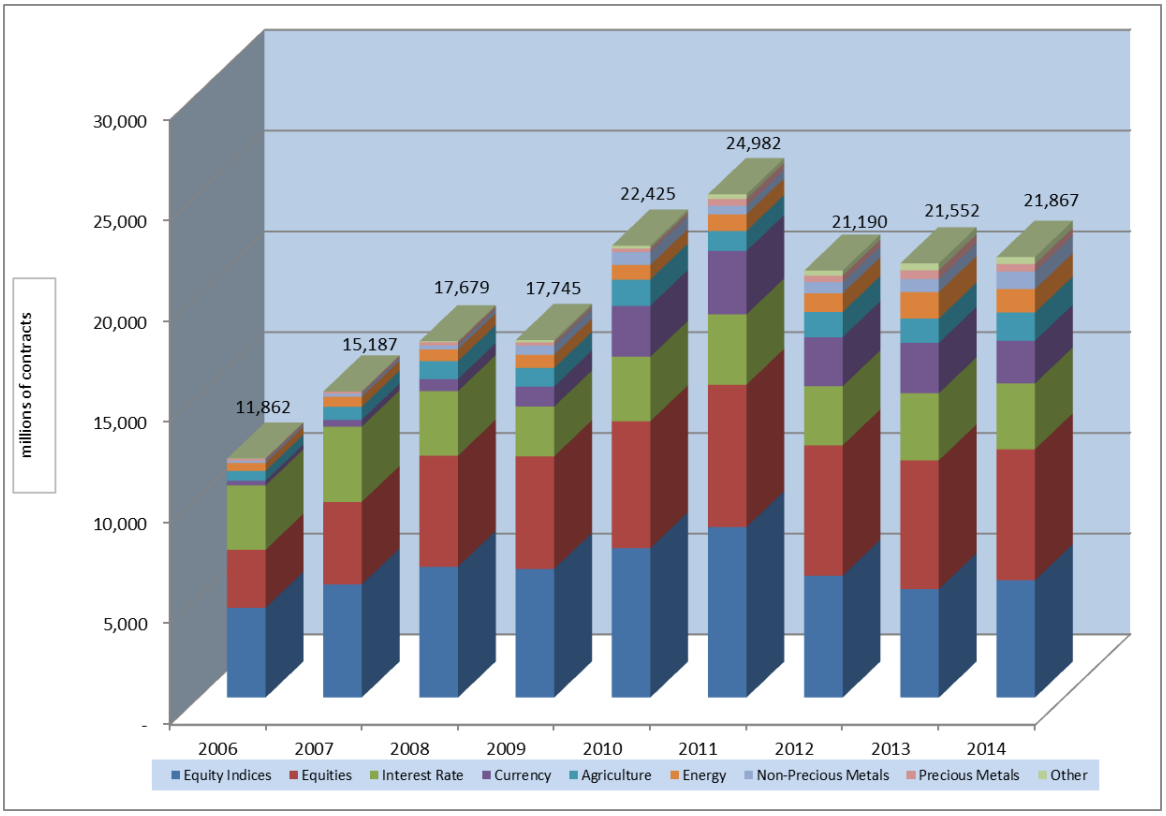
Bloomberg LIVE
The Listed Implied Volatility Engine

Background

The listed option markets around the globe have seen an explosion in terms of listings, product innovation and volume. The number of participants - buy-side, sell-side, brokers and strategists - continues to grow in this space. Acceptance of futures and options has grown among investors and money manager, who once shunned “derivatives” as highly speculative bets or as a dangerous investment choice. As a result of this growth, the amount of "messages" that Bloomberg receives now numbers over 25 billion per day in the US options market alone. A message is an electronic communication from an option exchange indicating that an option bid-ask price or bid-ask size has changed or that a trade has taken place. Given that in the largest derivatives asset class – equity and equity index - Bloomberg subscribes to 41 exchanges with a combined universe of over 6,300 underlyings and over 1,400,000 listed contracts, the amount of data that must be managed in real-time is substantial.

As the option market has matured and grown in acceptance, the "Greeks" that accompany options have also gone main-stream. Hardly a day goes by where one does not hear about the VIX or the market volatility. Options have become so commonplace, that implied volatility is no longer just an input or output to the option model -volatility is now an investable "asset class". With that, in the same way that traders and investors require real-time prices, sizes, time and sales and searches, volatility player require the same from their "security", which is implied volatility. This holds true for investors of all asset classes, from equities and equity indices to energy and precious metals. See the chart below with data as reported by the FIA.



Based on the number of contracts traded and/or cleared at 75 exchanges worldwide, as reported by the Futures Industry Association

What is Bloomberg LIVE and what does it do?

The Bloomberg LIVE service has been designed to support the listed option markets for all asset classes globally. Basically, LIVE consists of two parts; LIVEcalc, the option calculator and LIVEdb, the database. What it does is pretty simple in practice and very powerful in scope. The LIVE service subscribes to every option market prior to the open each day and listens to all activity during the trading session - this means all option trades as well as every "update" in terms of option price and sizes - all the "messages" – which is an indication of what is available to trade. In addition to all of the option data, LIVE subscribes to other internal databases and tickerplants at Bloomberg so that it has all of the inputs to calculate the implied volatility and Greeks – the derived data. LIVE will then, in real-time, calculate the implied volatility and Greeks for every option chain and stream it out to all option applications at the desktop and enterprise level. The data is also stored in 1 second intervals into the LIVEdb, the database until the close of the trading session. LIVE data is time-stamped so that it can be called at a later time or date by any application or function.

What makes LIVE so powerful is not only the streaming of real-time option data – market data and derived data – but also the storage of the time-stamped transparency data. LIVEdb will store all of the inputs and the outputs to the vol calculations. This not only serves as a centralized source for calculations that all applications can call (and ensure that all applications use the same calculation methodology) but it all provides transparency data so that clients can independently verify the calculations that we supply on and off the terminal. This intra-day data is currently saved for 30 calendar days and will also be used to drive our end-of-day history, providing open, high, low and close implied volatility per option contract. This provides functions like GV<GO> and SKEW<GO> with accurate end-of-day history.

While the LIVEdb stores all of this data in the stated granularity, each application may expose this data differently. For example, GIV defaults to 2-minute intervals to display the data on wake-up so that the screen is not "crammed" with too much data. Users do have the ability to zoom in and see finer granularity. QR will be able to use the tick-by-tick data to show the implied vol for each option trade. Regardless of how the data is exposed on the terminal, the 1-second granularity is stored and will be made available where needed. All calc-route fields will go to LIVE for implied vols and Greeks.

How does LIVE calculate Implied Volatility?

In order to compute implied volatility, we first need to calculate the implied forward for each of the listed expiration dates. In theory, tradable (European) option prices uniquely identify the forward via the put-call parity relationship. In practice, quoted bid/ask option prices identify a corresponding bid/ask forward price range for each strike.

We start with BDVD<GO> projections for ex-dividend dates and ex-dividend amounts and the relevant yield curve from ICVS<GO> to calculate an estimated implied forward. Given that BDVD is highly accurate and widely used in option pricing and that ICVS will provide a rate that is close to the average of all individual funding rates, this should land us very close to the implied forward:

estimated implied forward = spot * (1+ ICVS interest rate) / (1+ BDVD dividend yield)

For European options, we compute bid/ask ranges, and corresponding mid prices, for the forward at three strikes: the nearest to the ATM forward, and the two nearest strikes bracketing it. The implied forward is then the median of the three mid prices.

American options are involved, since the put-call parity formula must be applied to equivalent European option prices. This involves simultaneously identifying implied dividend and volatility in addition to the forward. As in the European exercise case above, we start with the same estimate of the implied forward, but also with corresponding estimates of dividend yield and put/call volatilities at the three chosen strikes. These trial values then determine the prices of the corresponding European options. We iterate the above procedure, refining estimates of the implied forward, dividend and volatilities in each iteration until convergence to values that are consistent with the American option prices observed at the three strikes.

When multiple listed expiries span a single dividend date, we imply a dividend amount that fits all those maturities in an aggregate sense. When an option maturity spans multiple dividend dates, the implied dividend is apportioned to each dividend date in accordance with pre-computed seasonality weights.

Additionally, futures are used when available as their prices are indicative of market expectation for dividends. In many cases, they are cleaner to use than options because their prices do not depend on implied volatility.

The above intraday procedures yield a raw implied dividend which is smoothed using those values calculated earlier in the day or on the prior day using a Kalman filtering process. The assumption here is that dividends should not vary very much day to day or intra-day unless there is an event that affects the dividend yield – this could be a company announcement that changes dividend policy or an event that affects the market perception on future payouts. While we look to capture these events that affect dividend payouts, we also strive to filter out the noise so that users can focus on changes in implied volatility, borrow cost and even interest rates. The implied forwards, dividends and borrow cost are time-stamped and stored in the LIVEdb.

We now plug all the inputs into our option model for every option on the chain and produce a series of volatility points and their Greeks for every underlying that has listed options.

The inputs that may be used are:

Spot is the most recently observed price for the asset that the option will derive its value from. This may be a stock or ETF price, index spot price or discounted future.

Strike Price is the price where the underlying asset will be exchanged between buyers and sellers.

Time to Expiry is the number of days (or minutes and seconds) between evaluation time and the expiration date and time of the option contract.

Interest rate is generally the risk-free rate of the currency in which the option is priced.

Dividends are the expected stream of income that the underlying will pay out between the time the option is traded and the expiration date, as determined by the options market.

Borrow Cost is the current "interest rate" for lending or borrowing the underlying asset - this has greater implications when pricing hard-to-borrow stocks which are underlyings that have little available shares to short.

Option Price is the bid, mid, ask or last from in the market, as viewable on OMON <GO>.

Implied Volatility is a measure of expected future variance or price fluctuation of the underlying asset during the life of the option contract.

**** Please note that implied borrow cost is currently included in the implied dividend number. See the What's Coming? section for details on a separate implied borrow value.***

This Bloomberg LIVE derived data is what clients will see ticking in all of the functions on the terminal. This is the dataset that is stored in the LIVEdb along with the implied forward – complete with transparency data. What we now have is a very fast, easy-to-access database with volatility tick data, including all the required inputs and related outputs of the option model. Again, this is done for every underlying, every asset class, globally, that has listed options. The data is stored in 1 second increments where there are only price updates for implied volatility and stored trade-by-trade for all transactions on the exchange. LIVE data may be viewed as a data source in a limited number of functions and applications, including *DES<GO>*, *Monitors*, *QRO<GO>, QRM<GO>*, *GIP<GO>* and *calc-route* for use in Excel and *FLDS<GO>.*

Clients also have access to the transparency data for equities and equity indices via GIV<GO>. Users can select Actions -> View Calc Inputs from the red toolbar. GIV will then "dot" the lines in the chart with the points where trades occurred or where prices and vols were snapped. Clicking on a dot in the chart will launch the pop-up that exposes the transparency data, as shown below.

LIVE data and volatility surface construction

Now that we have a database filled with all of these volatility points, we can use them to construct the volatility surface. This is a frequent topic of confusion as there are many ways to construct a surface and many possible requirements by the end user. Generally, practitioners have one of two requirements for a volatility surface: it must either be on-market or it must be arbitrage-free. Ideally, both requirements would be satisfied, but in practice that is often difficult to achieve.

The on-market surface is constructed using simple linear interpolation and either truncation or flat extrapolation. What this means is that the user will arrange the volatility points from the option chain into a grid, similar to the Term Structure view in OMON <GO>. The volatility surface or grid is essentially a big connect-the-dots of the listed points. This allows a user to find volatility level - in strike or moneyness, expiration date or fixed term – very easily.

For example, a trader needs to determine where vol is for the 3-month 100% moneyness in SPX. If the current month is September and the SPX is trading at 1693, it would involve looking at the Dec 1690 and 1695 lines and the Jan 1690 and 1695 and calculating the single point among those contracts. To ensure accuracy, you need to look at both calls and puts, which would require 8 contracts to calculate the single point. While there will be little difference in vol between these points individual points (it is SPX with a very liquid option market) and this exercise may seem over-engineered, this process is relevant for underlyings with thinner options chains and wider strike intervals.

This dataset is designated as the LIVE (currently Market) surface in Bloomberg and will soon be available as a Source in functions that provide the ability to select a source for data. The intent is to ensure that a client can navigate between listed options calculations and values on a volatility surface and have consistent numbers. Just as OMON matches GIV, which matches GV on a listed option, which matches Excel API, once rolled out, users will be able to select the Bloomberg LIVE as a source for a moneyness level and have GV match SKEW and also the Excel API when using moneyness or interpolated points.

LIVE data does not require an additional subscription fee, neither for the terminal nor via API. However, the history of the tick data is not viewable outside the terminal, but may eventually be bundled into a feed and sold as a separate data package.

LIVE is also the source of the volatility points and implied forwards for the BVOL or structured surface. The BVOL surface is filtered, cleaned and fitted to provide an arbitrage-free surface that is employs a model for extrapolation both in time and moneyness. For more information on how the BVOL surface is constructed, please refer to {DOCS # 2056700<GO>}. Note that the process to calculate the implied forward, dividends and borrow is the same for LIVE and BVOL.

Both LIVE and BVOL surfaces will soon be available as sources in on the terminal functions at no additional cost. Also, LIVE data will be available for use on clients desktop (Excel for example) but will require an Enterprise license to feed another system. BVOL data may not be used outside the terminal, desktop or otherwise, without a separate licensing agreement.

Unlike in LIVE at the contract level where datasets can be viewed using *Bid, Ask, Mid* or *Last*, the interpolated data is only exposed as *Bid, Ask* and *Mid.* In cases where *Last* is an available source, the data shown is *Mid* data as there is no true *Last.*

Data available in LIVE at the underlying (moneyness) level

The following is an example of the dataset available for SPX:

Tenor	80	85	90	95	97.5	100	102.5	105	110	115	120
1W	92.53	74.09	52.76	35.79	24.65	15.39	15.62	24.59	42.12	58.96	74.99
2W	75.42	61.01	44.39	30.65	22.06	14.82	14.35	20.32	33.80	46.82	59.43
3W	58.31	47.64	35.69	25.52	19.47	14.17	13.05	16.12	25.43	34.62	43.78
1M	33.90	28.60	23.32	18.10	15.71	13.45	11.25	9.99	13.61	17.05	21.57
2M	28.75	24.73	20.83	17.17	15.35	13.60	12.06	10.88	11.66	13.95	15.76
3M	26.33	23.01	19.85	16.98	15.37	13.97	12.65	11.58	11.08	12.22	15.57
6M	23.94	21.71	19.35	17.12	16.02	14.93	13.97	12.96	11.71	11.59	12.98
9M	22.81	21.00	19.10	17.34	16.39	15.58	14.67	13.93	12.61	11.96	11.98
1Y	22.41	20.68	19.12	17.48	16.64	16.01	15.33	14.58	13.42	12.52	12.19
18M	21.85	20.50	19.18	17.91	17.26	16.72	16.12	15.53	14.60	13.74	13.24
2Y	21.67	20.57	19.48	18.39	17.85	17.36	16.85	16.40	15.47	14.76	14.18

To load the correct "ticker" on the terminal, monitors or Excel and see the 17.12 outlined above in red, you would use "SPY US 6M 95 VOL LIVE Equity" as the ticker. SPY US is the underlying, 6M is the term or time to expiry, 95 is the percentage in moneyness or the ratio of strike to spot, VOL indicates the "yellow key", LIVE is the selected data source and *Equity* as the true yellow key. Given any underlying instrument with a listed option chain, you will be able to construct the "volatility tickers" using this naming convention. Once the correct ticker is loaded, a user can run GIP<GO> to see the intra-day tick history or add them to their Launchpad Monitor to view the intra-day price moves in real-time. Please note that LIVE, both at the option level and the underlying level, requires that the user subscribe to real-time pricing for both the option exchange and the underlying exchange in order to receive real-time data. If both exchanges are not permissioned, users will see data on a 30-minute delay.

**** Please contact your Bloomberg representative or press the HELP key twice to request entitlement privileges for LIVE data in Excel.***

Why has LIVE replaced the former Bloomberg option calculator?

We have essentially replaced our existing "calculator" with a faster, updated and more scalable service. These changes will improve our reliability as an option platform and impact to our clients will very positive. This rollout also allows us to provide even more data (see What's Coming, below).

Calculations will be faster, more accurate and fully consistent across applications. OPDF settings will be temporarily blocked except for OP calc-route fields and OMON Calc Mode.

Model outputs will be as follows:

Delta - 1% bump in spot => proportional (S-> S (1+0.01), delta centered 50 bps on each side)
Gamma - 1% bump in spot => same for delta
Vega - 1% bump in vol => additive (vol goes from 30% to 31%)

Rho - 1 BP bump in rates => additive (rates goes from 50bps to 51 bps)
Theta - 1 business day decay (sign negative)

What's coming?

Bloomberg LIVE is currently undergoing its next round of enhancements, which includes the addition of the following real-time fields:

Vanna - measures the sensitivity of the delta with respect to change in implied volatility.
Volga – (Vomma) the rate of change of Vega with respect to changes in implied volatility.
Charm – Delta decay or the change in Delta due to time passing.
Veta – Vega decay or the change in Vega due to time passing.
Vera – measure the sensitivity to Rho with respect to implied volatility.
Color – Gamma decay or the rate of change in Gamma due to time passing.
Speed – measures the rate of change in Gamma due to moves in spot.
Ultima – measure of sensitivity to Volga due to changes in implied volatility.
Zomma – measure of sensitivity to Gamma due to changes in implied volatility.

We are also working to parse the implied dividend number into more granular and separate implied dividend and implied borrow cost values. Currently, hard-to-borrow stocks that have elevated loan rates will show an inflated dividend yield.