Title: Variance Swaps Cheatsheet
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I have been researching Variance Swaps with a few other people. This post is to serve as a reference for discussions I'm about to have, to give you a rough overview of what they are about and as a primer for interested apes. I am a financial smoothbrain, but I can do maths, and that is why I will be focusing on some mathematical aspects. I believe other people in the group are writing some DD for smoothbrains in the coming days, so if you're completely lost fear not, rescue is on the way. I will be simplifying some things to the point where they are mathematically wrong. However, if you are in the position to recognize this you didn't need the respective explanation anyway (also, read the Goldman paper in this case), and if you aren't it doesn't matter, because an abstract understanding is better than no understanding.

A good resource for the mathematical aspects of Variance Swaps is [this Goldman paper](https://www.researchgate.net/publication/246869706_More_Than_You_Ever_Wanted_to_Know_About_Volatility_Swaps) from 1999 (found by u/Zinko83, I believe). Today, there are more diverse ways to hedge short variance swaps/create synthetic ones which can be optimized to certain aspects. So the absence of the patterns I'm going to describe doesn't mean that someone isn't playing variance.

What is a Variance Swap?

Mathematically, Variance is the square of Volatility (the Standard Deviation). Implied Variance is the square of Implied Volatility (yes, the IV from options).

A Variance Swap (VS) usually is a Forward contract (as in OTC Future, but they also exist as exchange traded products, like Volatility Indexes), where the delivery price depends on the amount of Variance that happened on the underlying over the contract's lifespan. **If the underlying is more volatile than anticipated the long side gets paid, and if it's less volatile the short side gets paid.**

Variance is computed as the sum of squared lognormal returns. Overly simplified and mathematically wrong: Stock moves 5, -3, 1, 0; the Variance then is the sum of 25, 9, 1, 0 = 35. **This means that few drastic changes have a higher impact than many small changes.**

See where I'm going with this? You probably guessed it already, [Citadel is famously short variance](https://volquant.medium.com/epic-failures-lessons-from-volatility-funds-blow-ups-6f4226c8334f) (courtesy of the find goes to a new addition to our group where I seem to have gotten the Reddit handle wrong), which is also why they got fucked in 2008. If you think they are retarded, think again. **Short Variance strategies have relatively high Sharpe Ratios (roughly double that of stonks) and can be incorporated into standard portfolios by replacing bonds.**

How do you hedge it?

The aforementioned Goldman paper describes a **"replicating portfolio" which most importantly consists mostly of options and a delta-neutral long position of shares.** Since we have better computers than in 1999, there are a lot more possibilities for hedging strategies, and you can optimize for lots of stuff, like the price of options, for delta, for vega, for delta and vega, for delta-hedging, whatever. Some strategies involve (temporary) short positions in shares. Usually though you go long. Before you get jacked: The position in shares is always tiny. This is the reason why Citadel Advisors only holds slightly more than 2300 shares (13F).

In order to be fully hedged you buy options for the entire range of strike prices, evenly spaced. This means that if the stock price moves outside of this range, you get fucked, even if you are properly hedged. If it does this repeatedly, you are pretty much done. Like Melvin.

The options in the portfolio are weighted by the squared inverse of the strike price. That means (*K* is the strike): **Per VS unit you need** ***1/K\^2*** **contracts. This means you need a shitton of Puts for low

strikes, and not a lot of options for high strikes** (you use Calls for higher strikes)**.** It also implies that the far OTM Puts on GME are hedges against short VSs.

For GME, this strategy is pretty easy to spot. First, let's take a look at the function [*f(x) = 1/x\^2*](https://www.wolframalpha.com/input/?i=1%2Fx%5E2&dataset;=).

[f\(x\) = 1\/x\^2. Source: Wolframalpha](https://preview.redd.it/quplp1v6m1s71.png?width=337&format;=png&auto;=webp&s;=08d37b0e6e25b6d8cb935997e9e9f5d27e155376)

Now let's take a look at a shitty graph of Jan22 options OI that I produced by selecting a random date (2021-07-23) in my spreadsheet.

[Keep in mind that in this graph the strikes are not on a linear scale.](https://preview.redd.it/a55h5bkkc1s71.png?width=605&format;=png&auto;=webp&s;=2dc81e654eb3df9b79f2a260e8fb65bac9958f01)

This was not done before January. My guess is that they felt really comfortable in their position, or, as Cohodes implied in the Komisar interview, too arrogant, and simply didn't hedge properly. Pair this with Melvin's stupidity to leverage himself to the tits and you are set up for disaster.

Interesting properties

The payoff is convex. This means if volatility goes ■, payoff goes ■. For the buyer. Generally though, this game is very profitable for the seller, especially since options IV tends to overestimate actual Variance (means they get paid for building the options portfolio which usually is more expensive than what comes out).

The SHFs can't drop the stock-price, because apart from apes buying, they would have to go long themselves lots of shares to delta-hedge, which is kind of funny, because they (or better their Market Making units) are short. And, more importantly, they can't drop the price suddenly, because that makes Variance (and therefore the payoff) moon. **This means they are stuck in their position.** Tough game.

Also, check out the following picture:

[Vega distributions for different options portfolios. Source: Goldman paper.](https://preview.redd.it/buobaxsbf1s71.png?width=633&format;=png&auto;=webp&s;=c3fa3e497de2a1d75a9caeda52e1435af8f241b1)

In the above graphic, **a** is the ideal Vega distribution, **b** is the Vega distribution when you don't fully hedge the entire strike range (and the reason the SHFs got fucked so hard), and **c** is the Vega distribution when you do what the paper suggests. The interesting thing here is that these disturbances get more violent close to maturity and with lower stock prices. This doesn't mean that VS are driving the price (they don't, or don't seem to, I checked), but that they can't get out.

Another aspect that makes the entire thing appear more nefarious is this: **If a company goes bankrup/gets delisted, trading activity slows and volatility goes down. So it makes perfect sense to sell VS against companies you intend to kill**, which is probably the reason why short VS are/were often paired with CDS.

Single-name variance is higher than basket/index variance, because the other stocks have a dampening (because the average over all instruments is the one that counts) effect. This is important for correlation plays. You can profit by going long the Variance of a basket and selling the index Variance. No, this does not explain SI in ETFs. It does mean that you profit from NeGaTiVe BeTa.

Closing thoughts

Variance Swaps actually can explain most of the idiosyncracies we were able to observe this year. Stay tuned for a *Speculation* post where I outline my thesis. Also (NoT fInAnCiAl AdViCe), stay away from Shitty Floors stock, it will not SqUeEzE.

TL;DR: Hedgies 'R' utterly and totally fuk. If apes DRS, that is.

Edit because stupid Reddit turned my f(x)-GIF into a non-functioning video. It's a PNG now.