KEY TERMS

American options 649
Call option 649
Cumulative probability 669
European options 649
Exercising the option 648
Expiration date 648
Option 648
Put–call parity 657
Put option 651
Standardized normal distribution 669
Strike or exercise price 648

SUGGESTED READING

The path-breaking article on options is:

Fischer Black and Myron Scholes. "The Pricing of Options and Corporate Liabilities." *Journal of Political Economy* 81 (May–June 1973).

For a detailed discussion of options, read:

J. Hull. *Options, Futures and Other Derivative Securities*. 5th ed., Upper Saddle River, N.J.: Prentice-Hall, 2003.

QUESTIONS & PROBLEMS

Options: General

23.1 Define the following terms associated with options.
- *a.* Option
- *b.* Exercise
- *c.* Strike price
- *d.* Expiration date
- *e.* Call option
- *f.* Put option

23.2 What is the difference between an American option and a European option?

23.3 Mr. Nash holds an American put option on Delta Triangle, a non–dividend-paying stock. The strike price of the put is $40, and Delta Triangle's stock is currently selling for $35 per share. The current market price of the put is $4.50. Is this option correctly priced? If not, should Mr. Nash buy or sell the option in order to take advantage of the mispricing?

23.4 A call option on Futura Corporation, a non–dividend-paying stock, currently trades for $4. The expiration date of the option is February 25 of next year. The exercise price of the option is $45.
- *a.* If this is an American option, on what dates can the option be exercised?
- *b.* If this is a European option, on what dates can the option be exercised?
- *c.* Suppose the current price of Futura Corporation's stock is $35 per share. Is this option worthless?

23.5 Consider a European call option on stock *A* that expires on December 21 and has a strike price of $50.
- *a.* If stock *A* is trading at $55 on December 21, what is the payoff to the owner of the option?
- *b.* If stock *A* is trading at $55 on December 21, what is the payoff to the seller of the option?
- *c.* If stock *A* is trading at $45 on December 21,what is the payoff to the owner of the option?
- *d.* If stock *A* is trading at $45 on December 21, what is the payoff to the seller of the option?
- *e.* Draw the payoff diagram to the owner of this option with respect to the stock price at expiration.
- *f.* Draw the payoff diagram to the seller of this option with respect to the stock price at expiration.
- *g.* If the seller of a call option never receives cash at expiration,why would anyone ever sell a call option?

23.6 Consider a European put option on stock *A* that expires on December 21 and has a strike price of $50.

a. If stock *A* is trading at $55 on December 21, what is the payoff to the owner of the option?

b. If stock *A* is trading at $55 on December 21, what is the payoff to the seller of the option?

c. If stock *A* is trading at $45 on December 21, what is the payoff to the owner of the option?

d. If stock *A* is trading at $45 on December 21, what is the payoff to the seller of the option?

e. Draw the payoff diagram to the owner of this option with respect to the stock price at expiration.

f. Draw the payoff diagram to the seller of this option with respect to the stock price at expiration.

23.7 Ms. Eisner sold 10 BCE put options and bought 5 BCE call options. Both options have the same exercise price of $80 and the same expiration date. Draw the payoff diagram with respect to the price of BCE stock at expiration.

23.8 Mr. Chang bought two Magna European call contracts and one Magna European put contract, both of which expire in three months. Each contract is for 100 options. The exercise price of each call is $70, and the exercise price of each put is $75.

a. What is the payoff of Mr. Chang's position at expiration if the market price of Magna stock on the expiration date is $65? What if the market price is $72? What if the market price is $80?

b. Draw Mr. Chang's payoff diagram with respect to the stock price at expiration.

23.9 Louise holds a six-month European call option contract on Hurricanes, Inc., a non–dividend-paying common stock. Each contract is for 100 options. The exercise price of each call option is $100, and the option will expire in moments. Assume there are no transaction costs or taxes associated with the contract.

a. What is her cash flow at expiration if the stock is selling for $130?

b. If the stock is selling for $90, what should Louise do?

23.10 The market price of an American call option written on Stock ABC with a strike price of $50 and 6 months until expiration is $8. ABC's stock is currently trading for $60.

a. Is there an arbitrage opportunity? If so, describe what you would do to take advantage of the mispricing.

b. What do arbitrage opportunities such as this imply about the lower bound on the price of American call options?

c. What is the upper bound on the price of American call options? Explain.

23.11 List the five factors that determine the value of an American call option. State how a change in each factor affects the option's value.

23.12 List the five factors that determine the value of an American put option. State how a change in each factor affects the option's value.

Put–Call Parity

23.13 General Eclectics, Inc., has both European call and put options traded on the Montreal Exchange. Both options have the same exercise price of $40 and both expire in one year. General Eclectic's stock does not pay dividends. The call and the put are currently selling for $8 and $2, respectively. The risk-free interest rate is 5 percent per annum. What should the stock price of General Eclectics, Inc., be in order to prevent arbitrage?

23.14 Gimpellian Software, Inc., is a non–dividend-paying common stock that currently trades for $135 per share. Kevin is interested in purchasing a European call option with a strike price of $140 and one year until expiration. Much to his dismay, he discovers that call options are not traded on Gimpellian's stock. In fact,the only options traded on Gimpellian's stock are put options with a strike price of $140 and one year until expiration. These put options are currently trading for \$2. The risk-free rate is 6 percent per annum.

a. Compare the market price of the put with the payoff from the immediate exercise of a put option with a strike price of \$140. Is this an arbitrage opportunity? Why or why not?

b. Is there a way for Kevin to obtain a synthetic call option with a strike price of \$140 and one year until expiration? If there is,what is it? How much would this synthetic call option cost?

c. Draw the payoff diagram at expiration of Kevin's synthetic call position with respect to the stock price.

The Two-State Option-Pricing Model

23.15 Ken is interested in buying a European call option written on EastJet Airlines, Inc., a non–dividend-paying common stock, with a strike price of \$110 and one year until expiration. Currently, EastJet's stock sells for \$100 per share. In one year, Ken knows that EastJet's stock will be trading at either \$120 per share or \$80 per share. Ken is able to borrow and lend at the risk-free interest rate of 2.5 percent per annum (effective annual yield).

a. How much should Ken expect to pay for his desired call option today?

b. If no options currently trade on EastJet's stock, is there a way for Ken to create a synthetic call option with identical payoffs to the call option described above? If there is, how would he do it?

c. How much does the synthetic call option cost? Is this greater than, less than, or equal to what the actual call option costs? Does this make sense?

23.16 Dana wishes to buy a European put option on BioLabs, Inc., a non–dividend-paying common stock, with a strike price of \$40 and six months until expiration. BioLabs' common stock is currently selling for \$30 per share, and Dana expects that the stock price will either rise to \$60 or fall to \$15 in six months. Dana can borrow and lend at the risk-free interest rate of 21 percent per annum (effective annual yield).

a. How much should Dana expect to pay for her desired put option today?

b. If no options currently trade on BioLabs' stock, is there a way for Dana to create a synthetic put option with identical payoffs to the put option described above? If there is, how would she do it?

c. How much does the synthetic put option cost? Is this greater than, less than, or equal to what the actual put option costs? Does this make sense?

23.17 Maverick Manufacturing, Inc., must purchase gold in three months to use in its operations. Maverick's management has estimated that if the price of gold were to rise above \$375 per ounce, the firm would go bankrupt. The current price of gold is \$350 per ounce. The firm's chief financial officer believes that the price of gold will either rise to \$400 per ounce or fall to \$325 per ounce over the next three months. Management wishes to eliminate any risk of the firm going bankrupt. Maverick can borrow and lend at the risk-free interest rate of 16.99 percent per annum (effective annual yield).

a. Would Maverick be interested in buying a call option or a put option on the price of gold? In order to avoid bankruptcy, what strike price and time to expiration would the firm like this option to have?

b. How much should such an option sell for in the open market?

c. If no options currently trade on gold, is there a way for Maverick to create a synthetic option with identical payoffs to the option described above? If there is, how would the firm do it?

d. How much does the synthetic option cost? Is this greater than, less than, or equal to what the actual option costs? Does this make sense?

23.18 Liz is interested in buying one share of an index fund that tracks the S&P/TSX 60. The fund does not pay any dividends. She believes that the fund will either increase by 25 percent or decrease by 20 percent over the next year. Liz is very risk averse and wishes to shield herself from any decrease in the value of the fund below \$1,300, without forfeiting any of the fund's upside potential. Liz can borrow and lend at the risk-free interest rate of 7 percent per annum (effective annual yield).

a. Would Liz be interested in buying a call option or a put option on the index fund? What strike price and time to expiration would she like this option to have?

b. How much should such an option sell for in the open market?

c. If no options currently trade on the index fund, is there a way for Liz to create a synthetic option with identical payoffs to the option described above? If there is, how would she do it?

d. How much does the synthetic option cost? Is this greater than, less than, or equal to what the actual option costs? Does this make sense?

The Black–Scholes Option Pricing Model

23.19 Myron Fisher is interested in purchasing a European call option on Meriwether and Associates, Inc., a non–dividend-paying common stock, with a strike price of $50 and one year until expiration. Meriwether's stock is currently trading at $55 per share, and the annual variance of its continuously compounded returns is 0.0625. Treasury bills that mature in one year yield a continuously compounded interest rate of 10 percent per annum. Use the Black–Scholes model to calculate the price of the call option that Myron is interested in buying.

23.20 John Goodfriend is interested in purchasing a European call option on Mozer, Inc., a non–dividend-paying common stock, with a strike price of $25 and six months until expiration. Mozer's stock is currently trading at $15 per share, and the annual variance of its continuously compounded returns is 0.25. Treasury bills that mature in six months yield a continuously compounded interest rate of 8 percent per annum. Use the Black–Scholes model to calculate the price of the call option that John is interested in buying.

23.21 Nikki is interested in purchasing a European call option on Brain Enhancers, Inc., a non–dividend-paying common stock, with a strike price of $100 and two years until expiration. Brain Enhancer's stock is currently trading at $100 per share, and the annual variance of its continuously compounded returns is 0.04. Treasury bills that mature in two years yield a continuously compounded interest rate of 5 percent per annum.

a. Use the Black–Scholes model to calculate the price of the call option that Nikki is interested in buying.

b. What does put–call parity imply about the price of a put with a strike price of $100 and two years until expiration?

23.22 David is interested in purchasing a European call option on Divine Vines, Inc., a non–dividend-paying common stock, with a strike price of $30 and three months until expiration. Divine's stock is currently trading at $60 per share, and the annual variance of its continuously compounded returns is 0.36. Treasury bills that mature in three months yield a continuously compounded interest rate of 3 percent per annum.

a. Use the Black–Scholes model to calculate the price of the call option that David is interested in buying.

b. What does put–call parity imply about the price of a put with a strike price of $30 and three months until expiration?

23.23 Marilyn wishes to buy a European call option on Scuba Solutions, Inc., a non–dividend-paying common stock, with a strike price of $35 and one year until expiration. Scuba Solutions is currently selling for $37 per share and Marilyn's estimate of the annual variance of its continuously compounded returns is 0.0225. Marilyn can borrow and lend at the continuously compounded risk-free rate of 7 percent per annum.

a. Use the Black–Scholes model to calculate the price of the call option that Marilyn is interested in buying.

b. Suppose Marilyn's estimate of the annual variance of the continuously compounded returns on Scuba's stock changes to 0.09. What is the new Black–Scholes price of the call option?

c. Does an increase in the volatility (variance) of the underlying asset increase or decrease the Black–Scholes price of a call option?

d. Scuba's stock price suddenly drops to \$20 per share after an announcement that the company will be shutting down its Mediterranean diving operations. Using Marilyn's new estimate of variance (0.09), calculate the Black–Scholes price of the call option.

23.24 An investor is said to take a position in a "collar" if he buys the asset, buys an out-of-the-money put option on the asset, and sells an out-of-the-money call option on the asset. The two options should have the same time to expiration. Suppose Marie wishes to purchase a collar on Hollywood, Inc., a non–dividend-paying common stock, with six months until expiration. She would like the put to have a strike price of \$50 and the call to have a strike price of \$120. The current price of Hollywood's stock is \$80 per share. Marie can borrow and lend at the continuously compounded risk-free rate of 10 percent per annum, and the annual variance of Hollywood's continuously compounded returns is 0.25. Use the Black–Scholes model to calculate the total cost of the collar that Marie is interested in buying.

Application of Options to Corporate Finance

23.25 It is said that the equityholders of a levered firm can be thought of as holding a call option on the firm's assets. Explain what is meant by this statement.

23.26 Strudler Real Estate, Inc., a construction firm financed by both debt and equity, is undertaking a new project. If the project is successful, the value of the firm in one year will be \$500 million, but if the project is a failure, the firm will only be worth \$320 million. The current value of Strudler is \$400 million, a figure that includes the prospects for the new project. Strudler has outstanding zero-coupon bonds due in one year with a face value of \$380 million. Treasury bills that mature in one year yield 7 percent per annum (effective annual yield). Strudler pays no dividends.

a. Use the two-state option pricing model to find the current value of Strudler's debt and equity.

b. Suppose Strudler has 500,000 shares of common stock outstanding. What is the price per share of the firm's equity?

c. Compare the market value of Strudler's debt to the present value of an equal amount of debt that is riskless with one year until maturity. Is the firm's debt worth more than, less than, or the same as the riskless debt's present value? Does this make sense? What factor might cause these two values to be different?

d. Suppose that in place of the project described above, Strudler's management decides to undertake a project that is even more risky. The value of the firm will either increase to \$800 million or decrease to \$200 million by the end of the year. Surprisingly, management concludes that the value of the firm today will remain at exactly \$400 million, if this risky project is substituted for the less risky one. Use the two-state option pricing model to determine the value of the firm's debt and equity if the firm plans on undertaking this new project. Which project do bondholders prefer?

23.27 Consider a firm that is financed by both debt and equity. The firm is worth \$1 million today and currently has 700 zero-coupon bonds outstanding that mature in six months. Each bond has a face value of \$1,000. The firm pays no dividends. The annual variance of the firm's continuously compounded asset returns is 0.16, and Treasury bills that mature in six months yield a continuously compounded interest rate of 8 percent per annum. Use the Black–Scholes model to calculate the individual values of the firm's debt and equity.