Is the VIX Index broken?

In this note, we provide background context on the recent claims that the VIX is broken and then rebut the two general forms that this claim usually takes. The third section addresses some of the more specific, recent explanations for what might be breaking the VIX, including a lengthier section on the recent hype around the rising popularity of zero-days-to-expiration ("0DTE") options. The fourth section notes what was actually unusual about volatility in the first half of 2022 and some of the consequences of the outlier behavior for some volatility strategies. In the final, fifth section, we attempt to partially answer the most difficult question: why.

Section 1: Background

The "VIX is broken" narrative is once again making the rounds in the financial media and blogs. Just for example and not intended as reading recommendations:

1. http://www.futuresmag.com/2014/06/23/vix-broken
2. https://www.bloomberg.com/news/articles/2017-05-03/do-volatility-tracking-securities-keep-the-vix-artificially-low

Actually, those were from 2014 and 2017, and there were a lot more over the years. We think that reminder is important in the context of digesting this latest round of the recycled claim. Here is a recent article from Bloomberg (December 2022), in which some interviewees promote the claim:

> https://www.bloomberg.com/news/articles/2022-12-22/wall-street-searching-for-clues-behind-the-vix-s-very-weird-year

Claims that the VIX is broken have usually taken one of two general forms over the years, as they generally do in the above article.

1. "The VIX is moving in the same direction as the S&P 500 too much….
   …They have usually moved in the opposite direction in the past."

2. "The VIX is too low….
   …It doesn't reflect the high level of fear in the market."
   …It doesn't match up very well with how much the S&P 500 is down."

Section 2: Is the VIX broken? Are these claims accurate?

In a word, no. We think points 1 and 2 below offer a simple and compelling rebuttal to the two main forms of the claim above:

1. In all rolling one-year time periods in the lifetime of the VIX Index (since 1990), it has moved in the same direction as the S&P 500 Index on an average of 21.3% of days, with a standard deviation of 5.4% and a range of 10.6% to 35.0%. In 2022, it happened on a totally unremarkable and insignificant 24.8% of days.

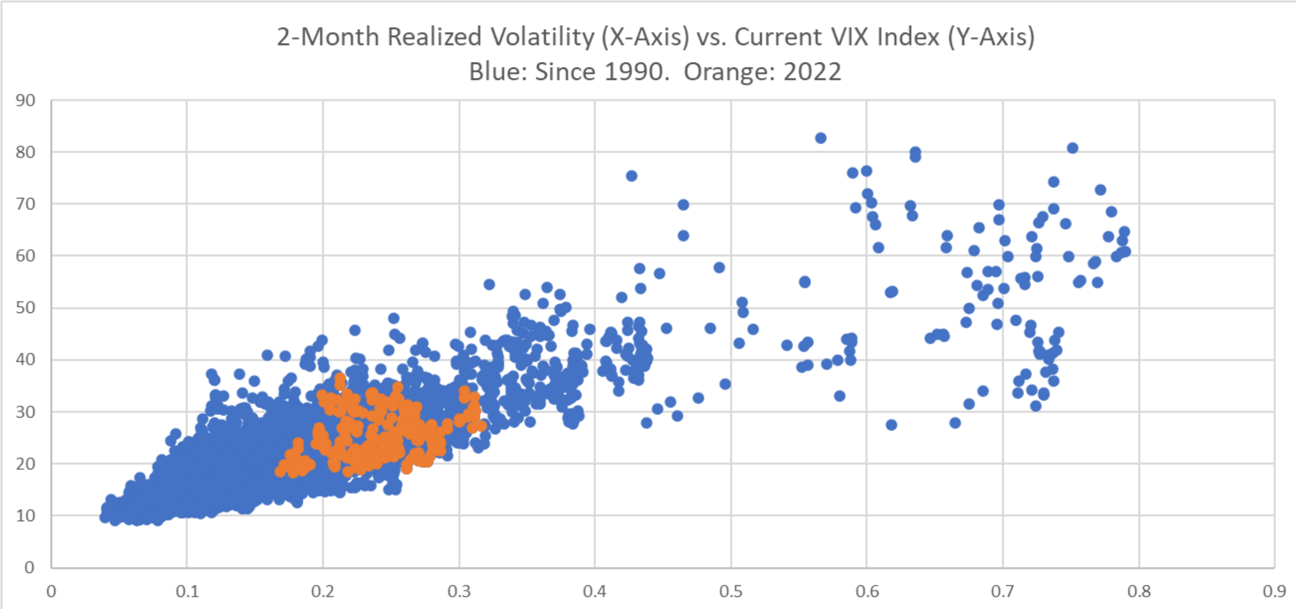
    a. More than half of all observations since 1990 deviated from 21.3% by more than 2022's observation of 24.8%.

2. The VIX is not really a "fear index," and the level of the VIX hasn't really been a particularly useful, medium-term forward indicator or warning sign. It also certainly does not measure the depth of S&P 500 drawdowns. The VIX is a measurement of the one-month implied volatility of the S&P 500, which is, roughly speaking, volatility market participants' expectations of the size of the daily swings in the S&P 500 in the near future. And volatility market participants weren't terribly far off for the year, reflected in the fairly accurate level of the VIX. The average level of the VIX was 25.6, and realized volatility was 24.0.

    a. Where do these expectations come from? Were market participants complacent and just lucky in 2022? How did the expectations end up being fairly accurate?

        i. Volatility is autocorrelated. In simplest terms, that means its previous reading impacts its current reading – it's sticky. Approximate recent volatility levels have been the main driver of near-term future volatility levels, and volatility market participants know this. Recent volatility is the main basis for their short-term future expectations, for the VIX.

            1. To illustrate, the following graph shows the strong relationship between trailing 2-month volatility in the S&P 500 (X-axis) vs. the current value of the VIX (Y-axis) for every day since 1990 (blue) and for 2022 (orange). Give or take just a bit of random variance, the orange dots were right in the heart of longer-term observations. And, again, they ended up being fairly accurate.



In summary, the VIX did its job, which does not include reflecting emotion or measuring equity market drawdowns. The VIX was right around the level of realized volatility for the year, and it accomplished that feat, roughly speaking, as it always has, by expecting the approximate level of recent volatility more or less to continue for a short time.

Section 3: What about all the explanations of why the VIX might be broken?

In search of explanations for why the VIX is broken, a number of ideas have been offered. Of course, in our view, the VIX is not broken, so no explanation is necessary. But let's consider several that, at first glance, appear to be plausible. To be clear, we are not stating that they all have exactly zero effect. It is conceivable they made a difference between, for example, a 25 and 25.5 level in the VIX. However, they cannot explain the difference between a 25 and a 40, 50, or even higher VIX reading, which is what we suspect many are seeking to understand.

Explanation 1 takes the general form that there has been less buying of volatility assets to drive up the VIX. However, the VIX is much more dependent on the level of very recent realized volatility than on variations in buying and selling of volatility instruments. The above scatter plot shows this correlation. Recall too that the VIX was generally accurate in 2022, with an average reading of 25.6 compared to 24.0 volatility; it wasn't significantly too low. Here is explanation 1 in the form it assumes in the Bloomberg article:

> *"We've had a dramatic selloff in the market driven by fears of higher rates and higher inflation — both catalysts that were very much anticipated by investors coming into this year," said Mandy Xu, head of equity derivatives strategy at Credit Suisse Group AG. "Leverage in the equities market has been taken down significantly by investors de-risking and moving to cash. You don't need to buy a put option when you're already in cash."*

Yet others argue that fear hasn't shown up in the VIX because paranoid pros already cut their stock holdings to the bone. In Bank of America Corp.'s survey of fund managers, cash holdings rose to 6.1% during the fall, the highest level since the immediate aftermath of the 2001 terrorist attack, while allocation to stocks fell to an all-time low.

Investors did not, in fact, anticipate much higher rates headed into 2022. At the beginning of the year, investors expected the fed funds rate at the end of 2022 to be about 0.7%. That expectation rose gradually over the course of the first half, or perhaps three quarters, of the year to the correct number, 4.3%. More on that in the last section below.

Leverage, or portfolio margining, was at rather high absolute levels heading into 2022, although it was less remarkable if adjusted for the high total value of the stock market. But, even if it were at low levels coming into the year, neither of the two quoted forms of "the world was already light on stock exposure" can be accurate. In the aggregate, the world owns every share of stock, and has a net zero derivatives position, at all times. When someone sells, someone else necessarily buys.

Explanation 2 takes the general form that gamma hedging by options dealers has affected realized volatility. This explanation is usually offered for higher VIX levels or as a warning that higher levels are coming, although it could theoretically explain slightly higher or lower levels of realized volatility.

A full explanation of gamma hedging is beyond the scope of this note but suffice it to say that the seller (buyer) of some volatility instruments may need to buy (sell) stock as it rises and sell (buy) stock as it falls, in order to hedge or maintain a market neutral position. There is always a buyer and a seller of volatility instruments, which have zero open interest in the absence of any trades. In other words, the net position is always zero, which might suggest no effect.

However, if dealers – market makers and liquidity providers – (i) are more likely to engage in the hedging activity just described, and (ii) are collectively net long or net short gamma, resulting in any net hedging activity, then this activity could magnify or reduce the size of equity market swings. Nevertheless, research attempts to quantify this phenomenon have found an essentially meaningless effect on the scale of this discussion (time frames that matter to long-term investors), perhaps a few basis-point magnification or reduction of ~1% daily moves in the S&P 500 over time. What possible additional effect may exist has mostly been found in intraday time scales rather than at longer time frames.

Explanation 3 is that the rise in popularity of very short-dated, including 0DTE, options is affecting volatility. At first glance, this appears to be a new one. However, it is really just a combination of the previous two explanations that have been making the rounds for years: (1) there is less buying of (in this recycling of the claim, VIX-calculation-included) options, and (2) there is more gamma hedging. Here it is from the Bloomberg article:

As violent reversals become a feature of 2022's stock market, options traders are seeking quick profits via contracts with a shelf life as short as less than 24 hours — a category known as zero day to expire, or 0DTE. During the third quarter, 0DTE options made up 44% of the S&P 500's total trading volume, data compiled by Goldman Sachs Group Inc. show.

In some ways, the proliferation of those fast-twitch contracts reflects heightened anxiety in the marketplace. Yet none of that is captured by the VIX, which is calculated based on only S&P 500 options expiring 23 to 37 days into the future.

(Many other sources of this explanation go on to explain that dealers are likely overwhelmingly the sellers of 0DTE and other very short-dated options. Therefore, they conclude, there is increased gamma hedging as a result, and this gamma hedging can magnify equity market moves.)

Note first the almost contradictory, or at least directionally-offsetting, nature of the explanations of how the rise of very short-dated options trading is affecting volatility. In one breath, they are not directly included in the VIX Index calculation, which supposedly would leave it lower than it should be. In many sources, in the next breath, they are also leading to more gamma hedging which supposedly would increase realized volatility and, as a result, increase the VIX (remember the scatter plot above – recent realized volatility is the primary driver of the VIX). Here we address the logic and then the numbers for the two components of this explanation for a broken VIX.

<u>Logic</u>

1. As for the exclusion of ultra-short-dated options from the VIX calculation, volatility measurements and prices, out to different time periods in the future, aren't exactly the same, but they are related. They are related mathematically because one-month variance is the variance of the first week plus the variance of the next three weeks. They are related conceptually because volatility is autocorrelated, or sticky. Practically, the way this works is that if market makers and liquidity providers (collectively, dealers) find themselves selling a lot of one-day to one-week volatility, then they raise volatility asset prices in other time periods, such as one month. In this way, the VIX, which directly measures one-month volatility, does indeed indirectly capture shorter-term volatility buying. And, of course, it's worth stating again that the VIX was fairly accurate in 2022.

    a. Furthermore, the shape of the S&P 500 implied volatility curve is about as expected, at the time of this writing. Implied volatility on one to two-day options is higher than implied volatility on the normal monthly-expiration options by approximately the mechanically expected amount – one to two-day options do not currently include the obviously lower vol weekends and holidays – give or take a few extra cents that dealers have been happy to extract from instant-gratification gamblers.

2. As for the increased gamma hedging, we addressed that under explanation 2 above. The effect found in research is small, not a market driver, and is mostly present in very short time periods (and, if anything, would have made vol higher, which is not what we think most are seeking to explain).

<u>Numbers</u>

1. As noted above, the VIX was rather accurate in 2022. It averaged 25.6 with volatility at 24.0. Visible in the scatter plot, volatility market participants set their expectations of short-

term future volatility (i.e., set the VIX) according to recent realized volatility, and it worked. That deviation between the VIX and realized volatility is small and unremarkable compared to normal spreads over the years. It's not as though the VIX should've been 40, 50, or even higher in 2022, but something, perhaps the rise of 0DTE-option popularity, suppressed it.

2. 0DTE option trading simply isn't large enough to have an impact on the S&P 500 that would be of importance to long-term investors. A high-end estimate of the increased volume, from proponents of these theories, is around 25 million extra contracts per day, across all options in all symbols and all times to expiration (including but not limited to 0DTE). Therefore, a very high-end estimate of the dollar amount of trading that gamma hedgers would need to trade is $60 billion per day.

That $60 billion estimate comes from the fact that 25 million option contracts represent 2.5 billion shares of stock, and it uses $50 as the average stock price. It further uses the following assumptions, which are all high-end estimates (the highest possible, in some cases), and combine to form what we believe is fairly characterized as a very high-end estimate:

- The market needs to move only 1% before these options have meaningful delta changes.
  - In reality, many of these options barely change their deltas in a 1% market move because they are "wings," or well over 1% out-of-the-money options.

- The delta change in the last point is 100% (the max possible change) on every single one of these options every single time the market moves at least 1% (which move size happened about 48% of the time in 2022).
  - This estimate is quite high considering none of the options change by that much, and most change by a lot less than that. As a reminder, some of the options aren't even 0DTE, which meaningfully reduces this effect.
  - Further, as noted above, a 1% move isn't sufficient to meaningfully change the deltas of many wings.
  - Yet further, out-of-the-money calls and puts cannot both become in-the-money (i.e., cannot both have a significant delta change) due to a market move in one direction.

- 100% of the increase in option volume represents a customer purchase from a dealer, creating even the possibility of all same-direction dealer gamma hedging.
  - If even 25% of it were customer sales, that would reduce the net dealer gamma hedging to 50% of the total volume (=75%-25%).

- The possibility in the previous point is fully realized; every dealer engages in 100% gamma hedging.
  - Some will not fully, or even partially, gamma hedge.
- 100% of stocks move in the same direction, creating the same net effect on the S&P 500 from gamma hedging.

US equities and associated/related/correlated futures trade well over $1 trillion notional value per day, so the $60b figure, which we believe was a very high-end estimate, represents <5% of the daily volume. That is not a particularly highly impactful participation rate. *And the true number, with more reasonable* *assumptions, is likely far less than 5%*; recall from the logic section that research attempts to quantify this effect have generally found only very small impacts on average over time.

Summarizing the analysis and conclusion of the numbers around 0DTE gamma hedging, if every single option of the 25 million additional option contracts went from not being hedged at all to being 100% hedged on a 1:1 basis for every share of stock it represents, and if all of that hedging were always by some miracle in the same direction, and if it all had to take place every single time the market moved just 1% in a day, it still wouldn't really matter all that much over time to long-term investors.

Ultimately, in our view, the VIX isn't broken, so no explanation is required. Its level has never been a meaningful forward indicator, a direct reflection of fear, or a measure of S&P 500 drawdowns. Based primarily on very recent volatility, the VIX indicates volatility market participants' expectations of short-term upcoming volatility, and it was quite accurate in 2022, generally reflecting the level of volatility in the S&P 500. However, even if we are wrong, and the VIX was distorted, the increased popularity of very short-term options trading, including 0DTE options trading, doesn't appear to hold the answer.

As a final note, given enough time, there may come a one-off day in which the S&P 500 moves 5%, and proponents of this theory declare victory, plausibly arguing that it only would have moved something like 4.0-4.5% in the absence of this effect. If and when that time comes, remember that it was a one-off day, not a daily effect, and the S&P 500 likely bounced right back – which, recall, could be up or down – shortly afterwards. This note is, once again, from the perspective of a long-term outlook. From that perspective, we believe there is still a stark lack of evidence that the tail (volatility markets) is meaningfully wagging the dog (equity markets).

Section 4: OK, maybe the VIX isn't broken, and the nuances of volatility markets aren't to blame, but volatility still seemed low. Is there any truth to that?

There were some strange things about volatility in the first half of 2022, even though the VIX was on target overall.

- It has been historically unusual, over all 6-month periods, for the S&P 500 to drop 20% or more with realized volatility below 25. In fact, that is in the worst 1% of all rolling 6-month S&P 500 returns with volatility below 25.

- It has also been historically quite unusual for volatility to be as choppy as it was in the first half of 2022. As an illustration, the VIX Index crossed above 30 on 9 separate occasions in that 6-month period. The average is 1.3 times per 6 months, and 9 times is the most in the history of the VIX.

As with all rare and unusual events, this one did not last. Both of these oddities normalized after the first half of the year. They were, however, not without consequences while they lasted, as the article correctly expressed:

Indeed, one popular protective trade of buying volatility calls, as shown by CBOE VIX Tail Hedge Index (VXTH), has not only failed to hedge losses in 2022 but in many cases created additional ones.

The above two bulleted observations contributed to the difficult time for VXTH, and for many other long and/or trend-following volatility strategies:

- As noted in the first bullet point, volatility remained only moderately elevated, given the size of the S&P 500 drop in the first half of the year. Moreover, volatility assets generally posted a loss for the full year. Despite the modest increase in the VIX Index, VIX futures, for example, were actually down 23.02% (SPVIXSTR Index).

- The extreme choppiness, noted in the second bullet point, was especially difficult for dynamic volatility strategies, with an element of trend following. Choppiness, after all, is essentially another way of saying repeated trend changes or turning points, which are not generally favorable events for trend-following models.

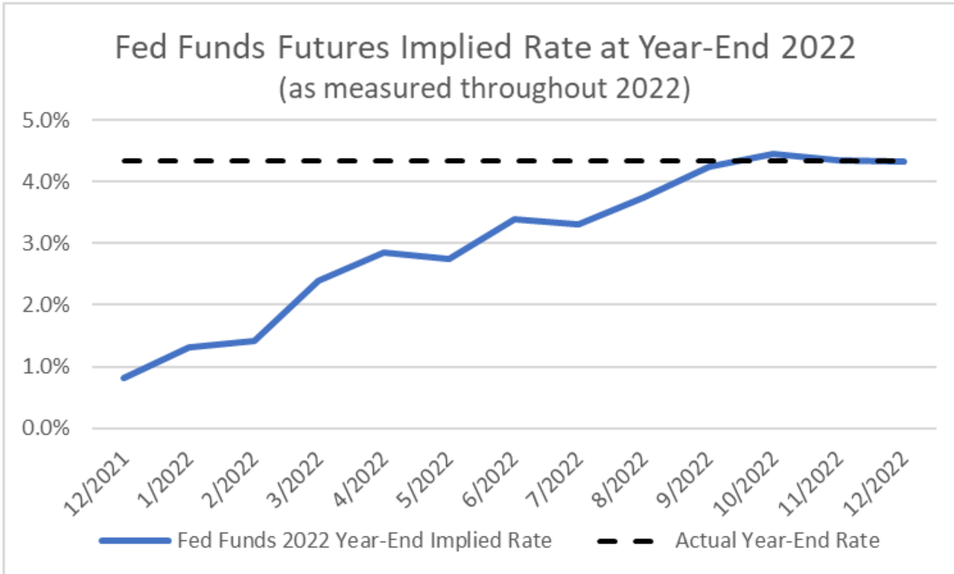
Section 5: If the broken VIX claims don't hold the answer, then what is the answer? Why was volatility low and choppy, without the big spike, or capitulation, that has accompanied some S&P 500 selloffs in the past?

Despite what the 24-hour news cycle and numerous "thought leaders" would have you believe, "why" is usually a question that is mostly not answerable, even in hindsight. The belief that we know these answers was called the Illusion of Understanding by Daniel Kahneman and the Narrative Fallacy by Nassim Taleb. The answer is generally a little bit of something knowable and a lot of random variance.

Nevertheless, we offer a theory for the relatively low realized volatility that accompanied the drop in equities in the first half of the year. It is the slow pace at which negative news trickled out this year. Of course, now we all know that central banks were slow to raise rates; that Russia would invade Ukraine; that China would lock down significant economic regions due to Covid-19; and that consumers would rapidly spend $4 trillion in extra savings from the pandemic, all of which would contribute to significant central bank rate hikes.

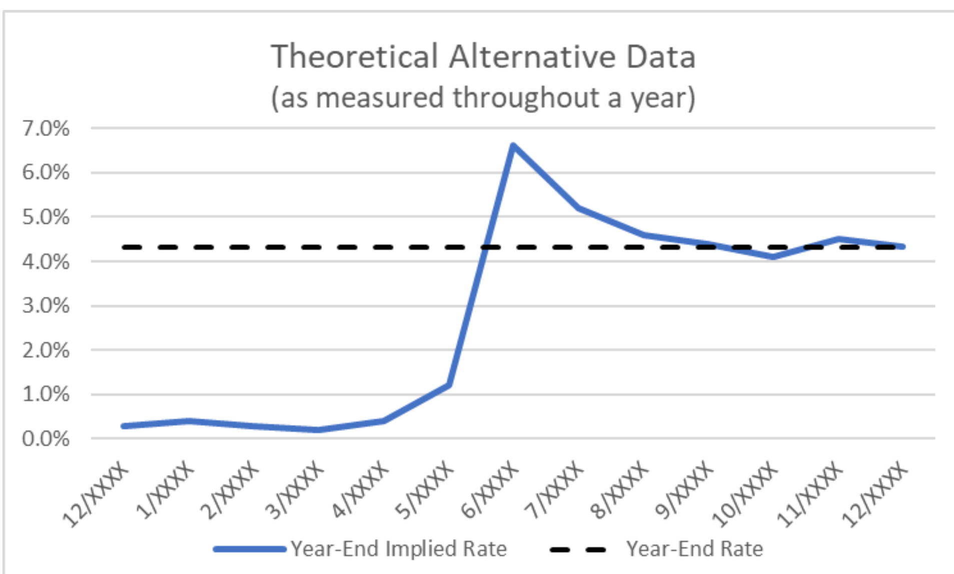
However, these pieces of news came out over time, and market participants did not collectively know them at the beginning of the year. It was only gradually and rather steadily that market participants came to terms with the need for higher rates. This statement can be made with a high degree of confidence simply based on how gradually and steadily implied interest rates rose throughout the first half, or perhaps three quarters, of the year.

To illustrate, we use the U.S. Fed as an example. The following graph shows the year-end Fed Funds interest rate, as it was implied by futures markets at each month-end in 2022. To avoid confusion, this is not a normal rate curve graph. This graph shows the interest rate for only one point in time (year-end 2022) as it was estimated by market participants over time in the past. The rate at only one point in time is hardly a complete picture of interest rates, so we also note that the interest rate at other points in time (2 years, 5 years, 10 years, 20 years) showed a qualitatively similar pattern throughout 2022.



The graph shows that the understanding by market participants that rates would have to be higher at the end of 2022 was gradual, not sudden – somewhat like the equity market selloff throughout 2022. Put another way, the mechanism – interest rates – for the repricing of the present value of future cash flows (i.e., for the repricing of stocks, at least in theory) moved gradually, much like the actual repricing of stocks themselves.

A sudden moment in time at which everyone realized rates would be much higher might have produced a markedly different type of equity market selloff, perhaps a more sudden, high volatility crisis. That realization might have looked like the following entirely theoretical graph, which does not represent any past data or prediction of future data. It is only meant to illustrate a possible contrast.



It is possible that such a moment would have been more akin to the Lehman bankruptcy in September 2008 or the worldwide Covid-19 lockdowns in March 2020 – it may have triggered a high volatility equity crisis, a potentially more favorable market downturn for long volatility and volatility trend-following strategies. However, as of yet, at least, it hasn't happened (that wording is not meant to imply a forward-looking prediction of any kind).

If you have any other questions about volatility in 2022, or in general, please reach out to us at info@abrfunds.com.

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