A Guide to the Pricing Conventions of SFE Interest Rate Products

- SFE 30 Day Interbank Cash Rate Futures
- Physical 90 Day Bank Bills
- SFE 90 Day Bank Bill Futures
- SFE 90 Day Bank Bill Futures Tick Value Calculations
- SFE 90 Day Bank Bill Options
- Australian Commonwealth Treasury Bonds
- SFE 10 Year Treasury Bond Futures
- SFE 10 Year Treasury Bond Futures Tick Value Calculations
- SFE 10 Year Treasury Bond Options
- SFE 3 Year Treasury Bond Futures Tick Value Calculations
- SFE 3 Year Bond Options
- Interest Rate Swap Futures
- 3 Year Interest Rate Swap Futures
- 10 Year Interest Rate Swap Futures

This brochure provides market users and back office system suppliers with a guide as to the pricing conventions of SFE interest rate futures and options.

The pricing conventions used for the majority of SFE's interest rate products differ from that used in many offshore futures markets. Unlike in Europe and the United States where interest rate securities are traded in the cash market on the basis of their capital price, the convention adopted in Australia is to price such instruments on the basis of their yield to maturity. Due to this convention, SFE's interest rate contracts are similarly traded on the basis of yield with the futures price quoted as 100 minus the yield to maturity expressed in per cent per annum.

While the obvious advantage of pricing interest rate contracts in this fashion is that their yield is transparent and can be easily compared to yields on cash market instruments, an important by-product is that the tick value on these products does not remain constant but rather changes in accordance with movements in the underlying interest rate. This variation is most pronounced in the 10 Year Treasury Bond futures contract and is less substantial for the 3 Year Treasury Bond futures contract and 90 Day Bank Bill futures contracts. For all these contracts, the tick value decreases as interest rates rise and increases as interest rates fall.

30 Day Interbank Cash Rate Futures

Unlike SFE's 90 day Bank Bill Futures and 3 and 10 year Treasury Bond Futures, the 30 Day Cash Rate Futures contract has a fixed tick. Under a fixed tick regime, the variation margins are calculated by multiplying the number of price movements (in points terms) by the fixed tick dollar value of AUD24.66 per 0.01% move by the number of contracts traded.

For example:

Trade Price = 94.735  
Number of Contracts = 100  
End of Day Settlement Price = 94.750

Variation Margin on Position = $3,699.00 (1.5pts x AUD24.66 x 100 contracts)

The cash rate futures contract gives an exposure to AUD3,000,000 per contract. Hence, the contract value of a position in the 30 Day Interbank Cash Rate Futures is equivalent to the face value of the contract multiplied by the number of contracts bought or sold.

Physical 90 Day Bank Bills

Unlike its best known equivalent in the United States - the Eurodollar time deposit - the value of a physical 90 Day Bank Bill is calculated according to a yield to maturity formula that discounts the face value to establish the appropriate interest cost over the 90 days.
The formula for the present value (P) of a bank bill is:

\[ P = \frac{\text{Face Value} \times 365}{365 + \left( \frac{\text{yield} \times \text{Days to Maturity}}{100} \right)} \]

The face value represents the bill's future value, i.e. its value at the end of its 90 day term. Please note the Australian convention is to use a 365 rather than a 360 day year.

In order to calculate the present value (P) of a 90 Day Bank Bill which has a face value of $100,000 and is trading at a yield to maturity of 5.50%, the following calculations are performed:

\[ P = \frac{100,000 \times 365}{365 + \left( \frac{5.5 \times 90}{100} \right)} = \$98,661.98 \]

This same formula can be applied to value Bank Bills with varying maturities (i.e. 30, 60, 90, 180 days) and face values (i.e. $100,000, $500,000, $1,000,000). These values would simply be inserted into the formula where appropriate.

**SFE 90 Day Bank Bills**

For SFE 90 Day Bank Bill Futures, where the contract value is always $1,000,000, and the term to maturity is exactly 90 days, the bank bill formula can be rewritten as:

\[ P = \frac{1,000,000 \times 365}{365 + \left( \frac{\text{yield} \times 90}{100} \right)} \]

where the yield is the futures price deducted from 100.

Therefore if a Bank Bill futures contract was trading at 95.00 (i.e. a yield of 5%) the value of the contract would be:

\[ P = \frac{1,000,000 \times 365}{365 + \left( \frac{5.0 \times 90}{100} \right)} = \$987,821.38 \]

**SFE 90 Day Bank Bill Futures Tick Value Calculations**

The dollar value of a 0.01% change in yield does not remain constant but rather varies in accordance with changes in the underlying interest rate.

Accordingly, to establish what the dollar value of a futures tick will be at a given price, the following calculations are made:

1. Use the contract valuation formula (as described above) to calculate the underlying value of the contract at the nominated futures price.
2. Apply the same formula to that same futures price minus 0.01 (i.e., increase the yield by 0.01%).
3. The difference between the two contract values represents the dollar value of the tick at the nominated futures price.

To determine the dollar value of a 0.01% change in yield of a Bank Bill futures contract which is trading at a price of 95.00 (i.e. a yield of 5.00%) the following calculations are performed:

1. Futures contract value at 95.00 (5.00%) = $987,821.38 (rounded to two decimal places)
2. Futures contract value at 94.99 (5.01%) = $987,797.32 (rounded to two decimal places)
3. Difference (value of 0.01% of premium) = $24.06
**SFE 90 Day Bank Bill Options**

Premiums for options on 90 Day Bank Bill futures are quoted in terms of annual percentage yield (e.g. 0.60% pa or 1.05% pa) with the value of a single point of premium (ie. 0.01% pa) calculated by comparing its contract value at the exercise price (expressed as 100 minus annual yield) and its value at that same exercise price less one point (0.01%).

For example, a 90 Day Bank Bill option with an exercise price of 95.00 and a premium of 0.065% pa would be valued as follows:

1. Futures contract value at 95.00 (5.00%) = $987,821.38
2. Futures contract value at 94.99 (5.01%) = $987,797.32
3. Difference (value of 0.01% of premium) = $24.06

Since we have 6.5 points of premium, the final premium in dollars is $156.39

To exactly match the premium in dollars as calculated by SFE Clearing the premium should be calculated in the following manner:

$24.06 x 0.065 = 1.5639 (rounded to four decimal places)
1.5639 x 100 = $156.39

A final important point to note is that, for an option with a particular exercise price, the value of 0.01% of premium is constant, while the tick value of the underlying futures contract is variable with the level of interest rates. To put it another way, the value of a move of a certain size in the futures market will not equate exactly in dollar terms with a move of the same size in the option premium. Investors should also be cautious about implementing conversion strategies owing to the differences in tick sizes between an option strike price and the prevailing futures price. For example, it can happen that an option appears to be priced slightly below its intrinsic value in terms of the yield when in fact, in dollar terms, the pricing is correct.

**Australian Commonwealth Treasury Bonds**

The formula for calculating the price per A$100 of an Australian Commonwealth Treasury Bond as supplied by the Reserve Bank of Australia is:

\[ P = \frac{v}{2} \left( e + g a_p + 100v^n \right) \]

where
- \( v = \frac{1}{1+i} \) where \( i \) is the annual percentage yield divided by 200.
- \( f \) = the number of days from the date of settlement to the next interest payment date
- \( d \) = the number of days in the half year ending on the next interest payment date
- \( c \) = the amount of interest payment (if any) per $100 face value at the next interest payment date
- \( g \) = the fixed half-yearly interest rate payable (equal to the annual fixed rate divided by 2).
- \( n \) = the number of full half-years between the next interest payment date and the date of maturity (equal to 2 times the number of years until maturity)
- \( a_n = \frac{v + v^2 + \ldots + v^n}{i} = \frac{(1 - v^n)}{i} \)

The convention adopted with Commonwealth Treasury Bonds is that interest is paid on the fifteenth day of the appropriate month with the last interest payment made at maturity.

Using the Reserve Bank pricing formula, the calculations which would be performed to value a Commonwealth Treasury Bond with a maturity of 15 October 2007, a coupon rate of 10.00%, a market yield of 5.70% and a settlement day of 7 April 1998 would be:

\( i = 0.02850000 \)
\( v = 0.97228974 \)
\( f = (2/4/98 + \text{T3 business (7/04/98 to 15/4/98)}) = 8 \)
\( d = 182 \)
\( g = 5 \)
n = 20
f/d = 0.04395604
c = 5

Using the above inputs, the bond would have a value of A$137.26505439 per $100 face value (inclusive of accrued interest).

SFE 10 Year Treasury Bond Futures

For SFE Treasury Bond futures, the pricing formula can be simplified because there is always an exact number of half years to maturity and hence there is no requirement to calculate accrued interest.

The formula for the value (P) of a 10 Year Bond futures contract on SFE is written as:

\[
P = 1000 \times \left[ \frac{c(1 - v^{20})}{i} + 100v^{20} \right]
\]

where:
- \(i\) = yield % pa divided by 200
- \(v = \frac{1}{1+i}\)
- \(n = 20\)
- \(c = \text{coupon rate}/2\)

Thus to value a 6% coupon 10 Year Treasury Bond contract which is trading at a price of 95.500 (i.e. A yield of 4.50% pa.), the inputs would be:

- \(i = 0.02250000\)
- \(v = 0.97799511\)
- \(n = 20\)
- \(c = 3\)

When these inputs are included in the formula, the contract value for the above contract will be A$111,972.78.

Note that the mathematical convention is that multiplication and division take precedence over, addition and subtraction. In the futures formula, this means that the division by \(i\) is performed before the addition of \(100v^{20}\).

To exactly match the contract value as calculated by SFE Clearing, steps C, D and G must be rounded to exactly eight decimal places, with 0.5 being rounded up. No other steps are rounded except K, which is rounded to two decimal places. SFE Clearing makes the calculation in the following manner:

<table>
<thead>
<tr>
<th></th>
<th>Futures Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>100 - price</td>
</tr>
<tr>
<td>B</td>
<td>(i = A/200)</td>
</tr>
<tr>
<td>C</td>
<td>(v = 1/(1 + B))</td>
</tr>
<tr>
<td>D</td>
<td>(v^{20})</td>
</tr>
<tr>
<td>E</td>
<td>(1 - v^{20} = 1 - D)</td>
</tr>
<tr>
<td>F</td>
<td>(3(1 - v^{20}) = 3x E)</td>
</tr>
<tr>
<td>G</td>
<td>(3(1 - v^{20})i = F/B)</td>
</tr>
<tr>
<td>H</td>
<td>(100v^{20} = 100 x D)</td>
</tr>
<tr>
<td>I</td>
<td>(G + H)</td>
</tr>
<tr>
<td>J</td>
<td>(1 x 1,000)</td>
</tr>
<tr>
<td>K</td>
<td>Rounded</td>
</tr>
</tbody>
</table>

SFE 10 Year Treasury Bond Futures Tick Value Calculations

The methodology used to calculate tick values for the 10 Year Treasury Bond Futures is identical to that outlined in the previous example for 90 Day Bank Bill Futures.
For example, to determine the dollar value of a 0.01% change in yield on a 10 Year Bond contract trading at a price of 94.360 (ie. A yield of 5.64%), the following calculations are performed.

1. Futures contract value at 94.360 (5.64%) = $102,723.06029
2. Futures contract value at 94.350 (5.65%) = $102,646.18681
3. Difference (value of 0.01% of premium) = $76.87349
or $76.87 rounded to two decimal places.

**SFE 10 Year Treasury Bond Options**

Like Bank Bill options, 10 Year bond options are quoted in terms of annual percentage yield (e.g. 0.410% or 0.525%), with the value of a single point of premium (ie. 0.01%) calculated as the difference between the contract value at the exercise price (expressed as 100 minus the annual yield) and its value at that exercise price less one point (0.01%).

Please note that when making these calculations, contract values are not rounded to the nearest cent before calculating this difference. Accordingly, the dollar value of an option on a 10 Year Treasury bond option with an exercise price of 94.000 and a premium of 0.140% would be calculated as follows:

1. Futures contract value at 94.000 = $100,000.0000
2. Futures contract value at 93.990 = $99,925.6470014
3. Difference (value 0.01% of premium) = $74.3529986

Since there is 14 points of premium, the final premium in dollars is calculated as:

$74.3529986 x 14 = $1,040.9420
which when rounded to the nearest cent gives $1040.94

**SFE 3 Year Treasury Bond Futures Tick Value Calculations**

For SFE Treasury Bond futures, the Reserve Bank of Australia government bond pricing formula can be simplified because there is always an exact number of half years to maturity and hence there is no requirement to calculate accrued interest.

The formula for the value (P) of a 3 Year Bond Futures contract on SFE is written as:

\[
P = 1000 \times \left[ \frac{c(1 - v^n)}{i} + 100v^6 \right]
\]

where:
- \(i\) = yield % pa divided by 200
- \(v = 1/(1+i)\)
- \(n\) = number of coupon payments. For the 3 Year contract this is 6.
- \(c\) = coupon rate/2

Thus to value a 6% coupon 3 Year Treasury Bond contract which is trading at a price of 95.505 (i.e. a yield of 4.495% pa.), the inputs would be:

- \(i = 0.022475\)
- \(v = 0.97801902\)
- \(n = 6\)
- \(c = 3\)

When these inputs are included in the formula, the contract value for the above contract will be A$104,180.10.

Note that the mathematical convention is that multiplication and division take precedence over, addition and subtraction. In the futures formula, this means that the division by \(i\) is performed before the addition of \(100v^6\).

To exactly match the contract value as calculated by SFE Clearing, steps C, D and G must be rounded to exactly eight decimal places, with 0.5 being rounded up. No other steps are rounded except K, which is rounded to two decimal places. SFE Clearing makes the calculation in the following manner:
Determined Variation Margins for 3 Year Treasury Bond Futures

SFE Clearing determines the variation or marked to market margin for variable tick contracts in the following by comparing the contract value for the previous end of day price (or the trade price if the contract was bought or sold that day) and that day's end of day settlement price or exit price.

For example:

1. Bought 10 3 Year Treasury Bond Futures at price of 95.505 (yield = 4.495%). The contract value determined using the bond formula is $104,180.10 per contract. The contract value for 10 contracts is $1,041,810.00
2. End of day settlement price for 3 Year Treasury Bond Futures is 94.490 (yield = 5.510%). The contract value is $101,338.06 x 10 contracts = $1,013,380.60
3. Variation Margin, determined by calculating the difference between the two contract values, that is, $1,041,810.00 - $1,013,380.60 = $28,420.40.

The margin payment made on the 10 lot position is $28,420.40.

Calculating the Tick Value for SFE 3 Year Treasury Bond Futures

The dollar value of a 0.010% change in yield does not remain constant but rather varies in accordance with changes in the underlying interest rate.

Accordingly, to establish what the dollar value of a futures tick will be at a given price, the following calculations are made:

4. Use the contract valuation formula (as described above) to calculate the underlying value of the contract at the nominated futures price.
5. Apply the same formula to that same futures price minus 0.010 (i.e., increase the yield by 0.010%).
6. The difference between the two contract values represents the dollar value of the tick at the nominated futures price.

For example, to calculate the dollar value of a 0.010% change in yield when the 6% coupon 3 Year contract is trading at a price of 94.760 (i.e. a yield of 5.240%), the following calculations are performed.

1. Futures contract value at 94.760 (5.240%) = $102,084.712282
2. Futures contract value at 94.750 (5.250%) = $102,056.939713
3. Difference (value 0.01% of premium) = $27.77367
Which when rounded to the nearest cent gives $27.77

SFE 3 Year Bond Options

Premiums for the 3 Year Bond options are calculated in exactly the same way as for 10 Year Bond options, by reference to the value of a one-point move in the underlying futures contract from the exercise price to the exercise price less one point.
To value a 6% coupon 3 Year Treasury Bond option which has a strike price of 94.50 and a premium of 0.240 points, the following calculations are made:

1. Futures contract value at 94.500 = $101,365.591694
2. Futures contract value at 94.490 = $101,338.0571088
3. Difference (value 0.010% of premium) = $27.534586

Since there is 24 points of premium, the final premium in dollars is calculated as:
$27.53441 x 24 = $660.83006
which when rounded to the nearest cent gives $660.83

A final important point to note is that, for an option with a particular exercise price, the value of 0.010% of premium is constant, while the tick value of the underlying futures contract is variable with the level of interest rates. To put it another way, the value of a move of a certain size in the futures market will not equate exactly in dollar terms with a move of the same size in the option premium. Investors should also be cautious about implementing conversion strategies owing to the differences in tick sizes between an option strike price and the prevailing futures price. For example, it can happen that an option appears to be priced slightly below its intrinsic value in terms of the yield when in fact, in dollar terms, the pricing is correct.

3 Year and 10 Year Interest Rate Swap Futures

The contract value formula for Interest Rate Swap Futures is a modified version of the Treasury Bond Futures pricing formula. The difference between the two formulas is the coupon rate. Interest Rate Swap Futures have a coupon rate of 6.5% as opposed to the 6% used for Treasury Bond Futures.

3 Year Interest Rate Swap Futures

The formula for the value \( P \) of 3 Year Interest Rate Swap Futures at SFE is written as:

\[
P = 1000 \times \left[ \frac{c(1-v^n)}{i} + 100v^n \right]
\]

where:
- \( i \) = yield % pa divided by 200
- \( v = 1/(1+i) \)
- \( n \) = the number of coupon payments
- \( c \) = coupon rate/2

Thus to value a 6.5% coupon 3 Year Interest Rate Swap Futures contract which is trading at a price of 94.30 (ie. a yield of 5.70% pa.), the inputs would be:

- \( i = 0.0285 \)
- \( v = 0.97228974 \)
- \( n = 6 \)
- \( c = 3.25 \)

When these inputs are included in the formula, the contract value for the above contract will be A$102,177.69.

Note that the mathematical convention is that multiplication and division take precedence over, addition and subtraction. In the futures formula, this means that the division by \( i \) is performed before the addition of \( 100v^n \).

To exactly match the contract value as calculated by SFE Clearing Corporation (SFEC), steps C, D and G must be rounded to exactly eight decimal places, with 0.5 being rounded up. No other steps are rounded except K, which is rounded to 2 decimal places. The SFEC makes the calculation in the following manner:

<table>
<thead>
<tr>
<th></th>
<th>Futures Price</th>
<th>94.30</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>100 – price</td>
<td>5.70</td>
</tr>
<tr>
<td>B</td>
<td>i = A/200</td>
<td>0.0285</td>
</tr>
</tbody>
</table>
### 10 Year Interest Rate Swap Futures

The formula for the value (P) of 10 Year Interest Rate Swap Futures at SFE is written as:

\[
P = 1000 \times \left[ \frac{c(1 - v^n)}{i} + 100v^n \right]
\]

where:
- \(i\) = yield \% pa divided by 200
- \(v = 1/(1+i)\)
- \(n\) = the number of coupon payments
- \(c\) = coupon rate/2

Thus to value a 6.5\% coupon 10 Year Interest Rate Swap Futures contract which is trading at a price of 95.500 (ie. a yield of 4.500\% pa.), the inputs would be:

- \(i = 0.0225\)
- \(v = 0.97799511\)
- \(n = 20\)
- \(c = 3.25\)

When these inputs are included in the formula, the contract value for the above contract will be A$115,963.71.

Note that the mathematical convention is that multiplication and division take precedence over, addition and subtraction. In the futures formula, this means that the division by \(i\) is performed before the addition of 100\(v^n\).

To exactly match the contract value as calculated by SFE Clearing Corporation (SFECC), steps C, D and G must be rounded to exactly eight decimal places, with 0.5 being rounded up. No other steps are rounded except K, which is rounded to 2 decimal places. The SFECC makes the calculation in the following manner:

<table>
<thead>
<tr>
<th>Futures Price</th>
<th>95.500</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>100 – price</td>
</tr>
<tr>
<td>B</td>
<td>(i = A/200)</td>
</tr>
<tr>
<td>C</td>
<td>(v = 1/(1 + B))</td>
</tr>
<tr>
<td>D</td>
<td>(v^n)</td>
</tr>
<tr>
<td>E</td>
<td>(1 - v^n = 1 - D)</td>
</tr>
<tr>
<td>F</td>
<td>3.25((1 - v^n) = 3.25 \times E)</td>
</tr>
<tr>
<td>G</td>
<td>3.25((1 - v^n)/i = F/B)</td>
</tr>
<tr>
<td>H</td>
<td>100(v^n) = 100 (x D)</td>
</tr>
<tr>
<td>I</td>
<td>(G + H)</td>
</tr>
<tr>
<td>J</td>
<td>(I \times 1,000)</td>
</tr>
<tr>
<td>K</td>
<td>Rounded</td>
</tr>
</tbody>
</table>