

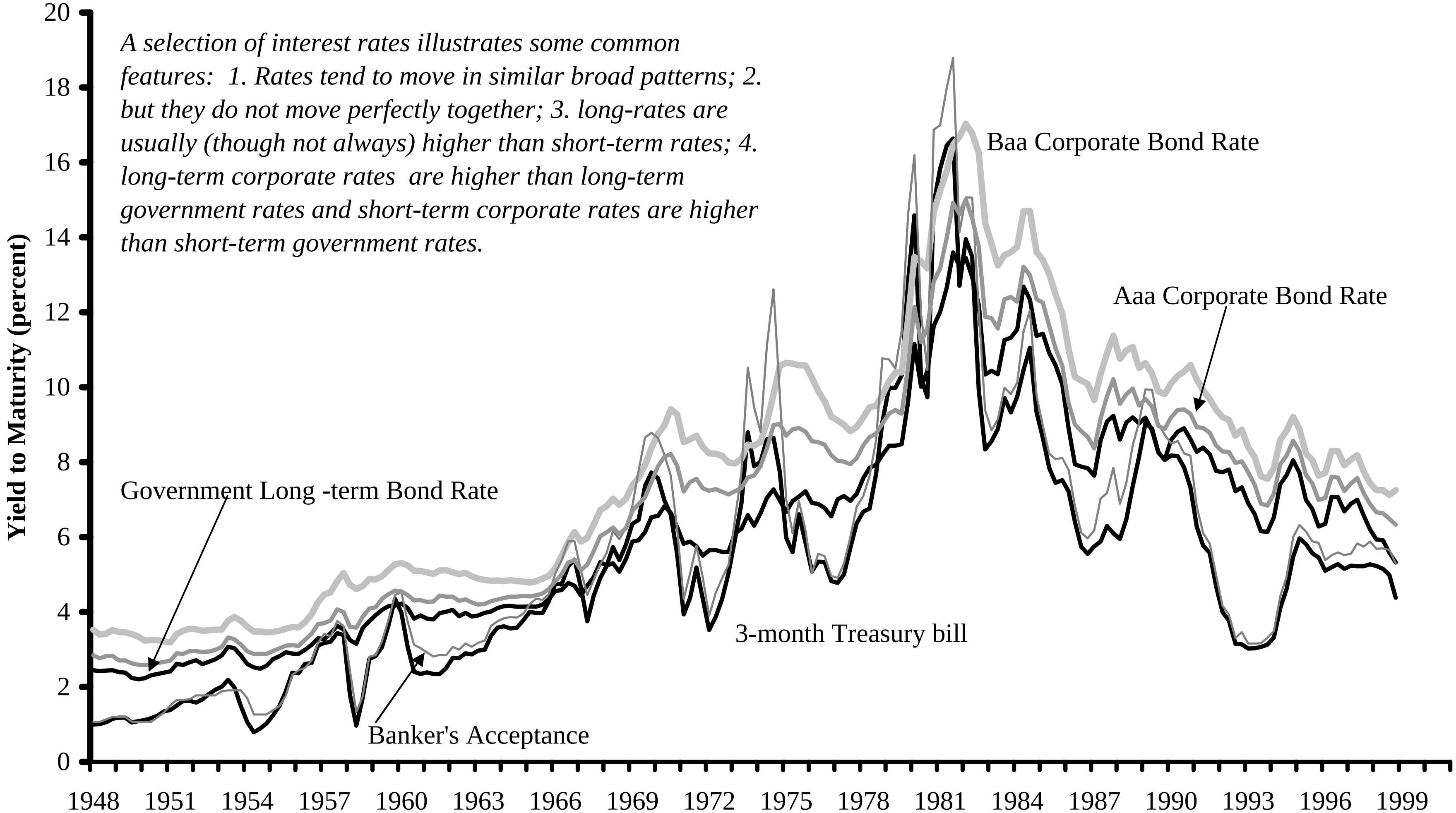
11 The Behavior of Interest Rates

Every six weeks or so, the financial news reports spend several days anticipating the announcement of the Federal Reserve's short-term interest-rate target and, once it has been announced, several days dissecting its policy implications. Whenever long-term bond rates rise or fall significantly, again it is a matter for intense financial commentary. Why? The short answer is that, for anyone who borrows money to pay for college, buy a car, or digital camera, or any other good, every rise in interest rates makes things a little bit tighter, and every fall a little bit easier. A significant drop in mortgage interest rates can start a boom, not only in the real estate market, but also in anything that might be financed with a home-equity loan. And equally, any significant rise, can quickly cool these markets off. It is vitally important to macroeconomics to understand how interest rates behave: What determines their levels? What makes them change?

11.1 Five Questions About Interest Rates

Look at Figure 11.1, which shows the time series of five rates of interest: a short government rate (the three-month Treasury bill rate); a short private-sector rate (the three-month bankers' acceptance rate); a long government rate (the average or composite yield on bonds over ten years in maturity); and two long private-sector rates for corporations with different degrees of riskiness (the Moody's Aaa and Baa bond rates). (The time series are a tangled skein, making the figure a little hard to read. But, as we shall see, the tangles themselves reflect an important fact about interest rates.) These five rates are chosen to represent the thousands of interest rates that are reported regularly. These thousands themselves represent the countless rates (one for each loan or financial

Figure 11.1
Selected Interest Rates



Source: Board of Governors of the Federal Reserve System, "Selected Interest Rates and Prices," release G.13.
Short rates converted from bank discount basis (author's calculations).

instrument) recorded in the history of the economy. The figure reveals several consistent patterns in the interrelationships of the different rates and suggests at least five questions.

The most striking feature of Figure 11.1 is that all of the interest rates seem to follow the same broad pattern. Not only do they all start low at the end of the 1940s, rise to a global peak in the early 1980s, and then fall into a middle range by the turn of the 21st century, their local peaks and troughs occur at more or less the same times. Yet despite the broad similarity, each series has a different history. In general, at any time, each series takes a distinct value. These observations point to the first two questions:

- *First, why do interest rates tend to move together?*
- *Second, why do they move only imperfectly together?*

There are further patterns in the data. Notice the two short-term interest rates (the rates on three-month Treasury bills and on bankers' acceptances) are typically, although not always, lower than the three long-term interest rates (on government and corporate Aaa and Baa bonds). Also notice that the Treasury bill rate is typically lower than the rate on bankers' acceptances and that the Treasury bond rate is uniformly lower than the two corporate bond rates. These observations suggest two more questions that can be seen as refinements of the second question:

- *Third, why do shorter maturity assets typically, but not uniformly, yield lower rates of interest than longer maturity assets?*
- *Fourth, why at each maturity do government assets yield lower rates of interest than private sector assets?*

The first four questions address the relationship of each interest rate to the others. A final question highlights the whole structure of the rates:

- *Fifth, what determines the overall level of interest rates?*

This chapter aims to answer these five questions.

11.2 The Market for Financial Assets

11.2.1 SUBSTITUTION AND ARBITRAGE

Similarity and Replacement Again

In Chapter 10 we explained the valuation of financial instruments through the principle of similarity and replacement. The value of one instrument was determined using a present-value formula with reference to the yield of another similar instrument. The yield (or opportunity cost) matters because the actors in financial markets are able to choose among competing instruments.

To one degree or another, all financial instruments are similar, but generally they are not identical. Each is issued by a different borrower with different chances of paying back the loan, each provides the lender with a different stream of income, and each may have its own special characteristics.

Recall from Chapters 8, Section 8.2.1 that any two goods are substitutes when a rise in the price of the first good reduces its demand and raises the demand for the other good. Recall from Chapter 10 that the price of a financial asset is inversely related to its yield or interest rate. Two financial assets are then **SUBSTITUTES** *when a fall in the yield or interest rate on the first asset (that is, a rise in its price) reduces the demand for that asset and raises the demand for the other asset.* Identical instruments are perfect substitutes. Similar instruments are, to various degrees, imperfect substitutes. If all financial assets are substitutes to some degree, then the demand for each asset depends on the interest rate on all competing assets.

Supply and Demand

Consider two similar corporate bonds – say, bonds issued by Proctor and Gamble (P&G) and by Clorox. What determines their yields? As usual, the universal answer to all economic questions is . . . supply and demand. Unfortunately, "supply" and "demand" are tricky terms in financial markets. Their proper applications depend on what we think is being traded. For example, if you borrow money from the bank to buy a car, we normally say that the bank has supplied you a loan. On the other hand, if the government sells you a bond, we normally say that the government has supplied you a bond. In the first example, you are the borrower and the bank, called "the supplier," is the lender. In the second example, you are the lender and the government, called "the supplier," is the borrower. The usage is correct in both cases. In the first case, you are treated as using your liability to buy money. In the second, you are treated as using money to buy the government's liability. Since there are two sides to every transaction, both are correct. It is a matter of point of view.

To avoid confusion, we shall adopt the convention of always referring the financial instrument itself as the object of trade. Borrowers use funds and *supply* the financial instrument; lenders are the source of funds and *demand* the financial instrument. In the case of the two bonds, the corporations are the suppliers, and the public are the demanders.

Reaching Equilibrium in a Financial Market

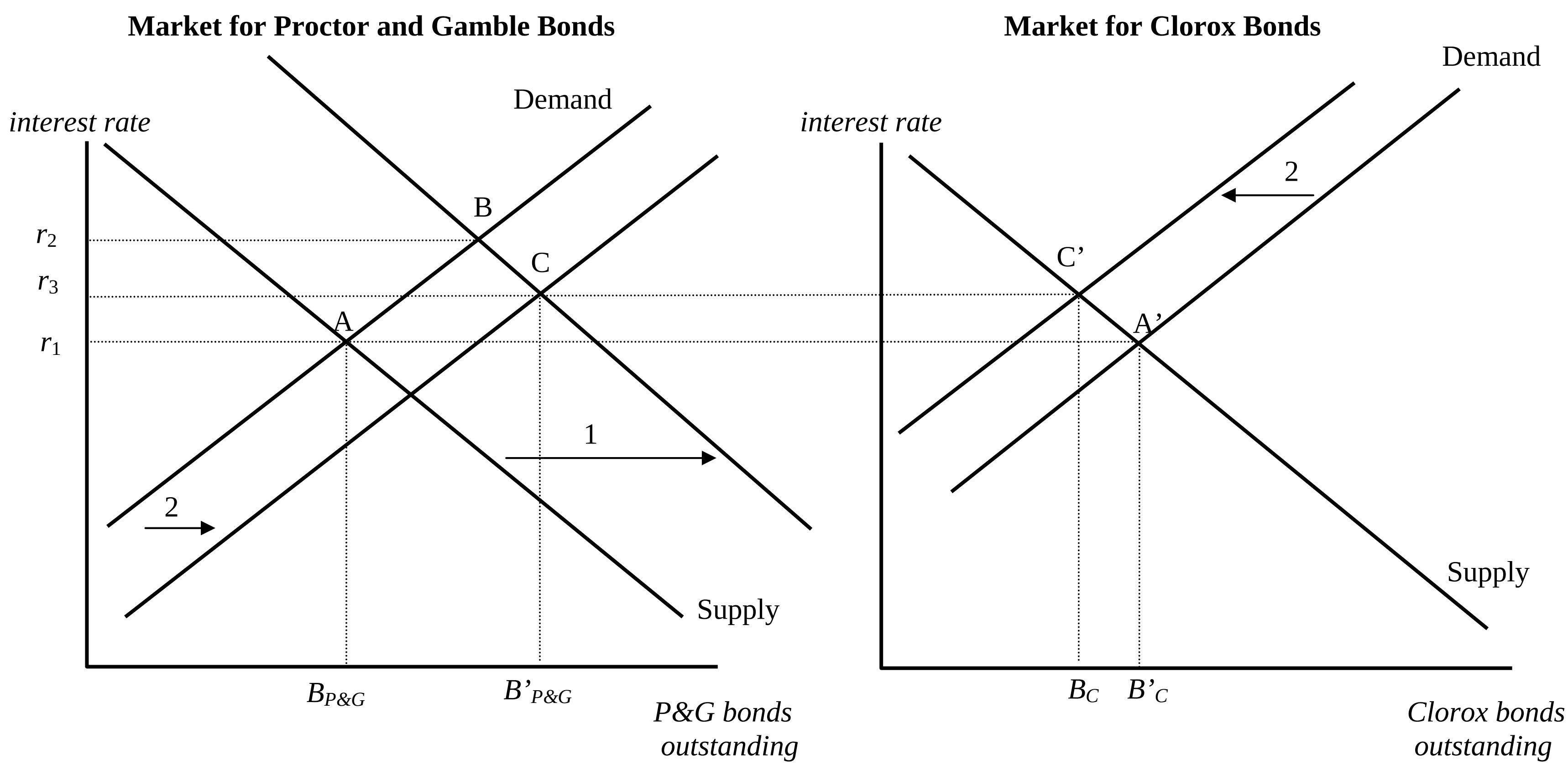
The markets for the two corporate bonds are shown in Figure 11.2. The yield to maturity of each bond is shown on the vertical axis and the number of bonds outstanding (or, equivalently, the total face value of the outstanding bonds) is shown on the horizontal axis.[1]

The supply and demand curves for labor or other goods or factors of production that we encountered in earlier chapters were supplies of and demands for flows of valuable commodities – so many hours of labor or so many kilowatt-hours of electricity. The commodities were demanded or supplied with the object of being used. The supply and demand for a financial asset are for stocks – a timeless number of dollars. Financial assets are demanded or supplied with the object of being held. They are of course held for the valuable flow of funds that they generate; but, unlike electricity that is used in the instant of its production, a thirty-year bond can fulfill a demand over the whole thirty years of its existence. The supply and demand for financial assets therefore depends on the entire stock of the assets outstanding (say, the stock of Clorox bonds) and not simply on the new issue of financial assets driven by the current need of the firm for funds.

The public's demand is shown in each panel of Figure 11.2 as an upward-sloping line. The higher the yield (the more each dollar lent earns), the more of either corporate bond the public is willing to purchase. The corporation's demand is shown in each panel

[1] Notice that, if the bonds are measured in terms of value, it is the face value and not the market value that is shown on the horizontal axis, because the market value changes with every change in yield according to the bond pricing formulae in Chapter 10 (for example, equation 10.13').

Figure 11.2
An Illustration of Arbitrage Between Two Financial Markets



Initially, the markets are in equilibrium at points A and A', with a common interest rate, r_1. *(1) An increase in the supply of Proctor and Gamble bonds shifts the supply curve rightward, which would* ceteris paribus *raise interest rates at point B to* r_2. *(2) Market participants move funds away from the lower yielding Clorox bonds towards the higher rate – a leftward shift of the Clorox-bond demand curve, lowering rates in that market, and a rightward shift of the Proctor-and-Gamble-bond demand curve, raising rates in that market. The process stops at points C and C' at which the rates are equal at* r_3 *in both markets.*

as a downward-sloping line.[2] The higher the yield (the more each dollar borrowed costs), the less the corporation is willing to borrow. The interest rate is determined where supply equals demand in each market. And the rate is initially shown the same (r_1) in each market on the assumption that P&G bonds and Clorox bonds are perfect substitutes.

Now consider what happens if Proctor and Gamble decides to fund a major investment project through issuing new bonds. At each rate of interest its desire for funds will be higher, shifting its supply curve rightward (shift 1). All other things equal, the equilibrium would move from point A to point B, and the interest rate would rise from r_1 to r_2. The reason is that since more bonds are available, the only way the public can be enticed to hold them is for them to become cheaper. As their price falls, their yields rise.

Notice that with the market for Proctor and Gamble bonds at point B while the market for Clorox bonds is still at point A', the yield on the Proctor and Gamble bonds is higher than the yield on Clorox bonds. Since both bonds are assumed to be practically identical in the eyes of the public, why would people remain content to hold lower yielding Clorox bonds?

They would not. Some people would sell their (expensive) Clorox bonds and use the proceeds to buy the (now cheaper) Proctor and Gamble bonds. As a result funds would leave the Clorox bond market and enter the Proctor and Gamble bond market. At each level of interest rates, the demand for Clorox bonds would fall. The demand curve would shift leftward in the right-hand panel.

[2] Notice that ordinary demand curves slope downward and ordinary supply curves upward. These are because we have expressed supply and demand as functions of interest rates, which are inversely related to bond prices. If we put bond prices on the vertical axis instead of interest rates, then the supply and demand curves for bonds would be just like the supply and demand curve for, say, apples.

Similarly, at each level of interest rates, the demand for Proctor and Gamble bonds would rise, and the demand curve would shift rightward in the left-hand. (Both demand shifts are shown as 2.) This shifting of funds will continue so long as the yield on Proctor and Gamble bonds is higher than the yield on Clorox bonds. Eventually the yield on Clorox bonds is driven up (their price falls) and the yield on Proctor and Gamble bonds is driven down (their price rises) from point B until a new equilibrium is reached at a point like C.

More Proctor and Gamble bonds are outstanding at the new equilibrium ($B_{P\&G}$ increased to $B'_{P\&G}$). There are two effects. First, the rise in interest rates encouraged the public to buy more bonds. Second, the incipient difference between the yields in the two markets ($r_2 > r_1$) encouraged the public to shift from Clorox to Proctor and Gamble bonds until the yields were brought back into equality (B_{Clorox} fell to B'_{Clorox} and both bonds yield r_3). There are fewer Clorox bonds at the new equilibrium. Because of the higher rates, Clorox prefers less debt and so would lower it by not rolling over bonds that come mature and, even, by buying back outstanding bonds, which are now cheaper. (This is only one of many possible examples. Other cases are addressed in Problem 11.1.)

Arbitrage

The process through which funds move between markets in search of higher yields is known as **ARBITRAGE**, which can be defined as *the simultaneous buying and selling of closely related goods or financial instruments in different markets to take advantage of* *price differentials.*[3] The person who engages in arbitrage, the so-called **arbitrageur**, buys the same good cheap in one market and sells it dear in another.

Actual financial markets are more complicated than the simple example of the two bonds. In reality there are many, many financial assets. They are almost all substitutes – sometimes extremely close substitutes. As a result, what happens in any market affects every market to some degree. The closer substitutes two assets are, the closer arbitrage drives their yields.

11.2.2 Efficient Markets

Inside and Outside Views of Financial Markets

Because there are large amounts of money at stake and because financial markets are well supplied with information, arbitrage is highly effective and works very quickly. In fact, the incentives reinforce the old adage, "he who hesitates is lost." As the market yield rises, the price of the bond falls. Anyone who fails to sell the high priced bond and purchase the low price bond quickly takes a capital loss. The value of his portfolio falls without any compensating gain in terms of the income stream – his bond yields the same coupons and has the same face value as before even though it is worth less on the market. As a result, the shift in demand happens quickly – often with very few trades being made and very few funds moving between markets. A bond seller immediately marks the price to where the equilibrium is anticipated to be, so that the yield jumps quickly to a value

[3] Some economists would restrict the definition to only those cases in which the profits are perfectly certain. But that would be a far narrower meaning than commonly encountered among financial professionals.

close to the final price, and the movements driven by actual flows of funds are relatively minor adjustments.

The effectiveness of arbitrage allows us to see financial markets from two perspectives. The first views the market from inside in terms of process. Highly motivated traders look for fleeting opportunities and exploit them quickly before they disappear. The process is complex, involving millions of trades every day.

The market can also be viewed from the outside in terms of outcomes. Since arbitrage is highly effective, it is reasonable for many purposes to assume that it is complete. All profit opportunities are competed away so quickly that we can assume that they do not exist at all. From this second perspective, financial markets can be thought of as highly efficient processors of information. If anyone in the market learns anything relevant to the profitability of financial assets, asset prices change rapidly to reflect the new information. Studies show, for example, that a report of a cold snap in Florida is reflected in the market for orange-juice futures in a few minutes – and, indeed, the market typically anticipates the reports with great accuracy, so that only the small difference between the report and the expectation of what would be reported need be processed at all.

The Efficient Markets Hypothesis

This view of the financial market as a highly effective processor of information is the critical element of the **EFFICIENT-MARKETS HYPOTHESIS**, which states *there are no* systematically *exploitable arbitrage opportunities based on information that is publicly available to financial markets.*

The efficient-markets hypothesis is sometimes illustrated with a lame joke: if you see a one-hundred dollar bill on the sidewalk, you should not bother to pick it up; because, if it were really there, someone would have picked it up already. The joke is misleading. The efficient-markets hypothesis does not say that arbitrage opportunities do not arise, only that they are not systematic. Systematic opportunities do not exist, *because* traders are ready and able to exploit them as quickly as they arise. If you see a one-hundred dollar bill on the sidewalk, you should pick it up quickly. It will not be there long. But having found the bill on the sidewalk at 34th and Vine, there is no reason to think that you will find another one there the next day.

The efficient-markets hypothesis says that no one can beat the market on average using publicly available information. In the comedy film, "Trading Places," the characters played by Dan Ackroyd and Eddie Murphy profit hugely through stealing the crop report for oranges and basing their trades on the futures market on how the market was likely to react once the report was made public. Profiting from truly private information is consistent with the efficient-markets hypothesis.

Similarly, the efficient-markets hypothesis is consistent with some people beating the market and making enormous profits on financial trading. It does not rule out luck. On average people who buy lottery tickets lose money. But someone wins the lottery – and sometimes for millions of dollars. Many traders, managers of mutual funds, and financial advisers believe that they can systematically outperform the market and can cite evidence of successive years of above average returns. How could we tell if this were skill or luck? For any individual, it is impossible. The real test is: will the luck continue?

One test would be to divide the market into above-average and below-average performers for, say, one year and then to see whether the above-average continue to beat the average in the next year. Many careful studies have shown that an above-average performance one year does not predict an above-average performance the next year. Luck rules.

Some traders filter through reams of financial data and find patterns of mispriced assets that appear to present profit opportunities. In many cases, these apparent profit opportunities are too small to exploit. The brokerage and other costs of transactions exceed the gains from arbitrage. Such mispricing is also consistent with the efficient-markets hypothesis. Some of the opportunities are genuine and traders make a business of exploiting them. Such traders keep the markets efficient. The efficient-markets hypothesis does not say that no one can make their living from such arbitrage activity. Rather, it says that the returns to such activity cannot on average exceed the amount that makes it just worth the traders' while to continue it. I could become a full time hunter of mislaid one-hundred dollar bills, and I might even earn enough to eat from this activity. Yet if it were vastly more profitable than other occupations for the same time and effort, everyone would become bill hunters, and most of us would starve.

The efficient-markets hypothesis is the dominant theory of the functioning of financial markets, but there are many people who do not believe it. They point to people who have made millions, to statistical evidence of systematic, unexploited profit opportunities, and to psychological theories of herd behavior. Often they simply believe that they are just smarter than everyone else. A simple question will often silence someone who claims to be able to locate unexploited profit opportunities: "if you're so smart, why aren't you rich?" Some do turn out to be rich. John Maynard Keynes, the most important macroeconomist of the 20th century, made fortunes both for himself and for King's College, Cambridge, of which he was bursar, through trading. Was this luck or skill? There is never an answer in the individual case, but if it is a skill, no one has ever shown how reliably to teach it to others. The statistical studies point more to luck than skill. The efficient-markets hypothesis remains the best account available of the working of financial markets.

Two Answers

We now have initial answers to the first two questions posed in Section 11.1:

- Interest rates tend to move together because financial assets are substitutes and profit-seeking traders engage in effective arbitrage;
- Interest rates do not move perfectly together because financial assets are not perfect substitutes.

These are only initial answers because they do not address some important issues. Substitution and arbitrage explain why, if yields move in some markets, yields in other markets tend to move sympathetically. They do not in themselves explain why the first yield moved. Similarly, imperfect substitutability can be regarded as just a name for the fact that arbitrage is ineffective in removing all differences in yields. It remains to explain why it is ineffective.

11.3 Risk

Bonds are not perfect substitutes because they are not perfectly alike. Even if two bonds have the same market price, they may have different structures. For example, some bonds do not have coupons and, even those bonds that do, have different coupon rates. Some bonds are callable, others are not. (A bond is *callable* when it is sold with the provision that it can be paid off before it matures.) Some bonds are exempt from Federal and/or state and local taxes; most bonds are not. There are other differences among bonds. In this section and the next, we focus on two of the most important: different bonds bear different degrees of risk and different bonds have different maturities.

Risk is a complex business. We focus on two key elements: default risk and price or interest-rate risk.

11.3.1 Default Risk

Risk and Return

The individual, corporation or other organization, such as a state or local government or a municipal utility district, that borrows funds through issuing a bond or taking out a loan might go bankrupt. In that case, the lender or bond holders face **DEFAULT RISK**: they might not get paid.

Some kinds of risk are more or less symmetrical. If I buy a share in Wal-Mart it may rise or fall. Some are asymmetrical. The typical state lottery ticket in most cases loses, but it costs only a dollar: there is a small *downside* risk. While winning is rare, a win might bring millions of dollars: there is a large *upside* risk. Anyone who values the low probability of a large gain against the high probability of a small loss might rationally purchase a lottery ticket. Default risk is also asymmetrical. No matter how well the company does, the bond will pay off only what it promised, but if the company fails it may not pay off at all: there is downside, but no upside, risk.[4]

The chances of default on any particular bond are typically quite low. The chances of default on personal loans are generally much higher. Only a fool would choose a bond with a high risk of default over one with the same yield and a lower risk of default. If the high-risk bond were cheap enough – that is, if its yield were enough larger than that on the low risk bond – it might become worthwhile to hold it. The additional yield or **risk premium** compensates for the higher risk.

A market player who purchases financial instruments that are more risky than the average market portfolio enjoys a higher yield but does not "beat the market." The advantages of the higher yield are offset by the disadvantages of higher risk: "no pain, no gain." Seen this way, the risk premium can be thought of as the price of risk. The higher average yield merely pays for the higher uncertainty of the yield from month to month or year to year.

Federal Government Bonds

Junk bonds stand at one extreme of the risk spectrum. U.S. federal government bonds stand at the other. They are virtually free of default risk. Governments have a monopoly on taxation and, therefore, a ready source of funds to repay their debt. More important, the typical U.S. government bond is a promise to pay dollars – also a government

[4] Notice that *shares* in the same company may have substantial upside risk – e.g., if the management has "bet the firm" on a new product, the shareholders may make a fortune or lose their shirts.

financial instrument. Since the federal government working with the Federal Reserve – effectively a government agency – can create as many dollars as necessary to fund its debt, it never has any reason to default.[5]

The key to its freedom from default risk is that federal government debt is denominated in dollars, which are within its control. Not every government is so favorably situated. State and local governments can default because they cannot print dollars. The debt of the central governments of other countries is equally free of default risk, so long as it is denominated in their national currencies.

Many developing countries find that they cannot borrow on international markets in their own currencies. Mexico, for instance, does not find it easy to sell peso-denominated bonds to foreigners, who usually prefer dollars, yen, or euros. Since Mexico cannot print dollars, its dollar-denominated bonds are just as subject to default risk as a corporate or municipal bond in the United States.

In the 1960s, the United States issued a small number of bonds denominated in Japanese yen. These were no different in principle than dollar-denominated Mexican debt; they carried some premium to cover default risk.

Rating Risk

Banks try to screen their personal and corporate borrowers to limit default. This is the reason that banks require borrowers to provide extensive information on their assets and

[5] Strictly speaking, the government could default if it decided not to pay its debt even though it always has the ability to pay. During the budget stalemate between President Clinton and Congress in 1995-96, the Treasury's funding authority lapsed, and it missed an interest payment on some government bonds. The financial markets, however, did not treat this as a default since there was never any question of the payments being made with a few days.

liabilities and why they check borrowers' payment histories with credit information agencies such as TransUnion, Equifax, and Experian. Riskier customers pay higher interest rates on loans.

Default risk matters for bonds as well. Firms and government agencies who wish to sell bonds on organized markets are able to do so effectively only if they pay a bond-rating agency to rank the riskiness of their debt. These agencies (the three most important are Moody's, Standard & Poor's , and Fitch) use information – partly gathered from the firms themselves – to assign ratings similar to letter grades. The rating scale for Standard & Poor's (AAA to D) is shown in Table 11.1 (Moody's and Fitch use similar scales).

Bonds with ratings in the upper-half of the rating scale (relatively low default risk) are referred to as **investment grade** and those in the lower half (high default risk) as **speculative**. The term **junk bond** became familiar starting in the 1980s. Although it sounds like a synonym for "worthless," junk bonds are just bonds below investment grade (i.e., below Moody's Baa or Standard & Poor's BBB). As such they carry a higher risk premium than safer bonds. The boom in the junk-bond market in the 1980s began with the financier Michael Milken and others who recognized that junk bonds were mispriced: their yields were too high relative to the actual risk reflected in their default histories. This presented the players in the market with an enormous arbitrage opportunity and made them extremely rich.[6]

The bond-rating agencies constantly monitor firms and municipalities. A downgraded

[6] So rich in Milken's case that he was able to pay a $600 million for six violations of securities law and still have enough wealth to metamorphose into an important philanthropist.

Table 11.1
Standard & Poor's Bond Ratings and Default Rates

Grade	Description	Cumulative Default Rate* (percent)
	INVESTMENT GRADE	
AAA	Highest quality. Ability to pay interest and principal very strong.	0.67
AA	High quality. Ability to pay interest and principal strong.	1.30
A	Medium to high quality. Ability to pay interest and principal, but more susceptible to changes in circumstances and the economy.	2.88
BBB	Medium quality. Adequate ability to pay, but highly susceptible to adverse circumstances.	9.77
	SPECULATIVE	
BB	Speculative. Less near-term likelihood of default relative to other speculative issues.	24.51
B	Current capacity to pay interest and principal, but highly susceptible.	
CCC	Likely to default, where payment of interest and principal is dependent.	41.09
CC	Debt subordinate to senior debt rated CCC.	
C	Debt subordinate to senior debt rated CCC-D.	
D	Currently in default, where interest or principal has not been made as promised.	60.70

*Cumulative average default rates after 15 years from initial rating.
Source: "Long-term Rating Definitions," *Standard & Poor's Credit Week*, February 11, 1991, p. 128; *S&P Ratings Performance*, February 2003.

rating adds substantial costs to borrowing. Critics worry that, because the firms pay to be rated, the agencies would accommodate them with higher ratings. While there is a genuine risk, importance of maintaining the reputation for impartiality on which their business depends mitigates the tendency of the agencies toward inflating ratings. Any systematic biased rating should show up in default rates out of line with the risk ratings. The pattern in Table 11.1 seems consistent with the agencies doing a reasonable job.

Still, the rating agencies are not perfect, and are sometimes behind the curve. In the collapse of the energy trading company Enron in 2001, its stock price had collapsed over a period of months, but Moody's and Standard & Poor's cut Enron's bond rating from investment grade to junk status only four days before it announced bankruptcy. The case of WorldCom, the telecommunications giant, was similar with the rating firms shifting from investment to junk ratings only shortly before bankruptcy in 2002. In the end, WorldCom bondholders received a mere 35.7¢ on the dollar.

Default Risk and Interest Rates

Table 11.1 also shows the average cumulative default rates over a 15-year period for bonds in each risk class. Roughly speaking, we can interpret the default rate on a BBB bond of 9.77 percent as saying that such a bond has a nearly 10 percent chance of not paying off in full if held for 15 years.[7]

If default meant that bondholder would receive nothing, then the expected yield would be (1 – *default rate*) × r_{BBB}, and arbitrage would force that return to be equal to the return

[7] In many defaults, bondholders do get repaid some fraction of what is owed.

on a government bond of the same maturity.[8] Say that the government bond yield is r_G = 5.00 percent then

$$(1 - \textit{default rate}) \times r_{BBB} = (1 - 0.0977) \times r_{BBB} = 5.00 = r_G.$$

So that

$$r_{BBB} = \frac{r_G}{1 - \textit{default rate}} = \frac{5.00}{1 - 0.0977} = 5.54 \text{ percent}.$$

A risk premium of 0.54 percentage points would be the arbitrageur's rationale response to the level of risk typically experienced in holding BBB bonds.

The actual difference in yields for bonds of different default risk is reflected in Figure 11.1. The plot of the BAA bond rate (moderately low risk) typically lies about 1 percentage point above the plot of the AAA bond rate (very low risk), which in turn lies about ¾ points above the plot of the government bond (virtually no default risk). The yield differentials between bonds in different risk categories are not constant. Default risks vary across the business cycle. The gap between high risk and low risk yields may widen in times of recession or economic crisis as market participants shift funds towards lower risk assets in a "flight to quality."

[8] Our calculation assumes that the both are zero-coupon bonds, which is unlikely. The result is, therefore, an approximation.

11.3.2 Price or Interest-Rate Risk

We learned in the last chapter that the price or market value of a bond moves inversely with its yield. Consider, for example, a $1000, 1-year discount bond when the market rate of interest on similar assets is 5 percent. Its price is p_B = 1000/(1.05) = 952.38. Now suppose that you purchased such a bond in the morning and decided by afternoon that you really needed the money and resold it. What would you get for it? That depends on the current rate of interest. If interest rates fell from 5 percent in the morning to 4 percent in the afternoon, then you could sell your bond for p_B = 1000/(1.04) = 961.54. You would have earned a **capital gain** of 0.96 percent (= 961.54/952.38 – 1). On the other hand, if rates had risen to 6 percent by afternoon, you would have taken a 0.94 percent **capital loss**. The **PRICE** (or **INTEREST-RATE**) **RISK** *of holding a bond is the risk of capital gains or losses as a result of changes in interest rates between the point of purchase and the point of sale*. (The "price" in the term "price risk" refers to the bond price, p_B, and not to the general price level or to inflation.)

Price risk is greater for debt of greater maturity. Table 11.2 shows the percentage change in the price of discount bonds as interest rates fall or rise one point from a baseline of 5 percent. At a 1-year maturity the capital gains and losses are around one percent, while at 10-year maturity they are around 10 percent, and at a 30-year maturity between 20 and 30 percent. The reason for the difference is clear from the formulae for bond prices. The general formula for a discount bond (see equation (10.14)) is $p_B = FV/(1 + r)^m$. A given change in r results in a much larger change in the denominator when m is large (the maturity is long) than when m is small (the maturity is short). While

Table 11.2
Market Interest Rates and Discount Bond Prices

Maturity	Market Interest Rates (percent) 5	4		6	
	Price	Price	Percentage Change vs. 5 percent rate	Price	Percentage Change vs. 5 percent rate
1-year	952.38	961.54	+ 0.96	943.40	– 0.94
10-year	613.91	675.56	+10.04	558.39	– 9.04
30-year	231.38	308.32	+32.25	174.11	–24.75

Notes: Prices are for $1000 pure discount bonds.

the numbers are different, the same is true for coupon bonds as well as for discount bonds.

All bonds, including federal government bonds, face price risk. Price risk explains at least some of the difference in yields for bonds of different maturities. Long bonds face greater price risk and, therefore, must earn a risk premium compared to short bonds. The longer the bond, the higher the risk premium. In Figure 11.1, the bankers' acceptance rate (a short commercial rate) is typically lower than the Aaa bond rate (a long commercial rate). The 3-month Treasury bill rate (a short government rate) is typically lower than the long government bond rate. Some of this difference reflects a premium that compensates for price risk.

Risk premia – whether they compensate for default risk or for price risk – ensure that the returns to holding risky assets are higher than the returns to holding safer assets. If one is willing to hold a portfolio that is more risky than the average market portfolio, then one can earn returns systematically higher than those enjoyed by the market in general. Such returns do not violate the efficient-markets hypothesis. They are not the result of unexploited arbitrage opportunities. Rather they reflect the "price" of risk. The oldest example of pricing risk is perhaps insurance. Many of the most important developments in financial markets – developments well beyond the scope of an intermediate macroeconomics textbook, but ones that might be studied in a course in corporate finance or money and banking – involve new ways to package, price, and trade various sorts of risk.

11.4 The Term Structure of Interest Rates

11.4.1 THE RELATIONSHIP OF INTEREST RATES OF DIFFERENT MATURITIES.

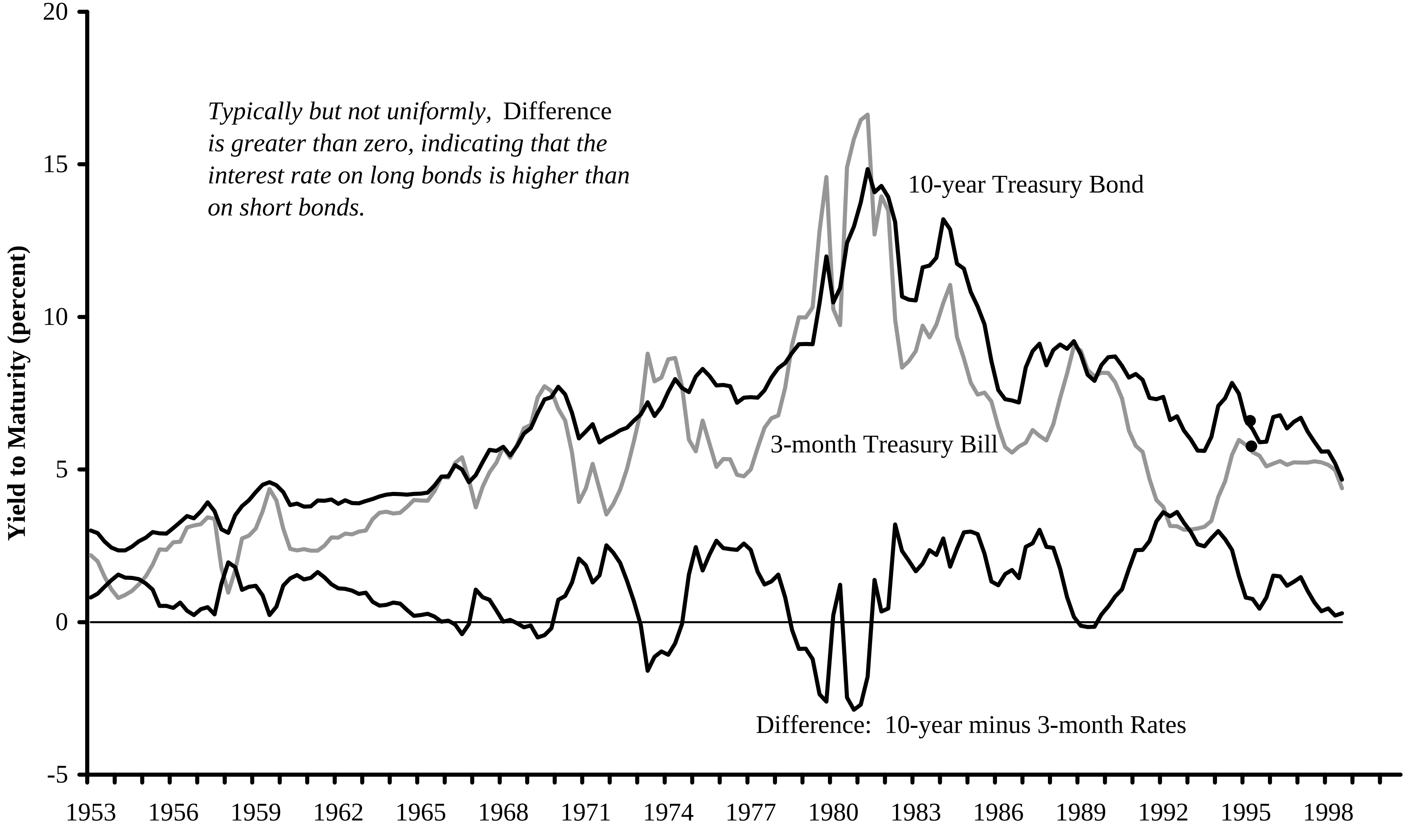
Look again at Figure 11.1. Although short rates are typically lower than long rates, they are sometimes (for example in the early 1980's) higher. Figure 11.3 plots the 10-year government rate and the 3-month Treasury bill rate and their difference. When the difference is negative, the short rate stands above the long rate. Something other than a premium for price risk must be at work.

To get a more detailed picture of the relationship of interest rates to maturity plot the yield to maturity on the vertical axis of a graph and the time to maturity on the horizontal axis (Figure 11.4 does this for October 2004). The black dots in Figure 11.4 mark the values at that date for the 3-month Treasury bill rate and the 10-year government bond rate plotted in Figure 11.3 (where they are also marked by black dots). In a sense Figure 11.4 takes a vertical slice of Figure 11.3. But Figure 11.4 allows us to incorporate the interest rates on bonds of other maturities at the same date . These values are shown as open circles.

The smooth line connecting the various points on the graph is known as a **YIELD CURVE**. The fact that the 10-year bond rate is above the 3-month Treasury bill rate and, more generally, that longer rates exceed shorter rates is reflected in the fact that the yield curve slopes up.[9] The relationship among the returns on bonds of different maturities is called the **TERM STRUCTURE OF INTEREST RATES**. The yield curve is one, particularly

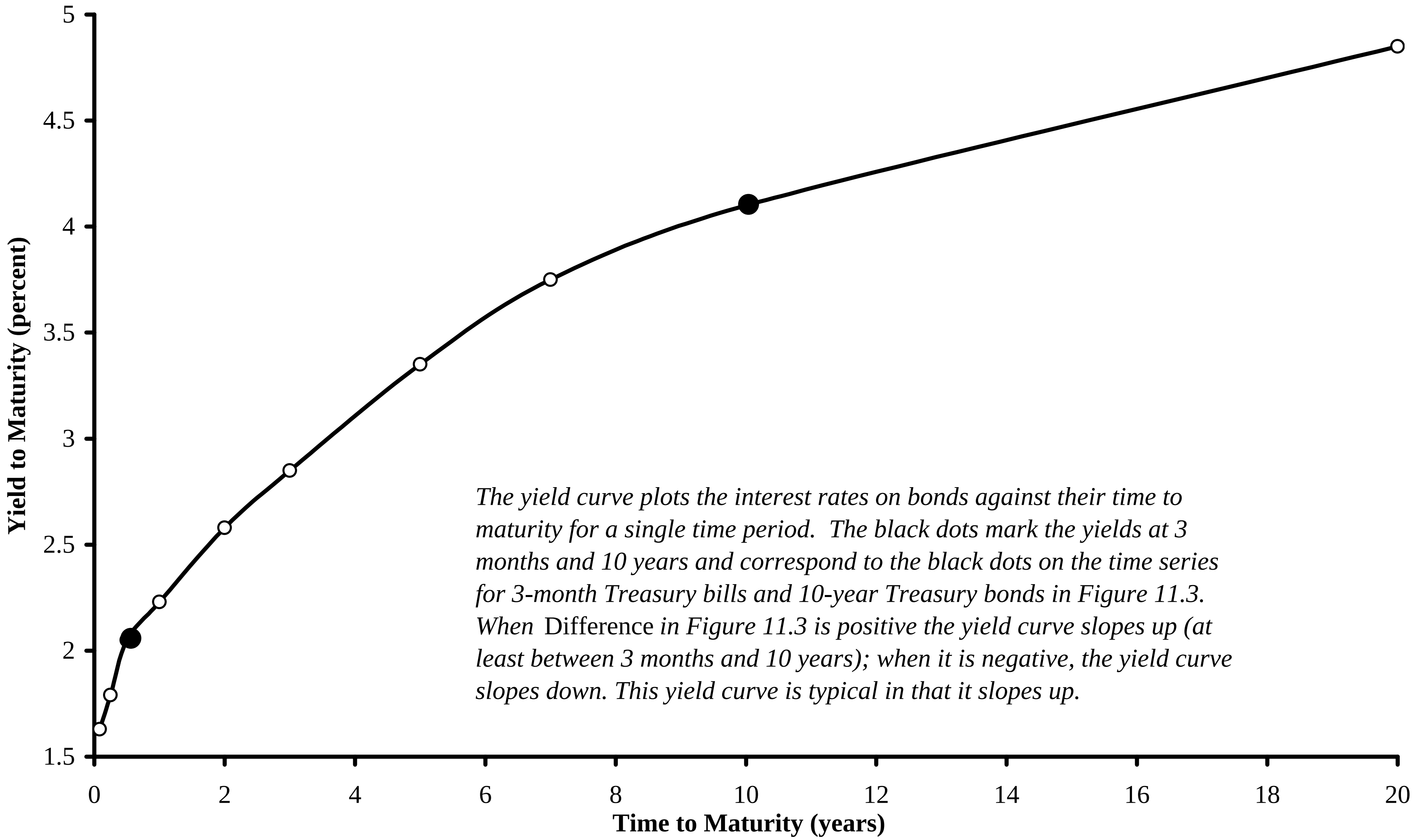
[9] A "dynamic yield curve" at www.stockcharts.com/charts/yieldcurve.html allows you to watch the history of the yield curve as a moving picture.

Figure 11.3
Ten-year Treasury Bond and Three-month Treasury Bill Rates



Source: Board of Governors of the Federal Reserve System, "Selected Interest Rates and Prices," release G.13.
3-month Treasury bill rate converted from bank discount basis (author's calculations).

Figure 11.4
The Treasury Yield Curve for October 2004



Source: Board of Governors of the Federal Reserve System, "Selected Interest Rates and Prices," release H.15. Constant maturity Rates.

useful, way of visualizing the term structure. Figure 11.3 offers another way. Whenever the difference in Figure 11.3 is positive, the yield curve slopes up (at least between three months and ten years) and, whenever the difference is negative, the yield curve slopes down. In order not to confuse characteristics of interest rates related to maturity with those related to default risk, yield curves should be plotted only for bonds of similar default risk.[10]

11.4.2 THE EXPECTATIONS THEORY OF THE TERM STRUCTURE

Arbitrage Across Different Maturities

How might we account for the term structure of interest rates? What explains the shape of the yield curve?

We must distinguish among bonds of different maturities. So, start with some notation: $r_{m,t}$ indicates the yield on a bond at time *t* that matures in *m* periods. For example, $r_{1,2001}$ is the yield in 2001 of a 1-year bond (that is, it matures in 2002); $r_{5, (3 \text{ May } 2008)}$ is the yield on 3 May 2008 of a 5-year bond (matures 3 May 2013); and $r_{0.25,t}$ is the yield at time *t* on a 3-month (1/4 year) bond (matures at *t* + 3 months).

Now consider a simple problem. You wish to put funds out at interest for two years. There are many ways that you can accomplish this, but consider two.

1. You might purchase a two-year bond. In that case, for each dollar you put out, you would earn $1 + r_{2,t}$ for the first year on your principal, and another $1 + r_{2,t}$ for the second year on both your principal and the first year's interest. The

[10] Variations in coupon structure also pose difficulties in comparing bonds. The most theoretically pure yield curves focus on zero-coupon (or pure discount) bonds.

total earned is $(1 + r_{2,t})(1 + r_{2,t}) = (1 + r_{2,t})^2$. For example, if the 2-year bond yields 11 percent per year, then each dollar is worth $(1.11)^2$ = \$1.23 at the end of two years.

2. Instead you might purchase a 1-year bond. Then, for each dollar you put out, you would earn $1 + r_{1,t}$ on your principal at the end of the first year. Then you would have to decide what to do with the funds. One possibility is to purchase another 1-year bond. Of course, in the meantime, market interest rates may have changed. So, unlike the case of the 2-year bond, you cannot know at the beginning exactly what return you will receive over two years. It depends on what the interest rate turns out to be at the beginning of the second year. As so often in economics, we feel the want of a crystal ball. In trying to decide *ex ante* whether to buy a one-year bond or a two-year bond, we have to form an expectation of what the 1-year bond rate will be one year in the future. Call this expected rate $r^e_{1,t+1}$. Then our principal and the first year's interest is expected to earn $1 + r^e_{1,t+1}$ in the second year and our best expectation of the total to be earned is $(1 + r_{1,t})(1 + r^e_{1,t+1})$.

Whether you should put your funds in the 1-year or the 2-year bond depends on what rate each bond yields and what rate a 1-year bond is expected to yield one year in the future. For example, consider the case a case in which $r_{1,t}$ = 10 percent and $r^e_{1,t+1}$ = 9 percent. Then, each dollar yields $(1 + r_{1,t})(1 + r^e_{1,t+1}) = (1.10)(1.09)$ = \$1.20. This is less than the \$1.23 yielded by the 2-year bond, so you – and other market participants – should prefer the 2-year bond. The difference in the yield presents an arbitrage opportunity. New demand would be directed towards the 2-year bonds, and some owners of 1-year bonds would want to sell them in order to buy 2-year bonds. These flows of funds would tend to drive the price of 2-year bonds up (that is, drive their yield down) and to drive the price of 1-year bonds down (that is, drive their yield up). Funds would continue to flow until each of the two ways of holding your funds for two years had the same yield.

For instance, if the expectations of the future 1-year rate were unaffected by the flow of funds, so that $r^e_{1,t+1}$ remained 9 percent come what may, then a 1-year rate $r_{1,t}$ = 12 percent and a 2-year rate $r_{2,t}$ = 10.5 eliminates the arbitrage opportunity: $(1 + r_{1,t})(1 + r^e_{1,t+1}) = (1.12)(1.09) = (1 + r_{2,t})^2 = (1.105)^2$

= \$1.22.

The differences between the returns on different arrangements of your portfolio seem small – a penny or two. But remember that it is a penny or two per dollar placed in a particular bond. One-year Treasury bills are issued in \$10,000 denominations, so that a penny per dollar is \$100 in total. The large players in financial markets, such as banks, mutual funds, and insurance companies, shift millions of dollars at a time. Very small differences in yields make significant differences in their bottom lines. The profit motive is strong, so it is reasonable to assume that arbitrage is complete. Setting aside the particular numbers of the last example, the relationship : $(1 + r_{1,t})(1 + r^e_{1,t+1}) = (1 + r_{2,t})^2$ is known as a **no-arbitrage condition**, which means that, when it holds, no profit opportunities are left to be exploited by arbitrageurs.

What works for two periods, generalizes to three or more periods. To put funds out at interest for three years, you might buy a series of 1-year bonds or a single 3-year bond. If the actual and expected interest rates for each strategy fulfill the condition: $(1 + r_{1,t})(1 + r^e_{1,t+1})(1 + r^e_{1,t+2}) = (1 + r_{3,t})^3$, then there are no arbitrage opportunities. In general, the yield on an *m*-period bond over its life should equal the expected yields of *m* 1-period bonds:

$$(1 + r_{m,t})^m = (1 + r_{1,t})(1 + r^e_{1,t+1})(1 + r^e_{1,t+2}) \ldots \ldots (1 + r^e_{1,t+m-2})(1 + r^e_{1,t+m-1}) \tag{11.1}$$

Solving for $r_{m,t}$,

$$r_{m,t} = \sqrt[m]{(1+r_{1,t})(1+r^e_{1,t+1})(1+r^e_{1,t+2})\ldots(1+r^e_{1,t+m-2})(1+r^e_{1,t+-1})} - 1 \tag{11.2}$$

In words: the gross yield on an *m*-period bond (that is, $1 + r_{m,t}$) is the geometric average of the gross yield on the *m* current and expected future 1-period bonds.

Equation (11.2) can be simplified for easier calculation. Taking logarithms of both sides and recalling that $\log(1 + x) \approx x$ (see the *Guide*, section G.11.2), when x is small, equation (11.1) can be written as

$$m(r_{m,t}) \approx r_{1,t} + r^e_{1,t+1} + r^e_{1,t+2} \ldots + r^e_{1,t+m-2} + r^e_{1,t+m-1}$$

or

(11.3) $$r_{m,t} \approx \frac{r_{1,t} + r^e_{1,t+1} + r^e_{1,t+2} \ldots + r^e_{1,t+m-2} + r^e_{1,t+m-1}}{m}.$$

In words: the yield on an *m*-period bond is approximately the arithmetic average of the yield on the *m* current and expected future 1-period bonds.

Expectations and the Shape of the Yield Curve

To understand what the no-arbitrage condition implies for the shape of the yield curve, consider an example in which the current and expected 1-year bond rates are:

$r_{1,t}$ = 6 percent,

$r^e_{1,t+1}$ = 7 percent,

$r^e_{1,t+2}$ = 8 percent,

$r^e_{1,t+3}$ = 9 percent.

If traders arbitrage perfectly, then equation (11.3) can be used to compute the rates on 1-year to 4-year bonds:[11]

$r_{1,t}$ = 6 percent

$r_{2,t}$ = (6+7)/2 = 6.5 percent,

$r_{3,t}$ = (6+7+8)/3 = 7 percent,

$r_{4,t}$ = (6+7+8+9)/4 = 7.5 percent.

[11] All of these calculations are strictly approximations according to equation (11.3). It is more convenient, however, to write them as equalities.

Figure 11.5 plots the yield curve for time *t* based on these calculations. Notice that the current and expected 1-year bond rates increase over time (between *t* and *t* + 3) and that implies that the yield curve at *t* slopes up. If short rates decreased over time, the yield curve would slope down. The no-arbitrage condition is consistent with yield curves of any shape. Consider another example:

$r_{1,t}$ = 8 percent,

$r^e_{1,t+1}$ = 7 percent,

$r^e_{1,t+2}$ = 9 percent,

$r^e_{1,t+3}$ = 5 percent.

The no-arbitrage condition, then, implies:

$r_{1,t}$ = 8 percent

$r_{2,t}$ = 7.5 percent,

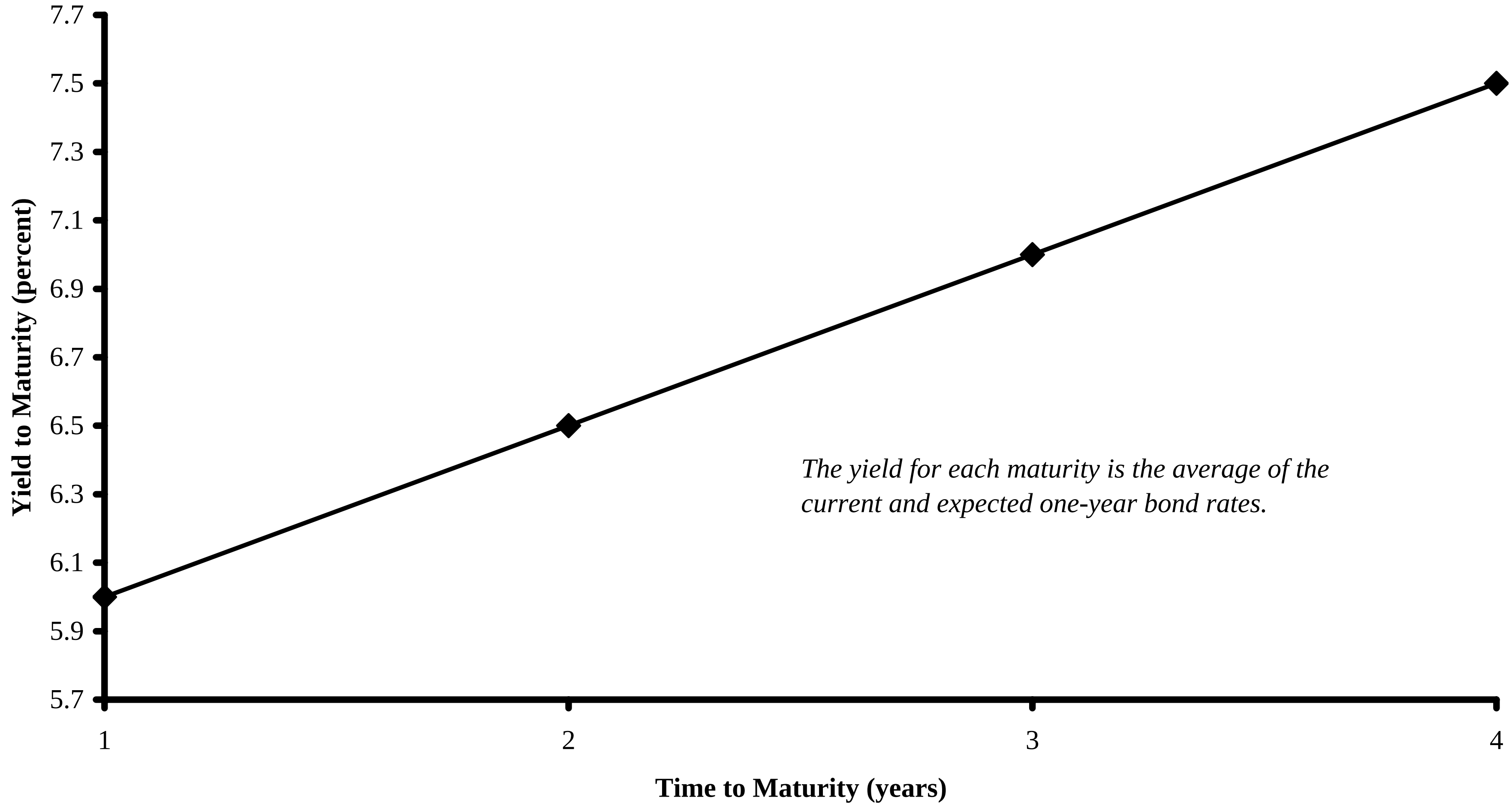
$r_{3,t}$ = 8 percent,

$r_{4,t}$ = 7.25 percent.

(The reader should check these values using equation (11.3).) Figure 11.6 plots the yield curve implied in this example. It slopes up and then down. (The smoothing option in *Excel's* scatterplot option is used to interpolate the values between data points.) In actual financial markets, yield curves typically slope up, but downward-sloping and even humped or S-shaped yield curves are observed from time to time.

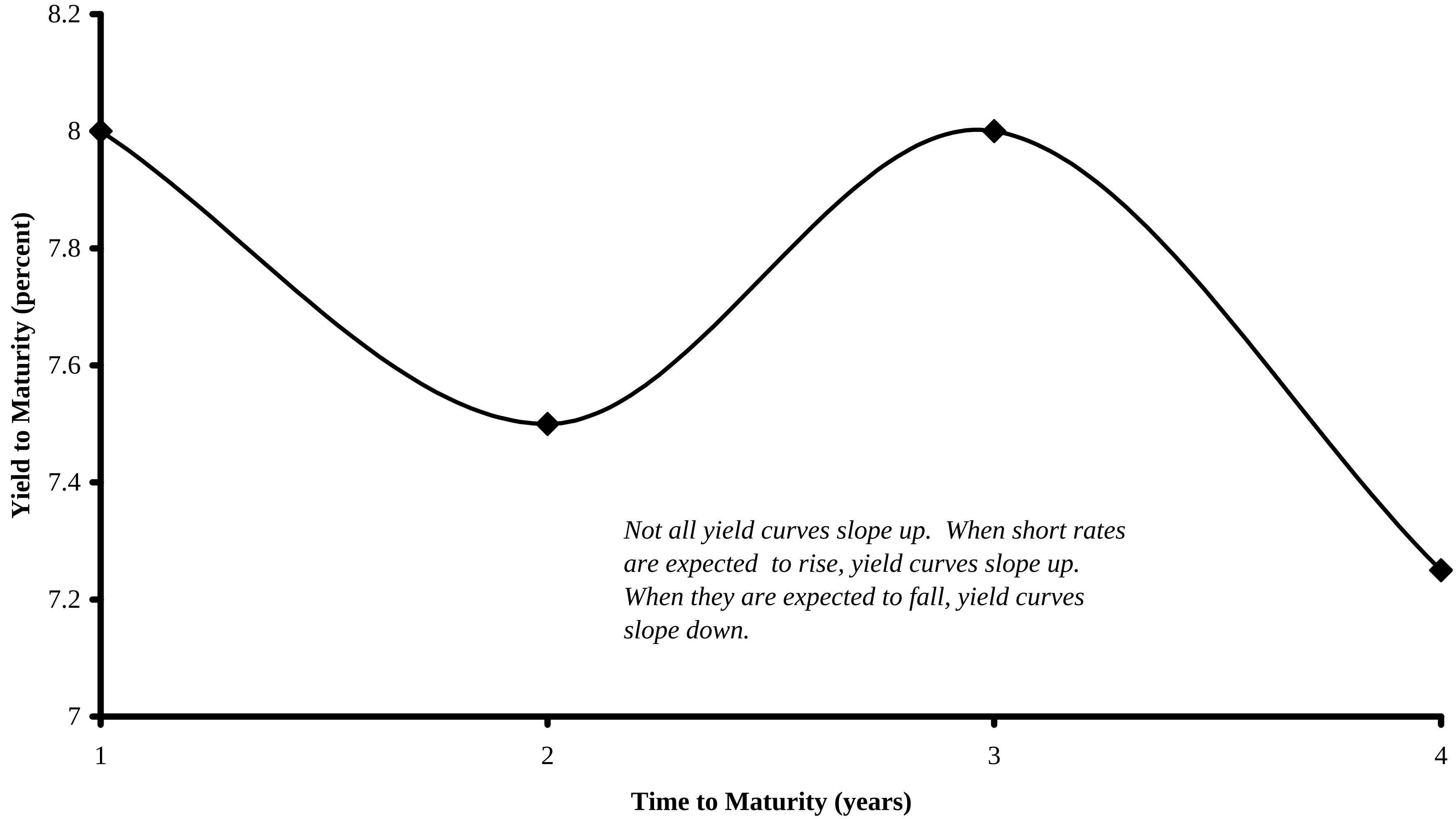
The explanation of the shape of yield curves as an implication of the no-arbitrage condition is known as the **EXPECTATIONS THEORY OF THE TERM STRUCTURE OF**

Figure 11.5
A Yield Curve Based on the Expectations-Theory of the Term Structure of Interest Rates



Source: See text

Figure 11.6
Another Yield Curve



Source: See text

INTEREST RATES. In its simplest form, as here, it ignores risk. Presently, we shall consider the role of risk in the term structure.

Alternative Portfolio Strategies

Our account of the shape of the yield curve seems to support the common view that the expectations theory of the term structure explains long rates as the average of current and expected short rates. But this is not accurate. There is nothing in our account that says that the pattern of short rates causes the pattern of longer rates. What it really says is that, unless the no-arbitrage condition is fulfilled, there will be profit opportunities to be exploited and that exploiting them makes them disappear. There are many arbitrage conditions that must be simultaneously fulfilled. It is natural to look at equation (11.3) and think in terms of 1-year rates explaining m-year rates. But it could equally be thought of as 1-quarter (that is, 3-month) rates explaining m-quarter rates. A 5-year bond rate would then be the average of twenty 3-month bill rates.

And it is more complex than that. For example, apply equation (11.3) to a 2-year and a 3-year bond at time t:

$$r_{2,t} = \frac{r_{1,t} + r^e_{1,t+1}}{2},$$

$$r_{3,t} = \frac{r_{1,t} + r^e_{1,t+1} + r^e_{1,t+2}}{3}.$$

The first expression can be rewritten as $2r_{2,t} = r_{1,t} + r^e_{1,t+1}$ and substituted into the second expression to yield

$$r_{3,t} = \frac{2r_{2,t} + r^e_{1,t+2}}{3}.$$

In words: a 3-year bond rate at *t* is the weighted average of a 2-year bond rate at *t* and the expected 1-year bond rate at *t* + 2. You should check that the following relationship is also true:

$$r_{3,t} = \frac{r_{1,t} + 2r^e_{2,t+1}}{3},$$

the 3-year bond rate at *t* is the weighted average of the current 1-year bond rate at *t* and the expected 2-year bond rate at *t* + 1.

In fact, the expectations theory of the term structure implies that every sequence of bonds – of whatever maturities – that carry the owner from one particular time (*t*) to another (*t* + *m*) must have the same return. There are as many no-arbitrage conditions as there are available ways to get funds from *t* to *t* + *m*.

Implicit Expectations

Expectations are critical to the analysis. Yet expectations are not directly observable. On the assumption that the expectations theory of the term structure (ignoring risk) is true, we can work out what market expectations must be for future rates. Consider a simple example. At time *t*, let the yields on different maturity bonds be given as follows:

$r_{1,t}$ = 2 percent

$r_{2,t}$ = 3 percent,

$r_{3,t}$ = 5 percent,

$r_{4,t}$ = 7 percent.

Now, say that we wish to know what the market expects the path of 1-year rates to be. The current 1-year rate is known: 2 percent. According to equation (11.3),

$r_{2,t} = 3 = \frac{r_{1,t} + r^e_{1,t+1}}{2} = \frac{2 + r^e_{1,t+1}}{2}$. Solving for the unknown, $r^e_{1,t+1} = 2r_{2,t} - r_{1,t} = 2 \cdot 3 - 2 = 4$.

The whole sequence of implied 1-year rates is then:

$r_{1,t}$ = 2 percent,

$r^e_{1,t+1}$ = 4 percent,

$r^e_{1,t+2}$ = 9 percent,

$r^e_{1,t+3}$ = 13 percent.

(Once again, you should use equation (11.3) to prove that these values are correct.) What the market expects has been extracted from its observable actions *on the condition that the expectations theory of the term structure is correct.*

11.4.3 The Role of Risk

As we have already mentioned and as is clear from Figure 11.3, most of the time yield curves slope up. If the simple expectations theory of the term structure presented in the last section is true, this should be a puzzling fact. The expectations theory says that yield curves slope up when future short rates are expected to rise. So if yield curves slope up almost always, then short rates should be expected to rise almost always. A quick look at Figure 11.1 shows that such an expectation is unreasonable. Short interest rates rise *and* fall. If the people assumed that they would always rise, their expectations would be frequently disappointed. Although expectations are never perfect, one would like to believe that people would learn from their mistakes and recognize that rates do sometimes fall. So is there some other explanation for the dominance of upward-sloping yield curves?

Recall that so far we have ignored the role of risk in the term structure. Also recall from Section 11.3.2 that price risk is greater the longer the maturity of a bond and that generally markets require higher returns, a **term premium** (a kind of risk premium), to compensate for higher risk. The term premium is shown as a function of maturity since longer maturity bonds face greater price risk.[12] We can therefore modify equation (11.3) to add in the term premium:

[12] It is possible for term premia to become smaller at long maturities. Some bondholders might prefer long maturities to match future obligations, so that the risk to them is holding a short bond and having to repurchase another at an unfavorable price when it matures. The evidence supports the view that most people prefer shorter maturities.

(11.4) $$r_{m,t} \approx \frac{r_{1,t} + r^e_{1,t+1} + r^e_{1,t+2} \ldots + r^e_{1,t+m-2} + r^e_{1,t+m-1}}{m} + \textit{term premium}(m).$$

To see what affect the addition of a risk premium has on the yield curve consider a case in which current and expected short rates are constant at 6 percent as shown in Table 11.3 and the term premium rises from zero for a 1-year bond by ¼ point each year of maturity. Without term premia, the yield curve would be constant. With term premia, it is rising. Figure 11.7 shows the yield curve with and without the term premia. The gap between them at any maturity is the term premium at that maturity.

11.5 Inflation and Interest Rates

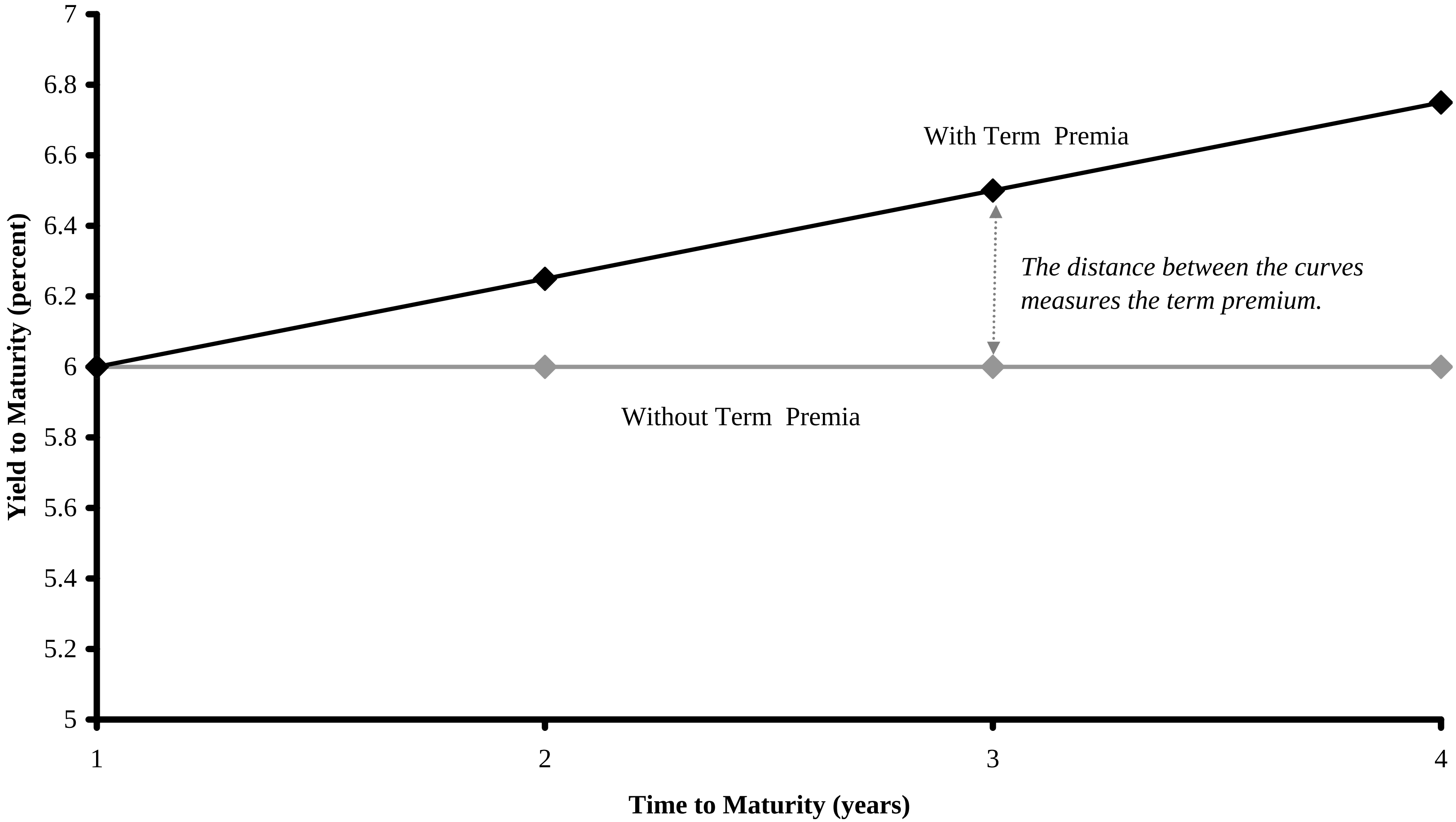
11.5.1 The Effect of Inflation on the Supply and Demand for Bonds

The analysis in this chapter has concentrated entirely on market or nominal rates of interest. We learned in the last chapter that the market rate can be decomposed into the sum of a real rate of interest and the rate of inflation. Since inflation rates have varied considerably over time, it would be interesting to know how that variation might have affected interest rates. At first blush, you might think that the question is answered already in knowing the decomposition $r_t = rr_t + \hat{p}^e_t$. An increase in expected inflation increases the market rate of interest. But that moves too quickly. We cannot know how any change in inflation affects nominal rates of interest until we know how it affects real rates of interest. For example, if real rates always fell when inflation rose, then nominal

Table 11.3
An Illustration of the Term Structure of Interest Rates with and without Term Premia

Current and Expected Short Rates		Current Rates on Bonds of Successive Maturites				
		Number of Years Until Bond Matures:	**Term Premium at Each Maturity**		**Implied Rate at Each Maturity without Term Premium**	**Implied Rate at Each Maturity with Term Premium**
$r_{1,t} =$	6.0	1	0.00	$r_{1,t} =$	6.00	6.00
$r^e_{1,t+1} =$	6.0	2	0.25	$r_{2,t} =$	6.00	6.25
$r^e_{1,t+2} =$	6.0	3	0.50	$r_{3,t} =$	6.00	6.50
$r^e_{1,t+3} =$	6.0	4	0.75	$r_{4,t} =$	6.00	6.75

Figure 11.7
Yield Curves with and without Term Premia



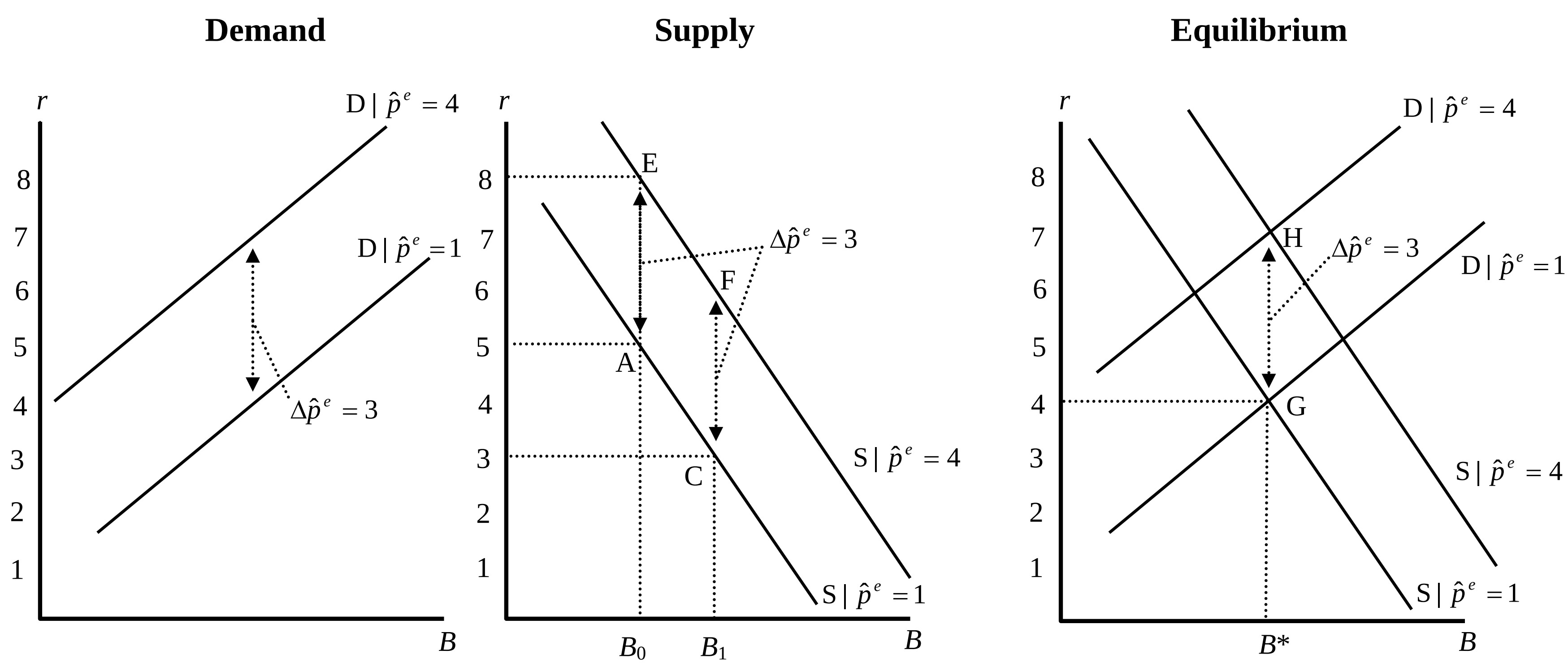
Source: See Table 11.3.

rates would stay constant. To decide what really happens requires us to think more carefully about the underlying economic behavior.

The key point is that rational people should not care about the nominal values of prices or interest rates. They should care about the real values, what their money will actually buy or what their savings will earn. Consider the market for a particular bond shown in Figure 11.8. The figure shows nominal interest rates (r) on the vertical axis as is customary. But, if real interest rates are what is important to people, then we must know the expected rate of inflation $\hat{p}^e$. For example, suppose that $\hat{p}^e$ = 1 percent. Then, both the demand curve (left-hand panel) and the supply curve (middle panel) are drawn conditional on that expected rate of inflation. A nominal rate r = 5 percent corresponds to a real rate rr = 5 – 1 = 4 percent. Similarly, a nominal rate r = 3 percent corresponds to a real rate rr = 2 percent. At the 4 percent real rate, the supply curve (point A) shows that borrowers wish to obtain B_0 in loans and, at the 2 percent real rate (point C), B_1.

What happens if the expected rate of inflation increases to $\hat{p}^e$ = 4 percent? Since the users of funds care about real rates, they should be willing to supply exactly the same amounts at the same real rates. But now each real rate corresponds to a higher nominal rate. A nominal rate of 8 percent (= rr + $\hat{p}^e$ = 4 + 4) corresponds to a real rate of 4 percent, and a nominal rate of 6 percent corresponds to a real rate of 2 percent. The whole supply curve, then, must shift vertically upward by exactly the change in the expected rate of inflation (that is, by 3 percentage points), so that it lies parallel to original curve. At point E the nominal interest rate is higher than at point A, but since the real rate has not changed, the supply of bonds remains at B_0. Similarly, the supply of

Figure 11.8
The Effect of a Change in the Expected Rate of Inflation on the Bond Market



Both the demand for, and the supply of, bonds and other loans depends on real rates of interest. If the rate of expected inflation increases (here by 3 percentage points), each real interest rate corresponds to a nominal interest rate higher by an amount equal to the change in the rate of inflation. As a result, both the supply and the demand curve for bonds must shift vertically up by the change in the rate of expected inflation, so that the equilibrium itself moves upward by the same amount and the volume of bonds remains unchanged.

bonds remains unchanged between points C and F. The issuer of the bond is willing to pay higher rates of interest for the same funds, because he can pay them back with money that is losing its value faster because of the higher inflation.

An exactly parallel argument suggests that the demand curve should also shift vertically at every point by an amount equal to the change in the rate of inflation. The lender must charge higher rates of interest for the same loan in order to ensure that the real return remains the same in the face of money that is losing its value faster.

The combined effect of these two adaptations to higher rates of inflation is that both the supply and demand curves shift vertically by the same amount, so that that the equilibrium (right-hand panel), which had been at 4 percent (point G), also shifts vertically to 7 percent (point H), and the equilibrium quantity of bonds (*B**) remains constant.

11.5.2 THE FISHER EFFECT AND THE FISHER HYPOTHESIS

The relationship between inflation rates and interest rates discussed in the last section is known as the Fisher effect, in honor of the great American economist Irving Fisher (1867-1947) who emphasized it in his analysis of interest rates. It may be useful to distinguish the Fisher effect from the Fisher hypothesis.

The **FISHER EFFECT** can be defined as *a point-for-point increase in the market rate of interest that results* ceteris paribus *from an increase in the expected rate of inflation*. The *ceteris paribus* clause is important. The Fisher effect is a theoretical claim that may be difficult to observe in the world because other things are not always equal.

The **FISHER HYPOTHESIS** can be defined as *the empirical phenomenon in which a change in market rates of interest is associated approximately point for point with a change in the actual rate of inflation.*[13] Figure 11.9 plots the 1-year and 10-year Treasury bond rates alongside the year-over-year CPI inflation rate. The Fisher hypothesis is clearly true to a first approximation.

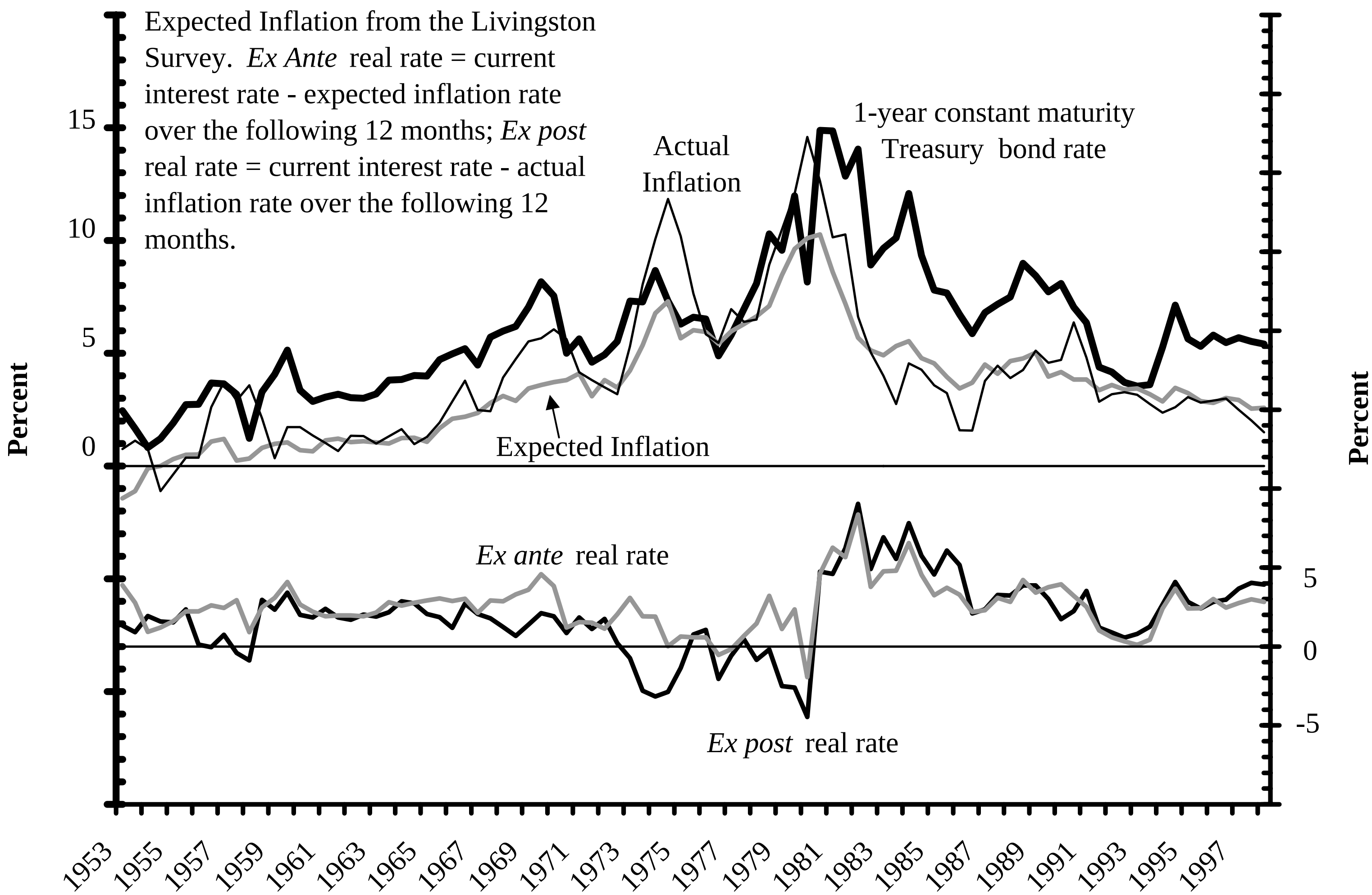
The Fisher hypothesis – as Fisher himself was well aware – does not hold exactly. One reason is that no inflation measure, such as the CPI, represents exactly the bundle that is relevant to the players in financial markets. Borrowers and lenders might have systematically different consumption bundles. Indeed, the relevant bundles need not be the same for all borrowers or all lenders.

A second reason is that taxes are levied on nominal interest payments. Higher interest rates, even if they are merely compensation for higher inflation rates, generate higher tax liabilities. Lenders would, therefore, require an extra increase in nominal interest rates to compensate for the loss of purchasing power due to inflation-induced tax-rate increases. In the United States, Federal income taxes have been indexed to inflation since 1985, so that standard deductions, tax brackets, and other features account for changing price levels. But not all states index or index completely and not all taxes are indexed.

Finally, and probably most important, there is no reason to believe that expectations of future inflation are formed perfectly or are captured by the past behavior of inflation. It may take some time to adjust expectations to an unexpected increase or decrease in actual inflation. During the adjustment period, real, rather than nominal, rates would be

[13] The terminology is not completely standardized. Different economists talk about the Fisher effect or hypothesis or relation or theorem sometimes as synonyms and sometimes drawing distinctions as we have done here.

Figure 11.9
Real and Nominal Interest Rates



Source: 1-year bond rate: Board of Governors of the Federal Reserve System; CPI: Bureau of Labor Statistics; Expected Inflation: Federal Reserve Bank of Philadelphia.

affected. This is easily seen in Figure 11.9. In the 1970s, when inflation accelerated, expectations of inflation lagged behind actual inflation and *ex post* real rates (the difference between the market rates and the actual rate of inflation in the figure) fell – and at some points became negative. After the mid-1980s, when inflation rates fell, again expectations lagged actual inflation and *ex post* real rates rose.

11.6 The Level of Real Interest Rates

So far in this chapter we have tried to account for the relationships among different interest rates and between interest rates and inflation. If we had a starting place (that is if we knew one real rate of interest) we should be able in principle to use information about the maturity, coupon structure, risk, tax rates, and expected inflation rates to deduce the rates on all other bonds. But where do we find the starting place – the one real rate? Or, to put it another way, what determines the level of the real yield on any particular financial asset? There are two answers to this question, depending on whether we concentrate on short rates or long rates.

11.6.1 Monetary Policy and Short Rates

At the short end of the market, the interaction of monetary policy and expected inflation rates determines the real rate. We shall examine monetary policy more carefully in Chapter 17. For the time being, a brief account will suffice.

Central banks (in the United States, the Federal Reserve) typically buy and sell short-term assets (largely Treasury bills) on the open market. When the central bank buys, it pays by crediting funds to the accounts that commercial banks hold with it, creating central-bank reserves (see Chapter 10, sections 10.1 and 10.3.2). When it sells, it deducts funds from these accounts, eliminating reserves. In the United States, these reserves are known to financial markets as **Federal funds**.

Commercial banks are required to hold reserves in a certain proportion to their deposit liabilities. There is an active overnight market, the **Federal funds market**, in which banks with an excess of reserves over their requirements lend to banks with a shortage. The Federal Reserve can set the interest rate in this market, known as the **Federal funds rate**, by raising or lowering the stock of available reserves through purchases or sales of short-term financial assets. Monetary policy today largely consists of setting a target for the Federal funds rate.

The Federal funds target is officially a target for a nominal rate of interest. The Federal Reserve's concern, however, is the real rate of interest. It sets the Federal funds rate at a level that it hopes will influence longer term interest rates through the yield curve with the aim of influencing investment expenditure. Investment expenditure, as we will consider in detail in Chapters 12 and 13, depends inversely on real rates. So the Federal Reserve's nominal target must be set with some view about the market's expectations of inflation – that is, with some view of what the real rate should be.

The expectations theory of the term structure tells us that longer rates are the average of current and expected short rates. The rates that the Federal Reserve sets at the extreme short end of the yield curve affect the whole yield curve in a way that depends on what the markets believe the Federal Reserve will do in future. Imagine that the Federal Reserve raised the (nominal) Federal funds rate by ½ percentage point and markets believed that they would hold it at this higher level for all eternity. Then, every longer-term rate would rise by ½ point. At the other extreme, imagine that markets believed the ½ point increase would be reversed the next day. Then, no longer-term interest rate would be affected hardly at all. In reality, markets make constantly shifting guesses about the course of future monetary policy – the financial press is populated by numerous "Fed watchers" – and the conviction with which these guesses are held fades rapidly as the market players look further into the future.

11.6.2 Arbitrage to Real Returns

At longer maturities, bonds are substitutes with shares in corporations. If the real returns on bonds, after accounting for risk, are greater than the returns on stocks, then arbitrageurs will direct funds towards bonds driving their rates down. Similarly, if the real returns on bonds are smaller, arbitrage will drive their rates up. The yields on stocks and bonds might be very different on average, but they should tend to move together over time.

Ultimately, the real yield on stocks – and, therefore, through arbitrage, the real yield on longer bonds – is determined by the profitability of corporations and the real return they earn on their capital. It is useful to distinguish between physical and financial returns. (The return on *physical* capital includes here the return on the organization, management and the so-called *human* capital – that is, the education, training, experience, and *esprit d'corps* of the workforce.) Sometimes financial returns may differ substantially from the underlying physical returns on capital. In such a case, one would expect arbitrage to drive their returns together. Unlike arbitrage among financial assets, arbitrage between physical capital and financial instruments can be slow, especially if it involves investment and the expansion of the corporation. We shall consider this process in more detail in Chapter 13. For now, it helps to reconcile a potential conflict in the determination of real rates.

How is it that real rates are determined both through monetary policy transmitted from the short end of the market through the term structure and simultaneously through arbitrage to the real returns on physical capital? Something has to give. That something is inflation.

Imagine that when the inflation rate is, say, 2 percent, the Federal Reserve sets short rates at 5 percent and intends to hold them there, so that the real rate on financial assets is 3 percent. But suppose that the real yield on physical capital is 5 percent. Arbitrage would then direct funds towards investment. If the economy had slack resources, aggregate demand and capacity utilization would rise. As the limits of capacity were reached, inflation would accelerate. If the Federal Reserve continued to hold interest rates at 5 percent, it would find that the real rate on financial assets was falling below its 3 percent target. Of course, as real rates fell further the incentive to invest in physical capital would increase, and inflation would accelerate further.

In the short run, the Federal Reserve might use a policy of holding real rates of interest on financial instruments below real rates of return on capital to stimulate an underemployed economy. In the long run, however, it would face accelerating inflation. Only by raising interest rates relative to the rate of inflation to set the yield on financial assets at about the same rate as the yield on physical capital could the Federal Reserve stop this inflationary process. Since the Federal Reserve does not directly observe the real rate of return on physical capital, this is largely a matter of trial and error. (The process of inflation and its interaction with monetary policy are more fully discussed in Chapters 16 and 17.)

11.7 The Five Questions About Interest Rates Revisited

We have covered many of the complexities of financial markets quickly. Let us conclude the chapter by taking stock of what we have learned about the five questions that motivated our investigations.

- *First, why do interest rates tend to move together?*

  Traders in financial markets seek the highest return on their available funds. All financial assets are, to some degree, substitutes. As a result any movement in the price or yield of any one financial asset opens up profit opportunities that are quickly arbitraged away. In the process of arbitrage, funds flow from low yielding assets (raising their yield) toward high yielding assets (lowering their yield). Upward or downward movements of the yields of any one asset tend to draw the yields on other assets along in the same direction.

- *Second, why do they move only imperfectly together?*

  Although all financial assets are substitutes, they are not perfect substitutes. Even when the markets have taken advantage of every profit opportunity, differences in maturity, coupon structure, risk, and other features ensure that differences in yield usually remain. Changing economic circumstances may change the importance of these differences over time, so that the yield differentials are not necessarily constant.

- *Third, why do shorter maturity assets typically, but not uniformly, yield lower rates of interest than longer maturity assets?*

  Differences in maturity are a particularly important example of the imperfect substitutability of financial assets. The expectations theory of the term structure of interest rates assumes that arbitrage is highly effective. When arbitrage is complete, longer rates are the average of shorter rates plus a premium that reflects the added price risk of the longer asset. Long rates are higher than short rates whenever short rates are expected to rise or whenever an expected fall in short rates is not large enough to offset the risk premia.

- *Fourth, why at each maturity do government assets yield lower rates of interest than private sector assets?*

  Governments whose debt is denominated in their own currencies, have no reason to default on that debt, because they are always able to create the money necessary to pay the interest and principal. Any organization that cannot create its own money – state and local governments, agencies, and corporations – or whose debts are not denominated in its own currency faces some risk of bankruptcy, and its debt carries some default risk. A premium in the form of a higher yield must be paid to reflect this default risk.

- *Fifth, what determines the overall level of interest rates?*

  The two principal influences on real interest rates are monetary policy at the short end of the maturity spectrum and arbitrage with the yields on physical assets at the long end. Monetary policy typically targets nominal interest rates, but does so with an eye to the inflation rate and hence to real rates. To a first approximation, the Fisher effect determines nominal rates as the sum of the real rate and the expected rate of inflation.

Appendix: The LM Curve

For much of the past seven decades, macroeconomists have used the LM curve, which relates GDP to interest rates, to characterize financial markets. Although we argue later that the LM curve is too simple to represent all the features of financial markets that are important to macroeconomics, it is so widely used that it may be useful, to explain it more fully. LM-curve analysis is less complete than, but does not contradict, the analysis of this and the preceding chapter.

11.A.1 Money Supply and Money Demand

The Real Supply of Money

LM-curve analysis focuses on the narrow monetary instruments used by the public in conducting its transactions – in the United States typically on the Federal Reserve's M1 or M2 (see Chapter 10, Table 10.3). Whichever definition of money we might choose, call its nominal supply M^S. The real supply of money can be written as M^S/p, where p is, of course, the price level. An increase in the nominal supply of money *ceteris paribus* *increases* the real supply by raising the numerator in M^S/p. An increase in the price level *decreases* the real supply by raising the denominator in M^S/p.

Transactions Demand for Money

The most common use of narrow money is as a transactions medium. The higher the level of transactions in the economy, the more money would be needed.

For instance, holding real transactions constant, if the prices of every good and service were to double (nominal GDP would increase, but real GDP would remain constant), then twice as many dollars would be needed to move the goods and services. Although the nominal demand for money (M^D) has risen, the real demand (M^D/p) remains constant both the numerator and the denominator in M^D/p change in the same proportion.

On the other hand, if real GDP doubles, more goods and services must be moved no matter what the price level. This is likely to require more real units of money. As a result, the real demand for money is likely to be an increasing function of real GDP.

Money Demand and Interest Rates

What is the opportunity cost of holding money? In other words, what alternatives do you have when you hold money? To keep things simple, assume that money is currency and non-interest-bearing checking deposits (roughly M1). If you hold a dollar in these forms, then you loose the interest that you might have earned from buying a government bond or placing your funds in a mutual fund. Call this rate of interest r.

Of course we ought to be concerned about the *real* and not the *nominal* return on any asset. The real return on our bond is $rr = r - \hat{p}^e$. To find the opportunity cost of holding money, we must compare this return to the rate of return on money itself. A dollar bill earns no interest. But if there is inflation then it loses its real value at approximately the rate of inflation (e.g., if inflation is 10 percent per year, the dollar yields –10 percent real returns). In general the real rate of return on money is $-\hat{p}^e$.

The opportunity cost of holding money is the difference in return between the next best alternative and the return on money itself. That is, the

opportunity cost of holding money = *real return on the bond* – *real return on money*

$$= rr - (-\hat{p}^e) = (r - \hat{p}^e) - (-\hat{p}^e) = r.$$

In other words, even though we are interested in real (not nominal) rates of return, the true opportunity cost of holding money is measured by the *nominal* rate of interest on an alternative financial asset.

We would modify this analysis slightly to account for interest-bearing checking accounts or for wider concepts of money (e.g., M2 or M3) that include interest-bearing instruments. But so long as the rates of return on these interest-bearing components of the monetary aggregate are not perfectly correlated with those on the alternative financial instrument, a similar analysis will apply (see Problem 11.18).

Money is like other goods: the higher the opportunity cost, the less of it we want to hold. Consider, first, how the **transactions demand for money** (that is, *the money held to facilitate purchases of goods and services*) is affected by higher interest rates. When the opportunity cost of money is high, we lose interest by holding more of it, so we find ways to hold less. For example, if interest rates are high enough, we might reduce the funds in our pockets and in our bank accounts and take funds out of interest-bearing mutual funds in smaller amounts more frequently. In other words, when interest rates rise, the transactions demand for money falls. Such close management costs us time and trouble, but the higher the opportunity cost, the more it will prove worth our while.

Since money is not subject to capital gains and losses as interest rates change, you can reduce the risk of your portfolio by including some proportion of money in it. You get lower risk, but at the cost of a lower return. Holding money for this purpose is known as the **speculative demand for money**. As interest rates rise, the cost to your portfolio of holding money rises (another expression of the opportunity cost), and you are likely to want to change the mix of the portfolio away from money towards higher yielding assets. In other words, when interest rates rise, the speculative demand for money falls.

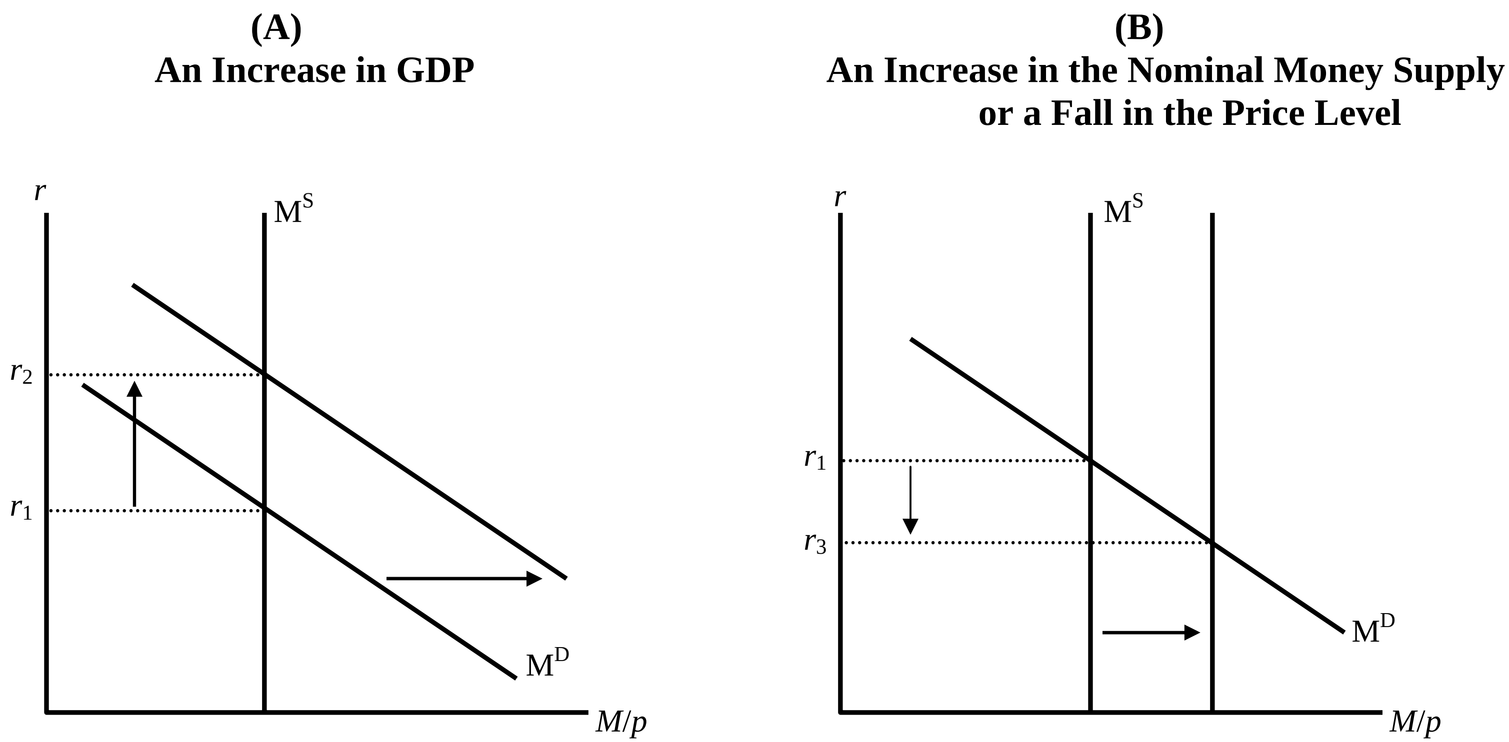
The Money Demand and Supply Curves

Money supply (M^S) and money demand (M^D) can each be represented on a diagram with the real stock of money (M/p) on the horizontal axis and the interest rate (r) on the vertical axis.

Since money supply does not depend on interest rates, it is shown in Figure 11.A.1 as a vertical line above the real stock of money. An increase in the nominal supply of money, holding prices constant, would shift this vertical line to the right. An increase in the price level, holding the nominal supply of money constant, would shift it to the left.

Since money demand is lower when the opportunity cost of money is higher and since the opportunity cost is measured by the nominal interest rate, the money demand

Figure 11.A.1
The Money Market



The supply of money is independent of interest rates, so the real money supply curve is a vertical line that shifts rightward when the nominal money supply increases and leftward when the price level decreases. The demand for money slopes downward since higher interest rates correspond to a higher opportunity cost of holding money. Each real money demand curve is drawn for a particular level of real GDP. Panel A shows the effect of an increase in real GDP: more money is demanded at each level of the interest rate, the money demand curve shifts rightward, and the interest rate rises. Panel B shows the effect of an increase in the real supply of money: the money supply curve shifts rightward and interest rates fall.

curve is shown as a downward sloping curve (M_1^D). Of course, money demand is also an increasing function of real GDP. As a result, M_1^D is drawn for a particular level of GDP. When GDP increases, the demand for money increases at each interest rate (that is, M^D shifts to the right).

In each panel of Figure 11.A.1, the interest rate is initially determined at the point at which money supply and money demand are equal: r_1. If real GDP increases, then money demand increases (M^D shifts to the rightward), and the equilibrium interest rate rises to r_2 (panel A). If the nominal money supply increases (or the price level falls), the real money supply increase (M^S shifts rightward), and the interest rate falls to r_3.

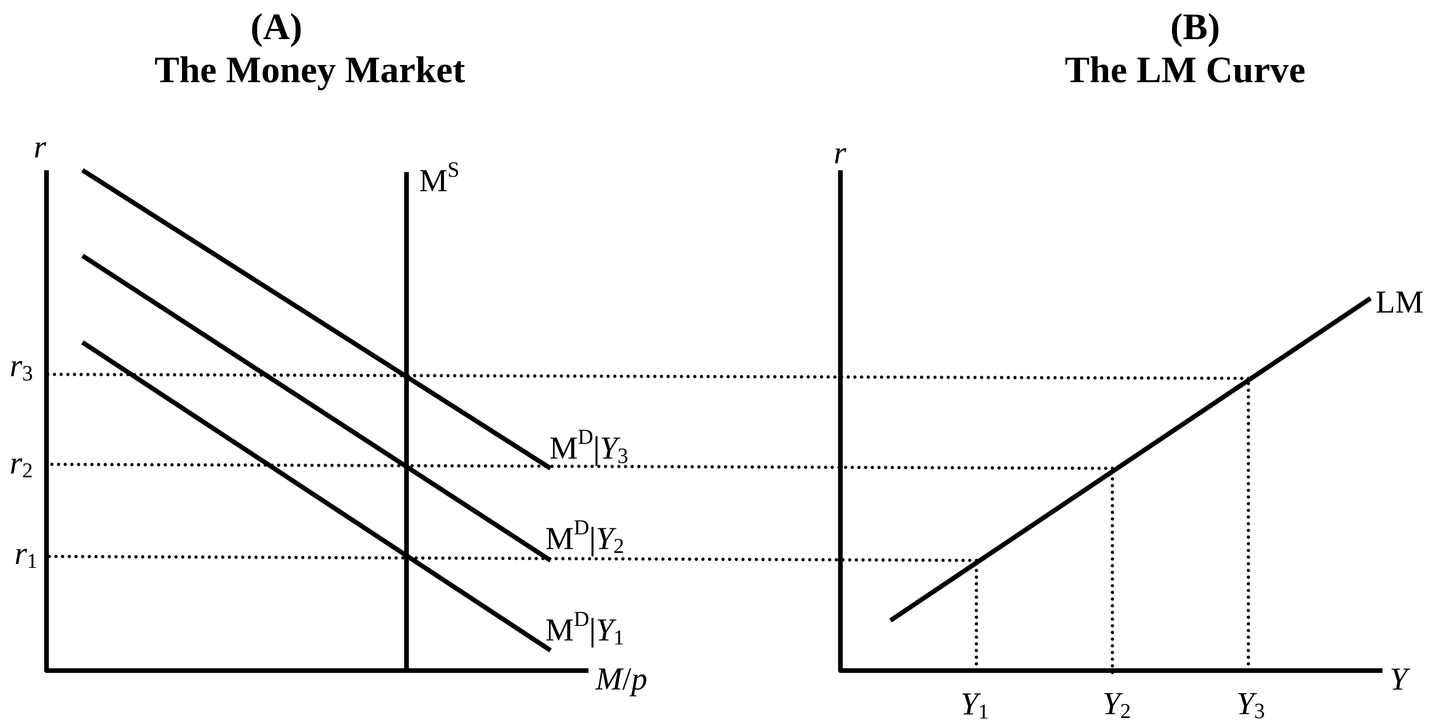
11.A.2 The LM Curve

Deriving the LM Curve

The LM curve translates the information in the money supply/money demand diagram onto a diagram with real GDP on the horizontal axis and interest rates on the vertical axis. Start in Figure 11.A.2 with GDP of Y_1. (The symbol $M^D|Y_1$ indicates that the money demand curve is drawn on the assumption that real GDP takes the value Y_1.) We see that Y_1 corresponds to the lowest money demand curve and the interest rate r_1 in panel (A). The point (Y_1, r_1) in panel (B) is the first point on the LM curve. Now consider a higher level of GDP: Y_2. This corresponds to the middle money-demand curve in panel (A) and to the interest rate r_2. Thus, (Y_2, r_2) in panel (B) is a second point on the LM curve.

Obviously, we could look at other levels of income and their corresponding money-demand curves and interest rates (not only (Y_3, r_3) but one for every level of real

Figure 11.A.2
Deriving the LM Curve



The money demand curve shifts rightward as real GDP increases. For a constant real money supply, the interest rate must rise with each shift (panel A). The LM curve matches each of these interest rates to the corresponding level of real GDP (panel B). The LM curve is the set of all levels of real GDP (Y) and interest rates (r) for which the money market is in equilibrium – i.e., real money supply equals real money demand.

GDP). Connecting all such points gives us the LM curve. The **LM curve** can be defined as *the locus of all combinations of real GDP and interest rates (given the real supply of money) for which the money market is in equilibrium (that is, for which the supply of money equals the demand for money).* The position and shape of the LM curve clearly depends on both the money supply and money demand.

What Shifts the LM Curve?

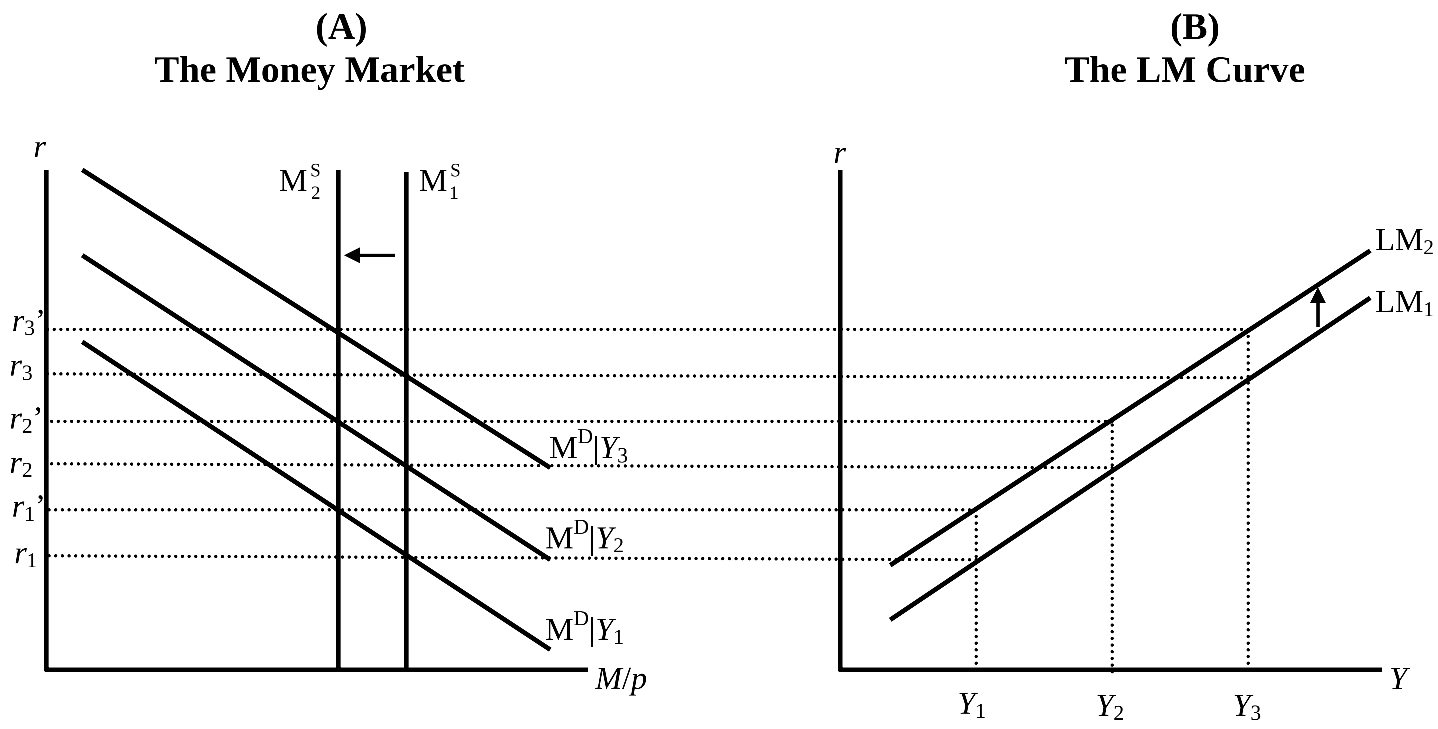
A change in interest rates or a change in real GDP *ceteris paribus* corresponds by definition to movements along the LM curve. But the LM curve can shift as well.

Suppose that the nominal supply of money falls. In the left-hand panel of Figure 11.A.3, this is shown as a leftward shift of the vertical real money-supply curve. For each of the three money demand curves (each drawn for a different level of real GDP), the interest rate rises: r_1 to r_1', r_2 to r_2', r_3 to r_3', and so forth. Translated to the right-hand panel, each level of real GDP now corresponds to a higher level of interest rates. In other words, the leftward shift of the real money-supply curve results in an upward shift of the LM curve. Clearly, an increase in the price level, which reduces the real supply of money, has exactly the opposite effect (see Problem 11.19).

What Use is the LM Curve?

The LM curve shows that an infinite number of combinations of interest rates and real GDP are compatible with equilibrium in the money market. It, therefore, does not tell us very much about the actual state of aggregate demand unless we can select a single point on it as the relevant one. For this we need another curve – the IS curve, which will be

Figure 11.A.3
A Decrease in the Real Supply of Money Shifts the LM Curve Vertically



Panel (A) shows the money demand curve for three different level of real GDP. When the real money supply is M_1^S, these correspond to interest rates r_1, r_2, and r_3 and to LM_1 in panel B. When the real money supply is reduced (either because the nominal money supply is reduced or prices rise), the money supply curve shifts to M_2^S which corresponds for each level of real GDP to the interest rates r_1', r_2', and r_3' and to LM_2 in panel B.

derived in Chapter 12. Even ahead of that, however, we can get an idea of what the LM curve is meant to tell us.

Start in Figure 11.A.4 with the LM curve is LM_1 and market interest rates at *r**. Then aggregate demand is given by the level of GDP at *r** – that is by *Y**. Now suppose that the interest rate remains constant at *r** and, at the same time, the LM curve shifts downwards (shift 1, due, e.g., to a fall in the price level), then aggregate demand would rise to Y_1. Of course, this could happen only if there was unused potential in the economy.

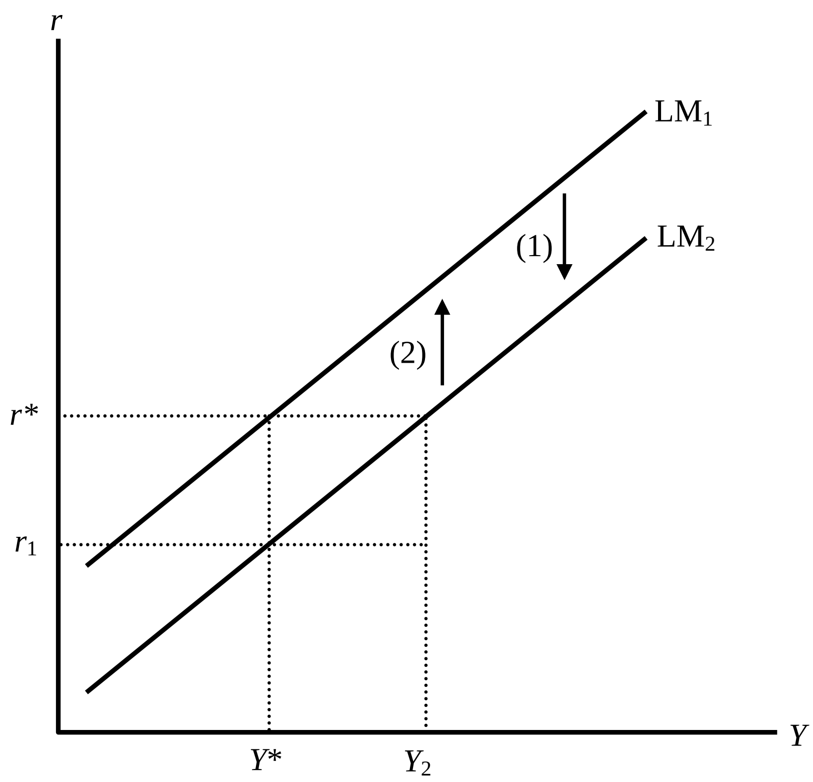
Consider another case, one in which the economy is already fully employed (at *Y**). Again suppose that the LM curve shifts upwards (perhaps due this time to an increase in the nominal money supply). There is pressure for aggregate demand to increase to Y_1, but that pressure cannot be realized because the economy is already at full potential. Firms find themselves with sales exceeding their production and so increase prices. The rising price level implies a falling real money supply, which results in an upward shift of the LM curve (shift 2). This process stops only when LM_2 has shifted all the way back to LM_1, and the interest rate has risen to *r** again at the original level of aggregate demand (*Y**) The interest rate rises as a result from *r** to r_1.

Both of these cases are merely preliminaries to show how the LM curve works. We complete the analysis of the LM curve in the appendices to Chapters 12 and 17.

11.A.3 The Limitations of the LM Model

We have discussed the LM curve in some detail in this appendix because it is so widely used among macroeconomics textbooks. It does not, however, form a core part of the

Figure 11.A.4
The LM Curve and Aggregate Demand



An increase in the nominal money supply shifts the LM curve downward (shift (1)). If the interest rate is held constant at r and if the economy is below its full potential so that aggregate supply is not a constraint, the aggregate demand rises from Y* to* Y_2*. But if the economy is at full potential so that real aggregate supply cannot rise to meet the higher aggregate demand, then firms will have to raise prices. The higher price level reduces the real supply of money, shifting the LM curve upwards (shift (2)) until the original equilibrium is reached at Y*.*

theory on which this book is based. It may be useful – without going into excessive detail – to say why. Mainly, it is because the LM model of financial markets is too limited to address the full range of questions that interests us. To be more specific.

- The LM model overemphasizes monetary instruments. Table 10.2 (also Figure 10.2) shows that monetary instruments are only 9.8 percent of all financial assets. M1's share is even smaller – only 1.8 percent.
- The LM model considers only a single interest rate, but which one is it? Central banks typically target short-term rates and hope to use them to influence long-term rates. Investment most likely depends on longer-term rates. The relevant opportunity cost for the transactions demand for money may be a short-term rate, while the relevant opportunity cost for the speculative demand for money may be a long-term rate. To get at some really important economic issues it helps to consider multiple interest rates of different maturities connected through the yield curve.
- Monetary policy is usually analyzed in the LM model as movements of the supply of money, which raises two problems: (a) central banks do not directly control a monetary aggregate such as M1, but instead influence it through their control over the monetary base or central-bank reserves (we take this up again in Chapter 17, especially the appendix); and (b) most central banks most of the time use an interest-rate target, rather than a money-supply target, to guide monetary policy, so that the LM curve encourages us to look at monetary policy from a perspective quite different to the one natural to actual monetary policy (we consider an exception to this rule in Chapter 17, appendix).

Summary

1. There are countless interest rates in the economy, but they tend to follow some consistent patterns: (i) they move broadly together; (ii) but they are not perfectly correlated; (iii) short-term financial instruments typically (but not uniformly) have lower rates than long-term instruments; (iv) Federal government financial instruments have lower rates than corporate or state and local instruments of similar maturity and lower risk instruments have lower rates than higher risk instruments.
2. All financial instruments are, to varying degrees, substitutes. Arbitrage is the process of shifting funds among close substitutes in search of unexploited profit opportunities. Arbitrage tends to drive the yields on financial instruments as close together as their degrees of substitutability will allow.
3. The efficient markets hypothesis states that there are no systematically exploitable arbitrage opportunities based on publicly available information.
4. Difference in risk, maturity, and payment structure explain differences in substitutability among financial instruments.
5. Default risk is the chance that a borrower will fail to pay off a loan.
6. Federal government debt is essentially free of default risk because the government's authority to tax and to create money leave it in a position always to pay off its debts so long as they are denominated in dollars.
7. Bond rating agencies classify firms and other borrowers according to the degree of anticipated default risk. Lower risk borrowers enjoy lower interest rates than higher risk borrowers.

8. Price risk (interest-rate risk) is the chance of capital gains or losses (change in the bond price) that occur as market interest rates move up and down. Price risk is greater the longer the maturity of the debt.

9. The term structure of interest rates is the pattern according to which interest rates vary with maturity. The yield curve is a graphical representation of the term structure that graphs the time to maturity on the horizontal axis and the yield to maturity on the vertical axis.

10. The expectations theory of the term structure of interest rates says that arbitrage will force interest rates into a pattern such that every way of moving funds from the current period to some future period through holding different chains of financial instruments of different maturities will have the same expected yield with an adjustment for a term premium that largely reflects price risk.

11. According to the expectations theory of the term structure, yield curves tend to slope up when short rates are expected to rise and to slope down when they are expected to fall. Yields curves slope up far more often than down, this bias is the result of the term premium rising with maturity.

12. Since people should rationally be concerned with real, and not nominal, returns, the nominal interest rate needed to justify either the supply of, or the demand for, any particular quantity of a financial instrument rises and falls point for point with changes in the rate of inflation. The theoretical point is known as the Fisher effect. The Fisher hypothesis is the claim that the Fisher effect characterizes financial markets pretty accurately in practice. The Fisher hypothesis may fail for various reasons – particularly, if expectations of future inflation are inaccurate.

13. The overall level of short-term interest rates is strongly affected by central-bank (Federal Reserve) monetary policies. The overall level of long-term interest rates is also affected through arbitrage to real rates of returns represented by the profits on capital invested in businesses.

Key Concepts

substitutes
arbitrage
efficient-markets hypothesis,
default risk
price (or interest-rate) risk
yield curve
term structure of interest rates.
expectations theory of the term structure of interest rates
Fisher effect
Fisher hypothesis

Suggestions for Further Reading

Some basic sources:

Stephen D. Smith, Raymond E. Spudeck, *Interest Rates: Principles and Applications*. New York: Harcourt Brace, 1993.

Marcia Stigum, *The Money Market*. New York: McGraw-Hill, 1989.

The efficient-markets hypothesis has provoked some lively debate:

Burton G. Malkiel, *A Random Walk Down Wall Street*, 7th edition. New York: Norton, 2000.

Andrew W. Lo and A. Craig MacKinlay, *A Non-Random Walk Down Wall Street*. Princeton: Princeton University Press, 2001.

Robert J. Shiller, *Irrational Exuberance*. Princeton: Princeton University Press, 2001.

Stephen F. LeRoy, "Rational Exuberance," *Journal of Economic Literature*, vol. 42, no. 3 (September 2004), pp. 783-804.

Problems

Data for this exercise are available on the course website under the link for Chapter 11 (**insert web link here**). Before starting these exercises, the student should review the relevant portions of the *Guide to Working with Economic Data*: sections G.4, G.7, G.9, G.11, and G.15.

Problem 11.1. Consider the scenario of section 11.2.1 (especially Figure 11.2).
(a) What would happen to the yields on P&G and Clorox bonds if Clorox decided to use extraordinary profits to buy back some of its bonds. Explain each step carefully.
(b) Assume that both Clorox and P&G bonds start with a AAA rating. What would happen to the yields on P&G and Clorox bonds if the bond rating on P&G bonds was reduced to BAA? Explain each step carefully.

Problem 11.2. A radio advertisement states that gasoline prices in the United States rise every summer and fall every winter, so that there is money to be made from buying gasoline futures in the winter and holding them until summer. (A future is a financial instrument that promises delivery of a commodity or the equivalent of its market price at a future date.) Is the underlying reasoning consistent with the efficient-markets hypothesis? Explain.

Problem 11.3. Differences in default risk should be reflected in interest rates as risk premia (section 11.3.1). To see how much calculate the typical risk premia between the rates on composite long-term U.S. Treasury bonds (as a measure of a bond free of default risk) and separately on Moody's Aaa and Baa corporate bond rates for the post-World War II period. Calculate the mean values. (Save your data for the next two questions.)

Problem 11.4. How does default risk vary across the business cycle? Plot the risk premia for Aaa and Baa corporate bonds calculated in Problem 11.3 against the NBER business cycle dates. Comment on their cyclical properties?

Problem 11.5. Table 11.1 gives the 15-year cumulative default rates on S&P AAA and BBB corporate bonds (corresponds to Moody's Aaa and Baa). If we assume that default means total loss to the bondholder (which it does not always) and if we assume that the typical long-term bond in the preceeding two problems is about 15 years maturity, then these default rates would predict that Aaa and Baa bonds would earn a rate high enough to give the same return on average as long-term Treasury bond rates accounting for risk: $(\textit{default rate} \times 0) + [(1 - \textit{default rate}) \times r_{corporate}] = r_{Treasury}$, so that $r_{corporate} = r_{Treasury} /(1 - \textit{default rate})$. Using this formula and the default rates in Table 11.1 (be careful with units: they are in percentage points), construct a predicted interest rate series for Aaa and Baa bonds. Plot these series against the actual Aaa and Baa series. How good are the predictions? What does this say about the effectiveness of bond-rating agencies?

Problem 11.6. Which is more risky: stocks, short-term bonds, or long term bonds? Which has the higher rate of return? Is there a clear tradeoff between risk and return? The yield over a one-year holding period for a one year bond is approximately its yield to maturity. The yield on a longer-term bond is its yield to maturity plus any capital gain or loss. To answer the questions, create three series. First, for stocks and long-term bonds calculated their *ex post* nominal capital gains or losses by calculating the percentage change of their price index (S&P 500 index for stocks, Lehmann Brothers index for bonds) over the over the 12 months following the current period: $capital\ gain_t = (price\ index_{t+12}/price\ index_t) - 1$. To get the total nominal return add the *dividend yield*$_t$ for stocks and the r_t for long-term bonds. Finally to get the *ex post* real rates of return subtract the 12-period ahead rate of CPI inflation ($\hat{p}_t = (p_{t+12} / p_t - 1)$ from each of these time series and from the time series of interest rates on 1-year bonds. For each of the three series, calculate the average real rates of return, the standard deviations, and the coefficients of variation, recording your data in a table. Answer the three questions at the beginning of the problem.

Problem 11.7. Suppose that the real rate of interest is constant at 2%. Suppose that people expect the following path for year-on-year inflation:

From Year to Year	Expected Rate of Inflation
2005 to 2006	2%
2006 to 2007	3%
2007 to 2008	4%
2008 to 2009	5%
2009 to 20010	6%

Finally suppose that people require a risk premium to hold bonds of longer maturities according to the following table:

Maturity	Risk Premium
1 Year	0.00%
2-year	0.25%
3-year	0.50%
4-year	0.75%
5-year	1.00%

(a) Calculate what the yield to maturity should be for each bond purchased in 2005, starting with a 1-year bond purchased in 2005 maturing in 2006 up to a 5-year bond purchased in 2005 maturing in 2010. Sketch the yield curve and label the points.

(b) Calculated the expected yield on a 3-year bond purchased in 2007 maturing in 2010.

The next four problems are a related set.

Problem 11.9. For a recent business cycle, plot the yield curve for U.S. Treasury bonds at the NBER peak and trough and for a date about midway through the expansion. (*Excel hint*: (i) create a series of maturities in adjacent cells moving from left to right: 0.0833, 0.25, 0.5, 1, 2, 3, 5, 7, 10 and highlight these cells; (ii) selected your dates and highlight the cells in adjacent columns containing the rates for each of these maturities at those dates; (iii) on the "Insert" menu, select "Chart" insert a chart, selecting the scatterplot option with points connected by a smooth line.) Depending on which business cycle you choose, two out of the three curves should slope upwards. The third may slope up or down but, in any case, is likely to be flatter than the others.

Problem 11.10. To get an idea of how the slope of the yield curve changes over time, create a series: *yieldslope = yield on 10-year Treasury bond rate – yield on 1-year Treasury bond rate*. When *yieldslope* is positive, the yield curve slopes up (at least between a maturity of 1 and 10 years), and when negative, it slopes down. Plot this series against the NBER business-cycle dates. (Save the series for the next problem.)

Problem 11.11. Create a scatterplot with scaled output (i.e., output scaled by potential output ($\tilde{Y}$) – see Chapter 6, section 6.5) on the horizontal axis and *yieldslope* from Problem 11.10 on the vertical axis. Add a regression line and display its equation and R^2.

Problem 11.12. Using the information from Problems 11.9-11.11, write a brief note on the relationship of the yield curve and the business cycle. (Both describe your findings and attempt to give a explanation of what you find.)

Problem 11.13. A 3-month Treasury bill rate should have virtually no price risk. Estimate the term premium for each maturity of Treasury bond by subtracting the time series for the 3-month rate from each of the others and taking the mean. Present your results in a table.

Problem 11.14. To see how well the Fisher hypothesis fits the data, estimate the *expected rate of inflation* using the actual past annual rate of CPI inflation ($\hat{p}_t = (p_t / p_{t-12} - 1)$). On separate graphs, plot the 1-year and the 10-year Treasury bond rates on the vertical axis against the inflation rates on the horizontal axis. Add the regression line and display the equation and R^2. What does the Fisher hypothesis predict for the values of the coefficients in the equation? How well does the Fisher hypothesis match the data? What is the implied estimate of the average real rate of interest?

Problem 11.15. Has the success of the Fisher hypothesis changed over time? Repeat Problem 11.14 for the 1-year bond rate only using data for the last 15 years and separately for any other 15-year period in the data. Comment on the relative performance of the hypothesis in each period.

Problem 11.16. Past inflation may not give a good estimate of future inflation. Repeat Problem 11.14 for the 1-year bond rate only using the Livingston expected inflation series instead of the calculated CPI inflation rate. Comment on the difference between your findings in the two problems. With respect to which set of data does the Fisher hypothesis work better?

Problem 11.17. The stock market is often cited as a leading indicator of the business cycle. Is it? Plot the S&P 500 index against the NBER business cycle dates. (Hint: use a logarithmic scale – why?) Comment on its cyclical properties. With respect to the post-World War II data, make a table showing the number of recessions for which a downturn in the stock market correctly predicted a downturn in the economy, how many downturns in the economy were not preceded by a downturn in the economy (false negative – type I error), how many downturns in the market were not followed by a downturn in economy (false positive – type II error) (see the *Guide,* section G.7).

Problem 11.18. In the Appendix we derived the money demand curve on the assumption that the real return on money was $-\hat{p}$. This was based on the assumption that currency and checking accounts do not bear interest. But, of course, some checking accounts do bear interest. Think about the case in which *all* money bears interest (perhaps we no longer use currency – just ATM cards). Then the

opportunity cost of holding money = real return on the bond – real return on money

$$= (r_{bond} - \hat{p}^e) - (r_{money} - \hat{p}^e) = r_{bond} - r_{money}.$$

What difference would this change make to the shape of the money demand curve? Would it still slope down? Would it be steeper or flatter? Consider two extreme cases: (i) r_{money} is fixed and does not vary when r_{bond} varies; and (ii) r_{money} varies point for point with r_{bond} so that their difference is constant. Which, if either, is likely to be closer to reality.

Problem 11.19. Explain in detail how and why the LM curve shifts when the price level increases.

Problem 11.20. Let real money demand be described by the equation:

$$\frac{M^D}{p} = 0.5Y - 0.5r$$

and nominal money supply by:

$$M^S = \overline{M}.$$

(a) Write down the general equation for the LM curve in terms of Y, r, $\overline{M}$, and p.
(b) If $\overline{M}$ =10,000 and p = 100, write down the specific equation for the LM curve and draw the curve.

(c) Using this last equation, if r = 5 percent, what is Y? (The equation presumes that r is measured in percentage points, so enter 5 – not 0.05.)

(d) If the money supply were increased to $\overline{M}$ =15,000, holding p and r constant, what would happen to aggregate demand (Y). Sketch the change in the curve compared to the one drawn in (b).

(e) If the money supply were increased to $\overline{M}$ =15,000, holding p and Y constant, what would happen to interest rates (r). Sketch the change in the curve compared to the one drawn in (b).

(f) If the money supply were increased to $\overline{M}$ =15,000, holding Y and r constant, what would happen to prices (p). Sketch the change in the curve compared to the one drawn in (b).