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ap_lba

Output parameters:

- Price
- Delta

This routine gives either the put price or the call price. The put price is obtained from the call price of a symmetric option by inversion : $K \leftrightarrow x$ and $r \leftrightarrow \delta$. This is the reason why almost all the functions are designed to compute the call option price.

Broadie and Detemple [1] have developped approximations for pricing standard american call options. They consider a european up and out call option with strike K , barriere L and rebate $(L - K)$. They maximise over L the price of this option.

Since the call up and out with rebate $(L - K)$ corresponds to exercise at the minimum of the hitting time of the boundary L and the maturity T , its price is smaller than the price of the american call option. Therefore, $C^l(x) = \max_L C(x, L)$ provides a lower bound for the price of the American call.

From this bound, they obtain the approximation by applying a multiplicative coefficient λ . This multiplicative parameter is obtained by Broadie and Detemple after a linear regression on 2500 options.

```
/*assign_var_temp*/
```

This function sets some temporary variables widely used in this program.

```
/*assign_var_temp_L*/
```

It sets temporary variables depending on L .

```
/*call_up_out*/
```

Gives $C(x, L)$, the price of an up and out european call option with barrier L and rebate $(L-K)$.

$$\begin{aligned}
C(x, L) = & (L - K) [\lambda^{\frac{2\phi}{\sigma^2}} N(d_0) + \lambda^{\frac{2\phi}{\sigma^2}} N(d_0 + 2f \frac{\sqrt{T}}{\sigma})] \\
& + x.e^{-\delta T} [N(d_1^-(L) - \sigma\sqrt{T}) - N(d_1^-(K) - \sigma\sqrt{T})] \\
& - \lambda^{-2\frac{r-\delta}{\sigma^2}} L.e^{-\delta T} [N(d_1^+(L) - \sigma\sqrt{T}) - N(d_1^+(K) - \sigma\sqrt{T})] \\
& - K.e^{-rT} [N(d_1^-(L)) - N(d_1^-(K))] \\
& - \lambda^{1-2\frac{r-\delta}{\sigma^2}} [N(d_1^+(L)) - N(d_1^+(K))]
\end{aligned}$$

Where : $f/b = \delta - r + \frac{1}{2}\sigma^2$

$$f = \sqrt{b^2 + 2r.\sigma^2}$$

$$\phi = \frac{1}{2}(b - f)$$

$$\alpha = \frac{1}{2}(b + f)$$

$$\lambda = \frac{x}{L}$$

$$d_0 = \frac{\log(\lambda) - f(T)}{\sigma\sqrt{T}}$$

$$d_1^+(x) = \frac{\log(\lambda) - \log(L) + \log(x) + b.T}{\sigma\sqrt{T}}$$

$$d_1^-(x) = \frac{-\log(\lambda) - \log(L) + \log(x) + b.T}{\sigma\sqrt{T}}$$

/*dCdl*/

Returns $\frac{\partial C(x, L)}{\partial L}$. This derivative value is necessary for the maximisation. It is based on the closed formula for $\frac{\partial C(x, L)}{\partial L}$.

/*maximise_C*/

Return the value L_{max} for which $C(x, L)$ is a maximum. This result is obtained by a dichotomy research started on the interval $[x, 1000(x + K)]$

/*low_coeff*/

Returns the multiplicative coefficient λ to obtain the approximation from the lower bound. This coefficient is obtained using Broadie and Detemple's formula.

/*call_low_approx*/

Calculates the lower bound applying the L_{max} value to the `/*call_up_out*/` function. Then multiplies the result by λ and returns the lowerbound approximation :

$$C_{lba}(x) = C(x, L_{max})$$

`/*call_low_delta*/`

Calculates the delta for the call option :

$$\frac{C_{lba}(x + 10^{-5}) - C_{lba}(x)}{10^{-5}}$$

`/*put_low_delta*/`

Calculates the delta for the put option :

$$\frac{P_{lba}(x + 10^{-5}) - P_{lba}(x)}{10^{-5}}$$

P_{lba} is the put price obtained from the symmetric call option : C_{lba} .

References

- [1] M.BROADIE J.DETEMPLE. American option valuation : new bounds, approximations and a comparison of existing methods. *Review of financial studies, to appear*, 1995. 1