Chapter 6

Bonds, Bond Prices, and the Determination of Interest Rates

Learning Objectives

1. Explain the relationship between bond pricing and present value.
2. Define the relationship among a bond's price and its coupon rate, current yield, yield to maturity, and holding period return.
3. Explain how bond prices are determined and why they change.
4. Identify the three major types of bond risk: default, inflation, and interest rate changes.

Bond Prices

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

How much should you be willing to pay for a bond?

- That depends on the bond characteristics.
- We will examine four basic types.

Bond Prices

1. **Zero-coupon or discount bond**
   - Promise a single payment on a future date
   - Example: Treasury bill
2. **Fixed-payment loan**
   - Sequence of fixed payments
   - Example: Mortgage or car loan
3. **Coupon bond**
   - Periodic interest payments + principal repayment at maturity
   - Example: U.S. Treasury Bonds and most corporate bonds
4. **Consol**
   - Periodic interest payments forever, principal never repaid
   - Example: U.K. government has some outstanding

Zero-Coupon Bonds

- U.S. Treasury bills (T-bills) are the most straightforward type of bond.
  - Each T-bill represents a promise by the U.S. government to pay $100 on a fixed future date.
  - No coupon payments - zero-coupon bonds
  - Also called pure discount bonds (or 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

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

- For a zero-coupon bond, the relationship between the price and the interest rate is the same as we saw on present value calculations.
- When the price moves, the interest rate moves with it, in the *opposite* direction.
- We can compute the interest rate from the price using the present value formula.

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

i = (\$100/\$95) - 1 = 0.0526 = 5.26%

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 =

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

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

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.

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

- There are two basic types of mortgages:
  - Conventional fixed-rate, and
  - Adjustable-rate, ARMs.
- Fixed-rate mortgages are easy but ARMs can be complicated.
  - The interest rate changes so payments change.
  - Choosing this means one should know about interest-rate indexes, margins, discounts, caps, negative amortization, and convertibility.

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

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

Yield to Maturity

- If Bond Price = $100,
  Yield to maturity = the coupon rate

- If Bond Price > $100,
  Yield to maturity < the coupon rate

- If Bond Price < $100,
  Yield to maturity > the coupon rate

  Bond Price $\uparrow \Rightarrow$ Yield to maturity $\downarrow$

Yield to Maturity

- This relationship should make sense.
- If you pay $95 for a $100 face value bond, 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.
- When the price of a bond is higher than face value, the bondholder incurs a capital loss.

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:

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

Current Yield

- We can see the relationship between the current yield and the coupon rate.
- Table 6.1 summarizes these relationships.

Bond price < Face value: Coupon rate < Current yield < Yield to maturity

Bond price = Face value: Coupon rate = Current yield = Yield to maturity

Bond price > Face value: Coupon rate > Current yield > Yield to maturity

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

- 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:

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

TOOLS OF THE TRADE

Reading the Bond Page

- Everyday the Wall Street Journal lists the previous day's closing yields for a wide variety of bonds that serve as benchmarks.

Table 6.2 Government Bonds

Yields and spreads over or under U.S. Treasurys on benchmark two-year and 10-year government bonds in selected other countries; arrows indicate whether the yield rose (Δ) or fell (▼) in the latest session.

Coupon (%)	Country/Maturity, in years		YIELD (%) Latest (·)	Previous	Month ago	Year ago	SPREAD UNDER/OVER U.S. TREASURYS, in basis points Latest	Year ago
1.000	**U.S.**	2	0.899 ▼	0.907	0.948	0.501	...	...
2.250		10	2.098 Δ	2.095	2.223	1.857	...	...
4.250	**France**	2	−0.328 Δ	−0.332	−0.292	−0.060	−122.7	−56.0
1.000		10	0.903 Δ	0.887	0.904	0.660	−119.5	−119.8
0.500	**Germany**	2	−0.376 Δ	−0.382	−0.328	−0.113	−127.5	−61.3
1.000		10	0.512 Δ	0.505	0.578	0.427	−158.6	−143.0
4.500	**Italy**	2	0.047 Δ	0.007	0.149	0.466	−85.2	−3.5
2.000		10	1.573 Δ	1.568	1.615	1.723	−52.5	−13.4
0.100	**Japan**	2	−0.027 Δ	−0.030	−0.026	−0.028	−92.6	−52.9
0.300		10	0.227 Δ	0.211	0.301	0.254	−187.1	−160.3
4.350	**Portugal**	2	0.120 Δ	0.079	0.115	0.321	−77.9	−18.0
2.875		10	2.693 Δ	2.683	2.524	2.644	59.5	78.7
1.000	**U.K.**	2	0.505 Δ	0.494	0.596	0.377	−39.4	−12.4
2.000		10	1.735 ▼	1.749	1.842	1.515	−36.3	−34.3

Source: Tullett Prebon, except * marked countries from ICAP plc; historical data prior to 6/8/11; Thomson Reuters

SOURCE: *The Wall Street Journal*, January 14, 2016.

TOOLS OF THE TRADE

Reading the Bond Page

Table 6.3 Corporate Bonds

Investment-grade spreads that tightened the most . . .

Issuer	Symbol	Coupon (%)	Maturity	SPREAD*, IN BASIS POINTS Current	Change	Last week	STOCK PERFORMANCE Close	% Chg
Freeport-McMoRan	FCX	2.375	March 15, '18	2306	−119	1593	$4.20	12.30
HSBC USA	HSBC	1.700	March 5, '18	87	−16	91	...	...
Kinder Morgan Energy Partners	KMI	9.000	Feb 1, '19	491	−14	464	13.98	7.95
Qualcomm	QCOM	3.000	May 20, '22	136	−13	150	47.73	3.54

. . . And spreads that widened the most

Continental Resources	CLR	4.500	April 15, '23	1036	130	836	$20.28	3.31
Freeport-McMoRan	FCX	4.550	Nov. 14, '24	1401	75	1133	4.20	12.30
Williams Partners	WPZ	5.250	March 15, '20	720	62	578	19.05	17.45
BHP Billiton Finance USA	BHP	6.250	Oct. 19, '75	488	58	421	...	...

*Estimated spread over 2-year, 3-year, 5-year, 10-year or 30-year hot-run Treasury; 100 basis points = one percentage point.; change in spread shown is for Z-spread.
Note: Data are for the most active issue of bonds with maturities of two years or more.

Source: MarketAxess Corporate BondTicker; WSJ Market Data Group.

SOURCE: *The Wall Street Journal*, January 14, 2016.

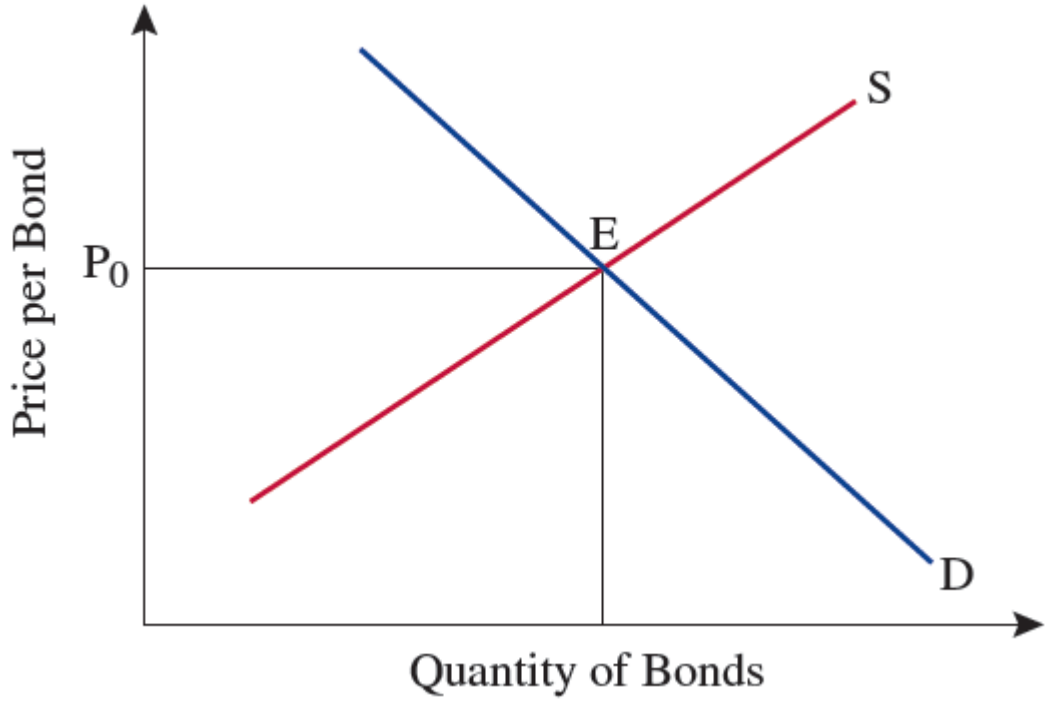
Bond Supply, Bond Demand and Equilibrium in the Bond Market

- 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.

Bond Supply, Bond Demand and Equilibrium in the Bond Market

- What if bond prices are above equilibrium?
  - Quantity supplied > quantity demanded.
  - With excess supply, supplier cannot sell bonds they want at current price.
  - Suppliers begin to cut the price.
  - Excess supply puts downward pressure on the price until supply equals demand.

Bond Supply, Bond Demand and Equilibrium in the Bond Market

- What if the price is below equilibrium?
  - Those who wish to buy bonds cannot get what they want at that price.
  - They start bidding up the price.
  - Excess demand puts upward pressure on the price until supply equals demand.

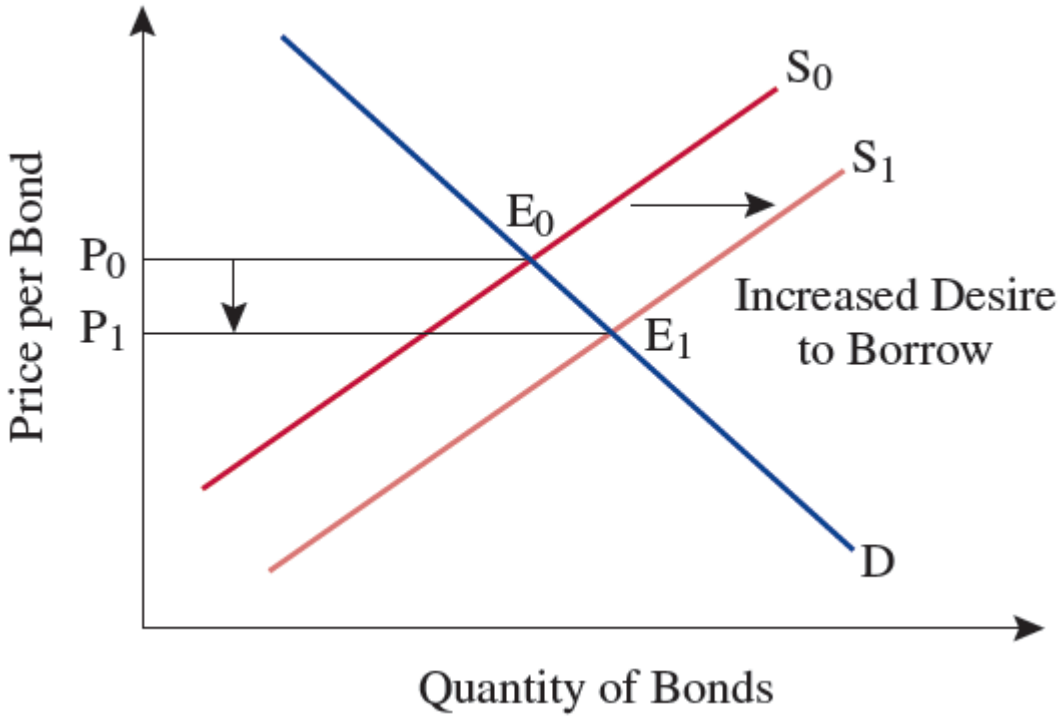
Bond Supply, Bond Demand and Equilibrium in the Bond Market

- To understand bond prices, we really need to understand what determines supply and demand.
- Remember the distinction between *moving along a curve* (change in quantity supplied or demanded) versus a *shift in the curve* (change in supply or demand).
- A shift in either supply or demand changes the price of bonds, so it changes yields as well.

Factors That Shift Bond Supply

1. Changes in Government Borrowing
   - Any increase in the government's borrowing needs increases the quantity of bonds outstanding, shifting the bond supply curve to the right.
2. Change in General Business Conditions
   - As business conditions improve, the bond supply curve shifts to the right.
3. Changes in Expected Inflation
   - When expected inflation rises, the cost of borrowing falls, shifting the bond supply curve to the right.

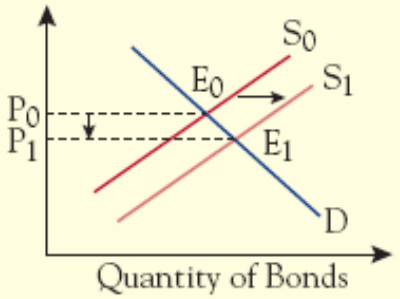
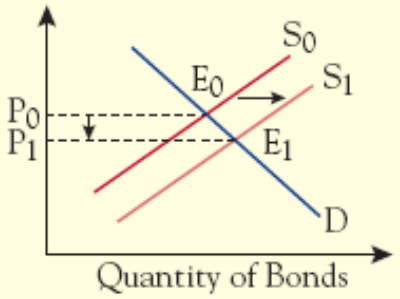
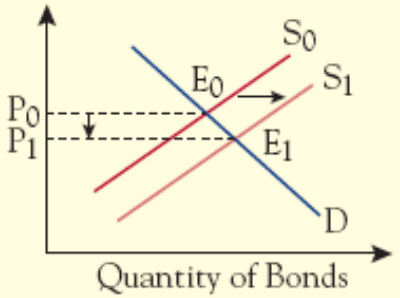
Factors That Shift Bond Supply



When borrowers' desire for funds increases, the supply curve shifts to the right.

This lowers bond prices, thereby raising interest rates.

Table 6.4 Factors That Shift Bond Supply to the Right, Lower Bond Prices, and Raise Interest Rates

Change	Effect on Bond Supply, Bond Prices, and Interest Rates	Shift in Bond Supply
An increase in the government's desired expenditure relative to its revenue	Bond supply shifts to the right, bond prices ↓, and interest rates ↑	
An improvement in general business conditions	Bond supply shifts to the right, bond prices ↓, and interest rates ↑	
An increase in expected inflation, reducing the real cost of repayment	Bond supply shifts to the right, bond prices ↓, and interest rates ↑	

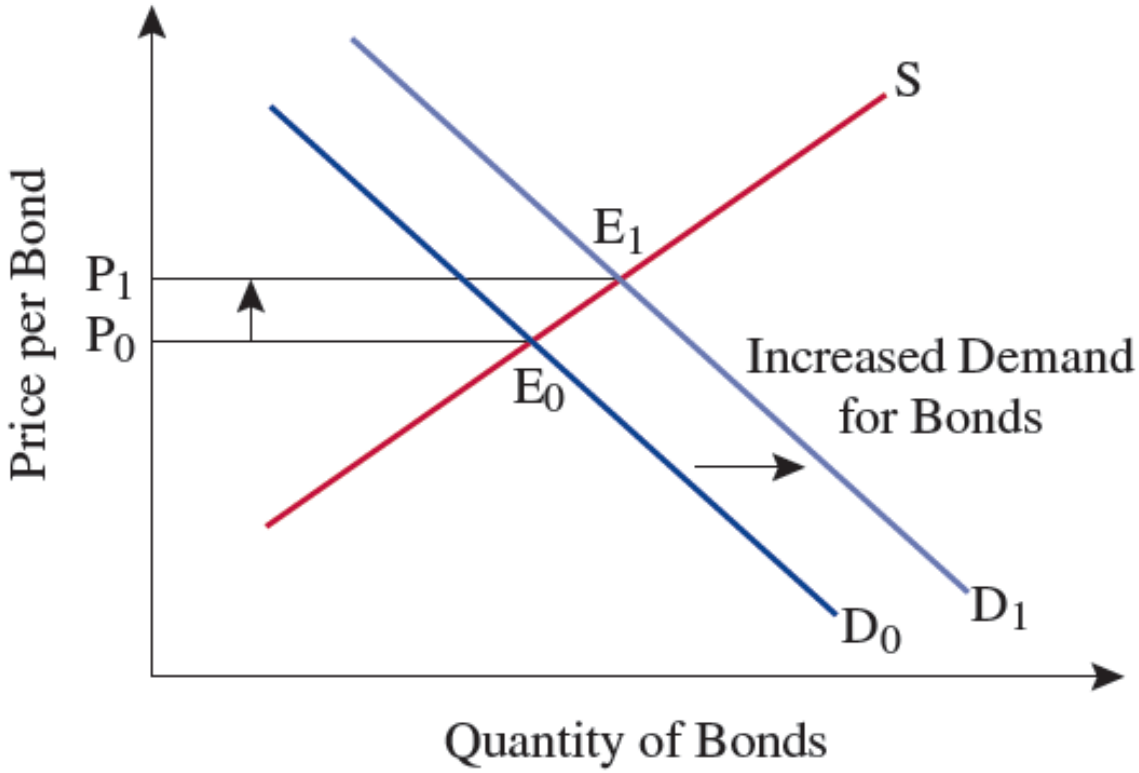
Factors That Shift Bond Demand

1. Wealth
   - Increases in wealth shift the demand for bonds to the right.
2. Expected Inflation
   - Declining inflation means promised payments have higher value - bond demand shifts right.
3. Expected Returns and Expected Interest Rates
   - If the expected return on bonds rises relative to the return on alternative investments, bond demand will shift right.
   - When interest rates are expected to fall, price prices are expected to rise shifting bond demand to the right.

Factors That Shift Bond Demand

4. Risk Relative to Alternatives
   - If bonds become less risky relative to alternative investments, demand for bonds shifts right.
5. Liquidity Relative to Alternatives
   - Investors like liquidity: the more liquid the bond, the higher the demand.
   - If bonds become less risky relative to alternative investments, demand for bonds shifts right.

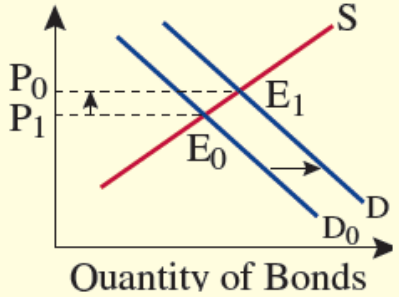
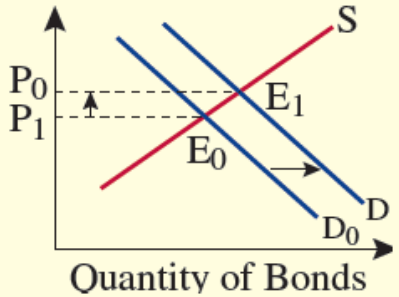
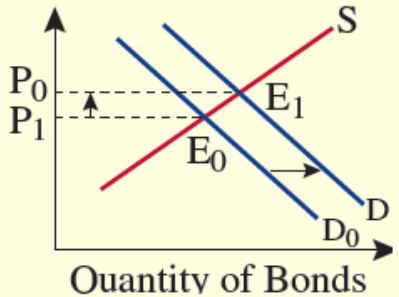
Factors That Shift Bond Demand



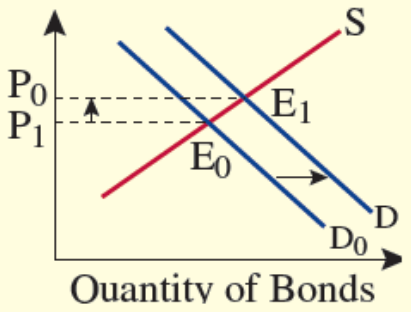
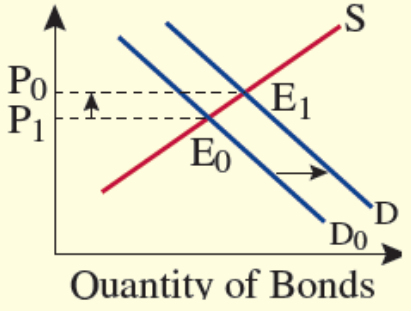
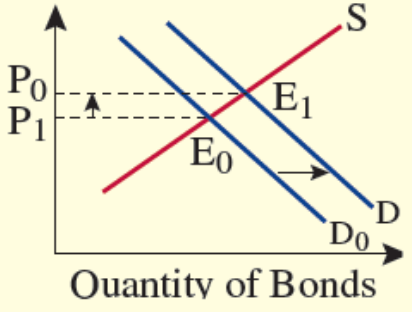
When bonds become more attractive for investors, the demand curve shifts to the right.

This raises bond prices, lowering interest rates.

Factors That Shift Bond Demand

Change	Effect on Bond Demand	Shift in Bond Demand
An increase in wealth increases demand for all assets including bonds.	Bond demand shifts to the right, bond prices ↑, and interest rates ↓	
A reduction in expected inflation makes bonds with fixed nominal payments more desirable.	Bond demand shifts to the right, bond prices ↑, and interest rates ↓	
A decrease in the expected future interest rate makes bonds more attractive.	Bond demand shifts to the right, bond prices ↑, and interest rates ↓	

Factors That Shift Bond Demand

An increase in the expected return on the bond relative to the expected return on alternatives makes bonds more attractive.	Bond demand shifts to the right, bond prices ↑, and interest rates ↓	
A fall in the riskiness of the bond relative to the riskiness of alternatives makes bonds more attractive.	Bond demand shifts to the right, bond prices ↑, and interest rates ↓	
An increase in the liquidity of the bond relative to the liquidity of alternatives makes bonds more attractive.	Bond demand shifts to the right, bond prices ↑, and interest rates ↓	

YOUR FINANCIAL WORLD

Understanding the Ads in the Newspaper

- You notice in the newspaper a company advertising that their bond mutual funds returned 11% last year.
- You remember interest rates being fairly low and the paper backs that up.
- How is the ad correct?
  - The ad is talking about last year's returns, when interest rates were falling.
  - When an ad states at the bottom that "Past Performance is No Indication of Future Returns" you should take it seriously.

Understanding Changes in Equilibrium Bond Prices and Interest Rates

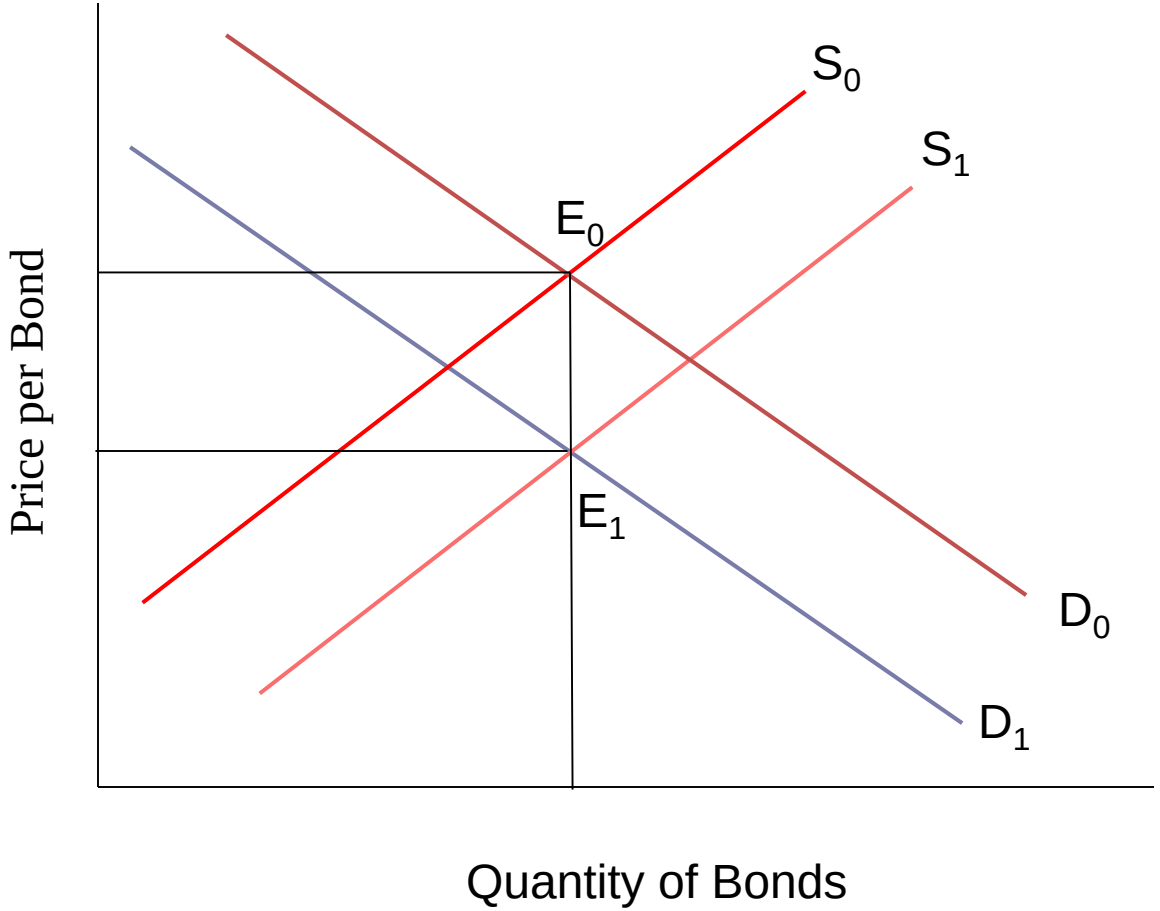
- Increasing expected inflation
  - Reduces the real cost of borrowing shifting bond supply to the right.
  - But, lowers real return on lending, shifting bond demand to the left.

Why Bonds Are Risky

Bonds are a promise to pay a certain amount in the future. How can that be risky?

1. Default risk - the chance the bond's issuer may not make payment.
2. Inflation risk - investor cannot be aware of the real of the payments made.
3. Interest rate risk - a rise in interest rates before bond is sold could mean a capital loss.

Understanding Changes in Equilibrium Bond Prices and Interest Rates



1) Shift S right

2) Shift D right

These two effects reinforce each other.

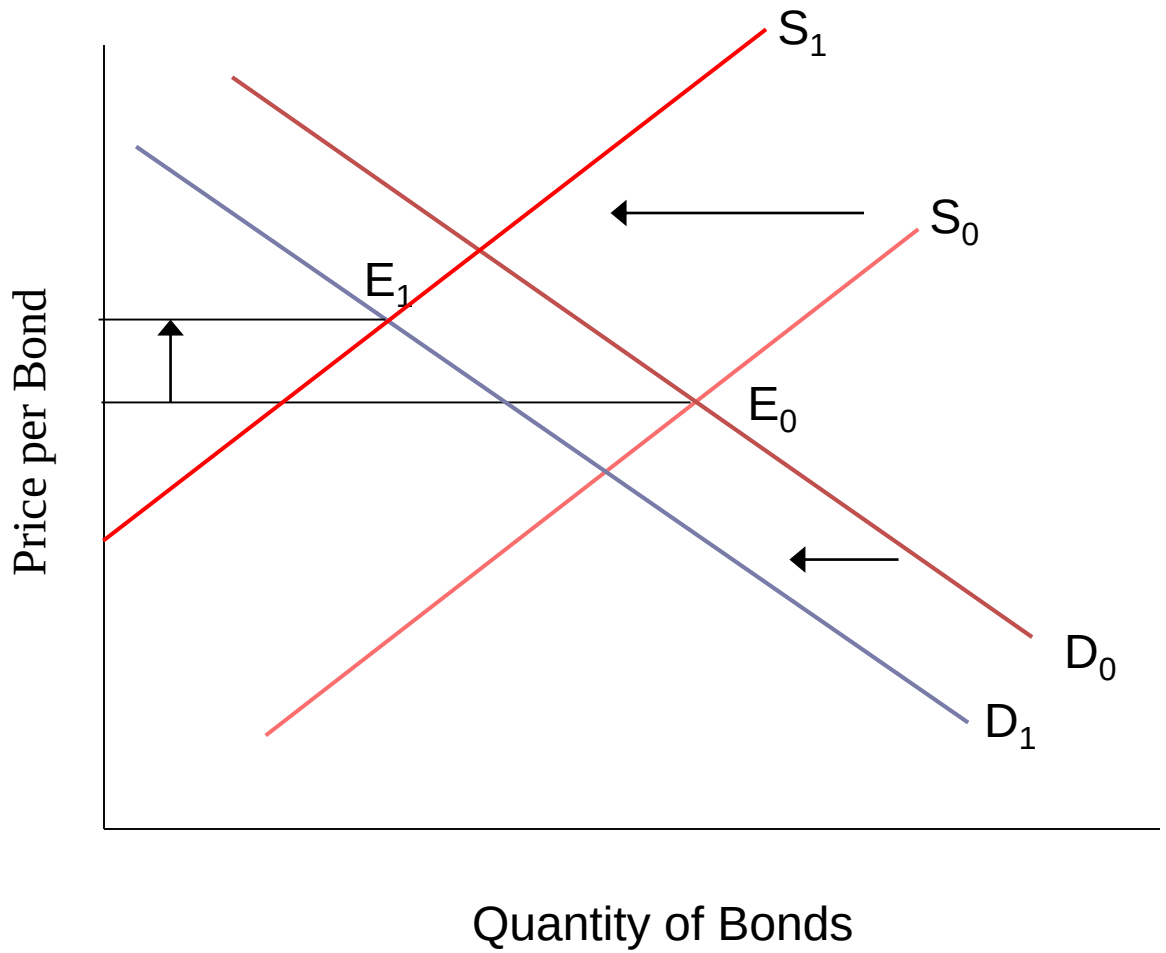
- Lower bond prices
- Raise interest rates

However, graphically unknown effect on quantity of bonds.

Understanding Changes in Equilibrium Bond Prices and Interest Rates

- A business cycle downturn:
  - Reduces business investment opportunities shifting bond supply to the left.
  - Reduces wealth, shifting bond demand to the left also.
- Although both shifts could give an ambiguous answer in terms of bond price, theory is not ambiguous.
  - In recessions, interest rates tend to fall meaning that bond prices should rise.

Understanding Changes in Equilibrium Bond Prices and Interest Rates



1) Shift S left

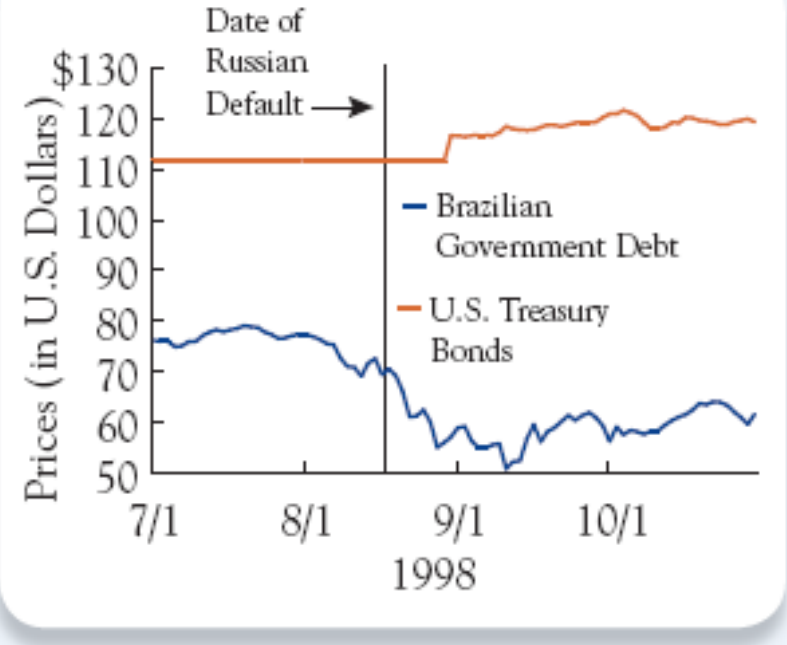
2) Shift D left

We know price increases so supply shifts more than demand.

APPLYING THE CONCEPT
WHEN RUSSIA DEFAULTED

- Investors' concerns about risk affect their demand for U.S. Treasuries.
- 1998, Russia defaulted and people lost confidence in emerging market countries.
- Safest assets are U.S. Treasuries.
- Demand increased, price increased, and yields declined.

Figure 6.6 Prices of Brazilian Government Debt and U.S. Treasury Bonds, July 1998 to October 1998



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

- Although there is little to no default risk with U.S. Treasury bonds, there is with other government and corporate bonds.
- 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 higher the default risk, the higher the yield.

APPLYING THE CONCEPT
SECURITIZATION

- *Securitization* is the process by which financial institutions pool various assets that generate a stream of payments and transform them into a bond that gives the bondholder a claim to those payments.
- Securitization has grown over the last 35 years, mortgage-backed securities account for the largest share of securitized debt (90%)

APPLYING THE CONCEPT
SECURITIZATION

- Securitization uses the efficiency of markets to lower the cost of borrowing by:
  1. Facilitating diversification of risks
  2. Making assets liquid
  3. Allowing greater specialization in the business of finance,
  4. Broadening markets
  5. Promoting innovations

YOUR FINANCIAL WORLD

Bonds Indexed to Inflation

- Inflation-indexed bonds are structured so that the government promises to pay you a fixed interest rate plus the change in the consumer price index (CPI).
- The U.S. Treasury sells two types of bonds that are adjusted for inflation.
  1. Series I savings bonds
  2. Treasury Inflation Protected Securities (TIPS)

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.

IN THE BLOG

Bond Market Liquidity: Should We Be Worried?

- Corporate bonds were highly illiquid before the crisis as well as after it
  - Turnover extremely low
  - Consist of a large number of small issues that are traded rarely because it is very costly
- Loss of liquidity in U.S. Treasury debt markets
  - Principle trading firms (PTFs)
- The resilience of intermediaries and the resilience of markets are mutually reinforcing