Chapter 18
Derivatives and Risk Management

Learning Objectives

After reading this chapter, students should be able to:

- Identify the circumstances in which it makes sense for companies to manage risk.
- Describe the various types of derivatives and explain how they can be used to manage risk.
- Value options using the Binomial and Black-Scholes Option Pricing Models.
- Discuss the various elements of risk management and the different processes that firms use to manage risks.

Lecture Suggestions

This chapter provides information on derivatives and how they are used in risk management. We begin by identifying the reasons why risk should be managed. Then, we give a brief background on derivatives. We illustrate a riskless hedge and present the Binomial Option Pricing Model. Next, we present the Black-Scholes Option Pricing Model to discuss the various factors that affect a call option's value. We specifically discuss forward and futures contracts, as well as other types of derivatives such as swaps and structured notes. In addition, we explain how derivatives are used to reduce risk through hedging, particularly with financial and commodity futures. Finally, we discuss risk management, define different types of risks, and then provide an approach to risk management that firms can follow.

What we cover, and the way we cover it, can be seen by scanning the slides and Integrated Case solution for Chapter 18, which appears at the end of this chapter solution. For other suggestions about the lecture, please see the "Lecture Suggestions" in Chapter 2, where we describe how we conduct our classes.

DAYS ON CHAPTER: 2 OF 56 DAYS (50-minute periods)

Answers to End-of-Chapter Questions

18-1 Risk management may increase the value of a firm because it allows corporations to (1) increase their use of debt; (2) maintain their optimal capital budget over time; (3) avoid costs associated with financial distress; (4) utilize their comparative advantages in hedging relative to the hedging ability of individual investors; (5) reduce both the risks and costs of borrowing by using swaps; (6) reduce the higher taxes that result from fluctuating earnings; and (7) initiate compensation systems that reward managers for achieving earnings stability.

18-2 The market value of an option is typically higher than its exercise value due to the speculative nature of the investment. Options allow investors to gain a high degree of personal leverage when buying securities. The option allows the investor to limit his or her loss but amplify his or her return. The exact amount this protection is worth is the premium over the exercise value.

18-3 There are several ways to reduce a firm's risk exposure. First, a firm can transfer its risk to an insurance company, which requires periodic premium payments established by the insurance company based on its perception of the firm's risk exposure. Second, the firm can transfer risk-producing functions to a third party. For example, contracting with a trucking company can in effect, pass the firm's risks from transportation to the trucking company. Third, the firm can purchase derivatives contracts to reduce input and financial risks. Fourth, the firm can take specific actions to reduce the probability of occurrence of adverse events. This includes replacing old electrical wiring or using fire resistant materials in areas with the greatest fire potential. Fifth, the firm can take actions to reduce the magnitude of the loss associated with adverse events, such as installing an automatic sprinkler system to suppress potential fires. Finally, the firm can totally avoid the activity that gives rise to the risk.

18-4 The futures market can be used to guard against interest rate and input price risk through the use of hedging. If the firm is concerned that interest rates will rise, it would use a short hedge, or sell financial futures contracts. If interest rates do rise, losses on the issue due to the higher interest rates would be offset by gains realized from repurchase of the futures at maturity--because of the increase in interest rates, the value of the futures would be less than at the time of issue. If the firm is concerned that the price of an input will rise, it would use a long hedge, or buy commodity futures. At the future's maturity date, the firm will be able to purchase the input at the original contract price, even if market prices have risen in the interim.

18-5 Swaps allow firms to reduce their financial risk by exchanging their debt for another party's debt, usually because the parties prefer the other's debt contract terms. There are several ways in which swaps reduce risk. Currency swaps, where firms exchange debt obligations denominated in different currencies, can eliminate the exchange rate risk created when currency must first be converted to another currency before making scheduled debt payments. Interest rate swaps, where counterparties trade fixed-rate debt for floating-rate debt, can reduce risk for both parties based on their individual views concerning future interest rates.

18-6 If the elimination of volatile cash flows through risk management techniques does not significantly change a firm's expected future cash flows and WACC, investors will be indifferent to holding a company with volatile cash flows versus a company with stable cash flows. Note that investors can reduce volatility themselves: (1) through portfolio diversification, or (2) through their own use of derivatives.

Solutions to End-of-Chapter Problems

18-1 Call option's market price = \$7; Stock's price = \$30; Option exercise price = \$25.

a. Exercise value = Current stock price – Exercise price
= \$30 – \$25
= \$5.00.

b. Premium value = Option's market price – Exercise value
= \$7 – \$5
= \$2.00.

18-2 Option's exercise price = \$15; Exercise value = \$22; Premium value = \$5; V = ? P_0 = ?

Premium = Market price of option – Exercise value
\$5 = V – \$22
V = \$27.

Exercise value = P_0 – Exercise price
\$22 = P_0 – \$15
P_0 = \$37.

18-3 **a.** The value of an option increases as the stock price increases, but by less than the stock price increase.

b. An increase in the volatility of the stock price increases the value of an option. The riskier the underlying security, the more valuable the option.

c. As the risk-free rate increases, the option's value increases. The expected growth rate of a firm's stock price increases as interest rates increase, but the present value of future cash flow decreases. The first effect dominates, so the price of a call option always increases as the risk-free rate increases.

d. The shorter the time to expiration of the option, the lower the value of the option. The option's value depends on the chances for an increase in the underlying stock price, and the longer the option's life, the higher the stock price may climb.

Therefore, conditions a, b, and c will cause an option's market value to increase.

18-4 $P = \$15$; $X = \$15$; $t = 0.5$; $r_{RF} = 0.10$; $\sigma^2 = 0.12$; $d_1 = 0.32660$; $d_2 = 0.08165$; $N(d_1) = 0.62795$; $N(d_2) = 0.53252$; $V = ?$

Using the Black-Scholes Option Pricing Model, you calculate the option's value as:

$$
\begin{aligned}
V &= P[N(d_1)] - Xe^{-r_{RF}t}[N(d_2)] \\
&= \$15(0.62795) - \$15e^{(-0.10)(0.5)}(0.53252) \\
&= \$9.4193 - \$15(0.9512)(0.53252) \\
&= \$9.4193 - \$7.5982 \\
&= \$1.8211 \approx \$1.82.
\end{aligned}
$$

18-5 Futures contract settled at $100^{16}/_{32}$% of \$100,000 contract value, so PV = 1.005 × \$1,000 = \$1,005 × 100 bonds = \$100,500. Using a financial calculator, we can solve for r_d as follows:

N = 20; PV = -1005; PMT = 30; FV = 1000; solve for I/YR = r_d = 2.9665% × 2 = 5.933% ≈ 5.93%.

If interest rates increase to 6.93%, then we would solve for PV as follows:

N = 20; I/YR = 6.93/2 = 3.465; PMT = 30; FV = 1000; solve for PV = \$933.7025 × 100 = \$93,370.25. Thus, the contract's value has decreased from \$100,500 to \$93,370.25.

18-6 **a.** In this situation, the firm would be hurt if interest rates were to rise by June 2012, so it would use a short hedge, or sell futures contracts. Since the 10-year U.S. Treasury notes futures contracts are for \$100,000 in 10-year Treasury notes, the firm must sell 200 contracts to cover its planned \$20,000,000 June bond issue. Since futures maturing in June are selling for $128^{11.5}/_{32}$ of par, the value of Kyoto BioTech's futures is about \$25,671,875. Should interest rates rise by June 2012, Kyoto BioTech Inc. will be able to repurchase the futures contracts at a lower cost, which will help offset their loss from financing at the higher interest rate. Thus, the firm has hedged against rising interest rates.

b. The firm would now pay 13% on the bonds. With an 11% coupon rate, the bond issue would bring in only \$17,796,299, so the firm would lose \$20,000,000 – \$17,796,299 = \$2,203,701:

N = 20; I/YR = 6.5; PMT = 1100000; FV = 20000000; and solve for PV = \$17,796,299.

However, the value of the short futures position began at \$25,671,875:

$128^{11.5}/_{32}$ of \$20,000,000 = 1.28359375(\$20,000,000) = \$25,671,875, or roughly N = 20; PMT = 600000; FV = 20000000; and PV = -25,671,875; and solve for I/YR/2 = 1.369378691.

I/YR = 1.369378691% × 2 = 2.738757383% ≈ 2.74%.

(Note that the future contracts are on hypothetical 10-year, 6% semiannual coupon bonds that are yielding about 2.75%.)

Now, if interest rates increased by 200 basis points, to 4.74%, the value of the futures contract will drop to \$21,988,572.

N = 20; I/YR = 4.74/2 = 2.37; PMT = 600000; FV = 20000000; and solve for PV = \$21,988,572.

Since Kyoto BioTech Inc. sold the futures contracts for \$25,671,875, and will, in effect, buy them back at \$21,988,572, the firm would make a \$25,671,875 – \$21,988,572 = \$3,683,303 profit on the transaction ignoring transactions costs.

Thus, the firm gained \$3,683,303 on its futures position, but lost \$2,203,701 on its underlying bond issue. On net, it gained \$3,683,303 – \$2,203,701 = \$1,479,602.

c. In a perfect hedge, the gains on futures contracts exactly offset losses due to rising interest rates. For a perfect hedge to exist, the underlying asset must be identical to the futures asset. Using the Kyoto BioTech example, a futures contract must have existed on Kyoto BioTech's own debt (it existed on 10-year U.S. Treasury notes) for the company to have an opportunity to create a perfect hedge. In reality, it is virtually impossible to create a perfect hedge, since in most cases the underlying asset is not identical to the futures asset.

18-7 **a.** The current exercise value of the put option is max(0, \$55 – \$60) = \$0. Since the market value of the put option is \$3.06, the premium associated with the put is \$3.06. The current exercise value of the call option is max(0, \$60 – \$55) = \$5. Since the market value of the call option is \$9.29, the premium associated with the call is \$4.29.

b. Remember, that the options will be exercised only if they yield a positive payoff. In this case, the put option will not be exercised. In addition, the initial investments for the options will be the market values of the options. The returns under each of the scenarios are summarized below:

Investment	Returns		
Own stock	[(\$70 – \$60)/\$60]	=	16.67%.
Buy call option	[(\$70 – \$55)/\$9.29] – 1	=	61.46%.
Buy put option	[(\$0)/\$3.06] – 1	=	-100%.

c. In this case, the call option will not be exercised. The returns under each of the scenarios are summarized below:

Investment	Returns		
Own stock	[(\$50 – \$60)/\$60]	=	-16.67%.
Buy call option	[(\$0)/\$9.29] – 1	=	-100%.
Buy put option	[(\$55 – \$50)/\$3.06] – 1	=	63.40%.

d. Recall, that the stock price is expected to be either \$50 or \$70, with equal probability. If Sunlina buys 0.6 shares of stock and sells one call option, her expected payoffs are:

Ending Price	× 0.60 =	Ending Stock Value	Ending Option Value
\$50	× 0.60 =	\$30	\$ 0
\$70	× 0.60 =	\$42	\$15

Sunlina's investment strategy would yield a payoff of \$30 – \$0 = \$30, if the ending stock price is \$50. Her investment strategy has a payoff of \$42 – \$15 = \$27, if the ending stock price is \$70. The strategies do not have identical payoffs; therefore, this is not a riskless hedged portfolio.

e. Recall, that the stock price is expected to be either \$50 or \$70, with equal probability. If Sunlina buys 0.75 shares of stock and sells one call option, her expected payoffs are:

Ending Price	× 0.75 =	Ending Stock Value	Ending Option Value
\$50	× 0.75 =	\$37.50	\$ 0
\$70	× 0.75 =	\$52.50	\$15

Sunlina's investment strategy would yield a payoff of \$37.50 – \$0 = \$37.50, if the ending stock price is \$50. Her investment strategy has a payoff of \$52.50 – \$15 = \$37.50, if the ending stock price is \$70. Since her payoff is guaranteed to be \$37.50, regardless of the ending stock price, this is a riskless hedged portfolio.

18-8 **a.** Data: P_0 = \$60; X = \$50; Price = \$45 or \$70; r_{RF} = 7%.

	Ending Price	Strike Price	=	Option Value
	\$45	\$50	=	\$ 0.00
	\$70	\$50	=	\$20.00
Range	\$25			\$20.00

b.

	Ending Price	× 0.80 =	Ending Stock Value	Ending Option Value
	\$45	× 0.80 =	\$36.00	\$ 0.00
	\$70	× 0.80 =	\$56.00	\$20.00
Range	\$25		\$20.00	\$20.00

c.

Ending Price	× 0.80 =	Ending Stock Value	+	Ending Option Value	=	Portfolio Value
\$45	× 0.80 =	\$36.00	+	\$ 0.00	=	\$36.00
\$70	× 0.80 =	\$56.00	+	-\$20.00	=	\$36.00

d. Cost of stock = 0.8(\$60) = \$48.00

e. PV = \$36/1.07 = \$33.64

f. Price of option = Cost of stock – PV of portfolio
= \$48.00 – \$33.64 = \$14.36

18-9

Current stock price	**\$50.00**	
Range of values	**\$40.00**	**\$70.00**
Exercise price	**\$55.00**	
r_{RF}	**4.00%**	
Time until expiration	**1 year**	

a. *Binomial Approach:*

Current Stock Price	Current Option Price		Ending Stock Value	Ending Option Value	Ending Portfolio Value
		Up	\$70.00	\$15.00	\$55.00
\$50.00	?				
		Down	\$40.00	\$ 0.00	\$40.00
		Range of outcomes:	\$30.00	\$15.00	\$15.00

b. Equalize ranges 15/\$30 = 0.5000 Buy 0.5000 shares and sell 1 option

c. and d.

Hedge Portfolio

Current Stock Price	Current Option Price		Ending Stock Value	Ending Option Value	Ending Portfolio Value
		↗	$70 × 0.5 = $35.00	$15.00	$20.00
$50.00 × 0.5 = $25.00	**?**				
		↘	$40 × 0.5 = $20.00	$ 0.00	$20.00
	Range of outcomes:		$15.00	$15.00	$ 0.00

e. PV of portfolio = \$20/1.04 = \$19.23

f. Current option price = Stock price − PV of portfolio
= \$25.00 − \$19.23 = \$5.77

Thus, the value of this option is \$5.77.

Comprehensive/Spreadsheet Problem

Note to Instructors:
The solution to the reworked part of this problem is provided at the back of the text; however, the solutions to Parts a and b are not. Instructors can access the *Excel* file on the textbook's web site or the Instructor's Resource CD.

18-10 a. Assume you have been given the following information on Xiang Xiang Enterprises:

P	**$15**	**X**	**$15**
t	**0.5**	r_{RF}	**10%**
σ^2	**0.12**		

First, we will use formulas from the text to solve for d_1 and d_2.

(d_1) = **0.32660**

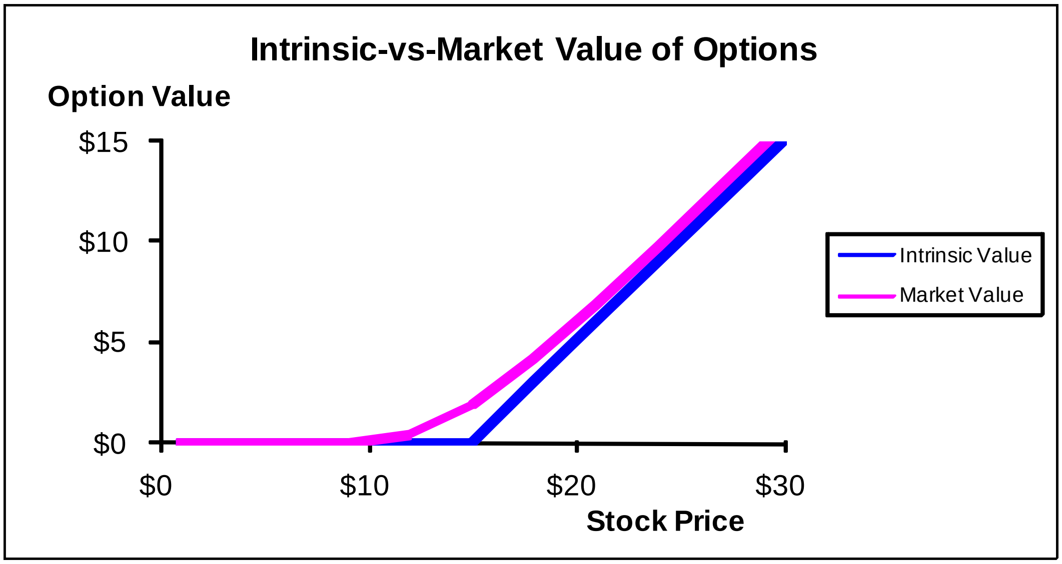
(d_2) = **0.08165**

Using the formula for option value and the normal distribution function, we can find the call option value.

V = **$1.82**

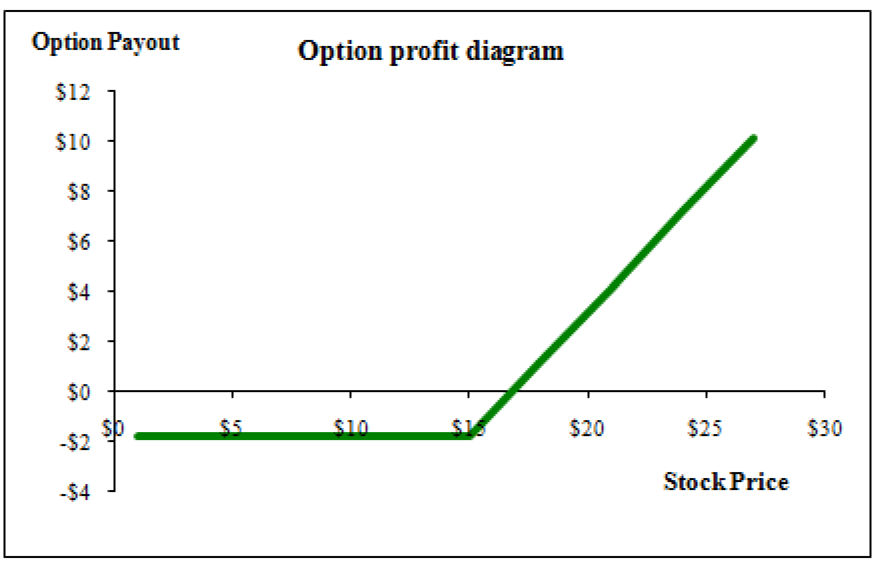
b.

Exercise Price	Current stock price	Option Value: Intrinsic Value	Option Value: B-S formula Value	Option Premium
		$0	$1.82	
$15.00	$1.00	$0.00	$0.00	$0.00
$15.00	$3.00	$0.00	$0.00	$0.00
$15.00	$6.00	$0.00	$0.00	$0.00
$15.00	$9.00	$0.00	$0.03	$0.03
$15.00	$12.00	$0.00	$0.45	$0.45
$15.00	$15.00	$0.00	$1.82	$1.82
$15.00	$18.00	$3.00	$4.09	$1.09
$15.00	$21.00	$6.00	$6.83	$0.83
$15.00	$24.00	$9.00	$9.76	$0.76
$15.00	$27.00	$12.00	$12.74	$0.74
$15.00	$30.00	$15.00	$15.73	$0.73



c.

X_{CALL} = if P= …	$15 Call
$1	-$1.82
$3	-$1.82
$6	-$1.82
$9	-$1.82
$12	-$1.82
$15	-$1.82
$18	$1.18
$21	$4.18
$24	$7.18
$27	$10.18



d.

P	$25	X	$30
t	0.5	r_{RF}	5%

	Ending Stock Price	Strike Price	Call Option Value
	$20	$30	$0
	$40	$30	$10
Range	$20		$10

Calculate the value of the portfolio at the end of 6 months. Remember that if the option is in-the-money, it will be sold.

Equalize range: 0.50

Ending Stock Price			Ending Stock Value		Ending Option Value	=	Value of Portfolio
$20	×	0.50	$10	+	$0		$10
$40	×	0.50	$20	+	-$10		$10

e. Step 1: Calculate the present value of the riskless portfolio today.

$$PV = \frac{\text{Future Portfolio Value}}{(1 + r_{RF})^t}$$

$$PV = \frac{\$10}{1.0247}$$

$$\boxed{PV = \$9.76}$$

Step 2: Calculate the cost of the stock in the portfolio.

Percentage of stock in portfolio 0.5
Current stock price $25

Cost of stock in portfolio = % of stock in portfolio × Stock price
Cost of stock in portfolio = 0.5 × $25
Cost of stock in portfolio = $12.50

Step 3: Calculate the value of the option.

Price of option = Cost of stock – PV of portfolio
Price of option = $12.50 – $9.76
Price of option = $2.74

Integrated Case

18-11
Equator Candies Ltd.
Derivatives and Corporate Risk Management

Assume that you have just been hired as a financial analyst by Equator Candies Ltd., a midsized Singapore company that specializes in creating exotic candies from tropical fruits such as mangoes, papayas, and durians. The firm's CEO, Roger Wong, recently returned from an industry corporate executive conference in Hong Kong. One of the sessions he attended was on the pressing need for smaller companies to institute corporate risk management programs. As no one at Equator Candies is familiar with the basics of derivatives and corporate risk management, Wong has asked you to prepare a brief report that the firm's executives can use to gain at least a cursory understanding of the topics.

To begin, you gather some outside materials on derivatives and corporate risk management and use those materials to draft a list of pertinent questions that need to be answered. In fact, one possible approach to the paper is to use a question-and-answer format. Now that the questions have been drafted, you must develop the answers.

A.	**Why might stockholders be indifferent to whether a firm reduces the volatility of its cash flows?**

Answer: **[Show S18-1 and S18-2 here.] If volatility in cash flows is not caused by systematic risk, then stockholders can eliminate the risk of volatile cash flows by diversifying their portfolios. Also, if a company decided to hedge away the risk associated with the volatility of its cash flows, the company would have to pass on the costs of hedging to the investors. Sophisticated investors can hedge**

risks themselves and thus they are indifferent as to who actually does the hedging.

B. **What are seven reasons risk management might increase the value of a corporation?**

Answer: **[Show S18-3 here.] There are no studies proving that risk management either does or does not add value. However, there are seven reasons why risk management might increase the value of a firm. Risk management allows corporations to (1) increase their use of debt; (2) maintain their optimal capital budget over time; (3) avoid costs associated with financial distress; (4) utilize their comparative advantages in hedging relative to the hedging ability of individual investors; (5) reduce both the risks and costs of borrowing by using swaps; (6) reduce the higher taxes that result from fluctuating earnings; and (7) initiate compensation programs to reward managers for achieving stable earnings.**

C. **What is an option? What is the single most important characteristic of an option?**

Answer: **[Show S18-4 here.] An option is a contract that gives its holder the right to buy (or sell) an asset at some predetermined price within a specified period of time. An option's most important characteristic is that it does not obligate its owner to take any action; it merely gives the owner the right to buy or sell an asset.**

D.	**Options have a unique set of terminology. Define the following terms: (1) call option; (2) put option; (3) exercise price; (4) striking, or strike, price; (5) option price; (6) expiration date; (7) exercise value; (8) covered option; (9) naked option; (10) in-the-money call; (11) out-of-the-money call; and (12) LEAPS.**

Answer: **[Show S18-5 through S18-7 here.]**

A call option is an option to buy a specified number of shares of a security within some future period.

A put option is an option to sell a specified number of shares of a security within some future period.

Exercise price is another name for strike price, the price stated in the option contract at which the security can be bought (or sold).

The strike price is the price stated in the option contract at which the security can be bought (or sold).

The option price is the market price of the option contract.

The expiration date is the date the option matures.

The exercise value is the value of a call option if it were exercised today, and it is equal to the current stock price minus the strike price.

A covered option is a call option written against stock held in an investor's portfolio.

A naked option is an option sold without the stock to back it up.

An in-the-money call is a call option whose exercise price is less than the current price of the underlying stock.

An out-of-the-money call is a call option whose exercise price exceeds the current price of the underlying stock.

LEAPS stands for long-term equity anticipation securities. They are similar to conventional options except they are long-term options with maturities of up to 2½ years.

E. Consider Equator Candies' call option with a $25 strike price. The following table contains historical values for this option at different stock prices:

Stock Price	Call Option Price
$25	$ 3.00
30	7.50
35	12.00
40	16.50
45	21.00
50	25.50

(1) Create a table that shows the (a) stock price, (b) strike price, (c) exercise value, (d) option price, and (e) premium of option price over exercise value.

Answer: [Show S18-8 and S18-9 here.]

Price of Stock (a)	Strike Price (b)	Exercise Value of Option (a) – (b) = (c)	Market Price of Option (d)	Premium (d) – (c) = (e)
$25.00	$25.00	$ 0.00	$ 3.00	$3.00
30.00	25.00	5.00	7.50	2.50
35.00	25.00	10.00	12.00	2.00
40.00	25.00	15.00	16.50	1.50
45.00	25.00	20.00	21.00	1.00
50.00	25.00	25.00	25.50	0.50

E. (2) What happens to the premium of option price over exercise value as the stock price rises? Why?

Answer: [Show S18-10 and S18-11 here.] As the table shows, the premium of the option price over the exercise value declines as the stock price increases. This is due to the declining degree of leverage

provided by options as the underlying stock price increases, and to the greater loss potential of options at higher option prices.

F. **In 1973, Fischer Black and Myron Scholes developed the Black-Scholes Option Pricing Model.**

(1) What assumptions underlie this model?

Answer: [Show S18-12 here.] The assumptions that underlie the Black-Scholes Option Pricing Model are as follows:

- The stock underlying the call option provides no dividends during the life of the option.
- No transactions costs are involved with the sale or purchase of either the stock or the option.
- The short-term, risk-free interest rate is known and is constant during the life of the option.
- Security buyers may borrow any fraction of the purchase price at the short-term, risk-free rate.
- Short-term selling is permitted without penalty, and sellers receive immediately the full cash proceeds at today's price for securities sold short.
- The call option can be exercised only on its expiration date.
- Security trading takes place in continuous time, and stock prices move randomly in continuous time.

F.	**(2) Write the three equations that constitute the model.**

Answer: **[Show S18-13 here.] The Black-Scholes Option Pricing Model consists of the following three equations:**

$$V = P[N(d_1)] - Xe^{-r_{RF}t}[N(d_2)].$$

$$d_1 = \frac{\ln(P/X) + [r_{RF} + (\sigma^2/2)]t}{\sigma\sqrt{t}}.$$

$$d_2 = d_1 - \sigma\sqrt{t}.$$

Here,

V = Current value of a call option with time t until expiration.

P = Current price of the underlying stock.

$N(d_i)$ = Probability that a deviation less than d_i will occur in a standard normal distribution. Thus, $N(d_1)$ and $N(d_2)$ represent areas under a standard normal distribution curve.

X = Exercise, or strike, price of the option.

$e \approx 2.7183$.

r_{RF} = Risk-free interest rate.

t = Time until the option expires (the option period).

$\ln(P/X)$ = Natural logarithm of P/X.

σ^2 = Variance of the rate of return on the stock.

F.	**(3)**	**What is the value of the following call option according to this model?** **Stock price = $27.00.** **Exercise price = $25.00.** **Time to expiration = 6 months.** **Risk-free rate = 6.0%.** **Stock return variance = 0.11.**

Answer: **[Show S18-14 and S18-15 here.] The input variables are:**

P = $27.00; X = $25.00; r_{RF} = 6.0%; t = 6 months = 0.5 years; and σ^2 = 0.11.

Now, we proceed to use the Black-Scholes Option Pricing Model:

$$V = \$27[N(d_1)] - \$25e^{-(0.06)(0.5)}[N(d_2)].$$

$$d_1 = \frac{\ln(\$27/\$25) + [(0.06 + 0.11/2)](0.5)}{(0.3317)(0.7071)}$$

$$= \frac{0.0770 + 0.0575}{0.2345} = 0.5736.$$

$$d_2 = d_1 - (0.3317)(0.7071) = d_1 - 0.2345$$
$$= 0.5736 - 0.2345 = 0.3391.$$

$$N(d_1) = N(0.5736) = 0.5000 + 0.2168 = 0.7168.$$

$$N(d_2) = N(0.3391) = 0.5000 + 0.1327 = 0.6327.$$

Therefore,

$$V = \$27(0.7168) - \$25e^{-0.03}(0.6327)$$
$$= \$19.3536 - \$25(0.97045)(0.6327)$$
$$= \$19.3536 - \$15.3500 = \$4.0036 \approx \$4.00.$$

Thus, under this model, the value of the call option is about $4.00.

G.	Disregard the information in Part F. Determine the value of a firm's call option using the binomial approach by creating a riskless hedge given the following information. A firm's current stock price is $15 per share. Options exist that permit the holder to buy one share of the firm's stock at an exercise price of $15. These options expire in 6 months, at which time the firm's stock will be selling at one of two prices, $10 or $20. The risk-free rate is 6%. What is the value of the firm's call option?

Answer: **[Show S18-16 through S18-19 here.]**

P	$15	X	$15
t	0.5	r_{RF}	6%

	Ending Stock Price	Strike Price	Call Option Value
	$10	$15	$0
	$20	$15	$5
Range	$10		$5

Step 1: Calculate the value of the portfolio at the end of 6 months. Remember that if the option is in-the-money, it will be sold.

Ending Stock Price	×	0.5	Ending Stock Value	+	Ending Option Value	=	Value of Portfolio
$10	×	0.5	$5	+	$0		$5
$20	×	0.5	$10	+	-$5		$5

Step 2: Calculate the present value of the riskless portfolio today.

$$PV = \frac{\text{Future Portfolio Value}}{(1 + r_{RF})^t}$$

$$PV = \frac{\$5}{1.0296}$$

$$\boxed{PV = \$4.86}$$

Step 3: Calculate the cost of the stock in the portfolio.			
Percentage of stock in portfolio	0.5		
Current stock price	$15		
Cost of stock in portfolio =	% of stock in portfolio	×	Stock price
Cost of stock in portfolio =	0.5	×	$15
Cost of stock in portfolio =	$7.50		

Step 4: Calculate the market value of the option.			
Price of option =	Cost of stock	–	PV of portfolio
Price of option =	$7.50	–	$4.86
Price of option =	$2.64		

H. What effect does each of the following call option parameters have on the value of a call option? (1) Current stock price; (2) exercise price; (3) length of the option period; (4) risk-free rate; (5) variability of the stock price.

Answer: [Show S18-20 and S18-21 here.]

1. **The value of a call option increases (decreases) as the current stock price increases (decreases).**

2. **As the exercise price of the option increases (decreases), the value of the option decreases (increases).**

3. **As the expiration date of the option is lengthened, the value of the option increases. This is because the value of the option depends on the chance of a stock price increase, and the longer the option period, the higher the stock price can climb.**

4. **As the risk-free rate increases, the value of the option tends to increase as well. Since increases in the risk-free rate tend to decrease the present value of the option's exercise price, they also tend to increase the current value of the option.**

5. The greater the variance in the underlying stock price, the greater the possibility that the stock's price will exceed the exercise price of the option; thus, the more valuable the option will be.

I. What are the differences between forward and futures contracts?

Answer: [Show S18-22 here.] Forward contracts are agreements where one party agrees to buy a commodity at a specific price on a specific future date and the other party agrees to make the sale. Goods are actually delivered under forward contracts.

A futures contract is similar to a forward contract, but with three key differences: (1) Futures contracts are "marked to market" on a daily basis, meaning that gains and losses are noted and money must be put up to cover losses. This greatly reduces the risk of default that exists with forward contracts. (2) With futures, physical delivery of the underlying asset is virtually never taken—the two parties simply settle with cash for the difference between the contracted price and the actual price on the expiration date. (3) Futures contracts are generally standardized instruments that are traded on exchanges, whereas forward contracts are generally tailor-made, are negotiated between two parties, and are not traded after they have been signed.

J. Explain briefly how swaps work.

Answer: [Show S18-23 here.] A swap is the exchange of cash payment obligations between two parties, usually because each party prefers the terms of the other's debt contract because the terms more closely match the firm's cash flows: Fixed for floating and floating for fixed. Swaps can reduce each party's financial risk.

K. Explain briefly how a firm can use futures and swaps to hedge risk.

Answer: [Show S18-24 and S18-25 here.] Hedging is usually used when a price change could negatively affect a firm's profits. A long hedge involves the purchase of a futures contract to guard against a price increase. A short hedge involves the sale of a futures contract to protect against a price decline. The purchase of a commodity futures contract will allow a firm to make a future purchase of the input at today's price, even if the market price on the item has risen substantially in the interim.

Swaps are used to better match each firm's cash flows. Most swaps today involve either interest payments or currencies. Suppose Company F has a $100 million, 20-year, fixed-rate issue and Company S has a 20-year, $100 million floating-rate bond outstanding. If S has stable cash flows and wants to lock in its cost of debt, it would prefer a fixed-rate obligation. If F has cash flows that fluctuate with the economy, rising when the economy is strong and falling when it is weak, it would prefer a floating-rate obligation. The reason is that interest rates also move up and down with the economy, so F has concluded that it would be better off with variable-rate debt. Thus, by swapping debt instruments the firms better match their cash flows and thus reduce their risk.

L. What is corporate risk management? Why is it important to all firms?

Answer: [Show S18-26 through S18-29 here.] Corporate risk management relates to the management of unpredictable events that have adverse consequences for the firm. This function is very important to a firm since it involves reducing the consequences of risk to the point where there should be no significant adverse effects on the firm's financial position.

Appendix 18A
Valuation of Put Options

Answer to Question

18A-1 The put-call parity relationship is explained by the following equation:

Put option + Stock = Call option + PV of exercise price

Each side of the equation represents a portfolio. If these portfolios have identical payoffs, they must have identical values. This is known as the put-call parity relationship.

Solutions to Problems

18A-1 Put option = V – P + $Xe^{-r_{RF}t}$ where V = value of the call option.

V = \$18.99 r_{RF} = 5%
P = \$45 t = 9/12 = 0.75 year
X = \$30

Put option = \$18.99 – \$45 + $\$30e^{-(0.05)(0.75)}$
= \$18.99 – \$45 + \$30(0.9632)
= \$18.99 – \$45 + \$28.90
= \$2.89.

18A-2 Put option = V – P + $Xe^{-r_{RF}t}$ where V = value of the call option.

V = \$9.59 r_{RF} = 5.5%
P = \$50 t = 6/12 = 0.5 year
X = \$46

Put option = \$9.59 – \$50 + $\$46e^{-(0.055)(0.5)}$
= \$9.59 – \$50 + \$46(0.9729)
= \$9.59 – \$50 + \$44.75
= \$4.34.