S&P Dow Jones Indices

A Division of S&P Global

S&P/BMV IPC VIX Index
Methodology

August 2023

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Introduction

Index Objective

The S&P/BMV IPC VIX Index measures the implied volatility of the S&P/BMV IPC Futures over the next 90 days.

Highlights

The index uses settlement prices for S&P/BMV IPC Index Futures put and call options to calculate a weighted average of the implied volatility of the options. The S&P/BMV IPC VIX Index is maintained by S&P Dow Jones Indices in agreement with the Bolsa Mexicana de Valores (BMV).

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 in agreement with the Bolsa Mexicana de Valores (BMV) 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 and the BMV so that the index continues to achieve its objective.

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Collaboration

The S&P/BMV IPC VIX Index is maintained by S&P Dow Jones Indices in agreement with the Bolsa Mexicana de Valores (BMV).

Pursuant to an Index Operation and License Agreement dated May 2015 (the "Agreement") between S&P Dow Jones Indices LLC ("S&P DJI") and Bolsa Mexicana de Valores, S.A.B. DE C.V. ("BMV"), as amended, S&P DJI and BMV have agreed to jointly publish and co-brand a family of indices (the "Indices"). The Indices will be co-branded with the S&P/BMV naming convention on June 5, 2017 in conjunction with S&P Dow Jones Indices' assumption of index calculation and maintenance. Prior to June 5, 2017, the Indices were calculated and maintained by BMV.

Index Construction

Approaches

The index is derived from the near-term and next-term options on the S&P/BMV IPC Index Futures. To minimize pricing anomalies from the heavy trading on expiring options during the last few trading days, options roll to the next term and third term when the near-term options have 10 calendar days to expire. The TIIE rate, TIIE 28-day rate, TIIE 91-day rate and TIIE 182-day rate are used to interpolate the risk free rates of each maturity. The index is calculated and published daily.

Derive VIX from Near-Term and Next-Term Options

The index generally uses put and call options in the two nearest-term expiration months in order to bracket a 90-day calendar period.

However, when the near-term options have less than 10 calendar days to expire, the index rolls to the second and third contract months in order to minimize pricing anomalies that might occur close to expiration.

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 value σ with a constant maturity of 90 days to expiration. The index 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	= 90-day implied volatility
σ_1	= Near-term volatility derived from the near-term options (see formula 5)
σ_2	= Next-term volatility derived from the next term options (see formula 5)
N_y	= Number of days in one year
N_m	= Number of days in three months = 90
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

Calculating Time to Maturity

The time to maturity (*T*) is measured in years. The calculation consists of three parts:

N_1 = Fractional number of days remaining from the calculation time until midnight of the current day

N_2 = Number of days between the current day and the settlement day

N_3 = Fractional number of days from midnight of the day prior to expiry to the settlement time on the expiry date

$$N_1 = \frac{\text{minutes remaining until midnight of the current day}}{24 * 60}$$

$$N_3 = \frac{\text{minutes from midnight to settlement time on expiry}}{24 * 60} \quad (2)$$

$$N_T = N_1 + N_2 + N_3$$

$$T = \frac{N_T}{N_y}$$

where:

N_y = Number of days in one year

N_T = Number of days until option expiration

Calendar days are used in all-the-day count calculations.

Interpolating Risk Free Rates

The TIIE rate (R_{on}), TIIE 28-day rate (R_{1m}), TIIE 91-day rate (R_{3m}) and TIIE 182-day rate (R_{6m}) are used to interpolate the risk free rates used in the near-term (R_1) and next-term (R_2).

$$R_1 = \frac{N_y}{N_{T_1}}\left\{T_{on}R_{on}\left[\frac{N_{1m} - N_{T_1}}{N_{1m} - N_{on}}\right] + T_{1m}R_{1m}\left[\frac{N_{T_1} - N_{on}}{N_{1m} - N_{on}}\right]\right\}$$

$$R_2 = \frac{N_y}{N_{T_2}}\left\{T_{3m}R_{3m}\left[\frac{N_{6m} - N_{T_2}}{N_{6m} - N_{3m}}\right] + T_{6m}R_{6m}\left[\frac{N_{T_2} - N_{3m}}{N_{6m} - N_{3m}}\right]\right\} \quad (3)$$

where:

R_1 = Near-term risk free rate

R_2 = Next-term risk free rate

N_{on} = Number of days remaining until the midnight of the next business day

N_{1m} = 28 days, as used in the 28-day TIIE rate interpolation

N_{3m} = 91 days, as used in the 91-day TIIE rate interpolation

N_{6m} = 182 days, as used in the 182-day TIIE rate interpolation

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

N_y = Number of days in one year

$$T_{on} = \frac{N_{on}}{N_y}$$
$$T_{1m} = \frac{N_{1m}}{N_y}$$
$$T_{3m} = \frac{N_{3m}}{N_y}$$
$$T_{6m} = \frac{N_{6m}}{N_y} \quad (4)$$

Note that the interpolation works when the near-term and next-term expirations are bracketed by the overnight-28 day and the 91-182-day maturities of interest rates, respectively. When the option expirations fall outside of the corresponding interest rate expirations, the correct interest rate must be selected. For example, if the near-term expiration is between 28 days and 91 days, the 28-day and 91-day TIIE rates are used to interpolate the near-term risk free rate, R_1; if the next-term expiration is beyond 182 days, the 91-day and 182-day TIIE rates are used to interpolate the next-term risk free rate, R_2.

Forward Index Level

For both near-term and next-term, the formula used to calculate the forward index level is as follows:

$$F = K + e^{RT} * (C_K - P_K) \quad (5)$$

where:

F = Forward index level

K = The strike price at which the absolute difference between the mid-price of the call and the put options is the smallest

T = Time to expiration (see formula 2)

R = Risk-free interest rate to expiration (see formula 3)

C_K= Mid price of calls at strike K

P_K = Mid price of puts at strike K

Option Selection Methodology

To select the options in the volatility calculation for both near-term and next-term,

- Sort all the options in ascending order by strike prices.
- Determine at-the-money strike K_0. It is the strike nearest to the forward index level F.
- Both put and call options at strike K_0 are selected.
- Out-of-money call options with strike prices higher than K_0 are selected.

Start with call option with strike price immediately higher than K_0 and move to successively higher strike prices (K). After encountering two consecutive calls with bid price of zero, no calls with higher strikes are considered.

Out-of-money put options with strike prices lower than K_0 are selected. Start with put option with strike price immediately lower than K_0 and move to successively lower strike prices (K). After encountering two consecutive puts with bid price of zero, no puts with lower strikes are considered.

Options which are not good quotes will be excluded. A good quote is a quote with a bid price and an ask price available:

where:

- 0 < bid price ≤ ask price (for all options)

and

- bid/ask price of selected call options ≤ bid/ask price of the call option at K_0

and

- bid/ask price of selected put options ≤ bid/ask price of the put option at K_0.

General Formula to Calculate Implied Volatilities

The index uses the settlement prices of options to calculate the implied volatilities.

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

$$\sigma^2 = \frac{2}{T}\sum_i \frac{\Delta K_i}{K_i^2} e^{RT} Q(K_i) - \frac{1}{T}\left[\frac{F}{K_0} - 1\right]^2 \quad (6)$$

where:

σ	= Implied volatility
T	= Time to expiration (see formula 2)
F	= Forward index level (see formula 5)
K_i	= Strike price of the i^{th} out-of-the-money option
ΔK_i	= Interval between strike prices (see formula 7)
K_0	= At-the-money strike
R	= Risk-free interest rate to expiration (see formula 3)
$Q(K_i)$	= Settlement price of each option with strike K_i

The index uses the S&P/BMV IPC Index futures price as the proxy for forward index level F. Define K_0 as the strike that is closest to F.

The index uses both puts and calls in the volatility calculation:

- Select call options that have strike prices greater than K_0 and a non-zero settlement price.
- Select put options that have strike prices less than K_0 and a non-zero settlement price.
- Select both the put and call at strike K_0 and a non-zero settlement price. Use the average of put and call settlement prices as $Q(K_0)$ in the calculation.

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

$$\Delta K_i = \frac{K_{i+1} - K_{i-1}}{2} \quad (7)$$

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

Rolling Between Option Contract Months

In calculating the index, when the near-term options have 10 days to expire, the index rolls to the second and third contract months.

Currency of Calculation and Additional Index Return Series

In addition to the indices detailed in this methodology, additional return series versions of the indices may be available, including, but not limited to the following: currency, currency hedged, decrement, fair value, inverse, leveraged, and risk control versions. For a list of available indices, please refer to the *S&P DJI Methodology & Regulatory Status Database*.

For information on the index calculation, please refer to S&P Dow Jones Indices' Index Mathematics Methodology.

For the inputs necessary to calculate certain types of indices, including decrement, dynamic hedged, fair value, and risk control indices, please refer to the Parameters documents available at www.spglobal.com/spdji/.

Index Governance

Index Committee

The S&P/BMV Index Committee maintains the index. The Index Committee is composed of full-time employees of S&P Dow Jones Indices and the BMV. The Index Committee meets regularly. At each meeting, the Index Committee may review pending corporate actions that may affect index constituents, statistics comparing the composition of the indices to the market, companies that are being considered as candidates for addition to an index, and any significant market events. In addition, the Index Committee may revise index policy covering rules for selecting companies, treatment of dividends, share counts 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 and based on all publicly available information.

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

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

Holiday Schedule

The index is calculated daily when BMV is open.

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

Rebalancing

The Index Committee may change the date of a given rebalancing for reasons including market holidays occurring on or around the scheduled rebalancing date. Any such change will be announced with proper advance notice where possible.

Unexpected Exchange Closures

For information on Unexpected Exchange Closures, 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, 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 the *S&P DJI Methodology & Regulatory Status Database* for a complete list of indices covered by this document.

Index	Bloomberg	RIC
S&P/BMV IPC VIX	SPBMVVIX	.SPBMVVIX

Index Data

Daily index level data are 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

ESG Disclosures

EXPLANATION OF HOW ENVIRONMENTAL, SOCIAL & GOVERNANCE (ESG) FACTORS ARE REFLECTED IN THE KEY ELEMENTS OF THE BENCHMARK METHODOLOGY[1]		
1.	**Name of the benchmark administrator.**	S&P Dow Jones Indices LLC.
2.	**Underlying asset class of the ESG benchmark.[2]**	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

[1] 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].

[2] 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

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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. 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.

Typically, when S&P DJI creates back-tested index data, S&P DJI uses actual historical constituent-level data (e.g., historical price, market capitalization, and corporate action data) in its calculations. As ESG investing is still in early stages of development, certain datapoints used to calculate certain ESG indices may not be available for the entire desired period of back-tested history. The same data availability issue could be true for other indices as well. In cases when actual data is not available for all relevant historical periods, S&P DJI may employ a process of using "Backward Data Assumption" (or pulling back) of ESG data for the calculation of back-tested historical performance. "Backward Data Assumption" is a process that applies the earliest actual live data point available for an index constituent company to all prior historical instances in the index performance. For example, Backward Data Assumption inherently assumes that companies currently not involved in a specific business activity (also known as "product involvement") were never involved historically and similarly also assumes that companies currently involved in a specific business activity were involved historically too. The Backward Data Assumption allows the hypothetical back-test to be extended over more historical years than would be feasible using only actual data. For more information on "Backward Data Assumption" please refer to the FAQ. The methodology and factsheets of any index that employs backward assumption in the back-tested history will explicitly state so. The methodology will include an Appendix with a table setting forth the specific

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