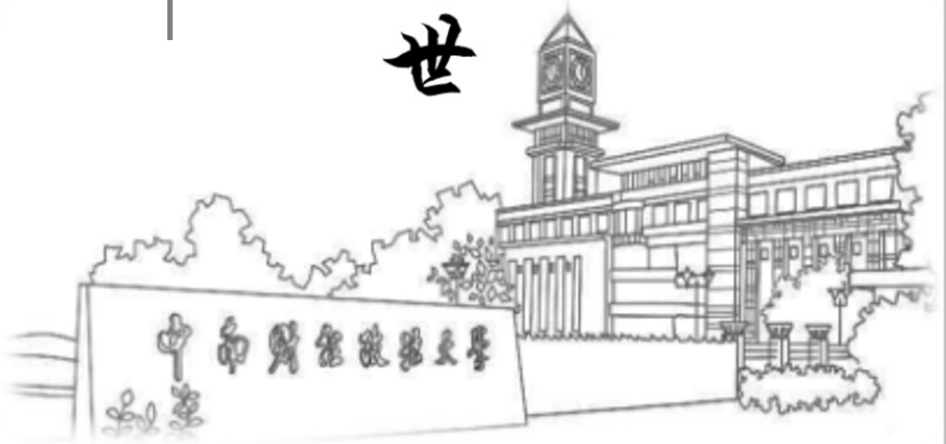
Financial Markets

博文明理
厚德濟世



Chapter 6: The Risk and Term Structure of Interest Rates

Preview

- We examine how the individual risk of a bond affects its rate (yield to maturity). We also explore how the general level of interest rates varies with the maturity of the debt instruments. Topics include:

  – Risk Structure of Interest Rates

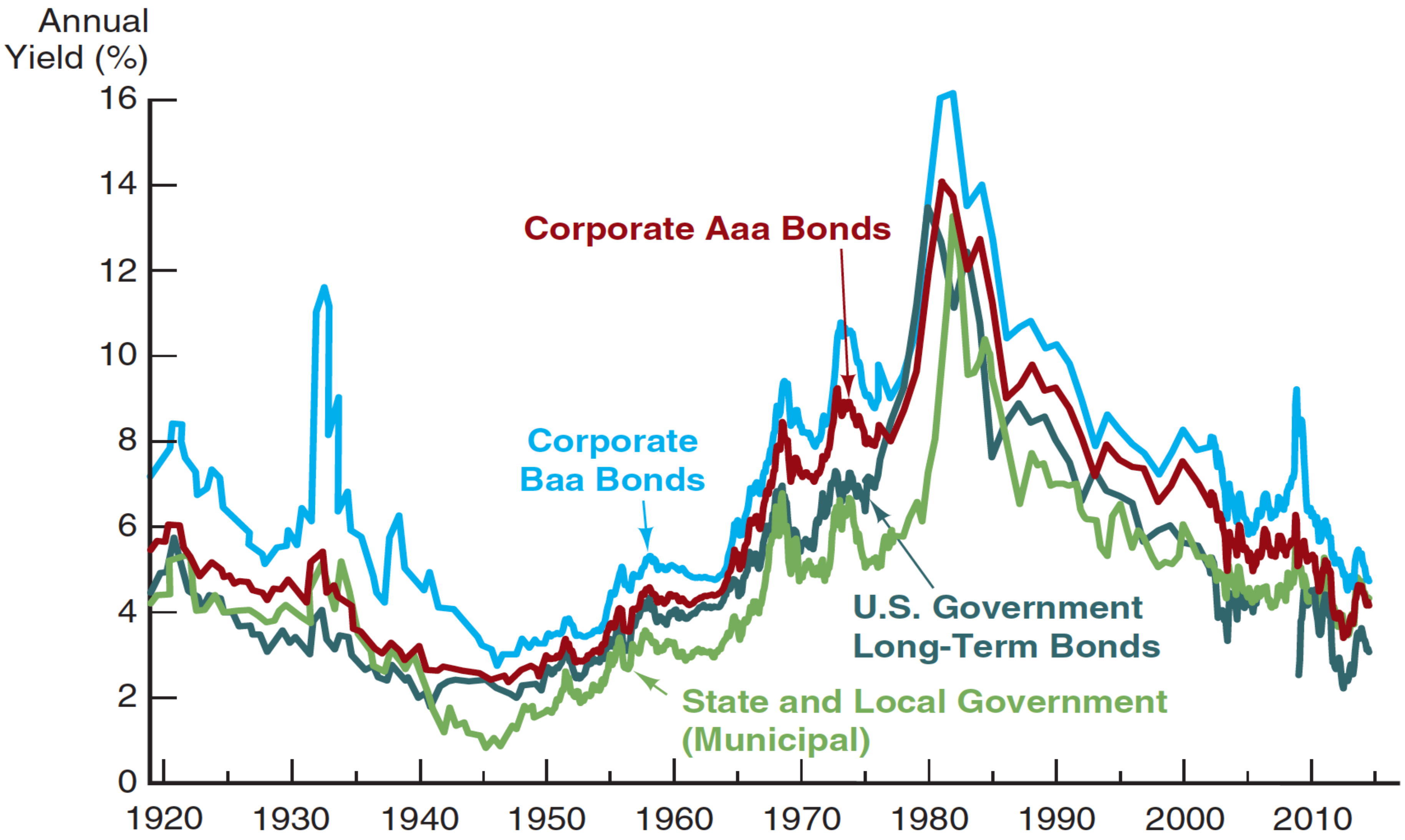
  – Term Structure of Interest Rates

Learning Objectives

- Identify and explain three factors explaining the risk structure of interest rates.

- List and explain the three theories of why interest rates vary across maturities.

Long-Term Bond Yields, 1919–2014



Risk Structure of Interest Rates

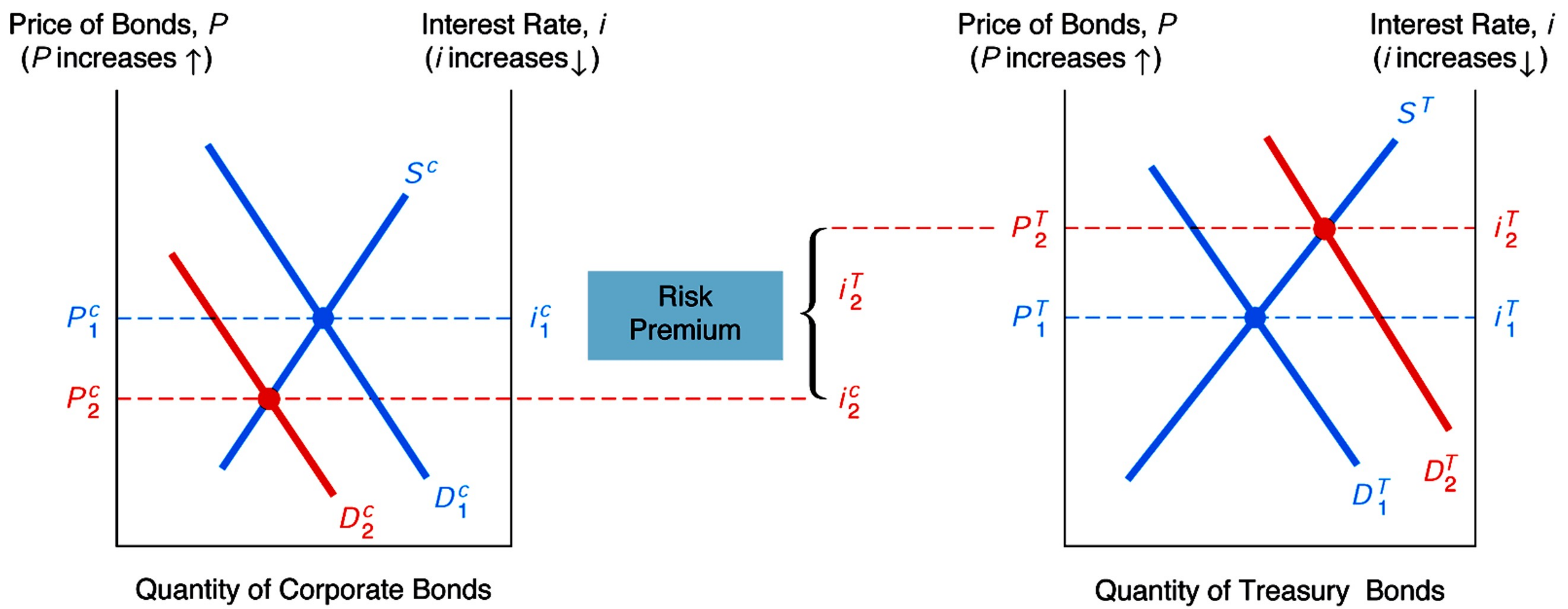
Bonds with the same maturity have different interest rates due to:

- Default risk
- Liquidity
- Tax considerations

Risk Structure of Interest Rates

- **Default risk**: probability that the issuer of the bond is unable or unwilling to make interest payments or pay off the face value
- **Risk premium:** the spread between the interest rates on bonds with default risk and the interest rates on (same maturity) Treasury bonds
- **Default-free bonds:** U.S. Treasury bonds are usually considered to have no default risk because in principle the federal government can always increase taxes to pay off its obligations.
- A bond with default risk will always have a positive risk premium, and an increase in its default risk will raise the risk premium.

Response to an Increase in Default Risk on Corporate Bonds



(a) Corporate bond market

(b) U.S. Treasury bond market

1.Risk of corp. bonds ↑, $D^c \downarrow$, D^c shifts

2.Excess Supply $\Rightarrow P^c \downarrow$, $i^c \uparrow$

1.Relative risk of T bonds ↓, $D^T \uparrow$, D^T shifts right

2.Excess Demand $\Rightarrow P^T \uparrow$, $i^T \downarrow$

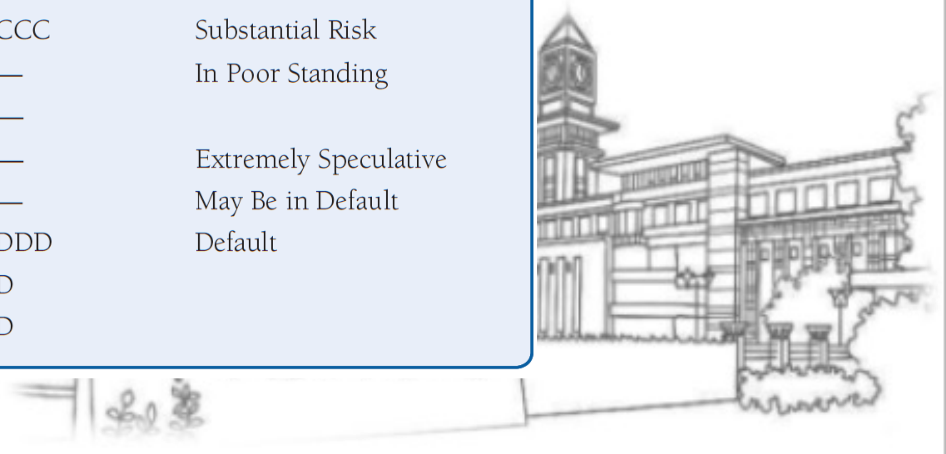
Default Risk Factor

- Default risk is an important component of the size of the risk premium.
- Because of this, bond investors would like to know as much as possible about the default probability of a bond.
- One way to do this is to use the measures provided by credit-rating agencies: Moody’s and S&P are examples.

Bond Ratings by Moody's, Standard and Poor's, and Fitch

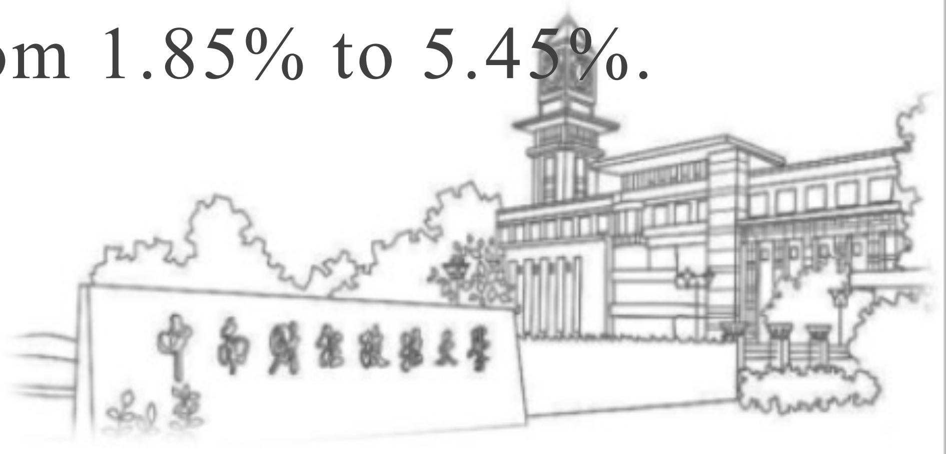
TABLE 1 Bond Ratings by Moody's, Standard and Poor's, and Fitch

	Rating Agency		
Moody's	**S&P**	**Fitch**	**Definitions**
Aaa	AAA	AAA	Prime Maximum Safety
Aa1	AA+	AA+	High Grade High Quality
Aa2	AA	AA	
Aa3	AA−	AA−	
A1	A+	A+	Upper Medium Grade
A2	A	A	
A3	A−	A−	
Baa1	BBB+	BBB+	Lower Medium Grade
Baa2	BBB	BBB	
Baa3	BBB−	BBB−	
Ba1	BB+	BB+	Noninvestment Grade
Ba2	BB	BB	Speculative
Ba3	BB−	BB−	
B1	B−	B−	Highly Speculative
B2	B	B	
B3	B−	B−	
Caa1	CCC+	CCC	Substantial Risk
Caa2	CCC	—	In Poor Standing
Caa3	CCC−	—	
Ca	—	—	Extremely Speculative
C	—	—	May Be in Default
—	—	DDD	Default
—	—	D	
—	D	D	



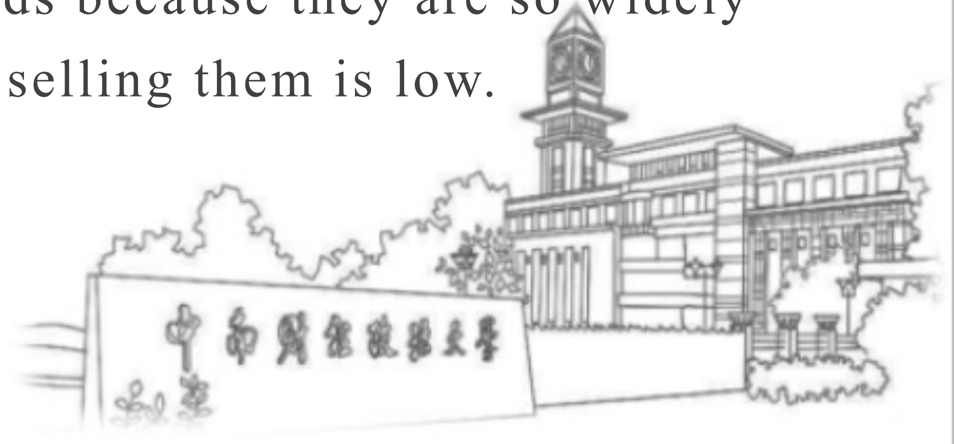
Case: The Subprime Collapse and the Baa-Treasury Spread

- Starting in 2007, the subprime mortgage market collapsed, leading to large losses for financial institutions.
- Because of the questions raised about the quality of Baa bonds, the demand for lower-credit bonds fell, and a “flight- to-quality” followed (demand for T-securities increased)
- Result: Baa-Treasury spread increased from 1.85% to 5.45%.



Liquidity Factor

- **Liquidity**: the relative ease with which an asset can be converted into cash
  - Cost of selling a bond
  - Number of buyers/sellers in a bond market
- The more liquid an asset is, the more desirable it is (higher demand), holding everything else constant.
- Treasury bonds are the most liquid of all long-term bonds because they are so widely traded that they are easy to sell quickly and the cost of selling them is low.

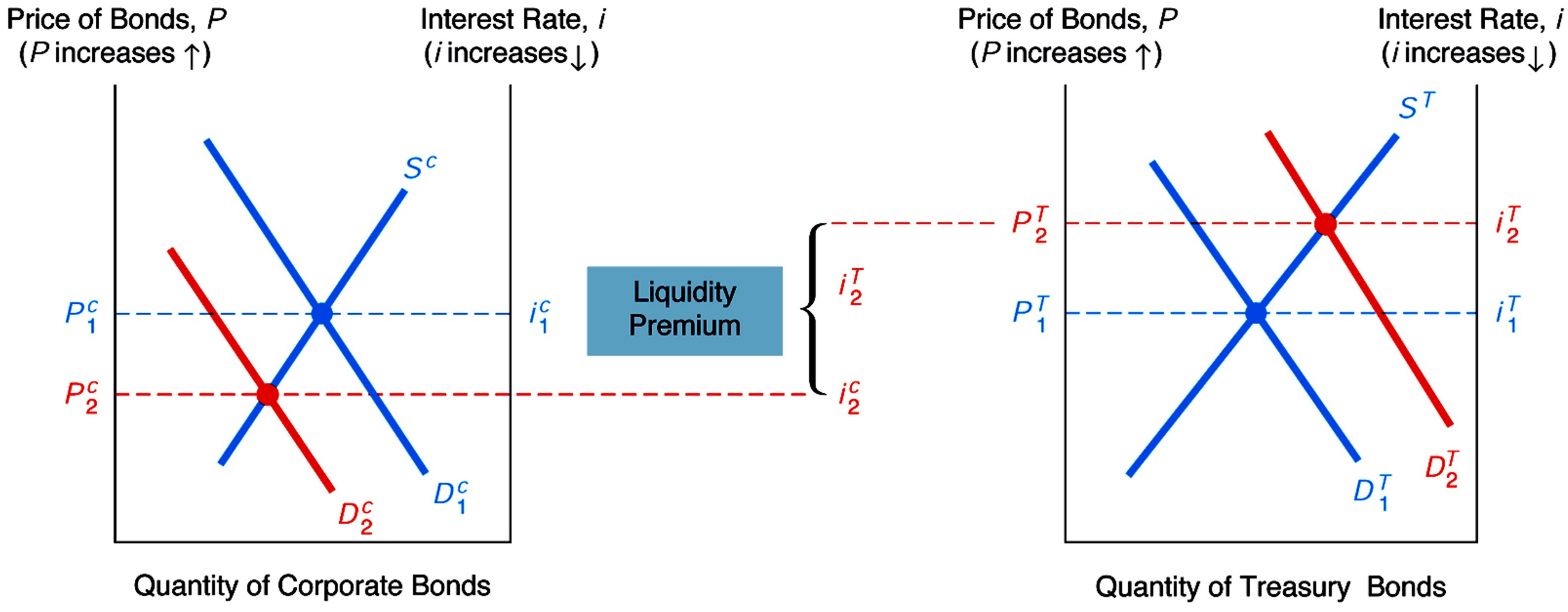


Liquidity Factor

- Corporate bonds are not as liquid because fewer bonds for any one corporation are traded; thus it can be costly to sell these bonds because it may be hard to find buyers quickly.

- The differences between interest rates on corporate bonds and Treasury bonds (that is, the risk premiums) reflect not only the corporate bond's default risk but its liquidity. This is why a risk premium is sometimes called a ***risk and liquidity premium***.

Decrease in Liquidity of Corporate Bonds



(a) Corporate bond market

(b) U.S. Treasury bond market

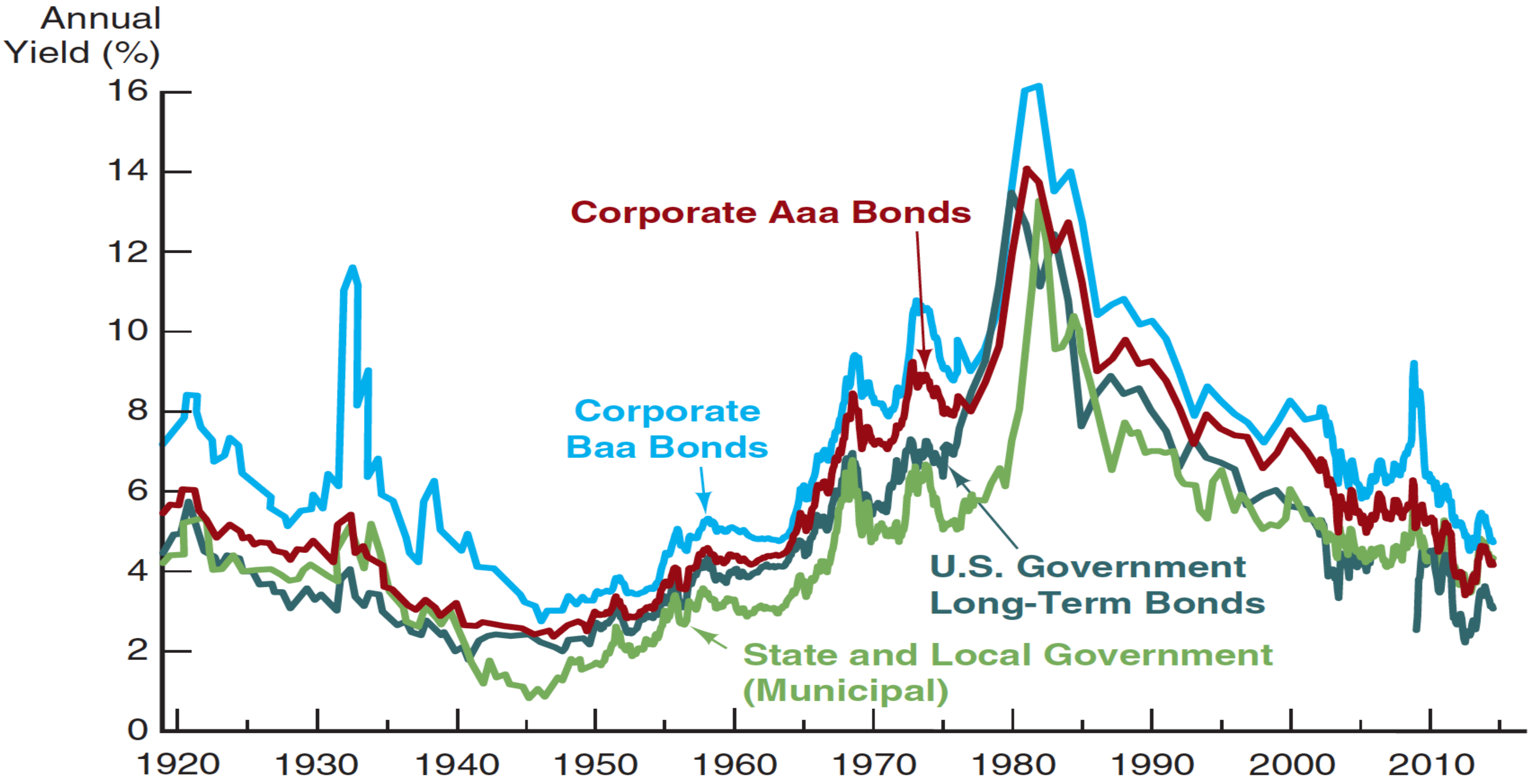
1.Liquidity of Corp. bonds ↓, D^c ↓, D^c shifts left

2.P^c ↓, i^c ↑

1.Relatively more liquid T bonds, D^T ↑, D^T shifts right

2.P^T ↑, i^T ↓

Income Taxes Factor



Income Taxes Factor

- An odd feature of the previous figure is that municipal bonds tend to have a lower rate the Treasuries. Why?

- Munis certainly can default. Orange County (California) is a recent example from the early 1990s.

- Munis are not as liquid a Treasuries.

Income Taxes Factor

- Interest payments on municipal bonds are exempt from federal income taxes.（This is also true in China after 2012）

- For the same before tax yield, their expected after tax returns are higher.

- Treasury bonds are exempt from state and local income taxes, while interest payments from corporate bonds are fully taxable.

Income Taxes Factor

- For example, suppose you are in the 31.2% tax bracket. From a 10%-coupon Treasury bond, you only receive $68.8 of the coupon payment because of taxes.

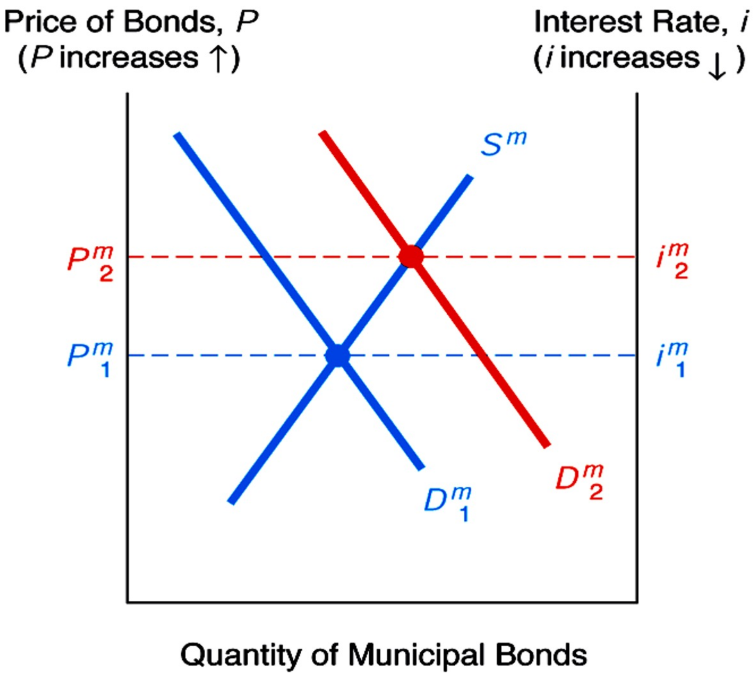
- However, from an 7%-coupon municipal bond, you net the full $70. For the higher return, you are willing to hold a riskier municipal bond (to a point).

Effects of the Obama Tax Increase on Bond Interest Rates

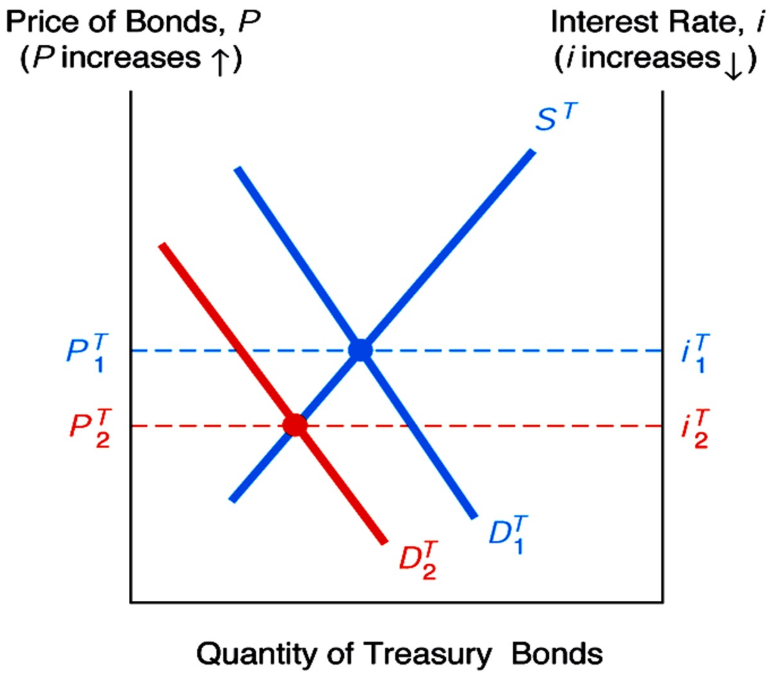
In 2013, Congress approved legislation favored by the Obama administration to increase the income tax rate on high-income taxpayers from 35% to 39%.

Consistent with supply and demand analysis, the increase in income tax rates for wealthy people helped to lower the interest rates on municipal bonds relative to the interest rate on Treasury bonds.

Tax Rate Chang on Municipal and Treasury Bonds



(a) Market for municipal bonds



(b) Market for Treasury bonds

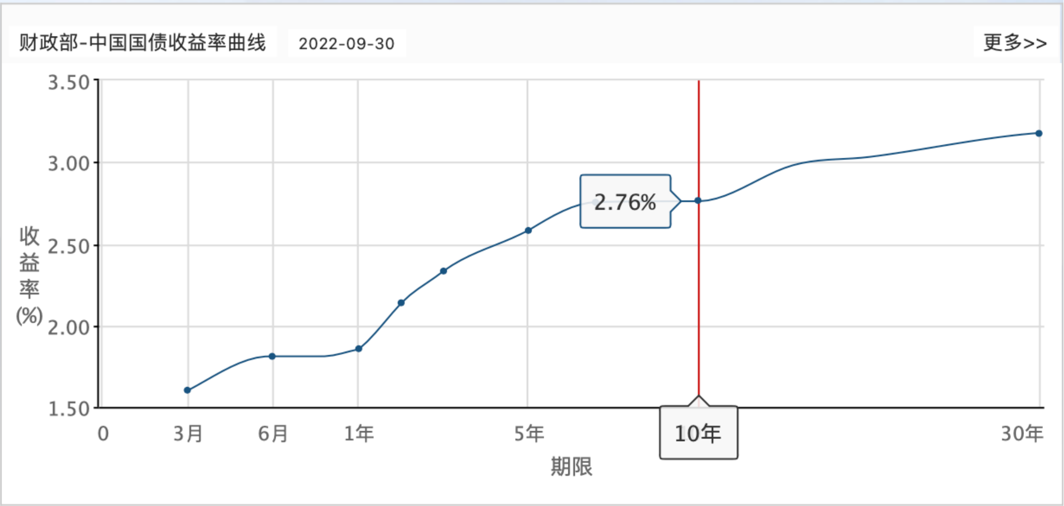
1.Tax rate ↑, Relative R^e on municipal bonds ↑, D^m ↑, D^m shifts right

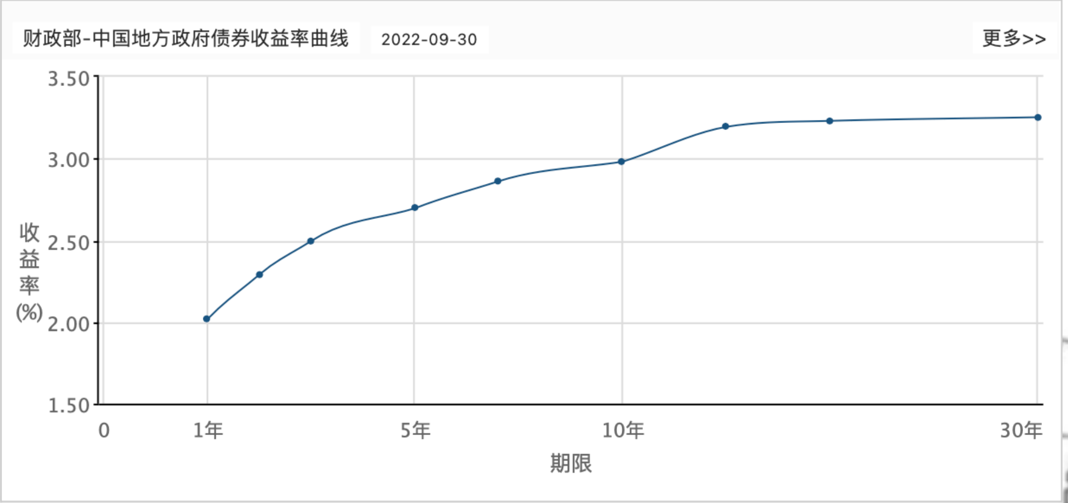
2.P^m ↑, i^m ↓

1.Tax rate ↑ Relative R^e on Treasury bonds ↓, D^T ↓, D^T shifts left

2.P^T ↓, i^T ↑

Gov Bond VS. Municipal Bond in China





Source: Ministry of Finance of the P.R.C

Term Structure of Interest Rates

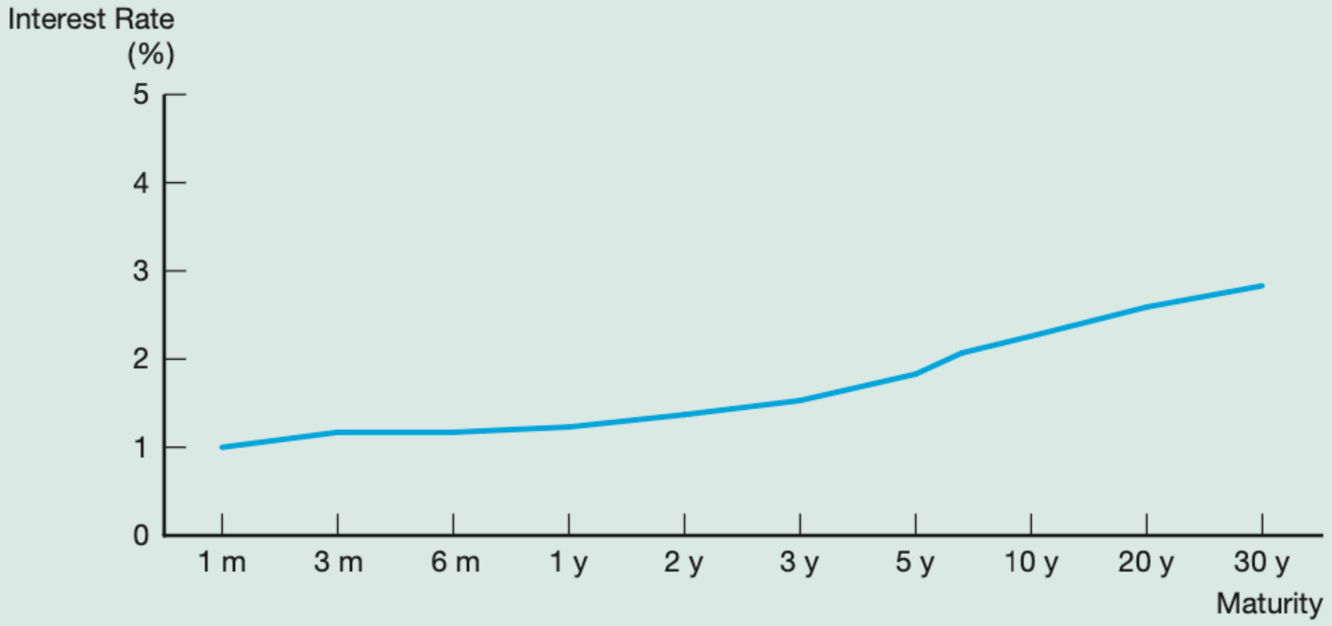
Now that we understand risk, liquidity, and taxes, we turn to another important influence on interest rates—maturity.

Bonds with identical risk, liquidity, and tax characteristics may have different interest rates because the time remaining to maturity is different

Yield Curves

Following the Financial News Yield Curves

Many newspapers and Internet sites such as http://www.finance.yahoo.com publish a daily plot of the yield curves for Treasury securities. An example for July 24, 2017 is presented here. The numbers on the vertical axis indicate the interest rate for the Treasury security, with the maturity term given on the horizontal axis, with "m" denoting "month" and "y" denoting "year."



Term Structure of Interest Rates

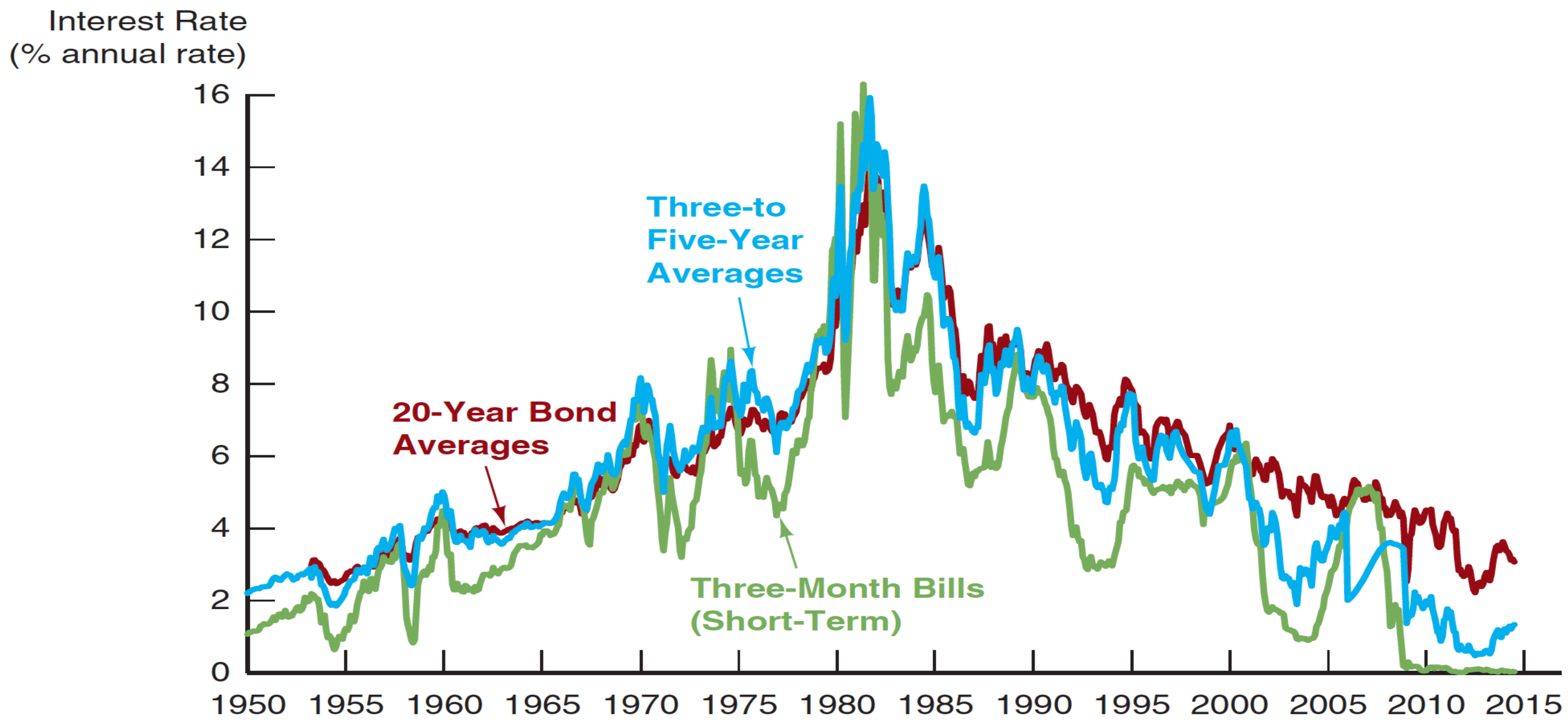
Yield curve: a plot of the yield on bonds with differing terms to maturity but the same risk, liquidity and tax considerations

- **Upward-sloping**: long-term rates are above short-term rates

- **Flat**: short- and long-term rates are the same

- **Inverted**: long-term rates are below short-term rates

Movements over Time of Interest Rates on U.S. Government Bonds with Different Maturities



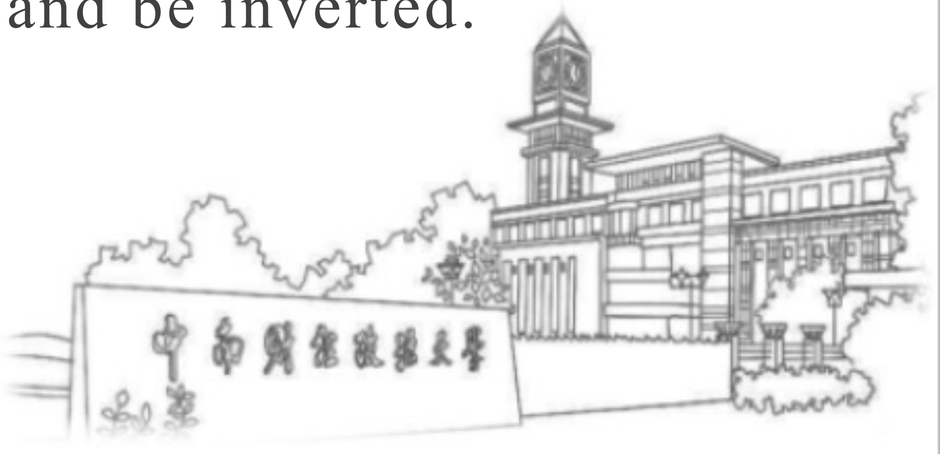
Term Structure of Interest Rates

The theory of the term structure of interest rates must explain these facts:

1. Interest rates on bonds of different maturities move together over time.

2. When short-term interest rates are low, yield curves are more likely to have an upward slope; when short-term rates are high, yield curves are more likely to slope downward and be inverted.

3. Yield curves almost always slope upward.



Term Structure of Interest Rates

Three theories to explain the three facts:

1. Expectations theory explains the first two facts but not the third.
2. Segmented markets theory explains the third fact but not the first two.
3. Liquidity premium theory combines the two theories to explain all three facts.

Expectations Theory

- **Key Assumption:** Bonds of different maturities are perfect substitutes

- **Implication:** R^e on bonds of different maturities are equal

- Investment strategies for **two-period horizon**

  1. Buy $1 of one-year bond and when matures buy another one-year bond

  2. Buy $1 of two-year bond and hold it

Expectations Theory

The important point of this theory is that if the Expectations Theory is correct, your *expected* wealth is the same (at the start) for both strategies.

Of course, your actual wealth may differ, if rates change *unexpectedly* after a year.

We show the details of this in the next few slides.

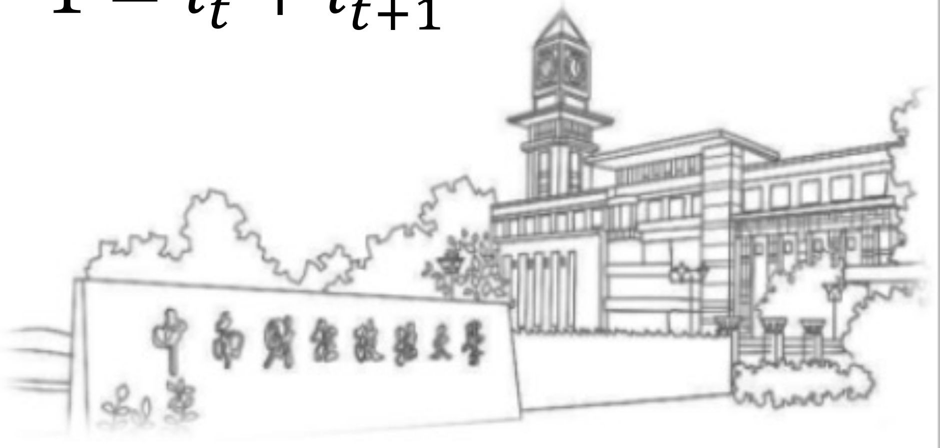
Expectations Theory

- Expected return from strategy 1

$$(1+i_2)(1+i_{t+1}^e)-1=1+i_t+i_{t+1}^e+i_t(i_{t+1}^e)-1$$

- Since $i_t(i_{t+1}^e)$ is also extremely small, expected return is approximately

$$(1+i_2)(1+i_{t+1}^e)-1=1+i_t+i_{t+1}^e-1=i_t+i_{t+1}^e$$



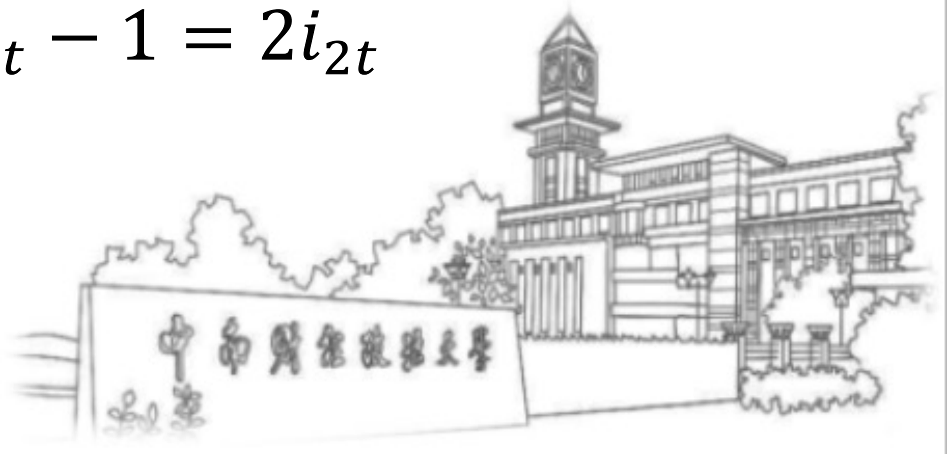
Expectations Theory

- Expected return from strategy 2

$$(1+i_{2t})(1+i_{2t})-1=1+2i_{2t}+(i_{2t})^2-1$$

- Since $(i_{2t})^2$ is extremely small, expected return is approximately

$$(1+i_{2t})(1+i_{2t})-1=1+2i_{2t}-1=2i_{2t}$$



Expectations Theory

From implication above expected returns of two strategies are equal, therefore

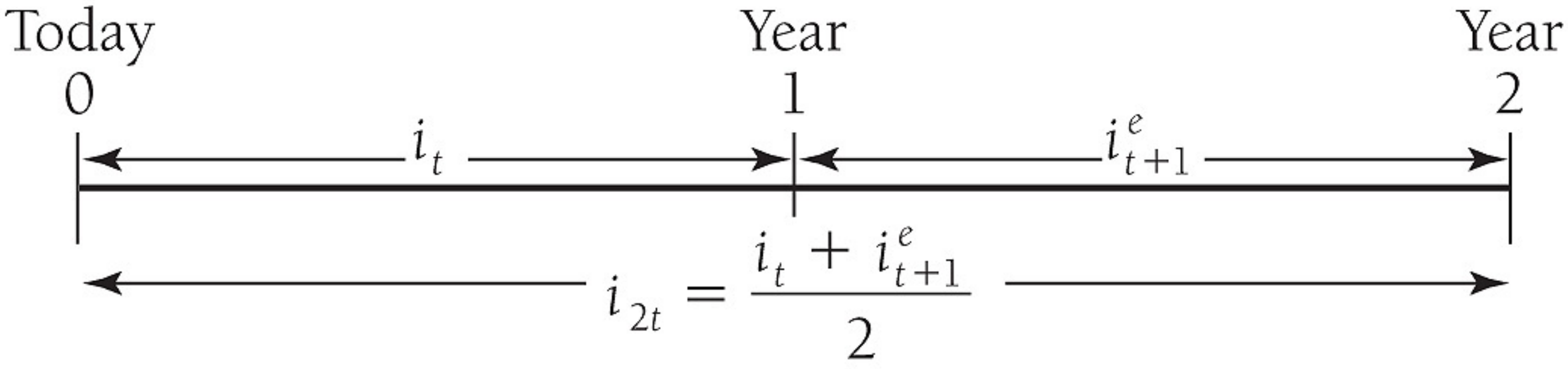
$$2i_{2t} = i_2 + i^e_{t+1}$$

Solving for i_{2t}

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

Expectations Theory

To help see this, here' s a picture that describes the same information:



More generally for *n*-period bond…

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

Equation simply states that the interest rate on a long-term bond equals the average of short rates <u>expected</u> to occur over life of the long-term bond.

More generally for n-period bond…

QUIZ

If bond traders expect the one-year t-bill rate to be 5%, 6%, 7%, 8% and 9% over the next five years, use the expectations theory to determine today's interest rates on 2-, 3- and 5-year notes.

More generally for n-period bond…

- Numerical example
  - One-year interest rate over the next five years are expected to be 5%, 6%, 7%, 8%, and 9%
- Interest rate on two-year bond today:

  $(5\% + 6\%)/2 = 5.5\%$
- Interest rate for five-year bond today:

  $(5\% + 6\% + 7\% + 8\% + 9\%)/5 = 7\%$
- Interest rate for one- to five-year bonds today:

  5%, 5.5%, 6%, 6.5% and 7%

Expectations Theory and Term Structure Facts

Explains why yield curve has different slopes

1. When **short rates are expected to rise in future**, average of future short rates = i_{nt} is above today's short rate; therefore yield curve is upward sloping.
2. When **short rates expected to stay same in future**, average of future short rates same as today’s, and yield curve is flat.
3. Only when **short rates expected to fall** will yield curve be downward sloping.

Expectations Theory and Term Structure Facts

Expectations theory explains fact 1—that short and long rates move together

1. Short rate rises are persistent
2. If $i_t \uparrow$ today, i^e_{t+1}, i^e_{t+2} etc. $\uparrow \Rightarrow$ average of future rates $\uparrow \Rightarrow i_{nt} \uparrow$
3. Therefore: $i_t \uparrow \Rightarrow i_{nt} \uparrow$
   (i.e., short and long rates move together)

Expectations Theory and Term Structure Facts

Explains fact 2—that yield curves tend to have upward slope when short rates are low and downward slope when short rates are high

1. When short rates are low, they are expected to rise to normal level.
2. Long rate = average of future short rates —yield curve will have steep upward slope.
3. When short rates are high, they will be expected to fall in future to their normal level.
4. Long rate will be below current short rate; yield curve will have downward slope.

Expectations Theory and Term Structure Facts

Doesn't explain fact 3—that yield curve usually has upward slope

Short rates are as likely to fall in future as rise, so average of expected future short rates will not usually be higher than current short rate. Therefore, yield curve will not usually slope upward.

Segmented Markets Theory

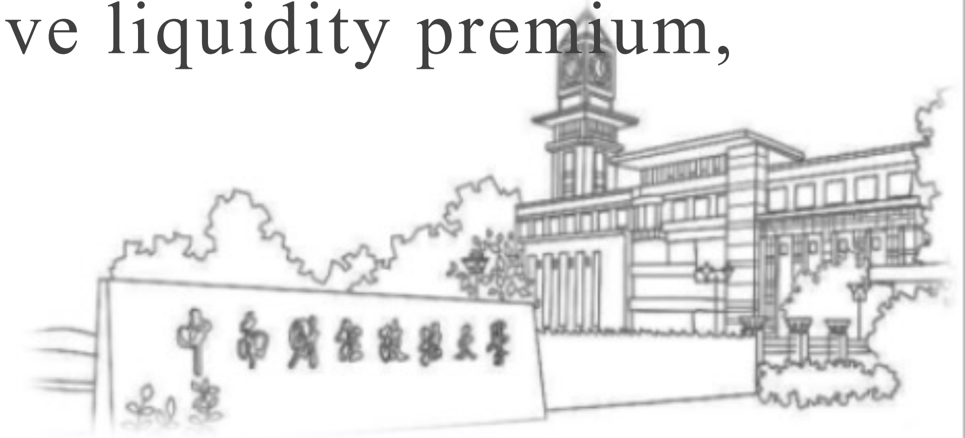
- **Key Assumption:** Bonds of different maturities are not substitutes at all
- **Implication:** Markets are completely segmented; interest rate at each maturity are determined separately

Segmented Markets Theory

- Explains fact 3—that yield curve is usually upward sloping
  - People typically prefer short holding periods and thus have higher demand for short-term bonds, which have higher prices and lower interest rates than long bonds
- Does not explain fact 1or fact 2 because its assumes long-term and short-term rates are determined independently.

Liquidity Premium & Preferred Habitat Theories

- **Key Assumption:** Bonds of different maturities are substitutes, but are not perfect substitutes
- **Implication:** Modifies Expectations Theory with features of Market Segmentation Theory
- Investors prefer short-term rather than long-term bonds. This implies that investors must be paid positive liquidity premium, l_{nt}, to hold long term bonds.



Liquidity Premium Theory

Results in following modification of Expectations Theory

$$i_{nt} = \frac{i_t + i^e_{t+1} + \cdots + i^e_{t+(n-1)}}{n} + l_{nt}$$

where l_{nt} is the liquidity premium for the n-period bond at time t.

l_{nt} is always positive and it rises with the maturity length.

Preferred Habitat Theory

- Investors have a preference for bonds of one maturity over another.
- They will be willing to buy bonds of different maturities only if they earn a somewhat higher expected return.
- Investors are likely to prefer short-term bonds over longer-term bonds.

The Relationship Between the Liquidity Premium (Preferred Habitat) and Expectations Theory

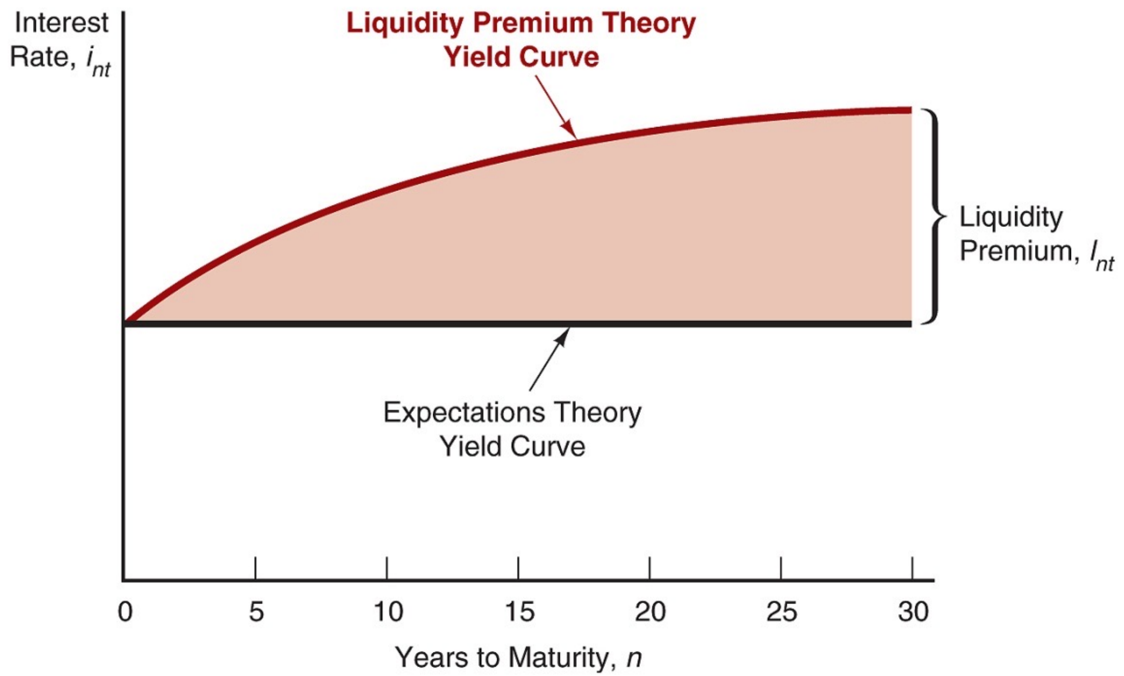


FIGURE 5.5 The Relationship Between the Liquidity Premium and Expectations Theory

Because the liquidity premium is always positive and grows as the term to maturity increases, the yield curve implied by the liquidity premium theory is always above the yield curve implied by the expectations theory and has a steeper slope. For simplicity, the yield curve implied by the expectations theory is drawn under the scenario of unchanging future one-year interest rates.

Numerical Example

1. One-year interest rate over the next five years: 5%, 6%, 7%, 8%, and 9%

2. Investors' preferences for holding short-term bonds so liquidity premium for one- to five-year bonds: 0%, 0.25%, 0.5%, 0.75%, and 1.0%

Numerical Example

- Interest rate on the two-year bond:

  0.25% + (5% + 6%)/2 = 5.75%

- Interest rate on the five-year bond:

  1.0% + (5% + 6% + 7% + 8% + 9%)/5 = 8%

- Interest rates on one to five-year bonds:

  5%, 5.75%, 6.5%, 7.25%, and 8%

- Comparing with those for the pure expectations theory, liquidity premium theory produces yield curves more steeply upward sloped

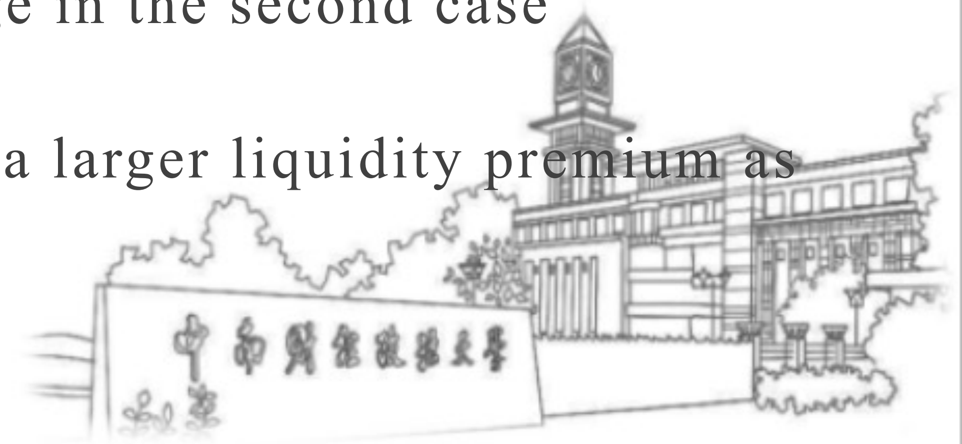
Liquidity Premium & Preferred Habitat Theories

$$i_{nt} = \frac{i_t + i^e_{t+1} + \cdots + i^e_{t+(n-1)}}{n} + l_{nt}$$

- Interest rates on different maturity bonds move together over time; explained by the first term in the equation

- Yield curves tend to slope upward when short-term rates are low and to be inverted when short-term rates are high; explained by the liquidity premium term in the first case and by a low expected average in the second case

- Yield curves typically slope upward; explained by a larger liquidity premium as the term to maturity lengthens



Yield Curves and the Market's Expectations of Future Short-Term Interest Rates According to the Liquidity Premium (Preferred Habitat) Theory

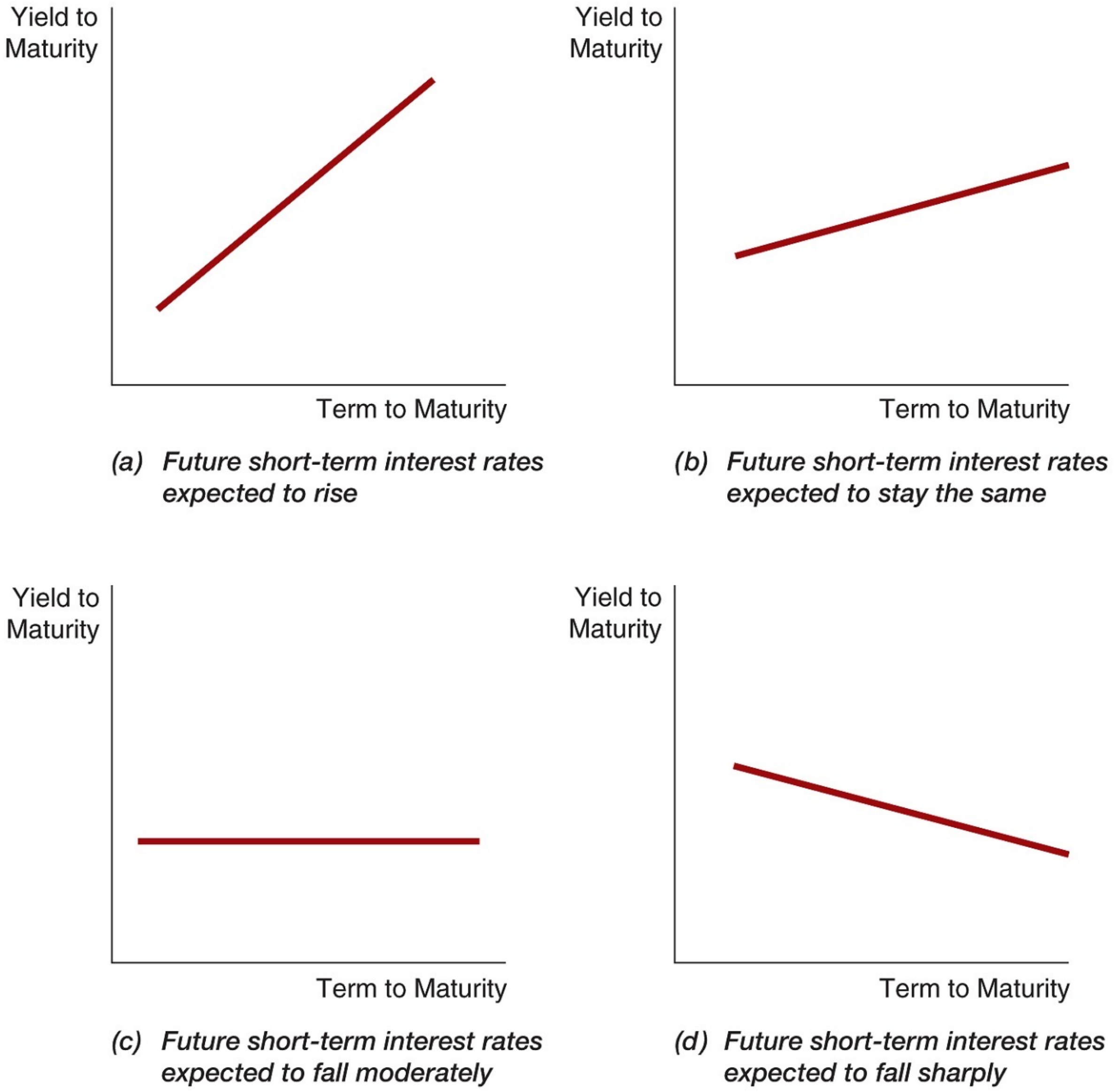


FIGURE 5.6 Yield Curves and the Market's Expectations of Future Short-Term Interest Rates According to the Liquidity Premium Theory

Evidence on the Term Structure

- Initial research (early 1980s) found little useful information in the yield curve for predicting future interest rates.

- Recently, more discriminating tests show that the yield curve has a lot of information about very short-term and long-term rates, but says little about medium-term rates.

Case: Interpreting Yield Curves

- The picture on the next slide illustrates several yield curves that we have observed for U.S. Treasury securities in recent years.

- What do they tell us about the public's expectations of future rates?

Yield Curves for U.S. Government Bonds

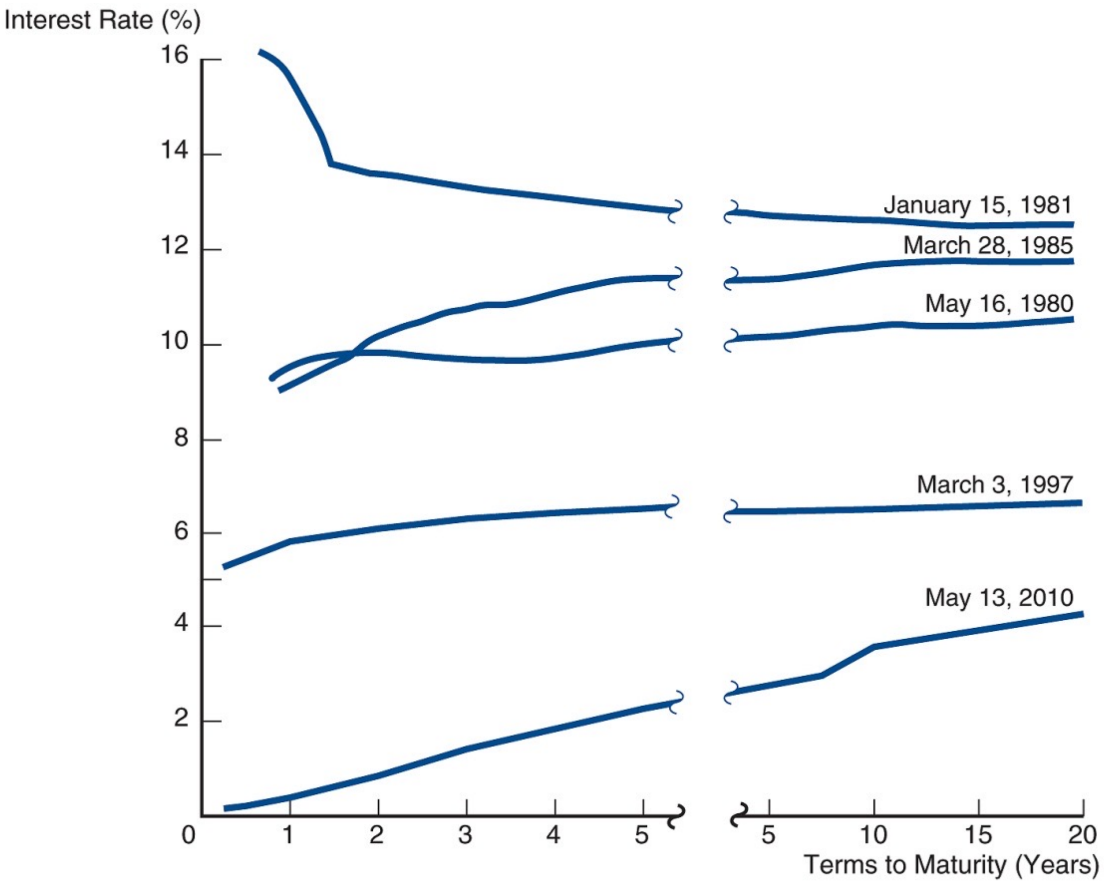


FIGURE 5.7 Yield Curves for U.S. Government Bonds

Sources: Federal Reserve Bank of St. Louis; *U.S. Financial Data*, various issues; *Wall Street Journal*, various dates.

Case: Interpreting Yield Curves

- The steep downward curve in 1981 suggested that short-term rates were expected to decline in the near future. This played-out, with rates dropping by 300 bps in 3 months.

- The upward curve in 1985 suggested a rate increase in the near future.

Case: Interpreting Yield Curves

- The slightly upward slopes from 1985 through (about) 2006 is explained by liquidity premiums. Short-term rates were stable, with longer-term rates including a liquidity premium (explaining the upward slope).

- The steep upward slope in 2010 suggests short term rates in the future will rise.

Mini-case: The Yield Curve as a Forecasting Tool

The yield curve does have information about future interest rates, and so it should also help forecast inflation and real output production.

- —Rising (falling) rates are associated with economic booms (recessions)
- —Rates are composed of both real rates and inflation expectations

The Practicing Manager: Forecasting Interest Rates with the Term Structure

- Expectations Theory: Invest in 1-period bonds or in two-period bond $\Rightarrow$

$$(1+i_t)(1+i_{t+1}^e)-1=(1+i_{2t})(1+i_{2t})-1$$

- Solve for forward rate,

$$i_{t+1}^e=\frac{(1+i_{2t})^2}{1+i_t}-1$$

i_{t+1}^e is called the **forward rate**, and i_t is called the **spot rate**

- Numerical example: $i_t=5\%, i_{2t}=5.5\%$

$$i_{t+1}^e=\frac{(1+0.055)^2}{1+0.05}-1=6\%$$

Forecasting Interest Rates with the Term Structure

- Compare 3-year bond versus 3 one-year bonds

$$(1+i_t)(1+i^e_{t+1})(1+i^e_{t+2})-1=(1+i_{3t})^3-1$$

- Using i^e_{t+1} derived in (4), solve for i^e_{t+2}

$$i^e_{t+2}=\frac{(1+i_{3t})^3}{(1+i_{2t})^2}-1$$

Forecasting Interest Rates with the Term Structure

- Generalize to:

$$i^e_{t+n} = \frac{(1 + i_{n+1t})^{n+1}}{(1 + i_{nt})^n} - 1$$

- Liquidity Premium Theory: $i_{nt} - l_{nt}$= same as expectations theory; replace i_{nt} by $i_{nt} - l_{nt}$ in to get adjusted forward-rate forecast

$$i^e_{t+n} = \frac{(1 + i_{n+1t} - l_{n+1t})^{n+1}}{(1 + i_{nt} - l_{nt})^n} - 1$$

Forecasting Interest Rates with the Term Structure

- Numerical Example $l_{2t} = 0.25\%, l_{1t} = 0, i_{1t} = 5\%, i_{2t} = 5.75\%$

$$i_{t+1}^{e} = \frac{(1 + 0.0575 - 0.0025)^2}{1 + 0.05} - 1 = 6\%$$

- Example: 1-year loan next year T-bond $+1\%, l_{2t} = 0.4\%, i_{1t} = 6\%, i_{2t} = 7\%$

$$i_{t+1}^{e} = \frac{(1 + 0.07 - 0.004)^2}{1 + 0.06} - 1 = 7.2\%$$

Loan rate must be $> 8.2\%$

Chapter Summary

- Risk Structure of Interest Rates: We examine the key components of risk in debt: default, liquidity, and taxes.

- Term Structure of Interest Rates: We examined the various shapes the yield curve can take, theories to explain this, and predictions of future interest rates based on the theories.

Acknowledgment

Slides here are adopted from the official slides published by Pearson Education Ltd.