

## QUESTION

Yara Inc is listed on the NYSE with a stock price of \$40 - the company is not known to pay dividends. We need to price a call option with a strike of \$45 maturing in 4 months. The continuously-compounded risk-free rate is 3%/year, the mean return on the stock is 7%/year, and the standard deviation of the stock return is 40%/year. What is the Black-Scholes call price?

## ANSWER

$S_0$  = stock price = \$40

$K$  = strike price = \$45 (It's an OTM call, hence intrinsic value = 0, price will be time premium only)

$T$  = 4 months =  $4/12 = 0.33$  years

$r$  = risk free rate = 3% = 0.03 / year

$\sigma$  = standard deviation = 40% = 0.4

Black Scholes formula for call option price (No dividends) =

$$C_0 = S_0 N(d_1) - Ke^{-rT} N(d_2)$$

$$\text{Where } d_1 = [\ln(S_0/K) + (r + \sigma^2/2) \times T] / \sigma \times \sqrt{T}$$

$$d_2 = [\ln(S_0/K) + (r - \sigma^2/2) \times T] / \sigma \times \sqrt{T}$$

$$d_1 = \frac{\ln\left(\frac{40}{45}\right) + \left(0.03 + \frac{0.42}{2}\right) \times 0.33}{0.4 \times \sqrt{0.33}}$$

$$d_1 = (-0.1178 + 0.0363) / 0.2298$$

$$d_1 = -0.0815 / 0.2298$$

$$d_1 = -0.3547$$

$$d_2 = \frac{\ln\left(\frac{40}{45}\right) + \left(0.03 - \frac{0.42}{2}\right) \times 0.33}{0.4 \times \sqrt{0.33}}$$

$$d_2 = (-0.1178 - 0.0165) / 0.2298$$

$$d_2 = -0.5844$$

From Standard Normal Distribution tables

$$N(d_1) = N(-0.3547) = 0.3613 \text{ (from interpolating between -0.35 and -0.36)}$$

$$N(d_2) = N(-0.5844) = 0.2793 \text{ (from interpolating between -0.58 and -0.59)}$$

Plugging back into Black Scholes formula

$$C_0 = 40 \times 0.3613 - \frac{45}{e^{0.099}} \times 0.2793$$

$$C_0 = 14.4520 - 12.4564$$

$C_0 = 1.9956 \simeq \$2.00$  is the price of Yara's call option with strike price \$45 and stock price \$40.