OPTIONS AND CORPORATE FINANCE

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For many workers, from senior management on down, employee stock options have become a very important part of their overall compensation. In 2005, companies began to record an explicit expense for employee stock options on their income statements, which allows us to see how much employee stock options cost. For example, in 2005, Dell Computer expensed about $1.094 billion for employee stock options, which works out to about $17,000 per employee. In the same year, search engine provider Google expensed about $200 million worth of employee stock options, which amounts to about $35,000 per employee.

Employee stock options are just one kind of option. This chapter introduces you to options and explains their features and what determines their value. The chapter also shows you that options show up in many places in corporate finance. In fact, once you know what to look for, they show up just about everywhere, so understanding how they work is essential.

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Options are a part of everyday life. "Keep your options open" is sound business advice, and "We're out of options" is a sure sign of trouble. In finance, an **option** is an arrangement that gives its owner the right to buy or sell an asset at a fixed price any time on or before a given date. The most familiar options are stock options. These are options to buy and sell shares of common stock, and we will discuss them in some detail in the following pages.

Of course, stock options are not the only options. In fact, at the root of it, many different kinds of financial decisions amount to the evaluation of options. For example, we will show how understanding options adds several important details to the NPV analysis we have discussed in earlier chapters.

Also, virtually all corporate securities have implicit or explicit option features, and the use of such features is growing. As a result, understanding securities that possess option features requires general knowledge of the factors that determine an option's value.

This chapter starts with a description of different types of options. We identify and discuss the general factors that determine option values and show how ordinary debt and equity have optionlike characteristics. We then examine employee stock options and the important role of options in capital budgeting. We conclude by illustrating how option features are incorporated into corporate securities by discussing warrants, convertible bonds, and other optionlike securities.

option
A contract that gives its owner the right to buy or sell some asset at a fixed price on or before a given date.

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14.1 Options: The Basics

An option is a contract that gives its owner the right to buy or sell some asset at a fixed price on or before a given date. For example, an option on a building might give the holder of the option the right to buy the building for $1 million any time on or before the Saturday prior to the third Wednesday of January 2010.

Options are a unique type of financial contract because they give the buyer the right, but not the obligation, to do something. The buyer uses the option only if it is profitable to do so; otherwise, the option can be thrown away.

There is a special vocabulary associated with options. Here are some important definitions:

exercising the option
The act of buying or selling the underlying asset via the option contract.

strike price
The fixed price in the option contract at which the holder can buy or sell the underlying asset. Also, the exercise price or striking price.

expiration date
The last day on which an option may be exercised.

American option
An option that may be exercised at any time until its expiration date.

European option
An option that may be exercised only on the expiration date.

1. **Exercising the option**: The act of buying or selling the underlying asset via the option contract is called *exercising the option*.
2. **Strike price**, or exercise price: The fixed price specified in the option contract at which the holder can buy or sell the underlying asset is called the *strike price* or *exercise price*. The strike price is often called the *striking price*.
3. **Expiration date**: An option usually has a limited life. The option is said to expire at the end of its life. The last day on which the option may be exercised is called the *expiration date*.
4. **American** and **European options**: An American option may be exercised any time up to and including the expiration date. A European option may be exercised only on the expiration date.

PUTS AND CALLS

Options come in two basic types: puts and calls. A **call option** gives the owner the right to *buy* an asset at a fixed price during a particular time period. It may help you to remember that a call option gives you the right to "call in" an asset.

A **put option** is essentially the opposite of a call option. Instead of giving the holder the right to buy some asset, it gives the holder the right to *sell* that asset for a fixed exercise price. If you buy a put option, you can force the seller of the option to buy the asset from you for a fixed price and thereby "put it to them."

What about an investor who *sells* a call option? The seller receives money up front and has the *obligation* to sell the asset at the exercise price if the option holder wants it. Similarly, an investor who *sells* a put option receives cash up front and is then obligated to buy the asset at the exercise price if the option holder demands it.[1]

call option
The right to buy an asset at a fixed price during a particular period.

put option
The right to sell an asset at a fixed price during a particular period of time. The opposite of a call option.

The asset involved in an option can be anything. The options that are most widely bought and sold, however, are stock options. These are options to buy and sell shares of stock. Because these are the best-known types of options, we will study them first. As we discuss stock options, keep in mind that the general principles apply to options involving any asset, not just shares of stock.

STOCK OPTION QUOTATIONS

On April 26, 1973, the Chicago Board Options Exchange (CBOE) opened and began organized trading in stock options. Put and call options involving stock in some of the

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[1]An investor who sells an option is often said to have "written" the option.

best-known corporations in the United States are traded there. The CBOE is still the largest organized options market, but options are traded in a number of other places today, including the New York, American, and Philadelphia stock exchanges. Almost all such options are American (as opposed to European).

A simplified quotation for a CBOE option might look something like this:

Prices at Close June 15, 2005							
RWJ (*RWJ*)					**Underlying Stock Price: 100.00**		
		Call			**Put**		
Expiration	**Strike**	**Last**	**Volume**	**Open Interest**	**Last**	**Volume**	**Open Interest**
Jun	95	6	120	400	2	80	1,000
July	95	6.50	40	200	2.80	100	4,600
Aug	95	8	70	600	4	20	800

The first thing to notice here is the company identifier, RWJ. This tells us that these options involve the right to buy or sell shares of stock in the RWJ Corporation. To the right of the company identifier is the closing price on the stock. As of the close of business on the day before this quotation, RWJ was selling for $100 per share.

The first column in the table shows the expiration months (June, July, and August). All CBOE options expire following the third Friday of the expiration month. The next column shows the strike price. The RWJ options listed here have an exercise price of $95.

The next three columns give us information about call options. The first thing given is the most recent price (Last). Next we have volume, which tells us the number of option *contracts* that were traded that day. One option contract involves the right to buy (for a call option) or sell (for a put option) 100 shares of stock, and all trading actually takes place in contracts. Option prices, however, are quoted on a per-share basis.

The last piece of information given for the call options is the open interest. This is the number of contracts of each type currently outstanding. The three columns of information for call options (price, volume, and open interest) are followed by the same three columns for put options.

For example, the first option listed would be described as the "RWJ June 95 call." The price for this option is $6. If you pay the $6, then you have the right any time between now and the third Friday of June to buy one share of RWJ stock for $95. Because trading takes place in round lots (multiples of 100 shares), one option contract costs you $6 × 100 = $600.

The other quotations are similar. For example, the July 95 put option costs $2.80. If you pay $2.80 × 100 = $280, then you have the right to sell 100 shares of RWJ stock any time between now and the third Friday in July at a price of $95 per share.

Table 14.1 contains a more detailed CBOE quote reproduced from *The Wall Street Journal* (online). From our discussion in the preceding paragraphs, we know that these are Apple Computer (AAPL) options and that AAPL closed at 59.24 per share. Notice that there are multiple strike prices instead of just one. As shown, puts and calls with strike prices ranging from 45 up to 90 are available.

To check your understanding of option quotes, suppose you want the right to sell 100 shares of AAPL for $65 anytime up until the third Friday in June. What should you do and how much will it cost you?

Check out these options exchanges:
www.cboe.com
www.pacificex.com
www.phlx.com
www.kcbt.com
www.liffe.com
www.euronext.com

TABLE 14.1   A Sample *Wall Street Journal* (Online) Option Quotation

Apple Computer Inc. (AAPL)   PRINT   HELP

Last	Change	% Change	Volume	52-Week High	52-Week Low	06/09/06 NASDAQ NM
59.24	-1.52	-2.50%	27,712,815	86.40(01/12/06)	35.75(06/14/05)	04:00 p.m. EDT USD

Options Show all months

June 2006 Options: Expand | Hide   In The Money

		Calls				Strike Price			Puts			
Last	Chg	Bid	Ask	Volume	Open Int.		Last	Chg	Bid	Ask	Volume	Open Int.
14.30	-0.60	14.20	14.40	18	469	45.00	0.05	0.00		0.05	2	2
11.80	-1.20	11.70	11.90	12	436	47.50	0.05	0.00	0.05	0.05	10	25
9.30	-1.50	9.20	9.40	36	1,237	50.00	0.05	0.00	0.05	0.05	512	5,349
4.47	-1.53	4.40	4.50	807	2,168	55.00	0.15	+0.05	0.10	0.15	287	7,649
2.34	-1.36	2.30	2.40	2,244	3,797	57.50	0.55	+0.25	0.50	0.55	2,084	10,724
				LAST TRADE		**59.24**	as of 6/9/2006					
0.94	-0.91	0.90	1.00	14,830	26,156	60.00	1.55	+0.65	1.55	1.70	5,073	21,294
0.30	-0.40	0.30	0.35	14,737	20,221	62.50	3.54	+1.29	3.40	3.60	1,372	11,811
0.10	-0.15	0.05	0.10	1,952	30,406	65.00	5.80	+1.20	5.70	5.90	1,309	11,097
0.05	-0.05	0.05	0.05	865	19,672	67.50	7.85	+1.15	8.10	8.40	257	6,232
0.05	0.00	0.05	0.05	21	19,446	70.00	10.00	+0.70	10.60	10.90	36	1,531
0.05	0.00	0.05	0.05	30	9,899	72.50	13.60	0.00	13.10	13.40	11	979
0.05	0.00	0.05	0.05	36	8,324	75.00	16.20	0.00	15.60	15.90	6,004	1,578
0.05	0.00	0.05	0.05	2	3,736	80.00	19.80	0.00	20.60	20.90	2	21
0.05	0.00	0.05	0.05	5	1,272	85.00	25.40	0.00	25.60	25.90	24	1
0.05	0.00	0.05	0.05	2	161	90.00	25.72	0.00	30.60	30.90	1	1

Because you want the right to sell the stock for $65, you need to buy a *put* option with a $65 exercise price. So you go online and place an order for one AAPL June 65 put contract. Because the June 65 put is quoted at $5.90 you will have to pay $5.90 per share, or $590 in all (plus commission).

Of course, you can look up option prices many places on the Web. To do so, however, you have to know the relevant ticker symbol. The option ticker symbols are a bit more complicated than stock tickers, so our nearby *Work the Web* box shows you how to get them along with the associated option price quotes.

How do you find option prices for options that are currently traded? To find out, we went to finance.yahoo.com, got a stock quote for JCPenney (JCP), and followed the Options link. As you can see below, there were 11 call option contracts and 11 put option contracts trading for JCPenney with a January 2008 expiration date.

View By Expiration: <u>Jun 06</u> | <u>Jul 06</u> | <u>Aug 06</u> | <u>Nov 06</u> | <u>Jan 07</u> | **Jan 08**

CALL OPTIONS   Expire at close Fri, Jan 18, 2008

Strike	Symbol	Last	Chg	Bid	Ask	Vol	Open Int
30.00	YMJAF.X	**32.10**	**0.00**	35.80	36.20	0	289
35.00	YMJAG.X	**25.90**	**0.00**	31.60	32.30	0	196
40.00	YMJAH.X	**26.90**	**0.00**	27.50	27.90	1	187
45.00	YMJAI.X	**21.70**	**0.00**	23.60	24.00	10	107
50.00	YMJAJ.X	**16.10**	**0.00**	19.90	20.30	14	134
55.00	YMJAK.X	**13.00**	**0.00**	16.60	17.00	14	162
60.00	YMJAL.X	**13.70**	**0.00**	13.50	13.90	15	559
65.00	YMJAM.X	**11.30**	**0.00**	10.80	11.20	15	1,279
70.00	YMJAN.X	**8.50**	**0.00**	8.50	8.90	20	489
75.00	YMJAO.X	**7.20**	**0.00**	6.50	6.90	1	507
80.00	YMJAP.X	**5.70**	**0.00**	4.90	5.20	1	232

PUT OPTIONS   Expire at close Fri, Jan 18, 2008

Strike	Symbol	Last	Chg	Bid	Ask	Vol	Open Int
30.00	YMJMF.X	**0.50**	**0.00**	0.45	0.55	0	48
35.00	YMJMG.X	**0.75**	**0.00**	0.75	0.95	15	141
40.00	YMJMH.X	**1.70**	**0.00**	1.25	1.45	5	213
45.00	YMJMI.X	**2.05**	**0.00**	1.95	2.20	50	365
50.00	YMJMJ.X	**2.80**	**0.00**	2.90	3.20	1	340
55.00	YMJMK.X	**5.20**	**0.00**	4.10	4.50	2	573
60.00	YMJML.X	**5.70**	**0.00**	5.80	6.20	2	347
65.00	YMJMM.X	**7.90**	**0.00**	7.90	8.30	30	559
70.00	YMJMN.X	**10.20**	**0.00**	10.40	10.80	20	146
75.00	YMJMO.X	**13.40**	**0.00**	13.40	13.80	10	146
80.00	YMJMP.X	**17.60**	**0.00**	16.90	17.30	41	41

Highlighted options are in the money.

(continued)

The Chicago Board Options Exchange (CBOE) sets the strike prices for traded options. The strike prices are centered around the current stock price, and the number of strike prices depends in part on the trading volume in the stock. If you examine the prices for the call options, you see that the quotes behave as you might expect. As the strike price of the call option increases, the option contract becomes less valuable. Examining the call option prices, we see that the $60 strike call option has a higher last trade price than the $55 strike call option. How is this possible? As you can see, the option contracts for JCPenney with a January 2008 expiration have not been very active. The prices for these two options never existed at the same point in time. You should also note that all of the options have a price divisible by $0.05. The reason is that options traded on the exchange have a five-cent "tick" size (the tick size is the minimum price increment). This means that any change in price is a minimum of five cents. So while you can price an option to the penny, you just can't trade on the "Penney."

OPTION PAYOFFS

Looking at Table 14.1, suppose you buy 50 June 60 call contracts. The option is quoted at $1, so the contracts cost $100 each. You spend a total of $50 \times \$100 = \$5,000$. You wait a while, and the expiration date rolls around.

Now what? You have the right to buy AAPL stock for $60 per share. If AAPL is selling for less than $60 a share, then this option isn't worth anything, and you throw it away. In this case, we say that the option has finished "out of the money" because the stock price is less than the exercise price. Your $5,000 is, alas, a complete loss.

If AAPL is selling for more than $60 per share, then you need to exercise your option. In this case, the option is "in the money" because the stock price exceeds the exercise price. Suppose AAPL has risen to, say, $64 per share. Because you have the right to buy AAPL at $60, you make a $4 profit on each share upon exercise. Each contract involves 100 shares, so you make $4 per share $\times$ 100 shares per contract = $400 per contract. Finally, you own 50 contracts, so the value of your options is a handsome $20,000. Notice that because you invested $5,000, your net profit is $15,000.

As our example indicates, the gains and losses from buying call options can be quite large. To illustrate further, suppose you simply purchase the stock with the $5,000 instead of buying call options. In this case, you will have about $5,000/59.24 = 84.40 shares. We can now compare what you have when the option expires for different stock prices:

Ending Stock Price	Option Value (50 contracts)	Net Profit or Loss (50 contracts)	Stock Value (84.40 shares)	Net Profit or Loss (84.40 shares)
$40	0	−$5,000	3,376	−1,624
50	0	−5,000	4,220	−780
60	0	−5,000	5,064	64
70	4,000	5,000	5,908	908
80	4,000	15,000	6,752	1,752
90	4,000	25,000	7,596	2,596

The option position clearly magnifies the gains and losses on the stock by a substantial amount. The reason is that the payoff on your 50 option contracts is based on $50 \times 100 = 5,000$ shares of stock instead of just 84.40.

In our example, notice that, if the stock price ends up below the exercise price, then you lose all $5,000 with the option. With the stock, you still have about what you started with. Also notice that the option can never be worth less than zero because you can always just throw it away. As a result, you can never lose more than your original investment (the $5,000 in our example).

It is important to recognize that stock options are a zero-sum game. By this we mean that whatever the buyer of a stock option makes, the seller loses, and vice versa. To illustrate, suppose, in our example just preceding, you *sell* 50 option contracts. You receive $5,000 up front, and you will be obligated to sell the stock for $60 if the buyer of the option wishes to exercise it. In this situation, if the stock price ends up below $60, you will be $5,000 ahead. If the stock price ends up above $60, you will have to sell something for less than it is worth, so you will lose the difference. For example, if the stock price is $80, you will have to sell 50 × 100 = 5,000 shares at $60 per share, so you will be out $80 − 60 = $20 per share, or $100,000 total. Because you received $5,000 up front, your net loss is $95,000. We can summarize some other possibilities as follows:

Ending Stock Price	Net Profit to Option Seller
$40	$5,000
50	5,000
60	5,000
70	−5,000
80	−15,000
90	−25,000

Notice that the net profits to the option buyer (calculated previously) are just the opposites of these amounts.

Put Payoffs | EXAMPLE 14.1

Looking at Table 14.1, suppose you buy 10 AAPL June 62.50 put contracts. How much does this cost (ignoring commissions)? Just before the option expires, AAPL is selling for $52.50 per share. Is this good news or bad news? What is your net profit?

The option is quoted at 3.60, so one contract costs 100 × 3.60 = $360. Your 10 contracts total $3,600. You now have the right to sell 1,000 shares of AAPL for $62.50 per share. If the stock is currently selling for $52.50 per share, then this is most definitely good news. You can buy 1,000 shares at $52.50 and sell them for $62.50. Your puts are thus worth $62.50 − 52.50 = $10 per share, or $10 × 1,000 = $10,000 in all. Because you paid $3,600 your net profit is $10,000 − 3,600 = $6,400.

Concept Questions

14.1a What is a call option? A put option?

14.1b If you thought that a stock was going to drop sharply in value, how might you use stock options to profit from the decline?

14.2 Fundamentals of Option Valuation

Now that we understand the basics of puts and calls, we can discuss what determines their values. We will focus on call options in the discussion that follows, but the same type of analysis can be applied to put options.

VALUE OF A CALL OPTION AT EXPIRATION

We have already described the payoffs from call options for different stock prices. In continuing this discussion, the following notation will be useful:

S_1 = Stock price at expiration (in one period)

S_0 = Stock price today

C_1 = Value of the call option on the expiration date (in one period)

C_0 = Value of the call option today

E = Exercise price on the option

From our previous discussion, remember that, if the stock price (S_1) ends up below the exercise price (E) on the expiration date, then the call option (C_1) is worth zero. In other words:

$$C_1 = 0 \quad \text{if } S_1 \leq E$$

Or, equivalently:

$$C_1 = 0 \quad \text{if } S_1 - E \leq 0 \qquad \qquad \text{[14.1]}$$

This is the case in which the option is out of the money when it expires.

If the option finishes in the money, then $S_1 > E$, and the value of the option at expiration is equal to the difference:

$$C_1 = S_1 - E \quad \text{if } S_1 > E$$

Or, equivalently:

$$C_1 = S_1 - E \quad \text{if } S_1 - E > 0 \qquad \qquad \text{[14.2]}$$

For example, suppose we have a call option with an exercise price of $10. The option is about to expire. If the stock is selling for $8, then we have the right to pay $10 for something worth only $8. Our option is thus worth exactly zero because the stock price is less than the exercise price on the option ($S_1 \leq E$). If the stock is selling for $12, then the option has value. Because we can buy the stock for $10, the option is worth $S_1 - E = \$12 - 10 = \$2$.

Figure 14.1 plots the value of a call option at expiration against the stock price. The result looks something like a hockey stick. Notice that for every stock price less than E, the value of the option is zero. For every stock price greater than E, the value of the call option is $S_1 - E$. Also, once the stock price exceeds the exercise price, the option's value goes up dollar for dollar with the stock price.

THE UPPER AND LOWER BOUNDS ON A CALL OPTION'S VALUE

Now that we know how to determine C_1, the value of the call at expiration, we turn to a somewhat more challenging question: How can we determine C_0, the value sometime *before* expiration? We will be discussing this in the next several sections. For now, we will establish the upper and lower bounds for the value of a call option.

As shown, the value of a call option at expiration is equal to zero if the stock price is less than or equal to the exercise price. The value of the call is equal to the stock price minus the exercise price ($S_1 - E$) if the stock price exceeds the exercise price. The resulting "hockey stick" shape is highlighted.
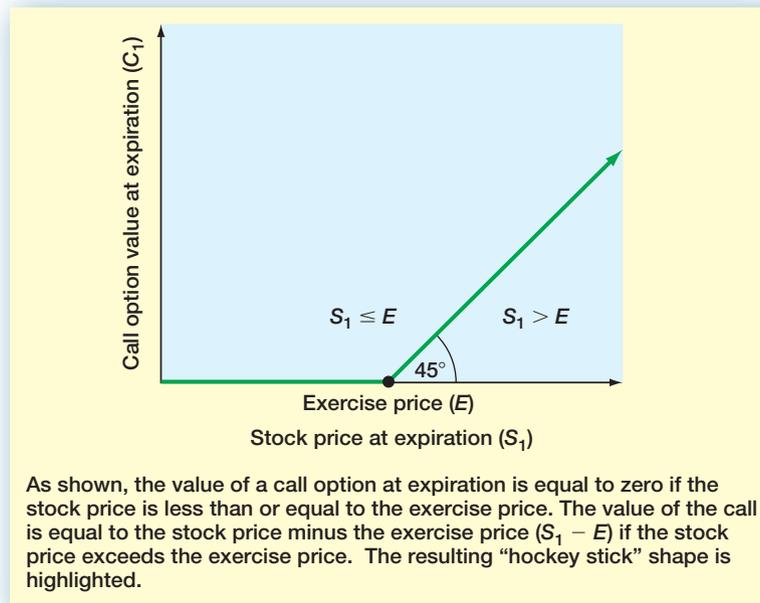
The Upper Bound   What is the most a call option can sell for? If you think about it, the answer is obvious. A call option gives you the right to buy a share of stock, so it can never be worth more than the stock itself. This tells us the upper bound on a call's value: A call option will always sell for no more than the underlying asset. So, in our notation, the upper bound is:

$$C_0 \leq S_0 \qquad\qquad\qquad\qquad\qquad\qquad\text{[14.3]}$$

The Lower Bound   What is the least a call option can sell for? The answer here is a little less obvious. First of all, the call can't sell for less than zero, so $C_0 \geq 0$. Furthermore, if the stock price is greater than the exercise price, the call option is worth at least $S_0 - E$.

To see why, suppose we have a call option selling for $4. The stock price is $10, and the exercise price is $5. Is there a profit opportunity here? The answer is yes because you could buy the call for $4 and immediately exercise it by spending an additional $5. Your total cost of acquiring the stock would be $4 + 5 = $9. If you were to turn around and immediately sell the stock for $10, you would pocket a $1 certain profit.

Opportunities for riskless profits such as this one are called *arbitrages* (say "are-bi-trazh," with the accent on the first syllable) or *arbitrage opportunities*. One who arbitrages is called an *arbitrageur*, or just "arb" for short. The root for the term *arbitrage* is the same as the root for the word *arbitrate*, and an arbitrageur essentially arbitrates prices. In a well-organized market, significant arbitrages will, of course, be rare.

In the case of a call option, to prevent arbitrage, the value of the call today must be greater than the stock price less the exercise price:

$$C_0 \geq S_0 - E$$

If we put our two conditions together, we have:

$$\begin{aligned} C_0 &\geq 0 & &\text{if } S_0 - E < 0 \\ C_0 &\geq S_0 - E & &\text{if } S_0 - E \geq 0 \end{aligned} \qquad\qquad\qquad\text{[14.4]}$$

FIGURE 14.2

Value of a Call Option before Expiration for Different Stock Prices

As shown, the upper bound on a call's value is given by the value of the stock ($C_0 \leq S_0$). The lower bound is either $S_0 - E$ or zero, whichever is larger. The highlighted curve illustrates the value of a call option prior to maturity for different stock prices.
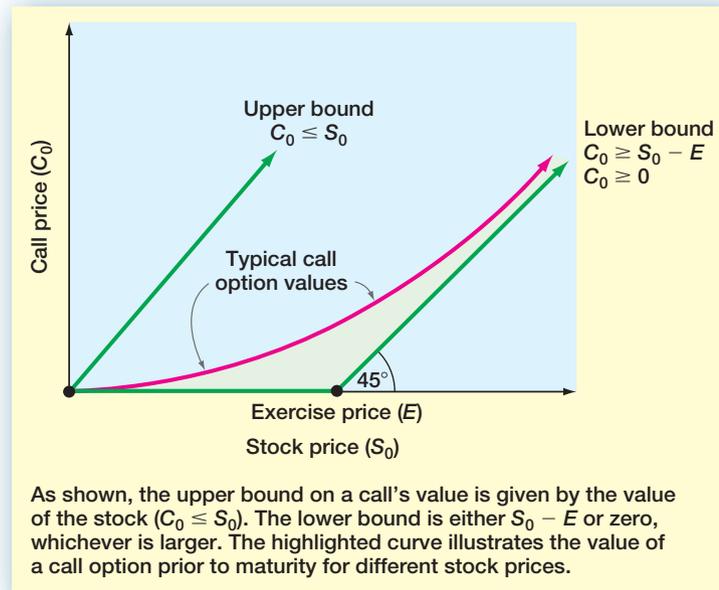
These conditions simply say that the lower bound on the call's value is either zero or $S_0 - E$, whichever is bigger.

Our lower bound is called the **intrinsic value** of the option, and it is simply what the option would be worth if it were about to expire. With this definition, our discussion thus far can be restated as follows: At expiration, an option is worth its intrinsic value; it will generally be worth more than that anytime before expiration.

Figure 14.2 displays the upper and lower bounds on the value of a call option. Also plotted is a curve representing typical call option values for different stock prices prior to maturity. The exact shape and location of this curve depend on a number of factors. We begin our discussion of these factors in the next section.

intrinsic value

The lower bound of an option's value, or what the option would be worth if it were about to expire.

A SIMPLE MODEL: PART I

Option pricing can be a complex subject, and we defer a detailed discussion to a later chapter. Fortunately, as is often the case, many of the key insights can be illustrated with a simple example. Suppose we are looking at a call option with one year to expiration and an exercise price of $105. The stock currently sells for $100, and the risk-free rate, R_f, is 20 percent.

The value of the stock in one year is uncertain, of course. To keep things simple, suppose we know that the stock price will be either $110 or $130. It is important to note that we *don't* know the odds associated with these two prices. In other words, we know the possible values for the stock, but not the probabilities associated with those values.

Because the exercise price on the option is $105, we know that the option will be worth either $110 − 105 = $5 or $130 − 105 = $25; but, once again, we don't know which. We do know one thing, however: Our call option is certain to finish in the money.

The Basic Approach   Here is the crucial observation: It is possible to exactly duplicate the payoffs on the stock using a combination of the option and the risk-free asset.

How? Do the following: Buy one call option and invest $87.50 in a risk-free asset (such as a T-bill).

What will you have in a year? Your risk-free asset will earn 20 percent, so it will be worth $87.50 × 1.20 = $105. Your option will be worth $5 or $25, so the total value will be either $110 or $130, just like the value of the stock:

Stock Value	vs.	Risk-Free Asset Value	+	Call Value	=	Total Value
$110		$105		$ 5		$110
130		105		25		130

As illustrated, these two strategies—buying a share of stock or buying a call and investing in the risk-free asset—have exactly the same payoffs in the future.

Because these two strategies have the same future payoffs, they must have the same value today or else there would be an arbitrage opportunity. The stock sells for $100 today, so the value of the call option today, C_0, is:

$$\$100 = \$87.50 + C_0$$
$$C_0 = \$12.50$$

Where did we get the $87.50? This is just the present value of the exercise price on the option, calculated at the risk-free rate:

$$E/(1 + R_f) = \$105/1.20 = \$87.50$$

Given this, our example shows that the value of a call option in this simple case is given by:

$$S_0 = C_0 + E/(1 + R_f)$$
$$C_0 = S_0 - E/(1 + R_f)$$

[14.5]

In words, the value of the call option is equal to the stock price minus the present value of the exercise price.

A More Complicated Case   Obviously, our assumption that the stock price in one year will be either $110 or $130 is a vast oversimplification. We can now develop a more realistic model by assuming that the stock price in one year can be *anything* greater than or equal to the exercise price. Once again, we don't know how likely the different possibilities are, but we are certain that the option will finish somewhere in the money.

We again let S_1 stand for the stock price in one year. Now consider our strategy of investing $87.50 in a riskless asset and buying one call option. The riskless asset will again be worth $105 in one year, and the option will be worth $S_1 - \$105$, the value of which will depend on what the stock price is.

When we investigate the combined value of the option and the riskless asset, we observe something very interesting:

$$\text{Combined value} = \text{Riskless asset value} + \text{Option value}$$
$$= \$105 + (S_1 - 105)$$
$$= S_1$$

Just as we had before, buying a share of stock has exactly the same payoff as buying a call option and investing the present value of the exercise price in the riskless asset.

Once again, to prevent arbitrage, these two strategies must have the same cost, so the value of the call option is equal to the stock price less the present value of the exercise price:[2]

$$C_0 = S_0 - E/(1 + R_f)$$

Our conclusion from this discussion is that determining the value of a call option is not difficult as long as we are certain that the option will finish somewhere in the money.

FOUR FACTORS DETERMINING OPTION VALUES

For information about options and the underlying companies, see www.optionsnewsletter.com.

If we continue to suppose that our option is certain to finish in the money, then we can readily identify four factors that determine an option's value. There is a fifth factor that comes into play if the option can finish out of the money. We will discuss this last factor in the next section.

For now, if we assume that the option expires in t periods, then the present value of the exercise price is $E/(1 + R_f)^t$, and the value of the call is:

Call option value = Stock value − Present value of the exercise price

$$C_0 = S_0 - E/(1 + R_f)^t$$ [14.6]

If we take a look at this expression, we see that the value of the call obviously depends on four things:

1. *The stock price:* The higher the stock price (S_0) is, the more the call is worth. This comes as no surprise because the option gives us the right to buy the stock at a fixed price.
2. *The exercise price:* The higher the exercise price (E) is, the less the call is worth. This is also not a surprise because the exercise price is what we have to pay to get the stock.
3. *The time to expiration:* The longer the time to expiration is (the bigger t is), the more the option is worth. Once again, this is obvious. Because the option gives us the right to buy for a fixed length of time, its value goes up as that length of time increases.
4. *The risk-free rate:* The higher the risk-free rate (R_f) is, the more the call is worth. This result is a little less obvious. Normally, we think of asset values as going down as rates rise. In this case, the exercise price is a cash *outflow,* a liability. The current value of that liability goes down as the discount rate goes up.

Concept Questions

14.2a What is the value of a call option at expiration?

14.2b What are the upper and lower bounds on the value of a call option anytime before expiration?

14.2c Assuming that the stock price is certain to be greater than the exercise price on a call option, what is the value of the call? Why?

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[2]You're probably wondering what would happen if the stock price were less than the present value of the exercise price, which would result in a negative value for the call option. This can't happen because we are certain that the stock price will be at least E in one year because we know the option will finish in the money. If the current price of the stock is less than $E/(1 + R_f)$, then the return on the stock is certain to be greater than the risk-free rate, which creates an arbitrage opportunity. For example, if the stock is currently selling for $80, then the minimum return will be ($105 − 80)/80 = 31.25\%$. Because we can borrow at 20 percent, we can earn a certain minimum return of 11.25 percent per dollar borrowed. This, of course, is an arbitrage opportunity.

Valuing a Call Option

14.3

We now investigate the value of a call option when there is the possibility that the option will finish out of the money. We will again examine the simple case of two possible future stock prices. This case will let us identify the remaining factor that determines an option's value.

A SIMPLE MODEL: PART II

From our previous example, we have a stock that currently sells for $100. It will be worth either $110 or $130 in a year, and we don't know which. The risk-free rate is 20 percent. We are now looking at a different call option, however. This one has an exercise price of $120 instead of $105. What is the value of this call option?

The Philadelphia Stock Exchange has a good discussion of options: www.phlx.com/products.

This case is a little harder. If the stock ends up at $110, the option is out of the money and worth nothing. If the stock ends up at $130, the option is worth $130 − 120 = $10.

Our basic approach to determining the value of the call option will be the same. We will show once again that it is possible to combine the call option and a risk-free investment in a way that exactly duplicates the payoff from holding the stock. The only complication is that it's a little harder to determine how to do it.

For example, suppose we bought one call and invested the present value of the exercise price in a riskless asset as we did before. In one year, we would have $120 from the riskless investment plus an option worth either zero or $10. The total value would be either $120 or $130. This is not the same as the value of the stock ($110 or $130), so the two strategies are not comparable.

Instead, consider investing the present value of $110 (the lower stock price) in a riskless asset. This guarantees us a $110 payoff. If the stock price is $110, then any call options we own are worthless, and we have exactly $110 as desired.

When the stock is worth $130, the call option is worth $10. Our risk-free investment is worth $110, so we are $130 − 110 = $20 short. Because each call option is worth $10, we need to buy two of them to replicate the value of the stock.

Thus, in this case, investing the present value of the lower stock price in a riskless asset and buying two call options exactly duplicates owning the stock. When the stock is worth $110, we have $110 from our risk-free investment. When the stock is worth $130, we have $110 from the risk-free investment plus two call options worth $10 each.

Because these two strategies have exactly the same value in the future, they must have the same value today, or arbitrage would be possible:

$$S_0 = \$100 = 2 \times C_0 + \$110/(1 + R_f)$$
$$2 \times C_0 = \$100 - 110/1.20$$
$$C_0 = \$4.17$$

Each call option is thus worth $4.17.

Don't Call Us, We'll Call You	**EXAMPLE 14.2**

We are looking at two call options on the same stock, one with an exercise price of $20 and one with an exercise price of $30. The stock currently sells for $35. Its future price will be either $25 or $50. If the risk-free rate is 10 percent, what are the values of these call options?

(continued)

The first case (with the $20 exercise price) is not difficult because the option is sure to finish in the money. We know that the value is equal to the stock price less the present value of the exercise price:

$$C_0 = S_0 - E/(1 + R_f)$$
$$= \$35 - 20/1.1$$
$$= \$16.82$$

In the second case, the exercise price is $30, so the option can finish out of the money. At expiration, the option is worth $0 if the stock is worth $25. The option is worth $50 − 30 = $20 if it finishes in the money.

As before, we start by investing the present value of the lowest stock price in the risk-free asset. This costs $25/1.1 = $22.73. At expiration, we have $25 from this investment.

If the stock price is $50, then we need an additional $25 to duplicate the stock payoff. Because each option is worth $20 in this case, we need $25/20 = 1.25 options. So, to prevent arbitrage, investing the present value of $25 in a risk-free asset and buying 1.25 call options must have the same value as the stock:

$$S_0 = 1.25 \times C_0 + \$25/(1 + R_f)$$
$$\$35 = 1.25 \times C_0 + \$25/(1 + .10)$$
$$C_0 = \$9.82$$

Notice that this second option had to be worth less because it has the higher exercise price.

THE FIFTH FACTOR

We now illustrate the fifth (and last) factor that determines an option's value. Suppose everything in our example is the same as before except that the stock price can be $105 or $135 instead of $110 or $130. Notice that the effect of this change is to make the stock's future price more volatile than before.

We investigate the same strategy that we used previously: Invest the present value of the lowest stock price ($105 in this case) in the risk-free asset and buy two call options. If the stock price is $105, then, as before, the call options have no value and we have $105 in all.

If the stock price is $135, then each option is worth $S_1 - E = \$135 - 120 = \$15$. We have two calls, so our portfolio is worth $105 + 2 \times 15 = \$135$. Once again, we have exactly replicated the value of the stock.

What has happened to the option's value? More to the point, the variance of the return on the stock has increased. Does the option's value go up or down? To find out, we need to solve for the value of the call just as we did before:

$$S_0 = \$100 = 2 \times C_0 + \$105/(1 + R_f)$$
$$2 \times C_0 = \$100 - 105/1.20$$
$$C_0 = \$6.25$$

The value of the call option has gone up from $4.17 to $6.25.

Based on our example, the fifth and final factor that determines an option's value is the variance of the return on the underlying asset. Furthermore, the *greater* that variance is, the *more* the option is worth. This result appears a little odd at first, and it may be somewhat surprising to learn that increasing the risk (as measured by return variance) on the underlying asset increases the value of the option.

The reason that increasing the variance on the underlying asset increases the value of the option isn't hard to see in our example. Changing the lower stock price to $105 from $110 doesn't hurt a bit because the option is worth zero in either case. However, moving the upper possible price to $135 from $130 makes the option worth more when it is in the money.

More generally, increasing the variance of the possible future prices on the underlying asset doesn't affect the option's value when the option finishes out of the money. The value is always zero in this case. On the other hand, increasing that variance increases the possible payoffs when the option is in the money, so the net effect is to increase the option's value. Put another way, because the downside risk is always limited, the only effect is to increase the upside potential.

In later discussion, we will use the usual symbol, σ^2, to stand for the variance of the return on the underlying asset.

A CLOSER LOOK

Before moving on, it will be useful to consider one last example. Suppose the stock price is $100, and it will move either up or down by 20 percent. The risk-free rate is 5 percent. What is the value of a call option with a $90 exercise price?

The stock price will be either $80 or $120. The option is worth zero when the stock is worth $80, and it's worth $120 − 90 = $30 when the stock is worth $120. We will therefore invest the present value of $80 in the risk-free asset and buy some call options.

When the stock finishes at $120, our risk-free asset pays $80, leaving us $40 short. Each option is worth $30 in this case, so we need $40/30 = 4/3 options to match the payoff on the stock. The option's value must thus be given by:

$$S_0 = \$100 = 4/3 \times C_0 + \$80/1.05$$
$$C_0 = (3/4) \times (\$100 - 76.19)$$
$$\quad = \$17.86$$

To make our result a little bit more general, notice that the number of options that you need to buy to replicate the value of the stock is always equal to $\Delta S/\Delta C$, where ΔS is the difference in the possible stock prices and ΔC is the difference in the possible option values. In our current case, for example, ΔS would be $120 − 80 = $40 and ΔC would be $30 − 0 = $30, so $\Delta S/\Delta C$ would be $40/30 = 4/3$, as we calculated.

Notice also that when the stock is certain to finish in the money, $\Delta S/\Delta C$ is always exactly equal to 1, so one call option is always needed. Otherwise, $\Delta S/\Delta C$ is greater than 1, so more than one call option is needed.

This concludes our discussion of option valuation. The most important thing to remember is that the value of an option depends on five factors. Table 14.2 summarizes these factors and the direction of their influence for both puts and calls. In Table 14.2, the sign in parentheses indicates the direction of the influence.[3] In other words, the sign tells us whether the value of the option goes up or down when the value of a factor increases. For example, notice that increasing the exercise price reduces the value of a call option. Increasing any of the other four factors increases the value of the call. Notice also that the time to expiration and the variance of return act the same for puts and calls. The other three factors have opposite signs in the two cases.

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[3]The signs in Table 14.2 are for American options. For a European put option, the effect of increasing the time to expiration is ambiguous, and the direction of the influence can be positive or negative.

TABLE 14.2

Five Factors That Determine Option Values

	Direction of Influence	
Factor	**Calls**	**Puts**
Current value of the underlying asset	(+)	(−)
Exercise price on the option	(−)	(+)
Time to expiration on the option	(+)	(+)
Risk-free rate	(+)	(−)
Variance of return on the underlying asset	(+)	(+)

We have not considered how to value a call option when the option can finish out of the money and the stock price can take on more than two values. A very famous result, the Black–Scholes option pricing model, is needed in this case. We cover this subject in a later chapter.

Concept Questions

14.3a What are the five factors that determine an option's value?

14.3b What is the effect of an increase in each of the five factors on the value of a call option? Give an intuitive explanation for your answer.

14.3c What is the effect of an increase in each of the five factors on the value of a put option? Give an intuitive explanation for your answer.

14.4 Employee Stock Options

Options are important in corporate finance in a lot of different ways. In this section, we begin to examine some of these by taking a look at **employee stock options**, or ESOs. An ESO is, in essence, a call option that a firm gives to employees giving them the right to buy shares of stock in the company. The practice of granting options to employees has become widespread. It is almost universal for upper management; but some companies, like The Gap and Starbucks, grant options to almost every employee. Thus, an understanding of ESOs is important. Why? Because you may soon be an ESO holder!

employee stock option (ESO)
An option granted to an employee by a company giving the employee the right to buy shares of stock in the company at a fixed price for a fixed time.

ESO FEATURES

Because ESOs are basically call options, we have already covered most of the important aspects. However, ESOs have a few features that make them different from regular stock options. The details differ from company to company, but a typical ESO has a 10-year life, which is much longer than most ordinary options. Unlike traded options, ESOs cannot be sold. They also have what is known as a "vesting" period: Often, for up to three years or so, an ESO cannot be exercised and also must be forfeited if an employee leaves the company. After this period, the options "vest," which means they can be exercised. Sometimes, employees who resign with vested options are given a limited time to exercise their options.

Why are ESOs granted? There are basically two reasons. First, going back to Chapter 1, the owners of a corporation (the shareholders) face the basic problem of aligning shareholder and management interests and also of providing incentives for employees to focus on corporate goals. ESOs are a powerful motivator because, as we have seen, the payoffs on options can be very large. High-level executives in particular stand to gain enormous wealth if they are successful in creating value for stockholders.

The second reason some companies rely heavily on ESOs is that an ESO has no immediate, up-front, out-of-pocket cost to the corporation. In smaller, possibly cash-strapped

See www. esopassociation.org *for a site devoted to employee stock options.*

companies, ESOs are simply a substitute for ordinary wages. Employees are willing to accept them instead of cash, hoping for big payoffs in the future. In fact, ESOs are a major recruiting tool, allowing businesses to attract talent that they otherwise could not afford.

ESO REPRICING

ESOs are almost always "at the money" when they are issued, meaning that the stock price is equal to the strike price. Notice that, in this case, the intrinsic value is zero, so there is no value from immediate exercise. Of course, even though the intrinsic value is zero, an ESO is still quite valuable because of, among other things, its very long life.

If the stock falls significantly after an ESO is granted, then the option is said to be "underwater." On occasion, a company will decide to lower the strike price on underwater options. Such options are said to be "restruck" or "repriced."

The practice of repricing ESOs is controversial. Companies that do it argue that once an ESO becomes deeply out of the money, it loses its incentive value because employees recognize there is only a small chance that the option will finish in the money. In fact, employees may leave and join other companies where they receive a fresh options grant.

For an employee stock option calculator, visit www.stockoptions.com.

For example, Cosi, the sandwich shop chain, repriced more than 800,000 options for top executives in early 2004. The biggest winner in the repricing appeared to be cofounder and VP Jay Wainwright. The exercise price on the 360,521 options he held dropped to $2.26 a share. The original strike prices ranged from $5.30 to $12.25. In defense of the repricing, Cosi stated that its goal was to motivate employees as part of a turnaround effort.

Critics of repricing point out that a lowered strike price is, in essence, a reward for failing. They also point out that if employees know that options will be repriced, then much of the incentive effect is lost. Because of this controversy, many companies do not reprice options or have voted against repricing. For example, pharmaceutical giant Bristol-Myers Squibb's explicit policy prohibiting option repricing states, "It is the board of directors' policy that the company will not, without stockholder approval, amend any employee or nonemployee director stock option to reduce the exercise price (except for appropriate adjustment in the case of a stock split or similar change in capitalization)." However, other equally well-known companies have no such policy, and some have been labeled "serial repricers." The accusation is that such companies routinely drop strike prices following stock price declines.

For more information about ESOs, try the National Center for Employee Ownership at www.nceo.org.

Today, many companies award options on a regular basis, perhaps annually or even quarterly. That way, an employee will always have at least some options that are near the money even if others are underwater. Also, regular grants ensure that employees always have unvested options, which gives them an added incentive to stay with their current employer rather than forfeit the potentially valuable options.

ESO BACKDATING

A scandal erupted in 2006 over the backdating of ESOs. Recall that ESOs are almost always at the money on the grant date, meaning that the strike price is set equal to the stock price on the grant date. Financial researchers discovered that many companies had a practice of looking backward in time to select the grant date. Why did they do this? The answer is that they would pick a date on which the stock price (looking back) was low, thereby leading to option grants with low strike prices relative to the current stock price.

Backdating ESOs is not necessarily illegal or unethical as long as there is full disclosure and various tax and accounting issues are handled properly. Before the Sarbanes–Oxley Act of 2002 (which we discussed in Chapter 1), companies had up to 45 days after the end of their fiscal years to report options grants, so there was ample leeway for backdating. Because of Sarbanes–Oxley, companies are now required to report option grants within two business days of the grant dates, thereby limiting the gains from any backdating.

Erik Lie on Option Backdating

Stock options can be granted to executive and other employees as an incentive device. They strengthen the relation between compensation and a firm's stock price performance, thus boosting effort and improving decision making within the firm. Further, to the extent that decision makers are risk averse (as most of us are), options induce more risk taking, which can benefit shareholders. However, options also have a dark side. They can be used to (i) conceal true compensation expenses in financial reports, (ii) evade corporate taxes, and (iii) siphon money from corporations to executives. One example that illustrates all three of these aspects is that of option backdating.

To understand the virtue of option backdating, it is first important to realize that for accounting, tax, and incentive reasons, most options are granted at-the-money, meaning that their exercise price equals the stock price on the grant date. Option backdating is the practice of selecting a past date (e.g., from the past month) when the stock price was particularly low to be the official grant date. This raises the value of the options, because they are effectively granted in-the-money. Unless this is properly disclosed and accounted for (which it rarely is), the practice of backdating can cause an array of problems. First, granting options that are effectively in-the-money violates many corporate option plans or other securities filings stating that the exercise price equals the fair market value on the grant day. Second, camouflaging in-the-money options as at-the-money options understates compensation expenses in the financial statements. In fact, under the old accounting rule APB 25 that was phased out in 2005, companies could expense options according to their intrinsic value, such that at-the-money options were not expensed at all. Third, at-the-money option grants qualify for certain tax breaks that in-the-money option grants do not qualify for, such that backdating can result in underpaid taxes.

Empirical evidence shows that the practice of backdating was prevalent from the early 1990s to 2005, especially among tech firms. As this came to the attention of the media and regulators in 2006, a scandal erupted. More than 100 companies were investigated for manipulation of option grant dates. As a result, numerous executives were fired, old financial statements were restated, additional taxes became due, and countless law suits were filed against companies and their directors. With new disclosure rules, stricter enforcement of the requirement that took effect as part of the Sarbanes-Oxley Act in 2002 that grants have to be filed within two business days, and greater scrutiny by regulators and the investment community, we likely have put the practice of backdating options behind us.

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Concept Questions

14.4a What are the key differences between a traded stock option and an ESO?

14.4b What is ESO repricing? Why is it controversial?

14.5 Equity as a Call Option on the Firm's Assets

Now that we understand the basic determinants of an option's value, we turn to examining some of the many ways that options appear in corporate finance. One of the most important insights we gain from studying options is that the common stock in a leveraged firm (one that has issued debt) is effectively a call option on the assets of the firm. This is a remarkable observation, and we explore it next.

Looking at an example is the easiest way to get started. Suppose a firm has a single debt issue outstanding. The face value is $1,000, and the debt is coming due in a year. There are no coupon payments between now and then, so the debt is effectively a pure discount bond. In addition, the current market value of the firm's assets is $980, and the risk-free rate is 12.5 percent.

In a year, the stockholders will have a choice. They can pay off the debt for $1,000 and thereby acquire the assets of the firm free and clear, or they can default on the debt. If they default, the bondholders will own the assets of the firm.

In this situation, the stockholders essentially have a call option on the assets of the firm with an exercise price of $1,000. They can exercise the option by paying the $1,000, or they can choose not to exercise the option by defaulting. Whether or not they will choose to exercise obviously depends on the value of the firm's assets when the debt becomes due.

If the value of the firm's assets exceeds $1,000, then the option is in the money, and the stockholders will exercise by paying off the debt. If the value of the firm's assets is less than $1,000, then the option is out of the money, and the stockholders will optimally choose to default. What we now illustrate is that we can determine the values of the debt and equity using our option pricing results.

CASE I: THE DEBT IS RISK-FREE

Suppose that in one year the firm's assets will be worth either $1,100 or $1,200. What is the value today of the equity in the firm? The value of the debt? What is the interest rate on the debt?

To answer these questions, we first recognize that the option (the equity in the firm) is certain to finish in the money because the value of the firm's assets ($1,100 or $1,200) will always exceed the face value of the debt. In this case, from our discussion in previous sections, we know that the option value is simply the difference between the value of the underlying asset and the present value of the exercise price (calculated at the risk-free rate). The present value of $1,000 in one year at 12.5 percent is $888.89. The current value of the firm is $980, so the option (the firm's equity) is worth $980 − 888.89 = $91.11.

What we see is that the equity, which is effectively an option to purchase the firm's assets, must be worth $91.11. The debt must therefore actually be worth $888.89. In fact, we really didn't need to know about options to handle this example because the debt is risk-free. The reason is that the bondholders are certain to receive $1,000. Because the debt is risk-free, the appropriate discount rate (and the interest rate on the debt) is the risk-free rate, and we therefore know immediately that the current value of the debt is $1,000/1.125 = $888.89. The equity is thus worth $980 − 888.89 = $91.11, as we calculated.

CASE II: THE DEBT IS RISKY

Suppose now that the value of the firm's assets in one year will be either $800 or $1,200. This case is a little more difficult because the debt is no longer risk-free. If the value of the assets turns out to be $800, then the stockholders will not exercise their option and will thereby default. The stock is worth nothing in this case. If the assets are worth $1,200, then the stockholders will exercise their option to pay off the debt and will enjoy a profit of $1,200 − 1,000 = $200.

What we see is that the option (the equity in the firm) will be worth either zero or $200. The assets will be worth either $1,200 or $800. Based on our discussion in previous sections, a portfolio that has the present value of $800 invested in a risk-free asset and ($1,200 − 800)/(200 − 0) = 2 call options exactly replicates the value of the assets of the firm.

The present value of $800 at the risk-free rate of 12.5 percent is $800/1.125 = $711.11. This amount, plus the value of the two call options, is equal to $980, the current value of the firm:

$$\$980 = 2 \times C_0 + \$711.11$$
$$C_0 = \$134.44$$

Because the call option in this case is actually the firm's equity, the value of the equity is $134.44. The value of the debt is thus $980 − 134.44 = $845.56.

Finally, because the debt has a $1,000 face value and a current value of $845.56, the interest rate is ($1,000/845.56) − 1 = 18.27%. This exceeds the risk-free rate, of course, because the debt is now risky.

EXAMPLE 14.3 | **Equity as a Call Option**

Swenson Software has a pure discount debt issue with a face value of $100. The issue is due in a year. At that time, the assets of the firm will be worth either $55 or $160, depending on the sales success of Swenson's latest product. The assets of the firm are currently worth $110. If the risk-free rate is 10 percent, what is the value of the equity in Swenson? The value of the debt? The interest rate on the debt?

To replicate the value of the assets of the firm, we first need to invest the present value of $55 in the risk-free asset. This costs $55/1.10 = $50. If the assets turn out to be worth $160, then the option is worth $160 − 100 = $60. Our risk-free asset will be worth $55, so we need

(continued)

($160 − 55)/60 = 1.75 call options. Because the firm is currently worth $110, we have:

$$\$110 = 1.75 \times C_0 + \$50$$
$$C_0 = \$34.29$$

The equity is thus worth $34.29; the debt is worth $110 − 34.29 = $75.71. The interest rate on the debt is about ($100/75.71) − 1 = 32.1%.

Concept Questions

14.5a Why do we say that the equity in a leveraged firm is effectively a call option on the firm's assets?

14.5b All other things being the same, would the stockholders of a firm prefer to increase or decrease the volatility of the firm's return on assets? Why? What about the bondholders? Give an intuitive explanation.

Options and Capital Budgeting

14.6

Most of the options we have discussed so far are financial options because they involve the right to buy or sell financial assets such as shares of stock. In contrast, **real options** involve real assets. As we will discuss in this section, our understanding of capital budgeting can be greatly enhanced by recognizing that many corporate investment decisions really amount to the evaluation of real options.

real option
An option that involves real assets as opposed to financial assets such as shares of stock.

To give a simple example of a real option, imagine that you are shopping for a used car. You find one that you like for $4,000, but you are not completely sure. So, you give the owner of the car $150 to hold the car for you for one week, meaning that you have one week to buy the car or else you forfeit your $150. As you probably recognize, what you have done here is to purchase a call option, giving you the right to buy the car at a fixed price for a fixed time. It's a real option because the underlying asset (the car) is a real asset.

The use of options such as the one in our car example is common in the business world. For example, real estate developers frequently need to purchase several smaller tracts of land from different owners to assemble a single larger tract. The development can't go forward unless all of the smaller properties are obtained. In this case, the developer will often buy options on the individual properties but will exercise those options only if all of the necessary pieces can be obtained.

These examples involve explicit options. As it turns out, almost all capital budgeting decisions contain numerous *implicit* options. We discuss the most important types of these next.

THE INVESTMENT TIMING DECISION

Consider a business that is examining a new project of some sort. What this normally means is management must decide whether to make an investment outlay to acquire the new assets needed for the project. If you think about it, what management has is the right, but not the obligation, to pay some fixed amount (the initial investment) and thereby acquire a real asset (the project). In other words, essentially all proposed projects are real options!

Based on our discussion in previous chapters, you already know how to analyze proposed business investments. You would identify and analyze the relevant cash flows and assess the net present value (NPV) of the proposal. If the NPV is positive, you would recommend taking the project, where taking the project amounts to exercising the option.

There is a very important qualification to this discussion that involves mutually exclusive investments. Remember that two (or more) investments are said to be mutually exclusive if we can take only one of them. A standard example is a situation in which we own a piece of land that we wish to build on. We are considering building either a gasoline station or an apartment building. We further think that both projects have positive NPVs, but, of course, we can take only one. Which one do we take? The obvious answer is that we take the one with the larger NPV.

Here is the key point. Just because an investment has a positive NPV doesn't mean we should take it today. That sounds like a complete contradiction of what we have said all along, but it isn't. The reason is that if we take a project today, we can't take it later. Put differently, almost all projects compete with themselves in time. We can take a project now, a month from now, a year from now, and so on. We therefore have to compare the NPV of taking the project now versus the NPV of taking it later. Deciding when to take a project is called the **investment timing decision**.

> **investment timing decision**
> The evaluation of the optimal time to begin a project.

A simple example is useful to illustrate the investment timing decision. A project costs $100 and has a single future cash flow. If we take it today, the cash flow will be $120 in one year. If we wait one year, the project will still cost $100, but the cash flow the following year (two years from now) will be $130 because the potential market is bigger. If these are the only two options, and the relevant discount rate is 10 percent, what should we do?

To answer this question, we need to compute the two NPVs. If we take it today, the NPV is:

$$NPV = -\$100 + 120/1.1 = \$9.09$$

If we wait one year, the NPV at that time would be:

$$NPV = -\$100 + 130/1.1 = \$18.18$$

This $18.18 is the NPV one year from now. We need the value today, so we discount back one period:

$$NPV = \$18.18/1.1 = \$16.53$$

So, the choice is clear. If we wait, the NPV is $16.53 today compared to $9.09 if we start immediately, so the optimal time to begin the project is one year from now.

The fact that we do not have to take a project immediately is often called the "option to wait." In our simple example, the value of the option to wait is the difference in NPVs: $16.53 − 9.09 = $7.44. This $7.44 is the extra value created by deferring the start of the project as opposed to taking it today.

As our example illustrates, the option to wait can be valuable. Just how valuable depends on the type of project. If we were thinking about a consumer product intended to capitalize on a current fashion or trend, then the option to wait is probably not very valuable because the window of opportunity is probably short. In contrast, suppose the project in question is a proposal to replace an existing production facility with a new, higher-efficiency one. This type of investment can be made now or later. In this case, the option to wait may be valuable.

The Investment Timing Decision	EXAMPLE 14.4

A project costs $200 and has a future cash flow of $42 per year forever. If we wait one year, the project will cost $240 because of inflation, but the cash flows will be $48 per year forever. If these are the only two options, and the relevant discount rate is 12 percent, what should we do? What is the value of the option to wait?

In this case, the project is a simple perpetuity. If we take it today, the NPV is:

NPV = −$200 + 42/.12 = $150

If we wait one year, the NPV at that time would be:

NPV = −$240 + 48/.12 = $160

So, $160 is the NPV one year from now, but we need to know the value today. Discounting back one period, we get:

NPV = $160/1.12 = $142.86.

If we wait, the NPV is $142.86 today compared to $150 if we start immediately, so the optimal time to begin the project is now.

What's the value of the option to wait? It is tempting to say that it is $142.86 − $150 = −$7.14, but that's wrong. Why? Because, as we discussed earlier, an option can never have a negative value. In this case, the option to wait has a zero value.

There is another important aspect regarding the option to wait. Just because a project has a negative NPV today doesn't mean that we should permanently reject it. For example, suppose an investment costs $120 and has a perpetual cash flow of $10 per year. If the discount rate is 10 percent, then the NPV is $10/.10 − 120 = −$20, so the project should not be taken now.

We should not just forget about this project forever, though. Suppose that next year, for some reason, the relevant discount rate fell to 5 percent. Then the NPV would be $10/.05 − $120 = $80, and we would take the project (assuming that further waiting isn't even more valuable). More generally, as long as there is some possible future scenario under which a project has a positive NPV, then the option to wait is valuable, and we should just shelve the project proposal for now.

MANAGERIAL OPTIONS

Once we decide the optimal time to launch a project, other real options come into play. In our capital budgeting analysis thus far, we have more or less ignored the impact of managerial actions that might take place *after* a project is launched. In effect, we assumed that, once a project is launched, its basic features cannot be changed.

In reality, depending on what actually happens in the future, there will always be opportunities to modify a project. These opportunities, which are an important type of real options, are often called **managerial options**. There are a great number of these options. The ways in which a product is priced, manufactured, advertised, and produced can all be changed, and these are just a few of the possibilities.

managerial options
Opportunities that managers can exploit if certain things happen in the future.

For example, look at Krispy Kreme. When the company first went public in 2000, consumers craved the company's doughnuts, and investors had the same craving for the company's stock. In fact, for the next four years, the company's stock was one of the best performers on Wall Street. By 2004, however, the company's business had grown stale,

highlighted by the announcement of a $24.4 million loss in the first quarter of the year. Company management placed much of the blame on the unexpected popularity of the low-carb Atkins diet, which, needless to say, reduced demand for Krispy Kreme's carb-heavy doughnuts.

Faced with falling sales, management announced several new initiatives for the company. Hoping to attract Atkins dieters back into its stores, the company expanded its product lines. Among the list of new items were sugar-free doughnuts, small packages of doughnuts at convenience stores, bags of coffee, frozen coffee at all of its stores, mini-rings, doughnut holes, and gift cards.

In addition to introducing new products, the company said it would only open 100 stores in 2004, down from the original forecast of 120 stores. This lowered capital spending for the year to $75 million, down from the original estimate of $110 million. And the company also planned to use at least two other design formats. The first design was an outside kiosk intended to make purchases more convenient for customers. The second design plan called for a smaller store that would sit on one-half to three-quarters of an acre, less than the typical one acre used by existing stores.

As the case of Krispy Kreme suggests, the possibility of future action is important. Unexpected events occur, and it is the job of management to respond to them. We discuss some of the most common types of managerial actions in the next few sections.

Contingency Planning   The various what-if procedures, particularly the break-even measures we discussed in an earlier chapter, have a use beyond that of simply evaluating cash flow and NPV estimates. We can also view these procedures and measures as primitive ways of exploring the dynamics of a project and investigating managerial options. What we think about in this case are some of the possible futures that could come about and what actions we might take if they do.

For example, we might find that a project fails to break even when sales drop below 10,000 units. This is a fact that is interesting to know; but the more important thing is to then go on and ask: What actions are we going to take if this actually occurs? This is called **contingency planning**, and it amounts to an investigation of some of the managerial options implicit in a project.

There is no limit to the number of possible futures or contingencies we could investigate. However, there are some broad classes, and we consider these next.

contingency planning
Taking into account the managerial options implicit in a project.

The Option to Expand   One particularly important option we have not explicitly addressed is the option to expand. If we truly find a positive NPV project, then there is an obvious consideration. Can we expand the project or repeat it to get an even larger NPV? Our static analysis implicitly assumes that the scale of the project is fixed.

For example, if the sales demand for a particular product were to greatly exceed expectations, we might investigate increasing production. If this is not feasible for some reason, then we could always increase cash flow by raising the price. Either way, the potential cash flow is higher than we have indicated because we have implicitly assumed that no expansion or price increase is possible. Overall, because we ignore the option to expand in our analysis, we *underestimate* NPV (all other things being equal).

The Option to Abandon   At the other extreme, the option to scale back or even abandon a project is also quite valuable. For example, if a project does not break even on a cash flow basis, then it can't even cover its own expenses. We would be better off if we just abandoned it. Our DCF analysis implicitly assumes that we would keep operating even in this case.

Sometimes, the best thing to do is punt. For example, consider the fate of the Volkswagen Phaeton luxury sedan. Don't be surprised if you haven't heard of this model. Unfortunately for VW, relatively few people have. Even fewer actually bought the high-priced sedan, which had a starting price of about $70,000 and reached $100,000+ for the top of the line. After selling fewer than 1,000 cars in the United States for the year, the company pulled the plug on U.S. sales of the Phaeton in late 2005. In another example, General Motors announced in May 2006 that it would no longer sell the H1 Alpha Hummer. This mammoth SUV had a price tag of $140,000 and got about 10 miles per gallon. With GM trying to establish itself as a more eco-friendly company, something about the gas-guzzling H1 Alpha did not fit the bill. The fact that GM sold only 374 H1s in 2005 may have had something to do with the decision as well.

More generally, if sales demand were significantly below expectations, we might be able to sell off some capacity or put it to another use. Maybe the product or service could be redesigned or otherwise improved. Regardless of the specifics, we once again *underestimate* NPV if we assume that the project must last for some fixed number of years, no matter what happens in the future.

The Option to Suspend or Contract Operations An option that is closely related to the option to abandon is the option to suspend operations. Frequently we see companies choosing to temporarily shut down an activity of some sort. For example, automobile manufacturers sometimes find themselves with too many vehicles of a particular type. In this case, production is often halted until the excess supply is worked off. At some point in the future, production resumes.

The option to suspend operations is particularly valuable in natural resource extraction. Suppose you own a gold mine. If gold prices fall dramatically, then your analysis might show that it costs more to extract an ounce of gold than you can sell the gold for, so you quit mining. The gold just stays in the ground, however, and you can always resume operations if the price rises sufficiently. In fact, operations might be suspended and restarted many times over the life of the mine.

Companies also sometimes choose to permanently scale back an activity. If a new product does not sell as well as planned, production might be cut back and the excess capacity put to some other use. This case is really just the opposite of the option to expand, so we will label it the option to contract.

For example, Delta Air Lines exercised its option to contract in October 2005 when it decided to discontinue operations of Song, its low-fare operation. Delta announced it would convert Song's 48 Boeing 757 planes back to Delta's traditional format. This decision made Song, with its 31 months of operations, one of the shortest-lived airlines in history.

Options in Capital Budgeting: An Example Suppose we are examining a new project. To keep things relatively simple, let's say that we expect to sell 100 units per year at $1 net cash flow apiece into perpetuity. We thus expect that the cash flow will be $100 per year.

In one year, we will know more about the project. In particular, we will have a better idea of whether it is successful. If it looks like a long-term success, the expected sales will be revised upward to 150 units per year. If it does not, the expected sales will be revised downward to 50 units per year. Success and failure are equally likely. Notice that because there is an even chance of selling 50 or 150 units, the expected sales are still 100 units, as we originally projected. The cost is $550, and the discount rate is 20 percent. The project can be dismantled and sold in one year for $400 if we decide to abandon it. Should we take it?

A standard DCF analysis is not difficult. The expected cash flow is $100 per year forever, and the discount rate is 20 percent. The PV of the cash flows is $100/.20 = $500, so the NPV is $500 − 550 = −$50. We shouldn't take the project.

This analysis ignores valuable options, however. In one year, we can sell out for $400. How can we account for this? What we have to do is to decide what we are going to do one year from now. In this simple case, we need to evaluate only two contingencies, an upward revision and a downward revision, so the extra work is not great.

In one year, if the expected cash flows are revised to $50, then the PV of the cash flows is revised downward to $50/.20 = $250. We get $400 by abandoning the project, so that is what we will do (the NPV of keeping the project in one year is $250 − 400 = −$150).

If the demand is revised upward, then the PV of the future cash flows at year 1 is $150/.20 = $750. This exceeds the $400 abandonment value, so we will keep the project.

We now have a project that costs $550 today. In one year, we expect a cash flow of $100 from the project. In addition, this project will be worth either $400 (if we abandon it because it is a failure) or $750 (if we keep it because it succeeds). These outcomes are equally likely, so we expect the project to be worth ($400 + 750)/2, or $575.

Summing up, in one year, we expect to have $100 in cash plus a project worth $575, or $675 total. At a 20 percent discount rate, this $675 is worth $562.50 today, so the NPV is $562.50 − 550 = $12.50. We should take the project.

The NPV of our project has increased by $62.50. Where did this come from? Our original analysis implicitly assumed we would keep the project even if it was a failure. At year 1, however, we saw that we were $150 better off ($400 versus $250) if we abandoned. There was a 50 percent chance of this happening, so the expected gain from abandoning is $75. The PV of this amount is the value of the option to abandon: $75/1.20 = $62.50.

Strategic Options   Companies sometimes undertake new projects just to explore possibilities and evaluate potential future business strategies. This is a little like testing the water by sticking a toe in before diving. Such projects are difficult to analyze using conventional DCF methods because most of the benefits come in the form of **strategic options**—that is, options for future, related business moves. Projects that create such options may be very valuable, but that value is difficult to measure. Research and development, for example, is an important and valuable activity for many firms, precisely because it creates options for new products and procedures.

To give another example, a large manufacturer might decide to open a retail outlet as a pilot study. The primary goal is to gain some market insight. Because of the high start-up costs, this one operation won't break even. However, using the sales experience gained from the pilot, the firm can then evaluate whether to open more outlets, to change the product mix, to enter new markets, and so on. The information gained and the resulting options for actions are all valuable, but coming up with a reliable dollar figure is probably not feasible.

Conclusion   We have seen that incorporating options into capital budgeting analysis is not easy. What can we do about them in practice? The answer is that we need to keep them in mind as we work with the projected cash flows. We will tend to underestimate NPV by ignoring options. The damage might be small for a highly structured, very specific proposal, but it might be great for an exploratory one.

strategic options
Options for future, related business products or strategies.

Concept Questions

14.6a Why do we say that almost every capital budgeting proposal involves mutually exclusive alternatives?

14.6b What are the options to expand, abandon, and suspend operations?

14.6c What are strategic options?

Options and Corporate Securities   14.7

In this section, we return to financial assets by considering some of the most common ways options appear in corporate securities and other financial assets. We begin by examining warrants and convertible bonds.

WARRANTS

A **warrant** is a corporate security that looks a lot like a call option. It gives the holder the right, but not the obligation, to buy shares of common stock directly from a company at a fixed price for a given time period. Each warrant specifies the number of shares of stock the holder can buy, the exercise price, and the expiration date.

The differences in contractual features between the call options that trade on the Chicago Board Options Exchange and warrants are relatively minor. Warrants usually have much longer maturity periods, however. In fact, some warrants are actually perpetual and have no fixed expiration date.

Warrants are often called *sweeteners* or *equity kickers* because they are often issued in combination with privately placed loans or bonds. Throwing in some warrants is a way of making the deal a little more attractive to the lender, and it is a common practice. Also, warrants have been listed and traded on the NYSE since April 13, 1970. In 2006, however, there were fewer than 20 issues of warrants listed.

In many cases, warrants are attached to the bonds when issued. The loan agreement will state whether the warrants are detachable from the bond. Usually, the warrant can be detached immediately and sold by the holder as a separate security.

warrant
A security that gives the holder the right to purchase shares of stock at a fixed price over a given period of time.

The Difference between Warrants and Call Options   As we have explained, from the holder's point of view, warrants are similar to call options on common stock. A warrant, like a call option, gives its holder the right to buy common stock at a specified price. From the firm's point of view, however, a warrant is different from a call option sold on the company's common stock.

The most important difference between call options and warrants is that call options are issued by individuals and warrants are issued by firms. When a call option is exercised, one investor buys stock from another investor. The company is not involved. When a warrant is exercised, the firm must issue new shares of stock. Each time a warrant is exercised, then, the firm receives some cash and the number of shares outstanding increases. Notice that the employee stock options we discussed earlier in the chapter are issued by corporations; so, strictly speaking, they are warrants rather than options.

To illustrate, suppose the Endrun Company issues a warrant giving holders the right to buy one share of common stock at $25. Further suppose the warrant is exercised. Endrun must print one new stock certificate. In exchange for the stock certificate, it receives $25 from the holder.

In contrast, when a call option is exercised, there is no change in the number of shares outstanding. Suppose Ms. Enger purchases a call option on the common stock of the Endrun Company from Mr. Swift. The call option gives Ms. Enger the right to buy (from Mr. Swift) one share of common stock of the Endrun Company for $25.

If Ms. Enger chooses to exercise the call option, Mr. Swift is obligated to give her one share of Endrun's common stock in exchange for $25. If Mr. Swift does not already own a share, he must go into the stock market and buy one.

The call option amounts to a side bet between Ms. Enger and Mr. Swift on the value of the Endrun Company's common stock. When a call option is exercised, one investor

gains and the other loses. The total number of shares outstanding of the Endrun Company remains constant, and no new funds are made available to the company.

Earnings Dilution   Warrants and (as we will see) convertible bonds frequently cause the number of shares to increase. This happens (1) when the warrants are exercised and (2) when the bonds are converted, causing the firm's net income to be spread over a larger number of shares. Earnings per share therefore decrease.

Firms with significant numbers of warrants and convertible issues outstanding will generally calculate and report earnings per share on a *diluted basis.* This means that the calculation is based on the number of shares that would be outstanding if all the warrants were exercised and all the convertibles were converted. Because this increases the number of shares, diluted EPS will be lower than "basic" EPS, which are calculated only on the basis of shares actually outstanding.

CONVERTIBLE BONDS

convertible bond

A bond that can be exchanged for a fixed number of shares of stock for a specified amount of time.

A **convertible bond** is similar to a bond with warrants. The most important difference is that a bond with warrants can be separated into distinct securities (a bond and some warrants), but a convertible bond cannot. A convertible bond gives the holder the right to exchange the bond for a fixed number of shares of stock anytime up to and including the maturity date of the bond.

Preferred stock can frequently be converted into common stock. A convertible preferred stock is the same as a convertible bond except that it has an infinite maturity date.[4]

conversion price

The dollar amount of a bond's par value that is exchangeable for one share of stock.

Features of a Convertible Bond   We can illustrate the basic features of a convertible bond by examining a particular issue. In December 2005, computer chip maker Intel issued $1.6 billion in convertible bonds. The bonds have a 2.95 percent coupon rate, mature in 2035, and can be converted into Intel common stock at a **conversion price** of $31.5296. Because each bond has a face value of $1,000, the owner can receive $1,000/31.5296 = 31.7162 shares of Intel's stock. The number of shares per bond, 31.7162 in this case, is called the **conversion ratio**.

conversion ratio

The number of shares per bond received for conversion into stock.

When Intel issued its convertible bonds, its common stock was trading at $26.32 per share. The conversion price was thus ($31.5296 − 26.32)/$26.32 = 19.79 percent higher than its actual stock price. This 19.79 percent is called the **conversion premium**. It reflects the fact that the conversion option in Intel's bonds was out of the money at the time of issuance; this is usually the case.

conversion premium

The difference between the conversion price and the current stock price, divided by the current stock price.

Value of a Convertible Bond   Even though the conversion feature of the convertible bond cannot be detached like a warrant, the value of the bond can still be decomposed into the bond value and the value of the conversion feature. We discuss how this is done next.

The easiest way to illustrate convertible bond valuation is with an example. Suppose a company called Micron Origami (MO) has an outstanding convertible bond issue. The coupon rate is 7 percent and the conversion ratio is 15. There are 12 remaining coupons, and the stock is trading for $68.

straight bond value

The value a convertible bond would have if it could not be converted into common stock.

Straight Bond Value   The **straight bond value** is what the convertible bond would sell for if it could not be converted into common stock. This value will depend on the general level of interest rates on debentures and on the default risk of the issuer.

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[4]The dividends paid are, of course, not tax deductible for the corporation. Interest paid on a convertible bond is tax deductible.

Suppose straight debentures issued by MO are rated B, and B-rated bonds are priced to yield 8 percent. We can determine the straight bond value of MO convertible bonds by discounting the $35 semiannual coupon payment and maturity value at 8 percent, just as we did in Chapter 7:

$$\text{Straight bond value} = \$35 \times (1 - 1/1.04^{12})/.04 + 1{,}000/1.04^{12}$$
$$= \$328.48 + 624.60$$
$$= \$953.08$$

The straight bond value of a convertible bond is a minimum value in the sense that the bond is always worth at least this amount. As we discuss next, it will usually be worth more.

Conversion Value The **conversion value** of a convertible bond is what the bond would be worth if it were immediately converted into common stock. We compare this value by multiplying the current price of the stock by the number of shares that will be received when the bond is converted.

For example, each MO convertible bond can be converted into 15 shares of MO common stock. MO common was selling for $68. Thus, the conversion value was $15 \times \$68 = \$1{,}020$.

A convertible cannot sell for less than its conversion value, or an arbitrage opportunity exists. If MO's convertible had sold for less than $1,020, investors would have bought the bonds, converted them into common stock, and sold the stock. The arbitrage profit would have been the difference between the value of the stock and the bond's conversion value.

Floor Value As we have seen, convertible bonds have two *floor values:* the straight bond value and the conversion value. The minimum value of a convertible bond is given by the greater of these two values. For the MO issue, the conversion value is $1,020 and the straight bond value is $953.08. At a minimum, this bond is thus worth $1,020.

Figure 14.3 plots the minimum value of a convertible bond against the value of the stock. The conversion value is determined by the value of the firm's underlying common stock. As the value of the common stock rises and falls, the conversion value rises and falls with it. For example, if the value of MO's common stock increases by $1, the conversion value of its convertible bonds will increase by $15.

conversion value
The value a convertible bond would have if it were to be immediately converted into common stock.

*For more about convertible bonds, see* www.convertbond.com.
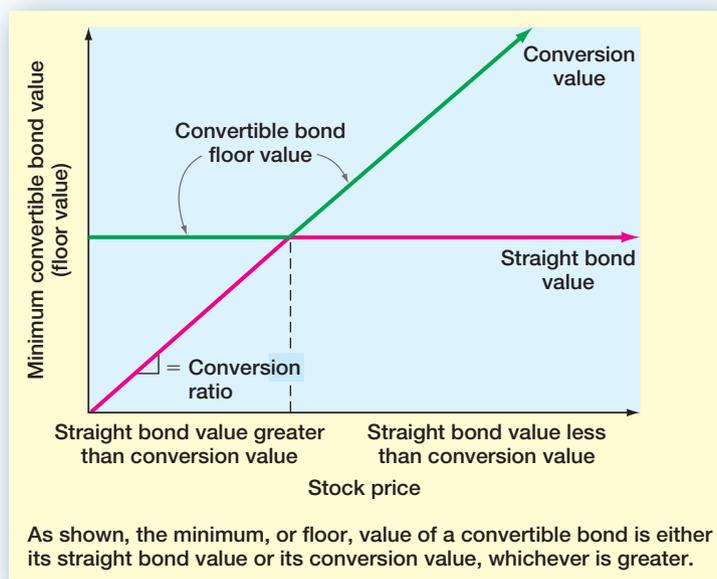
FIGURE 14.3

Minimum Value of a Convertible Bond versus the Value of the Stock for a Given Interest Rate

FIGURE 14.4

Value of a Convertible Bond versus the Value of the Stock for a Given Interest Rate

As shown, the value of a convertible bond is the sum of its floor value and its option value (highlighted region).
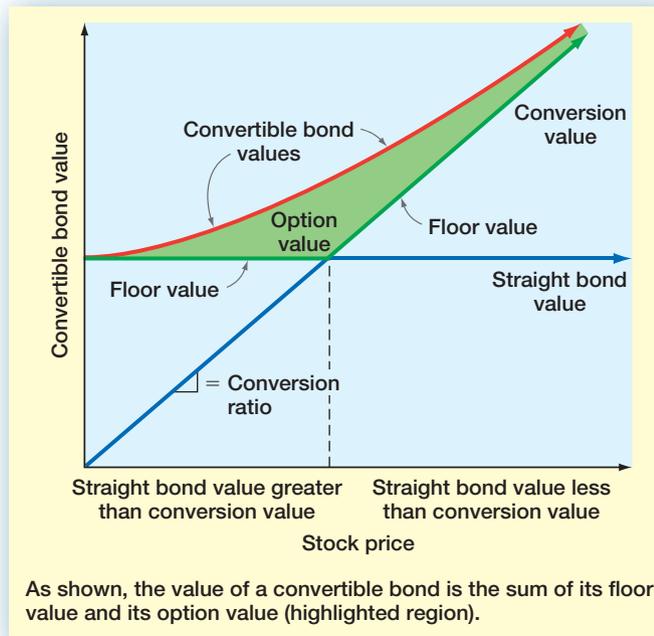
In Figure 14.3, we have implicitly assumed that the convertible bond is default-free. In this case, the straight bond value does not depend on the stock price, so it is plotted as a horizontal line. Given the straight bond value, the minimum value of the convertible depends on the value of the stock. When the stock price is low, the minimum value of a convertible is most significantly influenced by the underlying value as straight debt. However, when the value of the firm is very high, the value of a convertible bond is mostly determined by the underlying conversion value. This is also illustrated in Figure 14.3.

Option Value   The value of a convertible bond will always exceed the straight bond value and the conversion value unless the firm is in default or the bondholders are forced to convert. The reason is that holders of convertibles do not have to convert immediately. Instead, by waiting, they can take advantage of whichever is greater in the future: the straight bond value or the conversion value.

This option to wait has value, and it raises the value of the convertible bond over its floor value. The total value of the convertible is thus equal to the sum of the floor value and the option value. This is illustrated in Figure 14.4. Notice the similarity between this picture and the representation of the value of a call option in Figure 14.2, referenced in our earlier discussion.

OTHER OPTIONS

We've discussed two of the more common optionlike securities, warrants and convertibles. Options appear in many other places. We briefly describe a few in this section.

The Call Provision on a Bond   As we discussed in Chapter 7, most corporate bonds are callable. A call provision allows a corporation to buy the bonds at a fixed price for a fixed period of time. In other words, the corporation has a call option on the bonds. The cost of the call feature to the corporation is the cost of the option.

Convertible bonds are almost always callable. This means that a convertible bond is really a package of three securities: a straight bond, a call option held by the bondholder (the conversion feature), and a call option held by the corporation (the call provision).

Put Bonds   As we discussed in Chapter 7, put bonds are a relatively new innovation. Recall that such a bond gives the owner the right to force the issuer to buy the bond back at a fixed price for a fixed time. We now recognize that such a bond is a combination of a straight bond and a put option—hence the name.

A given bond can have a number of embedded options. For example, one popular type of bond is a LYON, which stands for "liquid yield option note." A LYON is a callable, putable, convertible, pure discount bond. It is thus a package of a pure discount bond, two call options, and a put option.

Insurance and Loan Guarantees   Insurance of one kind or another is a financial feature of everyday life. Most of the time, having insurance is like having a put option. For example, suppose you have $1 million in fire insurance on an office building. One night, your building burns down, which reduces its value to nothing. In this case, you will effectively exercise your put option and force the insurer to pay you $1 million for something worth very little.

Loan guarantees are a form of insurance. If you lend money to someone and they default, then, with a guaranteed loan, you can collect from someone else, often the government. For example, when you lend money to a commercial bank (by making a deposit), your loan is guaranteed (up to $100,000) by the government.

In two particularly well-known cases of loan guarantees, Lockheed (now Lockheed Martin) Corporation (in 1971) and Chrysler (now DaimlerChrysler) Corporation (in 1980) were saved from impending financial doom when the U.S. government came to the rescue by agreeing to guarantee new loans. Under the guarantees, if Lockheed or Chrysler had defaulted, the lenders could have obtained the full value of their claims from the U.S. government. From the lenders' point of view, the loans were as risk-free as Treasury bonds. These guarantees enabled Lockheed and Chrysler to borrow large amounts of cash and to get through difficult times.

Loan guarantees are not cost-free. The U.S. government, with a loan guarantee, has provided a put option to the holders of risky bonds. The value of the put option is the cost of the loan guarantee. This point was made clear by the collapse of the U.S. savings and loan industry in the early 1980s. The final cost to U.S. taxpayers of making good on the guaranteed deposits in these institutions was a staggering $150 billion.

In more recent times, following the September 11, 2001, terrorist attacks, Congress established the Air Transportation Stabilization Board (ATSB). The ATSB was authorized to issue up to $10 billion in loan guarantees to U.S. air carriers that suffered losses as a result of the attacks. By mid-2004, $1.56 billion in guarantees had been issued to six borrowers. Interestingly, recipients of loan guarantees are required to compensate the government for the risk being borne by the taxpayers. This compensation came in the form of cash fees and warrants to buy stock. These warrants represent between 10 and 33 percent of each company's equity. Because of recoveries (and, thus, stock price increases) at some borrowers, the ATSB's warrant portfolio became quite valuable, worth about $300 million in mid-2006.

Concept Questions

14.7a How are warrants and call options different?

14.7b What is the minimum value of a convertible bond?

14.7c Explain how car insurance acts like a put option.

14.7d Explain why U.S. government loan guarantees are not free.

14.8   Summary and Conclusions

This chapter has described the basics of option valuation and discussed optionlike corporate securities:

1. Options are contracts giving the right, but not the obligation, to buy and sell underlying assets at a fixed price during a specified period. The most familiar options are puts and calls involving shares of stock. These options give the holder the right, but not the obligation, to sell (the put option) or buy (the call option) shares of common stock at a given price.

   As we discussed, the value of any option depends on only five factors:

   a. The price of the underlying asset.
   b. The exercise price.
   c. The expiration date.
   d. The interest rate on risk-free bonds.
   e. The volatility of the underlying asset's value.

2. Companies have begun to use employee stock options (ESO) in rapidly growing numbers. Such options are similar to call options and serve to motivate employees to boost stock prices. ESOs are also an important form of compensation for many workers, particularly at more senior management levels.

3. Almost all capital budgeting proposals can be viewed as real options. Also, projects and operations contain implicit options, such as the option to expand, the option to abandon, and the option to suspend or contract operations.

4. A warrant gives the holder the right to buy shares of common stock directly from the company at a fixed exercise price for a given period of time. Typically, warrants are issued in a package with bonds. Afterwards, they often can be detached and traded separately.

5. A convertible bond is a combination of a straight bond and a call option. The holder can give up the bond in exchange for a fixed number of shares of stock. The minimum value of a convertible bond is given by its straight bond value or its conversion value, whichever is greater.

6. Many other corporate securities have option features. Bonds with call provisions, bonds with put provisions, and bonds backed by a loan guarantee are just a few examples.

CHAPTER REVIEW AND SELF-TEST PROBLEMS

14.1 **Value of a Call Option** Stock in the Nantucket Corporation is currently selling for $25 per share. In one year, the price will be either $20 or $30. T-bills with one year to maturity are paying 10 percent. What is the value of a call option with a $20 exercise price? A $26 exercise price?

14.2 **Convertible Bonds** Old Cycle Corporation (OCC), publisher of *Ancient Iron* magazine, has a convertible bond issue that is currently selling in the market for $950. Each bond can be exchanged for 100 shares of stock at the holder's option.

The bond has a 7 percent coupon, payable annually, and it will mature in 10 years. OCC's debt is BBB-rated. Debt with this rating is priced to yield 12 percent. Stock in OCC is trading at $7 per share.

What is the conversion ratio on this bond? The conversion price? The conversion premium? What is the floor value of the bond? What is its option value?

ANSWERS TO CHAPTER REVIEW AND SELF-TEST PROBLEMS

14.1 With a $20 exercise price, the option can't finish out of the money (it can finish "at the money" if the stock price is $20). We can replicate the value of the stock by investing the present value of $20 in T-bills and buying one call option. Buying the T-bill will cost $20/1.1 = $18.18.

   If the stock ends up at $20, the call option will be worth zero and the T-bill will pay $20. If the stock ends up at $30, the T-bill will again pay $20, and the option will be worth $30 − 20 = $10, so the package will be worth $30. Because the T-bill–call option combination exactly duplicates the payoff on the stock, it has to be worth $20 or arbitrage is possible. Using the notation from the chapter, we can calculate the value of the call option:

$$S_0 = C_0 + E/(1 + R_f)$$
$$\$25 = C_0 + \$18.18$$
$$C_0 = \$6.82$$

   With the $26 exercise price, we start by investing the present value of the lower stock price in T-bills. This guarantees us $20 when the stock price is $20. If the stock price is $30, then the option is worth $30 − 26 = $4. We have $20 from our T-bill, so we need $10 from the options to match the stock. Because each option is worth $4 in this case, we need to buy $10/4 = 2.5 call options. Notice that the difference in the possible stock prices (ΔS) is $10 and the difference in the possible option prices (ΔC) is $4, so $\Delta S/\Delta C = 2.5$.

   To complete the calculation, we note that the present value of the $20 plus 2.5 call options has to be $25 to prevent arbitrage, so:

$$\$25 = 2.5 \times C_0 + \$20/1.1$$
$$C_0 = \$6.82/2.5$$
$$= \$2.73$$

14.2 Because each bond can be exchanged for 100 shares, the conversion ratio is 100. The conversion price is the face value of the bond ($1,000) divided by the conversion ratio, or $1,000/100 = $10. The conversion premium is the percentage difference between the current price and the conversion price, or ($10 − 7)/7 = 43%.

   The floor value of the bond is the greater of its straight bond value or its conversion value. Its conversion value is what the bond is worth if it is immediately converted: $100 \times \$7 = \$700$. The straight bond value is what the bond would be worth if it were not convertible. The annual coupon is $70, and the bond matures in 10 years. At a 12 percent required return, the straight bond value is:

$$\text{Straight bond value} = \$70 \times (1 - 1/1.12^{10})/.12 + 1,000/1.12^{10}$$
$$= \$395.52 + 321.97$$
$$= \$717.49$$

This exceeds the conversion value, so the floor value of the bond is $717.49. Finally, the option value is the value of the convertible in excess of its floor value. Because the bond is selling for $950, the option value is:

$$\text{Option value} = \$950 - 717.49$$
$$= \$232.51$$

CONCEPTS REVIEW AND CRITICAL THINKING QUESTIONS

1. **Options** What is a call option? A put option? Under what circumstances might you want to buy each? Which one has greater *potential* profit? Why?

2. **Options** Complete the following sentence for each of these investors:
    a. A buyer of call options.
    b. A buyer of put options.
    c. A seller (writer) of call options.
    d. A seller (writer) of put options.

    "The (buyer/seller) of a (put/call) option (pays/receives) money for the (right/obligation) to (buy/sell) a specified asset at a fixed price for a fixed length of time."

3. **Intrinsic Value** What is the intrinsic value of a call option? How do we interpret this value?

4. **Put Options** What is the value of a put option at maturity? Based on your answer, what is the intrinsic value of a put option?

5. **Option Pricing** You notice that shares of stock in the Patel Corporation are going for $50 per share. Call options with an exercise price of $35 per share are selling for $10. What's wrong here? Describe how you can take advantage of this mispricing if the option expires today.

6. **Options and Stock Risk** If the risk of a stock increases, what is likely to happen to the price of call options on the stock? To the price of put options? Why?

7. **Option Rise** True or false: The unsystematic risk of a share of stock is irrelevant in valuing the stock because it can be diversified away; therefore, it is also irrelevant for valuing a call option on the stock. Explain.

8. **Option Pricing** Suppose a certain stock currently sells for $30 per share. If a put option and a call option are available with $30 exercise prices, which do you think will sell for more, the put or the call? Explain.

9. **Option Price and Interest Rates** Suppose the interest rate on T-bills suddenly and unexpectedly rises. All other things being the same, what is the impact on call option values? On put option values?

10. **Contingent Liabilities** When you take out an ordinary student loan, it is usually the case that whoever holds that loan is given a guarantee by the U.S. government, meaning that the government will make up any payments you skip. This is just one example of the many loan guarantees made by the U.S. government. Such guarantees don't show up in calculations of government spending or in official deficit figures. Why not? Should they show up?

11. **Option to Abandon** What is the option to abandon? Explain why we underestimate NPV if we ignore this option.

12. **Option to Expand** What is the option to expand? Explain why we underestimate NPV if we ignore this option.

13. **Capital Budgeting Options** In Chapter 10, we discussed Porsche's launch of its new Cayenne. Suppose sales of the Cayenne go extremely well and Porsche is forced to expand output to meet demand. Porsche's action in this case would be an example of exploiting what kind of option?

14. **Option to Suspend** Natural resource extraction facilities (such as oil wells or gold mines) provide a good example of the value of the option to suspend operations. Why?

15. **Employee Stock Options** You own stock in the Hendrix Guitar Company. The company has implemented a plan to award employee stock options. As a shareholder, does the plan benefit you? If so, what are the benefits?

™

QUESTIONS AND PROBLEMS

1. **Calculating Option Values** T-bills currently yield 6.2 percent. Stock in Pinta Manufacturing is currently selling for $55 per share. There is no possibility that the stock will be worth less than $50 per share in one year.
   a. What is the value of a call option with a $45 exercise price? What is the intrinsic value?
   b. What is the value of a call option with a $35 exercise price? What is the intrinsic value?
   c. What is the value of a put option with a $45 exercise price? What is the intrinsic value?

BASIC
(Questions 1–13)

2. **Understanding Option Quotes** Use the option quote information shown here to answer the questions that follow. The stock is currently selling for $94.

Option and NY Close	Expiration	Strike Price	Calls		Puts	
			Vol.	Last	Vol.	Last
RWJ						
	Mar	90	230	2.80	160	0.80
	Apr	90	170	6	127	1.40
	Jul	90	139	8.05	43	3.90
	Oct	90	60	10.20	11	3.65

   a. Are the call options in the money? What is the intrinsic value of an RWJ Corp. call option?
   b. Are the put options in the money? What is the intrinsic value of an RWJ Corp. put option?
   c. Two of the options are clearly mispriced. Which ones? At a minimum, what should the mispriced options sell for? Explain how you could profit from the mispricing in each case.

3. **Calculating Payoffs** Use the option quote information shown here to answer the questions that follow. The stock is currently selling for $114.

Option and NY Close	Expiration	Strike Price	Calls		Puts	
			Vol.	Last	Vol.	Last
Macrosoft						
	Feb	110	85	8.05	40	1.05
	Mar	110	61	9.30	22	1.95
	May	110	22	11.65	11	3.35
	Aug	110	3	13.70	3	5.15

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   a. Suppose you buy 10 contracts of the February 110 call option. How much will you pay, ignoring commissions?

   b. In part (a), suppose that Macrosoft stock is selling for $130 per share on the expiration date. How much is your options investment worth? What if the terminal stock price is $118? Explain.

   c. Suppose you buy 10 contracts of the August 110 put option. What is your maximum gain? On the expiration date, Macrosoft is selling for $104 per share. How much is your options investment worth? What is your net gain?

   d. In part (c), suppose you *sell* 10 of the August 110 put contracts. What is your net gain or loss if Macrosoft is selling for $103 at expiration? For $132? What is the break-even price—that is, the terminal stock price that results in a zero profit?

4. **Calculating Option Values** The price of Time Squared Corp. stock will be either $77 or $93 at the end of the year. Call options are available with one year to expiration. T-bills currently yield 6 percent.

   a. Suppose the current price of Time Squared stock is $80. What is the value of the call option if the exercise price is $75 per share?

   b. Suppose the exercise price is $85 in part (a). What is the value of the call option now?

5. **Calculating Option Values** The price of Dimension, Inc., stock will be either $65 or $85 at the end of the year. Call options are available with one year to expiration. T-bills currently yield 5 percent.

   a. Suppose the current price of Dimension stock is $75. What is the value of the call option if the exercise price is $45 per share?

   b. Suppose the exercise price is $70 in part (a). What is the value of the call option now?

6. **Using the Pricing Equation** A one-year call option *contract* on Cheesy Poofs Co. stock sells for $1,200. In one year, the stock will be worth $45 or $65 per share. The exercise price on the call option is $60. What is the current value of the stock if the risk-free rate is 9 percent?

7. **Equity as an Option** Rackin Pinion Corporation's assets are currently worth $1,040. In one year, they will be worth either $1,000 or $1,350. The risk-free interest rate is 6 percent. Suppose Rackin Pinion has an outstanding debt issue with a face value of $1,000.

   a. What is the value of the equity?

   b. What is the value of the debt? The interest rate on the debt?

   c. Would the value of the equity go up or down if the risk-free rate were 20 percent? Why? What does your answer illustrate?

8. **Equity as an Option** Buckeye Industries has a bond issue with a face value of $1,000 that is coming due in one year. The value of Buckeye's assets is currently $1,200. Jim Tressell, the CEO, believes that the assets in the firm will be worth either $900 or $1,500 in a year. The going rate on one-year T-bills is 7 percent.

   a. What is the value of Buckeye's equity? The value of the debt?

   b. Suppose Buckeye can reconfigure its existing assets in such a way that the value in a year will be $700 or $1,700. If the current value of the assets is unchanged, will the stockholders favor such a move? Why or why not?

9. **Calculating Conversion Value** A $1,000 par convertible debenture has a conversion price for common stock of $40 per share. With the common stock selling at $55, what is the conversion value of the bond?

10. **Convertible Bonds** The following facts apply to a convertible bond making semi-annual payments:

Conversion price	$50/share
Coupon rate	6.5%
Par value	$1,000
Yield on nonconvertible debentures of same quality	8%
Maturity	20 years
Market price of stock	$38/share

   a. What is the minimum price at which the convertible should sell?
   b. What accounts for the premium of the market price of a convertible bond over the total market value of the common stock into which it can be converted?

11. **Calculating Values for Convertibles** You have been hired to value a new 30-year callable, convertible bond. The bond has a 7 percent coupon, payable annually, and its face value is $1,000. The conversion price is $60, and the stock currently sells for $50.

   a. What is the minimum value of the bond? Comparable nonconvertible bonds are priced to yield 9 percent.
   b. What is the conversion premium for this bond?

12. **Calculating Warrant Values** A bond with 20 detachable warrants has just been offered for sale at $1,000. The bond matures in 15 years and has an annual coupon of $105. Each warrant gives the owner the right to purchase two shares of stock in the company at $15 per share. Ordinary bonds (with no warrants) of similar quality are priced to yield 12 percent. What is the value of one warrant?

13. **Option to Wait** Your company is deciding whether to invest in a new machine. The new machine will increase cash flow by $350,000 per year. You believe the technology used in the machine has a 10-year life; in other words, no matter when you purchase the machine, it will be obsolete 10 years from today. The machine is currently priced at $2,000,000. The cost of the machine will decline by $160,000 per year until it reaches $1,200,000, where it will remain. If your required return is 12 percent, should you purchase the machine? If so, when should you purchase it?

14. **Abandonment Value** We are examining a new project. We expect to sell 7,000 units per year at $65 net cash flow apiece for the next 10 years. In other words, the annual operating cash flow is projected to be $65 × 7,000 = $455,000. The relevant discount rate is 16 percent, and the initial investment required is $1,800,000.

   a. What is the base-case NPV?
   b. After the first year, the project can be dismantled and sold for $1,400,000. If expected sales are revised based on the first year's performance, when would it make sense to abandon the investment? In other words, at what level of expected sales would it make sense to abandon the project?
   c. Explain how the $1,400,000 abandonment value can be viewed as the opportunity cost of keeping the project in one year.

INTERMEDIATE
(Questions 14–20)

15. **Abandonment** In the previous problem, suppose you think it is likely that expected sales will be revised upward to 9,000 units if the first year is a success and revised downward to 4,000 units if the first year is not a success.

   a. If success and failure are equally likely, what is the NPV of the project? Consider the possibility of abandonment in answering.
   b. What is the value of the option to abandon?

16. **Abandonment and Expansion** In the previous problem, suppose the scale of the project can be doubled in one year in the sense that twice as many units can be produced and sold. Naturally, expansion would be desirable only if the project is a success. This implies that if the project is a success, projected sales after expansion will be 18,000. Again assuming that success and failure are equally likely, what is the NPV of the project? Note that abandonment is still an option if the project is a failure. What is the value of the option to expand?

17. **Intuition and Option Value** Suppose a share of stock sells for $75. The risk-free rate is 5 percent, and the stock price in one year will be either $85 or $95.

   a. What is the value of a call option with a $85 exercise price?
   b. What's wrong here? What would you do?

18. **Intuition and Convertibles** Which of the following two sets of relationships, at time of issuance of convertible bonds, is more typical? Why?

	A	B
Offering price of bond	$ 800	$1,000
Bond value (straight debt)	800	950
Conversion value	1,000	900

19. **Convertible Calculations** Rayne, Inc., has a $1,000 face value convertible bond issue that is currently selling in the market for $950. Each bond is exchangeable at any time for 25 shares of the company's stock. The convertible bond has a 7 percent coupon, payable semiannually. Similar nonconvertible bonds are priced to yield 10 percent. The bond matures in 10 years. Stock in Rayne sells for $36 per share.

   a. What are the conversion ratio, conversion price, and conversion premium?
   b. What is the straight bond value? The conversion value?
   c. In part (b), what would the stock price have to be for the conversion value and the straight bond value to be equal?
   d. What is the option value of the bond?

20. **Abandonment Decisions** Allied Products, Inc., is considering a new product launch. The firm expects to have annual operating cash flow of $25 million for the next 10 years. Allied Products uses a discount rate of 20 percent for new product launches. The initial investment is $100 million. Assume that the project has no salvage value at the end of its economic life.

   a. What is the NPV of the new product?
   b. After the first year, the project can be dismantled and sold for $50 million. If the estimates of remaining cash flows are revised based on the first year's experience, at what level of expected cash flows does it make sense to abandon the project?

CHALLENGE
(Questions 21–22)

21. **Pricing Convertibles** You have been hired to value a new 25-year callable, convertible bond. The bond has a 7.20 percent coupon, payable annually. The

conversion price is $160, and the stock currently sells for $38.50. The stock price is expected to grow at 11 percent per year. The bond is callable at $1,200, but, based on prior experience, it won't be called unless the conversion value is $1,300. The required return on this bond is 10 percent. What value would you assign?

22. **Abandonment Decisions** For some projects, it may be advantageous to terminate the project early. For example, if a project is losing money, you might be able to reduce your losses by scrapping out the assets and terminating the project rather than continuing to lose money all the way through to the project's completion. Consider the following project of Hand Clapper, Inc. The company is considering a four-year project to manufacture clap-command garage door openers. This project requires an initial investment of $9 million that will be depreciated straight-line to zero over the project's life. An initial investment in net working capital of $750,000 is required to support spare parts inventory; this cost is fully recoverable whenever the project ends. The company believes it can generate $8.5 million in pretax revenues with $3.6 million in total pretax operating costs. The tax rate is 38 percent and the discount rate is 16 percent. The market value of the equipment over the life of the project is as follows:

Year	Market Value (millions)
1	$6.50
2	6.00
3	4.50
4	0.00

  a. Assuming Hand Clapper operates this project for four years, what is the NPV?
  b. Now compute the project NPV assuming the project is abandoned after only one year, after two years, and after three years. What economic life for this project maximizes its value to the firm? What does this problem tell you about not considering abandonment possibilities when evaluating projects?

WEB EXERCISES

14.1 Option Prices You want to find the option prices for ConAgra Foods (CAG). Go to finance.yahoo.com, get a stock quote, and follow the "Options" link. What are the option premium and strike price for the highest and lowest strike price options that are nearest to expiring? What are the option premium and strike price for the highest and lowest strike price options expiring next month?

14.2 Option Symbol Construction What is the option symbol for a call option on Cisco Systems (CSCO) with a strike price of $40 that expires in October? Go to www.cboe.com, follow the "Trading Tools" link, then the "Symbol Directory" link. Find the basic ticker symbol for Cisco Systems options. Next, follow the "Strike Price Code" link. Find the codes for the expiration month and strike price and construct the ticker symbol. Now construct the ticker symbol for a put option with the same strike price and expiration.

14.3 Option Expiration Go to www.cboe.com, highlight the "Trading Tools" tab, then follow the "Expiration Calendar" link. On what day do equity options expire in the current month? On what day do they expire next month?

14.4 LEAPS Go to www.cboe.com, highlight the "Products" tab, then follow the "LEAPS®" link. What are LEAPS? What are the two types of LEAPS? What are the benefits of equity LEAPS? What are the benefits of index LEAPS?

14.5 FLEX Options Go to www.cboe.com, highlight the "Institutional" tab, then follow the "FLEX Options" link. What is a FLEX option? When do FLEX options expire? What is the minimum size of a FLEX option?

MINICASE

S&S Air's Convertible Bond

S&S Air is preparing its first public securities offering. In consultation with Danielle Ralston of underwriter Raines and Warren, Chris Guthrie decided that a convertible bond with a 20-year maturity was the way to go. He met the owners, Mark and Todd, and presented his analysis of the convertible bond issue. Because the company is not publicly traded, Chris looked at comparable publicly traded companies and determined that the average PE ratio for the industry is 12.5. Earnings per share for the company are $1.60. With this in mind, Chris has suggested a conversion price of $25 per share.

Several days later, Todd, Mark, and Chris met again to discuss the potential bond issue. Both Todd and Mark researched convertible bonds and have questions for Chris. Todd begins by asking Chris if the convertible bond issue will have a lower coupon rate than a comparable bond without a conversion feature. Chris informs him that a par value convertible bond issue would require a 6 percent coupon rate with a conversion value of $800, while a plain vanilla bond would have a 10 percent coupon rate. Todd nods in agreement and explains that the convertible bonds are a win–win form of financing. He states that if the value of the company stock does not rise above the conversion price, the company has issued debt at a cost below the market rate (6 percent instead of 10 percent). If the company's stock does rise to the conversion value, the company has effectively issued stock at a price above the current value.

Mark immediately disagrees, saying that convertible bonds are a no-win form of financing. He argues that if the value of the company stock rises to more than $25, the company is forced to sell stock at the conversion price. This means the new shareholders, in other words those who bought the convertible bonds, benefit from a bargain price. Put another way, if the company prospers, it would have been better to have issued straight debt so that the gains would not be shared.

Chris has gone back to Danielle for help. As Danielle's assistant, you've been asked to prepare another memo answering the following questions:

1. Why do you think Chris is suggesting a conversion price of $25? Given that the company is not publicly traded, does it even make sense to talk about a conversion price?

2. Is there anything wrong with Todd's argument that it is cheaper to issue a bond with a convertible feature because the required coupon is lower?

3. Is there anything wrong with Mark's argument that a convertible bond is a bad idea because it allows new shareholders to participate in gains made by the company?

4. How can you reconcile the arguments made by Todd and Mark?

5. In the course of the debate, a question comes up concerning whether or not the bonds should have an ordinary (not make-whole) call feature. Chris confuses everybody by stating, "The call feature lets S&S Air force conversion, thereby minimizing the problem that Mark has identified." What is he talking about? Is he making sense?