

## UNIVERSITY OF TEXAS AT AUSTIN

## Quiz # 8

Black-Scholes pricing.

**Problem 8.1.** The current price of a continuous-dividend paying stock is observed to be \$50 per share while its volatility is given to be 0.34. The dividend yield is projected to be 0.02.

The continuously compounded, risk-free interest rate is 0.05.

Consider a European call option with the strike price equal to \$40 and the exercise date in three months.

Using the Black-Scholes pricing formula, find the value  $V_C(0)$  of this option at time=0.

- (a) \$9.08
- (b) \$9.80
- (c) \$10.55
- (d) \$14.10
- (e) None of the above.

**Solution: (c)**

In our usual notation,

$$\begin{aligned} d_1 &= \frac{1}{\sigma\sqrt{T}} \left[ \ln \left( \frac{S(0)}{K} \right) + \left( r - \delta + \frac{1}{2}\sigma^2 \right) T \right] \\ &= \frac{1}{0.34\sqrt{1/4}} \left[ \ln \left( \frac{50}{40} \right) + \left( 0.05 - 0.02 + \frac{1}{2} \times 0.34^2 \right) \times \frac{1}{4} \right] = 1.44, \\ d_2 &= d_1 - \sigma\sqrt{T} = 1.27. \end{aligned}$$

The standard normal tables give us

$$N(d_1) = 0.9253, \quad N(d_2) = 0.8983.$$

Finally,

$$V_C(0) = S(0)e^{-\delta T}N(d_1) - Ke^{-rT}N(d_2) = 10.55.$$

**Problem 8.2.** (5 points) Consider a continuous-dividend-paying stock whose current price equals \$100 per share. The stock's dividend yield equals 0.01 while its volatility equals 0.25.

The continuously compounded risk-free interest rate is given to be 0.05.

Using the Black-Scholes model, calculate the price of a \$98-strike, three-month European put option on the above stock.

- (a) \$3.37
- (b) \$3.80
- (c) \$4.55
- (d) \$5.10
- (e) None of the above.

**Solution: (a)**

In our usual notation, the Black-Scholes pricing formula reads as

$$V_P(0) = Ke^{-rT}N(-d_2) - S(0)e^{-\delta T}N(-d_1)$$

with

$$\begin{aligned} d_1 &= \frac{1}{\sigma\sqrt{T}} \left[ \ln \left( \frac{S(0)}{K} \right) + \left( r - \delta + \frac{\sigma^2}{2} \right) T \right], \\ d_2 &= d_1 - \sigma\sqrt{T}. \end{aligned}$$

Using the provided data, we get

$$d_1 = \frac{1}{0.25\sqrt{\frac{1}{4}}} \left[ \ln \left( \frac{100}{98} \right) + \left( 0.05 - 0.01 + \frac{0.25^2}{2} \right) \times \frac{1}{4} \right] = 0.3041,$$
$$d_2 = 0.3041 - 0.125 = 0.1791.$$

Hence,

$$N(-d_1) = 1 - N(d_1) = 1 - 0.6179 = 0.3821, \quad \text{and} \quad N(-d_2) = 1 - N(d_2) = 1 - 0.5714 = 0.4286.$$

Finally,

$$V_P(0) = 98e^{-0.05/4} \times 0.4286 - 100e^{-0.01/4} 0.3821 = 3.3664.$$

**Problem 8.3.** (5 points) The current price of a continuous-dividend-paying stock is given to be \$92. The stock's volatility is 0.35 and its dividend yield is 0.02.

The continuously compounded risk-free interest rate is 0.05.

Consider a \$90-strike European call option on the above stock with exercise date in a quarter-year.

What is the Black-Scholes price of this call option?

- (a) 5.05
- (b) 7.66
- (c) 7.71
- (d) 7.89
- (e) None of the above.

**Solution:** (d)

$$d_1 = 0.26, d_2 = 0.08.$$

So,

$$V_C(0) = 92e^{-0.02/4} \times 0.6026 - 90e^{-0.05/4} \times 0.5319 \approx 7.89.$$