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T3 Volatility Indices

Bitcoin Volatility Index

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Bitcoin 30-day volatility index is constructed using BTC option prices, by linearly interpolating between the expected variances of two expirations closest to the 30-day time point, as follows:

$$\sigma = 100 \times \sqrt{\frac{t_1}{t_M}\frac{t_2 - t_M}{t_2 - t_1}\sigma_1^2 + \frac{t_2}{t_M}\frac{t_M - t_1}{t_2 - t_1}\sigma_2^2} \tag{1}$$

Here t_1 and t_2 are times to the option contract settlements (in seconds), and t_M is the number of secons in 30 days.

The variances $\sigma_{1,2}^2$ are calculated using simple variance swap approximation:

$$\sigma_n^2 = \frac{1}{T_n F_n^2}\left[2e^{r_n T_n}\sum_i \Delta K_{n,i} p_{n,i} - (F_n - K_{\text{ATM}n})^2\right] \tag{2}$$

where F is the corresponding forward price (see deatails below), T is time to options settlement (expressed in years); r is risk-free interest rate to expiration; K_{ATM} is at-the-money strike (see details below); K_i and p_i are selected options' strikes and mid prices (puts with strikes below K_{ATM}, calls with strikes above K_{ATM}, and ATM strike, for which an average between put and call prices is used); ΔK_i is average distance from the strike K_i to the two nearest selected options' strikes (or, in the case of the highest and the lowest strikes, distance to the nearest selected strike).

The options expirations to be used in the calculation are selected as the two subsequent expirations, at least three full days ahead in time (as observed at the opening of market on the considered date), which are 1st and 2nd closest to the date 30 days in the future.

For each of the expirations, the options to be used in the calculation are then selected, by removing in-the-money and far out-of-money options. The procedure is as follows:

- Find the at-the-money strike K_{ATM} as the strike with smallest absolute value of call-put price difference.
- Select call options with strikes above or equal to K_{ATM} and put options with strikes below or equal to K_{ATM}.
- Remove all the call (put) options with strikes higher (lower) or equal to the point, when the first strike with bid below $5 is encountered (when moving up (down) from K_{ATM}).

The forward F value for each expiration is implied from call-put price intersection:

- Calculate call-put mid price difference $\delta_{\mathrm{CP}} = p_{\mathrm{C}} - p_{\mathrm{P}}$ for all available stikes.
- If there is a strike for which $\delta_{\mathrm{CP}} = 0$, set F to this strike value. If not, proceed to the next step.
- Select the highest strike with positive and the lowest strike with negative δ_{CP}, K_1 and K_2.
- Calculate forward as $F = \frac{K_1 \delta_{\mathrm{CP}\,2} - K_2 \delta_{\mathrm{CP}\,1}}{\delta_{\mathrm{CP}\,2} - \delta_{\mathrm{CP}\,1}}$

The options' and forward prices, calculated this way, are then used in formula (1) for the final index calculation.

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