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# Generalized Black & Scholes option greeks

created by **Thijs van den Berg**

Call option:

$$\text{delta} = \frac{dC}{dS} = e^{(Y-r)T}N(d_1)$$

$$\text{gamma} = \frac{d^2C}{dS^2} = e^{(Y-r)T}\frac{n(d_1)}{S\sigma\sqrt{T}}$$

$$\text{vega} = \frac{dC}{d\sigma} = e^{(Y-r)T}n(d_1)\sqrt{T}$$

$$\begin{aligned}\text{theta} = \frac{dC}{dT} &= (Y-r)Se^{(Y-r)T}N(d_1)\\ &+ rKe^{-rT}N(d_2)\\ &+ \frac{Se^{(Y-r)T}n(d_1)\sigma}{2\sqrt{T}}\end{aligned}$$

$$\text{rho} = \frac{dC}{dr} = TKe^{(Y-r)T}N(d_2)$$

Put option:

$$\text{delta} = \frac{dP}{dS} = e^{(Y-r)T}N(-d_1)$$

$$\text{gamma} = \frac{d^2P}{dS^2} = e^{(Y-r)T}\frac{n(d_1)}{S\sigma\sqrt{T}}$$

$$\text{vega} = \frac{dP}{d\sigma} = e^{(Y-r)T}n(d_1)\sqrt{T}$$

$$\begin{aligned}\text{theta} = \frac{dP}{dT} &= (Y-r)Se^{(Y-r)T}N(-d_1)\\ &- rKe^{-rT}N(-d_2)\\ &+ \frac{Se^{(Y-r)T}n(d_1)\sigma}{2\sqrt{T}}\end{aligned}$$

$$\text{rho} = \frac{dP}{dr} = -TKe^{(Y-r)T}N(-d_2)$$

The equations are the greeks: delta, gamma, vega, theta, rho of the generalized Black and Scholes option model.

## Symbol list:

C Call price
P Put price
S Present value of the underlying
Y Yield of the underlying contract. Y=r for stock, Y=0 for futures
$\sigma$

| | |
|---|---|
| | Volatility of the underlying contract |
| r | Continuous compounded interest rate |
| T | Time till expiration |
| K | Strike (excercise) price |
| $N()$ | Cumulative normal distribution function |
| $n()$ | Normal density function |
| $\ln()$ | Natural logarithm (base e) |