Implied Volatilities

Computation methodology

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www.kaiko.com

Crypto Implied Volatilities

Computing implied volatilities for crypto options can be a difficult task due to a lack of liquidity and standardized instruments. This document describes the methodology used by Kaiko to overcome these issues.

Kaiko as an independent data provider is committed to publishing robust, accurate, and transparent Implied Volatility data feeds.

Kaiko IV suite

Derivatives analytics

Quantitative data tailored to the cryptocurrency derivatives market

The Kaiko Implied Volatility products are a suite of services allowing the computation of crypto options analytics, such as implied volatility and greeks. Our methodology is data-driven and tailored to the crypto options market to compute accurate and robust implied volatilities especially when they are liquidity issues (small trade volumes, missing quotes, or large bid/ask spreads).

IV Smile

Implied Volatility Smiles

Volatility curve of listed expiry dates computed for a set of strike prices. Our methodology includes space interpolation, allowing a consistent computation of implied volatilities on non-listed strikes.

IV Surface

Implied Volatility Surfaces

Implied volatility computation covering a range of expiry dates and strikes. Our methodology includes space and time interpolation, allowing a consistent computation of implied volatilities on any set of parameters and for any rolling option.

Technical documentation

The technical Rest API documentation for both products is available here:

https://docs.kaiko.com/v/kaiko-rest-api/analytics/implied-volatility

Data coverage & distribution

Available on BTC, and ETH options (new assets will be added as soon as enough liquidity is available on the market).

Single exchange IVs and market consensus IVs are both available.

Hourly updates.

Historical and Live IV.

Distributed through REST APIs.

Introduction

The crypto options market

Current state of the market

Derivatives to hedge risks, speculate, and leverage in a evolving market.

A nascent market, constantly evolving.

As crypto markets are much more volatile than traditional assets markets, the demand for derivatives products has increased over the past years. The first futures contracts emerged in 2011 but the real derivatives boom only occurred in 2016 with the invention of perpetual swaps and the first option contracts launched by Deribit, quickly followed by CME, Binance and several others.

Today, the crypto options market is growing, but it is still in its infancy and it is constantly evolving. As far as exchanges are concerned, the market is still largely dominated by Deribit which holds the majority of the market share in terms of volume (between 80% to 90% depending on the underlying), followed by players such as CME Group, Binance, OKX, or more recently Delta Exchange. And while we have seen new decentralized protocols offering crypto options (e.g. Ribbon) emerge, liquidity is not yet available on these protocols.

As far as the instruments are concerned, the only options that are truly liquid are vanilla options, they are concentrated on two assets (Bitcoin and Ethereum) and only a few expiration dates.

The challenge of non-standardized derivatives.

A highly fragmented market offering non-standardized instruments.

One of the main challenges of the crypto options market is that the tradable derivatives instruments are not standardized. Over the past months, certain features are becoming more prominent and we believe new platforms are tailoring their financial products to these features. But the heterogeneity of option characteristics between exchanges (expiration date, underlying, settlement rules, etc.), make it very difficult (if not impossible) to find two identical options on distinct exchanges.

In the table below, we have compiled some of the characteristics of the BTC options offered on four major exchanges. In this table, the reader can see the major differences between exchanges. The first, and by far the most important, is the underlying asset. No two exchanges use the same underlying asset: they are mostly proprietary indices based on different underlying pairs (BTC-USD, BTC-USDT or even BTC-USDT Futures). This means that even if two options on two platforms share the same expiration date and strike price, the settlement price could be different on the expiration date. As a result, we can observe a large price difference at the money or in the money, when the expiration date gets closer.

This lack of standardization makes the aggregation of prices and information more complex but also crucial.

	Deribit	CME	Binance	OKX	Delta Exchange
Underlying	Deribit BTC Index	CME Bitcoin Futures	Binance BTCUSDT Spot Index	Okex BTC/USD Index	BTCUSDT Index
Settlement price	“Exercise of an options contract will result in a settlement in BTC immediately after the expiry. The exercise-settlement value is calculated using the average of the Deribit BTC index over the last 30 minutes before the expiry.”	“Deliverable.”	“Cash settlement in USDT. The arithmetic mean of the Spot Price Index during the 0.5 hour preceding the expiration time as indexed by the platform.”	“[Cash settled in BTC]. We average market data of different exchanges in last trading hour for a final settlement price to prevent price manipulations.”	“[Cash settled in USDT]. The settlement price of an options contract is computed using its strike price and the 30 minute TWAP (Time Weighted Average Price) of the index (i.e. spot) price of the underlying asset.”
Available expiries	Up to 12 expiries (from 1D to 1Y).	Up to 10 expiries (from 1M to 1Y).	Up to 5 expiries (from 1D to 1M).	Up to 9 expiries (from 1D to 6M).	Up to 8 expiries (from 1D to 3M).
Expiry hour	08:00 UTC	16:00 UTC	08:00 UTC	08:00 UTC	12:00 UTC
Available strike prices	Strikes for a delta range of +/-0.1 to +/-0.9, so up to approx. [-75%, +1200%] of the underlying price.	Approx. [-75%, +300%] of the underlying price	Approx. 10 strikes (the range width depending on the time to expiry).	Approx. [-15%, +25%] of the underlying price	Between 6 and 15 strikes depending on the expiry.

*Tab.. 1– Main BTC options characteristics**

** The data presented here was extracted from the documentation of the different exchanges in February 2023. Some information may not be up to date.*

Methodology

Implied Volatility computation

A data-driven approach

This section details the steps required to calculate our implied volatility data feeds. An IV data feed is represented by a pair: an underlying asset and a source (which itself can be a single source or a market consensus from several venues).

The following process is repeated for each data feed every hour, ensuring that our indicators are stable and capture market movements.

Computation pipeline from raw data to derivatives analytics.

Step 1 – Data selection

This stage selects from the data set of all options prices from different venues, the best candidates for computing *real-world* implied volatilities.

Step 2 – Implied volatilities computation

This step consists of converting options prices into implied volatilities (or total implied variances). This requires the use of additional variables such as reference prices or discount factors.

Step 3 – Implied volatility smile calibration

Given the computed set of implied volatilities, we calibrate an SVI parameterization for each expiry date. The obtained parameters are used to calculate implied volatility smiles.

Step 4 – Time interpolation

For the *IV Surface* product, we apply a time interpolation step to allow the computation of implied volatilities at any expiry date.

STEP 1

DATA SELECTION

Selection of the exchange platforms

We have selected two platforms as candidates for our IV product: Deribit and OkX. Exchanges are selected based on their liquidity and influence on the market.

Other exchange platforms will be added in the future, as Kaiko's data coverage is enriched.

Considered options prices

Due to the lack of trading activity of some periods, and for some expiration dates or ranges of strikes, we consider option prices from two sources:

- Trades data: using both the price and the volume (for weighting purposes);
- Top of book order book data.

Aggregation of similar options prices

Table 1 in the introduction shows that the aggregation of options prices from different exchanges is theoretically impossible. However, we have decided to still aggregate *similar* (if not identical) options.

This is the case for most of the options listed by the platform Deribit and OkX.

Two options are considered as similar if they share the same:

- Underlying pair (even if the settlement rules are not the same)
- Option type (Call or Put)
- Expiration day
- Expiration type (European or American)
- Strike price

At the end of this step, our data set is composed of options prices from one or several sources.

STEP 2

IMPLIED VOLATILITY COMPUTATION

The Black & Scholes Implied Volatility

Consider a call (or put) with maturity T and strike K on an underlying with forward price F_t^T.
Its implied volatility Σ_K^T is the unique value that, when plugged into the Black-Scholes formula, returns the option's market price C_t :

$$C_t = C^{BS}(t, T, K, F_t^T, r_t, \Sigma_K^T) \qquad (1)$$

We extract implied volatilities from the options prices in our data set using the Newton-Raphson method.

In traditional finance, r_t, which represents a risk-free rate and is used to compute a discount factor D_t^T, can be considered as a raw financial data. Currently, there is no equivalent notion on crypto markets, and we detail below how we estimate discount factors.

Forward price and discount factor computation

In the crypto setting, there are not necessarily any forward instruments for the options under consideration and it may be unclear how to determine the value of F_t^T.

We choose to derive this value using the Interest Rate Parity Relation (IRP):

$$F_t^T = S_t D_t^T \quad (2)$$

The computation of implied volatilities thus boils down to determining the required discount factors.

Discount factors are obtained by using the IRP relation on available delta-one instruments. Their quotients with the underlying spot are aggregated on a 1-day time window, and the resulting discount factor is assumed to be constant on the entire day. The prices of the delta-one instruments are extracted from trades data, and those of the underlying spot are provided by the corresponding KAIKO Reference Rate. Forward values at expiry dates that do not correspond to any data point are obtained by a linear interpolation.

From prices to weighted implied volatilities

We transform our set of data prices made at step 1 into a set of weighted implied volatilities, using the formula above and the denoising and robustification techniques developed by our quantitative team and detailed in the paper *Unbiasing and robustifying implied volatility calibration in a cryptocurrency market with large bid-ask spreads and missing quotes* [Echenim, Gobet, Maurice].

At the end of this step, our data set is composed of weighted implied volatilities.

STEP 3

IMPLIED VOLATILITY SMILE CALIBRATION

Jump Wings SVI Parameterization

The *Stochastic Volatility Inspired* (SVI) parameterization was first introduced by Merrill Lynch in 1999* and aims to model the total implied variance:

$$\omega_t(k, \tau) := \sigma_t(k, \tau) \cdot \tau$$

as a function of two parameters: the forward log-moneyness k and the time-to-expiry τ.

Several SVI parameterizations exist. We choose to use the *Jump Wings SVI Parameterizations* (inspired by a similar parameterization attributed to Tim Klassen, then at Goldman Sachs), because its parameters can be interpreted financially.

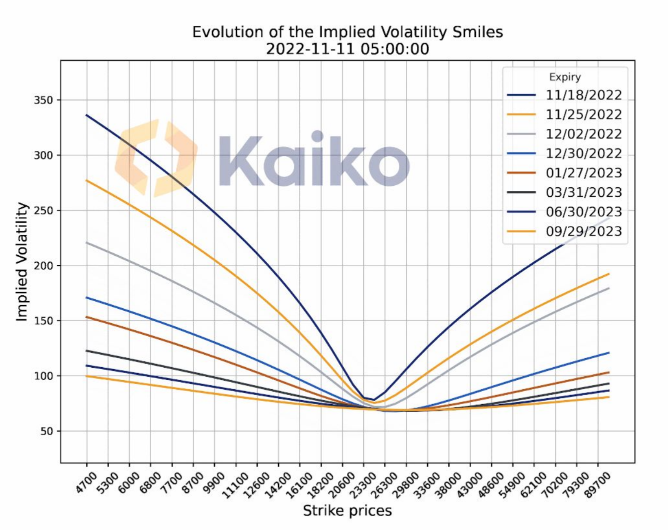
**Gatheral, J., "A parsimonious arbitrage-free implied volatility parameterization with application to the valuation of volatility derivatives", Presentation at* Global Derivatives*, 2004.*

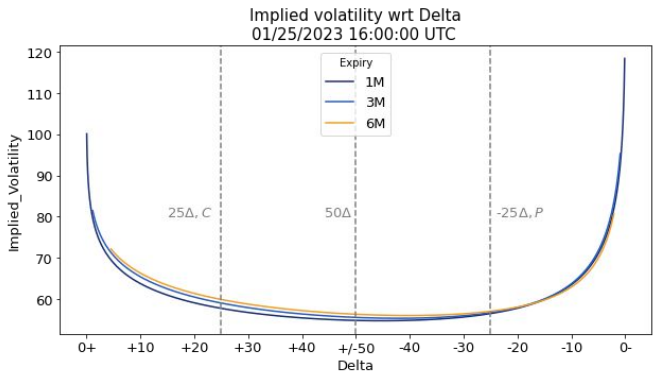
SVI Calibration

For each listed expiry date, we calibrate a Jump Wings SVI parameterization using the weighted implied volatilities from the previous step and adding a penalty term to prevent arbitrages.

At the end of this stage, we have a set of parameters for each listed expiry. These parameters can be used to compute an implied volatility for any strike (or forward log-moneyness) and listed expiration date.

Examples of IVs smiles wrt strike or delta





STEP 4

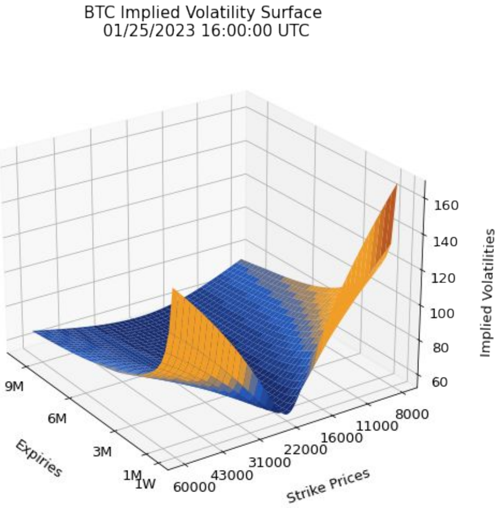
TIME INTERPOLATION

From a set of IV smiles to an IV surface

The implied volatility at an arbitrary expiry date and strike is obtained in two steps: computing the total implied variances at the previous and next expiry dates for the corresponding forward log-moneyness, and performing an interpolation on these variances.

NB: calendar arbitrage is prevented by one of the penalty terms added in the calibration step.

Example of an IV surface wrt strike and expiry



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