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VXTYN volatility futures

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CBOE launches VXTYN volatility futures

The Chicago Board Options Exchange launched futures on the CBOE/CBOT 10y US Treasury Note Volatility Index (VXTYN) today, 13 November 2014. In this report we explain the detailed mechanics and specifications of the VXTYN index and futures. We discuss potential applications of futures, their advantages and shortcomings.

Refer to important disclosures on page 8 to 10.

VXTYN volatility index

The CBOE/CBOT 10y US Treasury Volatility Index (VXTYN) is constructed as a measure of the market's expectation of 30d volatility of the 10y US Treasury (TY) futures, implied from market prices of options on those futures. The index level represents annualized price (log-normal) volatility expressed in percentage points. For example, at the time of writing, the VXTYN index at 5.26 corresponds to expected price volatility of underlying TY futures of 5.26% over a 30d horizon, expressed in annualized terms.

The calculation of the index closely resembles that of a well-know VIX index of S&P 500 volatility and can be summarized as a three-step process:

1. The CBOE selects two nearby option expirations from available serial and quarterly options on TY futures with more than eight business days to expiration. For example, at the time of writing, December (11/21/2014) and January (12/26/2014) expirations are used. Those expiration dates are rolled once a month.

2. The CBOE calculates a measure of expected futures volatility for each of the two expirations using prices of ATM and OTM calls and puts with non-zero bids. The formula used in this calculation is designed to represent a theoretical value of a variance swap on the realized volatility of the underlying futures contract. The exact formula can be found in the appendix.

3. The two measures of expected volatilities corresponding to nearby option expirations are linearly interpolated (or, in some cases, extrapolated) to compute the expected volatility over a 30d horizon, which is then rounded to the nearest tick (0.01).

The appendix provides a detailed example of calculating the VXTYN index. Because the index is based on listed CME/CBOE options it is sufficiently transparent and can be calculated frequently. In fact, CBOE updates the index every 15 seconds from 7:00am to 3:15pm Chicago time. By construction, the minimum change in the index level is 0.01.

VXTYN methodology closely mimics that of the VIX, but one distinction is worth mentioning. The VIX index is constructed by interpolating between two expirations for options on the same S&P 500 index, and therefore can be always interpreted as expected 30d volatility of the S&P 500 stock index. In contrast, the two option expirations used in the construction of the VXTYN index may correspond to different futures.

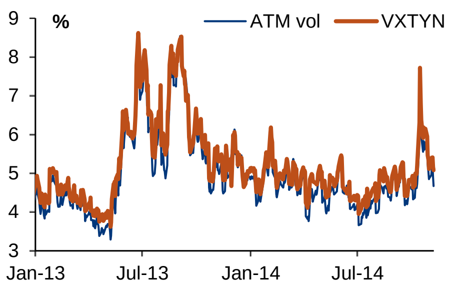
For example, at the time of writing, December options are written on TYZ4 futures and January options are written on TYH5 futures. When that is the case, the index may not be interpreted as expected volatility of a given TY futures. However, TY futures with consecutive settlement months would normally have close maturities, so the index can still be thought of as a representative measure of expected volatility in the corresponding sector of the curve.

VXTYN and ATM volatilities

Investors may be wondering why CBOE uses a convoluted formula involving OTM options in order to replicate the theoretical value of a variance swap rather than simply using ATM implied volatilities as a basis for the VXTYN index. One reason is that, from a theoretical standpoint, the value of the variance swap is a cleaner measure of expected realized variance than the one implied from ATM options. Theoretically, implied variance is an expected weighted average of realized variance along possible paths of the underlying, weighted by gamma. Because a variance swap has a constant gamma exposure, the fair value of a variance swap presents an unbiased (risk-adjusted) expectation of the variance realized over the life of the swap. In contrast, gamma of plain vanilla options changes with the move in the underlying, so implied volatilities generally present biased expectations of realized vol (see SRVX volatility index for more detail).

In the presence of the skew, the fair value of expected volatility implied by variance swaps is generally greater than ATM implied vol. In fact, the VXTYN index has generally traded above ATM implied vol (Chart 1). We constructed a measure of ATM vol by following exactly the same steps used to calculate the VXTYN described above, but using ATM volatility implied by the standard Black-Scholes model at Step 2. The VXTYN index has been above this measure of ATM vol by about 5% on average since 2013.

Chart 1: VXTYN tends to trade above ATM vol



Source: BofA Merrill Lynch Global Research

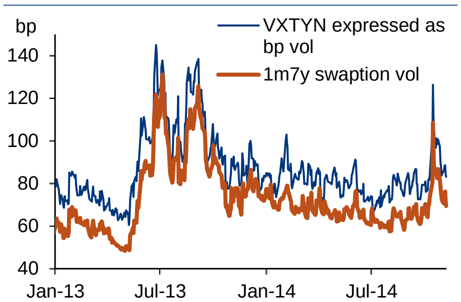
However, the index is highly directional with ATM volatility. The correlation of the index with ATM vol has been 99% and 93% in levels and daily changes, respectively. Therefore, taking a view on the VXTYN index is essentially the same as taking a view on the ATM vol of the underlying TY futures.

Price vol vs normal bp volatility

The VXTYN index represents annualized price (log-normal) volatility of the underling TY futures. To facilitate comparison with the OTC volatility market, investors may want to express VXTYN in terms of basis point (normal) volatility. When a switch option can be ignored, which is normally the case in a low rates environment, price volatility of the futures can be converted to normal volatility of the corresponding futures rate by normalizing the price vol by the modified duration of the futures, which in turn can be approximated by the modified duration of the CTD.

For example, the current CTD of the TYZ4 futures (2.25 7/21 bond) has the modified duration of about 6.1y, so price volatility of about 4.5% of corresponding ATM options translates to about 73.8(=100*4.5/6.1) bp of normal volatility. When the switch option is in the money, a basis model is required for such a calculation.

Chart 2: VXTYN index expressed in normal vol terms



Source: BofA Merrill Lynch Global Research

As an illustration, we compared the VXTYN index expressed in terms of normal volatility to implied normal volatility of 1m7y swaptions, which corresponds to expected volatility of swap rates in the same sector of the curve over the same 1m horizon. We normalized the VXTYN index by the average of modified durations of underlying futures for this analysis. The VXTYN has been highly directional with the swaption volatility, although it has tended to trade above the corresponding swaption vol with the average premium of about 20% since 2013 (Chart 2). This premium is due to two factors. First, the VXTYN index trades above ATM volatility of the underlying options, as explained above. Second, ATM volatility of TY options tends to exceeds that of swaptions because futures rates tend to be more volatile than swap rates.

VXTYN futures

VXTYN futures are standard futures that cash settle to the level of the VXTYN index at the time of maturity. Therefore, the price of the futures on a given date represents the market’s expectation of the VXTYN index (equal to expected 30d volatility of the TY futures) at the time of the futures’ maturity. This means the buyer of a futures contract would make money if the VXTYN index at expiration exceeds the futures price at initiation, and vice versa.

Contract specifications

The notional size of one contract is $1000. The minimum price interval (tick) is 0.01 index points, equal to the minimum tick size of the underlying VXTYN index. A one tick move in the price of the futures is therefore equal to a $10 price move per one contract. VXTYN futures trade from 7:00am to 3:15pm Chicago time.

Table 1: Expiration dates of VXTYN futures

Contract	Last trading date	Final settlement date
Jan 15	21-Jan-15	21-Jan-15
Feb 15	25-Feb-15	25-Feb-15
Mar 15	25-Mar-15	25-Mar-15
Apr 15	22-Apr-15	22-Apr-15

Source: CBOE

The CBOE launched VXTYN futures by listing just four contract months, with maturities in January, February, March and April. Exact maturity (settlement) dates are reported in Table 1. The CBOE also announced that it can list up to 12 contract months for trading going forward.

Settlement

On the settlement date trading of expiring futures terminates at 2pm Chicago time. The CBOE would then publish prices of underlying options on TY futures used in the calculation of the index around 2pm, along with a special quotation of the VXTYN index under ticker VXTYS. Futures settle to the level of the special quotation index.

Margin requirements

Initial margin for one futures contract is currently set at $1,078 and $980 for speculative and hedging accounts, respectively. The futures are also subject to standard maintenance and variation margins.

Investors may be interested in the efficiency of VXTYN futures from the perspective of initial margin payments. In Table 2 we compare initial collateral outlays required to establish a $25K shift vega position in VXTYN futures and 6m7y straddles (for speculative accounts). Such a position would require a purchase or sell of about 475 contracts in VXTYN futures or about $88mn notional of 6m7y straddles (with the premium of about $2.5mn).

Table 2: Initial collateral outlay required to initiate $25K shift vega position

	6m7y straddle	VXTYN futures
Notional	88mn	475 contracts
Premium	2.5mn	0
Initial collateral outlay, $K		
Long	625	512.05
Short	3625	512.05

Source: CBOE, BofA Merrill Lynch Global Research

Initial margin rules for OTC swaptions vary, but we assume a buyer (seller) of straddles would need to post 25% (45%) of the premium on the initial margin, which represents initial margin requirements for a typical investor. Note that a buyer of a swaption would claim the premium paid back on the variation margin, so the initial cash outlay would be only initial margin requirement. A seller of a swaption would need to post the premium received back on the variation margin, so the total collateral posted for a short straddle position would reflect the sum of the premium and initial margin.

Table 2 shows that VXTYN futures could be more efficient than swaptions from the perspective of initial collateral used. Of course, swaptions would also have delta and gamma risks, which explain greater collateral requirements.

Potential applications

Unlike plain vanilla options, VXTYN futures have no delta or gamma and therefore allow investors to have pure exposure to the level of implied volatility of TY futures. In this respect VXTYN futures are similar to OTC forward volatility agreement contracts (see Forward Vol Report for details). This property is extremely difficult to replicate with plain vanilla options without dynamically restriking option positions, and therefore could be very useful for a number of investors.

Among other potential usages, VXTYN futures could be attractive for hedging vega exposure of short-dated option portfolios and macro investors looking to express a view on the level of rates volatility without taking a non-linear gamma

Table 3: Expected variance for TYZ4 options

Futures price (F)				126.2812
ATM strike (K_0)				126
Time to expiration (T), y				0.0302
Interest rate (r), %				0.0444%
Strike	Type	Mid price	ΔK	Contribution to ∑
124.5	put	0.02344	0.5	7.56046E-07
125	put	0.04688	0.5	1.50002E-06
125.5	put	0.11719	0.5	3.72023E-06
126	put/call avg	0.41016	0.5	1.29177E-05
126.5	call	0.29688	0.5	9.27616E-06
127	call	0.15625	0.5	4.84382E-06
127.5	call	0.08594	0.5	2.64325E-06
128	call	0.04688	0.5	1.43053E-06
128.5	call	0.02344	0.5	7.09710E-07
129	call	0.02344	0.5	7.04219E-07
$(2/T)\sum\Delta K/K^2 \exp(rT)P$				2.54787E-03
$(1/T)(F/K_0-1)^2$				1.64855E-04
Variance(T_1)				2.38302E-03

Source: CBOE, BofA Merrill Lynch Global Research

Table 4: Expected variance for TYF5 options

Futures price (F)				125.5625
ATM strike (K0)				125.5
Time to expiration (T), y				0.1261
Interest rate (r), %				0.0350%
Strike	Type	Mid Price	ΔK	contribution to ∑
120.5	put	0.02344	0.5	8.07098E-07
121	put	0.02344	0.5	8.00442E-07
121.5	put	0.03906	0.5	1.32311E-06
122	put	0.05469	0.5	1.83720E-06
122.5	put	0.08594	0.5	2.86352E-06
123	put	0.125	0.5	4.13132E-06
123.5	put	0.1875	0.5	6.14691E-06
124	put	0.28906	0.5	9.40021E-06
124.5	put	0.42188	0.5	1.36093E-05
125	put	0.60156	0.5	1.92508E-05
125.5	put/call avrg	0.85938	0.5	2.72825E-05
126	call	0.67188	0.5	2.11610E-05
126.5	call	0.5	0.5	1.56235E-05
127	call	0.36719	0.5	1.13833E-05
127.5	call	0.26563	0.5	8.17030E-06
128	call	0.19531	0.5	5.96073E-06
128.5	call	0.14844	0.5	4.49497E-06
129	call	0.10938	0.5	3.28646E-06
129.5	call	0.08594	0.5	2.56231E-06
130	call	0.07031	0.5	2.08034E-06
130.5	call	0.05469	0.5	1.60567E-06
131	call	0.03906	0.5	1.13817E-06
131.5	call	0.03906	0.5	1.12953E-06
132	call	0.03125	0.5	8.96791E-07
132.5	call	0.02344	0.5	6.67527E-07
133	call	0.02344	0.5	6.62517E-07
133.5	call	0.02344	0.5	6.57564E-07
$(2/T)\sum\Delta K/K^2 \exp(rT)P$				2.67908E-03
$(1/T)(F/K_0-1)^2$				1.96676E-06
Variance(T_2)				2.67711E-03

Source: CBOE, BofA Merrill Lynch Global Research

risk. Availability of different expirations also allows investors to take views on the term structure of expected volatilities,

Some disadvantages of VXTYN futures include:

- **Lack of flexibility.** VXTYN futures can only be used to expresses view on volatility in a given (7y) sector of the curve. Being based on Treasury futures options, the VXTYN index also inherits an additional complication of the switch option, which may complicate hedging of fixed income portfolios.

- **Difficult replication of the index.** The construction of the VXTYN index is relatively complicated and difficult to replicate in comparison, for example, with implied volatilities on listed and OTC options. A snapshot of all underlying option prices is needed to be able to replicate the index at any point in time, including the closing levels. This may be a disadvantage for some relative value investors.

Appendix: example of VXTYN calculation

We present an example of VXTYN calculation for the 10 November 2014 close. CBOE calculates the closing level of the index using the snapshot of option prices around 3:15pm Chicago time, which we use in the calculation below. Note that those prices would be different from settlement option prices published by CME/CBOT.

The index is based on two sets of TY options: December (11/21/2014 expiration) options on TYZ4 futures and January (12/26/2014 expiration) options on TYH5 futures. The index uses all ATM and OTM calls and puts with non-zero bid prices (technically, with bid prices greater than 1/64). Tables 3 and 4 show strikes and corresponding mid-quote prices used in the calculation of the index for both expirations.

The CBOE calculates the measures of expected variance for each expiration using the following formula:

$$Variance(T) = \frac{2}{T}\sum_i \left(\frac{\Delta K_i}{K_i^2}\right) \exp(rT)\, P_i - \frac{1}{T}\left(\frac{F}{K_0} - 1\right)^2,$$ where

- K_0 is an ATM strike defined as the first strike below price F of the underlying futures. For example, given the price of the TYZ4 futures F=126.2812, K_0=126.

- The sum runs through ATM strike K_0 and OTM strikes K_i for calls and puts. For strikes below or equal K0 puts are used, while for strikes equal or greater than K_0 calls are used. The P_i are mid-prices (defined as an average between bid and ask quotes) of the corresponding calls and puts. For the ATM strike the average between call and put prices is used as P_0.

- ΔK_i is a strike interval defined as half the distance between two adjacent strikes corresponding to a given strike K_i. For the lowest (highest) strike, ΔK_i is simply the difference between the next higher strike and the lowest strike (the difference between the highest strike and the next lower strike).

- *T* is time to expiration expressed in years and computed as the ratio of minutes to expiration to the total number of minutes in a 365-day year (525,600).

- r is the T-bill interest rate corresponding to the time to expiration. The CBOE uses a cubic spline fitted to a constant maturity T-bill curve published by the US Treasury department on the previous business day to compute the interest rate before the market opens. Therefore, the rate remains constant throughout the day.

As discussed above, the formula used in this calculation attempts to approximate the theoretical of a variance swap on the underlying futures. Tables 3 and 4 report the details of the calculation.

Once Variance(T1) and Variance(T2) for both expirations are computed, the CBOE interpolates linearly between the two variances to compute the expected 30d variance using the following formula

$$VXTYN = 100[\{T_1 Variance(T_1)\frac{N_{T2}-N_{30}}{N_{T2}-N_{T1}} + T_2 Variance(T_2)\frac{N_{30}-N_{T1}}{N_{T2}-N_{T1}}\}\frac{N_{365}}{N_{30}}]^{1/2},$$

where:

- N_{T1} is the number of minutes to settlement of the near-term option.
- N_{T2} is the number of minutes to settlement of the longer-dated option.
- N_{30} is the number of minutes in a 30 day period (43,200)
- N_{365} is the number of minutes in a 365-day year (525,600)

In our example the interpolation can be computed as follows:

VXTYN=100*sqrt([0.0302*2.383e-03*(66285-43200)/(66285-15885)+0.1261*2.677e-03*(43200-15885)/(66285-15885)]*525600/43200)=5.1253

Rounding to the nearest tick gives VXTYN=5.13, which matches the closing level of the index published on 10 November 2014.

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