

The Black–Scholes formula calculates the price of European put and call options.

The value of a call option for a non-dividend-paying underlying stock in terms of the Black–Scholes parameters is:

$$C(S, t) = N(d_1)S - N(d_2)Ke^{-r(T-t)}$$
$$d_1 = \frac{1}{\sigma\sqrt{T-t}} \left[ \ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)(T-t) \right]$$
$$d_2 = \frac{1}{\sigma\sqrt{T-t}} \left[ \ln\left(\frac{S}{K}\right) + \left(r - \frac{\sigma^2}{2}\right)(T-t) \right]$$
$$= d_1 - \sigma\sqrt{T-t}$$

The price of a corresponding put option based on put-call parity is:

$$P(S, t) = Ke^{-r(T-t)} - S + C(S, t)$$
$$= N(-d_2)Ke^{-r(T-t)} - N(-d_1)S$$

For both:

- $N(\cdot)$  is the cumulative distribution function of the standard normal distribution
- $T - t$  is the time to maturity
- $S$  is the spot price of the underlying asset
- $K$  is the strike price
- $r$  is the risk free rate (annual rate, expressed in terms of continuous compounding)
- $\sigma$  is the volatility of returns of the underlying asset