Key Indicators for Observing Bitcoin's Volatility Landscape

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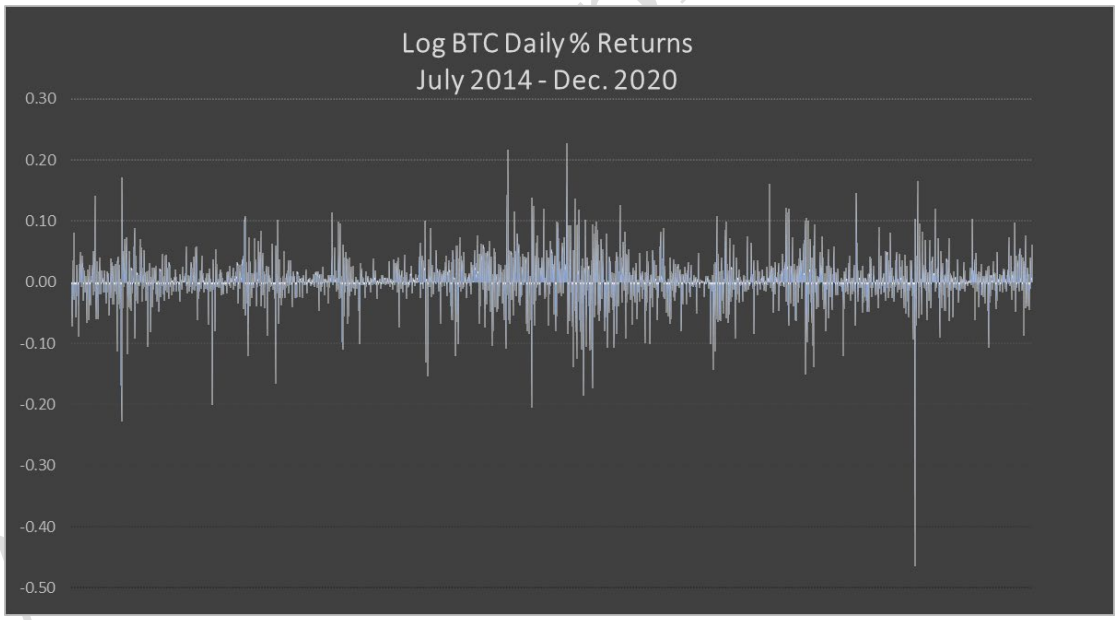
Introduction: What is Volatility, How it is Measured, and Why Do We Care

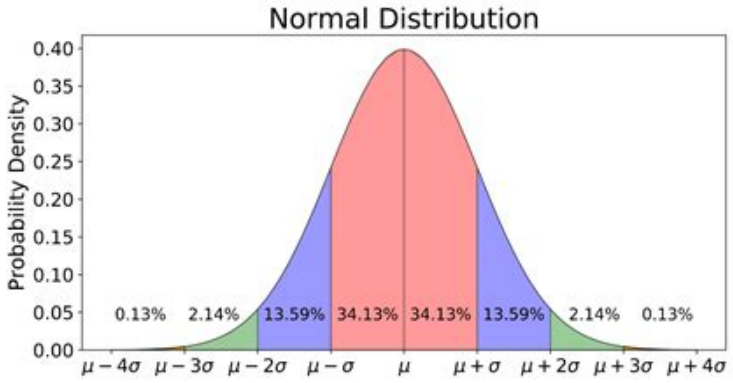
"Volatility" in finance represents the significance or extent of the change in asset prices and asset returns over time. It is the stark measure of "risk" – i.e., the more volatile an asset is, the riskier it is.



Source: Austere Capital; spot price data from finance.yahoo.com

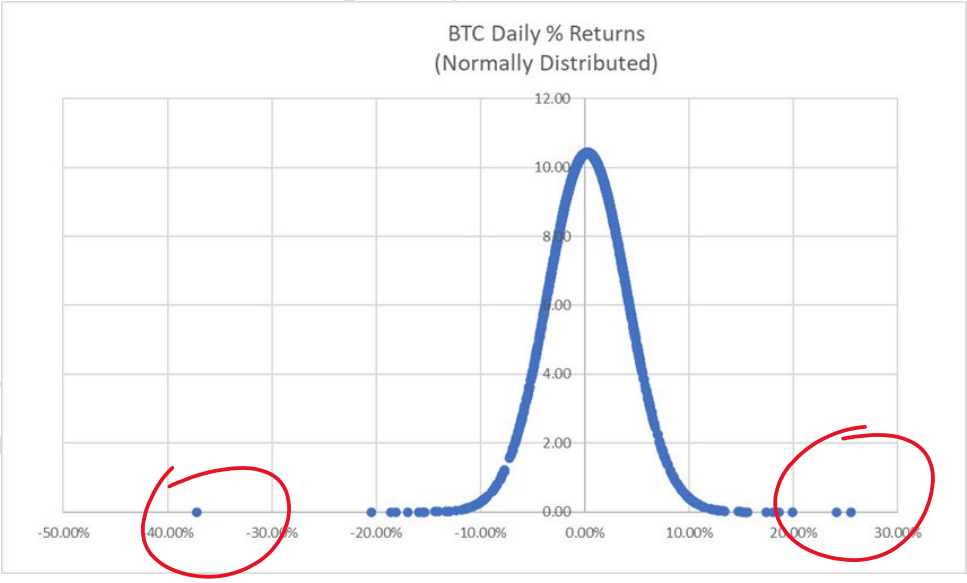
Above we have Bitcoin daily percentage returns (logged) from the last 6.5 years – in essence, its historical volatility. This is the first step in analyzing an asset's risk profile. Quite evidently, we witness several large moves or jumps.

The next step in measuring volatility is calculating its standard deviation, or "dispersion from the mean." Some variables, like human height and weight, are "normally distributed"[1] meaning it is quite easy to deduce specific probabilities due to the clustering of the data around the mean and the absence of fat tails or extreme observations.



Source: https://towardsdatascience.com/

Stock prices and stock returns meanwhile are not normally distributed, due to extreme events (i.e., market crashes). The greater the changes in an asset's price over time, the greater its dispersion, and thus the greater the chance for catastrophic "tail events" such as sudden market crashes (i.e., black swans).[2]



Source: Austere Capital; price data from finance.yahoo.com

[1] Also known as "Gaussian" distribution.

[2] Pinpointing Bitcoin's tail risk is the subject of a future paper - see "A Surface Level Look at the Distributions of Daily Percentage Returns of Bitcoin (BTC) and Gold (GLD)" by the author for additional information on BTC's tail risk, and "The Black Swan" by Nassim Nicholas Taleb for general information.

Above, we have Bitcoin's daily percentage returns from July 2014 to December 2020 "normally distributed."

As we saw in the first graph depicting logged daily % returns, we can infer that Bitcoin returns obviously do not fit this type of distribution[3] due to the presence of fat tails as denoted by the extreme observations (circled in red). The mean or shape of the curve is also considerably peakier than a normal distribution would dictate[4], otherwise denoting considerably less clustering around the mean.[5]

If you're a long time BTC "hodler", this should come as no surprise. Bitcoin's volatility is quite legendary as compared with traditional equities or even other dollar-hedge assets such as Gold.

OK, so we're aware of the fact that Bitcoin historically is more volatile than traditional assets. Now what?

So far, we've only looked at historical volatility. We need to scrutinize *forward-looking* volatility, or in other words, how volatile the market believes Bitcoin spot price will be 3, 6, 9, 12 months into the future.

Why do we care about forward-looking volatility?

In short: *effective risk managemen*t. Being able to clearly observe the market's expectations of Bitcoin's volatility landscape in the next 30 days to 12 months out, can enable us to utilize particular risk management practices depending on market conditions.

The purpose of this paper is to provide a clear lens when observing BTC's volatility landscape, and to sharpen our view of what the market believes to be the underlying future volatility.

We will scrutinize several key indicators which will in turn provide us with crucial information on the crypto market's forward-looking assessment of Bitcoin spot price volatility, ultimately enabling us to more effectively manage our portfolio risk.

The CBOE Volatility Index or "VIX"

The equity market's expectation of future volatility is traditionally measured via the CBOE[6] Volatility Index or VIX.

The VIX highlights the market's forward-looking perception of the volatility of the S&P 500 by analyzing the out-of-the-money (OTM) prices and implied volatilities of call and put bid-ask spreads with ~30-day expiries. In essence, it represents the market's premonition of volatility 30 days ahead.[7]

[3] Asset prices are generally modeled under a log-normal distribution.
[4] The sharpness of the peak of a distribution is known as "kurtosis."
[5] We can further confirm this by observing the "Summary Statistics" of BTC Daily Percentage Returns (see "A Surface Level Look at the Distributions of Daily Percentage Returns of Bitcoin (BTC) and Gold (GLD)" by the author for additional information).
[6] Chicago Board Options Exchange.
[7] The exact VIX formula is here - vixwhite.pdf cboe.com

In contrast, the leading volatility indicators for Bitcoin as presented in this paper aim for simplicity over the mathematically dense (yet rigorous and vital) local and stochastic volatility models as implemented by the VIX's methodology.

The goal is to provide key indicators for monitoring the crypto market's forward-looking volatility intuition for Bitcoin spot price, in lieu of a traditional VIX.[8]

The Significance of Implied Volatility Within Options

Historical volatility is a measure of past price movement, as we observed in the previous graphs.

For forward-looking volatility – better known as "implied volatility" – we turn to the derivatives market, namely options.[9]

The implied volatilities within option contracts are indicators of the market's future perception of that underlying asset's volatility. Furthermore, the implied volatility of an option contract at a particular strike price is positively affected by the inherent demand for that specific option. [10]

Tracked over time, if implied volatility is near the all-time high of its historical range, then it is most likely not an ideal time to enter into any "long" option positions, and vice versa.

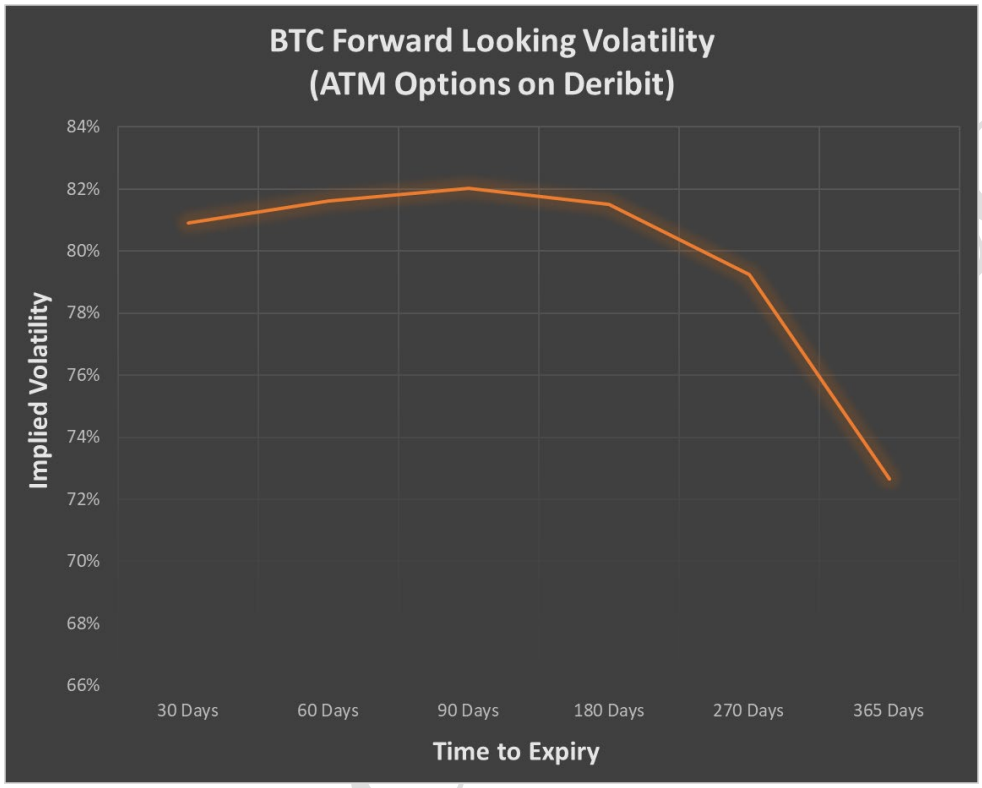
Alternatively, if implied volatility is deemed to be increasing, we can take this as a sign that the market expects a storm ahead, and thus we can instill the proper portfolio risk management measures to counter this increase (either by selling some of our position into cash, or by hedging with options[11]).

Vice versa, if IV is seen to be declining, we can afford to take on additional risk with our capital, as the market is pricing in calmer conditions in the future.[12]

We will utilize option data from the derivatives exchange Deribit (Bitcoin Futures and Options Exchange | Deribit.com) as it is by far the most liquid Bitcoin options exchange by volume.[13]

[8] Based on our own fundamental market predisposition, we can then use these indicators to discern whether or not implied volatility is "high" or "low" historically, after which we can mitigate portfolio risk by either selling into fiat or using option contracts. It's also important to note that any forward-looking volatility indicator is more of a "real-time" figure on what the market currently believes, and should not be used as a crystal ball. For more information on how the VIX underprices black swans see What Does the VIX Really Tell Us? (tradersmagazine.com).
[9] Option contracts are used most generally for hedging, or countering future volatility risk – this is why they hold a forward-looking volatility component within its pricing formula (known as the Black-Scholes Model).
[10] The goal of every derivatives quant is to correctly forecast implied volatility relative to the market's premonition. For simplicity purposes we will not be delving into local and stochastic volatility models and subsequent implied volatility surfaces. For an excellent book on the latter, see "The Volatility Surface, A Practioner's Guide" by Jim Gatheral.
[11] See the "Austere Capital Guide for Optimally Hedging Against BTC Price Declines."
[12] Of course, we can always disagree with the market's premonition and adjust our portfolio accordingly.
[13] The more liquid the exchange the smaller the bid-ask spreads, and thus less transaction costs per trade.

Key Indicator 1: "At-the-Money" Implied Volatility



Source: Austere Capital (data as of Dec. 28th, 2020)

The above graph represents the current implied volatilities of Bitcoin at-the-money (ATM) options as listed on Deribit.[14]

The line represents the market's perception of future Bitcoin volatility 30, 60, 90, 180, 270, and 365 days from today.

We can thus utilize ATM implied volatility as a basic "volatility barometer" as compared against Bitcoin's historical volatility range, which unsurprisingly is quite broad (the historical range for the implied volatility of ATM Bitcoin options listed on Deribit is **~50% to 100%+**).

As of this writing, December 28th, 2020, the 6-, 9-, and 12-month ATM IV average is **~80%**.

What does this 80% figure tell us?

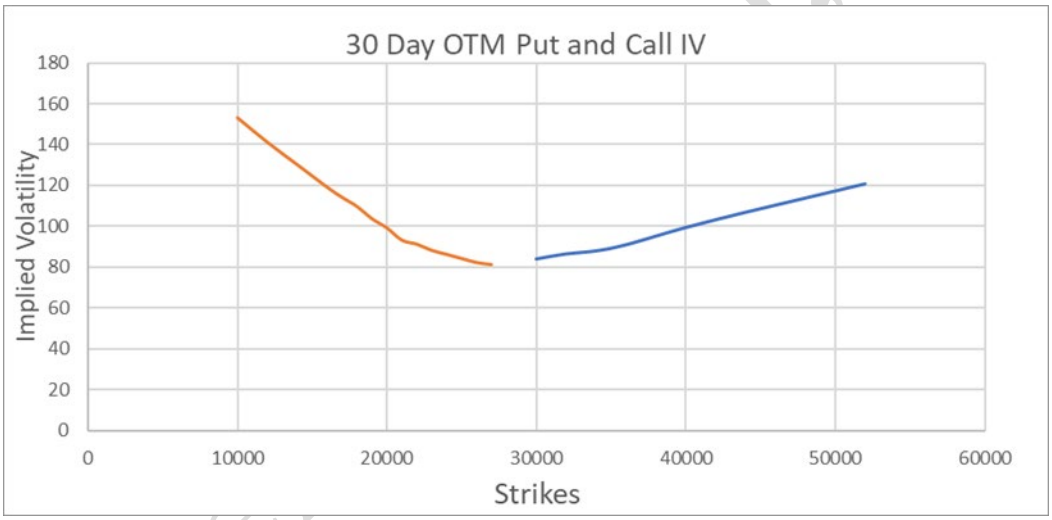
[14] By at-the-money we mean those options with strikes that are closest to the current spot price of BTC.

Numerically, a quick calculation discounting for time to expiry (using 6 months in this example) reveals that the market currently gives a 68.2% chance (1 standard deviation) that BTC spot price will move +/- ~$16,000 within the next 6 months.[15]

From a forward-looking standpoint, **80%** is most certainly on the higher end of Bitcoin's volatility range, which indicates that the market is expecting further gyration over the next 6 to 12 months. This is unsurprising as Bitcoin has been on quite the tear as of late and is in new price territory.

Does this mean we can expect volatility to come down soon? We highly doubt it - in our opinion, there is still plenty of implied volatility juice to squeeze here.[16]

Key Indicator 2: 30 Day Implied Volatility Slope ("Skew")



Source: Austere Capital (data as of Dec. 28th, 2020)

Implied volatility skew is an extensive subject of research by finance quants and academics alike. Skew is the difference in implied volatility of options with the same expiry but differing strikes.[17] Graphically, it represents the slope of the implied volatilities of out of the money options.

Above we have a clear visual of skew – rather than flat, horizontal lines as the Black-Scholes Model dictates, the lines are sloped (negatively for puts, positively for calls). As we venture further away from the money the implied volatility increases dramatically.[18]

[15] Current projected price move (assuming normality) = take the square root of the days to expiration and multiply by the implied volatility, multiply that result by the current asset price, then divide the whole product by the square root of 365.

[16] In other words, any ATM option with at least a 6-month expiry and an implied volatility of under 100% still has room to run (in our opinion) considering the recent price increase. For more information on implementing BTC option trades, reach out to us here Contact — Austere Capital.

[17] The Black-Scholes Model which is used to price options assumes that volatility should hold constant across option strikes with the same expiry, but that is not the case.

[18] Put options – mainly within equities – generally have higher implied volatilities since they serve as "portfolio insurance" against black swans (i.e., tail risk).

Observing changes in skew *over time* reveals immediate insights into how "fearful" the market is in the near-term of violent price moves in BTC spot price.

An in-depth analysis of skew is also a closer measure to the traditional VIX methodology, as it specifically scrutinizes the *level of demand* for out of the money options relative to those at the money, 30 days into the future. The higher in demand OTM options are relative to ATM options, the more near-term volatility the market expects.

Our final two indicators will explore 30-day skew in detail.

OTM Puts		
Strike	**IV**	**IV Slope**
27000	81	1.00
26000	82	2.00
25000	84	2.00
24000	86	2.00
23000	88	3.00
22000	91	2.00
21000	93	6.00
20000	99	4.50
19000	103.5	6.00
18000	109.5	4.50
17000	114	5.00
16000	119	5.50
14000	130	5.50
12000	141	6.00
10000	153	-
Average		**3.93**

OTM Calls		
Strike	**IV**	**IV Slope**
30000	84	1.25
32000	86.5	0.75
34000	88	1.50
36000	91	2.13
40000	99.5	1.88
44000	107	1.75
48000	114	1.75
52000	121	-
Average		**1.57**

Source: Austere Capital (data as of Dec. 28th, 2020)

First, we take a closer look at the slope of the implied volatilities between ATM and OTM options - the steeper this slope, the higher the expectation of future BTC spot price volatility.[19]

The linear slope average of the 30 Day OTM puts implied volatilities is **3.93**, and **1.57** for calls. We obtain this by taking the difference of IV divided by the difference in strikes, then averaging the results for all strikes. We then multiply each result by 1000 to compare the effect of a $1000 strike move on implied volatility.[20]

The slope of the OTM puts reveal that on average, for every change in strike of $1000 as we move further out of the money the corresponding option implied volatility increases by nearly 4%. Conversely for calls, every $1000 change in strike as we go further out of the money, on average, increases implied volatility by 1.6%.

As mentioned previously, the implied volatility skew for puts is always steeper, due to tail risk premia.

[19] Just as macroeconomists analyze the slope of the US Treasury Yield Curve in order to gauge market expectation of near-term vs. long-term national economic prospects, similar scrutiny may be applied here to deduce the crypto market's expectation of extreme volatility in the near 30-day future.

[20] Obviously, skew is not linear but curved – for simplicity purposes we take a linear approach.

If this skew becomes steeper over time (especially for puts), this indicates that there is an increase in demand for OTM options, and that the market is expecting an increase in near-term volatility.

Keep in mind that this skew slope indicator is a static measure and must be observed over time.

Key Indicator Three: 30 Day Skew Ratio

Finally, we will calculate the ratio of the average implied volatilities of OTM options to the average implied volatilities of ATM options. This metric provides us with a snapshot of a the OTM/ATM implied volatility spread, 30 days into the future.

OTM Calls IV (Average)	**98.88**
ATM Calls IV	**84.5**
Ratio	**1.17**
OTM Puts IV (Average)	**104.93**
ATM Puts IV	**82**
Ratio	**1.28**
OTM Put/Call Average IV	**83.25**
Ratio	**1.24**

Source: Austere Capital (data as of Dec. 28th, 2020)

The overall ratio is currently at **1.23** which means that on average, OTM options have an implied volatility 1.23x higher than that of ATM options.

Breaking this down into calls and puts respectively, we see that the call OTM/ATM spread ratio is **1.17** while the put ratio is significantly higher at **1.28**.

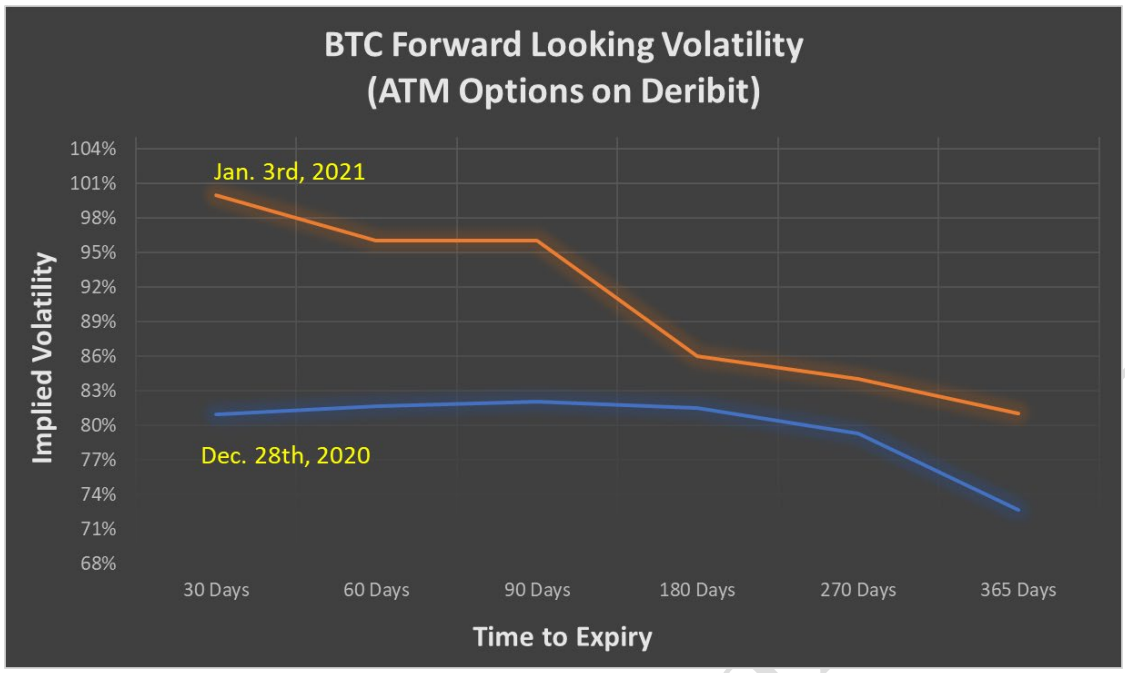
As with our previous indicator, we must monitor the skew ratio over time, in order to obtain a historical time series. We could then effectively compare the current OTM implied volatility premium over its historical range.[21]

Conclusion

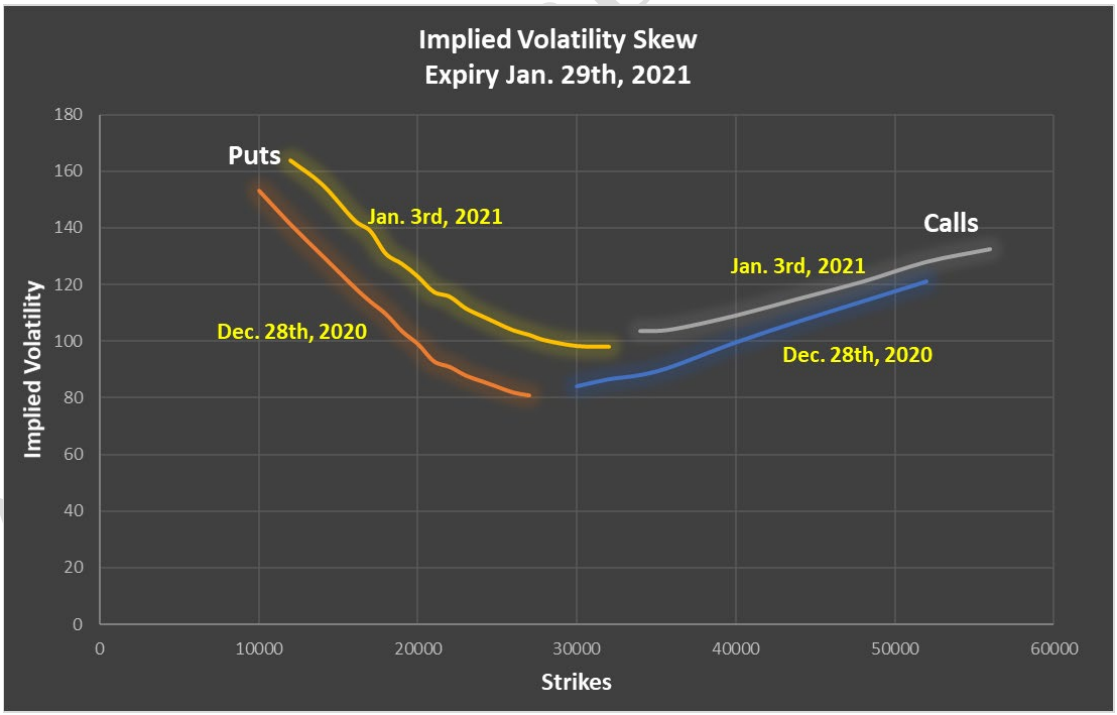
As of the date of this paper – January 3rd, 2021 – BTC spot price currently rests at $33,000, having increased ~65% in a little over two weeks' time.

At-the-money implied volatilities meanwhile have increased from 70% to nearly 90% on average, a 20-point jump.

[21] Analyzing an option's implied volatility and strike price over time reveals a "volatility surface" – a three-dimensional plot.



The 30 day – January 29th, 2021 – skew, or slope of the implied volatility for both calls and puts has even eased somewhat (i.e., become less steep).



Source: Austere Capital (price data from Jan. 3rd, 2021)

(As of Jan. 3rd, 2021)		*(As of Dec. 28th, 2020)*	
OTM Calls IV (Average)	**116.16**	OTM Calls IV (Average)	**98.88**
ATM Calls IV	**102.5**	ATM Calls IV	**84.5**
Ratio	**1.13**	Ratio	**1.17**
OTM Puts IV (Average)	**120.46**	OTM Puts IV (Average)	**104.93**
ATM Puts IV	**97**	ATM Puts IV	**82**
Ratio	**1.24**	Ratio	**1.28**

Even though implied volatility has increased dramatically, why has the skew become less steep?

Intuitively, in fast moving markets, options that were once just out of the money are now at the money. As there is higher demand occurring wherever the spot price is believed to be next (usually at the next strike, just out of the money), the skew tends to flatten in fast markets.[22]

Where do we go from here based on our key indicators?

BTC spot price is currently in uncharted waters, and as we mentioned previously, ATM options 6 months+ implied volatility levels are currently at ~90%. There is still plenty of implied volatility juice to squeeze, in our opinion, based on the historical range. Hence, we see implied volatility increasing to 100% and above in the near-term (next 30 days).

Meanwhile our above skew indicators are rendered inadequate as the expiries need to be at least ~30 days out to be robust measures.[23] The skew will be crucial to compare especially after the recent price rise – are investors concerned about the rapidity of the recent surge? Will they expect a pull back? The skew will reveal the answers to these questions.

References/Further Readings

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[22] There does not seem to be any confirmed research on this but it appears to be the case. Further, as the expiry date draws nearer for an option, the skew slope also decreases (see "Lecture 3: Asymptotics and Dynamics of the Volatility Skew Jim Gatheral").

[23] Due to the rapidly declining time value or "theta" of options expiring under 30 days. We can utilize the Feb. 26th expiry at ~54 days expiry.

8. Taleb, Nassim Nicholas. *The Black Swan*. 2007.

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