



Cboe Global Indices

Cboe S&P 500 Spot Volatility Index

METHODOLOGY

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1 Introduction

This document provides a transparent and easily accessible view of the methodology used to calculate the Cboe S&P 500 Spot Volatility Index (SPOTVOL), referred to in this document as “the Index”.

This methodology was developed by Torben G. Andersen and Viktor Todorov.

1.1 Index Objective

The Cboe S&P 500 Spot Volatility Index (SPOTVOL) aims to provide a jump-robust, unbiased estimator of S&P 500 spot volatility. The Index attempts to minimize the upward bias in the Black-Scholes implied volatility (BSIV) and Cboe Volatility Index (VIX) that is attributable to the volatility risk premium.

1.2 Supporting Documentation

This Methodology should be read in conjunction with the following document:

[Cboe_Index_Policies_Practices](#)

2 Index Construction

The construction of the Index is based on the theoretical work of Todorov (2019)¹. Specifically, following Carr and Madan (2001)², Todorov (2019)¹, and Todorov and Zhang (2021)³, it “spans” the risk-neutral conditional characteristic function of the price increment via a portfolio of short-dated out-of-the-money (OTM) S&P 500 (SPX) options and evaluates it at a high value of the characteristic exponent to minimize the impact of jumps.

The estimation is based on the following approximation:

$$\mathcal{L}_{t,T}(u) = \mathbb{E}_t^Q \left(e^{\frac{i u (x_{t+T} - x_t)}{\sqrt{T}}} \right) \approx e^{-\frac{u^2 \sigma_t^2}{2}}, \quad u > 0 \text{ and } T \approx 0$$

where:

- $\mathbb{E}_t^Q$ represents the expectation under the risk-neutral probability;
- x_t is the logarithm of the underlying stock price;
- T is time to maturity;
- i is the imaginary number i ; and
- σ_t^2 is the spot (diffusive) variance at time t .

¹ Todorov, V., “Nonparametric Spot Volatility from Options,” *Annals of Applied Probability* 29, 3590-3636, 2019.

² Carr, P. and Madan, D., “Optimal Positioning in Derivatives Securities,” *Quantitative Finance* 1, 19-37, 2001.

³ Todorov, V. and Zhang, Y., “Information Gains from Using Short-dated Options for Measuring and Forecasting Volatility”, *Journal of Applied Econometrics* 37, 368-391, 2021.

The option portfolio behind the Index weighs near-the-money options heavily, while the weights generally are smaller and declining for strike prices further out-of-the-money.

2.1 Pricing

The market data for the S&P 500 Index option quotes are sourced from the Cboe Options Exchange via the Options Price Reporting Authority (OPRA) feed.

3 Index Calculations

The following describes the methodology for calculating the Index, including applicable formulas and input data.

The Index is constructed based on the near-term and next-term options with time-to-maturity T_{near} and T_{next} :

$$SPOTVOL_t = 100 * \sqrt{\frac{V_{t,T_{near}} + V_{t,T_{next}}}{2}}$$

where:

- $V_{t,T_{near}}$ refers to the spot variance estimator based on near-term options; and
- $V_{t,T_{next}}$ refers to the spot variance estimator based on next-term options.

The option-based spot variance estimator at time t with business daytime-to-maturity T is given by:

$$V_{t,T} = -\frac{2}{T * u_{t,T}^2} \log(|\mathcal{L}_{t,T}(u_{t,T})|)$$

$$\mathcal{L}_{t,T}(u) = 1 - (u^2 + iu) \sum_{j=1}^{N_{t,T}} e^{iu[\log(K_{j-1}) - \log(F_{t,T})]} \left(\frac{O_{t,T}(K_{j-1})}{K_{j-1}^2} \right) \Delta_j$$

We set $u_{t,T} = \min(u_{t,T}^{(1)}, u_{t,T}^{(2)})$:

$$u_{t,T}^{(1)} = \min \{u \geq 0.01 : |\mathcal{L}_{t,T}(u)| \leq 0.2\}$$

$$u_{t,T}^{(2)} = \operatorname{argmin}_{u \in [0.01, \bar{u}_{t,T}]} |\mathcal{L}_{t,T}(u)|$$

$$\bar{u}_{t,T} = \sqrt{\frac{\frac{2}{T} \log\left(\frac{1}{0.05}\right)}{IVM_{t,T}^2}}$$

where:

- $N_{t,T}$ refers to the number of OTM strikes with maturity T;
- $F_{t,T}$ refers to the forward price with maturity T (please refer to section 3.4);
- K_j refers to the strike price;
- $O_{t,T}(K_j)$ refers to the option price for Strike K_j ;
- $\Delta_j = K_j - K_{j-1}$;
- T refers to the business day time-to-maturity (in years); and
- $IVM_{t,T}$ refers to business day implied volatility for the strike closest to the Forward (please refer to section 3.7).

3.1 Identifying Series and Data Filtering:

The Index calculation requires the selection of a near-term and next-term expiration that satisfies both strike and series level quote quality data requirements. All SPX expirations, including weekly options that expire in 3 to 60 business days, are selected in the initial universe. The high upper bound is used to allow for historical calculations during periods when only SPX standard expiries were listed.

In addition, the near and next-term expiries chosen must be no sooner than next weeks' first business day. The near-term time to expiry must be more than 2 business days and more than 4 calendar days. This ensures that the weekend effect is included in all the option-implied spot volatility index calculations. This additional constraint precludes calculating the Index on a Monday and using the same week's Wednesday and Friday expirations.

Only Monday, Wednesday, and Friday SPX expirations are used in the calculation to reduce the impact of higher strike increments observed during Tuesday and Thursday SPX expirations.

3.2 Calculating Time to Expiration

The time to expiry is calculated by finding the minutes of expiry and annualizing it by the number of minutes in 252 days.

$$T = \frac{(M_{Current\ Day} + M_{Settlement\ Day} + M_{Other\ Days})}{362880}$$

where:

- $M_{Current\ Day}$ refers to the minutes remaining until midnight of the current day;
- $M_{Settlement\ Day}$ refers to the minutes from midnight until 9:30 a.m. ET for standard SPX expirations and 4:00 p.m. for weekly SPX expirations; and
- $M_{Other\ Days}$ refers to the minutes in the business days between the current and expiration day.

3.3 Excluding Illiquid Strikes

For each expiration in the initial universe, illiquid option strikes with zero bids or an ask-bid ratio greater than 10 are excluded. The ask-bid ratio is used as an indicator of option chain liquidity as it represents the size of the bid-ask spread a trader must cross.

3.4 Forward Calculation

Like the Cboe Volatility Index, the Cboe S&P 500 Spot Volatility Index is calculated using at-the-money (ATM) and out-of-the-money (OTM) options. These options are identified by calculating the synthetic implied forward using put-call parity. Three near-the-money put call pairs are selected with a minimum absolute put-call price difference to calculate synthetic forwards using put-call parity. The absolute put-call difference will only be calculated for strikes with non-excluded put and call quotes.

The following formula outlines the Synthetic Forward Calculation for Strike K:

$$F_{t,T} = K + e^{rT} * [C_{t,T}(K) - P_{t,T}(K)]$$

where:

- K refers the strike price with the minimum absolute put-call difference;
- $C_{t,T}$ refers to the call option midprice with strike price K and expiry T;
- $P_{t,T}$ refers to the put option midprice with strike price K and expiry T;
- r refers to the 1-month T-bill Rate; and
- T refers to the annualized time to expiry.

The implied forward is calculated by taking the median of the three synthetic forward levels. Using the median provides robustness in terms of identifying the implied forward level. The ATM strike is then identified by taking the strike price directly below the implied forward. The ATM option is the call or put option with strike equal or immediately below the forward price, and if there are both call and put options at the ATM strike, the put option is used.

3.5 Selecting Near and Next-Term Expirations

Out-of-the-money series for each expiration are identified using the ATM strike. Expirations with fewer than three OTM series are excluded. These exclusions are made to meet sufficient data requirements.

The near and next-term expirations are determined by taking the two expirations with the smallest time to expiry.

3.6 Linearly Interpolating Strikes

To minimize the approximation error in computing the characteristic function $\mathcal{L}_{t,T}(\hat{u}_{t,T})$ attributable to an uneven strike price grid, strike price gaps with $\Delta K = \$5$ are filled by linearly interpolating the Black-Scholes implied volatility.

The first step involves determining implied volatilities for the valid option premiums using the Black-Scholes formula. Subsequently, uneven strike gaps of greater than \$5 are identified and the implied volatilities are

interpolated to cover the theoretical strikes added. Finally, using Black-Scholes on the added theoretical strikes implied volatilities, option prices are calculated.

3.7 Determination of IVM

$IVM_{t,T}$ represents the business day implied volatility at the implied forward theoretical strike. It is estimated by taking the weighted average of the implied volatility of the largest strike OTM put option and the lowest strike OTM call option.

$$IVM_{t,T} = \frac{F_{t,T} - K_p}{K_C - K_p} * \sigma_{t,T}^C(K_C) + \frac{K_C - F_{t,T}}{K_C - K_p} * \sigma_{t,T}^P(K_P)$$

where:

- K_C refers to the nearest-ATM call option strike;
- K_P refers to the nearest-ATM put option strike;
- $\sigma_{t,T}^C(K_C)$ refers to the business day call option implied volatility with strike K_C and expiry T ; and
- $\sigma_{t,T}^P(K_P)$ refers to the business day put option implied volatility with strike K_P and expiry T .

The nearest-ATM put, and call option implied volatilities are calculated by inverting the Black-Scholes.

4 Calculation and Dissemination

The Index is calculated and disseminated as follows on each Business Day. A Business Day is defined as a day when the Cboe Options Exchange is open for the Cboe Regular Trading Hours (RTH) session. The Index follows the Cboe Options Exchange holiday schedule.

Index Name	Index Ticker	Dissemination Frequency	Dissemination Hours
Cboe S&P 500 Spot Volatility Index	SPOTVOL	15 Seconds	Between 9:30 a.m. and 4:15 p.m. ET

5 Index Information

Index Name	Index Ticker	Base Date	Launch Date	Base Value	Currency
Cboe S&P 500 Spot Volatility Index	SPOTVOL	January 3, 2006	March 14, 2024	n/a	USD

6 Appendix 1 – Changes

Major changes described in this document since March 14, 2024 are as follows:

Change Summary	Effective Date	Previous Language	Updated Language
-	-	-	-

7 Appendix 2 – Document Information

Version Number	1.1
Last Revised Date	May 9, 2025

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