Private and Confidential

SPIKES7

SPY 7-day Volatility Index

Triple3 Partners Pty Ltd.

Suite 504, Level 5, 165 Phillip Street, Sydney NSW 2000, Australia.

AFSL 3372 36   ABN 20 135 656 236

T. +61 2 9231 5767   E. vol@triple3p.com   W. triple3p.com

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1. Index Calculation Formula

The SPIKES7 index is constructed using SPY index option prices, by interpolating between the variances of two closest expirations[1] on either side of the point exactly 7 days ahead in time, as follows:

$$\text{SPIKES7} = 100 \times \sqrt{\frac{t_1}{t_W}\frac{t_2 - t_W}{t_2 - t_1}\sigma_1^2 + \frac{t_2}{t_W}\frac{t_W - t_1}{t_2 - t_1}\sigma_2^2} \tag{1}$$

Here t_1 and t_2 are times to option contract settlements (in seconds), and t_W is the number of seconds in 7 days.

Volatilities for the two terms are calculated using variance swap approximation:

$$\sigma = \frac{1}{t}\left[2e^{rt}\sum_i \frac{\Delta K_i p_i}{K_i^2} - \left(\frac{e^{rt}(p^C_{\text{ATM}} - p^P_{\text{ATM}})}{K_{\text{ATM}}}\right)^2\right] \tag{2}$$

where t is time to options settlement (in years); r is risk-free interest rate to expiration; K_{ATM} is at-the-money strike (see details in calculation outline); K_i and p_i are selected options' strikes and 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); $p^C_{\text{ATM}} - p^P_{\text{ATM}}$ is the difference between call and put prices of the ATM options.

2. Options Reference Prices

SPIKES7 uses a proprietary "price dragging" technique to capture live options' prices as inputs for the index calculation. The price inputs that result from price dragging are called Cash Reference Prices (CRPs), and determined as follows:

[1] All standard monthly, quarterly, and Monday, Wednesday and Friday weekly expirations are used.

- Set all CRPs to 0 at SPY options market opening;
- For trades, only consider standard simple single-option trades (no combos). For quotes, only consider NBBO eligible bids and offers. Block trades, out of sequence prints, as well as trades resulting from complex transactions and stopped orders are ignored.
- On the opening quote, the opening bid is used as the CRP;
- When there is a trade, the CRP is set to trade price;
- For newly-placed ask (bid) quotes, if the ask (bid) is lower (higher) than current CRP, the CRP is set to ask (bid).

3. Data Selection

The SPY options' expirations to be used in the calculation are selected from a set of all standard monthly, quarterly, and Monday, Wednesday and Friday weekly expiries. The front expiration is selected as the furtherst expiry which is sooner than or is exactly 7 days ahead in time. The next closest expiration is selected as the back expiration. 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} implied by the option prices, as the strike closest to the point where intersection between call and put price curves occurs (use the lower of the two strikes, if the intersection falls exactly in the middle of two strikes or if the intersection represents a segment).[2]
- 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) than the point, when two optionson consecutive strikes with prices below or equal to 5 cents are first encountered (when moving up (down) from K_{ATM}).The options, selected this way, are then used in formula (1) for the final index calculation.

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DISCLAIMER

[2] In a rare case of low quality prices, when more than one intersection point is observed, the one closest to the current SPY index level is selected.