Chapter Fourteen

Bond Prices and Yields

Chapter Overview

- **Debt** (i.e., *fixed-income*) **securities** promise either a fixed stream of income or one that is determined according to a specified formula
- Bond markets
  - Treasury, corporate and international bonds
  - Bond pricing and returns
- Impact of default or credit risk on bond pricing
  - Fixed-income derivatives
    - Credit default swaps or collateralized debt obligations

Bond Characteristics

- A **bond** is a security that is issued in connection with a borrowing arrangement
  - Issuer agrees to make specified payments to the bondholder on specified dates
- **Par value** (i.e., **face value**) is the payment to the bondholder on the bond's maturity date
- **Coupon rate** is a bond's interest payments per dollar of par value
- **Bond indenture** is the contract between the issuer and the bondholder

Bond Example

- To illustrate, a bond with par value of $1,000 and coupon rate of 8% might be sold for $1,000.
- The bondholder is entitled to a payment of 8% of par value, or $80 per year, for the stated life of the bond, say, 30 years.
- At the end of the bond’s 30-year life, the issuer also pays the $1,000 par value to the bondholder.

Treasury Bonds and Notes

- Maturity
  - Treasury notes – 1 to 10 years
  - Treasury bonds – 10 to 30 years
- Both bonds and notes may be purchased directly from the Treasury
- Denominations
  - As small as $100, but $1,000 is more common

Treasury Bonds and Notes

U.S. Treasury Quotes

MATURITY	COUPON	BID	ASKED	CHANGE	ASKED YIELD (%)
May 15 18	1.000	100.3984	100.4141	−0.0859	0.791
May 15 19	0.875	99.8125	99.8281	−0.0859	0.933
Feb 15 21	7.875	130.5781	130.5938	−0.2656	1.225
Aug 15 25	6.875	144.4141	144.4297	−0.5391	1.670
Aug 15 25	2.000	102.2813	102.2969	−0.3438	1.730
May 15 30	6.250	152.3984	152.4609	−0.7969	1.950
Nov 15 41	3.125	111.7891	111.8203	−0.8750	2.496
May 15 46	2.500	97.9922	98.0234	−0.9063	2.595

Figure 14.1 Prices and yields of U.S. Treasury bonds

Source: *The Wall Street Journal Online*, May 16, 2016.

Corporate Bonds

- Like the government, corporations can also borrow money by issuing bonds.

ISSUER NAME	SYMBOL	COUPON	MATURITY	MOODY'S/S&P/ FITCH	HIGH	LOW	LAST	CHANGE	YIELD %
COMMONWEALTH BK AUSTRALIA MEDIUM TERM NT	CBAU3828562	2.250%	Mar 16 17	Aaa//AAA	100.892	100.892	100.892	0.0020	1.1102
WALGREENS BOOTS ALLIANCE INC	WAG4182650	4.800%	Nov 18 44	Baa2 /BBB /BBB	103.367	100.560	100.560	−2.0100	4.7634
ANHEUSER BUSCH INBEV FIN INC	BUD4327481	3.650%	Feb 01 26	A3 //	104.593	104.096	104.249	−0.0130	3.1254
HSBC HLDGS PLC	HBC3699239	6.100%	Jan 14 42	A1 //AA−	129.300	128.850	128.850	1.4860	4.2419
SOUTHERN CO	SO4365686	1.850%	Jul 01 19	Baa2 //A−	100.438	100.324	100.324	−0.0310	1.7411
WESTPAC BKG CORP	WBK4248362	1.550%	May 25 18	Aa2 //AA−	100.246	100.148	100.148	−0.1900	1.4738
GOLDMAN SACHS GROUP INC	GS4302031	4.750%	Oct 21 45	A3 /BBB+ /A	107.139	106.419	106.727	0.0500	4.3389
HSBC HLDGS PLC	HBC4365146	3.900%	May 25 26	A1 //	101.564	100.889	101.564	0.1580	3.7109
NEWELL BRANDS INC	NWL4346211	2.600%	Mar 29 19	Baa3 //BBB−	103.118	101.774	101.774	0.2360	1.9510
LLOYDS TSB BK PLC	LYG3833921	4.200%	Mar 28 17	A1 //A+	102.462	102.389	102.389	−0.0770	1.2682

Figure 14.2 Listing of corporate bonds

Source: FINRA (Financial Industry Regulatory Authority), May 31, 2016.

Bond Pricing

- A bond’s coupon and principal repayments all occur months or years in the future.
- Therefore, the price an investor is willing to pay for the bond depends on the value of dollars to be received in the future compared to dollars in hand today.
- This “present value” calculation depends in turn on market interest rates.

Bond Pricing

- As we have learned, the nominal risk-free interest rate equals the sum of

  (1) a real risk-free rate of return and

  (2) a premium above the real rate to compensate for expected inflation.

- In addition, because most bonds are not riskless, the discount rate will embody additional premium that reflects bond-specific characteristics (default risk, liquidity, etc.).

Bond Pricing

- We simplify for now by assuming there is one interest rate that is appropriate for discounting cash flows of any maturity.
- To value a security, we discount its expected cash flows by the appropriate discount rate.
- Bond value

  = Present value of coupons

  + Present value of par value

Bond Pricing
(1 of 2)

$$\text{Bond value} = \sum_{t=1}^{T} \frac{\text{Coupon}}{(1+r)^t} + \frac{\text{Par value}}{(1+r)^T}$$

- First term of right-hand side of equation is the present value of an annuity
  - Recall that the present value of a \$1 annuity that lasts for T periods when the interest rate equals r is $\sum_{t=1}^{T} \frac{1}{(1+r)^t} = \frac{1}{r}\left[1 - \frac{1}{(1+r)^T}\right]$.
- Second term is the present value of a single amount, the final payment of the bond's par value

Bond Pricing

Example 14.2 Bond Pricing

We discussed earlier an 8% coupon, 30-year maturity bond with par value of $1,000 paying 60 semiannual coupon payments of $40 each. Suppose that the interest rate is 8% annually, or $r = 4\%$ per six-month period. Then the value of the bond can be written as

$$\text{Price} = \sum_{t=1}^{60} \frac{\$40}{(1.04)^t} + \frac{\$1{,}000}{(1.04)^{60}} \tag{14.3}$$

$$= \$40 \times \text{Annuity factor}(4\%, 60) + \$1{,}000 \times \text{PV factor}(4\%, 60)$$

It is easy to confirm that the present value of the bond's 60 semiannual coupon payments of $40 each is $904.94 and that the $1,000 final payment of par value has a present value of $95.06, for a total bond value of $1,000. You can calculate this value directly from Equation 14.2, perform these calculations on any financial calculator (see Example 14.3 below), use a spreadsheet program (see column F of Spreadsheet 14.1), or use a set of present value tables.

The Inverse Relationship Between Bond Prices and Yields

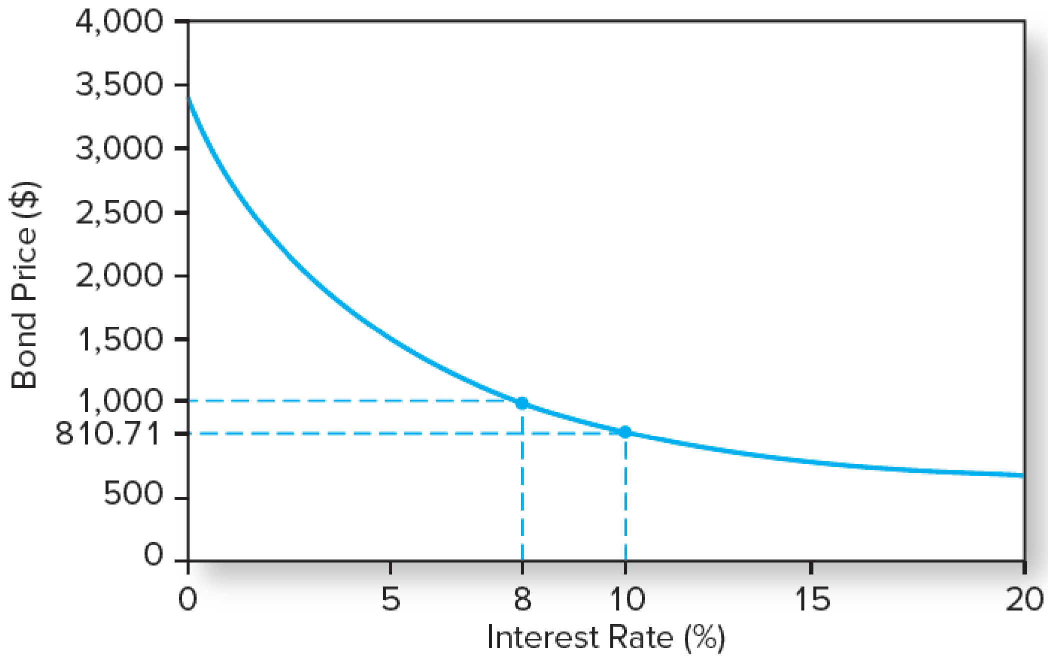


Figure 14.3 The inverse relationship between bond prices and yields. Price of an 8% coupon bond with 30-year maturity making semiannual payments

Bond Prices and Yields

- Inverse relationship between price and yield is a central feature of fixed-income securities
- Interest rate fluctuations represent the main source of risk in the fixed-income market
- The price curve is convex and becomes flatter at higher interest rates
- The longer the maturity of the bond, the more sensitive the bond’s price to changes in market interest rates

Bond Prices and Yields

- Corporate bonds typically are issued at par value.
- This means that the underwriters of the bond issue (the firms that market the bonds to the public for the issuing corporation) must choose a coupon rate that very closely approximates market yields.
  - If the coupon rate is inadequate, investors will not be willing to pay par value.

Bond Prices and Yields

- After the bonds are issued, bondholders may buy or sell bonds in secondary markets.
- In these markets, bond prices fluctuate inversely with the market interest rate.

Bond Prices and Yields

- If you buy the bond with an 8% coupon rate, and market rates subsequently rise, then you suffer a loss:
- You have tied up your money earning 8% when alternative investments offer higher returns.
- This is reflected in a capital loss on the bond – a fall in its market price.
- Thus, the longer the maturity, the greater the loss and the greater the drop in the bond price.

Bond Prices and Yields

- This explains why short-term Treasury securities such as T-bills are considered to be the safest.
- In addition to being free of default risk, they are also largely free of price risk attributable to interest rate volatility.

Bond Prices at Different Interest Rates

Table 14.2

Time to Maturity	Bond Price at Given Market Interest Rate 2%	4%	6%	8%	10%
1 year	1,059.11	1,038.83	1,019.13	1,000.00	981.41
10 years	1,541.37	1,327.03	1,148.77	1,000.00	875.35
20 years	1,985.04	1,547.11	1,231.15	1,000.00	828.41
30 years	2,348.65	1,695.22	1,276.76	1,000.00	810.71

Bond prices at different interest rates (8% coupon bond, coupons paid semiannually)

Bond Yields: Yield to Maturity

- In practice, an investor considering the purchase of a bond is not quoted a promised rate of return.
  - Instead, she must use the bond price, maturity date, and coupon payments to infer the return offered over the bond's life.
- The **yield to maturity (YTM)** is defined as the interest rate that makes the present value of a bond's payments equal to its price.

Bond Yields: Yield to Maturity

- **Yield to maturity (YTM)**
  - The standard measure of bond's rate of return
  - Interpreted as a measure of the average rate of return that will be earned on a bond if it is bought now and held until maturity
- To calculate YTM, solve the bond price equation for the interest rate given the bond's price

Yield to Maturity Example

- Suppose an 8% coupon, 30-year bond is selling for \$1,276.76. What is the YTM?

$$\$1276.76 = \sum_{t=1}^{60} \frac{\$40}{(1+r)^t} + \frac{1000}{(1+r)^{60}}$$

  - r = 3% per half year
  - Bond equivalent yield = 6%
  - EAR = $((1.03)^2) - 1$ = 6.09%

Bond Yields: YTM vs. Current Yield

- Yield to maturity
  - Bond’s internal rate of return
  - Interpreted as compound rate of return over life of the bond assuming all coupons can be reinvested at that yield
  - Proxy for average return

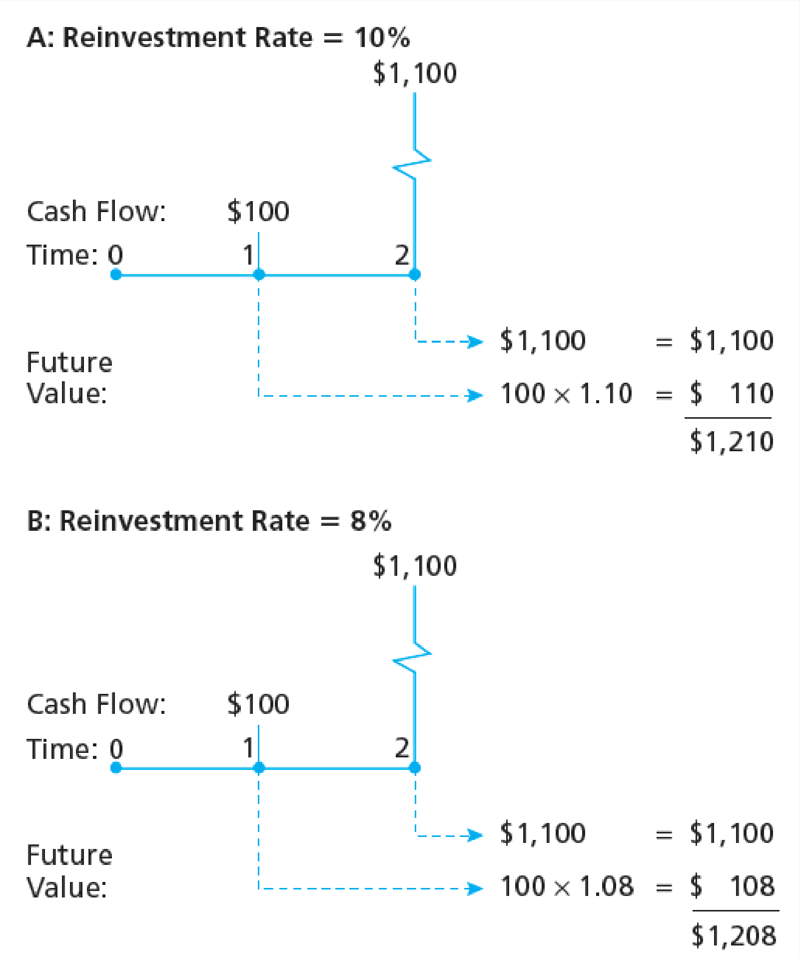
Bond Yields: YTM vs. Current Yield

- **Current yield** is the bond's annual coupon payment divided by its price
- The current yield of the 8%, 30-year bond selling at $1,276.76 is $80/$1276.76 = 6.27% > 6.09% (the yield to maturity)
- **Premium bonds** (bonds selling above par value): *Coupon rate > Current yield > YTM*
- **Discount bonds** (bonds selling below par value): *Coupon rate < Current yield < YTM*

Bond Yields: Realized Compound Return vs YTM

- YTM will equal the rate of return realized over the life of the bond if all coupons are reinvested to earn the bond’s YTM
- For example, a 2-year bond selling at par value paying a 10% coupon once a year.
- If the $100 coupon payment is reinvested at an interest rate of 10%, the $1,000 investment in the bond will grow after 2 years to $1,210.

Growth of Invested Funds



Bond Yields: Realized Compound Return vs YTM

- Initial value V_0= 1000, final value V_1= 1210
- The compound rate of return is calculated from $V_0(1+r)^2 = V_1$
- **Realized compound return** is the compound rate of return assuming that coupon payments are reinvested until maturity
- What if the reinvestment rate is not 10%?

Bond Yields: Realized Compound Return vs YTM

Example 14.8 Realized Compound Return

If the interest rate earned on the first coupon is less than 10%, the final value of the investment will be less than \$1,210, and the realized compound return will be less than 10%. To illustrate, suppose the interest rate at which the coupon can be invested is only 8%. The following calculations are illustrated in Figure 14.5, Panel B.

	Future value of first coupon payment with interest earnings = \$100 × 1.08 =	\$ 108
+	Cash payment in second year (final coupon plus par value)	\$1,100
=	Total value of investment with reinvested coupons	\$1,208

The realized compound return is the compound rate of growth of invested funds, assuming that all coupon payments are reinvested. The investor purchased the bond for par at \$1,000, and this investment grew to \$1,208.

$$V_0(1+r)^2 = V_2$$
$$\$1{,}000(1+r)^2 = \$1{,}208$$
$$r = .0991 = 9.91\%$$

Bond Yields: Realized Compound Return vs YTM

- If the reinvestment rate is larger, so will be the realized compound return.
- Otherwise, the realized compound return will fall below the YTM.
- The above example highlights the problem with conventional YTM when reinvestment rates can change over time.
  - Conventional YTM will not equal realized compound return.
  - Although realized compound return can be computed after the investment period, it cannot be computed in advance without a forecast of future reinvestment rates.
  - This reduces much of the attraction of the realized return measure.

Bond Yields: Realized Compound Return vs YTM

- Forecasting the realized compound yield over various holding periods or investment horizons is **horizon analysis**
- The forecast of total return depends on your forecasts of both the price of the bond you sell it at the end of your horizon and the rate at which you are able to reinvest coupon income.

Bond Yields: Realized Compound Return vs YTM

Example 14.9 Horizon Analysis

Suppose you buy a 30-year, 7.5% (annual payment) coupon bond for $980 (when its yield to maturity is 7.67%) and plan to hold it for 20 years. Your forecast is that the bond's yield to maturity will be 8% when it is sold and that the reinvestment rate on the coupons will be 6%. At the end of your investment horizon, the bond will have 10 years remaining until expiration, so the forecast sales price (using a yield to maturity of 8%) will be $966.45. The 20 coupon payments will grow with compound interest to $2,758.92. (This is the future value of a 20-year $75 annuity with an interest rate of 6%.)

On the basis of these forecasts, your $980 investment will grow in 20 years to $966.45 + $2,758.92 = $3,725.37. This corresponds to an annualized compound return of 6.90%:

$$V_0(1+r)^{20} = V_{20}$$
$$\$980(1+r)^{20} = \$3{,}725.37$$
$$r = .0690 = 6.90\%$$

Bond Yields: Realized Compound Return vs YTM

- Examples 14.8 and 14.9 demonstrate that as interest rates change, bond investors are subject to two offsetting sources of risk.
    - On one hand, when rates rise, bond prices fall, which reduces the value of the portfolio.
    - On the other hand, reinvested coupon income will compound more rapidly at those higher rates.
    - This reinvestment rate risk offsets price risk.
- In Chapter 16, we will explore this trade-off in more detail and will discover that by carefully tailoring their bond portfolios, investors can precisely balance these two effects for any given investment horizon.

Bond Prices Over Time

- A bond will sell at par value when its coupon rate equals the market interest rate. In this case, the coupon payments are sufficient to provide fair compensation for the time value of money.
- When the coupon rate is lower than the market interest rate, the coupon payments alone will not provide bond investors as high a return as they could earn elsewhere.
  - The bonds must sell below par value to provide a “built-in” capital gain on the investment.

Fair Holding-Period Return

- Suppose a bond was issued several years ago when the interest rate was 7%. The bond's annual coupon rate was set at 7%. Suppose for simplicity that the bond pays its coupon annually. Now, with three years left in the bond's life, the market interest rate is 8% per year. The bond's market price is

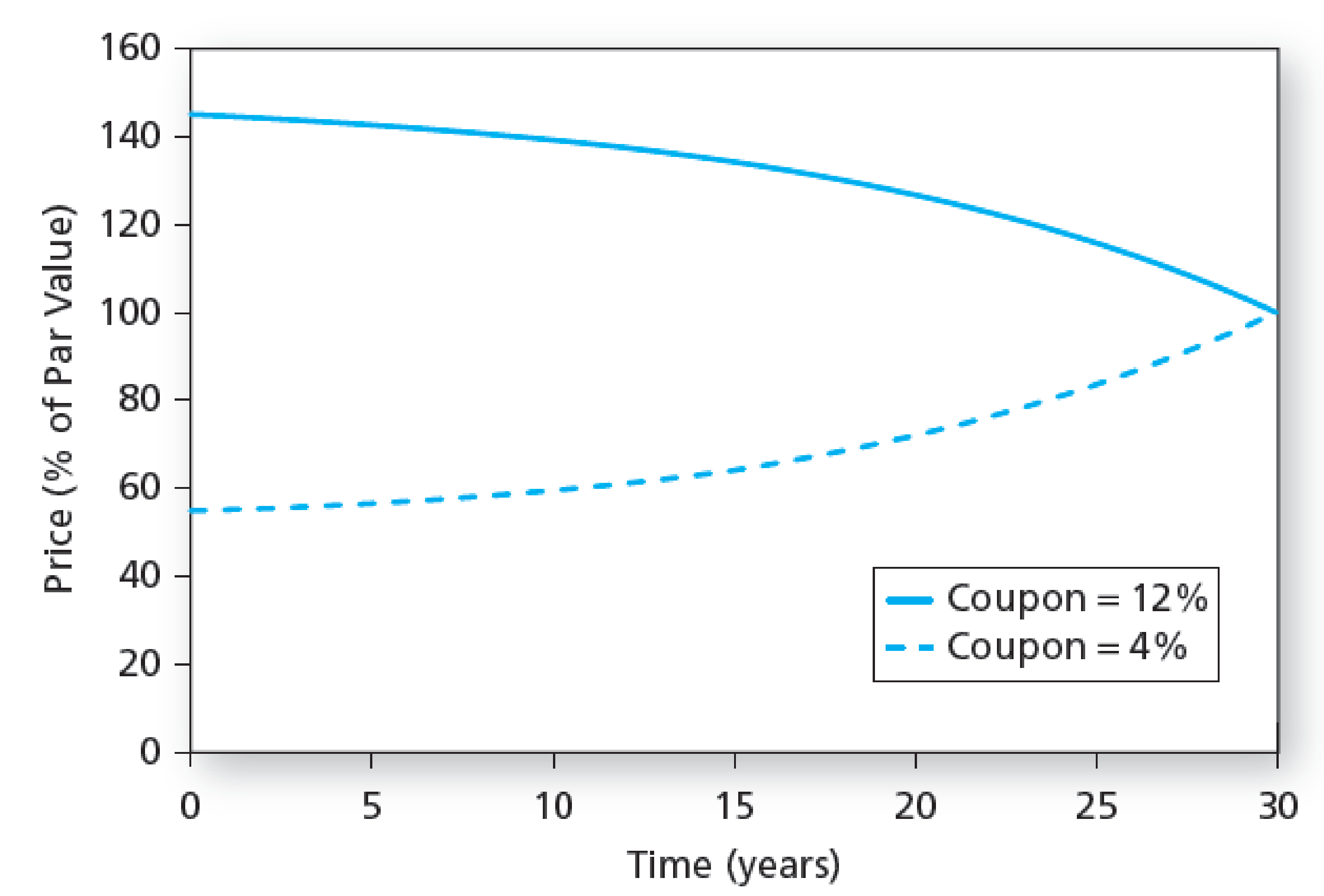
$$\$70 \times \text{Annuity factor }(8\%, 3) + \$1{,}000 \times \text{PV factor }(8\%, 3) = \$974.23$$

In another year, after the next coupon is paid and remaining maturity falls to two years, the bond will sell at

$$\$70 \times \text{Annuity factor }(8\%, 2) + \$1{,}000 \times \text{PV factor }(8\%, 2) = \$982.17$$

The capital gain is ______________________________. If an investor had purchased the bond at $974.23, the total return over the year is _____________________. The rate of return is thus _______________________.

Prices Path of Two 30-year Maturity Bonds



Bond Prices Over Time: YTM vs. HPR

YTM	HPR
• Average return if the bond is held to maturity • Depends on coupon rate, maturity, and par value • All of these are readily observable	• Rate of return over a particular investment period • Depends on the bond's price at the end of the holding period, an unknown future value • Can only be forecasted

Bond Prices Over Time: YTM vs. HPR

Example 14.11 Yield to Maturity versus Holding-Period Return

Consider a 30-year bond paying an annual coupon of $80 and selling at par value of $1,000. The bond's initial yield to maturity is 8%. If the yield remains at 8% over the year, the bond price will remain at par, so the holding-period return also will be 8%. But if the yield falls below 8%, the bond price will increase. Suppose the yield falls and the price increases to $1,050. Then the holding-period return is greater than 8%:

$$\text{Holding-period return} = \frac{\$80 + (\$1{,}050 - \$1{,}000)}{\$1{,}000} = .13, \text{ or } 13\%$$

Zero-Coupon Bond

- There are bonds that are issued intentionally with low coupon rates that cause the bond to sell at a discount from par value.
- The most common example of this type of bond is the zero-coupon bond, which carries no coupons and provides only one cash flow to their owners on the maturity date.
- U.S. Treasury bills are examples of short-term zero-coupon instruments.

Price of a 30-Year Zero-Coupon Bond Over Time

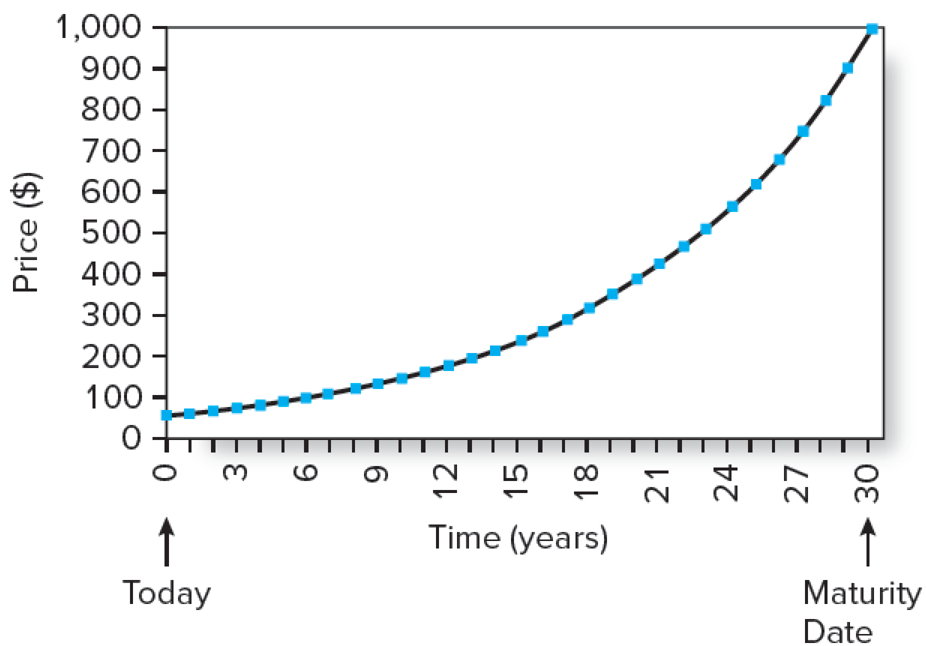


Figure 14.7 The price of a 30-year zero-coupon bond over time at a yield to maturity of 10%. Price equals $\$1{,}000/(1.10)^T$, where T is time until maturity.

Default Risk and Bond Pricing

- **Credit risk**, or default risk, is the risk the bond will not make all promised payments
- Rating companies
  - Moody's Investor Service, Standard & Poor's, and Fitch Investor Service
- Rating categories
  - Highest rating is AAA (or Aaa)
  - **Investment grade bonds** are rated BBB/Baa or above
  - **Speculative-grade/junk bonds** are rated below BBB/Baa

Bond Ratings

	Very High Quality		High Quality		Speculative		Very Poor	
Standard & Poor's	AAA	AA	A	BBB	BB	B	CCC	D
Moody's	Aaa	Aa	A	Baa	Ba	B	Caa	C

At times both Moody's and Standard & Poor's have used adjustments to these ratings: S&P uses plus and minus signs: A+ is the strongest A rating and A− the weakest. Moody's uses a 1, 2, or 3 designation, with 1 indicating the strongest.

Moody's	S&P	
Aaa	AAA	Debt rated Aaa and AAA has the highest rating. Capacity to pay interest and principal is extremely strong.
Aa	AA	Debt rated Aa and AA has a very strong capacity to pay interest and repay principal. Together with the highest rating, this group comprises the high-grade bond class.
A	A	Debt rated A has a strong capacity to pay interest and repay principal, although it is somewhat more susceptible to the adverse effects of changes in circumstances and economic conditions than debt in higher-rated categories.
Baa	BBB	Debt rated Baa and BBB is regarded as having an adequate capacity to pay interest and repay principal. Whereas it normally exhibits adequate protection parameters, adverse economic conditions or changing circumstances are more likely to lead to a weakened capacity to pay interest and repay principal for debt in this category than in higher-rated categories. These bonds are medium-grade obligations.

YTM and Default Risk

- Must distinguish between the bond's promised YTM and its expected YTM
  - Promised YTM will be realized only if the firm meets the obligations of the bond issue
  - Expected YTM must consider the possibility of a default

YTM and Default Risk

Example 14.13 Expected versus Promised Yield to Maturity

Suppose a firm issued a 9% coupon bond 20 years ago. The bond now has 10 years left until its maturity date, but the firm is having financial difficulties. Investors believe that the firm will be able to make good on the remaining interest payments, but at the maturity date, the firm will be forced into bankruptcy, and bondholders will receive only 70% of par value. The bond is selling at $750.

Yield to maturity (YTM) would then be calculated using the following inputs:

	Expected YTM	Stated YTM
Coupon payment	$45	$45
Number of semiannual periods	20 periods	20 periods
Final payment	$700	$1,000
Price	$750	$750

The stated yield to maturity, which is based on promised payments, is 13.7%. Based on the expected payment of $700 at maturity, however, the yield to maturity is only 11.6%. The stated yield to maturity is greater than the yield investors actually expect to earn.

YTM and Default Risk

- To compensate for the possibility of default, corporate bonds must offer a default premium.
- **Default premium** (also called a credit spread) is a difference between the promised yield on a corporate bond and the yield of an otherwise-identical government bond that is riskless in terms of default.

Yield Spreads

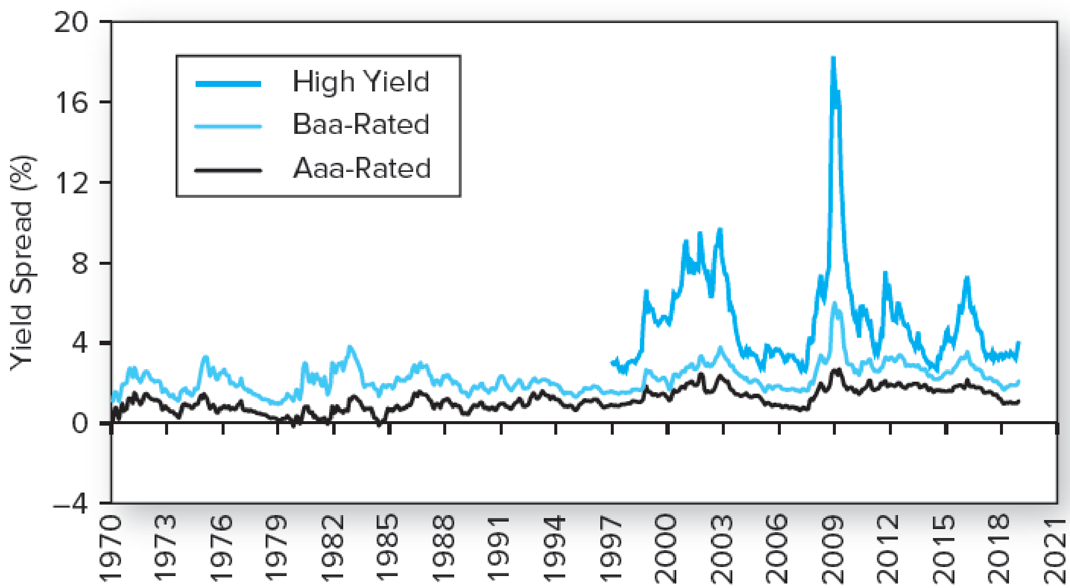


Figure 14.11 Yield spreads between corporate and 10-year Treasury bonds

Source: Federal Reserve Bank of St. Louis.

Yield Spreads

- The pattern of default premiums offered on risky bonds is sometimes called the risk structure of interest rates.
- The greater the default risk, the higher the default premium.