EE432 Monetary Theory and Policy

Lecture 3 Bond Price and Term Structure of Interest Rates

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Outline

- Bond Price and Bond Yield
- The Bond Market and the Determination of Interest Rates
- 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

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 payment***s

Coupon bond

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

Consol

– ***Periodic interest payments forever***, principal never repaid

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 <u>maturity</u>*.

Price of Coupon Bond =

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

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

Consols

- **Consols or perpetuities**, are like ***coupon bonds*** whose ***payments*** *last forever*
- The borrower *pays only interest*, ***never*** *repaying* the ***principal***
- The U.S. government sold consols once in 1900, but the Treasury has bought them all back
- The price of a consol is the *present value of all future interest payments*

$$P_{Consol} = \frac{\text{Yearly Coupon Payment}}{i}$$

Bond Yield

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.*

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

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

Yield to Maturity

- If you ***pay $95*** *for a* *<u>$100 face value bond</u>*, you will **receive** both the ***interest payments*** and the ***increase in value from $95 to $100***.
- This **rise in value** is referred to as a **capital gain** and is ***part of the return*** *on your investment*.

Current Yield

- Current yield is the *measure of the proceeds* the ***bondholder receives*** for making a loan.

$$\text{Current Yield} = \frac{\text{Yearly Coupon Payment}}{\text{Price Paid}}$$

- The current yield measures that ***part of the return from buying the bond*** that arises *solely* from the ***coupon payments***.
- If the **price is below par**, the **current yield** will be **below the yield to maturity**.

Current Yield

Example:

1 year, 5% coupon bond selling for $99

Current Yield = $\frac{5}{99} = 0.0505$, or ***5.05%***

Yield to maturity for this bond is ***6.06 percent*** found as the solution to:

$$\frac{\$5}{(1+i)} + \frac{\$100}{(1+i)} = \$99$$

Holding Period Returns

- The **holding period return** is the ***return to holding a bond*** and ***selling*** it **before maturity**.
- The holding period return can ***differ*** **from the** ***yield to maturity***.

Holding Period Returns

- The **one-year holding period return** is the **sum** of the ***yearly coupon payment divided by the price paid for the bond*** and the ***change in the price divided by the price paid***.

$$= \frac{\text{Yearly Coupon Payment}}{\text{Price Paid}} + \frac{\text{Change in Price of the Bond}}{\text{Price of the Bond}}$$

= Current Yield + Capital Gain (as a %)

Holding Period Returns

- Whenever the **price of a bond changes**, there is a ***capital gain or loss***.
- The *greater the price change*, the more important that *part of the holding period return* becomes.
- The ***longer the term of the bond***, the *greater those price movements* and *associated risk* can be.

The Bond Market and the Determination of Interest Rates

The Bond Market and the Determination of Interest Rates

- **How are bond prices determined** and ***why do they change?***
- We must look at **bond supply**, **bond demand**, and **equilibrium prices**.
  - First we will restrict discussion to the ***quantity of bonds outstanding*** - *stock of bonds*.
  - Secondly, we will talk about ***bond prices*** rather than interest rates.
  - Finally, we will consider the *market for a* ***one-year zero-coupon bond*** *with a* ***face value of $100***.

The Bond Market and the Determination of Interest Rates

- Assume an investor is planning to purchase **a one-year bond** and **hold until maturity**.
  - They have a **one-year** **investment horizon**.
  - The **holding period return** ***equals*** the bond's **yield to maturity** - both determined directly from price.
- The present value formula shows the relationship between price and yield as:

$$P = \frac{\$100}{1+i} \quad \text{or} \quad i = \frac{\$100 - P}{P}$$

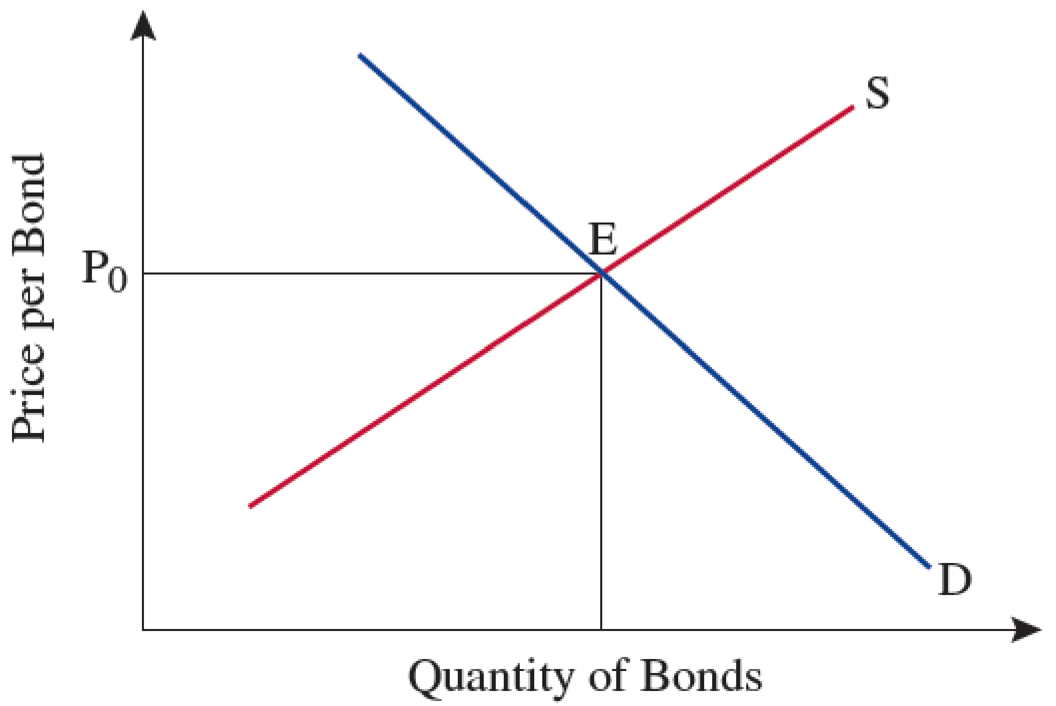
Bond Supply, Bond Demand and Equilibrium in the Bond Market

- Supply and demand determine bond prices (and bond yields).
- The ***bond supply curve*** is the **relationship between the price and the quantity of bonds** people are willing to sell, all else equal.
- The *higher the price of a bond*, the *larger the quantity supplied.*
  - The bond supply curve slopes upward.

Bond Supply, Bond Demand and Equilibrium in the Bond Market

- The ***bond demand curve*** is the relationship between **the price and the quantity of bonds that investors demand**, all else equal.
- The *price of bonds* is *inversely related to the yield*, the demand curve implies that the higher the demand for bonds, the higher the yield.
- The bond *demand curve slopes downward*.

Bond Supply, Bond Demand and Equilibrium in the Bond Market



Equilibrium is the point at which **supply equals demand**.

Risk Structure of Interest Rates

Why Bonds are Risky

- **Default risk** is the change that the ***issuer*** *may not make the* ***promised payment***
- **Inflation risk** an 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 *price of the bond* would be the *present value of the $105* payment.

  Price of risk free bond = ($100 + $5)/$1.05 = $100

- 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 **yield to maturity** does this price imply?

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

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

  = 16.67 percent - 5 percent = 11.67 percent.

- Any **risk premium** will *drive the price below $90* and *push the yield to maturity above 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 ***purchasing power of our** money,* not the number of dollars.
  - This means bondholders *care about* the ***real* interest rate.**
- How does inflation risk affect the 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 holding period return of a long-term bond*.
  - The **longer the term of the bond**, the ***larger the price change*** for a given change in the interest rate.
- For investors with *holding periods shorter than the maturity of the bond*, 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 lender will be repaid*** 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 Procter & Gamble China
	A	A	High-medium quality, with many strong attributes but somewhat vulnerable to changing economic conditions.	JPMorgan Chase Wells Fargo Israel
	Baa	BBB	Medium quality, currently adequate but perhaps unreliable over the long term.	Hewlett Packard Time Warner Brazil Italy
Noninvestment, Speculative Grade	Ba	BB	Some speculative element, with moderate security but not well safeguarded.	Goodyear Tire Nokia Portugal
	B	B	Able to pay now but at risk of default in the future.	Hertz Office Depot Kenya
Highly Speculative	Caa	CCC	Poor quality, clear danger of default.	Greece Venezuela
	Ca	CC	Highly speculative quality, often in default.	
	C	C	Lowest-rated, poor prospects of repayment though may still be paying.	
	D	D	In default.	

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* ***short-term financing.***
- The rating agencies rate the creditworthiness of commercial paper issuers *in the same way they do bond issuers.*

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 General Electric Procter & Gamble
	P-2	A-2	Satisfactory degree of safety for timely repayment.	General Mills Time Warner
	P-3	A-3	Adequate degree of safety for timely repayment.	Alcoa*
Speculative, below Prime Grade		B, C	Capacity for repayment is small relative to higher-rated issuers.	
Defaulted		D		

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

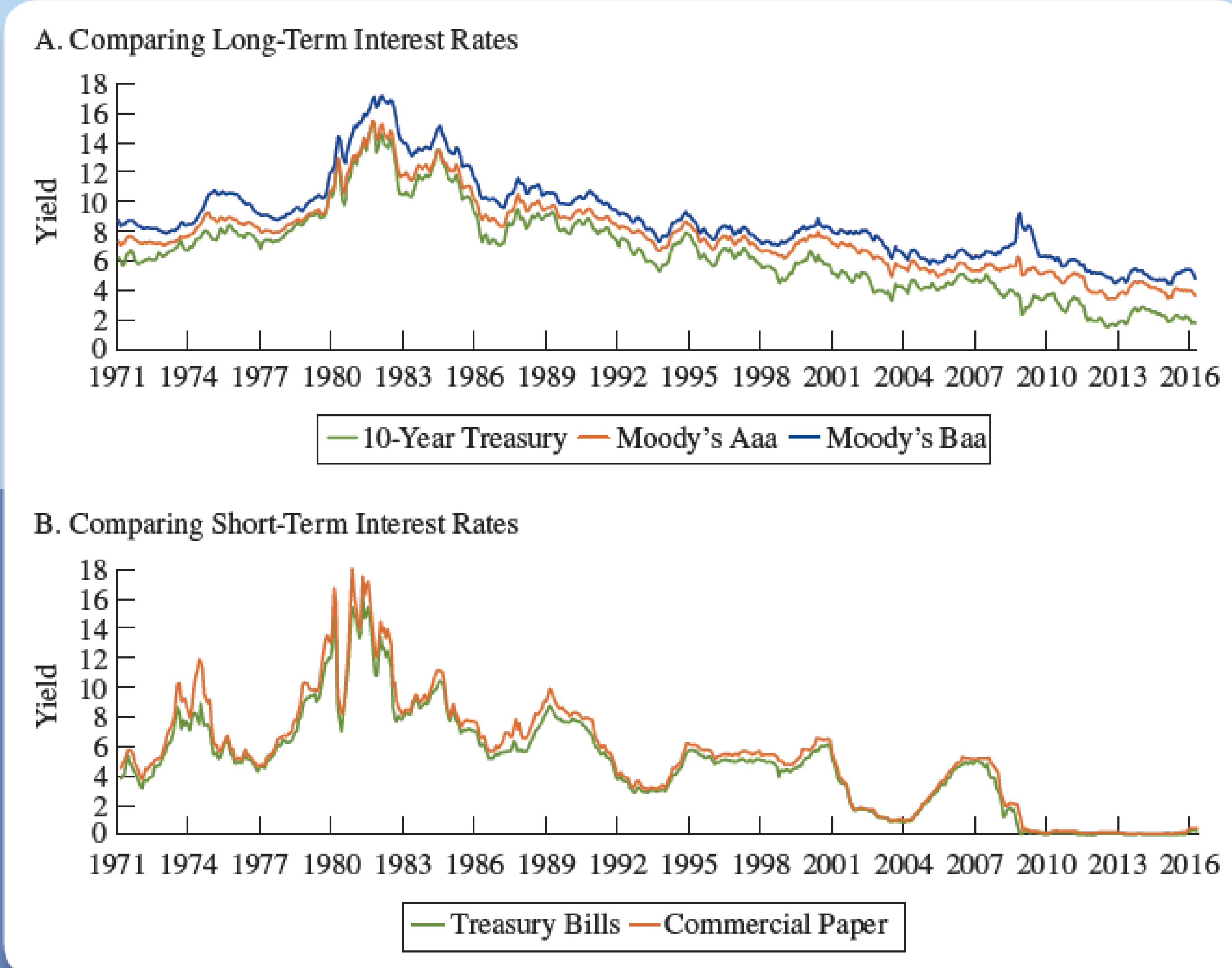
- **U.S. Treasury issues** are viewed as having *little default risk*, so they are used as **benchmark bonds**.
- **Yields** on other bonds are ***measured*** in terms of the **spread over Treasuries**.
- **Bond yield** is the sum of two parts:

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

The Impact of Ratings on Yields

- If bond ratings properly reflect risk, then the **lower the rating** if the issuer, ***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



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 rate increases* the *costs of funds*.
- **Investors** clearly must be **compensated for** assuming **risk**.

Term Structure of Interest Rates

Term Structure of Interest Rates

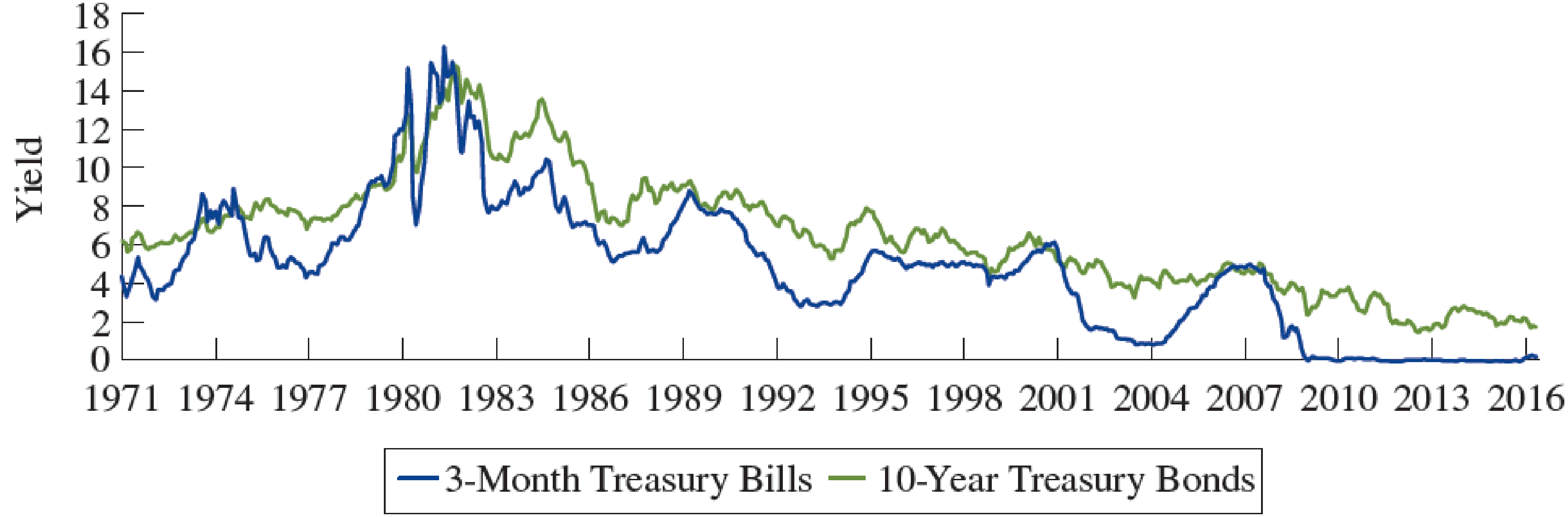
- Why do **bonds** with the *same default rate* but <u>*different maturity dates*</u> have ***different yields?***
  - **Long-term bonds** are like a *composite of a <u>series of short-term bonds.</u>*
  - Their **yield** depends on *what people expect to happen in the future.*

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



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 *not uncertainty about the future.*

The Expectations Hypothesis

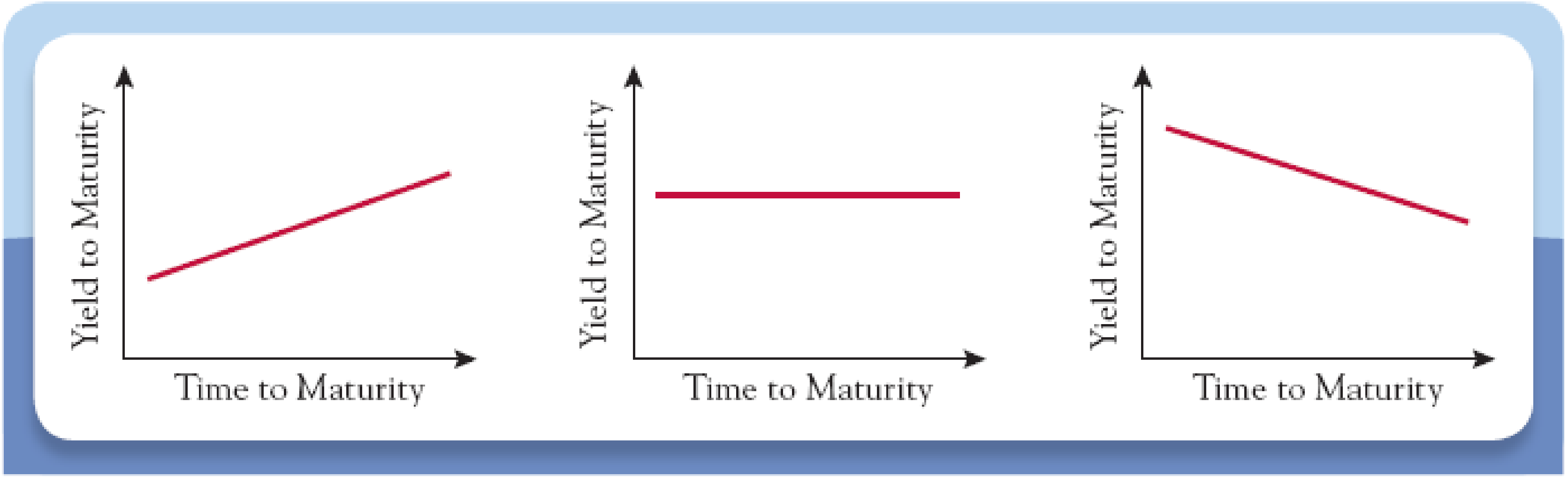
- If *there is no uncertainty*, then an investor will be *indifferent* between **holding a two-year bond** or a **series of two one-year bonds**.
  - Certainty means that the bonds of different maturities are perfect substitutes for each other.
- The **expectations hypothesis** implied that the *current 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 *yield curve will be flat.*

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:

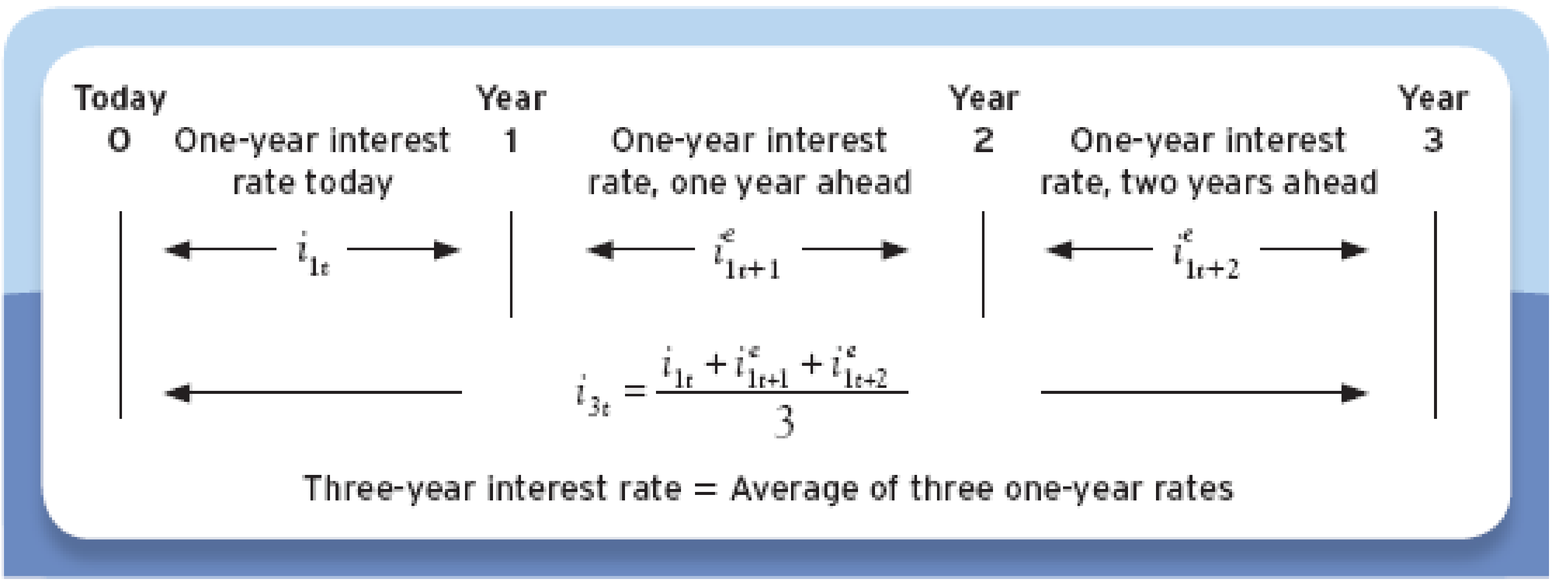
$$(1 + i_{2t})(1 + i_{2t}) = (1 + i_{1t})(1 + i^e_{1t+1})$$

- 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 holds 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 little effect 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 increases 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.

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

End of lecture