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Version | Publication Date
---|---
1.0 | August 8th 2022
1.1 | October 24th 2022
1.1.1 | February 13th 2023
1.2 | October 23rd 2023
1. Live Streaming CVOL Overview

The Live Streaming CVOLs provide an intra-day view of implied volatility across five different asset classes, derived from the world’s most actively traded options on futures. Live Streaming CVOLs provide a measure of the market’s expectation of forward risk, calculated every 15 seconds throughout the day, along with associated derivative indicators.

### Single Product Live Streaming CVOL Indices

#### Foreign Exchange – Single Product

<table>
<thead>
<tr>
<th>Contract</th>
<th>CVOL Group</th>
<th>CVOL Symbol</th>
<th>UpVar Symbol</th>
<th>DownVar Symbol</th>
<th>Skew Symbol</th>
<th>ATM Vol Symbol</th>
<th>Convexity Symbol</th>
</tr>
</thead>
</table>

#### Metals – Single Product

<table>
<thead>
<tr>
<th>Contract</th>
<th>CVOL Group</th>
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<th>UpVar Symbol</th>
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</table>

#### Energy – Single Product

<table>
<thead>
<tr>
<th>Contract</th>
<th>CVOL Group</th>
<th>CVOL Symbol</th>
<th>UpVar Symbol</th>
<th>DownVar Symbol</th>
<th>Skew Symbol</th>
<th>ATM Vol Symbol</th>
<th>Convexity Symbol</th>
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</thead>
<tbody>
<tr>
<td>Henry Hub Natural Gas (LN)</td>
<td>Tenor Selection 2</td>
<td>CVOL:NGVL</td>
<td>UPVAR:NGVL</td>
<td>DNVAR:NGVL</td>
<td>SKEW:NGVL</td>
<td>ATM VOL:NGVL</td>
<td>CONVEX:NGVL</td>
</tr>
<tr>
<td>Contract</td>
<td>CVOL Group</td>
<td>CVOL Symbol</td>
<td>UpVar Symbol</td>
<td>DownVar Symbol</td>
<td>Skew Symbol</td>
<td>ATM Vol Symbol</td>
<td>Convexity Symbol</td>
</tr>
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<td>-------------</td>
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</tr>
<tr>
<td>SOFR-SR3 90-day</td>
<td>Tenor Selection 7 (90 DTE)</td>
<td>CVOL:SRVL</td>
<td>UPVAR:SRVL</td>
<td>DNVAR:SRVL</td>
<td>SKEW:SRVL</td>
<td>ATMVOL:SRVL</td>
<td>CONVEX:SRVL</td>
</tr>
<tr>
<td>SR3 1-year Midcurve 90-day</td>
<td>Tenor Selection 7 (90 DTE)</td>
<td>CVOL:S1VL</td>
<td>UPVAR:S1VL</td>
<td>DNVAR:S1VL</td>
<td>SKEW:S1VL</td>
<td>ATMVOL:S1VL</td>
<td>CONVEX:S1VL</td>
</tr>
<tr>
<td>SR3 2-year Midcurve 90-day</td>
<td>Tenor Selection 7 (90 DTE)</td>
<td>CVOL:S2VL</td>
<td>UPVAR:S2VL</td>
<td>DNVAR:S2VL</td>
<td>SKEW:S2VL</td>
<td>ATMVOL:S2VL</td>
<td>CONVEX:S2VL</td>
</tr>
<tr>
<td>US 2-year T-Note (OZT) - Price</td>
<td>Tenor Selection 2</td>
<td>CVOL:TVUL</td>
<td>UPVAR:TVUL</td>
<td>DNVAR:TVUL</td>
<td>SKEW:TVUL</td>
<td>ATMVOL:TVUL</td>
<td>CONVEX:TVUL</td>
</tr>
<tr>
<td>US 5-year T-Note (OZF) - Price</td>
<td>Tenor Selection 4</td>
<td>CVOL:FVVL</td>
<td>UPVAR:FVVL</td>
<td>DNVAR:FVVL</td>
<td>SKEW:FVVL</td>
<td>ATMVOL:FVVL</td>
<td>CONVEX:FVVL</td>
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</table>
### Agriculture – Single Product

<table>
<thead>
<tr>
<th>Contract</th>
<th>CVOL Group</th>
<th>CVOL Symbol</th>
<th>UpVar Symbol</th>
<th>DownVar Symbol</th>
<th>Skew Symbol</th>
<th>ATM Vol Symbol</th>
<th>Convexity Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lean Hogs (HE)</td>
<td>Tenor Selection 6 (60DTE)</td>
<td>CVOL:HEVL</td>
<td>UPVAR:HEVL</td>
<td>DNVAR:HEVL</td>
<td>SKEW:HEVL</td>
<td>ATMVOL:HEVL</td>
<td>CONVEX:HEVL</td>
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<tr>
<td>Live Cattle (LE)</td>
<td>Tenor Selection 6 (60DTE)</td>
<td>CVOL:LEVL</td>
<td>UPVAR:LEVL</td>
<td>DNVAR:LEVL</td>
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<td>ATMVOL:LEVL</td>
<td>CONVEX:LEVL</td>
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<tr>
<td>Class III Milk (OC)</td>
<td>Tenor Selection 6 (60DTE)</td>
<td>CVOL:DCVL</td>
<td>UPVAR:DCVL</td>
<td>DNVAR:DCVL</td>
<td>SKEW:DCVL</td>
<td>ATMVOL:DCVL</td>
<td>CONVEX:DCVL</td>
</tr>
<tr>
<td>Feeder Cattle (GF)</td>
<td>Tenor Selection 6 (60DTE)</td>
<td>CVOL:GFVL</td>
<td>UPVAR:GFVL</td>
<td>DNVAR:GFVL</td>
<td>SKEW:GFVL</td>
<td>ATMVOL:GFVL</td>
<td>CONVEX:GFVL</td>
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</table>

### Broad Based Live Streaming CVOL Indices

<table>
<thead>
<tr>
<th>Name</th>
<th>CVOL Symbol</th>
<th>UpVar Symbol</th>
<th>DownVar Symbol</th>
<th>Skew Symbol</th>
<th>ATM Vol Symbol</th>
<th>Convexity Symbol</th>
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</thead>
<tbody>
<tr>
<td>FX G5 Volatility Index (EUVL, GBVL, JPVL, ADVL, CAVL)</td>
<td>CVOL:FXVL</td>
<td>UPVAR:FXVL</td>
<td>DNVAR:FXVL</td>
<td>SKEW:FXVL</td>
<td>ATMVOL:FXVL</td>
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</table>

### Foreign Exchange – Broad Based

<table>
<thead>
<tr>
<th>Name</th>
<th>CVOL Symbol</th>
<th>UpVar Symbol</th>
<th>DownVar Symbol</th>
<th>Skew Symbol</th>
<th>ATM Vol Symbol</th>
<th>Convexity Symbol</th>
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</table>

### Interest Rate – Broad Based

<table>
<thead>
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<th>Name</th>
<th>CVOL Symbol</th>
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<th>DownVar Symbol</th>
<th>Skew Symbol</th>
<th>ATM Vol Symbol</th>
<th>Convexity Symbol</th>
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</table>

### Metals – Broad Based

<table>
<thead>
<tr>
<th>Name</th>
<th>CVOL Symbol</th>
<th>UpVar Symbol</th>
<th>DownVar Symbol</th>
<th>Skew Symbol</th>
<th>ATM Vol Symbol</th>
<th>Convexity Symbol</th>
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<tbody>
<tr>
<td>Name</td>
<td>CVOL Symbol</td>
<td>UpVar Symbol</td>
<td>DownVar Symbol</td>
<td>Skew Symbol</td>
<td>ATM Vol Symbol</td>
<td>Convexity Symbol</td>
</tr>
<tr>
<td>----------------------------------</td>
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<td>--------------</td>
<td>----------------</td>
<td>-------------</td>
<td>----------------</td>
<td>------------------</td>
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<tr>
<td>(CLVL, NGVL, RBVL, HOVL)</td>
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<tr>
<td>(WVL, CVL, SLV, SOVL, SMVL, HEVL, LEVL, DCVL, GFVL)</td>
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<td></td>
<td></td>
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<tr>
<td>Commodity Volatility Index</td>
<td>CVOL:CMVL</td>
<td>UPVAR:CMVL</td>
<td>DNNVAR:CMVL</td>
<td>SKEW:CMVL</td>
<td>ATMVOL:CMVL</td>
<td>CONVEX:CMVL</td>
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<tr>
<td>(CLVL, NGVL, RBVL, HOVL, WVL, CVL, SLV, SIVL, GCVL, HGVL, LEVL, HEVL, DCVL)</td>
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</tr>
</tbody>
</table>
### 2. Product Calculation Windows

The following table outlines the periods of time (shown below in Eastern Standard Time) for which calculations will be performed for each Live Streaming CVOL index.

<table>
<thead>
<tr>
<th>Product</th>
<th>CVOL</th>
<th>Group</th>
<th>Start</th>
<th>End</th>
<th>Preliminary Settlement Time</th>
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<tbody>
<tr>
<td>DC</td>
<td>DCVL</td>
<td>Ags</td>
<td>10:00 AM ET</td>
<td>2:00 PM ET</td>
<td>2:00 PM ET</td>
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<td>OZW</td>
<td>WVL</td>
<td>Ags</td>
<td>3:00 AM ET</td>
<td>2:15 PM ET</td>
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<tr>
<td>OZS</td>
<td>SVL</td>
<td>Ags</td>
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<td>LEVL</td>
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<td>2:00 PM ET</td>
</tr>
<tr>
<td>OZM</td>
<td>SMVL</td>
<td>Ags</td>
<td>9:30 AM ET</td>
<td>2:15 PM ET</td>
<td>2:15 PM ET</td>
</tr>
<tr>
<td>OZL</td>
<td>SOVL</td>
<td>Ags</td>
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<td>2:15 PM ET</td>
<td>2:15 PM ET</td>
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<tr>
<td>HE</td>
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<td>2:00 PM ET</td>
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<tr>
<td>GF</td>
<td>GFVL</td>
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<td>3:00 PM ET</td>
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<td>FVVL</td>
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<td>4:45 PM ET</td>
<td>3:00 PM ET</td>
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<td>TY</td>
<td>TYVL</td>
<td>Interest Rate</td>
<td>2:00 AM ET</td>
<td>4:45 PM ET</td>
<td>3:00 PM ET</td>
</tr>
<tr>
<td>US</td>
<td>USVL</td>
<td>Interest Rate</td>
<td>8:00 AM ET</td>
<td>4:45 PM ET</td>
<td>3:00 PM ET</td>
</tr>
<tr>
<td>SR3</td>
<td>SRVL</td>
<td>Interest Rate</td>
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<td>4:45 PM ET</td>
<td>3:00 PM ET</td>
</tr>
<tr>
<td>S0</td>
<td>S1VL</td>
<td>Interest Rate</td>
<td>8:00 AM ET</td>
<td>4:45 PM ET</td>
<td>3:00 PM ET</td>
</tr>
<tr>
<td>S2</td>
<td>S2VL</td>
<td>Interest Rate</td>
<td>8:00 AM ET</td>
<td>4:45 PM ET</td>
<td>3:00 PM ET</td>
</tr>
<tr>
<td>ADU</td>
<td>ADVL</td>
<td>FX</td>
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<td>4:00 PM ET</td>
<td>3:00 PM ET</td>
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<td>4:00 PM ET</td>
<td>3:00 PM ET</td>
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<tr>
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<td>EUVL</td>
<td>FX</td>
<td>3:30 AM ET</td>
<td>4:00 PM ET</td>
<td>3:00 PM ET</td>
</tr>
<tr>
<td>GBU</td>
<td>GBVL</td>
<td>FX</td>
<td>3:30 AM ET</td>
<td>4:00 PM ET</td>
<td>3:00 PM ET</td>
</tr>
<tr>
<td>JPU</td>
<td>JPVL</td>
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<td>4:00 PM ET</td>
<td>3:00 PM ET</td>
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<td>1:00 PM ET</td>
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<td>2:15 PM ET</td>
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<td>ALVL</td>
<td>Metals</td>
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<td>2:15 PM ET</td>
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<tr>
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<td>CLVL</td>
<td>Energy</td>
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<tr>
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<td>RBVL</td>
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<td>4:45 PM ET</td>
<td>2:30 PM ET</td>
</tr>
<tr>
<td>OH</td>
<td>HOVL</td>
<td>Energy</td>
<td>10:00 AM ET</td>
<td>4:45 PM ET</td>
<td>2:30 PM ET</td>
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</tbody>
</table>
### Broad Based Live Streaming CVOL Indices

<table>
<thead>
<tr>
<th>Product</th>
<th>CVOL</th>
<th>Group</th>
<th>Start</th>
<th>End</th>
<th>Preliminary Settlement Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGVL</td>
<td>AGVL</td>
<td>Ags</td>
<td>10:00 AM ET</td>
<td>2:00 PM ET</td>
<td>2:00 PM ET</td>
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<td>TVL</td>
<td>Interest Rate</td>
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<td>4:45 PM ET</td>
<td>3:00 PM ET</td>
</tr>
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<td>TPVL</td>
<td>TPVL</td>
<td>Interest Rate</td>
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<td>4:45 PM ET</td>
<td>3:00 PM ET</td>
</tr>
<tr>
<td>FXVL</td>
<td>FXVL</td>
<td>FX (G5)</td>
<td>3:30 AM ET</td>
<td>4:00 PM ET</td>
<td>3:00 PM ET</td>
</tr>
<tr>
<td>MVL</td>
<td>MVL</td>
<td>Metals</td>
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<td>1:30 PM ET</td>
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<tr>
<td>EVL</td>
<td>EVL</td>
<td>Energy</td>
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<td>4:45 PM ET</td>
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<td>Commodity</td>
<td>10:00 AM ET</td>
<td>4:45 PM ET</td>
<td>2:00 PM ET</td>
</tr>
</tbody>
</table>

### 3. Input Data

The calculation of the Live Streaming CVOL single product indices uses the following data:

- The current UTC wall clock time \( t \)
- Time (in milliseconds) to Expiration for selected Tenor(s) \( T_1, T_2 ... T_N \)
- The target time horizon of the volatility index: \( T_H \)
- The Future bid and ask for each tenor \( N \) (used to calculate the Future mid, \( F_N \))
- The minimum price increment of the product \( z \)
- For Selected Option Expiration, \( T_N \), the vector of all listed strikes, \( K_i \)
- For each strike, \( K_i \), live Bid and Ask data for both Calls and Puts:
  - Call Asks and Bids: \( CA_i, CB_i \)
  - Put Asks and Bids: \( PA_i, PB_i \)
- Discounting SOFR interest rate curve with continuous integer offsets as made available on the previous business day relative to the current calculation day
- Metrics from the previous calculation at \( t - 1 \):
  - The ATM vol of the previous calculation: \( ATM_{t-1} \)
  - The CVOL calculation of the previous calculation: \( CVol_{t-1} \)
  - The Skew of the previous calculation: \( Skew_{t-1} \)
  - The total number of strikes by tenor used in the calculation after all filtering processes are completed: \( #K_{t-1,N} \)
  - The strike that represents the first Out-of-the-Money (OTM) Put in the prior period for tenor \( N \): \( K_{OTM,N} \)
- For Broad Based Indices (i.e. CVOL indices with more than one product making its composition), the following additional data is required:
  - The vega calculated for each strike of all outstanding options for a given product
  - The open interest for each strike of all outstanding options for a given product
  - The Contract Money Multiplier for a given product
- For CVOL indices calculated in yield space, the additional data is required:
  - The DV01 for a given tenor: \( DV01_N \)
4. Determining the Discount Rate

The Discount Rate is arrived at through a two-step process: (1) selection of the SOFR rate from the curve from the previous day’s End-of-Day fully interpolated curve and (2) calculation of the instantaneous rate to account for time passed during the calculation session.

1. The SOFR rate applied to a given contract is determined prior to the start of the calculation session. \( R_{N_{EOD}} \) is determined by taking the previous End-of-Day SOFR Discount Curve and designating the integer value for the selected tenors which is closest to but greater than the days to maturity.

2. To arrive at the instantaneous rate, the following formula is used:

\[
G_N = \exp \left( \frac{\ln(R_{N_{EOD}})}{T_{N_{EOD}}/T_N} \right)
\]

Where:

- \( R_{N_{EOD}} \) is the EOD SOFR rate queried that corresponds to the given tenor \( N \) for the given calculation session
- \( T_N \) is the Days To Expiry (DTE) of tenor \( T_N \) as expressed in milliseconds
- \( T_{N_{EOD}} \) is the DTE of the EOD SOFR rate \( R_{N_{EOD}} \)

5. Calculation Process

The following outlines the process to perform a Live Streaming CVOL calculation, including when reprint logic is invoked.

5.1. Determining the futures contract price

The synthetic futures contract price for the Live Streaming CVOL calculation is determined as follows:

- The strike \( K \) is determined as the strike for \( \text{Min} \left( |K - K_{seed_N}| \right) \) where:
  - \( CA_K \not= 0 \)
  - \( CB_K \not= 0 \)
  - \( PA_K \not= 0 \)
  - \( PB_K \not= 0 \)
- Strike \( K \) is used to determine the synthetic future:

\[
F_{synth} = K + 0.5 \times (CA_K + CB_K) - 0.5 \times (PA_K + PB_K)
\]

This value is compared against the value of the mid of the underlying Future (\( F_{underlying} \)) bid and ask. The value of the future \( F_N \) is determined as:

- If either the bid or ask of the underlying Future is not available but \( F_{synth} \) can be calculated, \( F_{synth} = F_N \)
• If \( F_{\text{synth}} \) is not calculable and \( F_{\text{underlying}} \) can be calculated, \( F_{\text{underlying}} = F_N \)
• If \( |F_{\text{synth}} - F_{\text{underlying}}| > 4z \), where \( z \) is the minimum option price tick, then \( F_{\text{synth}} = F_N \)

5.2. **Determining the set of strikes to be included in the calculation**

Once \( F_N \) is determined, the following filtering is applied to all Out-of-the-Money (OTM) options:

- All strikes whose Ask value is zero \((CA_K, PA_K = 0)\) are removed
- If the sum of three consecutive Call bids is zero \((i.e. CB_{K_i} + CB_{K_{i+1}} + CB_{K_{i+2}} = 0)\), where \( K_i \) is the closest strike of the three to \( F_N \), then ignore \( K_i \) and all records above \( K_i \)
- If the sum of three consecutive Put bids is zero \((i.e. PB_{K_i} + PB_{K_{i-1}} + PB_{K_{i-2}} = 0)\), where \( K_i \) is the closest strike of the three to \( F_N \), then ignore \( K_i \) and all records below \( K_i \)
- Of the remaining strikes, all strikes whose Bid value is zero \((CB_K, PA_K = 0)\) are removed.

5.3. **ATM Volatility Calculation**

Perform the ATM calculation for each tenor \( N \) and for the timeweighted ATM value by following the steps and formulae below:

- Determine the ATM option premium where \( F_N \) is not an existing strike:

\[
O_{0N} = \frac{0.5 \times (F - K_{-1}) \times (C_{K+1} + P_{K+1}) + 0.5 \times (K_{+1} - F) \times (P_{K-1} + C_{K-1})}{K_{+1} - K_{-1}}
\]

Where:

\( O_{0N} = \) the ATM option premium calculation for tenor \( N \)
\( K_{+1} = \) the strike above \( F \) as defined in ‘Determining the Strike Closest to the Money’ section
\( C_{K+1} = \) the call premium of strike \( K_{+1} \), with the premium being the mid of the bid and offer
\( C_{K-1} = \) the call premium of strike \( K_{-1} \), with the premium being the mid of the bid and offer
\( P_{K+1} = \) the call premium of strike \( K_{+1} \), with the premium being the mid of the bid and offer
\( P_{K-1} = \) the call premium of strike \( K_{-1} \), with the premium being the mid of the bid and offer

- Determine the ATM option premium where \( F_N \) is an existing:

\[
O_{0N} = 0.5 \times (C_{K_0} + P_{K_0})
\]

Where:

\( O_{0N} = \) the ATM option premium calculation for tenor \( N \)
\( K_0 = \) the strike equal to \( F \)
\( C_{K_0} = \) the call premium of strike \( K_0 \), with the premium being the mid of the bid and offer
$P_{K_0}$ = the call premium of strike $K_0$, with the premium being the mid of the bid and offer

- Determine the ATM volatility of tenor $N$:

$$ATM_N = 100 \sqrt{\frac{2\pi}{T_N}} \frac{O_{0N}}{F_N}$$

5.4. ATM Variance Adjustment

Calculate Delta $K$: The value of Delta $K$ ($\Delta K$) for each strike is determined by the following rules:

- If the option is the highest struck Call: $\Delta K = K_i - K_{i-1}$
- If the option is the lowest struck Put: $\Delta K = K_{i+1} - K_i$
- If the option is a Call at the strike where $K_i = F_N$: $\Delta K = (K_i - F)/2$
- If the option is a Put at the strike where $K_i = F_N$: $\Delta K = (F - K_i)/2$
- Otherwise: $\Delta K = (K_{i+1} - K_{i-1})/2$

ATM Adjustment: $VA_0$ is defined as the variance area as below:

$$VA_0 = \Delta K_0 \cdot O_0$$

Where:

- If the closest strike to ATM is below $F$, $\Delta K_0 = \frac{K_{i-1} + K_{i+1}}{2} - F$
- If the closest strike to ATM is above $F$, $\Delta K_0 = F - \frac{K_{i-1} + K_{i+1}}{2}$
- If there is a strike that is exactly ATM, $\Delta K$ is already determined
- If $F$ is a mid-point between $K_{i-1}$ and $K_{i+1}$, no adjustment is needed as $\Delta K = 0$
- $K_{i-1}$ is the closest to the money Put strike
- $K_{i+1}$ is the closest to the money Call strike

With $VA_0$ calculated, the Variance Area adjustments for the Put ($adjVA_{-1}$) and Call ($adjVA_{+1}$) wings are formulated below for the following scenarios:

- In the instance where the closest strike to ATM is below $F$, the calculated $VA_0$ is:
  $$adjVA_{-1} = VA_{-1} - VA_0$$
  $$adjVA_{+1} = VA_{-1} + VA_0$$
- In the instance where the closest strike to ATM is above $F$, the calculated $VA_0$ is:
  $$adjVA_{-1} = VA_{-1} + VA_0$$
  $$adjVA_{+1} = VA_{-1} - VA_0$$
- In the instance where there is a strike exactly equal to $F$ or $F$ is a midpoint between $K_{i-1}, K_{i+1}$, then $adjVA_{+1} = adjVA_{-1} = 0$

The calculated inputs above are entered into the Live CVOL calculation below:

$$\sigma_N = 100 \sqrt{\frac{2}{T_N} \left( \sum_{i=-m}^{-1} \frac{\Delta K_i}{F_N^2} G_N Q\left(P_{K_i}\right) + \frac{1}{F_N^2} G_N \ast (adjVA_{+1}) N + (adjVA_{-1}) N + \sum_{i=1}^{n} \frac{\Delta K_i}{F_N^2} G_N Q\left(C_{K_i}\right) \right)}$$
This can be simplified to:

\[
\sigma_N = 100 \times \sqrt{\frac{2}{T_N} \sum_{i=-m}^{n} \frac{\Delta K_i}{F_N} g_N Q(O_K)}
\]

Where:

- \( m \) is the index of the lowest struck Put
- \( n \) is the index of the highest struck Call
- \( Q(P_{K_i}), Q(C_{K_i}) \) are the option mid-price for the Puts and Calls respectively

### 5.5. Determining Time

The time \( T \) for each strip of options is the amount of time as a fraction of a year (365 days) from the current time until the expiry of those options.

\[
T_1 = \text{expiry}_1 - t
\]

When determining a constant forward-looking implied volatility measure using more than one tenor of options strips, then \( T \) will be designated with subscripting such as \( T_1 \) and \( T_2 \).

Each tenor of options will have its own variance metric, and these two-variance metrics will be time-weighted to a specific time horizon (for example 30 days \( T_H \), where \( H = 30 \text{DTE} \)). The time weighting applied is defined as follows:

\[
\sigma_H = \sqrt{\frac{(T_2 - T_H)\sigma_1^2 + (T_H - T_1)\sigma_2^2}{T_2 - T_1}}
\]

Where:

- \( T_1 \) is the time to expiry of the front tenor, as expressed in milliseconds
- \( T_2 \) is the time to expiry of the back tenor, as expressed in milliseconds
- \( T_H \) is the time horizon of the CVOL
- \( \sigma_1 \) is the variance of the front tenor
- \( \sigma_2 \) is the variance of the back tenor
- \( \sigma_H \) is the time-weighted CVOL level

### 5.6. Derivative Indicators

Below are the formulae for the CVOL metrics:

- \( DownVar_N = 100 \sqrt{\frac{2}{T_N} \left( \sum_{i=-m}^{n-1} \frac{\Delta K_i}{F_N} g_N Q(P_{K_i}) + \frac{1}{F_N} g_N \ast (adjVA_{-1})_N \right)} \)
- \( UpVar_N = 100 \sqrt{\frac{2}{T_N} \left( \frac{1}{F_N} g_N \ast (adjVA_{+1})_N + \sum_{i=1}^{n} \frac{\Delta K_i}{F_N} g_N Q(C_{K_i}) \right)} \)
• Skew Ratio\(_N\) = \(\frac{UpVar_N}{DownVar_N}\)

• Skew Difference\(_N\) = UpVar\(_N\) – DownVar\(_N\)

• Convexity\(_N\) = \(\frac{CVOLN}{ATMN}\)

• \(ATM_H = \sqrt{\frac{(T_2 - T_H)(ATM_1^2 + (T_N - T_1) + ATM_2^2)}{(T_2 - T_1)}}\)

Where:

• \(T_1\) = the time to the shorter dated tenor
• \(T_2\) = the time to the longer dated tenor
• \(T_H\) = the time to the target time-horizon
• \(ATM_1\) = the ATM value for tenor pertaining to tenor \(T_1\)
• \(ATM_2\) = the ATM value for tenor pertaining to tenor \(T_2\)
• \(ATM_H\) = the ATM value for time horizon \(T_H\)

6. Live Reprint Logic

The following section describes the metrics and thresholds used that can trigger a reprint of a given calculation.

• Data Checks:
  o Future Value Test: If a value for the Future (\(F_N\)) cannot be calculated (i.e. a synthetic Future value and the mid of the Future both cannot be calculated), the calculation fails and a reprint is issued.
  o Minimum Data Viability Test: If, after data filtering, there is not at least one strike in each option wing of each tenor, the calculation fails and a reprint is issued.

• Value Checks: The values of the current calculation (\(t\)) are compared against the last printed value (\(t-1\)), which represents the values of the last valid calculation for each of the following metrics:
  o ATM: If \(|ATM_t - ATM_{t-1}| > 0.02 \times ATM_{t-1}\), the test is failed and the values of \(t - 1\) are reprinted.
  o CVOL: \(|CVOL_t - CVOL_{t-1}| > 0.05 \times CVOL_{t-1}\), the test is failed and the values of \(t - 1\) are reprinted.
  o Strike Count (K Count): If \(K Count_t < 0.95 K Count_{t-1}\), the test is failed and the values of \(t - 1\) are reprinted.
  o Skew: If \(|Skew_t - Skew_{t-1}| > 0.1 \times Skew_{t-1}\), the test is failed and the values of \(t - 1\) are reprinted.

If the Live Streaming CVOL calculation has been reprinted for a period of 2 minutes or less, the checks described above are used to compare \(t\) against the last calculation that was not a reprinted value.
Establishment of new CVOL Level

If the Live Streaming CVOL calculation at time $t$ is proceeded by a reprinted calculation at $t-1$ and the period of time for which the reprinted value has been printing exceeds 2 minutes, the process below is followed:

- Calculate CVOL and ATM for three consecutive observations (referred to as $S_t, S_{t-1}, S_{t-2}$).
- Using $S_t, S_{t-1}, S_{t-2}$, calculate a moving average of CVOL and ATM (referred to as $CVOL_{MA}$, $ATM_{MA}$).
- If all the following tests pass, reprinting is ended and the metrics pertaining to $S_t$ are printed:
  - ATM: If $|ATM_{S_t} - ATM_{MA}| > 0.02 \times ATM_{MA}$, the test is failed and the values of $t - 1$ are printed.
  - CVOL: $|CVOL_{S_t} - CVOL_{MA}| > 0.05 \times CVOL_{MA}$, the test is failed and the values of $t - 1$ are printed.
  - Strike Count ($K_{Count}$): If $K_{Count_{S_t}} < 0.8 K_{Count_{t-1}}$, the test is failed and the values of $t - 1$ are printed.
- If any of the above tests fail, the process is repeated at the next calculation snapshot.

7. Market Opening Sequence

The Market Opening Sequence represents the first 5 minutes of the product calculation window. During this period the Live Streaming CVOL calculation is performed but not published to provide the algorithm time to become calibrated to the market data as a trading session begins.

For the beginning of a given trading session, the following logic is followed, noting that no values are published until the Market Opening Sequence has completed:

- At the beginning of a session, the last available End-of-Day CVOL number is used as the initial baseline for all metrics. The strike count by tenor is set to a baseline of 2 strikes by tenor.
- The first calculation in the Market Opening Sequence uses the baseline of the End-of-Day CVOL as the $t - 1$ calculation to compare all metrics against.
- The calculation follows the same process as set out in Calculation Approach and Live Re-Print Logic.
- At the end of the Market Opening Sequence, the most recent valid CVOL value is printed as the first print of the market session.
- If a valid CVOL was unable to be calculated during the Market Opening Sequence, the previous End-of-Day CVOL number will be printed. In this scenario, the calculation engine will continue to apply the approach set out in the Establishment of a new CVOL level above.

8. Tenor Selection Process

The Tenor Selection Groups are used to determine the tenor selection applied to each Live Streaming CVOL calculation. The option contracts used for a given calculation session remains the same throughout the entire calculation session, even if a change in expiry would theoretically cause a shift in the tenor selection. The first action in the Market Opening Sequence, prior to any calculation, is to apply the tenor selection criteria on existing contracts and identify the contracts to be used for the calculation session.
To determine which tenors are used, the available live DTEs are taken and rounded down to an integer value. If after rounding, the DTE is equal to the time horizon the CVOL is trying to measure (i.e. is exactly 30, 60, or 90 DTE), the tenor selection is assessed using the unrounded DTEs of the tenors to ensure two tenors are selected.

**Tenor Selection 1**

Tenor Selection 1 is not currently used for the Live Streaming CVOL calculation.

**Tenor Selection 2**

Far contract selection:

- The Monthly expiration > 30.0 DTE and greater than the DTE of the Near contract (if the Near expiry is > 30.0 DTE) and is the closest monthly to 30 DTE.

Near contract selection

- The Monthly expiration closest to 30.0 DTE and < 30.0 DTE and ≥ 10.0 DTE.
- If there is no contract 10.0 DTE ≤ Monthly < 30.0 DTE, then select the closest expiration to 30.0 DTE.

**Tenor Selection 3**

Tenor Selection 3 is not currently used for the Live Streaming CVOL calculation.

**Tenor Selection 4**

Far contract selection:

- The Monthly contract expiration > 30.0 DTE and closest to 30.0 DTE.

Near contract selection:

- The Monthly contract expiration 14.0 ≤ DTE < 30.0 and closest to 30.0 DTE.
- If the shorted dated monthly contract(s) expiration is/are DTE < 14.0 OR DTE > 30.0, then Friday Weekly 14.0 ≤ DTE ≤ 21.0 and closest to 30.0 DTE is selected.

**Tenor Selection 5**

Far contract selection

- The Monthly, Weekly or End-of-Month (EOM) expiration > 30.0 DTE and closest to 30.0 DTE.

Near contract selection

- The Monthly, Weekly or EOM expiration < 30.0 DTE and closest to 30.0 DTE.
Tenor Selection 6 (60 DTE)

In some instruments, the market dynamics cause the practical utility of the option contract to cease approximately one month before expiry. In these markets, a 60.0 day horizon is used as it is effectively equivalent to the 30.0 day horizons employed in the other CVOL indices.

Far contract selection:
- The Monthly expiration > 60.0 DTE and greater than the DTE of the Near contract (if the Near expiry is > 60.0 DTE) and is the closest monthly to 60.0 DTE.

Near contract selection
- The Monthly expiration closest to 60.0 DTE and < 60.0 DTE and ≥ 20.0 DTE.
- If there is no contract 20.0 DTE ≤ Monthly < 60.0 DTE, then select the closest expiration to 60.0 DTE.

Tenor Selection 7 (90 DTE)

In some instruments, the underlying future of the option contract has a quarterly expiration. In these markets, a 90.0 day horizon is used as it is effectively equivalent to the 30.0 day horizons employed in the other CVOL indices.

Far contract selection:
- The Monthly expiration > 90.0 DTE and greater than the DTE of the Near contract (if the Near expiry is > 90.0 DTE) and is the closest monthly to 90.0 DTE.

Near contract selection:
- The Monthly expiration closest to 90.0 DTE and < 90.0 DTE and ≥ 50.0 DTE.
- If there is no contract 50.0 DTE ≤ Monthly < 90.0 DTE, then select the closest expiration to 90.0 DTE.

9. Short Term Interest Rate (STIR) Methodology

Due to the nature of the STIR Futures market, the SOFR based Live Streaming CVOL indices require an alternative calculation methodology. The calculation of the single tenor volatility value is derived from the Live Streaming CVOL index calculation approach and is shown below:

\[
Single \ Tenor \ Index = \sigma_N = 100 \times \sqrt{\frac{2}{T} \sum_{t=1}^{n} \Delta K_t G_N Q(D_{K_t})}
\]
10. Yield-Volatility Methodology

In order to render the price-based volatility as a basis point volatility the DV01 is used. The DV01 is the change of a bond price for a 1 basis change of the rate associated with that bond. To convert a futures price volatility into a BP volatility, the transformation happens at the variance level.

\[ \sigma_{bp}^2 = \sigma^2 \cdot \frac{P^2}{DV01^2} \]

From the prior calculation

\[ \sigma = \sqrt{(T_2 - T_H) \cdot (\sigma_1^2) + (T_H - T_1) \cdot (\sigma_2^2)} \]

Substituting the DV01 formula

\[ \sigma_{bp} = \sqrt{(T_2 - T_H) \cdot (\sigma_1^2) \cdot \left( \frac{P^2}{DV01^2} \right) + (T_H - T_1) \cdot (\sigma_2^2) \cdot \left( \frac{P^2}{DV01^2} \right)} \]

\[ (T_2 - T_1) \]
11. Broad Based Indices

Due to the composition of the Broad-Based Indices with certain products having different market hours, the index calculation uses the last printed CVOL observation for each component. The weightings of the components of the Broad-Based Indices are determined by the Dollar Vega Data from the most recent End-of-Day data and persist for the entire day.

The following table outlines the current Broad Based Indices, with the market calculation times and the component times provided in the Product Calculation Windows section:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVL</td>
<td>Ag Products Volatility Index</td>
<td>OZC, OZW, OZS, OZM, OZL, LE, HE, DC, GF</td>
</tr>
<tr>
<td>ENVL</td>
<td>Energy Volatility Index</td>
<td>LO, LN, OB, OH</td>
</tr>
<tr>
<td>FXVL</td>
<td>FX Volatility Index</td>
<td>ENU, GBU, JPU, AUU, CAU</td>
</tr>
<tr>
<td>TPVL</td>
<td>Treasury Curve Volatility Index - Price</td>
<td>TU, FV, TY, US (price version)</td>
</tr>
<tr>
<td>TVL</td>
<td>Treasury Curve Volatility Index - Yield</td>
<td>TU, FV, TY, US (yield version)</td>
</tr>
<tr>
<td>CMVL</td>
<td>Commodities Volatility Index</td>
<td>LO, LN, OH, OB, OZC, OZW, OZS, HXE, OG, SO, LE, HE, DC</td>
</tr>
<tr>
<td>MEVL</td>
<td>Metals Volatility Index</td>
<td>OG, SO, HXE, PO, AL</td>
</tr>
</tbody>
</table>

The calculation of the indices described above is the sum of Implied Volatility Calculations weighted by the Dollar Vega Open Interest ($VOI). The dollar Vega Open Interest can be defined as follows:

\[ VOI_T = M \sum_{t=0}^{i} \sum_{k=0}^{j} v_{t,k} \times OI_{t,k} \]

We then use five days of $VOI$ to arrive at a five-day moving average as defined below:

\[ MA_{T=0} = \frac{\sum_{T=-5}^{T=0} VOI_T}{5} \]

Where:

- \( t \) tenor of a given option.
- \( T \) is the day of a given $VOI$, where \( T_{-5} \) is five settlement days prior to the current calculation day.
- \( k \) is the strike of a given option from the EoD settlement data
- \( v_{t,k} \) is the Vega of option position \( t, k \) from the EoD settlement data
- \( OI_{t,k} \) is the Open Interest of option position \( t, k \) (both Calls and Puts) from the EoD settlement data
- \( M \) is the contract multiplier/Contract Value Factor (CVF) associated with the product for the option position

Using the five-day moving averages, we formulate the weighting for each product using the following definition:

\[ W_n = \frac{MA_n}{\sum_{n=1}^{MA_n} W_n} \]
Where:

- $q$ is the number of products being combined into the index
- $MA_n$ is the 5-day moving average of the $VOL$

With the weightings calculated, we take the final step and calculate the index by combining the weightings and Volatility values for each respective product in the following manner:

$$\sigma_{index} = \sum_{n=1}^{q} \sigma_n \ast W_n$$

12. Publication

The Live Streaming CVOL Indices are calculated and published every 15 seconds during the times defined in Product Calculation Windows. The Live Streaming CVOL Indices follow the CME Globex Holiday Calendar.

If an error is reported in the input data or in the calculation, the Index is not re-calculated.