Chapter 6

The Risk and Term Structure of Interest Rates

Differences in Interest Rates

- bonds with the same term to maturity have different interest rates – why?

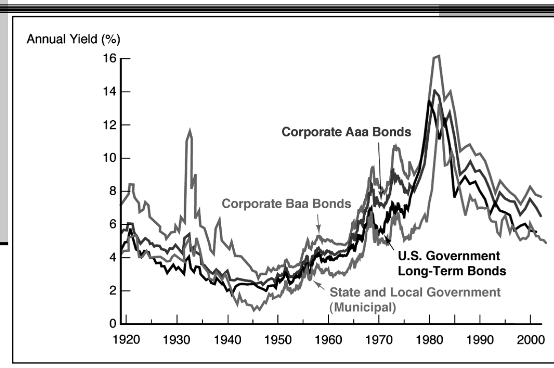
- Risk
  - *risk of default* = risk that the issuer be not able or not willing to make interest payments or repay the face value when due
  - bonds that have no risk of default are called *default-free bonds* (e.g., Treasury bonds)
  - *risk premium* = spread between the interest rates on bonds with risk of default and default-free bonds

Differences in Interest Rates (cont.)

- Liquidity
  - less liquid bonds have lower prices than more liquid bonds, hence interest rates are higher

- Income tax treatment of interest payments
  - municipal bonds versus other bonds
  - as interest income from municipal bonds is tax-free, interest rates are lower

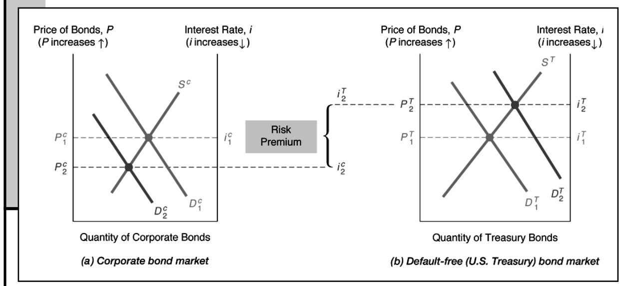
Risk Structure of Long-Term Bonds in the United States



Increase in Default Risk on Corporate Bonds

- Corporate bond market
  - expected return on corporate bonds ↓, demand for corporate bonds D^c ↓, D^c shifts left
  - risk of corporate bonds ↑, D^c ↓, D^c shifts left
  - P^c ↓, i^c ↑
- Treasury Bond Market
  - relative return on Treasury bonds ↑, demand for Treasury bonds D^T ↑, D^T shifts right
  - relative risk of Treasury bonds ↓, D^T ↑, D^T shifts right
  - P^T ↑, i^T ↓

Increase in Default Risk on Corporate Bonds – Graphical Exposition



Increase in Default Risk on Corporate Bonds

- Outcome: risk premium, $i^c - i^T$, rises
- Conclusions:
  - a bond with default risk will always have a positive risk premium.
  - moreover, if the risk of default increases, so will the risk premium.
  - hence the need to know how likely an issuer is to default.

Bond Ratings

Table 1 Bond Ratings by Moody's and Standard and Poor's

	Rating: Moody's	Rating: Standard and Poor's	Descriptions	Examples of Corporations with Bonds Outstanding in 2003
Investment-grade	Aaa	AAA	Highest quality (lowest default risk)	General Electric, Pfizer Inc., North Carolina State, Mobil Oil
	Aa	AA	High quality	Wal-Mart, McDonald's, Credit Suisse First Boston
	A	A	Upper medium grade	Hewlett-Packard, Anheuser-Busch, Ford, Household Finance
	Baa	BBB	Medium grade	Motorola, Albertson's, Pennzoil, Weyerhaeuser Co., Tommy Hilfiger
Junk bonds	Ba	BB	Lower medium grade	Royal Caribbean, Levi Strauss
	B	B	Speculative	Rite Aid, Northwest Airlines Inc., Six Flags
	Caa	CCC, CC	Poor (high default risk)	Revlon, United Airlines
	Ca	C	Highly speculative	US Airways, Polaroid
	C	D	Lowest grade	Enron, Oakwood Homes

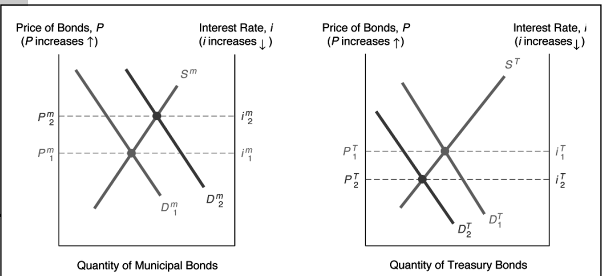
Corporate Bonds Become Less Liquid

- Corporate bond market
  - less liquid corporate bonds, $D^c \downarrow$, D^c shifts left
  - $P^c \downarrow$, $i^c \uparrow$
- Treasury bond market
  - relatively more liquid Treasury bonds, $D^T \uparrow$, D^T shifts right
  - $P^T \uparrow$, $i^T \downarrow$
- Outcome:
  - risk premium, $i^c - i^T$, rises
  - risk premium reflects not only corporate bonds' default risk, but also lower liquidity

Tax Advantages of Municipal Bonds

- municipal bonds are not default-free – then, why lower risk premium?
- Municipal bond market
  - federal tax exemption raises relative expected return on municipal bonds, demand for munis $D^m \uparrow$, D^m shifts right
  - $P^m \uparrow$, $i^m \downarrow$
- Treasury bond market
  - relative return on Treasury bonds $\downarrow$, $D^T \downarrow$, D^T shifts left
  - $P^T \downarrow$, $i^T \uparrow$
- Outcome: $i^m < i^T$

Tax Advantages of Municipal Bonds – Graphical Exposition



(a) Market for municipal bonds *(b) Market for Treasury bonds*

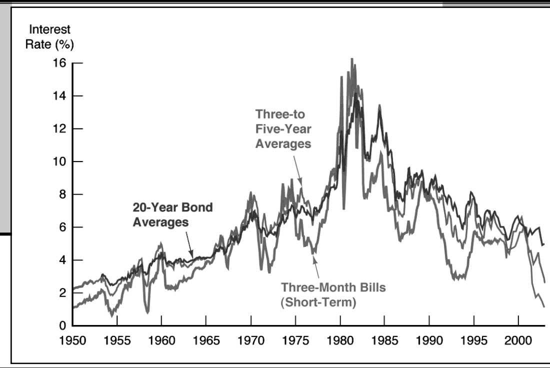
Term Structure of Interest Rates

- bonds with the same risk, liquidity and tax treatment have different interest rates if term to maturity is different
- *yield curve* = plot of yield on bonds with same characteristics but different term to maturity
- the yield curve describes the term structure of interest rates for that particular type of bonds

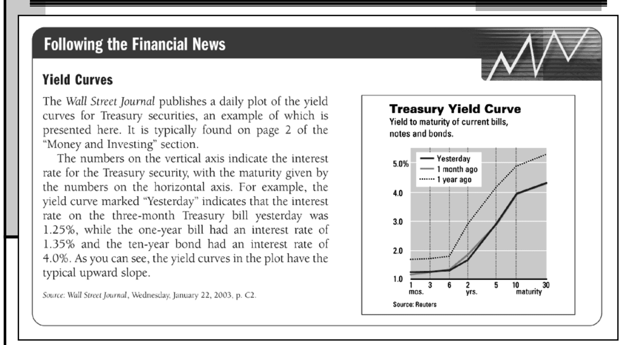
Term Structure of Interest Rates (cont.)

- Facts to be explained:
  1. interest rates on different maturity bonds seem to move together over time
  2. yield curves tend to have steep upward slopes when short rates (i.e., interest rates for short maturity bonds) are low, and downward slopes when short rates are high
  3. yield curves are typically upward sloping

Fact 1: Interest Rates on Different Maturity Bonds Move Together



Fact 2: Yield Curves Tend to Slope Upwards



Following the Financial News

Yield Curves

The *Wall Street Journal* publishes a daily plot of the yield curves for Treasury securities, an example of which is presented here. It is typically found on page 2 of the "Money and Investing" section.

The numbers on the vertical axis indicate the interest rate for the Treasury security, with the maturity given by the numbers on the horizontal axis. For example, the yield curve marked "Yesterday" indicates that the interest rate on the three-month Treasury bill yesterday was 1.25%, while the one-year bill had an interest rate of 1.35% and the ten-year bond had an interest rate of 4.0%. As you can see, the yield curves in the plot have the typical upward slope.

Source: Wall Street Journal, Wednesday, January 22, 2003, p. C2.

Three Theories of Term Structure

1. Expectations theory
   - explains facts 1 and 2, but not 3
2. Segmented markets theory
   - explains fact 3, but not 1 and 2
3. Liquidity premium (preferred habitat) theory
   - combines features of both expectations theory and segmented markets theory
   - explain all 3 facts

Expectations Theory

- Key Assumption
  - bonds with different maturities are perfect substitutes
- Implication
  - expected return on bonds of different maturities are equal
- Example - investment strategies for a two-period horizon
  - buy a \$1 one-year bond and when it matures use the proceeds to buy another one-year bond
  - buy a \$1 two-year bond and hold it to maturity

Comparing the Two Strategies

- expected return from strategy 1:

$$R^1 = \frac{(1+i_t)(1+i_{t+1})-1}{1} = i_t + i_{t+1} + i_t i_{t+1} \approx i_t + i_{t+1}$$

since $i_t i_{t+1}$ is usually very small

- expected return from strategy 2:

$$R_2 = \frac{(1+i_{2t})^2-1}{1} = 1 + 2i_{2t} + i_{2t}^2 - 1 \approx 2i_{2t}$$

since i_{2t}^2 is usually very small

- as the two returns should be equal:

$$i_{2t} = \frac{i_t + i_{t+1}}{2}$$

Expectations Theory – Implication

- more generally, for an n-year bond, the interest rate is given by

$$i_{nt} = \frac{i_t + i_{t+1} + ... + i_{t+(n-1)}}{n}$$

- in words: the interest rate on long (term) bond is equal to the average of short (term) rates expected to occur over the life of the long bond

Expectations Theory – Example

- suppose the one-year interest rates over the next five years are: 5%, 6%, 7%, 8%, and 9%
- the interest rate on a two-year bond is:

$$i_2 = \frac{5\% + 6\%}{2} = 5.5\%$$

- the interest rate on a five-year bond is:

$$i_5 = \frac{5\% + 6\% + 7\% + 8\% + 9\%}{5} = 7\%$$

- the interest rates on one- to five-year bonds are: 5%, 5.5%, 6%, 6.5%, and 7%

Expectations Theory and Term Structure Facts

- Explains why yield curve has different slopes:
  - when short rates are expected to rise in future, the average of future short rates (= i_{nt}) is above today's short rate, hence yield curve is upward sloping
  - when short rates are expected to stay the same in the future, the average of future short rates (= i_{nt}) is the same as today's, and yield curve is flat
  - only when short rates are expected to fall will the yield curve be downward sloping

Expectations Theory and Term Structure Fact 1

- Fact 1: short and long rates move together
  - short rate rises are persistent
  - if i_t rises today, then i_{t+1}, i_{t+1} etc. increase, hence the average of future rates goes up, meaning that i_{nt} rises
  - therefore: $i_t \uparrow \Rightarrow i_{nt} \uparrow$, i.e., short and long rates move together

Expectations Theory and Term Structure Fact 2

- Fact 2: relationship between yield curve slope and short rates
  - when short rates are low, they are expected to rise to the "normal level", and the long rate (the average of future short rates) will be well above today's short rate – hence, the yield curve will have a steep upward slope
  - when short rates are high, they are expected to fall in the future, and the long rate will be below the current short rate – hence, the yield curve will have a downward slope

Expectations Theory and Term Structure Fact 3

- Fact 3: yield curves usually have an upward slope
  - if yield curves slope upwards, it means that people usually expect short rates to rise in the future
  - but short rates are as likely to fall in the future as rise, so the average of future short rates (i.e., the long rate) will not usually be higher than the current short rate
  - therefore, the yield curve will *not* usually slope upward

Segmented Markets Theory

- Key Assumption
  - bonds of different maturities are not substitutes at all
- Implication
  - markets are completely segmented: interest rates at each maturity are determined separately (e.g., if you save for kids' college, you are interested only in long-term bonds)

Segmented Markets Theory and Term Structure Facts

- Explains Fact 3: yield curves are usually upward sloping
  - people typically prefer short holding periods and thus have higher demand for short-term bonds
  - hence, short-term bonds have higher prices and lower interest rates than long bonds
- Does not explain Fact 1 or Fact 2
  - as it assumes that long and short rates are determined independently, it cannot predict any relationship between them

Liquidity Premium Theory

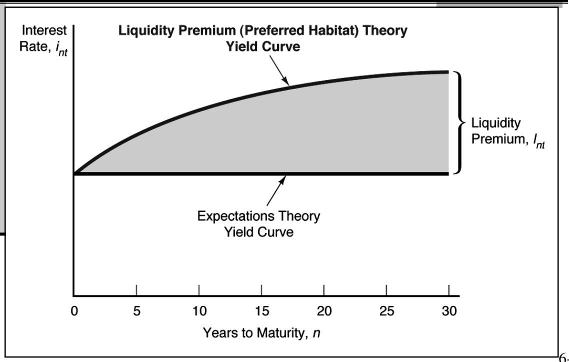
- Key Assumption
  - bonds of different maturities are substitutable, but they are not perfect substitutes
- Implication
  - modifies Expectations theory with features of Segmented markets theory
  - investors prefer short to long bonds (less interest-rate risk), hence they must be paid a positive liquidity (term) premium, l_{nt}, to hold long-term bonds $\Rightarrow$ the long rate becomes:

$$i_{nt} = \frac{i_t + i_{t+1} + ... + i_{t+(n-1)}}{n} + l_{nt}$$

Preferred Habitat Theory

- Key Assumption
  - investors have a strong preference for bonds of one maturity (preferred habitat) over another
  - investors are more likely to prefer short-term bonds
- Implication
  - investors need to be paid a premium to be willing to buy bonds of maturities other than their preferred one
  - hence same implications as the Liquidity premium theory

Relationship Between the Liquidity Premium and Expectations Theories



Liquidity Premium – Numerical Example

- suppose one-year interest rates over the next five years are: 5%, 6%, 7%, 8% and 9%
- because of investors' preference for holding short-term bonds, the liquidity premiums for one to five-year bonds are: 0%, 0.25%, 0.5%, 0.75% and 1.0%
- interest rate on a two-year bond:

$$i_{nt} = \frac{5\% + 6\%}{2} + 0.25\% = 5.75\%$$

- interest rate on the five-year bond:

$$i_{nt} = \frac{5\% + 6\% + 7\% + 8\% + 9\%}{5} + 1\% = 8\%$$

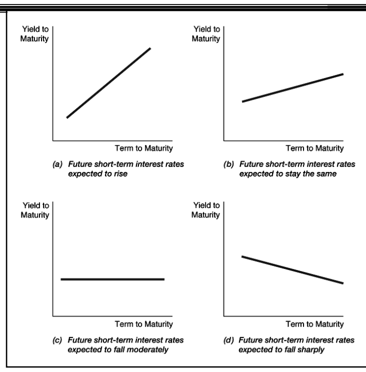
Liquidity Premium – Numerical Example (cont.)

- interest rates on one- to five-year bonds are: 5%, 5.75%, 6.5%, 7.25% and 8%.
- remember that the interest rates on one- to five-year bonds predicted by the Expectations theory are: 5%, 5.5%, 6%, 6.5%, and 7%
- comparing these two sets of numbers, notice that the liquidity premium (preferred habitat) theory produces yield curves more steeply upward sloped

Liquidity Premium (Preferred Habitat) and Term Structure Facts

- Explains all three facts
  - explains Fact 1 and Fact 2 using the same explanations as expectations hypothesis because the long rate is determined by the average of future short rates
  - explains Fact 3 (usual upward sloped yield curves) by investors' preference for short-term bonds

Yield Curves and Market Predictions of Future Short Rates



Interpreting Yield Curves, 1980–2000