CHAPTER 5

Valuing Bonds

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Bondholders once received a beautifully engraved certificate like this one for a bond issued by a piano manufacturer. Nowadays their ownership is simply recorded on an electronic database.

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Investment in new plant and equipment requires money—often a lot of money. Sometimes firms may be able to save enough out of previous earnings to cover the cost of investments, but often they need to raise cash from investors. In broad terms, we can think of two ways to raise new money from investors: borrow the cash or sell additional shares of common stock.

If companies need the money only for a short while, they may borrow it from a bank; if they need it to make long-term investments, they generally issue bonds, which are simply long-term loans. When companies issue bonds, they promise to make a series of fixed interest payments and then to repay the debt. As long as the company generates sufficient cash, the payments on a bond are certain. In this case bond valuation involves straightforward time-value-of-money computations. But there is some chance that even the most blue-chip company will fall on hard times and will not be able to repay its debts. Investors take this default risk into account when they price the bonds and demand a higher interest rate to compensate.

Companies are not the only bond issuers. State and local governments also raise money by selling bonds. So does the U.S. Treasury. There is always some risk that a company or municipality will not be able to come up with the cash to repay its bonds, but investors in Treasury issues can be confident that the government will make the promised payments. Therefore, in the first part of this chapter we focus on Treasury bonds and sidestep the issue of default. We show how bond prices are determined by market interest rates and how those prices respond to changes in rates. We also consider the yield to maturity and discuss why a bond's yield may vary with its time to maturity.

Later in the chapter we look at corporate bonds, where there is a possibility of default. We will see how bond ratings provide a guide to the default risk and how low-grade bonds offer higher promised yields.

In Chapter 13 we will look in more detail at the securities that companies issue, and we will see that there are many variations on bond design. But for now, we keep our focus on garden-variety bonds and general principles of bond valuation.

After studying this chapter you should be able to:

- Distinguish among a bond's coupon rate, current yield, and yield to maturity.
- Find the market price of a bond given its yield to maturity, find a bond's yield given its price, and demonstrate why prices and yields vary inversely.
- Show why bonds exhibit interest rate risk.
- Understand why investors pay attention to bond ratings and demand a higher interest rate for bonds with low ratings.

5.1 Bond Characteristics

bond
Security that obligates the issuer to make specified payments to the bondholder.

coupon
The interest payments paid to the bondholder.

face value or **principal**
Payment at the maturity of the bond. Also called par value or maturity value.

coupon rate
Annual interest payment as a percentage of face value.

Governments and corporations borrow money by selling **bonds** to investors. The money they collect when the bond is issued, or sold to the public, is the amount of the loan. In return, they agree to make specified payments to the bondholders, who are the lenders. When you own a bond, you generally receive a fixed interest payment each year until the bond matures. This payment is known as the **coupon** because most bonds used to have coupons that the investors clipped off and mailed to the bond issuer to claim the interest payment. At maturity, the debt is repaid: The borrower pays the bondholder the bond's **face value** (equivalently, its *principal* or *par value*).

How do bonds work? Consider a U.S. Treasury bond as an example. Several years ago, the U.S. Treasury raised money by selling 5.5 percent coupon, 2008 maturity Treasury bonds. Each bond has a face value of $1,000. Because the **coupon rate** is 5.5 percent, the government makes coupon payments of 5.5 percent of $1,000, or $55 each year.[1] When the bond matures in February 2008, the government must pay the $1,000 face value of the bond in addition to the final coupon payment.

Suppose that in 2005 you decided to buy the "5.5s of 2008," that is, the 5.5 percent coupon bonds maturing in 2008. If you planned to hold the bond until maturity, you would then have looked forward to the cash flows shown in Figure 5–1. The initial cash flow is negative and equal to the price you have to pay for the bond. Thereafter, the cash flows equal the annual coupon payment, until the maturity date in 2008, when you receive the $1,000 face value of the bond plus the final coupon payment.

Reading the Financial Pages

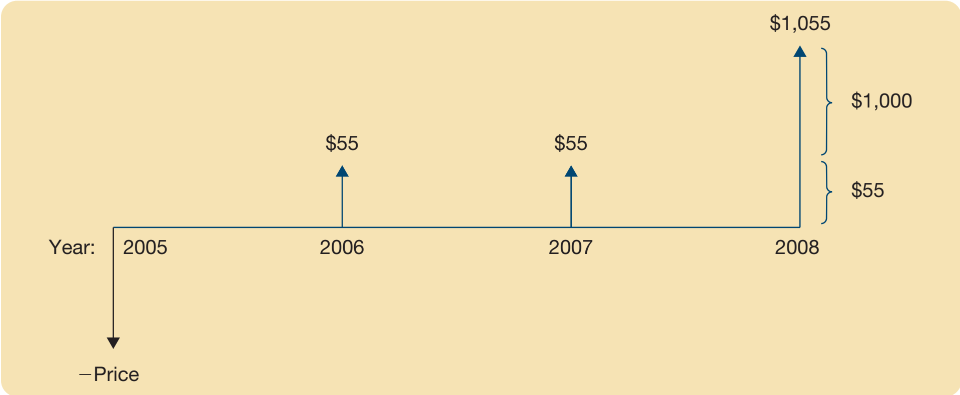
The prices at which you can buy and sell bonds are shown each day in the financial press. Figure 5–2 is an excerpt from the bond quotation page of *The Wall Street Journal* and shows the prices of bonds and notes that have been issued by the United States Treasury. (A *note* is just a bond with a maturity of less than 10 years at the time it is issued.[2]) The entry for the 5.5 percent bond maturing in February 2008 that we just looked at is highlighted. The letter *n* indicates that it is a note.

Prices are generally quoted in 32nds rather than decimals. Thus for the 5.5 percent bond the *asked price*—the price investors pay to *buy* the bond from a bond dealer—is shown as 105:23. This means that the price is 105 and 23/32, or 105.719 percent of face value. Therefore each bond costs $1,057.19.

[1] In the United States, these coupon payments typically would come in two semiannual installments of $27.50 each. To keep things simple for now, we will assume one coupon payment per year.

[2] The longest bonds that the Treasury issues mature in thirty years, though there was a period between 2001 and 2005 when the longest maturity bond issued was ten years.

FIGURE 5–1 Cash flows to an investor in the 5.5 percent coupon bond maturing in the year 2008



The *bid price* is the price investors receive if they sell the bond to a dealer. Just as the used-car dealer earns his living by reselling cars at higher prices than he paid for them, so the bond dealer needs to charge a *spread* between the bid and the asked price. Notice that the spread for the 5.5 percent bonds is only $\frac{1}{32}$, or about .03 percent, of the bond's value. Don't you wish that used-car dealers charged similar spreads?

The next column in the table shows the change in price since the previous day. The price of the 5.5 percent bonds has fallen by $\frac{1}{32}$. Finally, the column "Ask Yld" stands for *ask yield to maturity,* which measures the return that investors will receive if they buy the bond at the asked price and hold it to maturity in 2008. You can see that the 5.5 percent Treasury bonds offer investors a yield to maturity of 3.47 percent. We will explain shortly how this figure was calculated.

FIGURE 5–2 Treasury bond quotes from The Wall Street Journal, February 16, 2005

Treasury Bonds, Notes and Bills

February 15, 2005

Explanatory Notes

Representative Over-the-Counter quotation based on transactions of $1 million or more. Treasury bond, note and bill quotes are as of mid-afternoon. Colons in bid-and-asked quotes represent 32nds; 101:01 means 101 1/32. Net changes in 32nds. n-Treasury note. i-Inflation-Indexed issue. Treasury bill quotes in hundredths, quoted on terms of a rate of discount. Days to maturity calculated from settlement date. All yields are to maturity and based on the asked quote. Latest 13-week and 26-week bills are boldfaced. For bonds callable prior to maturity, yields are computed to the earliest call date for issues quoted above par and to the maturity date for issues below par. *When issued.

Source: eSpeed/Cantor Fitzgerald

U.S. Treasury strips as of 3 p.m. Eastern time, also based on transactions of $1 million or more. Colons in bid and asked quotes represent 32nds; 99:01 means 99 1/32. Net changes in 32nds. Yields calculated on the asked quotation. ci-stripped coupon interest. bp-Treasury bond, stripped principal. np-Treasury note, stripped principal. For bonds callable prior to maturity, yields are computed to the earliest call date for issues quoted above par and to the maturity date for issues below par.

Source: Bear, Steams & Co. via Street Software Technology Inc.

RATE	MATURITY MO/YR	BID	ASKED	CHG	ASK YLD	RATE	MATURITY MO/YR	BID	ASKED	CHG	ASK YLD
Government Bonds & Notes						1.875	Jul 13i	103:06	103:07	−16	1.46
1.500	Feb 05n	100:00	100:00	1	1.49	4.250	Aug 13n	101:15	101:16	−6	4.04
1.625	Mar 05n	99:29	99:30	1	2.14	12.000	Aug 13	127:17	127:18	−6	3.55
3.125	May 07n	99:13	99:14	−1	3.38	2.375	Jan 25i	110:00	110:00	−34	1.78
2.750	Aug 07n	98:13	98:14	...	3.41	7.625	Feb 25	140:08	140:09	−20	4.54
3.250	Aug 07n	99:19	99:20	−1	3.41	6.875	Aug 25	130:24	130:25	−19	4.55
6.125	Aug 07n	106:13	106:14	−2	3.41	6.000	Feb 26	119:09	119:10	−18	4.56
3.000	Nov 07n	98:25	98:26	−1	3.46	6.750	Aug 26	129:27	129:28	−18	4.56
3.625	Jan 08i	108:06	108:07	−2	0.77	6.500	Nov 26	126:19	126:20	−18	4.56
3.000	Feb 08n	98:19	98:20	−1	3.48	6.625	Feb 27	128:14	128:15	−19	4.56
5.500	Feb 08n	105:22	105:23	−1	3.47	6.375	Aug 27	125:10	125:11	−19	4.56
3.375	Feb 08n	99:20	99:21	−1	3.49	6.125	Nov 27	122:00	122:01	−18	4.56
2.625	May 08n	97:08	97:09	−2	3.51	3.625	Apr 28i	135:09	135:10	−29	1.76
5.625	May 08n	106:12	106:13	−2	3.51	5.500	Aug 28	113:16	113:17	−17	4.56
3.250	Aug 08n	99:00	99:01	−2	3.54	5.250	Nov 28	110:00	110:00	−17	4.55
3.125	Sep 08n	98:17	98:18	−2	3.56	5.250	Feb 29	110:04	110:05	−18	4.55
3.125	Oct 08n	98:15	98:16	−2	3.56	3.875	Apr 29i	141:16	141:17	−36	1.76
3.375	Nov 08n	99:09	99:10	−1	3.57	6.125	Aug 29	123:04	123:05	−18	4.55
4.750	Nov 08n	104:04	104:05	−2	3.55	6.250	May 30	125:15	125:16	−19	4.54
3.375	Dec 08n	99:08	99:09	−2	3.58	**5.375**	**Feb 31**	**113:21**	**113:22**	**−19**	**4.48**
3.250	Jan 09n	98:25	98:26	−2	3.58	3.375	Apr 32i	137:07	137:08	−32	1.66

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Self-Test 5.1

Find the 5.625 May 08 Treasury bond in Figure 5–2.

a. How much does it cost to buy the bond?
b. If you already owned the bond, how much would a bond dealer pay you for it?
c. By how much did the price change from the previous day?
d. What annual interest payment does the bond make?
e. What is the bond's yield to maturity?

5.2 Interest Rates and Bond Prices

In Figure 5–1 we set out the cash flows received by an investor in 5.5 percent Treasury bonds. How much would you have been willing to pay for these cash flows? The value of a security is the present value of the cash flows it will pay to its owners. To find this value, we need to discount each future payment by the current interest rate.

The 5.5s were not the only Treasury bonds that matured in 2008. Almost identical bonds maturing at the same time offered an interest rate of about 3.5 percent. So, if the 5.5s had offered a lower return than 3.5 percent, no one would have been willing to hold them. Equally, if they had offered a *higher* return, everyone would have rushed to sell their other bonds and buy the 5.5s. In other words, if investors were on their toes, the 5.5s had to offer the same 3.5 percent rate of interest as similar Treasury bonds. You might recognize 3.5 percent as the opportunity cost of the funds invested in the bond, as we discussed in Chapter 2. This is the rate that investors could earn by placing their funds in similar securities rather than in this bond.

We can now calculate the present value of the 5.5s of 2008 by discounting the cash flows at 3.5 percent:

$$\text{PV} = \frac{\$55}{(1+r)} + \frac{\$55}{(1+r)^2} + \frac{\$1{,}055}{(1+r)^3}$$

$$= \frac{\$55}{(1.035)} + \frac{\$55}{(1.035)^2} + \frac{\$1{,}055}{(1.035)^3} = \$1{,}056.03$$

Bond prices are usually expressed as a percentage of their face value. Thus we can say that our 5.5 percent Treasury bond is worth 105.603 percent of face value, and its price would usually be quoted as 105.603, or about $105\frac{19}{32}$. (The price of the bond shown in Figure 5–2 is $105\frac{23}{32}$, which is slightly higher than our calculation. This is largely due to rounding error in the interest rate we have used to discount the bond's cash flows.)

Did you notice that the coupon payments on the bond are an annuity? In other words, the holder of our 5.5 percent Treasury bond receives a level stream of coupon payments of $55 a year for each of 3 years. At maturity the bondholder gets an additional payment of $1,000. Therefore, you can use the annuity formula to value the coupon payments and then add on the present value of the final payment of face value:

$$\textbf{PV} = \textbf{PV(coupons)} + \textbf{PV(face value)}$$

$$= \textbf{(coupon} \times \textbf{annuity factor)} + \textbf{(face value} \times \textbf{discount factor)}$$

$$= \$55 \times \left[\frac{1}{.035} - \frac{1}{.035(1.035)^3}\right] + 1{,}000 \times \frac{1}{1.035^3}$$

$$= \$154.09 + \$901.94 = \$1{,}056.03$$

If you need to value a bond with many years to run before maturity, it is usually easiest to value the coupon payments as an annuity and then add on the present value of the final payment.

Self-Test 5.2

Calculate the present value of a 6-year bond with a 9 percent coupon. The interest rate is 12 percent.

EXAMPLE 5.1 ▶ Bond Prices and Semiannual Coupon Payments

Thus far we've assumed that interest payments occur annually. This is the case for bonds in many European countries, but in the United States most bonds make coupon payments *semiannually.* So when you hear that a bond in the United States has a coupon rate of 5.5 percent, you can generally assume that the bond makes a payment of \$55/2 = \$27.50 every 6 months. Similarly, when investors in the United States refer to the bond's interest rate, they usually mean the semiannually compounded interest rate. Thus an interest rate quoted at 3.5 percent really means that the 6-month rate is 3.5/2 = 1.75 percent.[3] The actual cash flows on the Treasury bond are illustrated in Figure 5–3. To value the bond a bit more precisely, we should have discounted the series of semiannual payments by the semiannual rate of interest as follows:

$$\text{PV} = \frac{\$27.50}{(1.0175)} + \frac{\$27.50}{(1.0175)^2} + \frac{\$27.50}{(1.0175)^3} + \frac{\$27.50}{(1.0175)^4} + \frac{\$27.50}{(1.0175)^5} + \frac{\$1{,}027.50}{(1.0175)^6}$$
$$= \$1{,}056.49$$

Thus, once we allow for the fact that coupon payments are semiannual, the value of the 5.5s is 105.649 percent of face value, which is slightly higher than the value that we obtained when we assumed annual coupon payments.[4] Since semiannual coupon payments just add to the arithmetic, we will often stick to our simplification and assume annual interest payments. ◀

How Bond Prices Vary with Interest Rates

As interest rates change, so do bond prices. For example, suppose that investors demanded an interest rate of 5.5 percent on 3-year Treasury bonds. What would be the price of the Treasury 5.5s of 2008? Just repeat the last calculation with a discount rate of $r = .055$:

$$\text{PV at } 5.5\% = \frac{\$55}{(1.055)} + \frac{\$55}{(1.055)^2} + \frac{\$1{,}055}{(1.055)^3} = \$1{,}000.00$$

Thus when the interest rate is the same as the coupon rate (5.5 percent in our example), the bond sells for its face value.

We first valued the Treasury bond using an interest rate of 3.5 percent, which is lower than the coupon rate. In that case the price of the bond was *higher* than its face value. We then valued it using an interest rate that is equal to the coupon and found that bond price equaled face value. You have probably already guessed that when the

[3] You may have noticed that the semiannually compounded interest rate on the bond is also the bond's APR, although this term is not generally used by bond investors. To find the effective rate, we can use a formula that we presented in Section 4.6:

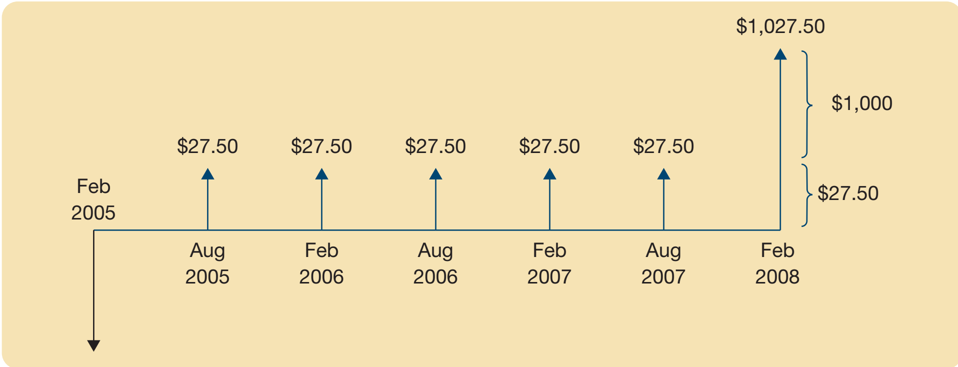
$$\text{Effective annual rate} = \left(1 + \frac{\text{APR}}{m}\right)^m - 1$$

where m is the number of payments each year. In the case of our Treasury bond,

$$\text{Effective annual rate} = \left(1 + \frac{.035}{2}\right)^2 - 1 = 1.0175^2 - 1 = .0353, \text{ or } 3.53\%$$

[4] Why is the present value a bit higher in this case? Because now we recognize that half the annual coupon payment is received only 6 months into the year, rather than at year-end. Since part of the coupon income is received earlier, its present value is higher. The value we find is still a bit below the price shown in *The Wall Street Journal.* This is because we originally rounded the interest rate up to 3.5 percent.

FIGURE 5–3 Cash flows to an investor in the 5.5 percent coupon bond maturing in 2008. The bond pays semiannual coupons, so there are two payments of $27.50 each year.



cash flows are discounted at a rate that is *higher* than the bond's coupon rate, the bond is worth *less* than its face value. The following example confirms that this is the case.

EXAMPLE 5.2 ► Interest Rates and Bond Prices

Investors will pay $1,000 for a 5.5 percent, 3-year Treasury bond when the interest rate is 5.5 percent. Suppose that the interest rate is higher than the coupon rate at (say) 15 percent. Now what is the value of the bond? Simple! We just repeat our initial calculation but with $r = .15$:

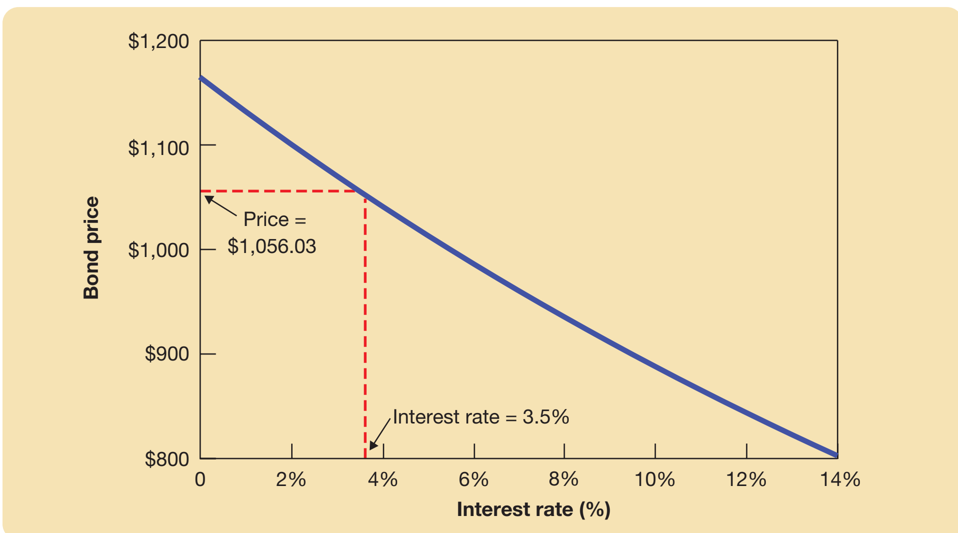
$$\text{PV at 15\%} = \frac{\$55}{(1.15)} + \frac{\$55}{(1.15)^2} + \frac{\$1{,}055}{(1.15)^3} = \$783.09$$

The bond sells for 78.31 percent of face value. ◄

This is a general result. When the market interest rate exceeds the coupon rate, bonds sell for less than face value. When the market interest rate is below the coupon rate, bonds sell for more than face value.

Suppose that interest rates rise. On hearing the news, bond investors appear disconsolate. Why? Don't they like higher interest rates? If you are not sure of the answer, look at Figure 5–4, which shows the present value of the 5.5 percent Treasury bond for different interest rates. For example, imagine yields soar from 3.5 to 10 percent. Our bond would then be worth less than $900, creating a loss to bondholders of some 16 percent. Conversely, bondholders have reason to celebrate when market

FIGURE 5–4 The value of the 5.5 percent bond falls as interest rates rise.



interest rates fall. You can see this also from Figure 5–4. For instance, if interest rates fall to 2 percent, the value of our 5.5 percent bond would increase to $1,100.

Figure 5–4 also illustrates a fundamental relationship between interest rates and bond prices: When the interest rate rises, the present value of the payments to be received by the bondholder falls and bond prices fall. Conversely, declines in the interest rate increase the present value of those payments and result in higher prices.

A warning! People sometimes confuse the interest, or coupon, *payment* on the bond with the *interest rate*—that is, the return that investors require. The $55 coupon payments on our Treasury bond are fixed when the bond is issued. The coupon rate, 5.5 percent, measures the coupon payment ($55) as a percentage of the bond's face value ($1,000) and is therefore also fixed. However, the interest rate changes from day to day. These changes affect the *present value* of the coupon payments but not the payments themselves.

5.3 Current Yield and Yield to Maturity

Suppose you are considering the purchase of a 3-year bond with a coupon rate of 10 percent. Your investment adviser quotes a price for the bond. How do you calculate the rate of return the bond offers?

For bonds priced at face value the answer is easy. The rate of return is the coupon rate. We can check this by setting out the cash flows on your investment:

	Cash Paid to You in Year:			
You Pay	1	2	3	Rate of Return
$1,000	$100	$100	$1,100	10%

Notice that in each year you earn 10 percent on your money ($100/$1,000). In the final year you also get back your original investment of $1,000. Therefore, your total return is 10 percent, the same as the coupon rate.

Now suppose that the market price of the 3-year bond is $1,136.16. Your cash flows are as follows:

	Cash Paid to You in Year:			
You Pay	1	2	3	Rate of Return
$1,136.16	$100	$100	$1,100	?

current yield Annual coupon payments divided by bond price.

What's the rate of return now? Notice that you are paying out $1,136.16 and receiving an annual income of $100. So your income as a proportion of the initial outlay is $100/$1,136.16 = .088, or 8.8 percent. This is sometimes called the bond's **current yield.**

However, total return depends on both interest income and any capital gains or losses. A current yield of 8.8 percent may sound attractive only until you realize that the bond's price must fall. The price today is $1,136.16, but when the bond matures 3 years from now, the bond will sell for its face value, or $1,000. A price decline (i.e., a *capital loss*) of $136.16 is guaranteed, so the overall return over the next 3 years must be less than the 8.8 percent current yield.

Let us generalize. A bond that is priced above its face value is said to sell at a *premium.* Investors who buy a bond at a premium face a capital loss over the life of the bond, so the return on these bonds is always less than the bond's current yield. A bond priced below face value sells at a *discount.* Investors in discount bonds face a capital *gain* over the life of the bond; the return on these bonds is *greater* than the current yield: Because it focuses only on current income and ignores prospective price increases or decreases, the *current* yield does not measure the bond's total rate of return. It overstates the return of premium bonds and understates that of discount bonds.

yield to maturity Interest rate for which the present value of the bond's payments equals the price.

We need a measure of return that takes account of both coupon payments and the change in a bond's value over its life. The standard measure is called **yield to maturity.** The yield to maturity is the answer to the following question: At what interest rate would the bond be correctly priced? The yield to maturity is defined as the discount rate that makes the present value of the bond's payments equal to its price.

If you can buy the 3-year bond at face value, the yield to maturity is the coupon rate, 10 percent. We can check this by noting that when we discount the cash flows at 10 percent, the present value of the bond is equal to its $1,000 face value:

$$\text{PV at 10\%} = \frac{\$100}{(1.10)} + \frac{\$100}{(1.10)^2} + \frac{\$1{,}100}{(1.10)^3} = \$1{,}000.00$$

But suppose the price of the 3-year bond is $1,136.16. In this case the yield to maturity is only 5 percent. At that discount rate, the bond's present value equals its actual market price, $1,136.16:

$$\text{PV at 5\%} = \frac{\$100}{(1.05)} + \frac{\$100}{(1.05)^2} + \frac{\$1{,}100}{(1.05)^3} = \$1{,}136.16$$

EXAMPLE 5.3 ▶ Calculating Yield to Maturity for the Treasury Bond

We found the value of the 5.5 percent coupon Treasury bond by discounting at a 3.5 percent interest rate. We could have phrased the question the other way around: If the price of the bond is $1,056.03, what return do investors expect? We need to find the yield to maturity, in other words, the discount rate *r,* that solves the following equation:

$$\text{Price} = \frac{\$55}{(1+r)} + \frac{\$55}{(1+r)^2} + \frac{\$1{,}055}{(1+r)^3} = \$1{,}056.03$$

To find the yield to maturity, most people use either a financial calculator or a spreadsheet. For our Treasury bond you would enter a PV on your calculator of $1,056.03.[5] The bond provides a regular payment of $55, entered as PMT = 55. The bond has a future value of $1,000, so FV = 1,000. The bond life is 3 years, so $n = 3$. Now compute the interest rate, and you will find that the yield to maturity is 3.5 percent. The nearby boxes review the use of spreadsheets and financial calculators in bond valuation problems. ◀

The yield to maturity is a measure of a bond's total return, including both coupon income and capital gain. If an investor buys the bond today and holds it to maturity, his or her return will be the yield to maturity. Bond investors often refer loosely to a bond's "yield." It's a safe bet that they are talking about its yield to maturity rather than its current yield.

The only *general* procedure for calculating yield to maturity is trial and error. You guess at an interest rate and calculate the present value of the bond's payments. If the present value is greater than the actual price, your discount rate must have been too low, so you try a higher interest rate (since a higher rate results in a lower PV). Conversely, if PV is less than price, you must reduce the interest rate. When a financial

[5] Actually, on most calculators you would enter this as a negative number, –1,056.03, because the purchase of the bond represents a cash *outflow.* See the nearby box on financial calculators.

FINANCIAL CALCULATOR

Bond Valuation on a Financial Calculator

In Chapter 4 we saw that financial calculators can compute the present values of level annuities as well as the present values of one-time future cash flows. Coupon bonds present both of these characteristics: The coupon payments are level annuities, and the final payment of face value is an additional one-time payment. Thus for the coupon bond we looked at in Example 5.3, you would treat the periodic payment as PMT = \$55, the final or future one-time payment as FV = \$1,000, the number of periods as n = 3 years, and the interest rate as the yield to maturity of the bond, i = 3.5 percent. You would thus compute the value of the bond using the following sequence of key strokes. By the way, the order in which the various inputs for the bond valuation problem are entered does not matter.

Hewlett-Packard HP-10B	Sharp EL-733A	Texas Instruments BA II Plus
55 PMT	55 PMT	55 PMT
1000 FV	1000 FV	1000 FV
3 N	3 n	3 N
3.5 I/YR	3.5 i	3.5 I/Y
PV	COMP PV	CPT PV

Your calculator should now display a value of –1,056.03. The minus sign reminds us that the initial cash flow is negative: You have to pay to buy the bond.

You can also use the calculator to find the yield to maturity of a bond. For example, if you buy this bond for \$1,056.03, you should find that its yield to maturity is 3.5 percent. Let's check that this is so. You enter the PV as –1,056.03 because you buy the bond for this price. Thus to solve for the interest rate, use the following key strokes:

Hewlett-Packard HP-10B	Sharp EL-733A	Texas Instruments BA II Plus
55 PMT	55 PMT	55 PMT
1000 FV	1000 FV	1000 FV
3 N	3 n	3 N
–1056.03 PV	–1056.03 PV	–1056.03 PV
I/YR	COMP i	CPT I/Y

Your calculator should now display 3.5 percent, the yield to maturity of the bond.

calculator or spreadsheet program finds a bond's yield to maturity, it uses a similar trial-and-error process.

EXAMPLE 5.4 ▶ Yield to Maturity with Semiannual Coupon Payments

Let's redo Example 5.3, but this time we assume the coupons are paid semiannually. Instead of three annual coupons of \$55, the bond makes six semiannual payments of \$27.50. We can find the *semiannual* yield to maturity on our calculators by using these inputs: n = 6 (semiannual) periods, PV = –1,056.03, FV = 1,000, PMT = 27.50. We then compute the interest rate to find that it is 1.76 percent. This of course is a 6-month, not an annual, rate. Bond dealers typically annualize the semiannual rate by doubling it, so the yield to maturity would be quoted as 1.76 × 2 = 3.52 percent. [In Excel (see the nearby box), you can confirm that =YIELD(DATE(2005,2,15),DATE(2008,2,15),.055,105.603,100,2) = .0352.] A better way to annualize would be to account for compound interest. A dollar invested at 1.76 percent for two 6-month periods would grow to \$1 × $(1.0176)^2$ = \$1.0355. The *effective* annual yield is therefore 3.55 percent. ◀

Self-Test 5.3

A 4-year maturity bond with a 14 percent coupon rate can be bought for \$1,200. What is the yield to maturity if the coupon is paid annually? What if it is paid semiannually? You will need a spreadsheet or a financial calculator to answer this question.

5.4 Bond Rates of Return

When you invest in a bond, you receive a regular coupon payment. As bond prices change, you may also make a capital gain or loss. For example, suppose you buy the 5.5 percent Treasury bond today for a price of \$1,056.03 and sell it next year at a price

SPREADSHEET SOLUTIONS

Bond Valuation

Excel and most other spreadsheet programs provide built-in functions to compute bond values and yields. They typically ask you to input both the date you buy the bond (called the *settlement date*) and the maturity date of the bond.

The Excel function for bond value is

=PRICE(settlement date, maturity date, annual coupon rate, yield to maturity, final payment, number of coupon payments per year).

An interactive version of this spreadsheet can be found at **www.mhhe.com/bmm5e** or on the Student CD.

For our 5.5 percent coupon bond, we would enter the values in column B in the spreadsheet below. Alternatively, we could simply enter the following function in Excel:

=PRICE(DATE(2005,02,15),DATE(2008,02,15), .055,.035,100,1).

The DATE function in Excel, which we use for both the settlement and maturity date, uses the format DATE (year,month,day).

Notice that the coupon rate and yield to maturity are expressed as decimals, not percentages. In most cases, final payment will be 100 (i.e., 100 percent of face value), and the resulting price will be expressed as a percent of face value. Occasionally, however, you may encounter bonds that pay off at a premium or discount to face value.

The value of the bond, assuming annual coupon payments, is 105.603 percent of face value, or $1,056.03. If we wanted to assume semiannual coupon payments, we would simply change the entry in cell B12 to 2, and the bond value would change to 105.649 percent of face value, as we found in Example 5.1.

	A	B	C	D	E	F
1						
2		Valuing bonds using a spreadsheet				
3						
4		6.5% coupon		6% coupon		
5		maturing May 2005		10-year maturity		
6						
7	Settlement date	5/15/02		1/1/00		
8	Maturity date	5/15/05		1/1/10		
9	Annual coupon rate	0.065		0.06		
10	Yield to maturity	0.039		0.07		
11	Final payment (% of face value)	100		100		
12	Coupon payments per year	1		1		
13						
14	Bond price (% of par)	107.229		92.976		
15						
16						
17		The formula entered here is: =PRICE(B7,B8,B9,B10,B11,B12)				

FPO

excel

Please visit us at www.mhhe.com/bmm5e or refer to your Student CD

rate of return Total income per period per dollar invested.

of $1,080. The return on your investment is the $55 coupon payment plus the price change of ($1,080 – $1,056.03) = $23.97. The **rate of return** on your investment of $1,056.03 is

$$\textbf{Rate of return} = \frac{\textbf{coupon income + price change}}{\textbf{investment}}$$

$$= \frac{\$55 + \$23.97}{\$1{,}056.03} = .0748, \text{ or } 7.48\%$$

Because bond prices fall when market interest rates rise and rise when market rates fall, the rate of return that you earn on a bond also will fluctuate with market interest rates. This is why we say bonds are subject to interest rate risk.

Do not confuse the bond's rate of return over a particular investment period with its yield to maturity. The yield to maturity is defined as the discount rate that equates the bond's price to the present value of all its promised cash flows. It is a measure of the average rate of return you will earn over the bond's life if you hold it to maturity. In contrast, the rate of return can be calculated for any particular holding period and is based on the actual income and the capital gain or loss on the bond over that period. The difference between yield to maturity and rate of return for a particular period is emphasized in the following example.

In this example, we assume that the first coupon payment comes in exactly one period (either a year or a half-year). In other words, the settlement date is precisely at the beginning of the period. However, the PRICE function will make the necessary adjustments for intraperiod purchase dates.

Suppose now that you wish to find the price of a 10-year maturity bond with a coupon rate of 6 percent (paid annually), selling at a yield to maturity of 7 percent. You are not given a specific settlement or maturity date. You can still use the PRICE function to value the bond. Simply choose an arbitrary settlement date (January 1, 2000 is convenient) and let the maturity date be 10 years hence. The appropriate inputs appear in column D of the spreadsheet on the previous page, with the resulting price, 92.976 percent of face value, appearing in cell D14. You can confirm this value on your calculator using the inputs: n = 10, i = 7, FV = 1000, PMT = 60.

Excel also provides a function for yield to maturity. It is

=YIELD(settlement date, maturity date, annual coupon rate, bond price, final payment as percent of face value, number of coupon payments per year).

For example, to find the yield to maturity in Example 5.3, we would use column B in the spreadsheet below. If the coupons were paid semiannually, as in Example 5.4, we would change the entry for payments per year to 2 (see cell D12), and the yield would increase to 3.52 percent.

	A	B	C	D	E	F	G
1							
2			Finding yield to maturity using a spreadsheet				
3		May 2005 maturity bond, coupon rate = 6.5%, maturity = 3 years					
4							
5		Annual coupons		Semiannual coupons			
6							
7	Settlement date	5/15/02		5/15/02			
8	Maturity date	5/15/05		5/15/05			
9	Annual coupon rate	0.065		0.065			
10	Bond price	107.229		107.229			
11	Final payment (% of face value)	100		100			
12	Coupon payments per year	1		2			
13							
14	**Yield to maturity (decimal)**	**0.0390**		**0.0392**			
15							
16							
17		The formula entered here is: =YIELD(B7,B8,B9,B10,B11,B12)					

excel

Please visit us at www.mhhe.com/bmm5e or refer to your Student CD

EXAMPLE 5.5 ▶ Rate of Return versus Yield to Maturity

Our 5.5 percent coupon bond with maturity 2008 currently has 3 years left until maturity and sells today for $1,056.03. Its yield to maturity is 3.5 percent. Suppose that by the end of the year, interest rates have fallen and the bond's yield to maturity is now only 2.0 percent. What will be the bond's rate of return?

At the end of the year, the bond will have only 2 years to maturity. If investors then demand an interest rate of 2.0 percent, the value of the bond will be

$$\text{PV at 2.0\%} = \frac{\$55}{(1.020)} + \frac{\$1{,}055}{(1.020)^2} = \$1{,}067.95$$

You invested $1,056.03. At the end of the year you receive a coupon payment of $55 and have a bond worth $1,067.95. Your rate of return is therefore

$$\text{Rate of return} = \frac{\$55 + (\$1{,}067.95 - \$1{,}056.03)}{\$1{,}056.03} = .0634, \text{ or } 6.34\%$$

The yield to maturity at the start of the year was 3.5 percent. However, because interest rates fell during the year, the bond price rose and this increased the rate of return. ◀

Self-Test 5.4

Suppose that the bond's yield to maturity had risen to 5 percent during the year. Confirm that its rate of return would have been less than the yield to maturity.

Is there *any* connection between yield to maturity and the rate of return during a particular period? Yes: If the bond's yield to maturity remains unchanged during an investment period, its rate of return will equal that yield. We can check this by assuming that the yield on 5.5 percent Treasury bonds stays at 3.5 percent. If investors still demand an interest rate of 3.5 percent at the end of the year, the value of the bond will be

$$PV = \frac{\$55}{(1.035)} + \frac{\$1,055}{(1.035)^2} = \$1,037.99$$

At the end of the year you receive a coupon payment of \$55 and have a bond worth \$1,037.99, slightly less than you paid for it. Your total profit is \$55 + (\$1,037.99 − \$1,056.03) = \$36.96. The return on your investment is therefore \$36.96/\$1,056.03 = .035, or 3.5 percent, just equal to the yield to maturity.

When interest rates do not change, the bond price changes with time so that the total return on the bond is equal to the yield to maturity. If the bond's yield to maturity increases, the rate of return during the period will be less than that yield. If the yield decreases, the rate of return will be greater than the yield.

Self-Test 5.5

Suppose you buy the bond next year for \$1,037.99, and hold it for yet another year, so that at the end of that time it has only 1 year to maturity. Show that if the bond's yield to maturity is still 3.5 percent, your rate of return also will be 3.5 percent and the bond price will be \$1,019.32.

The solid curve in Figure 5–5 plots the price of a 30-year maturity, 5.5 percent Treasury bond over time assuming that its yield to maturity is currently 3.5 percent and remains at 3.5 percent. The price declines gradually until the maturity date, when it finally reaches face value. In each period, the price decline offsets the coupon income by just enough to reduce total return to 3.5 percent. The dashed curve in Figure 5–5 shows the corresponding price path for a bond with a 2 percent coupon that sells at a discount to face value. In this case, the coupon income would provide less than a competitive rate of return, so the bond sells below face value. Its price gradually approaches face value, however, and the price gain each year brings its total return up to the market interest rate.

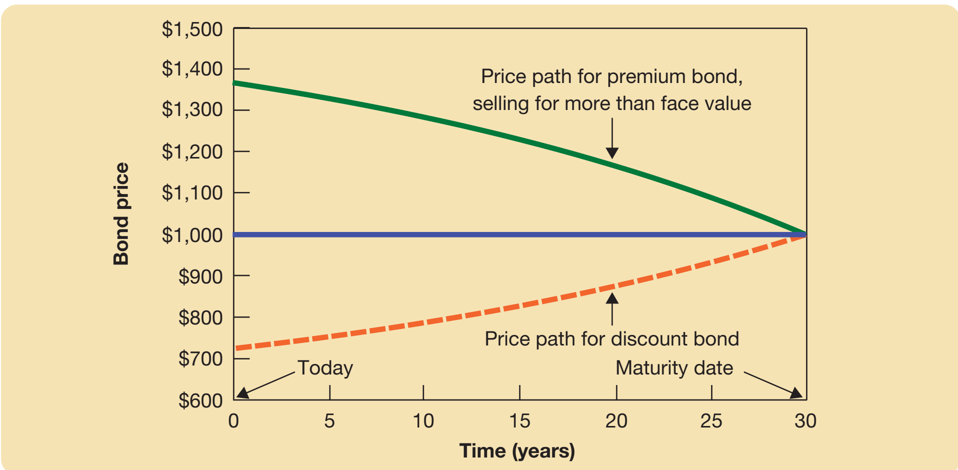


FIGURE 5–5 Bond prices over time, assuming an unchanged yield to maturity. Prices of both premium and discount bonds approach face value as their maturity date approaches.

Interest Rate Risk

interest rate risk
The risk in bond prices due to fluctuations in interest rates.

We have seen that bond prices fluctuate as interest rates change. In other words, bonds exhibit **interest rate risk.** Bond investors cross their fingers that market interest rates will fall, so that the price of their bond will rise. If they are unlucky and the market interest rate rises, the value of their investment falls.

But all bonds are not equally affected by changing interest rates. Compare the two curves in Figure 5–6. The green line shows how the value of the 3-year, 5.5 percent coupon bond varies with the level of the interest rate. The purple line shows how the price of a 30-year, 5.5 percent bond varies with the level of interest rates. You can see that the 30-year bond is more sensitive to interest rate fluctuations than the 3-year bond. This should not surprise you. If you buy a 3-year bond when the market interest rate is 5.5 percent and rates then rise, you will be stuck with a bad deal—you have just loaned your money at a lower rate than it would have been if you had waited. However, think how much worse it would be if the loan had been for 30 years rather than 3 years. The longer the loan, the more income you have lost by accepting what turns out to be a low interest rate. This shows up in a bigger decline in the price of the longer-term bond. Of course, there is a flip side to this effect, which you can also see from Figure 5–6. When interest rates fall, the longer-term bond responds with a greater increase in price.

Self-Test 5.6

Suppose that the market interest rate rises overnight from 3.5 percent to 8 percent. Calculate the present values of the 5.5 percent, 3-year bond and of the 5.5 percent, 30-year bond both before and after this change in interest rates. Confirm that your answers correspond with Figure 5–6. Use your financial calculator or a spreadsheet.

5.5 The Yield Curve

yield curve
Graph of the relationship between time to maturity and yield to maturity.

Look back for a moment to Figure 5–2. The U.S. Treasury bonds are arranged in order of their maturity. Notice that the longer the maturity, the higher the yield. This is usually the case, though sometimes long-term bonds offer *lower* yields.

In addition to showing the yields on individual bonds, *The Wall Street Journal* also shows a daily plot of the relationship between bond yields and maturity. This is known as the **yield curve.** You can see from the yield curve in Figure 5–7 that bonds with 3

FIGURE 5–6 **Plots of bond prices as a function of the interest rate. Long-term bond prices are more sensitive to the interest rate than prices of short-term bonds.**

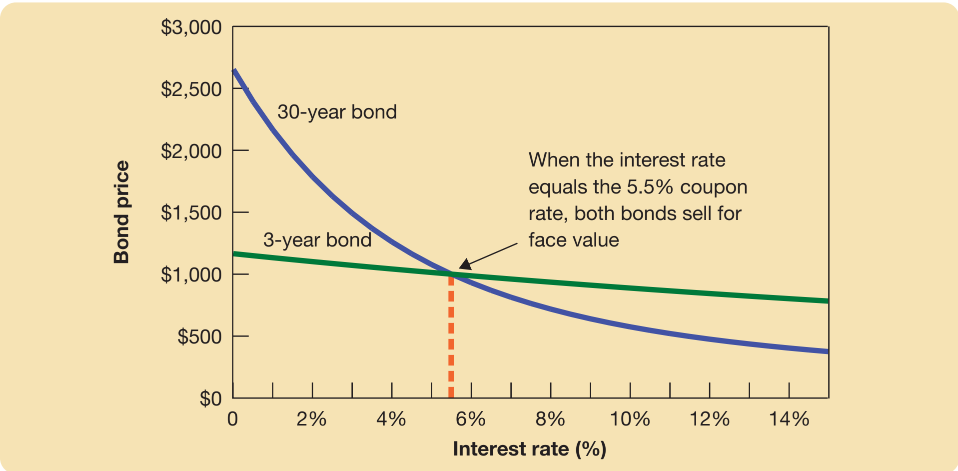
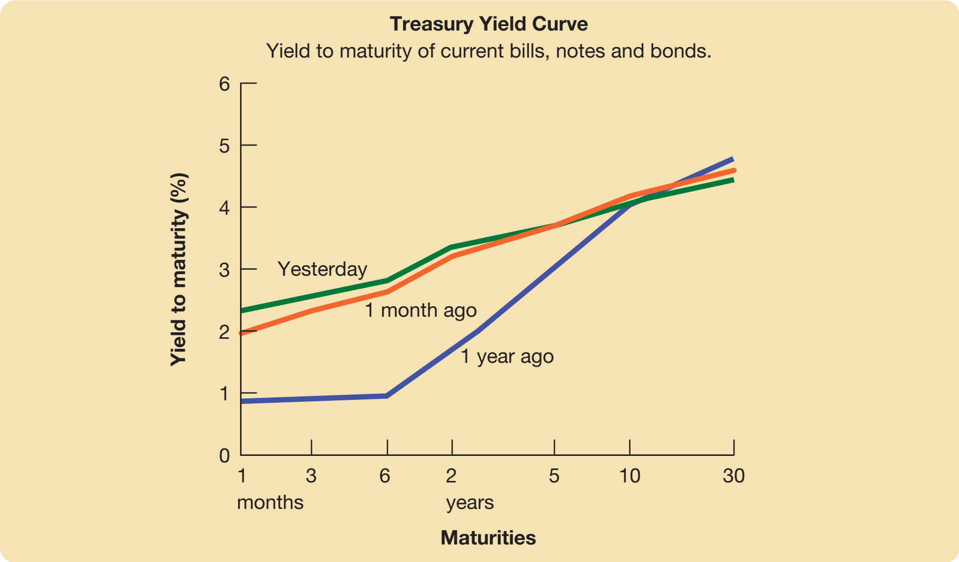


FIGURE 5–7 **The yield curve.** A plot of yield to maturity as a function of time to maturity for Treasury bonds on February 15, 2005.



Source: *Wall Street Journal* February 16, 2005.

months to maturity offered a yield of about 2.5 percent; those with 20 years to maturity offered a yield of about 4.5 percent.

Why didn't everyone buy long-maturity bonds and earn an extra 2 percentage points? Who were those investors who put their money into short-term Treasuries at only 2.5 percent?

Even when the yield curve is upward-sloping, investors might rationally stay away from long-term bonds for two reasons. First, the prices of long-term bonds fluctuate much more than prices of short-term bonds. Figure 5–6 illustrates that long-term bond prices are more sensitive to shifting interest rates. A sharp increase in interest rates could easily knock 20 or 30 percent off long-term bond prices. If investors don't like price fluctuations, they will invest their funds in short-term bonds unless they receive a higher yield to maturity on long-term bonds.

Second, short-term investors can profit if interest rates rise. Suppose you hold a 1-year bond. A year from now, when the bond matures, you can reinvest the proceeds and enjoy whatever rates the bond market offers then. Rates may be high enough to offset the first year's relatively low yield on the 1-year bond. Thus you often see an upward-sloping yield curve when future interest rates are expected to rise.

Nominal and Real Rates of Interest

In Chapter 4 we drew a distinction between nominal and real rates of interest. The cash flows on the 5.5 percent Treasury bonds are fixed in nominal terms. Investors are sure to receive an interest payment of \$55 each year, but they do not know what that money will buy them. The *real* interest rate on the Treasury bonds depends on the rate of inflation. For example, if the nominal rate of interest is 3.5 percent and the inflation rate is 2 percent, then the real interest rate is calculated as follows:

$$1 + \text{real interest rate} = \frac{1 + \text{nominal interest rate}}{1 + \text{inflation rate}} = \frac{1.035}{1.02} = 1.0147$$

$$\text{Real interest rate} = .0147 = 1.47\%$$

Since the inflation rate is uncertain, so is the real rate of interest on the Treasury bonds.

You *can* nail down a real rate of interest by buying an indexed bond, whose payments are linked to inflation. Indexed bonds have been available in some countries for many years, but they were almost unknown in the United States until 1997 when the U.S. Treasury began to issue inflation-indexed bonds known as *Treasury Inflation-*

Interest Rates and Bond Prices

Bond Calculator

Log on to **www.smartmoney.com** to find a simple bond calculator that shows how prices change as interest rates change. Check whether a change in yield has a greater effect on the price of a long-term or a short-term bond.

Yield Curve

In Figure 5–7 we showed a picture of the Treasury yield curve. When the pros want to see the relationship between yields of bonds with different maturities, they usually look at their Bloomberg terminals. You also can see the current yield curve by logging on to the Web site **www.bloomberg.com** and clicking on *U.S. Treasuries.* Usually yield curves slope upward. Is this still the case? Can you explain why? Notice that the same page also compares the yields on nominal Treasury bonds with those on TIPS. Suppose you are confident that inflation will be 2 percent. Which bonds are the better buy?

Back briefly to yield curves. Log on to **www.smartmoney.com** and find *The Living Yield Curve,* which provides a moving picture of the yield curve. How does today's yield curve compare with yield curves in the past? Do short-term interest rates move more or less than long-term rates?

Treasury Strips

You can also measure the yield curve by looking at the yields on *Treasury strips*. These are government bonds that make only a single payment at maturity. You can find these yields by logging on to the band screener at **finance.yahoo.com.** Try plotting the yields against maturity. How does the result compare with the Bloomberg yield curve?

Protected Securities, or *TIPS.* The real cash flows on TIPS are fixed, but the nominal cash flows (interest and principal) are increased as the consumer price index increases. For example, suppose the U.S. Treasury issues 3 percent, 2-year TIPS. The **real** cash flows on the 2-year TIPS are therefore

	Year 1	Year 2
Real cash flows	$30	$1,030

The *nominal* cash flows on TIPS depend on the inflation rate. For example, suppose inflation turns out to be 5 percent in year 1 and a further 4 percent in year 2. Then the *nominal* cash flows would be

	Year 1	Year 2
Nominal cash flows	$\$30 \times 1.05 = \$31.50$	$\$1{,}030 \times 1.05 \times 1.04 = \$1{,}124.76$

These cash payments are just sufficient to provide the holder with a 3 percent real rate of interest.

As we write this in early 2005, five-year TIPS offer a yield of 1.2 percent. This yield is a *real* interest rate. It measures the amount of extra goods your investment will allow you to buy. The 1.2 percent real yield on TIPS is 3.0 percent less than the 4.2 percent yield on nominal 5-year Treasury bonds.[6] If the annual inflation rate proves to be higher than 3.0 percent, you will earn a higher return by holding TIPS; if the

[6] You can identify the TIPS bonds in Figure 5–2 by the *i* that appears after the maturity date. You will see that the reported yields to maturity on these bonds are lower than those on the nominal bonds.

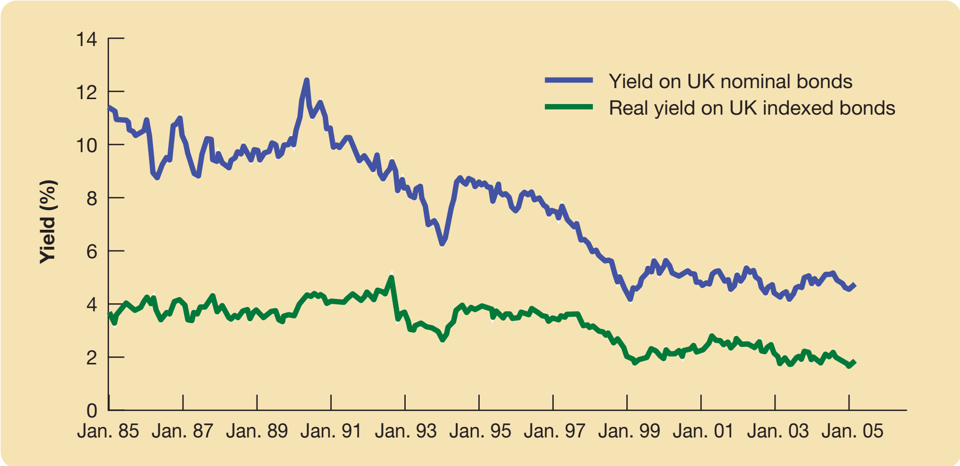


FIGURE 5–8 The bottom line shows the real yield on long-term indexed bonds issued by the UK government. The top line shows the yield on UK government long-term nominal bonds. Notice that the real yield has been much more stable than the nominal yield.

inflation rate is lower than 3.0 percent, the reverse will be true. The nearby box discusses the case for investments in TIPS.

Real interest rates depend on the supply of savings and the demand for new investment. As this supply–demand balance changes, real interest rates change. But they do so gradually. We can see this by looking at the United Kingdom, where the government has issued indexed bonds since 1982. The green line in Figure 5–8 shows that the (real) interest rate on these bonds has fluctuated within a relatively narrow range.

Suppose that investors revise upward their forecast of inflation by 1 percent. How will this affect interest rates? If investors are concerned about the purchasing power of their money, the changed forecast should not affect the real rate of interest. The *nominal* interest rate must therefore rise by 1 percent to compensate investors for the higher inflation prospects.

The blue line in Figure 5–8 shows the nominal rate of interest in the United Kingdom since 1985. You can see that the nominal rate is much more variable than the real rate. When investors were worried about inflation in the late 1980s, the nominal interest rate was about 7 percentage points above the real rate. As we write this in spring 2005, inflation fears have eased and the nominal interest rate in the United Kingdom is less than 3 percentage points above the real rate.

5.6 Corporate Bonds and the Risk of Default

Our focus so far has been on U.S. Treasury bonds. But the federal government is not the only issuer of bonds. State and local governments borrow by selling bonds.[7] So do corporations. Many foreign governments and corporations also borrow in the United States. At the same time U.S. corporations may borrow dollars or other currencies by issuing their bonds in other countries. For example, they may issue dollar bonds in London that are then sold to investors throughout the world.

There is an important distinction between bonds issued by corporations and those issued by the U.S. Treasury. National governments don't go bankrupt—they just print more money.[8] So investors do not worry that the U.S. Treasury will *default* on its

[7] These *municipal bonds* enjoy a special tax advantage; investors are exempt from federal income tax on the coupon payments on state and local government bonds. As a result, investors are prepared to accept lower yields on this debt.

[8] But they can't print money of other countries. Therefore, when a foreign government borrows dollars, investors worry that in some future crisis the government may not be able to come up with enough dollars to repay the debt. This worry shows up in the yield that investors demand on such debt. For example, in late 2001, the Argentine government defaulted on over $80 billion of debt. Bondholders were subsequently offered new bonds worth about a third of the face value of the defaulting bonds.

FINANCE IN PRACTICE

A New Leader in the Bond Derby?

With Wall Street pundits fixated on deflation, the idea of buying Treasury bonds that protect you against inflation seems as crazy as preparing for a communist takeover. But guess what? Treasury Inflation-Indexed Securities are actually a great deal right now. Even if the consumer price index rises only 1.7% annually over the next three decades—a mere tenth of a percentage point above the current rate—buy-and-hold investors will be better off with 30-year inflation-protected securities, commonly known as TIPS, than with conventional Treasuries.

TIPS have yet to catch on with individual investors, who have bought only a fraction of the $75 billion issued so far, says Dan Bernstein, research director at Bridgewater Associates, a Westport (Conn.) money manager. Individuals have shied away from TIPS because they're hard to understand and less liquid than ordinary Treasuries.

If you buy a conventional $1,000, 30-year bond at today's 5.5% rate, you are guaranteed $55 in interest payments each year, no matter what the inflation rate is, until you get your principal back in 2029. Let's say you buy TIPS, now yielding 3.9% plus an adjustment for the consumer price index, and inflation falls to 0.5% from the current 1.6%. Because of the lower inflation rate, you'll get only $44 annually. Nevertheless, even if the economy falls into deflation, you'll get the face value of the bonds back at maturity.

Less Volatile

But if inflation spikes up, TIPS would outshine conventional bonds. For example, a $1,000, 30-year TIPS with a 4% coupon would yield $40 in its first year. If inflation rises by three points, your principal would be worth $1,030. The $30 gain plus the interest would translate into a 7% total return.

TIPS are attractive for another reason: They're one-quarter to one-third as volatile as conventional Treasuries because of their built-in inflation protection. So investors who use them are less exposed to risk, says Christopher Kinney, a manager at Brown Brothers Harriman. As a result, a portfolio containing TIPS can have a higher percentage of its assets invested in stocks, potentially boosting returns without taking on more risk.

Even so, the price of TIPS can change. If the Federal Reserve hikes interest rates, they'll fall. If it lowers rates, they'll rise. That won't be a concern if you hold the TIPS until maturity, of course.

Source: Reprinted from April 5, 1999, issue of BusinessWeek by special permission, copyright © 1999 by the McGraw-Hill Companies.

bonds. However, there is some chance that corporations may get into financial difficulties and may default on their bonds. Thus the payments promised to corporate bondholders represent a best-case scenario: The firm will never pay more than the promised cash flows, but in hard times it may pay less.

default (or credit) risk The risk that a bond issuer may default on its bonds.

default premium The additional yield on a bond investors require for bearing credit risk.

The risk that a bond issuer may default on its obligations is called **default risk** (or **credit risk**). It should be no surprise to find that to compensate for this default risk companies need to promise a higher rate of interest than the U.S. Treasury when borrowing money. The difference between the promised yield on a corporate bond and the yield on a U.S. Treasury bond with the same coupon and maturity is called the **default premium.** The greater the chance that the company will get into trouble, the higher the default premium demanded by investors.

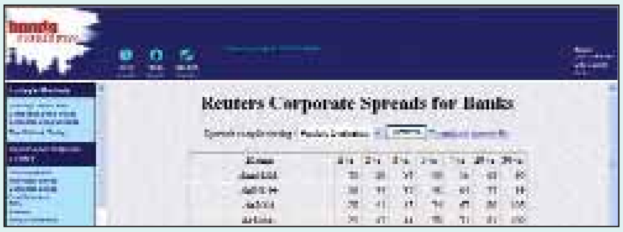
The safety of most corporate bonds can be judged from bond ratings provided by Moody's, Standard & Poor's, or other bond-rating firms. Table 5–1 lists the possible

TABLE 5–1 Key to Moody's and Standard & Poor's bond ratings. The highest-quality bonds are rated triple A, then come double-A bonds, and so on.

Moody's	Standard & Poor's	Safety
Aaa	AAA	The strongest rating; ability to repay interest and principal is very strong.
Aa	AA	Very strong likelihood that interest and principal will be repaid.
A	A	Strong ability to repay, but some vulnerability to changes in circumstances.
Baa	BBB	Adequate capacity to repay; more vulnerability to changes in economic circumstances.
Ba	BB	Considerable uncertainty about ability to repay.
B	B	Likelihood of interest and principal payments over sustained periods is questionable.
Caa	CCC	Bonds that may already be in default or in danger of imminent default.
Ca	CC	
C	C	Little prospect for interest or principal on the debt ever to be repaid.

INTERNET INSIDER

Bond Ratings and Yields



Bond Ratings

You can find the most recent bond rating for any company by logging on to the Web sites of one of the ratings companies, try www.fitchratings.com (you need to register to use Moody's and Standard & Poor's sites, but not the Fitch Web site). Try finding the bond rating for some sample companies. Were they investment-grade or below?

Default Spreads

In Figure 5–9 we showed how bonds with greater credit risk have promised higher yields to maturity. This yield spread goes up when the economic outlook is particularly uncertain. You can check how much extra yield low-grade bonds offer today by looking at the entry for corporate bond spreads on **www.bondsonline.com.** Is the yield spread greater for short-term or long-term bonds? Can you explain why? Incidentally, the Bondsonline Web site also offers some useful explanations of bond markets and a facility for searching for bonds with different characteristics.

bond ratings in declining order of quality. For example, the bonds that receive the highest Moody's rating are known as *Aaa* (or "triple A") bonds. Then come *Aa* ("double A"), *A, Baa* bonds, and so on. Bonds rated Baa and above are called **investment grade,** while those with a rating of Ba or below are referred to as *speculative grade, high-yield,* or **junk bonds.**

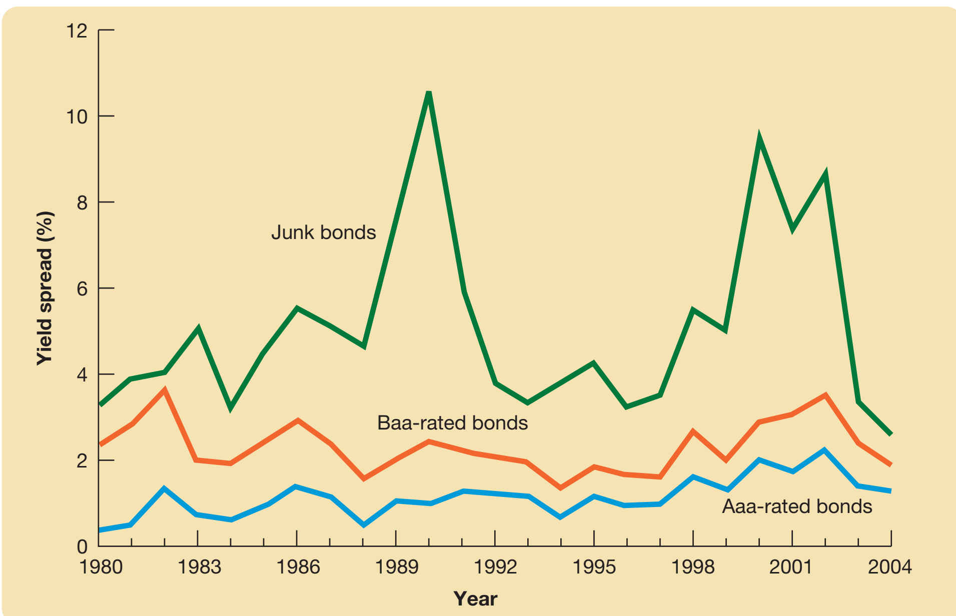
investment grade Bonds rated Baa or above by Moody's or BBB or above by Standard & Poor's.

junk bond Bond with a rating below Baa or BBB.

It is rare for highly rated bonds to default. For example, since 1971 fewer than 1 in 1,000 triple-A bonds have defaulted within 10 years of issue. However, when an investment-grade bond does default, the shock waves can be considerable. For example, in May 2001 WorldCom sold $11.8 billion of bonds with an investment-grade rating. Within little more than a year WorldCom filed for bankruptcy, and its bondholders lost more than 80 percent of their investment. For low-grade issues, defaults are less rare. For example, over half of the bonds that were rated CCC by Standard & Poor's at issue have defaulted within 10 years.

As you would expect, the yield on corporate bonds varies with the bond rating. Figure 5–9 shows the extra yield on corporate bonds compared with U.S. Treasuries. You

FIGURE 5–9 Yield spreads between corporate and 10-year Treasury bonds.



can see that the yield spreads rise as safety falls off. For example, as the economy went into recession in 1990, the promised yield on junk bonds climbed to more than 10 percent higher than the yield on Treasuries. You might have been tempted by the higher promised yields on the lower-grade bonds. But remember, these bonds do not always keep their promises.

EXAMPLE 5.6 ▶ Promised versus Expected Yield to Maturity

Bad Bet Inc. issued bonds several years ago with a coupon rate (paid annually) of 10 percent and face value of $1,000. The bonds are due to mature in 6 years. However, the firm is currently in bankruptcy proceedings, the firm has ceased to pay interest, and the bonds sell for only $200. Based on *promised* cash flow, the yield to maturity on the bond is 63.9 percent. (On your calculator, set PV = –200, FV = 1,000, PMT = 100, n = 6, and compute i.) But this calculation is based on the very unlikely possibility that the firm will resume paying interest and come out of bankruptcy. Suppose that the most likely outcome is that after 3 years of litigation, during which no interest will be paid, debtholders will receive 27 cents on the dollar—that is, they will receive $270 for each bond with $1,000 face value. In this case the expected return on the bond is 10.5 percent. (On your calculator, set PV = –200, FV = 270, PMT = 0, n = 3, and compute i.) When default is a real possibility, the promised yield can depart considerably from the expected return. In this example, the default premium is greater than 50 percent. ◀

Variations in Corporate Bonds

Most corporate bonds are similar to the 5.5 percent Treasury bonds that we examined earlier in the chapter. In other words, they promise to make a fixed nominal coupon payment for each year until maturity, at which point they also promise to repay the face value. However, you will find that there is greater variety in the design of corporate bonds. We will return to this issue in Chapter 13, but here are a few types of corporate bonds that you may encounter.

Zero-Coupon Bonds Corporations sometimes issue zero-coupon bonds. In this case, investors receive $1,000 face value at the maturity date but do not receive a regular coupon payment. In other words, the bond has a coupon rate of zero. You learned how to value such bonds in Chapter 4. These bonds are issued at prices considerably below face value, and the investor's return comes from the difference between the purchase price and the payment of face value at maturity.

Floating-Rate Bonds Sometimes the coupon rate can change over time. For example, floating-rate bonds make coupon payments that are tied to some measure of current market rates. The rate might be reset once a year to the current Treasury bill rate plus 2 percent. So if the Treasury bill rate at the start of the year is 6 percent, the bond's coupon rate over the next year would be set at 8 percent. This arrangement means that the bond's coupon rate always approximates current market interest rates.

Convertible Bonds If you buy a convertible bond, you can choose later to exchange it for a specified number of shares of common stock. For example, a convertible bond that is issued at face value of $1,000 may be convertible into 50 shares of the firm's stock. Because convertible bonds offer the opportunity to participate in any price appreciation of the company's stock, investors will accept lower interest rates on convertible bonds.

Bond issuers are always trying to invent new types of bonds that they hope will appeal to a particular clientele of investors. So, in addition to these fairly common types of bonds, you may also encounter some more peculiar beasts. Here are a couple of examples:

- Managers of insurance companies constantly worry about the possibility of a major hurricane or earthquake that could prompt a flood of costly claims. Some companies therefore shed part of the risk by issuing *catastrophe* (or *Cat*) *bonds.* Cat bonds promise relatively high returns, but the payments on the bond are reduced if a specified type of disaster occurs. Therefore, the bondholders help to provide insurance against catastrophes.
- Most of us hope for a long life. But longevity can create a problem for pension funds that are committed to paying out a regular sum each year until we die. Therefore, pension funds might value an opportunity to protect themselves against an increase in life expectancy. That is the idea behind the *longevity bond* issued by a French bank in 2004. Each year payments on the bond are higher if more of the population survives the extra year. If life expectancy increases, a pension fund may have to pay out for longer than it planned; but if it also owned a longevity bond, it would have the consolation of a boost to its investment income.

Cat bonds are fairly rare and longevity bonds even rarer; most corporate bonds are of the common or garden variety. But bond issuers are always on the lookout for innovative forms of debt that they hope will attract investors.

SUMMARY

What are the differences between the bond's coupon rate, current yield, and yield to maturity?

A bond is a long-term debt of a government or corporation. When you own a bond, you receive a fixed interest payment each year until the bond matures. This payment is known as the coupon. The **coupon rate** is the annual coupon payment expressed as a fraction of the bond's **face value.** At maturity the bond's face value is repaid. In the United States most bonds have a face value of $1,000. The **current yield** is the annual coupon payment expressed as a fraction of the bond's price. The **yield to maturity** measures the average rate of return to an investor who purchases the bond and holds it until maturity, accounting for coupon income as well as the difference between purchase price and face value.

How can one find the market price of a bond given its yield to maturity and find a bond's yield given its price? Why do prices and yields vary inversely?

Bonds are valued by discounting the coupon payments and the final repayment by the yield to maturity on comparable bonds. The bond payments discounted at the bond's yield to maturity equal the bond price. You may also start with the bond price and ask what interest rate the bond offers. The interest rate that equates the present value of bond payments to the bond price is called the yield to maturity. Because present values are lower when discount rates are higher, price and yield to maturity vary inversely.

Why do bonds exhibit interest rate risk?

Bond prices are subject to **interest rate risk,** rising when market interest rates fall and falling when market rates rise. Long-term bonds exhibit greater interest rate risk than short-term bonds.

Why do investors pay attention to bond ratings and demand a higher interest rate for bonds with low ratings?

Investors demand higher promised yields if there is a high probability that the borrower will run into trouble and default. **Credit risk** implies that the promised yield to maturity on the bond is higher than the expected yield. The additional yield investors require for bearing credit risk is called the **default premium.** Bond ratings measure the bond's credit risk.

QUIZ

1. **Bond Yields.** A 30-year Treasury bond is issued with face value of $1,000, paying interest of $60 per year. If market yields increase shortly after the T-bond is issued, what happens to the bond's
   a. coupon rate?
   b. price?
   c. yield to maturity?
   d. current yield?
2. **Bond Yields.** If a bond with face value of $1,000 and a coupon rate of 8 percent is selling at a price of $970, is the bond's yield to maturity more or less than 8 percent? What about the current yield?
3. **Bond Yields.** A bond with face value $1,000 has a current yield of 7 percent and a coupon rate of 8 percent. What is the bond's price?
4. **Bond Pricing.** A 6-year Circular File bond pays interest of $80 annually and sells for $950. What is its coupon rate, current yield, and yield to maturity?
5. **Bond Pricing.** If Circular File (see question 4) wants to issue a new 6-year bond at face value, what coupon rate must the bond offer?
6. **Bond Yields.** A bond has 10 years until maturity, a coupon rate of 8 percent, and sells for $1,100.
   a. What is the current yield on the bond?
   b. What is the yield to maturity?
7. **Coupon Rate.** General Matter's outstanding bond issue has a coupon rate of 10 percent and a current yield of 9.6 percent, and it sells at a yield to maturity of 9.25 percent. The firm wishes to issue additional bonds to the public at face value. What coupon rate must the new bonds offer in order to sell at face value?
8. **Financial Pages.** Turn back to Figure 5–2. What is the current yield of the 5.625 percent, May 2008 maturity bond? What was the closing asked price of the bond on the previous day?

PRACTICE PROBLEMS

9. **Bond Prices and Returns.** One bond has a coupon rate of 8 percent, another a coupon rate of 12 percent. Both bonds have 10-year maturities and sell at a yield to maturity of 10 percent. If their yields to maturity next year are still 10 percent, what is the rate of return on each bond? Does the higher coupon bond give a higher rate of return?

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10. **Bond Returns.**
    a. If the bond in Quiz question 6 has a yield to maturity of 8 percent 1 year from now, what will its price be?
    b. What will be the rate of return on the bond?
    c. If the inflation rate during the year is 3 percent, what is the real rate of return on the bond?

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11. **Bond Pricing.** A General Motors bond carries a coupon rate of 8 percent, has 9 years until maturity, and sells at a yield to maturity of 7 percent.
    a. What interest payments do bondholders receive each year?
    b. At what price does the bond sell? (Assume annual interest payments.)
    c. What will happen to the bond price if the yield to maturity falls to 6 percent?
12. **Bond Pricing.** A 30-year maturity bond with face value of $1,000 makes annual coupon payments and has a coupon rate of 8 percent. What is the bond's yield to maturity if the bond is selling for
    a. $900?
    b. $1,000?
    c. $1,100?

13. **Bond Pricing.** Repeat the previous problem assuming semiannual coupon payments.

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14. **Bond Pricing.** Fill in the table below for the following zero-coupon bonds. The face value of each bond is $1,000.

Price	Maturity (years)	Yield to Maturity
$300	30	__
$300	__	8%
__	10	10%

15. **Consol Bonds.** Perpetual Life Corp. has issued consol bonds with coupon payments of $60. (Consols pay interest forever and never mature. They are perpetuities.) If the required rate of return on these bonds at the time they were issued was 6 percent, at what price were they sold to the public? If the required return today is 10 percent, at what price do the consols sell?

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16. **Bond Pricing.** Sure Tea Co. has issued 9 percent annual coupon bonds that are now selling at a yield to maturity of 10 percent and current yield of 9.8375 percent. What is the remaining maturity of these bonds?
17. **Bond Pricing.** Large Industries bonds sell for $1,065.15. The bond life is 9 years, and the yield to maturity is 7 percent. What must be the coupon rate on the bonds?
18. **Bond Prices and Yields.**
    a. Several years ago, Castles in the Sand, Inc., issued bonds at face value at a yield to maturity of 7 percent. Now, with 8 years left until the maturity of the bonds, the company has run into hard times and the yield to maturity on the bonds has increased to 15 percent. What has happened to the price of the bond?
    b. Suppose that investors believe that Castles can make good on the promised coupon payments, but that the company will go bankrupt when the bond matures and the principal comes due. The expectation is that investors will receive only 80 percent of face value at maturity. If they buy the bond today, what yield to maturity do they expect to receive?
19. **Bond Returns.** You buy an 8 percent coupon, 10-year maturity bond for $980. A year later, the bond price is $1,100.
    a. What is the new yield to maturity on the bond?
    b. What is your rate of return over the year?
20. **Bond Returns.** You buy an 8 percent coupon, 20-year maturity bond when its yield to maturity is 9 percent. A year later, the yield to maturity is 10 percent. What is your rate of return over the year?

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21. **Interest Rate Risk.** Consider three bonds with 8 percent coupon rates, all selling at face value. The short-term bond has a maturity of 4 years, the intermediate-term bond has maturity 8 years, and the long-term bond has maturity 30 years.
    a. What will happen to the price of each bond if their yields increase to 9 percent?
    b. What will happen to the price of each bond if their yields decrease to 7 percent?
    c. What do you conclude about the relationship between time to maturity and the sensitivity of bond prices to interest rates?

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22. **Rate of Return.** A 2-year maturity bond with face value of $1,000 makes annual coupon payments of $80 and is selling at face value. What will be the rate of return on the bond if its yield to maturity at the end of the year is
    a. 6 percent?
    b. 8 percent?
    c. 10 percent?
23. **Rate of Return.** A bond that pays coupons annually is issued with a coupon rate of 4 percent, maturity of 30 years, and a yield to maturity of 7 percent. What rate of return will be earned by an investor who purchases the bond and holds it for 1 year if the bond's yield to maturity at the end of the year is 8 percent?
24. **Bond Risk.** A bond's credit rating provides a guide to its risk. Long-term bonds rated Aa currently offer yields to maturity of 7.5 percent. A-rated bonds sell at yields of 7.8 percent. If a 10-

year bond with a coupon rate of 7 percent is downgraded by Moody's from Aa to A rating, what is the likely effect on the bond price?

25. **Real Returns.** Suppose that you buy a 1-year maturity bond for $1,000 that will pay you back $1,000 plus a coupon payment of $60 at the end of the year. What real rate of return will you earn if the inflation rate is
    a. 2 percent?
    b. 4 percent?
    c. 6 percent?
    d. 8 percent?

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26. **Real Returns.** Now suppose that the bond in the previous problem is a TIPS (inflation-indexed) bond with a coupon rate of 4 percent. What will the cash flow provided by the bond be for each of the four inflation rates? What will be the real and nominal rates of return on the bond in each scenario?

27. **Real Returns.** Now suppose the TIPS bond in the previous problem is a 2-year maturity bond. What will be the bondholder's cash flows in each year in each of the inflation scenarios?

CHALLENGE PROBLEM

28. **Interest Rate Risk.** Suppose interest rates increase from 8 to 9 percent. Which bond will suffer the greater percentage decline in price: a 30-year bond paying annual coupons of 8 percent or a 30-year zero-coupon bond? Can you explain intuitively why the zero exhibits greater interest rate risk even though it has the same maturity as the coupon bond?

STANDARD &POOR'S

1. Go to Market Insight (**www.mhhe.com/edumarketinsight**) and find the bond rating of Toyota (TM) and General Motors (GM) in the Financial Highlights section of Market Insight. Why is the bond rating (i.e., S&P Issuer Credit Rating) of Toyota superior to that of GM? Is one firm in better financial health? Compare the ratio of EBIT to interest payments for the two firms. Which has the "healthier" ratio? Which has the lower indebtedness, as measured by the ratio of debt to equity?

SOLUTIONS TO SELF-TEST QUESTIONS

5.1 a. The asked price is $106^{13}/_{32}$ = 106.40625 percent of face value, or $1,064.0625.
b. The bid price is $106^{12}/_{32}$ = 106.375 percent of face value, or $1,063.75.
c. The price decreased by $^{2}/_{32}$ = .0625 percent of face value, or $.625.
d. The annual coupon is 5.625 percent of face value, or $56.25, paid in two semiannual installments.
e. The yield to maturity, based on the asked price, is given as 3.51 percent.

5.2 The coupon is 9 percent of $1,000, or $90 a year. First value the 6-year annuity of coupons:

$$\begin{aligned} PV &= \$90 \times (\text{6-year annuity factor}) \\ &= \$90 \times \left[\frac{1}{.12} - \frac{1}{.12(1.12)^6}\right] \\ &= \$90 \times 4.11 = \$370.03 \end{aligned}$$

Then value the final payment and add:

$$PV = \frac{\$1{,}000}{(1.12)^6} = \$506.63$$

$$\text{PV of bond} = \$370.03 + \$506.63 = \$876.66$$

5.3 The yield to maturity assuming annual coupons is about 8 percent, because the present value of the bond's cash returns is $1,199 when discounted at 8 percent:

$$\begin{aligned} PV &= PV\text{ (coupons)} + PV\text{ (final payment)} \\ &= (\text{coupon} \times \text{annuity factor}) + (\text{face value} \times \text{discount factor}) \\ &= \$140 \times \left[\frac{1}{.08} - \frac{1}{.08(1.08)^4}\right] + \$1{,}000 \times \frac{1}{1.08^4} \\ &= \$463.70 + \$735.03 = \$1{,}199 \end{aligned}$$

To obtain a more precise solution on your calculator, these would be your inputs:

	Annual Payments	Semiannual Payments
n	4	8
PV	–1,200	–1,200
FV	1000	1000
PMT	140	70

Compute *i* to find yield to maturity (annual payments) = 7.97 percent. Yield to maturity (semi-annual payments) = 4.026 percent per 6 months, which would be reported in the financial press as 8.05 percent annual yield.

5.4 The 5.5 percent coupon bond with maturity 2008 starts with 3 years left until maturity and sells for $1,056.03. At the end of the year, the bond has only 2 years to maturity and investors demand an interest rate of 5 percent. Therefore, the value of the bond becomes

$$PV \text{ at } 5\% = \frac{\$55}{(1.05)} + \frac{\$1{,}055}{(1.05)^2} = \$1{,}009.30$$

You invested $1,056.03. At the end of the year you receive a coupon payment of $55 and have a bond worth $1,009.30. Your rate of return is therefore

$$\text{Rate of return} = \frac{\$55 + (\$1{,}009.30 - \$1{,}056.03)}{\$1{,}056.03} = .0078, \text{ or } .78\%$$

The yield to maturity at the start of the year was 3.5 percent. However, because interest rates rose during the year, the bond price fell and the rate of return was below the yield to maturity.

5.5 By the end of this year, the bond will have only 1 year left until maturity. It will make only one more payment of coupon plus face value, so its price will be $1,055/1.035 = $1,019.32. The rate of return is therefore

$$\frac{\$55 + (\$1{,}019.32 - \$1{,}037.99)}{\$1{,}037.99} = .035, \text{ or } 3.5\%$$

5.6 At an interest rate of 3.5 percent, the 3-year bond sells for $1,056.03. If the interest rate jumps to 8 percent, the bond price falls to $935.57, a decline of 11.4 percent. The 30-year bond sells for $1,367.84 when the interest rate is 3.5 percent, but its price falls to $718.56 at an interest rate of 8 percent, a much larger percentage decline of 47.5 percent.