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cf_fixed_calllookback

Let

- $T =$ maturity date $\quad (T > t)$
- $K =$ strike price
- $x =$ spot price
- $M =$ current maximum $\mathrm{M_{0,t}}$
- $t =$ pricing date
- $\sigma =$ volatility
- $r =$ interest rate
- $\delta =$ dividend yields
- $\theta = T - t$
- $b = r - \delta$

Floating strike lookback options can be priced using Goldman-Sosin-Gatto formula [1] while fixed strike lookback options can be priced using Conze-Viswanathen formula[2].

We set, as $0 \leq u \leq v \leq T$,

$$M_{u,v} = \sup_{u \leq \tau \leq v} S_\tau \qquad \text{and} \qquad m_{u,v} = \inf_{u \leq \tau \leq v} S_\tau$$

and

- $d_1 = \dfrac{\log\left(\frac{x}{K}\right) + \left(b + \frac{\sigma^2}{2}\right)\theta}{\sigma\sqrt{\theta}} \qquad d_2 = d_1 - \sigma\sqrt{\theta}$
- $e_1 = \dfrac{\log\left(\frac{x}{M_{0,t}}\right) + \left(b + \frac{\sigma^2}{2}\right)\theta}{\sigma\sqrt{\theta}} \qquad e_2 = e_1 - \sigma\sqrt{\theta}$
- $f_1 = \dfrac{\log\left(\frac{x}{M_{0,t}}\right) + \left(b + \frac{\sigma^2}{2}\right)\theta}{\sigma\sqrt{\theta}} \qquad f_2 = f_1 - \sigma\sqrt{\theta}$

Fixed Lookback Call Option

PAYOFF $\quad C_T = (M_{t,T} - K)_+$

Both price and delta depend on K and $M_{0,t}$.

- IF $K > M_{0,t}$ THEN

PRICE
$$C(t,x) = xe^{-\delta\theta}N(d_1) - Ke^{-r\theta}N(d_2)$$
$$+xe^{-r\theta}\frac{\sigma^2}{2b}\left[-\left(\frac{x}{K}\right)^{-\frac{2b}{\sigma^2}} N\left(d_1 - \frac{2b}{\sigma}\sqrt{\theta}\right) + e^{b\theta}N(d_1)\right]$$

DELTA
$$\frac{\partial C(t,x)}{\partial x} = e^{-\delta\theta}N(d_1)\left(1 + \frac{\sigma^2}{2b}\right) + e^{-\delta\theta}\frac{n(d_1)}{\sigma\sqrt{\theta}} - e^{-r\theta}\frac{K}{x}\frac{n(d_2)}{\sigma\sqrt{\theta}}$$
$$+e^{-r\theta}\left(\frac{x}{K}\right)^{-\frac{2b}{\sigma^2}} N\left(d_1 - \tfrac{2b}{\sigma}\sqrt{t}\right)\left(1 - \frac{\sigma^2}{2b}\right)$$

- IF $K \leq M_{0,t}$ THEN

PRICE
$$C(t,x) = e^{-r\theta}(M_{0,t} - K) + xe^{-\delta\theta}N(e_1) - M_{0,t}e^{-r\theta}N(e_2)$$
$$+xe^{-r\theta}\frac{\sigma^2}{2b}\left[-\left(\frac{x}{M_{0,t}}\right)^{-\frac{2b}{\sigma^2}} N\left(e_1 - \frac{2b}{\sigma}\sqrt{\theta}\right) + e^{b\theta}N(e_1)\right]$$

DELTA
$$\frac{\partial C(t,x)}{\partial x} = e^{-\delta\theta}N(e_1)(1 + \frac{\sigma^2}{2b}) + e^{-\delta\theta}\frac{n(e_1)}{\sigma\sqrt{\theta}} - e^{-r\theta}\frac{M_{0,t}}{x}\frac{n(d_2)}{\sigma\sqrt{\theta}}$$
$$+e^{-r\theta}\left(\frac{x}{M_{0,t}}\right)^{-\frac{2b}{\sigma^2}} N\left(e_1 - \tfrac{2b}{\sigma}\sqrt{t}\right)\left(1 - \frac{\sigma^2}{2b}\right)$$

References

[1] B.M.GOLDMAN H.B.SOSIN M.A.GATTO. Path dependent options: buy at low, sell at high. *J. of Finance*, 34:111–127, 1979. 1

[2] A.CONZE R.VISWANATHAN. Path dependent options: the case of lookback options. *J. of Finance*, 46:1893–1907, 1992. 1