S&P Dow Jones Indices

A Division of S&P Global

S&P/JPX JGB VIX
Methodology

November 2024

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Introduction

Index Objective and Highlights

The S&P/JPX JGB VIX uses the VIX®[1] methodology to measure the fair market value of a constant 30-day forward volatility of 10-year JGB futures prices. While options have various expirations, the VIX indicates the implied volatility of the fixed 30-day period that is implied by the near-term and next-term options.

The index uses put and call options on the 10-year JGB futures to calculate the implied volatility, which differs from at-the-money (ATM) implied volatility in that it captures volatility across all strikes contained in the skew of out-of-the-money (OTM) option prices and represents a model-free and "strikeless" volatility measure.

Supporting Documents

This methodology is meant to be read in conjunction with supporting documents providing greater detail with respect to the policies, procedures and calculations described herein. References throughout the methodology direct the reader to the relevant supporting document for further information on a specific topic. The list of the main supplemental documents for this methodology and the hyperlinks to those documents is as follows:

Supporting Document	URL
S&P Dow Jones Indices' Options Indices Policies & Practices Methodology	Options Indices Policies & Practices Methodology
S&P Dow Jones Indices' Index Mathematics Methodology	Index Mathematics Methodology

This methodology was created by S&P Dow Jones Indices to achieve the aforementioned objective of measuring the underlying interest of each index governed by this methodology document. Any changes to or deviations from this methodology are made in the sole judgment and discretion of S&P Dow Jones Indices so that the index continues to achieve its objective.

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[1] The VIX® methodology is the property of the Cboe Exchange, Inc. ("Cboe"). Cboe has granted S&P Dow Jones Indices a license to use the VIX methodology to create the S&P/JPX JGB VIX. Cboe is the appointed calculation agent for the S&P/JPX JGB VIX and S&P Dow Jones Indices distributes the index level.

Index Construction

Approaches

The S&P/JPX JGB VIX is derived from the near-term and next-term options on 10-year JGB futures. The next-term options are usually the second month. When the second month options are not available, the index will use the third month options instead.

Deriving VIX from Near-term and Next-term Options

The Osaka Exchange (OSE) lists options in a quarterly March-June-September-December cycle with an additional one or two of the closest serial months. Each option expires on the last trading day of the month prior to its expiry month. The S&P/JPX JGB VIX uses put and call options in the two nearest-term expiration months in order to bracket a 30-day calendar period. After the first month contract expires, the original second month contract becomes the first month; the index then uses the original third month contract which becomes the second month.

For each maturity, put and call options are used to calculate the implied volatility. The detailed calculation is described in the next section.

The near-term volatility, σ_1, and the next-term volatility, σ_2, are interpolated to arrive at a single volatility value, σ, with a constant maturity of 30 days to expiration. The S&P/JPX JGB VIX is derived by taking σ (the square root of σ^2) and multiplying by 100.

$$VIX = \sigma * 100$$

(1)

$$\sigma^2 = \frac{N_y}{N_m}\left\{T_1\sigma_1^2\left[\frac{N_{T_2} - N_m}{N_{T_2} - N_{T_1}}\right] + T_2\sigma_2^2\left[\frac{N_m - N_{T_1}}{N_{T_2} - N_{T_1}}\right]\right\}$$

where:

- σ = 30-day implied volatility
- σ_1 = Near-term volatility derived from the near-term options (see *formula 2*)
- σ_2 = Next-term volatility derived from the next-term options (see *formula 2*)
- N_y = Number of days in one year
- N_m = Number of days in one month
- T_1 = Time to expiration (in years) of the near-term options
- T_2 = Time to expiration (in years) of the next-term options
- N_{T1} = Number of days between the current day and the expiration date of the near-term options
- N_{T2} = Number of days between the current day and the expiration date of the next-term options

Risk Free Rates

The Japan government bond zero one-month rate is used as the risk free rate for both near- and next-term maturities. If the interest rate is less than zero, the index uses zero as the risk free rate in the calculation.

General Formula to Calculate Implied Volatilities

For the near-term and the next-term, respectively, implied volatilities are calculated using both option puts and calls. The general formula is:

$$\sigma^2 = \frac{2}{T}\sum_i \frac{\Delta K_i}{K_i^2} e^{RT} Q(K_i) - \frac{1}{T}\left[\frac{F}{K_0} - 1\right]^2 \quad (2)$$

where:

σ = Implied volatility

T = Time to option expiration

F = Underlying JGB futures price

K_i = Strike price of the i^{th} out-of-the-money option

ΔK_i = Interval between strike prices (see *formula 3*)

K_0 = Strike closest to F

R = Risk free interest rate to expiration

$Q(K_i)$ = Settlement price of each option with strike K_i

K_0 is the strike price closest to the JGB futures price, F. If equidistant, K_0 is the lower of the two strikes.

To select the options in the volatility calculation,

- Sort all the options in ascending order by strike prices.
- Select call options above K_0, including the first strike for which the settlement price is 0 or 0.01, if any.
- Select put options below K_0, including the first strike for which the settlement price is 0 or 0.01, if any.
- Select both put and call options at K_0, and use the average as the settlement price $Q(K_0,)$ in the above equation. If only a call or put option exists at K_0, use only the available price as $Q(K_0)$.

Generally, ΔK_i is half the distance between the strike on either side of K_i and is calculated as follows:

$$\Delta K_i = \frac{K_{i+1} - K_{i-1}}{2} \quad (3)$$

At the upper and lower edges of any given strip of options, ΔKi is simply the difference between K_i and the adjacent strike price.

Contract Rebalancing

After the first month contract expires, the original second month contract becomes the first month; the index then uses the original third month contract which becomes the second month.

History Availability

Index history availability is shown in the table below.

Index	Launch Date	First Value Date
S&P/JPX JGB VIX (End-of-Day)	10/02/2015	01/15/2008
S&P/JPX JGB VIX (Real-Time)	07/10/2019	--

Index Governance

Index Committee

The S&P/JPX JGB VIX Index Committee maintains the index. S&P Dow Jones Indices chairs the Committee, which is comprised of members representing both S&P Dow Jones Indices and JPX Market Innovation & Research. The Committee meets regularly. At each meeting, the Committee reviews any significant market events. In addition, the Committee may revise index policies, including all matters relating to index construction, maintenance, or other matters.

S&P Dow Jones Indices considers information about changes to its indices and related matters to be potentially market moving and material. Therefore, all Index Committee discussions are confidential.

S&P Dow Jones Indices' Index Committees reserve the right to make exceptions when applying the methodology if the need arises. In any scenario where the treatment differs from the general rules stated in this document or supplemental documents, clients will receive sufficient notice, whenever possible.

In addition to the daily governance of indices and maintenance of index methodologies, at least once within any 12-month period, the Index Committee reviews the methodology to ensure the indices continue to achieve the stated objectives, and that the data and methodology remain effective. In certain instances, S&P Dow Jones Indices may publish a consultation inviting comments from external parties.

For information on Quality Assurance and Internal Reviews of Methodology, please refer to S&P Dow Jones Indices' Options Indices Policies & Practices Methodology.

Index Policy

Announcements

All methodology changes are posted to S&P Dow Jones Indices' Web site and announced via email to all clients. The latest available methodology is posted on the Web site at *www.spglobal.com/spdji/*.

Announcements of the daily index values are made after the market close each business day.

For more information on S&P Dow Jones Indices' announcements, please refer to the Announcement Policy located on our Web site, www.spglobal.com/spdji/.

Holiday Schedule

The index is calculated daily when the Osaka Exchange is open, excluding holidays and weekends.

A complete holiday schedule for the year is available at www.spglobal.com/spdji/.

Unexpected Exchange Closures

In situations where an exchange is forced to close early due to unforeseen events, such as computer or electric power failures, weather conditions or other events, S&P Dow Jones Indices calculates the value of the index based on most recent option price published by the Osaka Exchange. If the exchange fails to open due to unforeseen circumstances, S&P Dow Jones Indices may determine not to publish the index for that day.

For further information on Unexpected Exchange Closures, please refer to S&P Dow Jones Indices' Options Indices Policies & Practices Methodology.

Recalculation Policy

For more information on the recalculation policy and Error Correction, please refer to S&P Dow Jones Indices' Options Indices Policies & Practices Methodology.

For information on Calculations and Pricing Disruptions, Market Disruption Events, and Holidays during Roll Period, Expert Judgment, and Data Hierarchy, please refer to S&P Dow Jones Indices' Options Indices Policies & Practices Methodology.

Contact Information

For questions regarding an index, please contact: index_services@spglobal.com.

Index Dissemination

Index levels are available through S&P Dow Jones Indices' Web site at *www.spglobal.com/spdji/,* major quote vendors (see codes below), numerous investment-oriented Web sites, and various print and electronic media.

Tickers

The table below lists headline indices covered by this document. All versions of the below indices that may exist are also covered by this document. Please refer to *S&P DJI's All Indices by Methodology Report* for a complete list of indices covered by this document.

Index	BBG	RIC
S&P/JPX JGB VIX (End-of-Day)	SPJGBV	.SPJGBV
S&P/JPX JGB VIX (Real-Time)	SPJGBVRT	.SPJGBVRT

Index Data

Index level data is available via subscription.

For product information, please contact S&P Dow Jones Indices, www.spglobal.com/spdji/en/contact-us.

Web site

For further information, please refer to S&P Dow Jones Indices' Web site at www.spglobal.com/spdji/.

Appendix A

Real Time Calculations

The index is calculated and published every 15 seconds based on the same formula as the daily index calculations applied to live best bid and offer (BBO) quotes from the limit order book for near- and next-month options. The next-month options are usually the second month. When the second month options are not available, the index will use the third month options instead.

One complication that arises at times is the absence of quoting activity for a sufficient set of options to calculate the index intraday. To handle this issue, the index uses a simple volatility curve-based model to estimate theoretical prices for all options every 15 seconds, which are used to fill missing prices. The specification of the volatility curve-based model is intended to keep the pricing close to the settlement prices provided by the exchange.

Real-time calculations are published between 8:46:00 – 11:00:00 and 12:31:00 – 15:00:00 JST.

Calibrating The Implied Volatility Surface At Market Open. At the beginning of each day, take the implied volatility curves calibrated to the previous day's settlement prices as the starting shape of the curves for that day. Implied volatility curves for near-term, next-term, call, and put options are maintained separately to best match settlement prices. The index uses the Black model[2] to derive implied volatility of each option.

To calibrate the curves:

1. At the beginning of each day, calculate implied volatilities based on the previous day's settlement prices.
2. At the beginning of each month, the volatility curve calibrated to the previous day's settlement prices of the next-term options is used as the volatility curve for the near-term options at the start of the day since the next-term becomes the near-term that day.
3. At the beginning of each month, for newly listed next-term options, set the volatility curve equal to the near-term volatility curve parallel shifted downwards by 0.1%.
4. On a roll date (end of the month), the instrument used for near-term and next-term should be the same as the instruments included in the settlement calculation. The volatility curve calibrated to the previous day's settlement prices of the next-term options is used as the volatility curve for the near-term options. And the next available month (May contract) is used as the next-term volatility curve since the next-term (April contract) is not published by OSE on that date.

Example: assumes FEB instrument expires on 2/28

		27-Feb		28-Feb		1-Mar	
Real-Time	Options	Feb	March	March	May	March	April
	Future	March	June	June	June	June	June
Close	Options	Feb	March	March	May	March	April
	Future	March	June	June	June	June	June

[2] Black, Fischer (1976). The pricing of commodity contracts, Journal of Financial Economics, 3, 167-179.

Updating The Options And Futures Prices From The Order Book Every 15 Seconds. At the end of each 15-second interval, determine the options price for each strike and underlying futures price for both near- and next-term:

1. For options and futures, if both bid and offer prices exist for the same security, take the midpoint as the price.
2. For options and futures, if there is only a bid or an offer or neither, mark as unavailable (NaN).
3. If the near-term future price is NaN during normal trading hours, use the most recently quoted futures price. If there are no quotes at the beginning of the day, use the previous day's settlement price.
4. If the next-term future price is NaN during normal trading hours, use the current near-term futures price and the last updated near- and next-term future prices to infer the missing current next-term price: $nextF_t = nearF_t * \frac{nextF_{t-1}}{nearF_{t-1}}$. If there are no quotes at the beginning of the day, use the previous day's settlement prices as the last updated prices.

Updating The Implied Volatility Curves Every 15 Seconds. Use updated options prices from the current order book to update the implied volatility curves:

1. Calculate implied volatilities corresponding to each ATM and OTM price in the order book.
2. Shift the previous implied volatility curves by the average of differences between available implied volatilities on each curve. Only use options with prices greater than 0.01, and shift the volatility curve only when two or more valid implied volatilities are observed.
3. If only near-term options are quoted in the beginning of the trading session, parallel shift the volatility curves for the next-term puts and calls by anchoring to the near-term curves.
4. If only next-term options are quoted in the beginning of the trading session, parallel shift the volatility curves for the near-term puts and calls by anchoring to the next-term curves.

Updating The S&P/JPX JGB VIX Every 15 Seconds. Calculate the S&P/JPX JGB VIX using the updated implied volatility curves:

1. Calculate theoretical prices corresponding to each strike based on the volatility curves.
2. Calculate the S&P/JPX JGB VIX using the main formula using observed prices if available, and theoretical prices otherwise.

Appendix B

The Black Model

The Black model is a variant of the Black-Scholes option pricing model. It uses a discounted futures (or forward) price F instead of the spot price of the underlying. It states the price for a European option of maturity *T* on a futures contract with strike price *K* is:

$$c = e^{-rT}[F * N(d_1) - K * N(d_2)]$$

$$p = e^{-rT}[K * N(-d_2) - F * N(-d_1)]$$

$$d_1 = \frac{\ln\left(\frac{F}{K}\right) + T * \sigma^2/2}{\sigma\sqrt{T}}$$

$$d_2 = \frac{\ln\left(\frac{F}{K}\right) - T * \sigma^2/2}{\sigma\sqrt{T}}$$

where:

c = European call price

p = European put price

r = Risk free interest rate

T = Option maturity

F = Underlying futures prices

N = Cumulative normal distribution function

K = Option strike

σ = Volatility

For any options in the market, the index uses a solver to find its implied volatility so that the option price calculated by the Black model matches the observed option price in the market as closely as possible.

Appendix C

ESG Disclosures

EXPLANATION OF HOW ENVIRONMENTAL, SOCIAL & GOVERNANCE (ESG) FACTORS ARE REFLECTED IN THE KEY ELEMENTS OF THE BENCHMARK METHODOLOGY[3]		
1.	**Name of the benchmark administrator.**	S&P Dow Jones Indices LLC.
2.	**Underlying asset class of the ESG benchmark.[4]**	N/A
3.	**Name of the S&P Dow Jones Indices benchmark or family of benchmarks.**	S&P DJI Options Indices Benchmark Statement
4.	**Do any of the indices maintained by this methodology take into account ESG factors?**	No
Appendix latest update:		January 2021
Appendix first publication:		January 2021

[3] The information contained in this Appendix is intended to meet the requirements of the European Union Commission Delegated Regulation (EU) 2020/1817 supplementing Regulation (EU) 2016/1011 of the European Parliament and of the Council as regards the minimum content of the explanation of how environmental, social and governance factors are reflected in the benchmark methodology and the retained EU law in the UK [The Benchmarks (amendment and Transitional Provision) (EU Exit) Regulations 2019].

[4] The 'underlying assets' are defined in European Union Commission Delegated Regulation (EU) 2020/1816 supplementing Regulation (EU) 2016/1011 of the European Parliament and of the Council as regards the explanation in the benchmark statement of how environmental, social and governance factors are reflected in each benchmark provided and published.

Disclaimer

Performance Disclosure/Back-Tested Data

Where applicable, S&P Dow Jones Indices and its index-related affiliates ("S&P DJI") defines various dates to assist our clients by providing transparency. The First Value Date is the first day for which there is a calculated value (either live or back-tested) for a given index. The Base Date is the date at which the index is set to a fixed value for calculation purposes. The Launch Date designates the date when the values of an index are first considered live: index values provided for any date or time period prior to the index's Launch Date are considered back-tested. S&P DJI defines the Launch Date as the date by which the values of an index are known to have been released to the public, for example via the company's public website or its data feed to external parties. For Dow Jones-branded indices introduced prior to May 31, 2013, the Launch Date (which prior to May 31, 2013, was termed "Date of introduction") is set at a date upon which no further changes were permitted to be made to the index methodology, but that may have been prior to the Index's public release date.

Please refer to the methodology for the Index for more details about the index, including the manner in which it is rebalanced, the timing of such rebalancing, criteria for additions and deletions, as well as all index calculations.

Information presented prior to an index's launch date is hypothetical back-tested performance, not actual performance, and is based on the index methodology in effect on the launch date. However, when creating back-tested history for periods of market anomalies or other periods that do not reflect the general current market environment, index methodology rules may be relaxed to capture a large enough universe of securities to simulate the target market the index is designed to measure or strategy the index is designed to capture. For example, market capitalization and liquidity thresholds may be reduced. In addition, forks have not been factored into the back-test data with respect to the S&P Cryptocurrency Indices. For the S&P Cryptocurrency Top 5 & 10 Equal Weight Indices, the custody element of the methodology was not considered; the back-test history is based on the index constituents that meet the custody element as of the Launch Date. Also, the treatment of corporate actions in back-tested performance may differ from treatment for live indices due to limitations in replicating index management decisions. Back-tested performance reflects application of an index methodology and selection of index constituents with the benefit of hindsight and knowledge of factors that may have positively affected its performance, cannot account for all financial risk that may affect results and may be considered to reflect survivor/look ahead bias. Actual returns may differ significantly from, and be lower than, back-tested returns. Past performance is not an indication or guarantee of future results.

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Prospective users of an S&P DJI ESG Index are encouraged to read the relevant index methodology and related disclosures carefully to determine whether the index is suitable for their potential use case or investment objective.