side) of the S&P 500 distribution acquires more weight, and the probabilities of downside returns become more significant. The SKEW index methodology is different from a simple put implied vol minus call implied vol (skew reading) that many traders reference.

Post-GFC there have been two main types of investors seeking volatility strategies: (1) those with the seemingly insatiable desire for low volatility equity and income solutions, selling volatility; and (2) those pursuing downside protection strategies, buying volatility. Generally speaking, those pursuing downside protection strategies will purchase out-of-the-money put options and those pursuing short volatility strategies predominantly sell near dated at-the-money options or out-of-the-money calls, thus increasing skew. Post GFC, SKEW has increased as shown in Exhibit 4 because of this trading activity.

Call overwriting strategies selling ATM and OTM index calls are decreasing upside call implied volatility.

Exhibit 4: CBOE SKEW Index January 1990 to June 2017

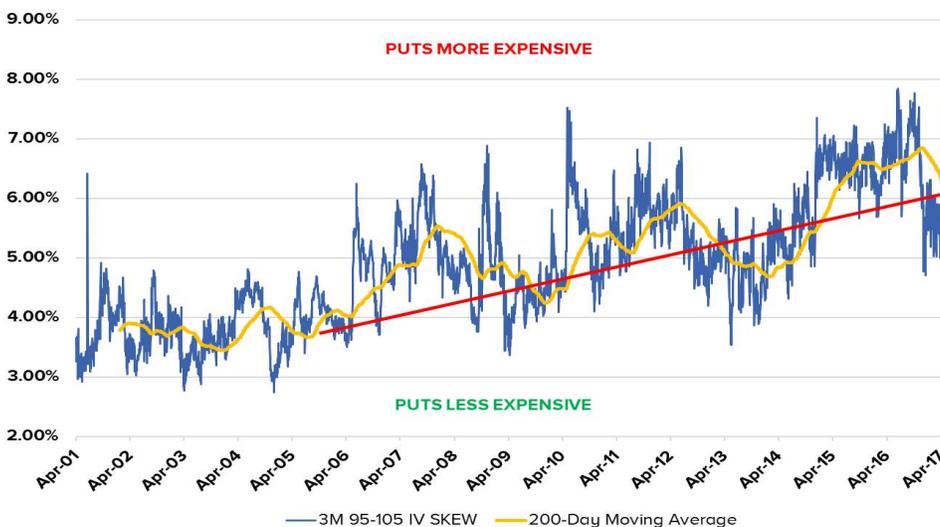


Source: CBOE, Bloomberg. Notes: This information is not intended as a recommendation to invest in any particular asset class or strategy or as a promise of future performance. Indexes are unmanaged and used for illustrative purposes only. They are not intended to be indicative of any fund or strategy's performance.

Exhibit 5 is a more traditional way traders view implied volatility skew. Rather than looking at skew through the lens of probability of returns, as does the SKEW Index, this method simply takes the difference of put implied volatility minus call implied volatility. Looking at 3M 95% strike put implied vol minus 105% strike call implied vol, shows us that skew has increased substantially.

Hedgers and index option trading desks are increasingly needing to buy short dated, deep OTM puts to satisfy regulatory tests and stringent internal risk guidelines.

Exhibit 5: 3M S&P 500 Implied Volatility 95% Put – 105% Call SKEW April 2001 to June 2017



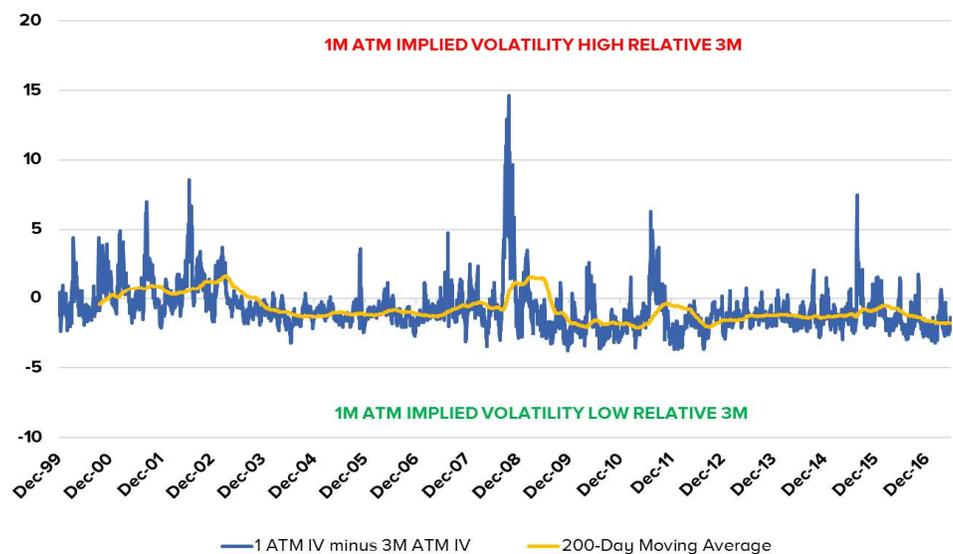
Source: CBOE, Bloomberg. Notes: This information is not intended as a recommendation to invest in any particular asset class or strategy or as a promise of future performance. Indexes are unmanaged and used for illustrative purposes only. They are not intended to be indicative of any fund or strategy's performance.

VOLATILITY TERM STRUCTURE

A simple way to look at S&P 500 Index options term structure is the CBOE 1 Month Volatility Index commonly referred to as the VIX Index minus the CBOE 3 Month Volatility Index commonly referred to as the VXV Index. We can speculate that term structure has steepened in part due to volatility selling strategies selling near dated, primarily at-the-money puts and calls relative to longer dated. As shown in Exhibit 6 this spread and smoothed average ratcheted lower in the low volatility period starting in 2013

Term structure has steepened in part due to volatility selling strategies selling near dated, primarily at-the-money puts and calls relative to longer dated.

Exhibit 6: CBOE VIX minus CBOE VXV Index January 2002 to June 2017



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Exhibit 7 shows this concept by calendar year. Between 2003-2007, the average spread of CBOE VIX Index minus the CBOE VXV Index was -0.9 versus -1.9 from 2013 to June 2017. Because these indexes look at a strip of options, those being at-the-money and out-of-the-money puts and calls, we can also simply look at the at-the-money variety. The 1M minus 3M at-the-money implied volatility spread shows a similar result. There has been a distinct steepening of the volatility term structure between the 2003-2007 low volatility period and the 2013-2017 low volatility period.

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Exhibit 7: Calendar Year CBOE VIX minus CBOE VXV Index January 2002 to June 2017

Year(s)	VIX Average	VXV Average	VIX-VXV Average	1M-3M ATM IV
2002	27.0	26.3	0.7	1.0
2003	22.0	22.6	-0.6	-0.2
2004	15.5	17.0	-1.5	-1.2
2005	12.8	13.9	-1.1	-1.1
2006	12.8	13.7	-0.8	-1.1
2007	17.5	17.9	-0.4	-0.7
2008	32.7	31.1	1.6	0.9
2009	31.5	32.9	-1.5	-1.3
2010	22.6	24.9	-2.3	-1.8
2011	24.2	25.4	-1.2	-0.8
2012	17.8	20.4	-2.6	-1.8
2013	14.2	15.8	-1.5	-1.3
2014	14.2	15.6	-1.4	-1.3
2015	16.7	18.5	-1.8	-0.9
2016	15.8	18.3	-2.4	-1.3
2017 (to June)	11.6	13.8	-2.2	-2.0
Low Vol 2003-2007	16.1	17.0	-0.9	-0.9
Low Vol 2013-2017	14.8	16.7	-1.9	-1.4

Source: CBOE, Bloomberg. Notes: This information is not intended as a recommendation to invest in any particular asset class or strategy or as a promise of future performance. Indexes are unmanaged and used for illustrative purposes only. They are not intended to be indicative of any fund or strategy's performance.

VOLATILITY OF VOLATILITY

The VVIX is a volatility of volatility (“vol of vol”) measure. The VVIX is calculated from the price of a portfolio of liquid at- and out-of-the-money VIX options. The calculation method is the same as the CBOE VIX Index, thus the volatility in this case is implied volatility of volatility.

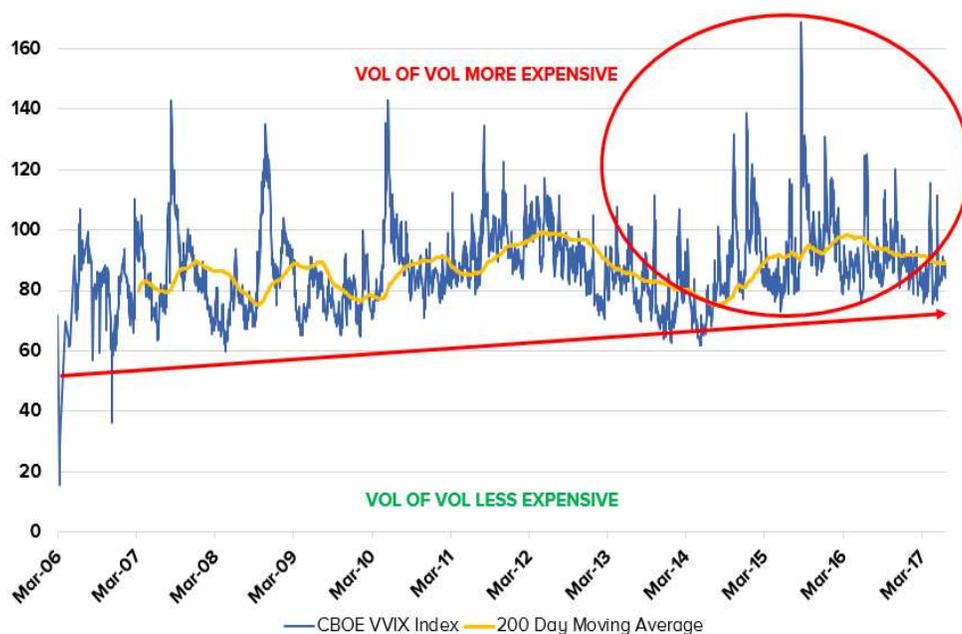
The increase in AUM of VIX-based strategies has resulted in:

1. Increasing spikes in volatility of volatility (volatility of VIX) , shown in Exhibit 8, as investors move in and out of exposure using VIX futures or easily accessible VIX ETP’s for both institutional and retail investors.
2. Vol of vol being more erratic even relative to 2007-2009.
3. The vol of vol index measure having a stronger volatility floor as investors trade more vol of vol.

A different way to look at vol of vol is through the realized volatility of the VIX. Exhibit 9 shows the realized volatility of the VIX generally increasing post GFC. Investors today can easily move in and out of VIX based exposure. This has contributed to sharp rises and falls in the VIX as exposures are adjusted or investors aggressively position portfolios.

As investors have moved in and out of VIX based exposure given accessible trading instruments, spikes in vol of vol have increased.

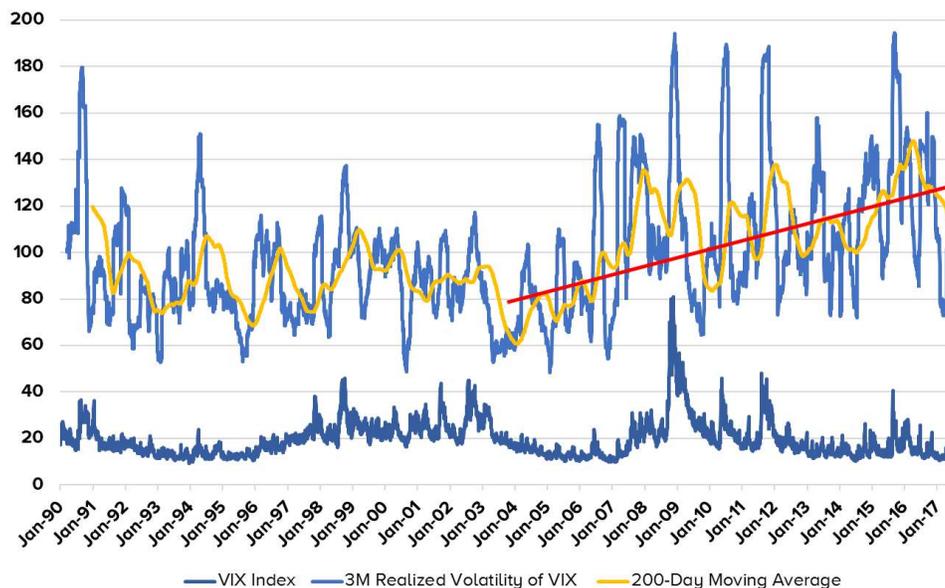
Exhibit 8: CBOE VVIX Index March 2006 to June 2017



Source: CBOE, Bloomberg. Notes: This information is not intended as a recommendation to invest in any particular asset class or strategy or as a promise of future performance. Indexes are unmanaged and used for illustrative purposes only. They are not intended to be indicative of any fund or strategy's performance.

A different way to look at vol of vol is through the realized volatility of the VIX.

Exhibit 9: VIX Index and 3M Realized Volatility of VIX, Jan 1990 to June 2017



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Exhibit 10 ranks the top 10 VIX drawdowns and drawups in the entire history of the index from 1990. This approach ranks the top 10 consecutive day drawdowns or consecutive day drawups. 7 of the top 10 drawdowns occurred at or since 2013. Only 3 of the top 10 drawups occurred at or since 2013. Investors seem willing to sell volatility spikes aggressively day over day alongside buying equity aggressively upon dips. The age-old-adage of, “The market takes the elevator down and the stairs up”, has been replaced by, “the market takes the elevator down and the elevator up”. We have seen this time and time again, as the buy the dip mentality (and sell the volatility spike) has held, thus decreasing the duration and severity of equity market sell offs.

The age-old-adage of, “The market taking the elevator down and the stairs up”, has been replaced by, “the market takes the elevator down and the elevator up”.

Exhibit 10: Top 10 Drawdowns and Drawups in VIX Index History to June 2017

Rank	Start Date	End Date	VIX Start	VIX End	% Change	Days
1	8/14/2015	8/24/2015	12.83	40.74	218%	6
2	8/3/2011	8/8/2011	23.38	48.00	105%	3
3	5/3/2010	5/7/2010	20.19	40.95	103%	4
4	10/21/1997	10/30/1997	19.53	38.2	96%	7
5	3/23/1994	4/4/1994	12.31	23.87	94%	7
6	2/22/2007	2/27/2007	10.18	18.31	80%	3
7	12/5/2014	12/12/2014	11.89	21.08	77%	5
8	8/2/1990	8/6/1990	20.43	35.91	76%	2
9	10/24/2016	11/4/2016	13.02	22.51	73%	9
10	8/31/2001	9/17/2001	24.92	41.76	68%	6

= At or since 2013
 # of readings since 2013 =
3 of 10

Rank	Start Date	End Date	VIX Start	VIX End	% Change	Days
1	6/24/2016	7/1/2016	25.76	14.77	-43%	5
2	7/9/2015	7/17/2015	19.97	11.95	-40%	6
3	3/16/2011	3/25/2011	29.4	17.91	-39%	7
4	12/16/2014	12/24/2014	23.57	14.37	-39%	6
5	10/3/2011	10/14/2011	45.45	28.24	-38%	9
6	5/7/2010	5/12/2010	40.95	25.52	-38%	3
7	12/28/2012	1/8/2013	21.79	13.62	-37%	6
8	5/17/2017	5/26/2017	15.59	9.81	-37%	7
9	10/15/2014	10/21/2014	25.27	16.08	-36%	4
10	8/24/2015	8/28/2015	40.74	26.05	-36%	4

= At or since 2013
 # of readings since 2013 =
7 of 10

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Conclusions

- **Volatility Surface:** There is no doubt, the volatility surface has been impacted by the growth of volatility strategies. Strategies selling near-dated volatility futures and near-dated ATM options have impacted the vol surface and underlying vol metrics.
- **Volatility Metrics:** Volatility skew has steepened, as OTM puts are more expensive than ATM options. Volatility term structure has steepened, as near-dated volatility is sold relative to longer-dated volatility. The vol of vol has increased as investors aggressively trade positions.
- **Strategy Construction:** Strategies that are arbitrarily confined to near-dated and/or at-the-money options based on longstanding published indexes or historical strategy construction techniques, are missing a richer opportunity set.
- **Be Aware of the Feedback Loop:** A feedback loop in volatility is likely occurring as we have discussed. This amplifies volatility moves in both directions. This amplified change has led to higher vol of vol and has the potential to create more serious volatility than experienced in the 2008 GFC.
- **Avoid the “Loved”:** As the opening quote states, “It is better to be feared than loved, if you cannot be both”. By seeking a richer opportunity set, we find the “feared” seeking better return opportunity and are cautious with the “loved”.

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