S&P INDICES

S&P/TSX 60 VIX
INDEX METHODOLOGY

TMX

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Table of Contents

Introduction

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.

The S&P/TSX 60 VIX is a measure of market expectations of near-term volatility conveyed by S&P/TSX 60 stock index option prices.

Highlights

The S&P®/TSX® 60 VIX® seeks to measure the 30-day implied volatility of the Canadian stock market, using S&P/TSX 60 index options.

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 S&P/TSX 60 VIX (TSX VIX) approximates the 30-day volatility that is implied by the near-term and next-term options.

[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 S&P/TSX 60 VIX 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 a 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

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

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

$$N_T = N_1 + N_2 + N_3$$

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

where:

N_y = Number of days in one year

N_T = Number of days until option expiration

Calendar days are used in all 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).

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

$$R_2 = \frac{N_y}{N_{T_2}}\left\{T_{1m}R_{1m}\left[\frac{N_{2m}-N_{T_2}}{N_{2m}-N_{1m}}\right]+T_{2m}R_{2m}\left[\frac{N_{T_2}-N_{1m}}{N_{2m}-N_{1m}}\right]\right\} \quad (3)$$

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.

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:

$$\sigma^2 = \frac{2}{T}\sum_i \frac{\Delta K_i}{K_i^2} e^{RT} Q(K_i) - \frac{1}{T}\left[\frac{F}{K_0} - 1\right]^2 \quad (5)$$

where:

σ = Implied volatility

T = Time to expiration (see formula 2)

F = Forward index level (see formula 6)

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

ΔK_i = Interval between strike prices (see formula 7)

K_0 = First strike below the forward index level (F)

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

$Q(K_i)$ = Strike mid-price of each option with strike K_i

The at-the-money strike, K, is the strike price at which the difference between the call and the put prices is the smallest. The formula used to calculate the forward index level is:

$$F = K + e^{RT} * (C_K - P_K) \quad (6)$$

where:

F = Forward index level

K = The strike price at which the difference between the call and the put prices 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

Next, determine K_0, the strike price immediately below the forward index level, F.
To select the options in the volatility calculation,

- Sort all the options in ascending order by strike prices.
- At strike K_0 select both the call and the put. Use the average price as the option price.

- Select call options that have strike prices greater than K_0 and a non-zero bid price. After encountering two consecutive calls with a bid price of zero, do not select any other calls.
- Select put options that have strike prices less than K_0 and a non-zero bid price. After encountering two consecutive puts with a bid price of zero, do not select any other puts.

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.

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

The S&P/TSX Index Committee maintains the S&P/TSX 60 VIX. The Index Committee meets regularly. At each meeting, the Index Committee reviews any significant market events. In addition, the Index Committee may revise index policy for timing of rebalancings or other matters.

Standard & Poor's considers information about changes to its indices and related matters to be potentially market moving and material. Therefore, all Index Committee discussions are confidential.

Index Policy

Announcements

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

Holiday Schedule

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

Unscheduled Market 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, Standard & Poor's will calculate the value of the index based on most recent option price published by Montreal Stock Exchange. If an exchange fails to open due to unforeseen circumstances, Standard & Poor's may determine not to publish the index for that day.

Index Dissemination

Historical index returns are available through Standard & Poor's index data group for subscription via FTP.

Tickers

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

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