Chapter 6 Interest Rates and Bond Valuation

Key Concepts and Skills

- After studying this chapter, you should be able to:
  - Identify important bond features and types of bonds.
  - Describe bond values and why they fluctuate.
  - Discuss bond ratings and what they mean.
  - Evaluate the impact of inflation on interest rates.
  - Explain the term structure of interest rates and the determinants of bond yields.

Chapter Outline

6.1 Bonds and Bond Valuation
6.2 More on Bond Features
6.3 Bond Ratings
6.4 Some Different Types of Bonds
6.5 Bond Markets
6.6 Inflation and Interest Rates
6.7 Determinants of Bond Yields

Bond Definitions

- Bond
  - Debt contract
  - Interest-only loan
- Par value (face value) ~ $1,000
- Coupon rate
- Coupon payment
- Maturity date
- Yield to maturity

Key Features of a Bond (1 of 2)

- Par value:
  - Face amount
  - Re-paid at maturity
  - Assume $1,000 for corporate bonds
- Coupon interest rate:
  - Stated interest rate
  - Usually = YTM at issue
  - Multiply by par value to get coupon payment

Key Features of a Bond (2 of 2)

- Maturity:
  - Years until bond must be repaid
- Yield to maturity (YTM):
  - The market required rate of return for bonds of similar risk and maturity
  - The discount rate used to value a bond
  - Return if bond held to maturity
  - Usually = coupon rate at issue
  - Quoted as an APR

Bond Value

- Bond Value = PV(coupons) + PV(par)
- Bond Value = PV(annuity) + PV(lump sum)
- Remember:
  - As interest rates increase present values decrease

    (r ⬆→ PV ⬇)
  - As interest rates increase, bond prices decrease and vice versa

The Bond-Pricing Equation

$$\text{Bond Value} = C\left[\frac{1-\frac{1}{(1+\text{YTM})^{t}}}{\text{YTM}}\right] + \frac{F}{(1+\text{YTM})^{t}}$$

PV(Annuity) PV(lump sum)

C = Coupon payment; F = Face value

⬅ Return to Quiz

Texas Instruments BA-II Plus

N = number of periods to maturity

I/Y = period interest rate = YTM

PV = present value = bond value

PMT = coupon payment

FV = future value = face value = par value

Spreadsheet Formulas

=FV(Rate,Nper,Pmt,PV,0/1)

=PV(Rate,Nper,Pmt,FV,0/1)

=RATE(Nper,Pmt,PV,FV,0/1)

=NPER(Rate,Pmt,PV,FV,0/1)

=PMT(Rate,Nper,PV,FV,0/1)

- Inside parens: (RATE,NPER,PMT,PV,FV,*0/1*)
- "0/1" Ordinary annuity = 0 (default)
  Annuity Due = 1 (must be entered)

Pricing Specific Bonds on the TI BAII+

- Bond Worksheet: ***2nd BOND*** (above "***9***")
- SDT CPN RDT RV ACT 2/Y YLD PRI
  - SDT = Actual Settlement date (enter MM.DDYY)
  - CPN = Annual rate in %
  - RDT = Actual Redemption (maturity) date
  - RV = Redemption value as a % of par
  - ACT = ACT/360 day count setting
  - 2/Y = 2/Y – 1/Y coupons per year
  - YLD = Yield to redemption
  - PRI = Dollar price per $100 of par value

Pricing Specific Bonds in Excel

=PRICE(Settlement,Maturity,Rate,Yld,Redemption, Frequency,Basis)

=YIELD(Settlement,Maturity,Rate,Pr,Redemption, Frequency,Basis)

- Settlement = actual date as a serial number
- Maturity = actual date as a serial number
- Redemption and Pr(ice) = % of par value
- Rate (coupon) and Yld = annual rates as decimals
- Frequency = # of coupons per year
- Basis = day count convention (enter "***2***" for ACT/360)

Valuing a Discount Bond with Annual Coupons

- Coupon rate = 10%
- Annual coupons
- Par = $1,000
- Maturity = 5 years
- YTM = 11%

Using the calculator:

5	N
11	I/Y
100	PMT
1000	FV

CPT PV = -963.04

Using the formula:

B = PV(annuity) + PV(lump sum)

B = 369.59 + 593.45 = 963.04

$$B = 100\left[\frac{1-\frac{1}{(1.11)^5}}{0.11}\right] + \frac{1000}{(1.11)^5}$$

Using Excel: **=PV(0.11, 5, 100, 1000, 0)**

Note: When YTM > Coupon rate → Price < Par = "Discount Bond"

Valuing a Premium Bond with Annual Coupons

- Coupon rate = 10%
- Annual coupons
- Par = $1,000
- Maturity = 20 years
- YTM = 8%

Using the calculator:

20	N
8	I/Y
100	PMT
1000	FV

CPT PV = -1196.36

Using the formula:

B = PV(annuity) + PV(lump sum)

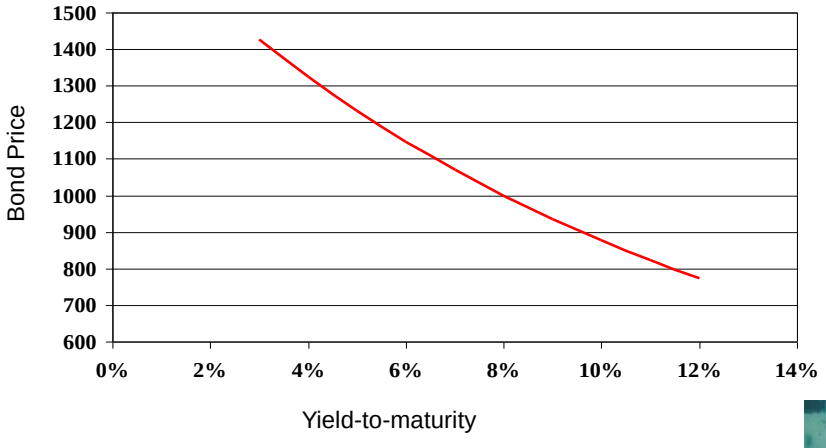
B = 981.81 + 214.55 = 1196.36

$$B = 100\left[\frac{1-\frac{1}{(1.08)^{20}}}{0.08}\right] + \frac{1000}{(1.08)^{20}}$$

Using Excel: **=PV(0.08, 20, 100, 1000, 0)**

Note: When YTM < Coupon rate → Price > Par = "Premium Bond"

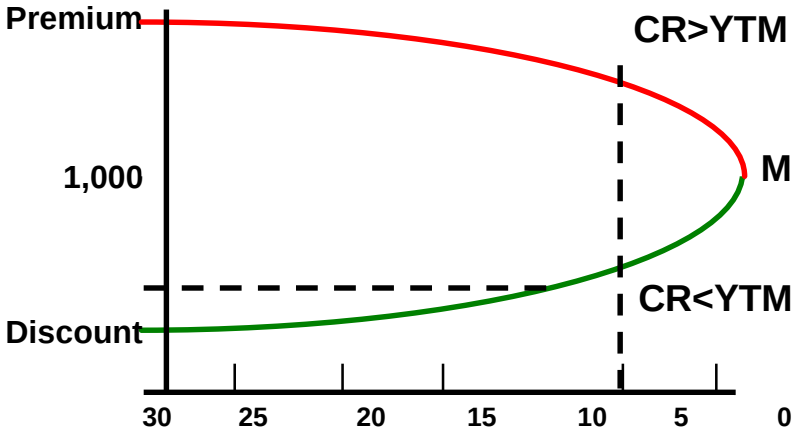
Graphical Relationship Between Price and Yield-to-Maturity



Bond Prices: Relationship Between Coupon and Yield

- Coupon rate = YTM ➡ Price = Par
- Coupon rate < YTM ➡ Price < Par
  - "Discount bond" … Why?
- Coupon rate > YTM ➡ Price > Par
  - "Premium bond" … Why?

Bond Value ($) versus Years Remaining to Maturity



The Bond-Pricing Equation Adjusted for Semiannual Coupons

$$\text{Bond Value} = \frac{C}{2}\left[\frac{1 - \frac{1}{(1+\text{YTM}/2)^{2t}}}{\text{YTM}/2}\right] + \frac{F}{(1+\text{YTM}/2)^{2t}}$$

C = Annual coupon payment ➡ C/2 = Semi-annual coupon

YTM = Annual YTM (as an APR) ➡ YTM/2 = Semi-annual YTM

t = Years to maturity ➡ 2t = Number of 6-month periods to maturity

Semiannual Bonds
Example 6.1

- Coupon rate = 14% - Semiannual
- YTM = 16% (APR)
- Maturity = 7 years
  - Number of coupon payments? (2t or N)
    - 14 = 2 x 7 years
  - Semiannual coupon payment? (C/2 or PMT)
    - $70 = (14% x Face Value)/2
  - Semiannual yield? (YTM/2 or I/Y)
    - 8% = 16%/2

Example 6.1

- Semiannual coupon = $70
- Semiannual yield = 8%
- Periods to maturity = 14

$$\text{Bond Value} = \frac{C}{2}\left[\frac{1-\frac{1}{\left(1+\frac{YTM}{2}\right)^{2t}}}{\frac{YTM}{2}}\right] + \frac{F}{\left(1+\frac{YTM}{2}\right)^{2t}}$$

- Bond value =
- $70[1 – 1/(1.08)^{14}] / .08 + 1000 / (1.08)^{14} = \mathbf{917.56}$

$$B = 70\left[\frac{1-\frac{1}{(1.08)^{14}}}{0.08}\right] + \frac{1000}{(1.08)^{14}}$$

Using the calculator:

14	**N**
8	**I/Y**
70	**PMT**
1000	**FV**
CPT PV = -917.56	

Using Excel: **=PV(0.08, 14, 70, 1000, 0)**

Interest Rate Risk (1 of 2)

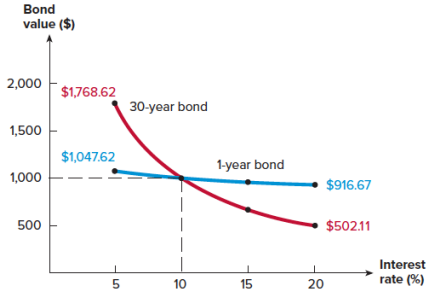
- Price Risk
  - Change in price due to changes in interest rates
  - Long-term bonds have more price risk than short-term bonds
  - Low coupon rate bonds have more price risk than high coupon rate bonds

Interest Rate Risk (2 of 2)

- Reinvestment Rate Risk
  - Uncertainty concerning rates at which cash flows can be reinvested
  - Short-term bonds have more reinvestment rate risk than long-term bonds
  - High coupon rate bonds have more reinvestment rate risk than low coupon rate bonds

Figure 6.2

FIGURE 6.2 Interest rate risk and time to maturity



Value of a Bond with a 10 Percent Coupon Rate for Different Interest Rates and Maturities

	Time to Maturity	
Interest Rate	1 Year	30 Years
5%	$1,047.62	$1,768.62
10	1,000.00	1,000.00
15	956.52	671.70
20	916.67	502.11

Computing Yield-to-Maturity (YTM)

- Yield-to-maturity (YTM) = the market required rate of return implied by the current bond price
- With a financial calculator,
  - Enter N, PV, PMT, and FV
  - **Remember the sign convention**
    - PMT and FV need to have the same sign (+)
    - PV the opposite sign (-)
    - CPT I/Y for the yield

YTM with Annual Coupons

Consider a bond with a 10% annual coupon rate, 15 years to maturity and a par value of $1000. The current price is $928.09.

– Will the yield be more or less than 10%?

15	N
928.09 PV (enter as a negative)	
1000	FV
100	PMT
CPT PV	= 11% ⬅Result = YTM

Using Excel: **=RATE(15, 100, -928.09, 1000, 0)**

YTM with Semiannual Coupons (1 of 2)

Suppose a bond with a 10% coupon rate and semiannual coupons, has a face value of $1000, 20 years to maturity and is selling for $1197.93.

– Is the YTM more or less than 10%?

– What is the semiannual coupon payment?

– How many periods are there?

YTM with Semiannual Coupons (2 of 2)

Suppose a bond with a 10% coupon rate and semiannual coupons, has a face value of $1,000, 20 years to maturity and is selling for $1,197.93.

40	N
1197.93	PV (negative)
1000	FV
50	PMT
CPT PV	4% (= ½ YTM)

YTM = 4%*2 = 8%

NOTE: Solving a semi-annual payer for YTM results in a 6-month yield.

The calculator & Excel solve what you enter.

Using Excel: **=RATE(40, 50, -1197.93, 1000, 0) = 4%**

Table 6.1

TABLE 6.1

Summary of bond valuation

I. Finding the value of a bond

Bond value = $C \times [1 - 1/(1 + r)^t]/r + F/(1 + r)^t$

where:

C = Coupon paid each period

r = Rate per period

t = Number of periods

F = Bond's face value

II. Finding the yield on a bond

Given a bond value, coupon, time to maturity, and face value, it is possible to find the implicit discount rate, or yield to maturity, by trial and error only. To do this, try different discount rates in the preceding formula until the calculated bond value equals the given bond value. Remember that increasing the rate *decreases* the bond value.

Debt or Equity

- Debt
  - Not an ownership interest
  - No voting rights
  - Interest is tax-deductible
  - Creditors have legal recourse if interest or principal payments are missed
  - Excess debt can lead to financial distress and bankruptcy
- Equity
  - Ownership interest
  - Common stockholders vote to elect the board of directors and on other issues
  - Dividends are not tax deductible
  - Dividends are not a liability of the firm until declared. Stockholders have no legal recourse if dividends are not declared
  - An all-equity firm cannot go bankrupt

The Bond Indenture

"Deed of Trust"

Contract between issuing company and bondholders includes:

- Basic terms of the bonds
- Total amount of bonds issued
- Secured versus Unsecured
- Sinking fund provisions
- Call provisions
  - Deferred call
  - Call premium
- Details of protective covenants

Return to Quiz

Bond Classifications

- Registered vs. Bearer Bonds
- Security
  - Collateral – secured by financial securities
  - Mortgage – secured by real property, normally land or buildings
  - Debentures – unsecured
  - Notes – unsecured debt with original maturity less than 10 years
- Seniority
  - Senior versus Junior, Subordinated

Bond Characteristics and Required Returns

- Coupon rate
  - f(risk characteristics of the bond when issued)
  - Usually ≈ yield at issue
- Which bonds will have the **higher** coupon, all else equal?
  - Secured debt versus a debenture
  - Subordinated debenture versus senior debt
  - A bond with a sinking fund versus one without
  - A callable bond versus a non-callable bond

Bond Ratings – Investment Quality

- High Grade
  - Moody's Aaa and S&P AAA – capacity to pay is extremely strong
  - Moody's Aa and S&P AA – capacity to pay is very strong
- Medium Grade
  - Moody's A and S&P A – capacity to pay is strong, but more susceptible to changes in circumstances
  - Moody's Baa and S&P BBB – capacity to pay is adequate, adverse conditions will have more impact on the firm's ability to pay

Return to Quiz

Bond Ratings – Speculative

- Low Grade
  - Moody's Ba, B, Caa and Ca
  - S&P BB, B, CCC, CC
  - Considered speculative with respect to capacity to pay. The "B" ratings are the lowest degree of speculation.
- Very Low Grade
  - Moody's C and S&P C – income bonds with no interest being paid
  - Moody's D and S&P D – in default with principal and interest in arrears

Government Bonds (1 of 2)

- Municipal Securities
  - Debt of state and local governments
  - Varying degrees of default risk, rated similar to corporate debt
  - Interest received is tax-exempt at the federal level
  - Interest usually exempt from state tax in issuing state

Government Bonds (2 of 2)

- Treasury Securities = Federal government debt
  - Treasury Bills (T-bills)
    - Pure discount bonds
    - Original maturity of one year or less
  - Treasury notes
    - Coupon debt
    - Original maturity between one and ten years
  - Treasury bonds
    - Coupon debt
    - Original maturity greater than ten years

Example 6.4

A taxable bond has a yield of 8% and a municipal bond has a yield of 6%

- If you are in a 40% tax bracket, which bond do you prefer?
  - 8%(1 - .4) = 4.8%
  - The after-tax return on the corporate bond is 4.8%, compared to a 6% return on the municipal
- At what tax rate would you be indifferent between the two bonds?
  - 8%(1 – T) = 6%
  - T = 25%

Zero Coupon Bonds

- Make no periodic interest payments (coupon rate = 0%)
- Entire yield-to-maturity comes from the difference between the purchase price and the par value (capital gains)
- Cannot sell for more than par value
- Sometimes called zeroes, or deep discount bonds
- Treasury Bills and U.S. Savings bonds are good examples of zeroes

Floating Rate Bonds

- Coupon rate floats depending on some index value
- Examples – adjustable rate mortgages and inflation-linked Treasuries
- Less price risk with floating rate bonds
  - Coupon floats, so is less likely to differ substantially from the yield-to-maturity
- Coupons may have a "collar" – the rate cannot go above a specified "ceiling" or below a specified "floor"

Other Bond Types

- Structured notes
- Convertible bonds
- Put bonds
- Many types of provisions can be added to a bond
  - Important to recognize how these provisions affect required returns
  - Who does the provision benefit?

Bond Markets

- Primarily over-the-counter transactions with dealers connected electronically
- Extremely large number of bond issues, but generally low daily volume in single issues
- Getting up-to-date prices difficult, particularly on small company or municipal issues
- Treasury securities are an exception

Work the Web Example

- Bond information is available online
- One good site:

  http://finra-markets.morningstar.com/BondCenter/Default.jsp
- Click on this link to go to the site
  - Use "Quick Bond Search" to observe the yields for various bond types, and the shape of the yield curve.

Corporate Bond Quotations

ABC 8.375 Jul 15, 2033 100.641 8.316 362 30 763,528

- What company are we looking at?
- What is the coupon rate? If the bond has a $1000 face value, what is the coupon payment each year?
- When does the bond mature?
- What was the trading volume on that day?
- What is the quoted price? (Ask price)
- How does the bond's yield compare to a comparable Treasury note/bond?
  - 8.316 = Last yield
  - 362 = basis point difference vs 30-yr T-Bond

Treasury Quotations (1 of 3)

U.S. Treasury Quotes

Treasury note and bond data are representative over-the-counter quotations as of 3 p.m. Eastern time.

FIGURE 6.3

Sample *Wall Street Journal* U.S. Treasury note and bond prices

Maturity	Coupon	Bid	Asked	Chg	Asked Yield
1/31/2019	1.500	99.5469	99.5625	–0.0078	2.205
12/31/2021	2.125	97.8906	97.9063	0.0703	2.749
1/31/2022	1.500	95.6563	95.6719	0.0547	2.762
2/28/2023	2.625	99.2109	99.2266	0.1172	2.801
9/30/2023	1.375	92.7969	92.8125	0.1172	2.847
2/29/2024	2.125	96.1172	96.1328	0.1484	2.864
7/31/2024	2.125	95.7344	95.7500	0.1172	2.887
1/31/2025	2.500	97.6328	97.6484	0.1953	2.892
4/30/2025	2.875	99.8359	99.8516	0.2109	2.899
11/15/2026	6.500	126.6406	126.6563	0.3125	2.906
2/15/2029	5.250	120.9453	121.0078	0.4063	2.941
5/15/2030	6.250	132.8984	132.9609	0.4688	2.949
2/15/2036	4.500	120.9375	121.0000	0.5625	2.964
5/15/2037	5.000	129.0938	129.1563	0.6641	2.973
11/15/2039	4.375	121.3047	121.3672	0.6953	3.014
5/15/2040	4.375	121.5313	121.5938	0.7500	3.021
8/15/2041	3.750	111.6875	111.7500	0.7500	3.040
5/15/2042	3.000	99.1875	99.2188	0.7266	3.046
2/15/2043	3.125	101.1641	101.1953	0.7344	3.056
2/15/2044	3.625	110.0313	110.0625	0.6875	3.056
8/15/2046	2.250	84.6797	84.7109	0.6016	3.064
5/15/2047	3.000	98.7578	98.7891	0.6953	3.063
5/15/2048	3.125	101.1875	101.2188	0.7422	3.062

Source: www.wsj.com, 6/14/2018.

Treasury Quotations (2 of 3)

- Highlighted quote in Figure 6.3

5/15/2030	**6.250**	**132.8984**	**132.9609**	**0.4688**	**2.949**

  - When does the bond mature?
  - What is the coupon rate on the bond?
  - What is the bid price? What does this mean?
  - What is the ask price? What does this mean?
  - How much did the price change from the previous day?
  - What is the YTM based on Ask price?

Treasury Quotations (3 of 3)

5/15/2030	**6.250**	**132.8984**	**132.9609**	**0.4688**	**2.949**

  - Maturity = May 15, 2030
  - Coupon rate = 6.250% per year
  - Bid price = 132.8984 % of par
    - Price at which dealer is willing to buy from you
  - Ask price = 132.9609 % of par
    - Price at which dealer is willing to sell to you
  - Bid-Ask Spread = Dealer's profit
  - Change = ask price is up .4688 % since the previous day
  - Asked Yield = 2.949%

Quoted Price versus Invoice Price

- Quoted bond prices = “clean” price
  - Net of accrued interest
- Invoice Price = “dirty” or “full” price
  - Price actually paid
  - Includes accrued interest
- Accrued Interest
  - Interest earned since last coupon payment is owed to bond seller at time of sale

Inflation and Interest Rates

- Real rate of interest
  =Change in purchasing power
- Nominal rate of interest
  = Quoted rate of interest,
  = Change in purchasing power and inflation

- The ex ante nominal rate of interest includes our desired real rate of return plus an adjustment for expected inflation

The Fisher Effect

The Fisher Effect defines the relationship between real rates, nominal rates and inflation

$$(1 + R) = (1 + r)(1 + h)$$

R = nominal rate (Quoted rate)

r = real rate

h = *expected* inflation rate

Approximation: $R = r + h$

Return to Quiz

Example 6.6

If we require a 10% real return and we expect inflation to be 8%, what is the nominal rate?

- R = (1.1)(1.08) – 1 = .188 = 18.8%
- Approximation: R = 10% + 8% = 18%
- Because the real return and expected inflation are relatively high, there is significant difference between the actual Fisher Effect and the approximation.

Term Structure of Interest Rates

- Term structure: The relationship between time to maturity and yields, all else equal
  - The effect of default risk, different coupons, etc. has been removed.
- Yield curve: Graphical representation of the term structure
  - Normal = upward-sloping ➡ L/T > S/T
  - Inverted = downward-sloping ➡ L/T < S/T

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Figure 6.5 A: Upward-Sloping Yield Curve

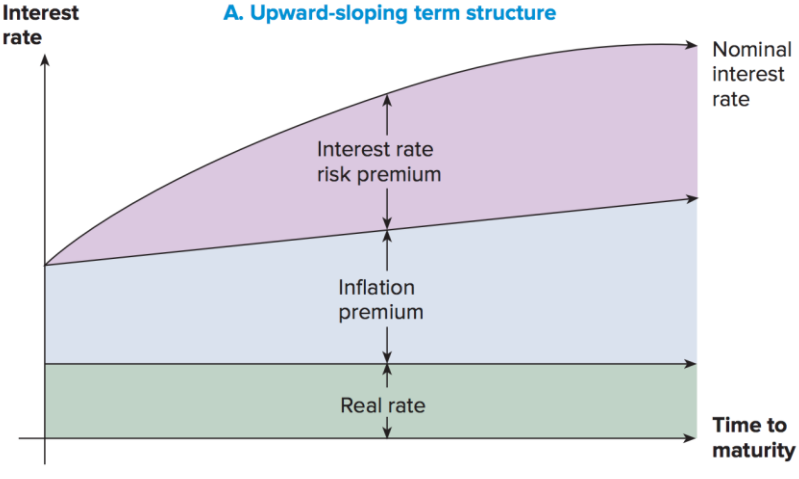


Figure 6.5 B: Downward-Sloping Yield Curve

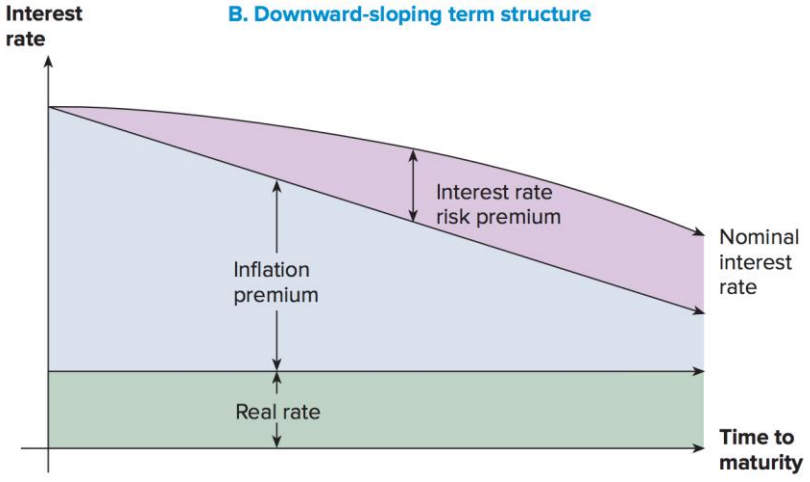


Figure 6.6: Treasury Yield Curve

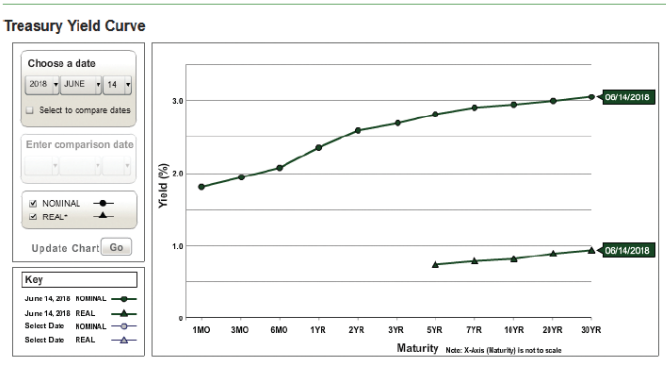


FIGURE 6.6

The Treasury yield curve
June 14, 2018

Source: www.treasury.gov, June 14, 2018

More information can be found at this link.

Factors Effecting Required Return

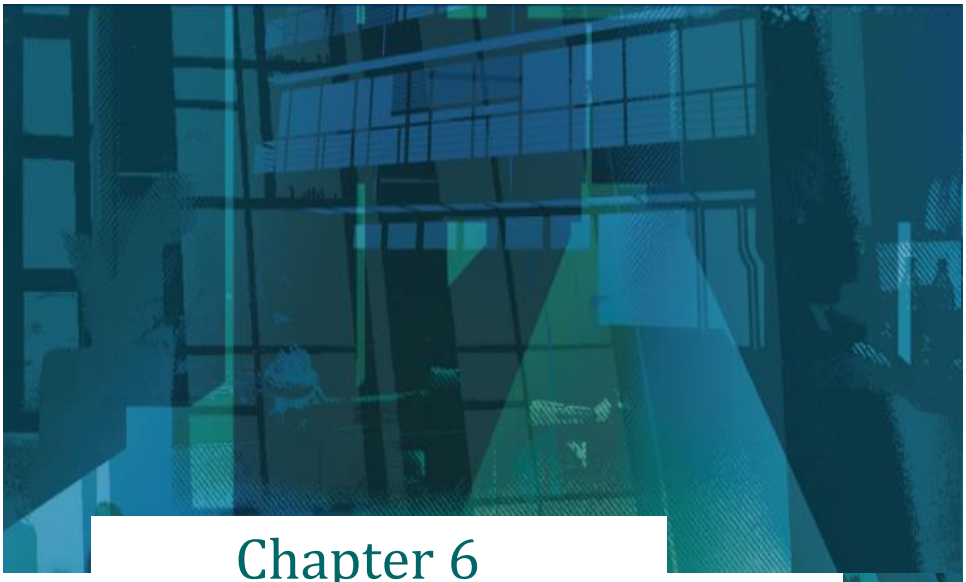
- Default risk premium – bond ratings
- Taxability premium – municipal versus taxable
- Liquidity premium – bonds that have more frequent trading will generally have lower required returns
- Maturity premium – longer term bonds will tend to have higher required returns.

Anything else that affects the risk of the cash flows to the bondholders will affect the required returns

Return to Quiz

Quick Quiz

- How do you find the value of a bond and why do bond prices change? (Slide 6.8)
- What is a bond indenture and what are some of the important features? (Slide 6.30)
- What are bond ratings and why are they important? (Slide 6.33)
- How does inflation affect interest rates? (Slide 6.49)
- What is the term structure of interest rates? (Slide 6.51)
- What factors determine the required return on bonds? (Slide 6.55)



Chapter 6

END