How expensive are Bitcoin options?

Pre and post Crypto Black Thursday analysis

By Olivier Mammet, June 15, 2020

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Introduction

Bitcoin options traded volumes have been steady since 2019. On Deribit alone, ₿2,511 worth of quarterly options (March, June, September, and December contracts) have traded over the first five months of 2020 (Figure 1). The beginning of the year has been busy in terms of market moving events generating large spikes in volatility, raising the level of interest for derivatives, be it to hedge positions or to take advantage of the high volatility.
Two main events affected the market: the so called ‘Crypto Black Thursday’ of March 12th, with a collapse of the market (followed by a prompt recovery) and the Bitcoin halving, an event that occurs approximately once in four years. Beyond the usual study of traded volumes and generic implied volatilities, we decided to analyze options’ valuations from a trading perspective, and relative to other developed markets.
We used options trade data for Deribit from January 1st, 2020 to May 31st, 2020 and focused on March and June contracts.

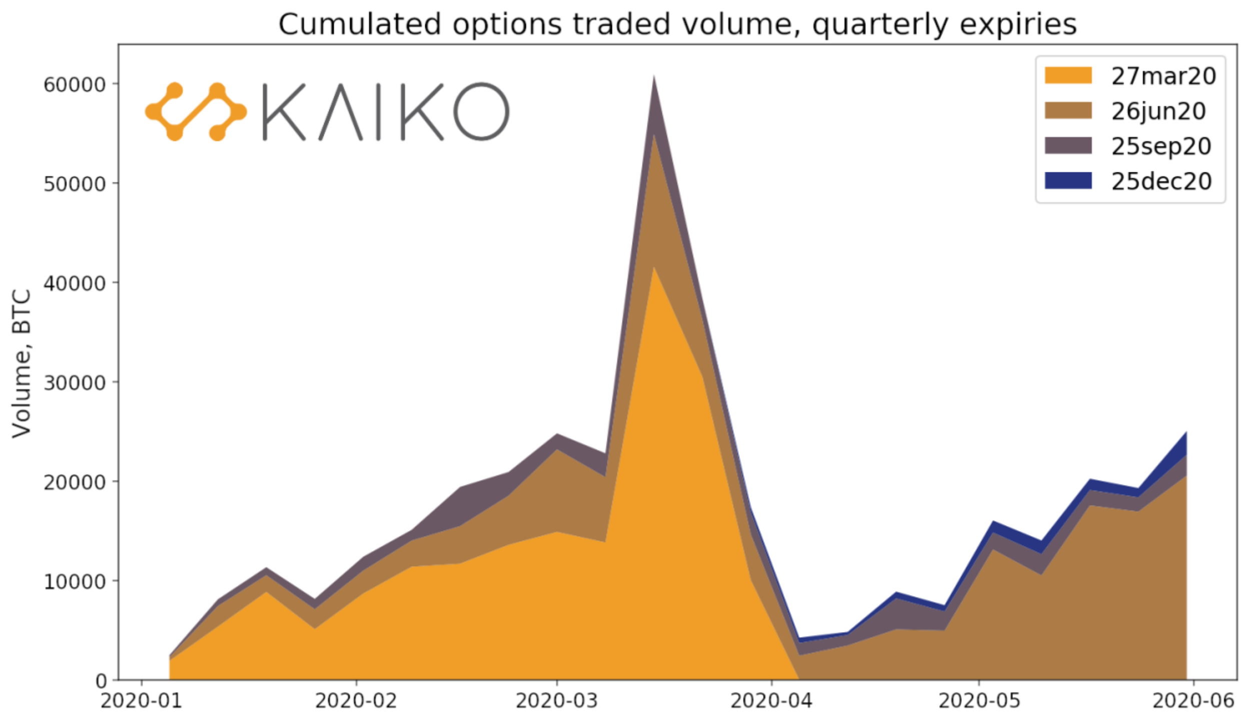

Figure 1: Total weekly options traded volumes for 2020 quarterly expiries, Deribit. Source: Kaiko

Takeaways

- Over the study period, implied volatilities track realized volatilities with different regimes, showing a slow return to normal following the Black Thursday crash, but with a similar shape to SP500 options.
- During 'normal' market conditions (pre-crash and about one-month post-crash), Bitcoin options were not particularly expensive, with implied volatilities averaging around 110% to 120% of realized volatilities.

Options pricing and hedging basics

To assess how expensive options on any underlying assets (in our case BTC/USD) really are, let us have a look at the basics of options pricing and hedging.

1. What is an option's premium anyway?

The premium paid to buy an option reflects the likelihood that it will be exercised on maturity (in the case of a European option) and its expected payout. Many aspects of an option's premium behavior can be expressed qualitatively: the higher the strike of a call option, the lower the premium; the longer the time to maturity, the higher the premium … Still, for the market to develop beyond pure speculation, one needs to be able to compute quantitatively, the 'fair' premium of an option given the market conditions at any given time.

When introduced, the Black–Scholes–Merton model (later referred to as BSM) solved this problem by providing participants with a 'fair' pricing equation for European options under specific conditions [2].

Delta Hedging

Specifically, the authors showed that at any point in time, it is possible to build a riskless portfolio (as in, not exposed to movements of the underlying asset) by combining an option and some quantity (Delta) of its underlying asset. Since an option's PnL profile is convex (nonlinear in the underlying asset price), the resulting portfolio will only be risk-less for a short period of time and will require periodic rebalancing (adjustment in the quantity of the underlying asset) to remain risk-less over time. Such a portfolio is called 'Delta hedged'.

Rebalancing

This rebalancing has an intrinsic cost, always positive to an options' seller who needs to buy more of the underlying asset as its price rises and sell when it falls (buy high and sell low generating a negative PnL). The more volatile (up or down movements around a given price) the underlying asset, the more frequent the rebalancing, hence the higher the cost.

Pricing formula

By making assumptions regarding the distribution of an option's underlying returns, Black Scholes, and Merton showed that a closed form solution exists to estimate the total rebalancing cost C of the 'Delta Hedged' portfolio over time which must equal the 'fair' premium of the option.

$$C(S_t, t) = N(d_1)S_t - N(d_2)PV(K)$$
$$d_1 = \frac{1}{\sigma\sqrt{T-t}}\left[\ln\left(\frac{S_t}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)(T-t)\right]$$
$$d_2 = d_1 - \sigma\sqrt{T-t}$$

Where:

S_t : *Underlying spot price at t*
K : *Call option strike price*
σ : *Underlying volatility*
r : *Risk free rate*
T : *Option time to maturity in years*

Figure 2: BSM formula for a European call option

All things being equal (Spot price, Strike Price, Time to maturity, level of interest rates), the fair value of an option only depends on the expected realized volatility (Sigma) of the underlying asset over time [*]. Therefore, from a market maker's perspective (running a delta hedged portfolio with no directional exposure), options trading is equivalent to trading volatility.

This is the reason why traders look at implied volatility derived from options traded prices as a better measure of the actual 'cost' of an option.

2. Real world option trading

One of the assumptions of the BSM model is continuous trading / rebalancing. In the real non-frictionless world, it is impractical to trade the underlying asset continuously (trading costs alone would make it impossible), so options' market makers only rebalance their portfolio sporadically:

- When needed after a move of the underlying of a certain amplitude
- Under a regular schedule (usually daily)
- A combination of the two (most used in practice)

Under a regular rebalancing schedule, the PnL of a Delta hedged portfolio basically consists [*] of the sum of:

- The fraction of the premium collected / paid since the last rebalancing (by an option seller / option buyer). It is called 'Theta decay'
- The rebalancing cost paid by the seller / collected by the buyer to bring the portfolio back to neutral due to the convexity. It is called 'Gamma'

$$Daily\ PnL = Gamma - Theta\ Decay$$
$$Daily\ PnL = \Gamma - \Theta$$
$$(case\ of\ an\ option's\ buyer)$$

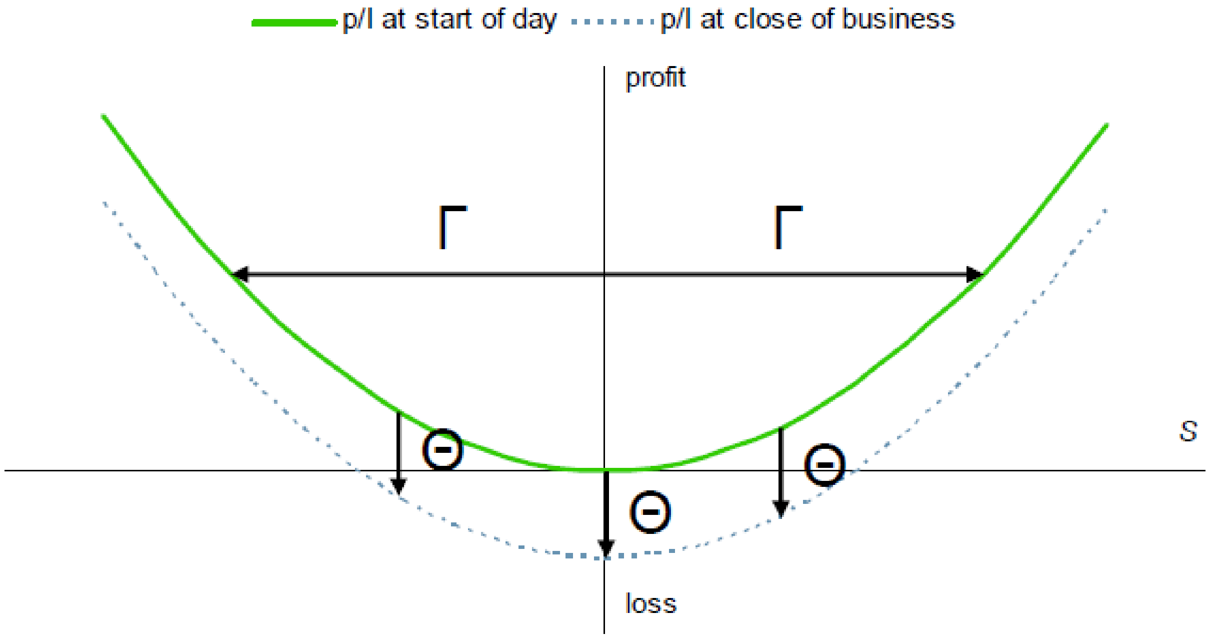

Figure 3: PnL of a Delta-hedged long option position

The net PnL of an option's portfolio will thus depend on the relationship between the two terms (Theta and Gamma). Daily, the Gamma collected (as a function of the underlying asset movement during the day) will go against the Theta paid (share of the premium).

It is precisely as a consequence of the above that most traders look at implied volatilities, expressed in daily movements of the underlying, to estimate how expensive an option actually is with respect to the expected realized volatility (at least for short dated ones: from a few days to a few months).

Note on options dynamics:

Options pricing and hedging is a vast domain, going way beyond the scope of this article. In particular, the Gamma (convexity of the green line on Figure 3) and Theta of an option are not constant and are functions of the price factors (S, K, Sigma, r, T). Implied volatilities must be looked at as 'average' values over an option's lifespan. As a result, certain areas have much higher sensitivities to the parameters than others. For example, at the money options (S ~ K) have a higher Gamma than out of the money ones. Short dated options also have a higher Gamma than long dated ones. Combined, at the money, short dated options have the highest risk profile with respect to the underlying price which is why their price (implied volatilities) are the most volatile.

Implied and realized volatilities

1. A developed market: SP500 options

Developed markets are highly liquid and options will tend to trade close to their ‘fair’ value with an abundance of market makers trading implied vs. realized volatilities. For comparison, we looked at S&P500 futures historical volatility between Jan 1st and May 31st, 2020 and compared it with the VIX on a day to day basis. The VIX index represents a live picture of 30-day implied volatilities from listed options [3]. We computed the historical volatility as the standard deviation of returns as per the usual practice, but other methods can be used leading to different interpretations (as analyzed in our previous article: **Bitcoin Historical Volatility — Why the Calculation Method Matter**.

$$r_t = \ln(P_t/P_{t-1})$$

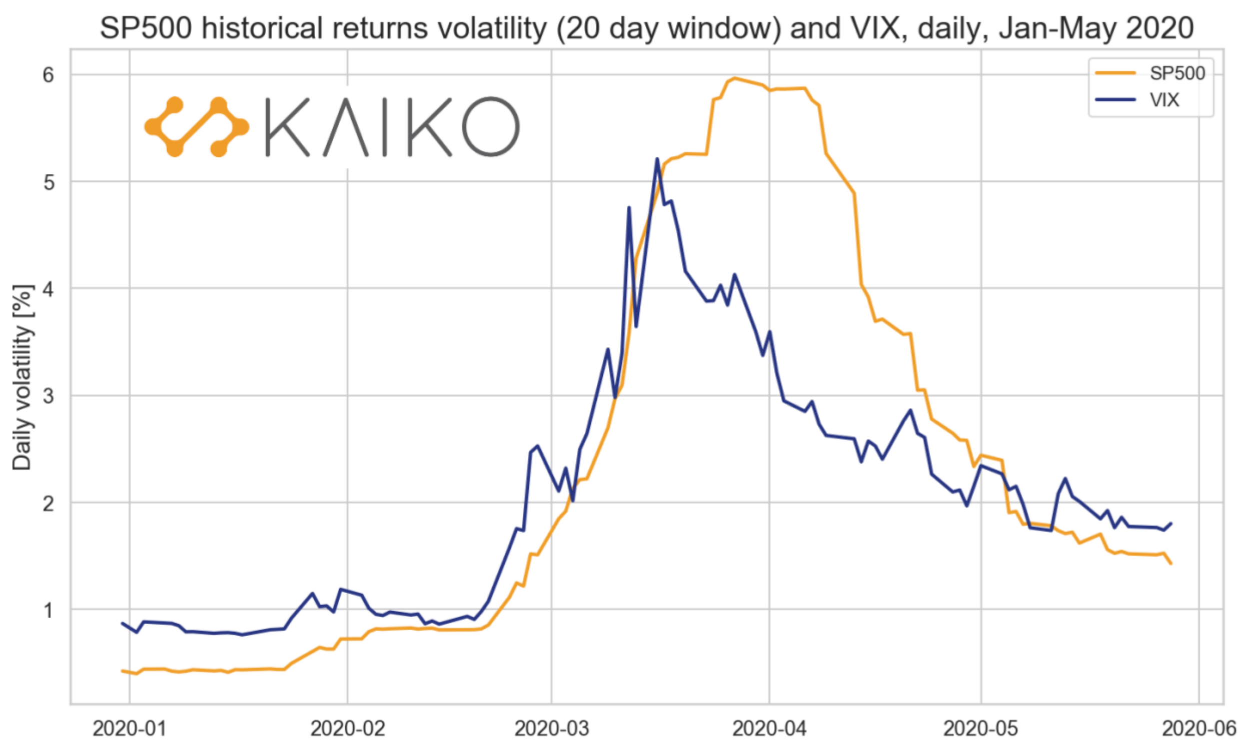

Figure 4: 20-day SP500 log-return standard deviation (historical volatility) vs. VIX index, Source: CME.

Figure 5: VIX to SP500 historical volatility ratio. Source: CME

February and March 2020 brough us extremely high levels of realized volatility for equities (in the order of 6% daily for the SP500) on the back of the spread of Covid-19 (Figure 4) The standard deviation of returns went from a 0.5% - 1.0% per day range to a 2.0% - 6.0% range within a few days, before gradually coming down and stabilizing in a 1.5% - 2.0% range towards the end of our sample period. Implied volatility followed through, remaining above the 20-day historical volatility window until mid-March but came back down quickly, trading at a discount (ratio of VIX to realized between 50% and 100%) until early May. This is due to historical volatility being impacted by high initial swings early March that remained within the computation window for 20 days. Actual returns were by then already less volatile with traders selling options and pushing implied volatilities back down.

2. Bitcoin Options

Bitcoin also had its fair share of market moving events over the first months of the year. We had the 'Crypto Black Thursday' of March 12th with a collapse of the market followed by a quick recovery and the Bitcoin halving which did not really live up to the expectations that had been building up in terms of price volatility. As per our analysis of SP500 implied and realized volatilities, we looked at Bitcoin options over the same period (Figure 6).

BTC historical volatility

As per SP500, we computed the historical volatility as the standard deviation of returns (30-day window) for the perpetual contract. We also computed the exponentially weighted moving average (EWMA), building on our previous article regarding historical volatilities [1].

BTC options implied volatility

As a measure of the implied volatilities, we computed for each trading day the average implied volatility for at the money options (ATM):

$$\sigma_{day\ d}^{implied} = \frac{1}{n} \sum_{trade=i}^{n} \sigma_{i,d}^{ATM}$$

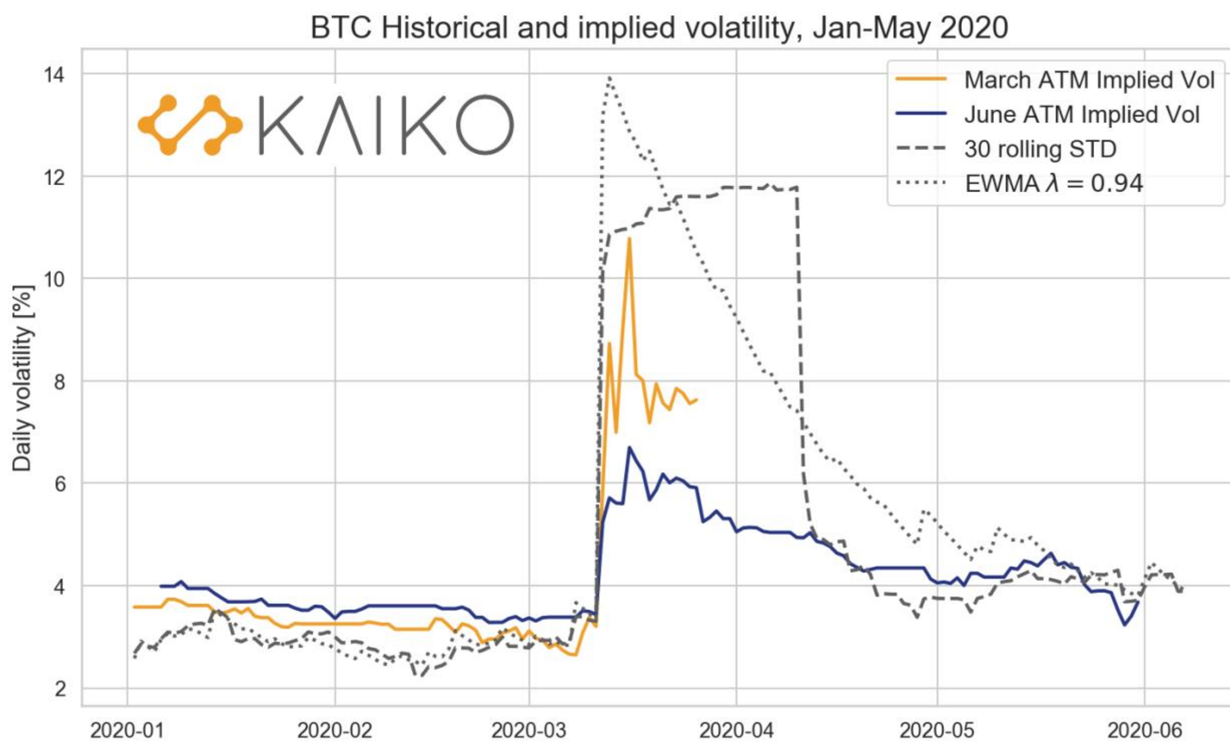

Figure 6, Historical (30-day STD and EWMA) Volatility and Implied (March and June contracts) Volatility. Deribit

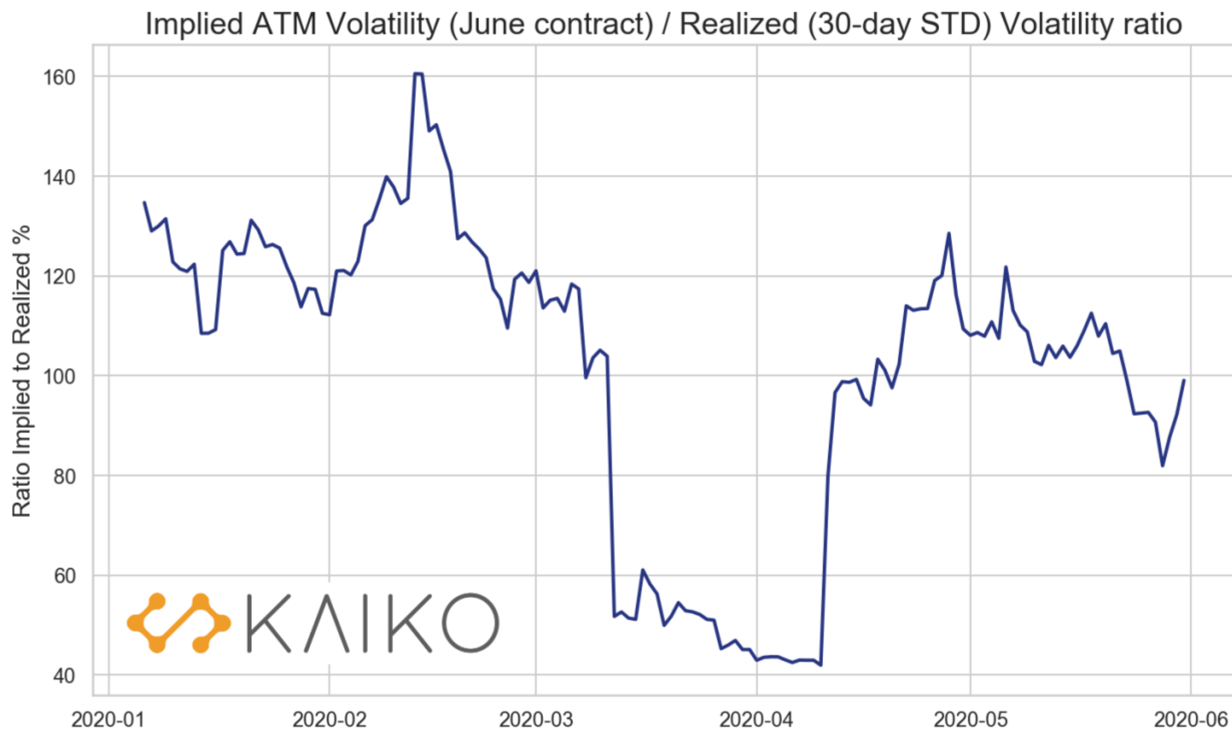

Figure 7: Implied ATM Volatility to realized (30-day) ratio, June contracts. Deribit

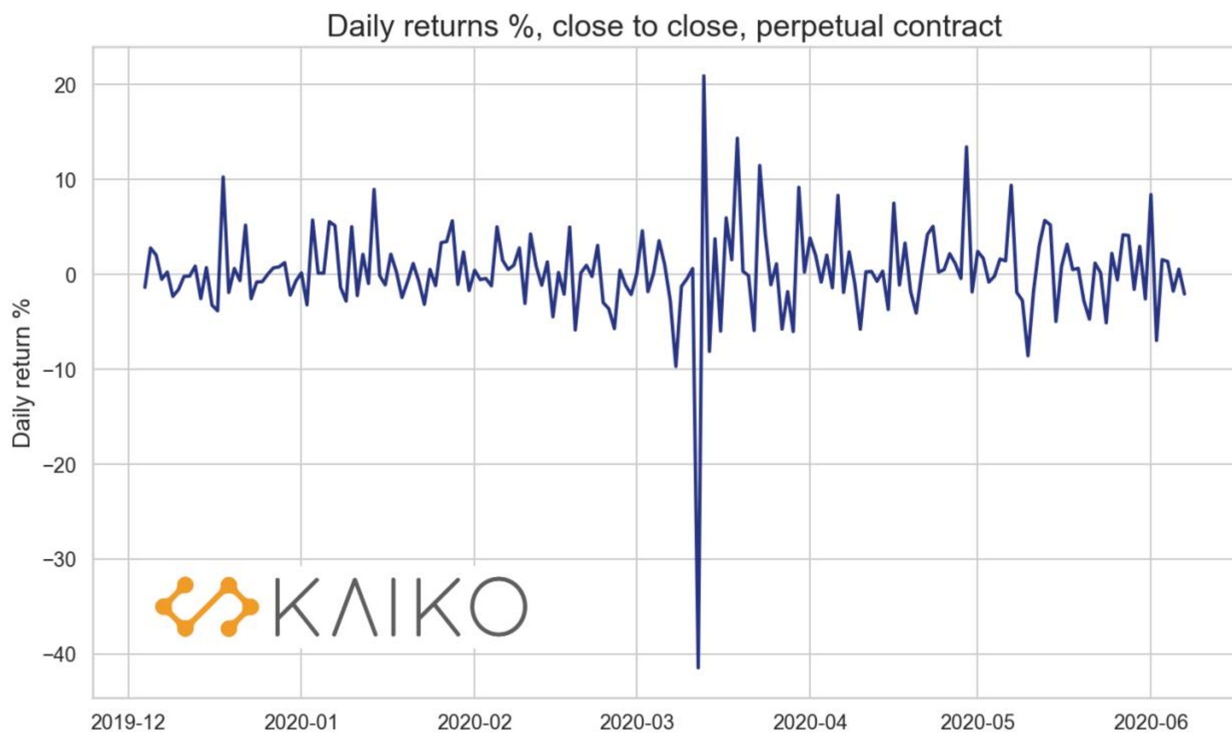

Figure 8: Daily returns %, BTC/USD perpetual contract, close to close. Deribit

Analysis

The realized volatility shows a hump post ‘Black Thursday Crash’, going from a range of 2.5% to 3.5% per day to a range of 10.5% to 12.0% entirely due to the March 12th market drop of nearly 40% (figure 8). Once out of the rolling window, the 30-day standard deviation of log returns came back down around the 4.0% mark where it has remained since then.
The EWMA curve converges back quicker initially but the effect of the single day 40% drop tends to last longer compared to the standard deviation method (past the 30-day window).
ATM implied volatilities did spike on March 12th, reaching a high of about 6.5% per day (June contracts) but started converging back to the 4.0% area within a few days.

Implied volatility curves between the March and June contracts crossed each other during the event. June contracts were initially more expensive in terms of implied volatilities accounting for the added extra time value due to the longer expiry date. Post-crash, March implied volatilities traded much higher (8.0% to 10.0% per day) to account for the extra convexity (Gamma) due to the short remaining time to maturity (about 10 days). (see our note on options dynamics in the first section).

In terms of the ratio of Implied to Realized (Figure 7), we notice that pre-crash, ATM volatilities were trading between 110% and 160% of rolling 30 day realized vols. They dipped below the 60% mark (again due to the one-day event) for 30 days and came back between 80% to 120% of realized vols towards the end of the period. The pattern, magnitude and ranges were remarkably like the ones observed for equity volatilities over the timeframe studied.

Conclusion

The first few months of the year have been eventful for Bitcoin marketwise mostly due to the ‘Crypto Black Thursday’ of March 12th when the market collapsed about 40%, followed by a prompt recovery. Such an extreme shock presented a good opportunity to investigate the behavior of the options market in terms of volatility pricing.
We observed that after the initial shock, implied volatilities of at the money (ATM) options did converge back in a short period of time, showing a constant supply from market makers willing to trade Gamma in this volatile environment.
We also found out that pre- and post-crash periods showed implied to realized volatility ratios averaging around 110% to 120%, of the same magnitude of the other developed market we looked at: SP500 options.

Despite their still recent introduction, Bitcoin options (as traded on Deribit per our dataset) showed clear signs of maturity both in terms of costs (implied to realized ratios) and trading behavior post shock (in our case a 40% drop).

References

[1] Bitcoin Historical Volatility — Why the Calculation Method Matters

[2] https://en.wikipedia.org/wiki/Black%E2%80%93Scholes_model

[3] https://www.investopedia.com/terms/v/vix.asp

[*] Excluding higher order terms