An introduction to volatility, VIX, and VXX

- What is volatility?
- Is it possible to "buy" the VIX?
- VIX futures, options, and VXX

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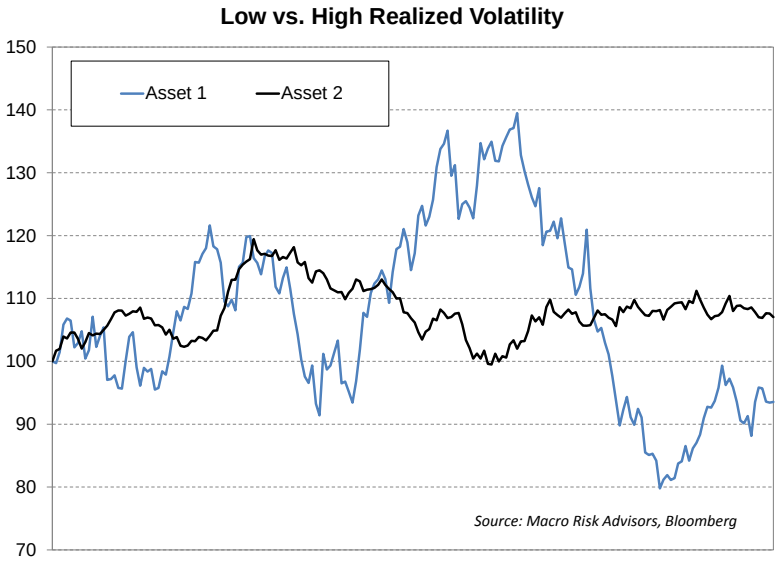
In this piece, we explain the basic concepts of volatility and introduce VIX futures, options, and the VXX. We will approach these products from the standpoint of an investor who wants long exposure to volatility, saving discussion of more advanced techniques (e.g. VIX structures and strike selection, shorting volatility) for following pieces.

What is volatility?

Practitioners often speak of volatility in two ways: **realized volatility** and **implied volatility**.

Realized volatility refers to how volatile something *has been*; it is backward-looking. Here, we show two price charts. Asset 1 has had a higher "realized volatility."



Practitioners generally measure stock volatility by looking at daily percentage moves over a certain time period, e.g. "3-month realized volatility" refers to the volatility of daily price changes over the past 3 months. The number is typically quoted on an annualized basis; for example, a stock that moves 2% a day on average could be said to have a realized vol of around 32%.

Implied volatility refers to the market's price of volatility; it is forward-looking. How do we know the market price of volatility? We derive it from the option prices.

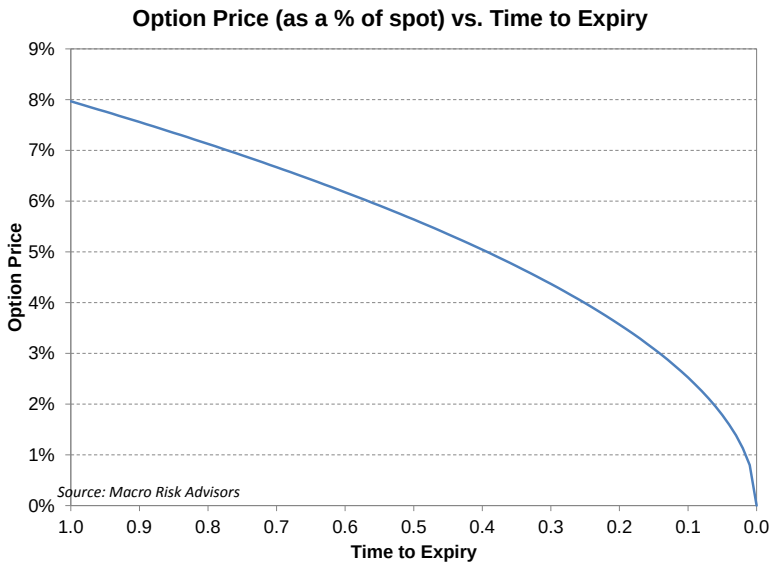
For example, consider call options on two $100 stocks that don't pay dividends. If the two call options are otherwise identical (e.g. strike, time to maturity, etc.) and the call option on stock A is more expensive, then stock A can be said to have a higher implied vol.

Generally (but not always), the market charges a premium for implied volatility. In other words, if a stock typically realizes 16 vol, the options might trade at 18 vol (a 2 vol premium).

The element of time

The key to understanding volatility (and options) is **time.** Unlike a stock, options are *time-limited contracts***.** An option with more time to expiry will *always* be more expensive than an identical option with less time to expiry.

Imagine that the S&P is at 2,000 and we buy a call option struck at 2,500. We would pay more money for the call option with one year to expiry than the call option with one month to expiry, because it gives us more time to end above 2,500. Now let's say the S&P 500 stays flat at 2,000 until the option expires. Over time, the call option will "decay" and eventually expire worthless.



The concept of **time decay** is fundamental to understanding volatility trading. **You never "own" volatility, you just "rent" the exposure.** Every bet on volatility has an implicit *time limit*.

Volatility is not a financial asset

Volatility is not a claim on tangible assets like a company's stock or a bond, and cannot be owned directly. The only way to have P&L exposure to volatility is to trade **derivatives:** either derivatives on an asset (e.g. options), or derivatives on volatility itself (e.g. volatility futures and options).

Options can never be free

If options were free, we could make money risk-free. Because options can never be free (they must always have some value, however likely they are to expire worthless), *implied volatility can never be zero*. This gives us a lower bound for the VIX: we know it can never be zero. In fact, since 1990, there have been only nine days when the VIX closed below 10.

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The VIX

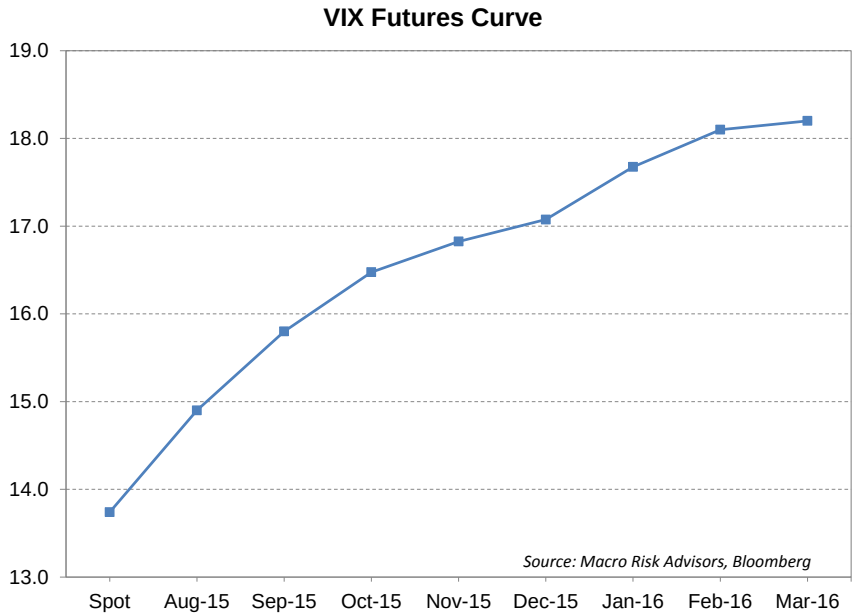
The VIX is a measure of 30-day implied volatility in S&P 500 options. Roughly speaking, it looks at the cost of S&P puts and calls of every strike with 30 calendar days to expiry, and turns this into one number. Importantly, one cannot "buy" the VIX, because it is just a calculation. In reality, if we tried to replicate the VIX by buying the 1-month S&P options that go into its calculation, we would be subject to time decay: the next day, we would own 29-day options. Eventually, we would own 1-day options, and on expiry, most of our options would expire worthless.

However, we can trade derivatives on the VIX: VIX futures, VIX options, and ETFs holding VIX futures such as VXX.

VIX Futures

VIX futures are cash settled futures contracts on the VIX (which tracks the cost of one-month S&P options). In normal times, futures trade at a premium to the spot price; in other words, the curve is upward sloping or in contango.

The **upward-sloping** curve (pictured below) does not necessarily mean that investors think volatility will be higher in the future. They trade at a premium to spot because **1) there is a decay cost to owning volatility** and 2**) more time to expiry means more could happen**, and thus a higher volatility risk premium is charged. I like to think of this as "renting" long volatility exposure. To understand why this decay cost exists, imagine if there were no decay cost and the futures always traded flat to spot. Then you would always buy VIX futures when VIX was very low (let's say 9-12), because you know that the VIX cannot go to zero, and make a riskless profit. For this reason, we generally see the steepest curves (highest decay cost) when the VIX is low.



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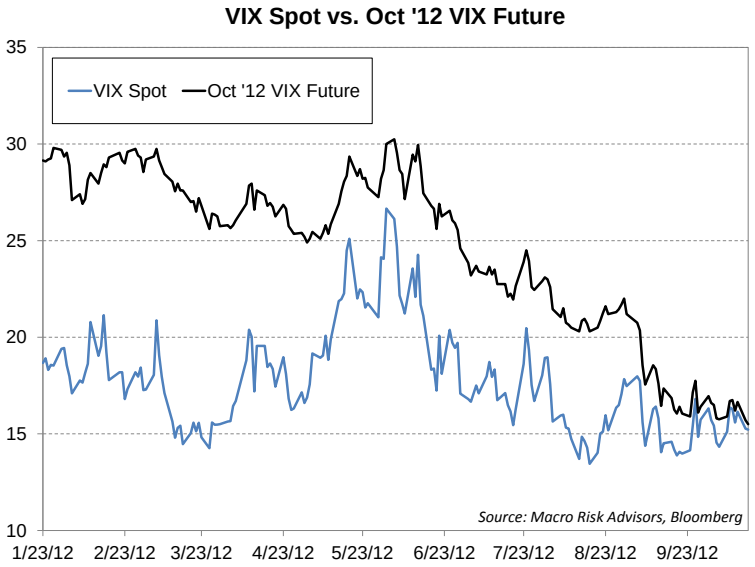
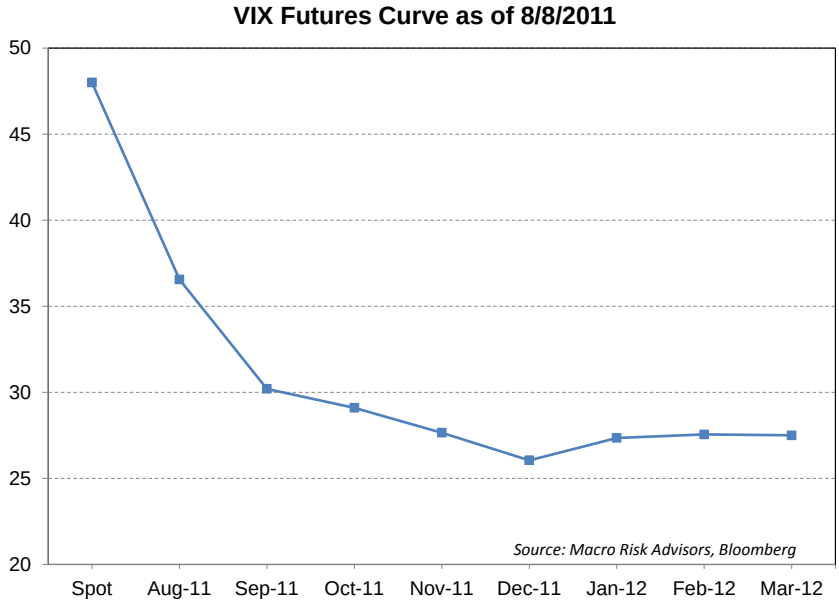
In the absence of any volatility events, over time VIX futures tend to decline in price towards VIX spot, as illustrated here. As such, selling VIX futures is generally consistently profitable (but with occasional large drawdowns) and buying VIX futures is generally a losing trade (with occasional windfall gains).



Likewise, when the VIX spikes, we can see a **downward-sloping (or inverted)** VIX curve (pictured below). In this case, it reflects overwhelming demand for near-dated protection, or that investors think the recent volatility will not last in the long term. Of course, shorting VIX futures when the curve inverts is no guarantee of making money, as it can always get more inverted.



Generally speaking, near-dated futures are more reactive than long-dated futures, and will track VIX spot most closely. A futures contract with only 1 day to expiry will come close to tracking VIX spot.

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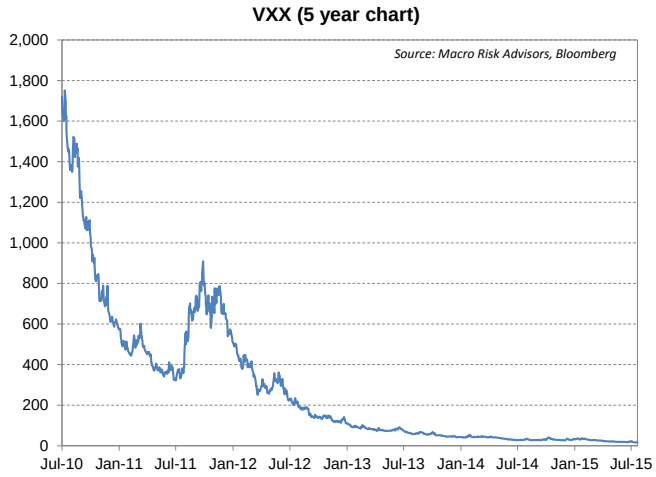
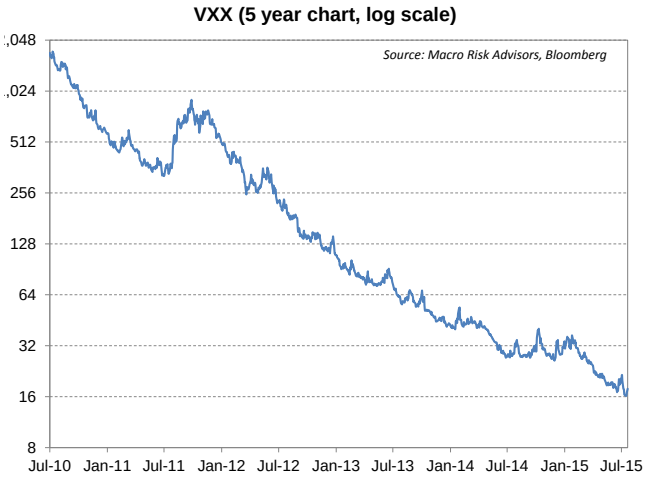
VXX

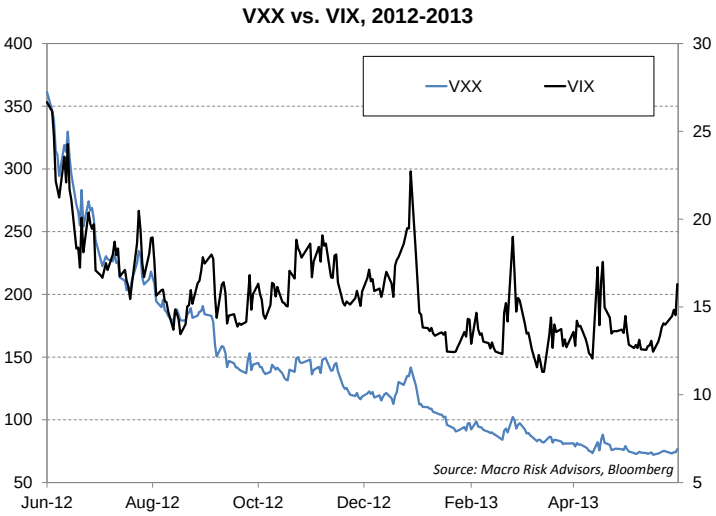
VXX is an ETF that holds VIX futures. It holds first and second month VIX futures, rolling them on a daily basis to keep a weighted one-month exposure. VXX will have a high correlation to VIX spot, but not track it exactly – generally, its daily moves will be of a lower magnitude than VIX spot. For example, on July 27th VIX spot was up 13.5%, while the VXX was up 5.5%.

As we mentioned above, owning VIX futures has a decay cost. This becomes quite apparent if you look at a long-term chart of the VXX (below). There is no limit to how low VXX can go, because it represents a trading strategy rather than a financial asset. VXX has had three 1-for-4 splits in its 6 year history and will have countless more in the future. We can estimate the monthly "cost" to owning VXX from the steepness/flatness of the VIX futures curve. Generally speaking, we can expect a "drag" of anywhere from 5-10% per month (independent of what VIX futures do).





Importantly, this drag means we can be "right" about the ultimate direction of volatility, and *still lose money*. For example, let's say we buy VXX when the VIX is 12. Several months pass, and the VIX goes to 20. Yet we find that we are only flat (or even down) money on the VXX buy. The reason comes back to **time decay** – to make money buying volatility, you not only need to be right about the direction and magnitude, you also need to be right about how quickly it happens.



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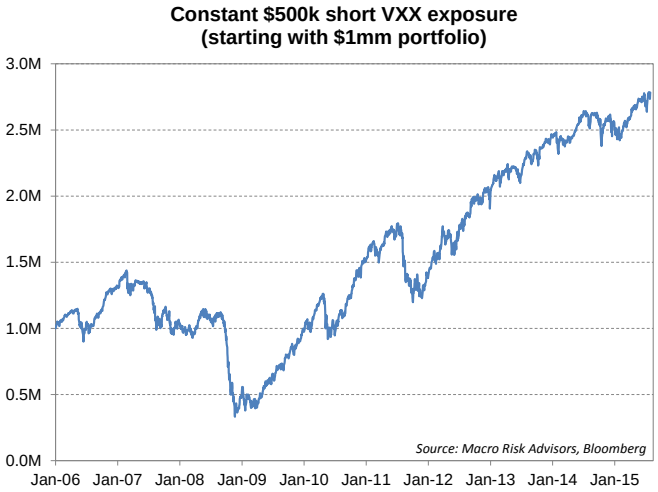
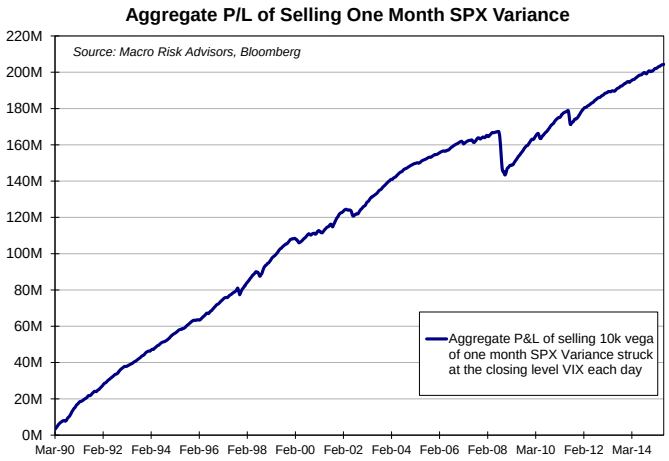
This constant decay does not mean VXX is a "flawed product" as some claim. Simply put, it is impossible to own optionality (or volatility) without paying decay, and the constant decline of VXX reflects this.

Why doesn't everyone just short VXX?

Given the headwinds to being long volatility – paying time decay and getting the direction right – one might ask, "Why not just short VXX"? The answer is that people do, and selling volatility (whether it be through directly shorting VXX, or selling volatility premium in other ways) is a popular trade. Of course, being short volatility puts us at risk of unlimited, unpredictable loss. Would you rather make steady money 95% of the time and lose big money 5% of the time, or the other way around? The answer lies in one's risk tolerance, investment mandate, and ability to withstand loss.





Long volatility through buying VXX

Buying VXX will give us a constant exposure to the reactive front end of the VIX futures curve. However, as discussed above, we will be paying decay. As our VXX position decays away, we will have less and less exposure to volatility. While this limits our loss to the amount of VXX we bought originally, it also limits our exposure to long volatility over time. The volatility of August 2011 was little consolation to somebody who bought VXX when it was first listed in 2009! In other words, to keep the same exposure to volatility, we need to constantly add to our VXX position. This is exactly the same problem that buyers of option protection face: you need to constantly renew the hedge.

A sensible way of thinking about our VXX exposure is **1) the maximum amount we expect to lose in decay per month** and **2) the maximum amount we expect to lose due to implied volatility decreasing**. These amounts may end up being far more than we expect to make on an increase in volatility, especially if we don't have a good idea of when this happens.

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For example, suppose the one-month VIX future is 15. We estimate the monthly VXX drag at 8% per month. We think the one-month VIX future can increase to 20 (a 33% increase). We think the lowest the one-month VIX future can go is 13.5.

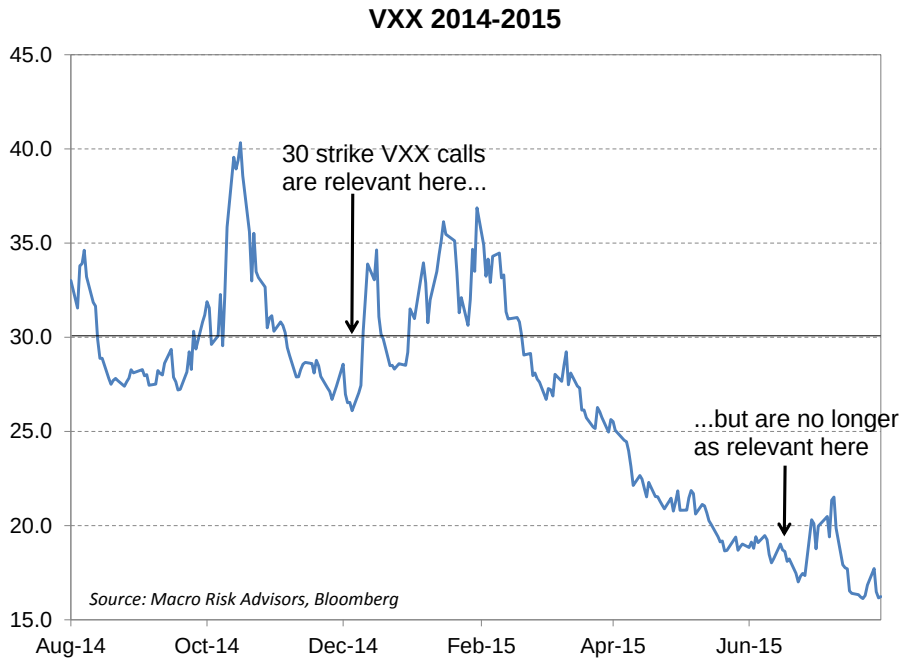
Suppose we spend $100k on VXX. In the "neutral" scenario where the one-month VIX future is flat, we can expect to lose 8% over a month.

In the worst case scenario, the one-month VIX future decreases to 13.5 (a 10% decline) *and* we pay the 8% decay, for a 17k loss (100 * 0.9 * 0.92 = ~83).

The gain in the best case scenario depends on the timing. If the one-month VIX future instantly goes to 20, we make 33%. If it goes to 20 after 2 months' wait, we first lose 15% in decay, taking our exposure down to 85k (100 * .92 * .92), then we make 33% on the 85k notional, taking the value of our position to 113k. We end up making only 13% on the original investment.

Options on VIX and VXX

If we buy call options on VXX, we limit our potential loss, but due to the "drag", over the long term we will be slowly slipping away from our strike price. When the spike in volatility comes, we may find that VXX is far below the strike price and our options are irrelevant. As such, we recommend keeping VXX call option exposure short-dated (e.g. 1 month or less to expiry) and only buying these when we are highly confident of an imminent increase in volatility. There are very few cases when it makes sense to buy long-dated VXX calls as opposed to a different type of hedge.



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If we buy call options in the VIX, we face a similar problem of decay as VIX futures "roll down" the curve. This problem is pronounced for long-dated VIX options. Even if we get a vol spike, we find that long-dated VIX futures are generally not very reactive. The good thing about VIX options is that the strikes are meaningful because the VIX has a "range" (while VXX prices are meaningless in the long term and highly path-dependent).

Most importantly, we need to compare the cost of long-dated VIX calls with the potential cost (and reward) of rolling near-dated VIX calls. If we think volatility increases by the end of the year but don't know exactly when, it may be a better trade to roll near-dated VIX calls rather than buy long-dated VIX calls. The decision will come down to the shape of the VIX curve and our view on the future path of volatility.

Conclusions

- Volatility can't be "owned" like a stock or a bond.
- You need to trade derivatives (or ETFs tracking them) to have exposure to volatility.
- All volatility bets have a time limit.
- Long exposure to volatility costs money. You pay money to be long volatility and are paid money to be short volatility.
- Options can't be free. By extension, the VIX can never be zero.
- We can't buy the VIX. If we could, we would always buy the VIX when it is low, because we would be guaranteed to eventually make money (since it can't go to zero).
- The VIX futures curve is upwards sloping in "normal" times, and downwards sloping in times of market stress.
- The VXX can decrease infinitely, and has no low. Unlike VIX prices, VXX prices are meaningless, and only make sense in relation to a previous or future price (since the VXX price reflects a portfolio's value).

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