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The Behavior of Bitcoin Implied Volatility

Implications for exchange-traded products and delta-hedging options.

Bitcoin (BTC) is a purely speculative asset. Its price is constantly being manipulated using trading strategies that are illegal in the US, Europe, and most other jurisdictions that regulate financial markets.  

The professional traders that engage in these activities would be jailed for many years if their activities were not confined to the so-called ‘self-regulated’ exchanges that are registered in places where such rules do not apply. I write having just witnessed its fourth major price bubble in 10 years: BTC is currently trading at around US$20,000, down from an all-time high of US$70,000 in November 2021. This latest crash was started by a coordinated attack on the Terra/Luna algorithmic stablecoin in the second week of May, followed by (and rumors say linked to) a credit crisis in the Celsius network. The latest insolvency is of hedge fund Three Arrows Capital (3AC). The automatic liquidation by the Deribit options exchange of some very large bitcoin and ether option positions was succeeded by Deribit starting bankruptcy proceedings to recover at least part of the $80m loan it made to 3AC. And as I write this (in early July) Voyager, another crypto broker-dealer involved in borrowing digital assets in exchange for extremely high yields (up to 12%) is about to reach insolvency after issuing a default notice to 3AC for failing to make payments on loans amounting to about $674m.  

As a result of these ongoing shenanigans the price of bitcoin is excessively volatile. Indeed, bitcoin is probably the most volatile asset in many Trad-Fi portfolios. I’ve taken a personal interest in crypto for a long time – which is not surprising given my enduring interests in both novelty and volatility. In fact, months, if not years, before commercial providers started to offer bitcoin options data, my Ph.D. student Arben Imeraj began using the Deribit API (such as it is) to download 15-minute snapshots of all bitcoin options trades. Using these data, Alexander and Imeraj (2021) compute a term structure of VIX-type bitcoin implied volatility indices and analyze the determinants of the bitcoin variance risk premium. Subsequently, we built the first live-streamed bitcoin implied volatility index (BVIN), which was launched by CryptoCompare in 2020. The BVIN reached 120% during the June 2022 market crash. Even through the relatively tranquil periods earlier this year, the index rested at around 60%. To put this in context, after the recent market turmoil following the FOMC’s rate rise of 75 basis points in June 2022, the S&P500 VIX only jumped up to 30%.  

Since January this year, the total open interest on all bitcoin option contracts has fluctuated between about US$5 billion and US$10 billion, with monthly trading volumes between US$15 billion and US$23 billion. Over 90% of this activity takes place on a platform called Deribit, which is one of several so-called ‘self-regulated’ centralized crypto derivatives exchanges. Originally registered in the Netherlands, in February 2020, the exchange moved to Panama in order to avoid compliance with the European Anti-Money Laundering Directive, 5AMLD. As a result, its clients continue to retain anonymity, with identities linked only to their wallet addresses. Also, the exchange is not required to make any report on suspicious activity of any type, including market manipulation. Like numerous other ‘self-regulated’ crypto exchanges, Deribit trades 24/7. As well as European options on bitcoin, it offers similar products on ether, as well as calendar and perpetual futures. But the Deribit futures market is relatively small; indeed their futures are
mainly used for delta-hedging their options.

Deribit bitcoin options are inverse products, meaning that they are margined and settled in BTC, but they are quoted against the US dollar (USD) just like standard options. Their attraction lies in being able to trade on Deribit without any fiat currency — in fact, all deposits to Deribit must be in BTC. To obtain the option pay-off, one needs to calculate the difference between the BTC value in USD and the option strike (also quoted in USD) and convert the result to bitcoin using the settlement price index value at maturity. The underlying price for Deribit bitcoin options is an index of BTC spot prices from the major centralized crypto exchanges, and the settlement price is a 30-minute average of this index. In addition to quarterly expires up to 12 months ahead Deribit issues new options with 1-day, 2-day, 1-week, 2-week, and 3-week expiries, and new series are added on Deribit when the underlying price rises above the highest or below the lowest strike available.

To examine the dynamics of bitcoin implied volatility, we take the last traded bitcoin option price at 00:00 UTC every day to calculate a term structure of implied volatility indices at 10, 20, 30, 60, and 90 days. The evolution of this term structure since January 2020 is depicted in Figure 1. On March 13, 2020, the 10-day BVIN exceeded 200%. This was just after bitcoin spot prices fell over 30% in a few hours during the 'black Thursday' crash. At this point in time, the term structure was in strong contango, with the 90-day BVIN registering around 125%. The next BVIN peak was not until 2021, and this time it corresponded to upward jumps in the bitcoin price, which rose from about US$23,000 on January 22 to over US$40,000 on February 19, 2021. Again, quite unlike equity volatility. But the next hike in bitcoin volatility again occurred during a crash. This was on
May 19, 2021, when numerous retail investors had their highly-leveraged positions in crypto futures automatically liquidated—a debacle that has resulted in some high-profile class-action lawsuits.

Figure 2 illustrates the evolution of the bitcoin smile over the same period, i.e., January 1, 2020, until May 31, 2022. The moneyness axis represents the liquid range of synthetic 30-day options, from out-of-the-money (OTM) puts with moneyness 0.7 to OTM calls with moneyness 1.3. On each day, we interpolate the implied volatility surface using shape-preserving, piecewise cubic Hermite polynomials and check the prices afterward to ensure the no-arbitrage constraint for convexity with respect to strike holds. To avoid any calendar arbitrage possibilities, we also ensured the total implied variance was always increasing with maturity. From Figure 2, we see that the bitcoin implied volatility curve changes shape much more often than equity volatility skews. A negative skew is apparent on Black Thursday, and again in May 2021 and in May 2022. But positive skews also occur (e.g., in February 2021) and very often the curve takes on a flat, symmetric smile shape rather like the implied volatility curves for foreign exchange options.

Most of the research on dynamic delta hedging has been done on equity index options. But, given the very different features of implied volatilities that we have observed here, we might ask—how well do the findings from the equity option hedging literature translate into bitcoin options? Alexander and Imeraj (2021) analyze the robust dynamic delta hedging of bitcoin options using a set of smile-implied and other smile-adjusted deltas that are either model-free, in the sense that they are the same for every scale-invariant stochastic and/or local volatility model, or they are based on simple regime-dependent parameterizations of local volatility. About 80% of trading activity is on expires of less than four weeks, so the paper focuses on comparing the hedging performance of different smile-adjusted deltas with synthetic constant maturities of 10, 20, and 30 days for a wide range of OTM call and put options.

We find that there are periods when the sticky-moneyness delta significantly outperforms the standard Black-Scholes delta. The minimum-variance delta is also better than Black-Scholes, but only for at-the-money (ATM) options where it coincides with the sticky-tree delta. Efficiency gains from smile-adjusted delta-hedging can exceed 30% for OTM puts, and average about 15% when hedging short-term OTM calls during periods when the implied volatility curve slopes upwards. The advantage of using the perpetual contract as the hedging instrument (instead of the calendar futures of the same maturity as the option) is especially evident for the longer-term contracts where the basis on calendar futures is still rather large.

An alternative view of Figure 2 is presented in the upper graph of Figure 3. This clearly shows that the minimum of the implied volatility curve almost always occurs at the ATM strike. The typical shape is an asymmetric smile with deep OTM puts having higher volatilities than deep OTM calls, but all volatilities move along with ATM vol-

[Figure 3: Implied Volatilities and At-The-Money Deviations. 30-day implied volatilities by moneyness (above), and their at-the-money deviations (below) measured as the difference between a fixed-moneyness volatility and the at-the-money volatility.]
Trading on ‘self-regulated’ exchanges does not prevent fraudulent and manipulative acts and practices, and neither does it protect investors and the public interest

atility in a highly correlated fashion. The lower graph of Figure 3 presents the same information, but in deviation form, i.e., we take the difference between the fixed-moneyness volatility and the ATM volatility. It would not be easy to model these deviations using statistical factor analysis. Once more, bitcoin volatilities behave unlike equity index options where one only needs to build a model to forecast ATM volatility in order to predict the entire surface using ATM deviations (Alexander, 2008). Instead, one might consider applying machine learning techniques such as the LSTM model, not only the 30-day volatilities depicted in the upper graph of Figure 3, as described by Bloch and Book (2022).

The term structure of bitcoin implied volatilities still has regular swings between high-volatility periods of backwardation and relatively calm periods of contango. This behavior is similar to commodity options but quite unlike equity options – for instance, the VIX term structure rarely remains in backwardation for longer than a few days. The reason for this is that investors in the VXX volatility exchange-traded products use the opportunity of a sharp rise in volatility to redeem, so the exchange-traded product (ETP) market makers sell their hedges in VIX futures, thus creating a downward pressure on the VIX itself.

The bitcoin ETP market is still at a very early stage. In the US, the SEC has only approved ETPs on the bitcoin implied volatility platform during periods when the ‘self-regulated’ exchanges remain open. Bitcoin spot ETP applications have been refused by the SEC (but not market regulators in other countries) because their trading on ‘self-regulated’ exchanges does not prevent fraudulent and manipulative acts and practices, and neither does it protect investors and the public interest.

I hope Gary Gensler and Dan Berkowitz have the sense to deny applications for bitcoin implied volatility index futures and the suite of bitcoin volatility ETPs that would no doubt ensue because the market making in these products would have the same effect on the bitcoin implied volatility term structure as they have had on the S&P 500 – i.e. mass redemptions would ensure as soon as the curve moves into backwardation, bringing it back into contango almost immediately.

ETPs on bitcoin implied volatility futures may seem attractive – because their price should increase when the bitcoin spot price crashes and when it jumps upward, as in February 2021. But they could catch a large bunch of uninformed would-be investors who seek their insurance value yet do not understand the effect these products would have on the curve’s backwardation behavior. To approve such products would, in my view, be a recipe for disaster.

REFERENCES

ENDNOTES
2. These events have received a huge amount of media coverage. See, for instance, Nansen Analytics (https://www.nansen.ai/research/on-chain-forensics/demystifying-terrausd-de-peg), and The Guardian (https://www.theguardian.com/technology/2022/jun/29/crypto-crisis-digital-currencies-boom-collapse-bitcoin-terra) and The FT (https://www.ft.com/content/2a250cc7-34df-481c-83f2-7c637165811c) and Reuters (https://www.reuters.com/technology/crypto-lender-voyager-files-bankruptcy-2022-07-06). Also see Alexander, Deng and Zou (2021) for an explanation of leverage selection and automatic liquidation on ‘self-regulated’ crypto derivatives exchanges and its effect on optimal hedging.
3. See historical values and live BVIN updates here. (https://www.cryptocompare.com/indices/bvin/)
4. Data and analytics on these and other useful statistics are available from www.theblock.co and www.skew.com.
7. The calculation is identical to that for a foreign exchange option, but the theoretical validity of this approach is questionable. See my paper with Chen and Imeraj on Inverse Options.

About the Author
Carol Alexander is an expert in crypto asset and derivatives markets, financial risk analysis, high-frequency data analysis, blockchains, pricing and hedging financial instruments, volatility analysis, investment strategies, benchmarking and portfolio management. She has had a dual career in both industry and as an academic and is currently Professor of Finance at the University of Sussex and Visiting Professor at Peking University Business School.