S&P/ASX 200 VIX
Methodology

February 2018

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Introduction

Index Objective

The S&P®/ASX® 200 VIX seeks to measure the 30-day implied volatility (ASX VIX) of the S&P/ASX 200 Index.

Highlights

The S&P/ASX 200 VIX (ASX VIX) is a real-time index that reflects investor sentiment about the expected volatility in the Australian benchmark equity index, the S&P/ASX 200.

The ASX VIX reflects expected equity market volatility over the next 30 days by using mid prices for S&P/ASX 200 put and call options to calculate a weighted average of the implied volatility of the options.

The ASX VIX at relatively high levels implies a market expectation of large changes in the S&P/ASX 200 over the next 30 days, indicating that investor sentiment is uncertain. Conversely, a relatively low ASX VIX value implies a market expectation of little change, suggesting greater levels of investor confidence in the stability of the market.

In 1993, the Chicago Board Options Exchange (CBOE®) introduced the CBOE Volatility Index, VIX®, which was originally designed to measure the market's expectation of 30-day volatility implied by the at-the-money S&P 100® Index (OEX®) option prices. Ten years later, in 2003, VIX was updated to reflect a new way to measure expected volatility. The new VIX is based on the S&P 500® (SPX^SM), the core index for U.S. equities, and estimates the expected volatility by averaging the weighted prices of SPX puts and calls over a wide range of strike prices. By supplying a script for replicating volatility exposure with a portfolio of SPX options, this new methodology transformed VIX from an abstract concept into a practical standard for trading and hedging volatility.

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' Equity Indices Policies & Practices Methodology	Equity Indices Policies & Practices
S&P Dow Jones Indices' Commodities Indices Policies & Practices Methodology	Commodities Indices Policies & Practices

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.

Index Construction

Approaches

The S&P/ASX 200 VIX is derived from the near term and next term options on the S&P/ASX 200. To minimize the pricing anomalies from the heavy trading on the expiring options during the last few trading days, options roll to the next term and third term when the near-term options have less than a week to expire. The overnight RBA rate, 1-month, 2-month and 3-month BBSW rates are used to interpolate the risk free rates of each maturity. The index is calculated and published between 10:10AM and 4:15PM, local time.

Deriving VIX from Near-term and Next-term Options

The ASX VIX generally uses put and call options in the two nearest-term expiration months in order to bracket a 30-day calendar period.

However, when the near-term options have less than a week to expire, the ASX VIX 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.

We interpolate the near term volatility σ_1 and the next term volatility σ_2 to arrive at a single value σ with a constant maturity of 30 days to expiration. VIX is derived by taking σ (the square root of σ^2) and multiplying by 100.

$$VIX = \sigma * 100$$

$$\sigma^2 = \frac{N_y}{N_m}\left\{T_1\sigma_1{}^2\left[\frac{N_{T_2} - N_m}{N_{T_2} - N_{T_1}}\right] + T_2\sigma_2{}^2\left[\frac{N_m - N_{T_1}}{N_{T_2} - N_{T_1}}\right]\right\} \qquad (1)$$

where:

σ = 30-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 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 time and the expiration time of the near term options

N_{T2} = Number of days between the current time and the expiration time of the next term options

Calculating Time to Maturity

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

N_1 = Fractional number of days remaining from the current 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 (12:00 noon) on the expiry date

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

$$N_3 = \frac{minutes\ from\ midnight\ to\ settlement\ time\ on\ expiry}{24*60}$$

$$N_T = N_1 + N_2 + N_3$$

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

(2)

where:

N_y = Number of days in one year

N_T = Number of days until option expiration

Calendar days are used in all day count calculations.

Interpolating Risk Free Rates

We use the RBA overnight rate (R_{on}), BBSW 1-month rate (R_{1m}), and BBSW 2-month rate (R_{2m}) to interpolate the risk free rates used in near term (R_1) and next term (R_2).

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

$$R_2 = \frac{N_y}{N_{T_2}}\left\{T_{1m}R_{1m}\left[\frac{N_{2m} - N_{T_2}}{N_{2m} - N_{1m}}\right] + T_{2m}R_{2m}\left[\frac{N_{T_2} - N_{1m}}{N_{2m} - N_{1m}}\right]\right\}$$

(3)

where:

R_1 = Near-term risk free rate

R_2 = Next-term risk free rate

R_{on} = RBA overnight rate

R_{1m} = BBSW 1-month rate

R_{2m} = BBSW 2-month rate

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

N_{1m} = 30 days, as we are using a one-month BBSW rate in the interpolation

N_{2m} = 60 days, as we are using a two-month BBSW rate in the interpolation

N_{T1} = Number of days between the calculation time on the current day and 12:00 noon on the expiration date of the near-term options

N_{T2} = Number of days between the calculation time) on the current day and 12:00 noon on the expiration date of the next-term options

N_y = Number of days in one year

$$T_{on} = \frac{N_{on}}{N_y}$$

$$T_{1m} = \frac{N_{1m}}{N_y} \tag{4}$$

$$T_{2m} = \frac{N_{2m}}{N_y}$$

Note that the interpolation works when the near-term and next-term expirations are bracketed by the overnight - 1 month and 1 month - 2 month maturities of interest rates, respectively. When the option expirations fall outside of the corresponding interest rate expirations, which will most likely happen during the roll period, we need to pick the correct BBSW rates. For example, if the near term expiration is between 1 and 2 months, we use the 1-month and 2-month BBSW rates to interpolate the near-term risk free rate R_1; if the next term expiration is between 2 and 3 months, we use the 2- and 3-month BBSW rates 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:

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

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 (se 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. 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. 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 $\leq$ ask price (for all options); and
- bid/ask price of selected call options $\leq$ bid/ask price of the call option at K_0; and
- bid/ask price of selected put options $\leq$ bid/ask price of the put option at K_0

General Formula to Calculate Implied Volatilities

For the near-term and the next-term, respectively, implied volatilities are calculated using the selected put and call options. The general formula is:

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

where:

$\sigma =$ Implied volatility

$T =$ Time to expiration (see formula 2)

$F =$ Forward index level (see formula 5)

$K_i =$ Strike price of the ith out-of-the-money option

$\Delta K_i =$ Interval between strike prices (see formula 7)

$K_0 =$ At-the-money strike

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

$Q(K_i) =$ Mid-price of each selected option with strike K_i; Use the average mid-price of the put and call options if $K_i = K_0$

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

$$\Delta K_i = \frac{K_{i+1} - K_{i-1}}{2} \tag{7}$$

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 S&P/ASX 200 VIX, when the near-term options have less than a week to expire, ASX VIX rolls to the second and third contract months. When the options expire on a Thursday, the ASX VIX usually rolls on the prior Friday if the Australian Securities Exchange is open. If Friday is a holiday, the index rolls on the next business day when the Australian Securities Exchange is open.

Start Date

The index start date is January 2, 2008.

Index Governance

Index Committee

Each of S&P Dow Jones Indices' global indices is the responsibility of an Index Committee that monitors overall policy guidelines and methodologies, as well as additions to and deletions from these indices. S&P Dow Jones Indices chairs the S&P/ASX Index Committee, which is comprised of five voting members representing both S&P Dow Jones Indices and the Australian Securities Exchange.

Decisions made by the Index Committee include all matters relating to index construction and maintenance. The Index Committee meets regularly to review market developments and convenes as needed to address major corporate actions.

It is the sole responsibility of the Index Committee to decide on all matters relating to methodology, maintenance, constituent selection and index procedures. The Index Committee makes decisions based on all publicly available information and discussions are kept confidential to avoid any unnecessary impact on market trading.

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' Commodities Indices Policies & Practices document.

Index Policy

Announcements

Announcements of the daily index values are made before the open of the next trading day.

Holiday Schedule

The index is calculated daily, throughout the calendar year. The only days the index is not calculated is on days when the ASX is officially closed.

A complete holiday schedule for the year is available on the S&P Dow Jones Indices' Web site at *www.spdji.com*.

Unscheduled Exchange Closures

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

For information on Calculations and Pricing Disruptions, Expert Judgment, Data Hierarchy, Unexpected Exchange Closures and Error Corrections, please refer to S&P Dow Jones Indices' Commodities Indices Policies & Practices document.

Contact Information

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

Index Dissemination

Historical index returns are available through S&P Dow Jones Indices' index data group for subscription via FTP.

Tickers

The table below lists headline indices covered by this document. All currency, currency hedged, risk control, and return type versions of the below indices that may exist are also covered by this document. Please contact index_services@spglobal.com for a complete list of indices covered by this document.

Index	RIC	Bloomberg
S&P/ASX 200 VIX	.AXVI	AS51VIX

FTP

Daily index level data is available via FTP subscription.

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

Web site

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

Appendix

Methodology Changes

Methodology changes since January 1, 2015 are as follows:

Change	Effective Date (After Close)	Methodology	
		Previous	**Updated**
Definition of the at-the-money strike, K_0.	01-Dec-17	K_0 is set equal to F, the forward index level.	K_0 is defined as the strike that is nearest to F, the forward index level.
Options selected in the volatility calculation.	01-Dec-17	If strike $K < K_0$, use put prices; if strike $K >= K_0$, use call prices.	If strike $K < K_0$, use put prices; if strike $K > K_0$, use call prices; if strike $K = K_0$, use the average price of the put and the call.
		After encountering two consecutive puts with a bid price of zero, do not select any other puts; after encountering two consecutive calls with a bid price of zero, do not select any other calls.	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. 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. 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.

Disclaimer