CME Group
A CME/Chicago Board of Trade Company

Special Executive Report

S-4695 **March 26, 2008**

LANGUAGE CLARIFICATION AMENDMENTS TO THE INTERPRETATION TO CME RULE 584 – CME GLOBEX® OPTIONS VOLATILITY QUOTE TRADING, EFFECTIVE IMMEDIATELY

CME Group adopted language clarification revisions to the Whaley Option Pricing Model for American-style options as provided in the Interpretation to new CME Rule 584. CME Group made these language clarification changes to the Whaley Option Pricing Model to make notation within the document internally consistent. Please note that the changes are non-substantive in nature and are effective immediately. Also, please note that there are no changes to CME Rule 584 or the first part of the Interpretation.

The language clarification amendments follow in Appendix 1 with the deletions bracketed and overstruck, and additions underlined. Also, for ease of review, these deletions and additions are highlighted. Appendix 2 is a clean copy of the relevant portion of the Interpretation incorporating the changes.

If you have any questions, please contact Steve Youngren, Associate Director, Financial Product Development, at 312-930-4583 or via e-mail at Steve.Youngren@cmegroup.com.

Appendix 1.

Language Clarification Amendments

New Rule 584 – CME GLOBEX® OPTIONS VOLATILITY QUOTE TRADING and Its Interpretation to Allow for Volatility Quoting and Trading in Selected CME Group Options on Futures Products Traded on CME Globex. The rule amendments follow with additions underlined and deletions bracketed and overstruck.

[Text of CME Rule 584 does not change.]

INTERPRETATIONS & SPECIAL NOTICES RELATING TO CHAPTER 5

INTERPRETATION OF RULE 584.—CME GLOBEX OPTIONS VOLATILITY QUOTE TRADING

[Beginning of CME Rule 584 does not change.]

Whaley Option Pricing Model for American-style Options

The following model is based on the Barone-Adesi-Whaley model as described in the Journal of Finance, Vol. 42 No.2, pages 301-320. The model uses analytic approximation techniques to solve for the price of the American-style option. The model estimates a value for S* which is the underlying price above which the option should be exercised. The value of S* is then used to determine the value of the option. For call options, the model estimates S* by satisfying the following equation:

(LHS – RHS / K < 0.00001 (Please see notes 1-4 at the end of this section.)

Where

$LHS = S^* - K$

$\cancel{[RHS = c(S, T) + [(1 - e^{(b-r)T} N(d_1)) * (S^* / q_2)]]}$

$\underline{RHS = c(S, T) + [(1 - e^{(b-r)T} N(d_1(S^*_I))) * (S^* / q_2)]}$

$d_1 = [\ln(S^* / K) + (b \underline{+} [\cancel{б}]\ \underline{\sigma}^2 / 2)T] / [\cancel{б}]\ \underline{\sigma} \sqrt{T}$

$d_2 = d_1 - [\cancel{б}]\ \underline{\sigma} \sqrt{T}$

$q_2 = [-(N - 1) + \sqrt{(N-1)^2 + 4M/k}\ / 2$

$M = 2 * r / [\cancel{б}]\ \underline{\sigma}^2$

$N = 2 * b / [\cancel{б}]\ \underline{\sigma}^2$

$k = 1 - e^{-rT}$

N(.) is the cumulative univariate normal distribution.

n(.) is the univariate normal density function.

$[\cancel{Б}]\underline{\sigma}$ = *volatility (e.g. 10% per annum = 0.10)*

T = time until expiration in years (e.g. 90 days = 0.247)

r = interest rate (e.g. 8% per annum = 0.08)

b = cost of carry, assumed to be zero for the purposes of this calculation

K = strike price

S = underlying price

After each iteration, the estimate of S is adjusted by:*

$$S^*_{i+1} = [K + RHS - b_i S^*_i] / (1 - b_i)$$

where

$$b_i = e^{(b-r)T} N[d_1(S^*_i)](1 - 1/q_2) + [1 - e^{(b-r)T} n[d_1(S^*_i)] / [\cancel{б}]\ \underline{\sigma} \sqrt{T}] / q_2$$

Once the correct value of S is found, the value of the call and the call's delta are found by solving:*

$$C(S,T) = [\cancel{C}]\underline{c}(S,T) + A_2 (S / S^*)^{q_2}$$

Where

$$A_2 = (S^* / q_2)(1 - e^{b-r)T} N[d_1(S^*)])$$

$$\Delta = \Delta_e + A_2 * q_2 * (S / S^*)^{q_2} / S$$

c(S,T) = the price of a European style call option.

Δ_e = *the delta of the European style call option.*

For put options, the model estimates S by satisfying:*

(LHS –RHS) / K < 0.00001

where

$LHS = K – S^*$

~~$[RHS = p(S, T) - [(1 - e^{(b-r)T}\ N(d_1)) * (S^* / q_1)]]$~~

$\underline{RHS = p(S, T) – [(1 – e^{(b-r)T} * (N[-d_1 (S^*_i)])) * (S^* / q_1)]}$

$d_1 = [\ln(S^* / K) + (b + [\cancel{\text{б}}]\underline{\sigma}^2/2)T] / [\cancel{\text{б}}]\ \underline{\sigma}\ \sqrt{T}$

$d_2 = d_1 + [\cancel{\text{б}}]\ \underline{\sigma}\ \sqrt{T}$

$q_1 = [-(N – 1) - \sqrt{(N-1)^2 + 4M / k}\ / 2$

$M = 2 * r / [\cancel{\text{б}}]\ \underline{\sigma}\ ^2$

$N = 2 * b / [\cancel{\text{б}}]\ \underline{\sigma}\ ^2$

$k = 1 – e^{-rT}$

N(.) is the cumulative univariate normal distribution.

n(.) is the univariate normal density function.

$[\cancel{\text{Б}}]\ \underline{\sigma}$ *= volatility (e.g. 10% per annum = 0.10)*

T = time until expiration in years (e.g. 90 days = 0.247)

r = interest rate (e.g. 8% per annum = 0.08)

b = cost of carry, assumed to be zero for the purposes of this calculation

K = strike price

S = underlying price

After each iteration, the estimate of S is adjusted by:*

$$S^*_{i+1} = [K - RHS + b_i S^*_i] / (1 + b_i)$$

where

$b_i = -e^{(b - r)T} -N[d_1(S^*_i)](1 – 1/q_1) - [1 + e^{(b - r)T} n[d_1(S^*_i)] / [\cancel{\text{б}}]\ \underline{\sigma}\ \sqrt{T}] / q_1$

Once the correct value of S is found, the value of the put and the put's delta are found by solving:*

$P(S,T) = p(S,T) + A_1 (S / S^*)^{q_1}$

where

$A_1 = -(S^* / q_1)(1- e^{(b- r)T} N[d_1(S^*)])$

$\Delta = \Delta_e + A_1 * q_1 * (S / S^*)^{q_1} / S$

p(S,T) = the price of a European style put option.

Δ_e *= the delta of the European style put option.*

Note 1. CME Group's Falcon engine goes slightly further in its precision to 0.000001 (one more decimal place).

Note 2. CME Group's Falcon engine also has a maximum number of iterations that it will perform on the equation discussed in Note 1 to fall within the tolerance level. If after 10,000 iterations the Falcon engine calculation is not within a tolerance of 0.000001, it will fall back to the European model instead.

Note 3. CME Group's Falcon engine does not implement any notion of a carrying-cost or foreign interest rate. The *b* variable is always equal to zero in the equations. If for some reason the Falcon engine does start to use *b*, it is worth noting that if *b* is ever greater than or equal to the interest rate *r,* the Falcon engine automatically falls back to the European model.

Note 4. CME Group's Falcon engine uses the Black Option Pricing Model (see Appendix A) in place of the Merton Model referred to in the abstract of Giovanni Barone-Adesi and Robert E. Whaley's article in the June 1987 *Journal of Finance* (Volume XLII, No. 2).

End of Interpretation to Rule 584.

Appendix 2.

Clean Copy of the Section Containing Amendments

New Rule 584 – CME GLOBEX OPTIONS VOLATILITY QUOTE TRADING and Its Interpretation to Allow for Volatility Quoting and Trading in Selected CME Group Options on Futures Products Traded on CME Globex.

[Text of CME Rule 584 does not change.]

INTERPRETATIONS & SPECIAL NOTICES RELATING TO CHAPTER 5

INTERPRETATION OF RULE 584.—CME GLOBEX OPTIONS VOLATILITY QUOTE TRADING

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$(LHS - RHS / K < 0.00001$ (Please see notes 1-4 at the end of this section.)

Where

$LHS = S^* - K$

$RHS = c(S, T) + [(1 - e^{(b-r)T} N(d_1(S^*_I))) * (S^* / q_2)]$

$d_1 = [\ln(S^* / K) + (b + \sigma^2/2)T] / \sigma \sqrt{T}$

$d_2 = d_1 - \sigma \sqrt{T}$

$q_2 = [-(N - 1) + \sqrt{(N-1)^2 + 4M/k} \ / 2$

$M = 2 * r / \sigma^2$

$N = 2 * b / \sigma^2$

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T = time until expiration in years (e.g. 90 days = 0.247)

r = interest rate (e.g. 8% per annum = 0.08)

b = cost of carry, assumed to be zero for the purposes of this calculation

K = strike price

S = underlying price

After each iteration, the estimate of S is adjusted by:*

$S^*_{i+1} = [K + RHS - b_i S^*_i] / (1 - b_i)$
where

$b_i = e^{(b-r)T} N[d_1(S^*_i)](1 - 1/q_2) + [1 - e^{(b-r)T} n[d_1(S^*_i)] / \sigma \sqrt{T}] / q_2$

Once the correct value of S is found, the value of the call and the call's delta are found by solving:*

$C(S,T) = c(S,T) + A_2 (S / S^*)^{q_2}$
Where

$A_2 = (S^* / q_2)(1 - e^{b-r)T} N[d_1(S^*)])$

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c(S,T) = the price of a European style call option.

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For put options, the model estimates S by satisfying:*

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where

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$RHS = p(S, T) - [(1 - e^{(b-r)T} * (N[-d1(S^*_I)])) * (S^* / q_1)]$

$d_1 = [\ln(S^*/K) + (b + \sigma^2/2)T] / \sigma \sqrt{T}$

$d_2 = d_1 + \sigma \sqrt{T}$

$q_1 = [-(N - 1) - \sqrt{(N-1)^2 + 4M/k} / 2$

$M = 2 * r / \sigma^2$

$N = 2 * b / \sigma^2$

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where

$$b_i = -e^{(b-r)T} N[d_1(S^*_i)](1 - 1/q_1) - [1 + e^{(b-r)T} n[d_1(S^*_i)] / \sigma \sqrt{T}\,] / q_1$$

Once the correct value of S is found, the value of the put and the put's delta are found by solving:*

$$P(S,T) = p(S,T) + A_1 (S / S^*)^{q_1}$$

where

$$A_1 = -(S^* / q_1)(1 - e^{(b-r)T} N[d_1(S^*)])$$

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End of Interpretation to Rule 584.