FX Options Vol Converter User Guide and Methodology

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This document is designed to be a user guide to highlight the functionality of the FX Options Vol Converter.

Overview

The FX Options Vol Converter converts the extensive listed options pricing available on the CME, into an OTC-equivalent volatility surface, allowing OTC users to easily compare pricing and optimize execution.

- Available for 5 currency pairs: EUR/USD, JPY/USD, GBP/USD, AUD/USD, CAD/USD

- Provides live updates between 1am and 4pm CST. Outside of these hours, the Settle view described below will be displayed and remain available as a view options during the live session.

- All of the views in the FX Options Vol-Converter display OTC-equivalent values derived from CME traded premium quotes using the process described in the Methodology. These values are displayed using OTC conventions, such that for the inverted CME pairs of JPY/USD and CAD/USD, the display represent values in USD/JPY and USD/CAD format (Puts and Calls are on the USD). However, the Drilldown window (explained below) retrieves the original CME contract formats and data (so inverted strikes and types, i.e. Puts and Calls are on the JPY).

- The Risk Reversal (RiskRev) values in the Summary View are displayed as Call-Put. E.g. in EUR/USD this means EUR Call-EUR Put, in USD/JPY it means USD Call-USD Put.

1. summary view:

The OTC Surface summary view shows the OTC-equivalent implied volatility surface at fixed tenors and deltas from a converted CME live price stream, with the ability to see a particular side of the market (Bid, Mid, Ask or Settle) that is of interest (see figure 1). The Settle view provides an OTC-equivalent surface based on CME's daily 2 p.m. settlement values and is available for reference until the close of the next trading day.

Figure 1: Summary view

CME FX Options Vol Converter - JPY/USD (JPU)

OTC-Equivalent Vol — Bid | Ask | **Mid** | Settle

Tenor	Put									Call								Tenor	RiskRev		Butterflies	
	5Δ	10Δ	15Δ	20Δ	25Δ	30Δ	35Δ	40Δ	50Δ	40Δ	35Δ	30Δ	25Δ	20Δ	15Δ	10Δ	5Δ		25Δ	10Δ	25Δ	10Δ
1D	9.65	9.35	9.19	9.09	9.02	8.97	8.94	8.93	8.92	8.96	8.99	9.04	9.10	9.19	9.32	9.51	9.87	1D	-0.08	-0.16	0.14	0.50
1W	8.64	8.18	7.96	7.83	7.76	7.72	7.70	7.70	7.76	7.88	7.98	8.10	8.25	8.45	8.73	9.16	9.94	1W	-0.49	-0.98	0.25	0.91
2W	8.00	7.66	7.50	7.42	7.39	7.38	7.39	7.42	7.52	7.69	7.81	7.95	8.12	8.35	8.65	9.11	9.93	2W	-0.74	-1.45	0.23	0.86
3W	7.63	7.31	7.18	7.13	7.11	7.12	7.15	7.19	7.34	7.55	7.69	7.86	8.07	8.33	8.69	9.21	10.16	3W	-0.96	-1.90	0.25	0.92
1M	7.69	7.32	7.17	7.10	7.08	7.09	7.12	7.17	7.33	7.56	7.72	7.91	8.14	8.44	8.84	9.43	10.52	1M	-1.06	-2.11	0.28	1.05
2M	7.94	7.39	7.15	7.02	6.97	6.95	6.97	7.01	7.16	7.42	7.60	7.81	8.08	8.44	8.92	9.64	10.99	2M	-1.12	-2.26	0.36	1.35
3M	8.19	7.82	7.70	7.67	7.68	7.74	7.82	7.92	8.20	8.58	8.82	9.12	9.47	9.92	10.52	11.41	13.02	3M	-1.79	-3.59	0.38	1.42
6M	8.55	7.94	7.69	7.57	7.53	7.54	7.58	7.65	7.88	8.23	8.47	8.76	9.11	9.57	10.20	11.14	12.87	6M	-1.58	-3.20	0.44	1.66
9M	8.40	7.78	7.52	7.41	7.37	7.37	7.42	7.50	7.74	8.10	8.34	8.64	9.01	9.48	10.13	11.10	12.89	9M	-1.64	-3.32	0.45	1.70
1Y	8.45	7.81	7.54	7.42	7.38	7.39	7.44	7.52	7.77	8.15	8.40	8.71	9.10	9.60	10.27	11.28	13.16	1Y	-1.72	-3.48	0.47	1.78

Using Mid prices - last updated 8/3/2020 11:21 AM CST

The OTC-Equivalent Vol surface can be refreshed by clicking on the browser button shown below:
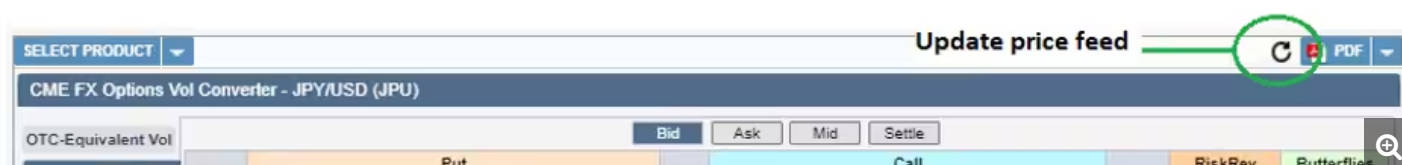
In the Summary view, a drill down functionality may be accessed by clicking on any bucket on the surface (see figure 1a). This will highlight the underlying CME instruments most closely associated with the implied volatility value within the bucket and show the unadjusted pricing data for each. This view allows you to quickly find the associated instruments on CME and recognize the option/futures price combination that feeds into the OTC-equivalent volatility.

For example, in Figure 1a below, when selecting the USD/JPY 2M tenor 30 Delta Put with an OTC-equivalent volatility of 6.89, the dropdown populates the specific CME contract info underlying this value: two October JYP/USD Call Options (JPUV00), two November JPY/USD Call Options (JPUXV0), and their associated DTE (Days To Expiration). It also shows their strikes, prices, deltas, underlying future, and future price. For inverted CME pairs such as JPY/USD and CAD/USD, there are two additional columns (1/Strike) and (1/Fut) displaying the inverse value for the strike and future price to provide a quick confirmation in OTC-like convention.

Figure 1a: OTC Surface drilldown
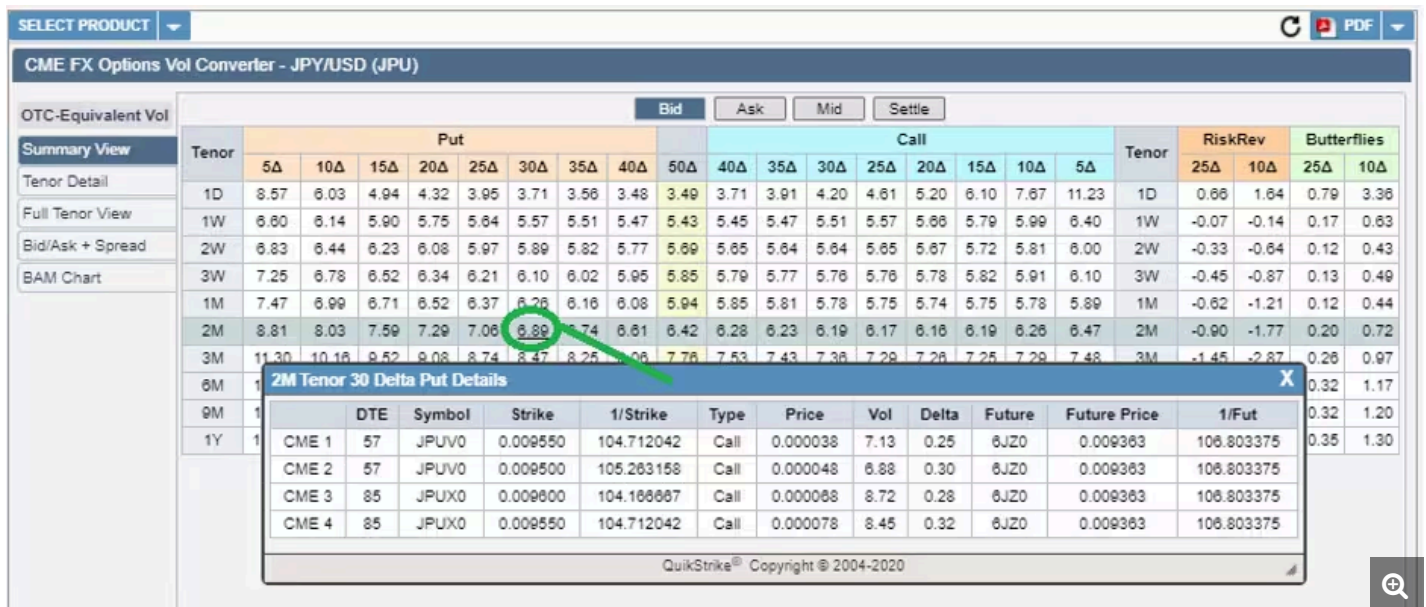
2. Tenor Detail view:

The Tenor Detail view compares contributing CME instruments nearest a specific tenor bucket, depicting a graph of the full delta curve. As with the OTC Surface view, you can drill down on a tenor/delta bucket and view a specific side of the market (Bid, Mid, Ask, or Settle).

Figure 2 below shows the OTC-equivalent implied volatility of the EUR/USD 2W tenor (row 2 in the table) alongside the underlying CME contracts most closely associated with this specific option tenor, the September EUR/USD Options (EUUU0) and October EUR/USD Options (EUUV0) – in rows 1 and 3 respectively. The OTC-equivalent volatilities for each are depicted in the graph to show the full delta curve, allowing you to easily compare implied volatility measures of fixed tenors and deltas to associated CME instruments. Please note that when one of the CME contracts has an equivalent DTE to the OTC tenor, the two curves will be identical, and the option graph line will cover the CME line such that only two curves will be visible.

Figure 2: Tenor Detail

		Bid	Ask	Mid	Settle		1D	1W	2W	3W	1M	2M	3M	6M	9M	1Y
OTC-Equivalent Vol																
Summary View	Symbol	DTE			Put							Call				
Tenor Detail			5Δ	10Δ	15Δ	20Δ	25Δ	30Δ	35Δ	40Δ	50Δ	40Δ	35Δ	30Δ	25Δ	20Δ	15Δ	10Δ	5Δ
Full Tenor View	JPUX0	85	11.40	10.26	9.62	9.18	8.84	8.56	8.33	8.14	7.82	7.58	7.47	7.39	7.31	7.26	7.23	7.25	7.40
Bid/Ask + Spread	3M	92	11.42	10.25	9.59	9.14	8.79	8.51	8.28	8.08	7.75	7.50	7.39	7.30	7.23	7.17	7.15	7.17	7.31
BAM Chart	JPUZ0	113	11.59	10.35	9.65	9.16	8.79	8.49	8.24	8.03	7.68	7.41	7.30	7.20	7.11	7.05	7.01	7.02	7.15

Using Bid prices - last updated 8/13/2020 12:56 PM CST

3. Full Tenor view:

The Full Tenor view is an extended surface detailing the implied volatilities of fixed tenors and associated CME contracts intermingled for an overview of the full surface.

Figure 3: Full Tenor view

SELECT PRODUCT ▼

CME FX Options Vol Converter - JPY/USD (JPU)

OTC-Equivalent Vol

				Bid	Ask	Mid	Settle														
				Put									Call								
Tenor	Expires	DTE	WDTE	5Δ	10Δ	15Δ	20Δ	25Δ	30Δ	35Δ	40Δ	50Δ	40Δ	35Δ	30Δ	25Δ	20Δ	15Δ	10Δ	5Δ
1D	8/14/2020	1	1	7.04	6.02	5.50	5.16	4.92	4.74	4.61	4.50	4.36	4.30	4.30	4.33	4.38	4.47	4.63	4.90	5.48
2JYQ0	8/14/2020	1	1	7.04	6.02	5.50	5.16	4.92	4.74	4.61	4.50	4.36	4.30	4.30	4.33	4.38	4.47	4.63	4.90	5.48
MJ3Q0	8/17/2020	4	2	6.04	5.44	5.11	4.89	4.73	4.60	4.50	4.42	4.29	4.21	4.19	4.18	4.18	4.20	4.24	4.34	4.57
WJ3Q0	8/19/2020	6	4	6.82	6.32	6.04	5.85	5.70	5.59	5.49	5.41	5.29	5.20	5.17	5.14	5.13	5.13	5.15	5.20	5.34
1W	8/20/2020	7	5	7.19	6.66	6.36	6.15	5.99	5.86	5.76	5.67	5.53	5.42	5.38	5.35	5.33	5.32	5.33	5.37	5.49
3JYQ0	8/21/2020	8	6	7.45	6.90	6.58	6.37	6.20	6.06	5.95	5.86	5.70	5.58	5.54	5.49	5.46	5.44	5.44	5.46	5.55
MJ4Q0	8/24/2020	11	7	6.66	6.23	5.98	5.81	5.68	5.57	5.48	5.41	5.29	5.19	5.16	5.13	5.10	5.09	5.09	5.11	5.19
WJ4Q0	8/26/2020	13	9	7.16	6.68	6.40	6.20	6.05	5.93	5.83	5.74	5.60	5.50	5.45	5.42	5.39	5.37	5.36	5.38	5.46
2W	8/27/2020	14	10	7.34	6.83	6.54	6.34	6.18	6.06	5.95	5.86	5.71	5.60	5.55	5.51	5.47	5.45	5.44	5.45	5.53
4JYQ0	8/28/2020	15	11	7.49	6.97	6.67	6.46	6.30	6.16	6.05	5.96	5.80	5.68	5.63	5.58	5.55	5.52	5.50	5.51	5.57
MJ5Q0	8/31/2020	18	12	7.17	6.70	6.42	6.23	6.08	5.95	5.85	5.76	5.61	5.49	5.44	5.40	5.36	5.33	5.31	5.31	5.35
WJ1U0	9/2/2020	20	14	7.42	6.92	6.63	6.43	6.28	6.15	6.04	5.95	5.80	5.68	5.63	5.58	5.55	5.52	5.50	5.51	5.56
3W	9/3/2020	21	15	7.58	7.07	6.78	6.57	6.41	6.28	6.17	6.07	5.92	5.79	5.74	5.69	5.65	5.61	5.59	5.59	5.63
JPUU0	9/4/2020	22	16	7.73	7.21	6.91	6.70	6.53	6.40	6.28	6.19	6.02	5.89	5.83	5.78	5.73	5.69	5.66	5.65	5.68
2JYU0	9/11/2020	29	20	7.99	7.42	7.09	6.86	6.68	6.53	6.41	6.30	6.12	5.98	5.92	5.87	5.82	5.78	5.75	5.75	5.80
1M	9/14/2020	32	21	7.78	7.23	6.92	6.69	6.52	6.38	6.26	6.16	5.98	5.84	5.78	5.73	5.68	5.64	5.61	5.59	5.62
MJ2U0	9/14/2020	32	21	7.78	7.23	6.92	6.69	6.52	6.38	6.26	6.16	5.98	5.84	5.78	5.73	5.68	5.64	5.61	5.59	5.62
JPUV0	10/9/2020	57	40	9.03	8.21	7.74	7.42	7.17	6.98	6.81	6.67	6.44	6.27	6.19	6.13	6.08	6.05	6.03	6.06	6.18
2M	10/13/2020	61	41	9.08	8.23	7.76	7.42	7.17	6.97	6.80	6.65	6.42	6.24	6.17	6.10	6.05	6.02	6.00	6.03	6.15
JPUX0	11/6/2020	85	59	11.43	10.28	9.63	9.18	8.83	8.56	8.33	8.13	7.81	7.56	7.46	7.37	7.29	7.24	7.21	7.23	7.38
3M	11/13/2020	92	63	11.45	10.27	9.60	9.14	8.79	8.50	8.27	8.07	7.74	7.48	7.38	7.28	7.21	7.15	7.12	7.14	7.29
JPUZ0	12/4/2020	113	77	11.61	10.36	9.65	9.16	8.79	8.49	8.24	8.02	7.67	7.39	7.28	7.18	7.09	7.03	6.99	6.99	7.12
JPUF1	1/8/2021	148	100	11.55	10.25	9.51	9.00	8.61	8.30	8.04	7.81	7.44	7.16	7.03	6.93	6.84	6.76	6.72	6.72	6.84

4. Bid/Ask view + Spread

The Bid/Ask + spread view shows the bid and ask implied volatility values in one view for convenience (Figure 4). It also can display the spread between bid and ask (Figure 4a) to help identify areas of trader focus (a tighter spread may reflect active two-way engagement in that specific area of the curve).

Figure 4: Bid/Ask view

SELECT PRODUCT ▼

CME FX Options Vol Converter - JPY/USD (JPU)

OTC-Equivalent Vol

	Bid/Ask	Spread										
	PUTS						CALLS					
TENOR	10Δ	15Δ	20Δ	25Δ	35Δ	50Δ	35Δ	25Δ	20Δ	15Δ	10Δ	TENOR
1D	6.06/7.97	5.79/7.54	5.59/7.25	5.45/7.04	5.23/6.74	5.01/6.49	4.86/6.38	4.80/6.40	4.78/6.44	4.78/6.53	4.80/6.71	1D
1W	6.58/7.67	6.30/7.25	6.10/6.96	5.95/6.76	5.74/6.47	5.54/6.23	5.42/6.14	5.38/6.17	5.38/6.23	5.40/6.33	5.46/6.52	1W
2W	6.77/7.60	6.50/7.21	6.31/6.94	6.16/6.74	5.94/6.46	5.72/6.20	5.57/6.06	5.50/6.04	5.48/6.06	5.48/6.12	5.49/6.23	2W
3W	7.03/7.62	6.73/7.24	6.52/6.98	6.36/6.79	6.12/6.50	5.87/6.23	5.71/6.08	5.64/6.04	5.62/6.04	5.61/6.07	5.63/6.15	3W
1M	7.17/7.81	6.85/7.36	6.62/7.06	6.45/6.83	6.19/6.50	5.93/6.19	5.75/6.02	5.67/5.98	5.64/5.99	5.63/6.03	5.64/6.13	1M
2M	8.17/8.87	7.79/8.19	7.37/7.72	7.12/7.43	6.78/7.01	6.40/6.61	6.17/6.37	6.09/6.20	6.06/6.20	6.07/6.32	6.12/6.42	2M

Figure 4a: Spread view

5. BAM Chart

The BAM Chart display graphically the vol smile for the Bid/Mid/Ask for a select Tenor.

Methodology

The below provides a basic overview of the process, a more technical description will be available in a separate research paper to be published soon.

The conversion process:

1. Extract bid/ask premium price for all strikes and maturities in CME FX pairs

2. Adjust for the difference in the underlying by converting CME strikes to OTC equivalent strikes

   - Align quote format as needed by flipping CME American term to OTC European term (i.e. USD/JPY, USD/CAD)

   - Adjust CME strike by removing the expected forward swap differential between spot and future at option expiration

3. Back out volatility from premium price attached to new OTC equivalent strikes

4. Use a SABR stochastic volatility model to build an interpolated delta/volatility surface used to:

   - Generate an implied volatility run at standard OTC Tenor and Delta buckets

   - Allow drilldown on any of the standard OTC tenor/delta bucket to view the original details of the nearest CME contracts (up to 4) most responsible for that interpolated OTC-equivalent value.

5. Steps above performed for the mid, bid and ask side of the vol surface to allow trade level comparison

Some of the Math:

Converting American Term to OTC Term

Let's assume replicates the payoff V of a long XXXUSD call option with strike K and maturity T. For to be equivalent one has to buy K units of USDXXX put option with strike . Finally, we multiply the ratio by to change the premium currency from USD to XXX.

$$V'_{USDXXX}\left(\omega' = 1 - \omega, F' = \frac{1}{F}, K' = \frac{1}{K}, T_{exp}, T_{del}^{ETD}\right) = \frac{V_{XXXUSD}\left(\omega, F, K, T_{exp}, T_{del}^{ETD}\right)}{K} \times Spot_{USDXXX}$$

Where:

- $V_{fut}\left(t, Fut_{t,T_{del}^{CME}}, K_{fut}, T_{exp}, T_{del}^{CME}\right)$ is the CME option premium at time t with future underlying, strike K_{fut}, expiry T_{exp} and T_{del}^{otc} value date;

- $V_{spot}\left(t, Spot_{T_{exp}}, K_{spot}, T_{exp}, T_{del}^{otc}\right)$ is the CME option premium at time t with $Spot_{T_{exp}}$ underlying, strike K_{spot}, expiry T_{exp} and T_{del}^{CME} value date;

- ϕ is the future minus spot basis at expiry time T_{exp};

- $Fut_{T_{exp},T_{del}^{CME}}$ is the future rate value from T_{exp} to T_{del}^{CME} at time T_{exp}. $Spot_{T_{exp}}$ is the spot rate value at time T_{exp}

We need to know the value of ϕ at time t, however we only know its value at time T_{exp}. Given the information we have at time t, the expectation of ϕ should be a good approximation of ϕ. Such expectation is observable at time t, as Fut(t,T_{del}^{CME}) is traded on the CLOB and Fwd(t,T_{exp}) can be interpolated from the OTC forward curve:

Changing Option Underlying from Future to Spot

We define V_{spot} as the premium of a CME option delivering on the OTC value date (T_{del}^{otc}), and, V_{fut} the premium of a CME option with a future underlying (T_{del}^{CME}). Both options share the same expiry date T_{exp}. The two option premiums are equal if we make a small adjustment to V_{spot} strike, called K_{spot}, to consider the future-spot basis ϕ. The equation below defines the relationship in detail.

$$E_t[\phi] = \phi' = Fut_{t,T_{del}^{CME}} - Fwd_{t,T_{exp}}$$

SABR Calibration to OTC-Equivalent premium

Objective function

$$\min_{\alpha,\nu_1,\nu_2} \sum_{i=1}^{N} \omega_i \left(V_i - V\left(K_i, T_{exp}, \sigma_{SABR}(F, K_i, \alpha, \beta, \nu_1, \nu_2)\right)\right)^2$$
$$s.t.\, 0 < \alpha < 1, -\infty < \nu_1 < \infty, 0 < \nu_2 < \infty$$

SABR

$$\sigma_{SABR} = \frac{nominator}{denominator} \cdot \frac{z}{\chi(z)}$$

$$nominator = \alpha \cdot \left(1 + \left(\frac{(1-\beta)^2 \cdot \alpha^2}{(F \cdot K)^{1-\beta} \cdot 24} + \frac{\rho \cdot \beta \cdot \nu \cdot \alpha}{(F \cdot K)^{\frac{1-\beta}{2}} \cdot 4} + \frac{(2 - 3 \cdot \rho^2) \cdot \nu^2}{24}\right) \cdot T_{exp}\right)$$

$$denominator = (F \cdot K)^{\frac{1-\beta}{2}} \cdot \left(1 + \frac{(1-\beta)^2 \cdot \left(\log\left(\frac{F}{K}\right)\right)^2}{24} + \frac{(1-\beta)^4 \cdot \left(\log\left(\frac{F}{K}\right)\right)^4}{1920}\right)$$

$$z = \frac{\nu}{\alpha} \cdot (F \cdot K)^{\frac{1-\beta}{2}} \cdot \log\left(\frac{F}{K}\right)$$

Unconstrained Optimizer with Bounded Interval for SABR parameters:

Transform $x \in (-\infty, \infty)$ to $x' \in (L, U)$ using: $\qquad x' = \frac{1}{2}\left((U + L) + (U - L)\tanh(\gamma x)\right)$

For more information

Visit The FX Options Vol Converter to start using the tool.

For questions about this tool, contact FXteam@cmegroup.com.