Daily Settlement Price Methodology – Exchange Traded Options

The Australian Clearing House (ACH) is the central counterparty and clearing facility for the ASX. The ACH uses the Derivative Pricing System to settle Exchange Traded Options on a daily basis. This document provides a broad overview of the procedure used to determine daily settlement prices.

The Derivatives Pricing System (DPS)

Throughout the day the Derivatives Pricing System ("DPS") receives a real-time feeds of market price information originated by market makers. This information includes details of bids, offers and trades in the derivatives market. In addition it receives details of changes to the best bid and offer prices in the underlying equities market as well as changes in the values of underlying stock indices.

DPS processes the real-time information and records in its database details of all the changes to the best current bid and offer prices (commonly referred to as 'top line quotes') for derivatives. The information written to the database also includes the removal of bids/offers, eg when a best bid is withdrawn and there is no replacement bid available. Additionally, changes to underlying prices and derivatives traded prices are recorded in the DPS database. Each element of price data is time stamped with the time that it is received by DPS. Inevitably there is a large amount of data stored in the database.

Determination Of Daily Settlement Prices

Implied Volatility

It is important to note for its internal calculations the daily settlement process predominantly works with option volatilities rather than premiums. Market price information is therefore translated into implied volatility at an early stage. Implied volatility is then used to calculate a fair price. It is the fair price that is then publicised to the market and is used for margin calculations.

Daily Price Determination Process

DPS splits the trading day into a number of user-defined periods. At the end of each of these periods the daily price determination process herein referred to as "the process" is automatically initiated.

The process requires a starting point for each option series (an example of an option series is a BHP Dec 07 $28.00 Put). This is usually the completion point produced by the process for the immediately preceding period. In the absence of any other data being available for the current period, then this starting point will simply be carried forward to become the completion value for the period currently being processed. However, the existence of other relevant data may prevent this from occurring. Relevant data includes changes in the underlying price, bids, offers and trades for the particular traded entity. Data for other related traded entities may also be considered relevant. For example, data relating to another option series for the same month and option type (i.e. put or call) or data for a different month and same option type.

Assume that the last event in a period was a trade. Using data stored in the DPS database, the process will determine the value of the underlying price immediately prior to the trade and using that underlying price it will calculate the implied volatility.

Assume that there was no trade but there was a bid and an offer. In the absence of any further information, the price of the option would be considered to be the mid-point of the bid and offer. If the bid and offer were current at the end of the period then the underlying price immediately prior to the end of the period would be used when calculating implied volatility. However if, for example, the offer was withdrawn shortly before the end of the period then the process would use the

underlying price that prevailed at the time the offer was withdrawn.

Unpriced Series

An "unpriced series" is a series where the market data available is insufficient to derive a price eg, where only a bid or an offer is available.

In order to calculate a price for an Unpriced Series the several decisions need to be made. DPS considers:

1. The implied volatility of other series in the Price Set, i.e. all options with the same underlying, expiry date, option type and exercise style.
2. The implied volatilities calculated in the previous period; and
3. The implied volatility of other options for the same option type with a different expiry date.

The course of action at which the process ultimately arrives, is dependent on the circumstances and quality of information available to the process. See the Appendix for more detail on the interpolation and extrapolation used to determine prices.

Strike Offsets and volatility curves

Within a price set, options are sequenced in ascending strike price order. The process works with the collection of options for a Price Set and endeavours to form a volatility curve (often termed a 'volatility smile') for the Price Set.

DPS numbers each series for a Price Set. The numbering is sequential, increasing by 1, in ascending strike price sequence. However, the first series in a Price Set is usually assigned a negative number. The starting number is assigned so that the series that is closest to the underlying price (i.e. the at-the-money series) is always given a strike offset of zero. The following illustrates the assignment of Strike Offsets, assuming that the current underlying price is $9.87.

Strike Price	Strike Offset
8.00	-4
8.50	-3
9.00	-2
9.50	-1
10.00	0
10.50	1
11.00	2
11.50	3

DPS uses Strike Offset to relate the volatility curve of a Price Set for the current period, with the volatility curve generated for a previous period. The horizontal shift of the volatility curve (due to a change in the underlying price) is accommodated by comparing the previously calculated volatility for each Strike Offset with the latest volatility for the same numbered Strike Offset.

The process compares the volatility curve established for a previous period against price information gathered for the current period. **In this way, a vertical shift is accommodated.** While performing this comparison, the process may identify an increase or decrease in volatility. Where applicable, this increase/decrease will be applied to all Unpriced Series within the Price Set within the current period.

Price Corrections

Under extreme circumstances it is possible for option prices for a Price Set to be illogical; for example the price of calls should not increase as the strike increases. Similarly, the price of puts should not decrease as the strike price increases. As a final check of its results, the process will make sure that this rule holds true.

Additionally, when a fair option price is calculated (using the latest underlying price and the computed implied volatility) it is possible, in extreme circumstances, that the fair option price is less than an active bid or greater than an active offer. In such circumstance the fair option price will be increased to equal the active bid or decreased to equal the active offer.

Price Polishing

Price polishing is the final step in the process. It ensures that all prices determined to conform to the contract specifications in terms of number of decimal places and tick size.

XJO Index Options

The daily settlement price determination for XJO Index Options is identical to Exchange Traded Options in all aspects except that XJO Index Options are priced off the XJO Future which in turn is priced using SFE SPI 200® Futures market data where it is available.

Appendix: Interpolation and Extrapolation

Where there is insufficient price information to calculate the implied volatility for a series it is necessary to perform extrapolation or interpolation.

In notional terms a graph is built with strike price on the x-axis and volatility on the y-axis. Where an implied volatility has been calculated (e.g. for 'Priced Series') the appropriate point is entered onto the graph. In this way a 'volatility smile' is drawn.

Interpolation

Where an unpriced option series sits within options series for which implied volatility is known, linear interpolation is used to derive the implied volatility of the unpriced series.

For example: If we know the implied volatility of strikes 10 and 12 but not 11, then the implied volatilities of strikes 10 and 12 are referenced to estimate the implied volatility of 11.

Extrapolation

Where an unpriced series falls outside a range of strikes with known implied volatilities, linear extrapolation is used to derive the implied volatility of the unpriced series.

For example: We know the implied volatility of strikes 10 and 11 but not 12, the implied volatilities of strikes 10 and 11 are referenced to estimate the implied volatility of 12.

Steps:

1. Determine the gradient between the two nearest strikes with known volatilities.
2. To determine the implied volatility for a particular strike (target strike) when the reference strike nearest to the target strike is closer to the at-the-money (zero) strike than the target strike:

- If the gradient (calculated in 1 above) is sloping upward away from the zero strike (i.e. consistent with a standard smile curve), the implied volatility is calculated by using the gradient multiplied by a *deceleration factor*.
- If the calculated gradient is not sloping upward away from the zero strike, the implied volatility is calculated by using a zero gradient.

3. To determine the implied volatility for a particular strike (target strike) when the reference strike nearest to the target strike is further from the at-the-money (zero) strike than the target strike:

- If the gradient (calculated in 1 above) is sloping down towards the zero strike (i.e. consistent with a standard smile curve) and the target strike is on the same 'side' of the smile as the reference points, then the implied volatility is calculated by using the gradient.
- If the target strike is on the other 'side' of the smile from the nearest reference point or the calculated gradient is not sloping down towards the zero strike, the implied volatility is calculated by using a zero gradient.

The deceleration factor is held as a system parameter (extrapolation adjustment percentage) to decrease the impact of extrapolation.