EE432 Monetary Theory and Policy

Lecture 3 The Risk and Term Structure of Interest Rates

Dr. Chamadanai Marknual
Faculty of Economics, Thammasat University

Semester 1/2021

Outline

- Bond Price and Bond Yield
- Risk Structure of Interest Rates
- Bond Rating
- Term Structure of Interest Rates

Chapter 6

Bonds, Bond Prices, and the Determination of Interest Rates

Bond Price and Bond Yield

Note: Basic concepts of bond pricing
and risk structure of interest rates are taken from Chapter 6

Bond Prices

- A **standard bond** specifies the ***fixed amounts to be paid*** and the ***exact dates of the payments***.

Bond price: *How much should you be* ***willing to pay*** *for a bond?*

- That *depends on* the *bond characteristics*.

Terminology for Bonds and Loans

- **Principal *given*** *to* ***borrower*** when *loan is made*
  - **Simple loan =** principal + interest repaid at one date
- **Fixed-payment loan: *series*** *of (often equal)* ***repayments***
- **Bond** is *issued at some price*
- **Face Value (**aka **Par)** is ***repayment*** *at* ***maturity date***
- **Zero coupon bond** *pays* ***only face value*** *at* ***maturity***
- **Coupon bond** also *makes* ***periodic coupon payments***, equal to *coupon rate times face value*

Bonds and Loans

Zero-coupon or discount bond

– Promise a ***single payment*** on a future date

Fixed-payment loan

– ***Sequence of fixed payments***

Coupon bond

– ***Periodic interest payments*** + ***principal repayment*** at maturity

Zero-Coupon Bonds

- **Treasury bills** are the most *straightforward type of bond.*
  - Each treasury bill represents a ***promise*** by the government ***to pay $100 on a fixed future date***.
  - ***No coupon payments*** - **zero-coupon bonds**
  - Also called pure **discount bonds** since the ***price*** *is* ***less than*** *face value - they sell at a discount*.
- **Price** of ***$100 face value*** zero-coupon bond

$$= \frac{\$100}{(1+i)^n}$$

Zero-Coupon Bonds

<u>Price</u> of *$100 face value* zero-coupon

Assume i = 5%

Price of a **One-Year Treasury Bill**

$$= \frac{100}{(1+0.05)} = \$95.24$$

Price of a **Six-Month Treasury Bill**

$$= \frac{100}{(1+0.05)^{1/2}} = \$97.59$$

Zero-Coupon Bonds

- When the ***price movement*** *is observed*, the ***interest rate moves*** with it, in the <u>***opposite direction***</u>
- We can ***compute*** the <u>***interest rate***</u> from the price using the *present value formula*

The *price* of a one-year T-bill is *$95*

i = ($100/$95) - 1 = 0.0526 = <u>*5.26%*</u>

Fixed-Payment Loans

Conventional ***home mortgages*** and ***car loans*** are **fixed-payment loans**.

- They *promise* a fixed number of ***equal payments*** at *regular intervals*.
- **Amortized loans** - the borrower **pays off *part of the principal*** *along with the* ***interest*** for the *life of the loan*.

- *Value* of a **Fixed Payment Loan**

$$\frac{FixedPayment}{(1+i)}+\frac{FixedPayment}{(1+i)^2}+\cdots+\frac{FixedPayment}{(1+i)^n}$$

- The ***sum of the present value*** of the payments.

Coupon Bonds

- The issuer of a ***coupon bond*** promises to make a ***series of periodic interest payments*** *(coupon payments)*, plus a ***principal payment*** *at maturity*.

Price of Coupon Bond =

$$P_{CB} = \left[\frac{CouponPayment}{(1+i)^1} + \frac{CouponPayment}{(1+i)^2} + \ldots\ldots + \frac{CouponPayment}{(1+i)^n} \right]$$

$$+ \frac{FaceValue}{(1+i)^n}$$

Yield to Maturity

- The most useful measure of the **return on holding a bond** is called the **yield to maturity**:
  - The **yield** bondholders *receive if they* ***hold*** *the bond to its* ***maturity*** when *the* ***final principal payment*** *is made.*

Price of 1yr 5% Coupon Bond = $\dfrac{\$5}{(1+i)}+\dfrac{\$100}{(1+i)}$

- The ***value*** of ***i*** that ***solves the equation*** is the **yield to maturity**.

Risk Structure of Interest Rates

Note: Basic concepts of bond pricing
and risk structure of interest rates are taken from Chapter 6

Why Bonds are Risky

- **Default risk** is the change that the ***issuer*** *may not make the* ***promised payment***
- **Inflation risk** occurs when investor ***can't be sure*** of what the ***real value of the payments will be***, even if they are made
- **Interest rate risk** arises from a ***bondholder's*** *investment horizon*, which ***may be shorter than*** *the* ***maturity*** *of the bond*

Default Risk

- In **determining** what happens to **bond prices** when we consider **default risk**, we can look at an example of a ***corporate bond***.
- Assume the *one-year risk-free interest rate is 5 percent.*
- A *company* has *issued a 5 percent coupon bond* with *a face value of $100*.

Default Risk

- If this **bond was risk-free**, the ***<u>price of the bond</u>*** would be the ***present value*** *of the* ***$105*** payment

Price of risk free bond

= ($100 + $5)/$1.05 = $100

Default Risk

- Suppose, however, *there is a 10% probability that the* ***company will go bankrupt*** before paying back the loan
  - Assume the **outcome** *is* ***either $105 or $0***
  - **Expected value** *equals* **$94.50**

Price of bond

= $94.50/1.05 = $90

Default Risk

- If the *price of the bond is $90*, what **<u>yield to maturity</u>** does this price imply?

  Promised yield on bond = $105/$90 - 1 = 0.1667

- Since the **default risk premium** is the *<u>promised yield to maturity</u> minus the <u>risk-free rate</u>*:

  = 16.67 percent - 5 percent = 11.67 percent.

- **Any risk premium** will ***drive*** *the* **price *<u>below</u>*** *$90* and ***push*** *the* **yield to maturity *<u>above</u>*** *16.67 percent*.
- The **<u>higher the default risk, the higher the yield</u>**.

Inflation Risk

- With few exceptions, ***bonds promise to make fixed-dollar payments***.
- Remember that we care about the ***<u>purchasing power</u>*** *<u>of our money,</u>* not the number of dollars.
  - This means bondholders *care about* the ***real*** **interest rate.**

Inflation Risk

- Think of the **interest rate** having *three components:*
  1. The **real interest rate**
  2. **Expected inflation**, and
  3. ***Compensation*** for **inflation risk**.
- Example:
  - **Real interest rate** is **3 percent**.
  - *Inflation could be either 1 percent or 3 percent*.
  - **Expected inflation** is **2 percent**, with a standard deviation of 1.0 percent.

Inflation Risk

- **Nominal interest rate** should equal
  - 3 percent **real interest rate** +
  - 2 percent **expected inflation** +
  - **Compensation for inflation risk**
- The ***greater the inflation risk***, *the* ***larger the compensation for it***.

Interest-Rate Risk

- **Interest-rate risk** arises from the fact that *investors don't know the **<u>holding period return</u>** of a long-term bond*.
  - The **longer the term of the bond**, the ***<u>larger the price change</u>*** for a *given change in the interest rate*.
- For investors with *holding periods* ***<u>shorter than the maturity of the bond</u>***, the potential for a *change in interest rates creates risk*.
  - The *more likely* the **interest rates are to change** *during the bondholder's investment horizon*, the **larger the risk of holding a bond**.

Chapter 7

The Risk and Term Structure of Interest Rates

Bond Rating

Ratings and the Risk Structure of Interest Rates

- **Default** is one of the ***most important risks*** a *bondholder faces*.

- **Independent companies (rating agencies)** have arisen to *evaluate the* <u>*creditworthiness*</u> *of potential borrowers*.

Bond Ratings

- The best known **bond rating services** are
  - Moody's
  - Standard & Poor's
- They ***monitor*** *the* ***status*** *of individual* ***bond issuers*** and assess the ***likelihood a <u>lender</u> will <u>be repaid</u>*** by the bond issuer.
- A **high rating** suggests that a bond issuer will have **little problem** meeting a ***bond's payment obligations.***

Bond Ratings

- Firms or governments with an *exceptionally strong financial position* carry the ***highest ratings*** and are able to issue the highest-rated bonds, **Triple A**.
- The **top four categories** are considered **investment-grade bonds**.
  - These bonds have a ***very low risk of default***.
  - ***Reserved for*** most government issuers and corporations that are ***among the most financially sound.***

Bond Ratings

- The <u>**distinction**</u> between **investment-grade** and **speculative**, **noninvestment-grade** is important.
  - A number of regulated institutional investors are <u>***not***</u> ***allowed to invest*** in bonds rated *below investment grade*, which is **Baa** on *Moody's scale* or **BBB** on *Standard and Poor's scale*.

Table 7.1 A Guide to Bond Ratings

	Moody's	Standard & Poor's	Description	Examples of Issuers with Bonds Outstanding in 2016
Investment Grade	Aaa	AAA	Bonds of the best quality with the smallest risk of default. Issuers are exceptionally stable and dependable.	Johnson & Johnson Microsoft Canada
	Aa	AA	Highest quality with slightly higher degree of long-term risk.	Google/Alphabet Procter & Gamble South Korea
	A	A	High-medium quality, with many strong attributes but somewhat vulnerable to changing economic conditions.	JPMorgan Chase Wells Fargo China
	Baa	BBB	Medium quality, currently adequate but perhaps unreliable over the long term.	Hewlett Packard Italy Portugal
Noninvestment, Speculative Grade	Ba	BB	Some speculative element, with moderate security but not well safeguarded.	Goodyear Tire Nokia Brazil
	B	B	Able to pay now but at risk of default in the future.	Hertz Greece Kenya
Highly Speculative	Caa	CCC	Poor quality, clear danger of default.	Ferrellgas Partners Sable Permian Resources
	Ca	CC	Highly speculative quality, often in default.	
	C	C	Lowest-rated, poor prospects of repayment though may still be paying.	Venezuela*
	D	D	In default.	

*While the Moodys rating for Venezuela is C, the Standard and Poor's rating is SD for "selective default."

For a more detailed definition of ratings see Moody's website, www.moodys.com, or Standard and Poor's website, www.standardandpoors.com.

Bond Ratings

- **Speculative grade bonds** are bonds issued by companies and countries that may have *difficulty* meeting their *bond payments* but are *not at risk of immediate default*.
- **Highly speculative bonds** consist of ***debts*** that are in *serious risk of default*.
- All bonds with grades ***below investment grade*** are often referred to as **junk bonds** or ***high-yield bonds***.

Bond Ratings

- Types of **junk bonds**:
  - ***Fallen angels*** are bonds that were *once investment-grade*, but their *issuers fell on hard times*.
  - Bonds issued by *issuers* about which *there is little known.*
- Material changes in a *firm's or government's financial conditions* precipitate changes in its debt ratings.
  - **Ratings downgrade** - *lower* an issuer's bond *rating*.
  - **Ratings upgrade** - *upgrade* an issuer's bond *rating*.

Commercial Paper

- **Commercial paper** is a short-term version of a bond.
  - The borrower offers **no collateral** so the **debt is *unsecured*.**
  - Commercial paper is
    - **Issued on a discount basis**, as a zero-coupon bond specifying a ***single future payment*** with ***no associated coupon payments.***
    - Has maturity of less than 270 days.
  - Roughly *one-third* is held by *money-market mutual funds.*

Commercial Paper

- Most **commercial paper** is ***issued*** with a ***maturity of 5 to 45 days*** and is ***used*** *exclusively* ***for <u>short-term financing</u>.***
- The **rating agencies** *rate* the **creditworthiness** of *commercial paper* issuers ***<u>in the same way they do bond issuers</u>***.

Commercial Paper

Table 7.2 Commercial Paper Ratings

	Moody's	Standard & Poor's	Description	Examples of Issuers with Commercial Paper Outstanding in 2016
Investment or Prime Grade	P-1	A-1+, A-1	Strong likelihood of timely repayment.	Coca-Cola ExxonMobil Yale University
	P-2	A-2	Satisfactory degree of safety for timely repayment.	General Electric General Mills Harley-Davidson
	P-3	A-3	Adequate degree of safety for timely repayment.	
Speculative, below Prime Grade		B, C	Capacity for repayment is small relative to higher-rated issuers.	
Defaulted		D		

SOURCE: Thomas K. Hahn, "Commercial Paper," *Instruments of the Money Market*, Chapter 9, Federal Reserve Bank of Richmond, 1998; www.moodys.com; and www.standardandpoors.com.

The Impact of Ratings on Yields

- **Bond ratings** are designed to ***reflect default risk.***
- The **lower the rating**
  - The *higher the risk of default*.
  - The *lower* its *price* and the *higher* its *yield*.
- To understand quantitative ratings, it is easier to **compare them to a benchmark.**

The Impact of Ratings on Yields

- **U.S. Treasury issues** are viewed as having *little default risk*, so they are used as **benchmark bonds**.
- **Yields** on other bonds are ***measured*** in terms of the **spread over Treasuries**.
- **Bond yield** is the sum of two parts:

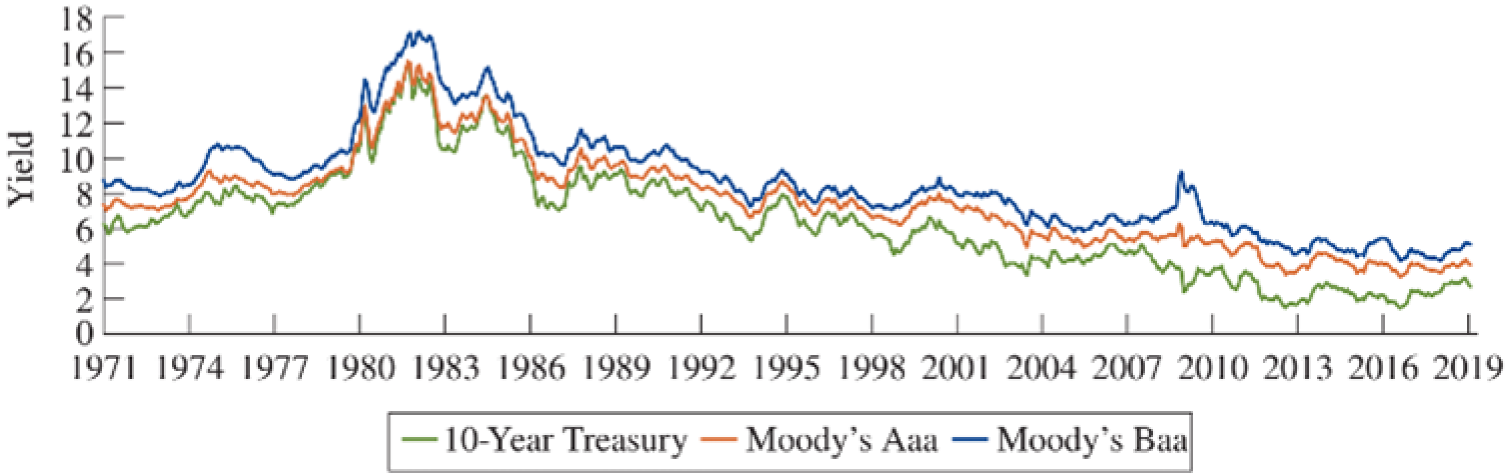
  = U.S. **Treasury yield** + **Default risk premium**

The Impact of Ratings on Yields

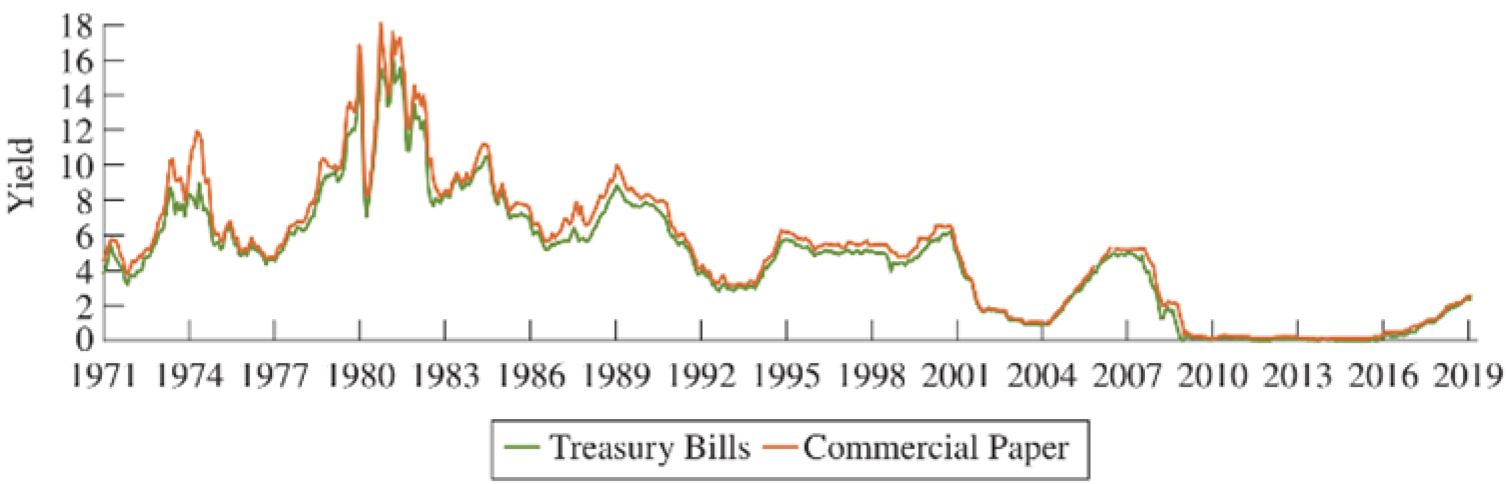
- If bond ratings properly reflect risk, then the **lower the rating**, ***the higher the default-risk premium***.
- *When Treasury yields move*, all *other yields move with them*.

Figure 7.2 The Risk Structure of Interest Rates

A. Comparing Long-Term Interest Rates



B. Comparing Short-Term Interest Rates



SOURCE: Board of Governors of the Federal Reserve System, [FRED data codes: GS10, AAA, BAA, CPN3M (since 1997), and TB3MS].

The Impact of Ratings on Yields

- ***Changes in the U.S. Treasury yields* account for** most of *the* ***movement in the Aaa and Baa*** *bond yields.*
- From 1979-2016, the ***10-year U.S. Treasury bond yield*** has *averaged* almost a *full percentage point* ***below the average yield on Aaa bonds*** and two percentage points ***below the average yield on Baa bonds***.
- Clearly ratings are **crucial** to **corporations' ability to raise financing.**
  - A ***lower rating*** *increases* the ***costs of funds***.
- **Investors** clearly must be **compensated for** assuming **risk**.

Term Structure of Interest Rates

Term Structure of Interest Rates

- Why do **bonds** with the *same default rate* but *different maturity dates* have ***different yields?***
  - **Long-term bonds** are like a *composite of a series of short-term bonds.*
  - Their **yield** depends on *what people expect to happen in the future.*

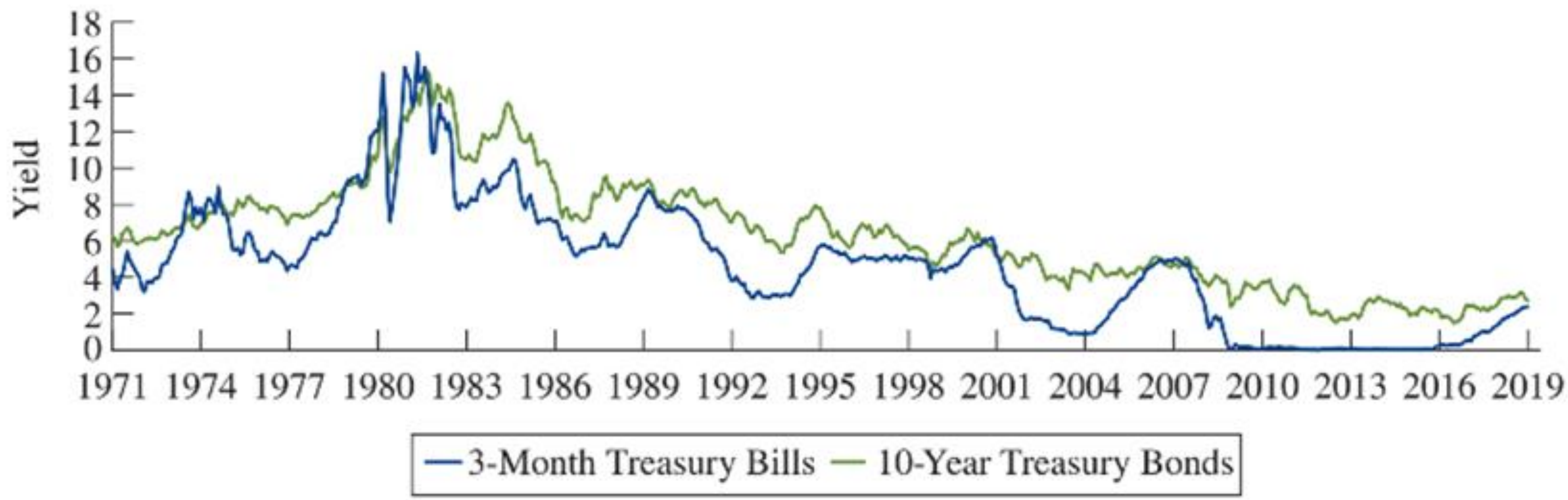
Term Structure of Interest Rates

- The *relationship among bonds with the same risk characteristics* but *different maturities* is called the **term structure of interest rates**.
- Comparing 3-month and 10-year Treasury yields we can see:

1. ***Interest rates of different maturities*** tend to ***move together***.
2. ***Yields on short-term bonds*** are **more volatile** than yields on long-term bonds.
3. ***Long-term yields*** tend to **be higher** than short-term yields.

Term Structure of Interest Rates

Figure 7.3 The Term Structure of Treasury Interest Rates



SOURCE: Board of Governors of the Federal Reserve System. [FRED data codes: TB3MS and GS10]

The Expectations Hypothesis

- The ***expectations hypothesis*** of the ***term structure*** focuses on the ***risk-free interest rate***.
- The **risk-free interest rate** *can be* ***computed***, assuming *there is* ***no uncertainty*** *about the future.*

The Expectations Hypothesis

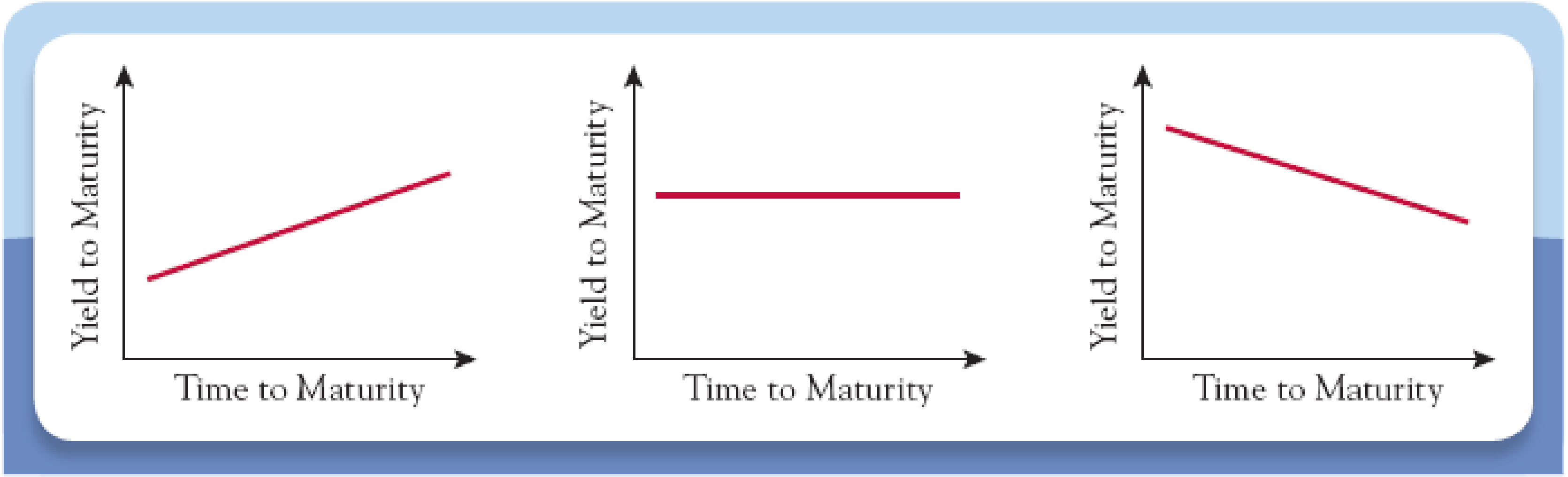
- If *there is no uncertainty*, then an investor will be *indifferent* between **holding a two-year bond** or a **series of two one-year bonds**.
  - Certainty means that the **bonds of different maturities** are **perfect substitutes** *for each other*.
- The **expectations hypothesis** implied that the ***current two-year interest rate*** *should* ***equal*** *the* ***average of current one-year rate*** and the ***one-year interest rate one year in the future***.

The Expectations Hypothesis

- When *interest rates are expected to rise*, **long-term interest rate** *will be higher than* **short-term interest rates.**
  - The **yield curve** which **plots *the yield to maturity*** on the *vertical axis* and the ***time to maturity*** on the *horizontal axis*, will ***slope up***.
- This also means:
  - If **interest rates are expected to fall**, the *yield curve will slope down.*
  - If **expected to stay the same**, the <u>*yield curve will be flat.*</u>

The Expectations Hypothesis

Figure 7.5 The Expectations Hypothesis and Expectations of Future Short-term Interest Rates



The Expectations Hypothesis

- If *bonds of different maturities* are **perfect substitutes for each other**, then we can construct *investment strategies* that must have the *same yields*.
    1. **Invest in a <u>two-year bond</u>** and *hold it to maturity*
    2. **Invest in two <u>one-year bonds</u>**, *one today and one when the first matures.*

The Expectations Hypothesis

- The **expectations hypothesis** tells us investors will be indifferent between the two options.
- This means they must have the same return:

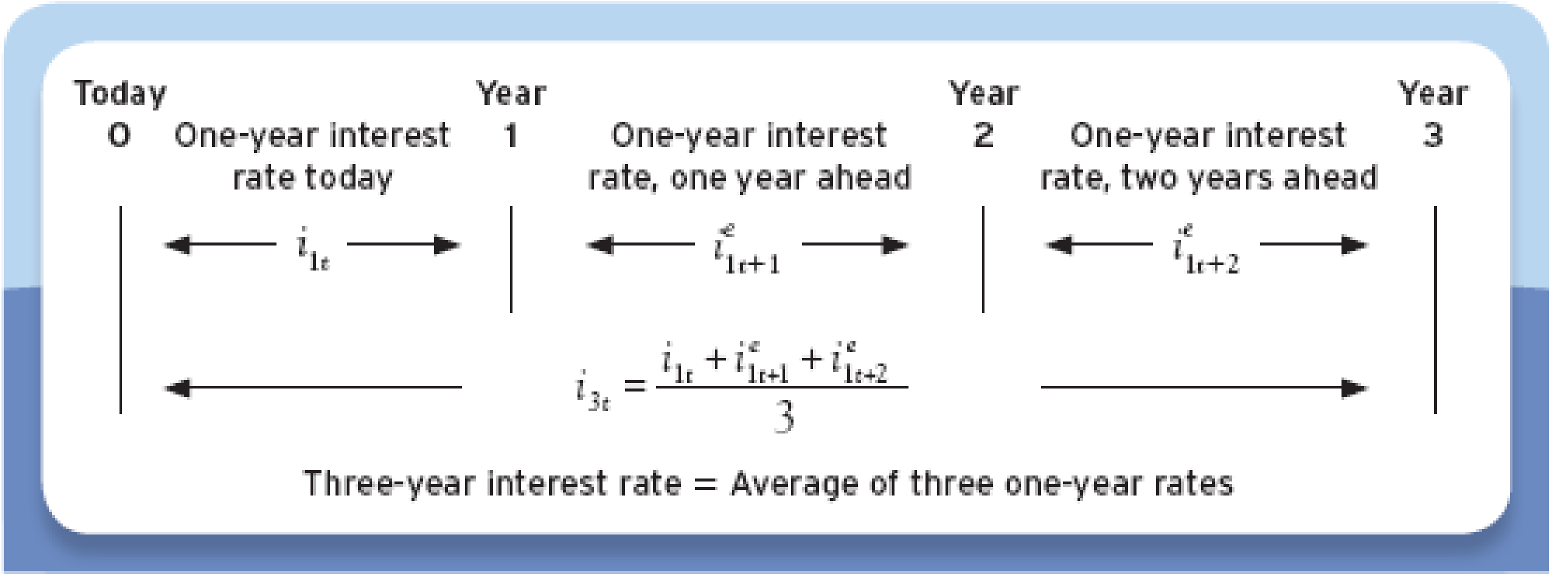
$$(1 + i_{2t})(1 + i_{2t}) = (1 + i_{1t})(1 + i^{e}_{1t+1})$$

- We can now write the ***two-year interest rate*** as the ***average of the current and future expected one-year interest rates***:

$$i_{2t} = \frac{i_{1t} + i^{e}_{1t+1}}{2}$$

The Expectations Hypothesis

The Expectations Hypothesis of the Term Structure:



The Expectations Hypothesis

- We can *generalize* this: a **bond with *n* years to maturity** is the ***average*** **of *n* expected future one-year interest rates**:

$$i_{nt} = \frac{i_{1t} + i^e_{1t+1} + i^e_{1t+2} + \ldots + i^e_{1t+n-1}}{n}$$

The Expectations Hypothesis

Does this **hypothesis** *explain* the *three observations* we started with?

1. **Interest rates of different maturities** will ***move together.***
   - We can see *this* <u>*holds*</u> *from the previous equation*.
2. **Yields on short-term bonds will be more volatile** than yields on long-term bonds.
   - **Long-term rates** are ***averages of short-term rates***, so *changing one short-term rate* has <u>little effect</u> on the *long term rate*.

The Liquidity Premium Theory

- **Risk** is the key to understanding the *upward slope of the yield curve.*
- *Bondholders face* both **inflation** and **interest-rate risk.**
  - The ***longer the term of the bond***, the ***greater both types of risk.***
- Computing **real return** from nominal return requires a <u>**forecast of *expected* future inflation**</u>.
  - *A bond's **inflation risk** <u>**increases**</u> with its **time to maturity***.

The Liquidity Premium Theory

- **Interest-rate risk** arises from the **mismatch** between the *investor's investment horizon* and a *bond's time to maturity.*
  - If a bondholder plans to *sell a bond prior to maturity*, changes in the interest rate generate *capital gains or losses*.
  - The **longer the term of the bond**, *the greater the price changes for a given change in interest rates* and the **larger the potential for capital losses**.
- Investors require *compensation for the increase in risk* they take for buying longer term bonds.

The Liquidity Premium Theory

- We can think about **bond yields** as having two parts:
  - One that is **risk free**: explained by the *expectations hypothesis.*
  - One that is a **risk premium**: explained by *inflation and interest-rate risk.*
- Together this forms the **liquidity premium theory** of the term structure of interest rates.

$$i_{nt} = rp_n + \frac{i_{1t} + i^e_{1t+1} + i^e_{1t+2} + \dots + i^e_{1t+n-1}}{n}$$

End of lecture