S&P Dow Jones Indices

A Division of S&P Global

S&P/TSX 60 VIX
Methodology

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Introduction

Index Objective

The S&P/TSX VIX index seeks to measure the 30-day implied volatility of the Canadian stock market, using S&P/TSX 60 index options. The index is considered a measure of market expectations of near-term volatility.

Highlights

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, one that continues to be widely used by financial theorists, risk managers and volatility traders alike. The new VIX is based on the S&P 500® (SPX℠), 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.

The new VIX[1] methodology is considered by many to be the world's premier barometer of investor sentiment and market volatility.

VIX has negative correlations to the stock market historically and is considered a useful tool to hedge the potential downturn of the broad equity market. While equity options have various expirations, the VIX indicates the implied volatility of the fixed 30-day period.

The index approximates the 30-day volatility that is implied by the near-term and next-term options.

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' 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.

[1] The VIX® methodology is the property of the Chicago Board Options Exchange ("CBOE"). CBOE has granted Standard & Poor's Financial Services LLC ("S&P"), a license to use the VIX methodology to create the S&P/TSX 60 VIX Index.

Index Construction

Approaches

The index is derived from the near-term and next-term options on the S&P/TSX 60. To minimize the pricing anomalies on the expiring options during the last few trading days, options roll to the next-term and third-term five (5) calendar days prior to expiration. The CORRA (Canadian Overnight Repo Rate) and the CDOR (Canadian Dealer Offered Rate) 1-month, 2-month and 3-month rates are used to interpolate the risk free rates of each maturity.

Deriving VIX from Near-term and Next-term Options

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

However, within five (5) calendar days prior to expiration, the TSX VIX rolls to the second and third contract months in order to minimize pricing anomalies that might occur close to options 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. TSX VIX is derived by taking σ (the square root of σ^2) and multiplying by 100.

$$VIX = \sigma * 100$$

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

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 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. It consists of three parts:

N_1 = Fractional number of days remaining 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

$$
\begin{aligned}
N_1 &= \frac{minutes\,remaining\,until\,midnight\,of\,the\,current\,day}{24*60} \\
N_3 &= \frac{minutes\,from\,midnight\,to\,settlement\,time\,on\,expiry}{24*60} \\
N_T &= N_1 + N_2 + N_3 \\
T &= \frac{N_T}{N_y}
\end{aligned}
\tag{2}
$$

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

$$
\begin{aligned}
R_1 &= \frac{N_y}{N_{T_1}}\left\{T_{on}R_{on}\left[\frac{N_{1m}-N_{T_1}}{N_{1m}-N_{on}}\right]+T_{1m}R_{1m}\left[\frac{N_{T_1}-N_{on}}{N_{1m}-N_{on}}\right]\right\} \\
R_2 &= \frac{N_y}{N_{T_2}}\left\{T_{1m}R_{1m}\left[\frac{N_{2m}-N_{T_2}}{N_{2m}-N_{1m}}\right]+T_{2m}R_{2m}\left[\frac{N_{T_2}-N_{1m}}{N_{2m}-N_{1m}}\right]\right\}
\end{aligned}
\tag{3}
$$

where:

R_1 = Near-term risk free rate

R_2 = Next-term risk free rate

R_{on} = CORRA rate

R_{1m} = CDOR 1-month rate

R_{2m} = CDOR 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 CDOR rate in the interpolation

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

$$T_{on} = \frac{N_{on}}{N_y}$$
$$T_{1m} = \frac{N_{1m}}{N_y} \quad (4)$$
$$T_{2m} = \frac{N_{2m}}{N_y}$$

Note that the interpolation works when the near-term and next-term expirations are bracketed by the overnight 1-month and the 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 interest rates. For example, if the near-term expiration is between 1 and 2 months, we shall use the 1-month and 2-month CDOR rates to interpolate the near-term risk free rate, R_1; if the next-term expiration is between 2 and 3 months, we shall use 2-month and 3-month CDOR 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:

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

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 (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 ≤ 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

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

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

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)
$Q(K_i)$	= 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

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

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.

Currency, Currency Hedged, and Risk Control Indices

Additional currency, currency hedged, and risk control versions of the indices may be available. For a list of available currency, currency hedged, and risk control indices, please contact Client Services at index_services@spglobal.com.

For more information on currency, currency hedged, and risk control indices, please refer to S&P Dow Jones Indices' Index Mathematics Methodology.

Contract Rebalancing

In calculating the S&P/TSX 60 VIX, options are rolled on the 5th calendar day prior to the expiration of the near-term options when the Montreal Exchange is open, excluding weekends and holidays.

Start Date

The index history begins on October 1, 2009.

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/TSX Index Committee, which is comprised of members representing both S&P Dow Jones Indices and the TSX.

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 after close each business day.

Holiday Schedule

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

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' Equity 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	Bloomberg	Reuters
S&P/TSX 60 VIX	VIXC	.GSPVIXC

Index Data

Daily index level data is available via 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.

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