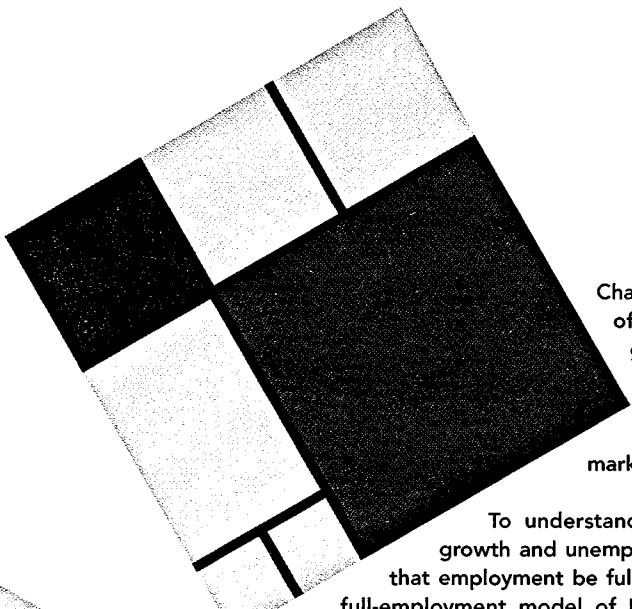


Sticky-Price Macroeconomics

PART



Chapters 4 through 8 do not give a complete picture of the macroeconomy. In Chapters 4 through 8, growth is smooth from year to year. But in the real world growth is not. In Chapters 4 through 8, supply and demand in the labor market are always in balance. But in the real world the labor market is not always in equilibrium.

To understand these business-cycle fluctuations in economic growth and unemployment, we need a model that does not require that employment be full and real GDP be equal to potential output. The full-employment model of Part 3 is not of help because its flexible-price assumption guarantees full employment. Here in Part 4, therefore, we need to break this flexible-price assumption to build a useful model of the business cycle.

From this point forward, prices will be "sticky": They will not move freely and instantaneously in response to changes in demand and supply. We will use this sticky-price model to account for business-cycle fluctuations.

Building this sticky-price model of the macroeconomy is the task of Part 4. Chapter 9 focuses on how, when prices are sticky, the inventory adjustment process is the key to understanding how GDP can fall below or rise above potential output. Chapter 10 analyzes how changes in the interest rate affect investment, exports, and GDP. Chapter 11 focuses on equilibrium in the money market and the balance of aggregate demand and aggregate supply. Chapter 12 focuses on monetary policy, expectations, and inflation. It links the sticky-price model of Part 4 back to the flexible-price model of Part 3 by analyzing which model is most useful in which sets of circumstances.

CHAPTER

9

The Sticky-Price Income-Expenditure Framework: Consumption and the Multiplier

QUESTIONS

What are "sticky" prices?

What factors might make prices sticky in the short run?

In the short run when prices are sticky, what determines the level of real GDP?

When prices are sticky, what happens to real GDP if some component of planned total expenditure rises or falls?

What is the spending multiplier? What factors determine its size?

Over the past decade real GDP in the American economy has grown at an average rate of 3.3 percent per year. At the same time, the American unemployment rate has fluctuated around an average level consistent with stable inflation — a *natural rate of unemployment* — of roughly 5.0 percent.¹ During the past decade, the inflation rate in the United States has been low: an average of about 1.8 percent per year as measured by the price index associated with GDP, the GDP deflator.²

If Chapters 4 through 8 gave a complete picture of the macroeconomy, this economic growth would have been smooth. Real GDP would have grown 3.4 percent — the CBO's estimate of the current rate of growth of potential GDP — year after year, not just on average. The unemployment rate would have remained steady at its natural rate of approximately 5.0 percent. And inflation would have been steady as well, determined by the rates of growth of potential output and the money stock and the velocity of money.

And if this were the case, the analysis in Chapters 4 and 5 would provide a complete picture of how potential output grew over time. The analysis in Chapters 6 and 7 would explain why real GDP equals potential output and how national income is divided among the different components of total expenditure. The analysis in Chapter 8 would detail how the price level and the inflation rate are determined. It would be the last chapter in this textbook. Your survey of macroeconomics would be finished now.

But it isn't. This is not the case. Chapters 4 through 8 do not give a complete picture of the macroeconomy. Growth is not at all smooth; on a year-to-year time scale, it is not even guaranteed. In 1982 real GDP was not 3.4 percent more but 1.9 percent less than it was in 1981 (see Figure 9.1). Between 1979 and 1982 the unemployment rate rose by 3.9 percentage points, and it rose again by 2.2 percentage points between 1989 and 1992. Unemployment may have been only 4 percent at the end of 2000, but it was 7.6 percent in the middle of 1992. Inflation at the end of 2000 may have been only 2.2 percent per year, but in 1981 it was 9.4 percent.

These fluctuations are called *business cycles*. A business cycle has two phases: an expansion or boom phase as production, employment, and prices all grow rapidly, and a subsequent recession or depression phase during which inflation falls or prices slump, unemployment rises, and production falls. During booms, output grows faster than trend, investment spending amounts to a higher-than-average share of GDP, unemployment falls, and inflation usually accelerates. During recessions, output falls, investment spending is a low share of real GDP, unemployment rises, and inflation usually decelerates. Compared to the overall upward trend of long-run growth, these short-run fluctuations (with the exception of the Great Depression) appear relatively small. But, as we noted in Chapter 1, they have a large impact on the lives of those unlucky enough to lose their jobs or to fail to find jobs when a recession hits.

¹This natural rate of unemployment is not a constant; it moves slowly over time. And we are never sure what it was until after the fact.

²As measured by the Consumer Price Index — the CPI — the average rate of inflation has been higher: 2.4 percent. This difference exists because the prices of capital goods, chiefly computers and communications equipment, have been falling in nominal terms over the past decade. Capital goods are by and large not bought by households, and so do not make it into the CPI.

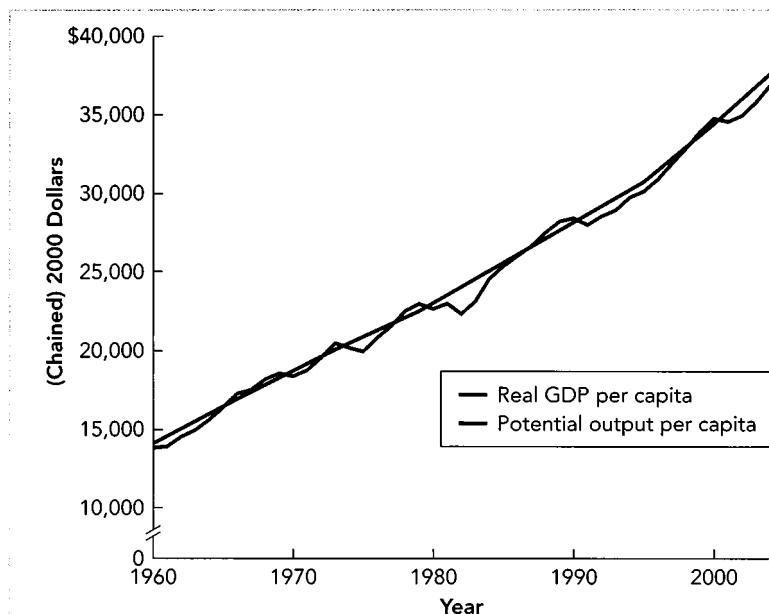


FIGURE 9.1
Real GDP and Potential Output per Capita 1960–2004

From year to year real GDP per capita fluctuates around potential output. The flexible-price full-employment classical model of Chapters 6 and 7 cannot account for these fluctuations in real GDP per capita relative to potential output per capita.

Source: The 2004 edition of *The Economic Report of the President* (Washington, DC: Government Printing Office).

9.1 STICKY PRICES

Sticky Prices

To understand business cycles, we need a model that does not guarantee full employment and in which real GDP does not always equal potential output. Business cycles are not fluctuations in potential output. They are fluctuations of actual production around potential output—above potential output when the economy is “overheated,” and below potential output when the economy possesses substantial “slack.” Thus the full-employment model of Chapters 6 through 8 is of no help here. Its assumption that prices are flexible guarantees full employment. The flexible-price assumption allowed us to start our analysis in a simple and straightforward way, by noting that the labor market would clear, that as a result firms would fully employ workers who wanted to work, and thus that real GDP and household income would be equal to potential output. (And the flexible-price assumption is not a bad one to make if employment is nearly full, either because there have been no large disturbances to demand in a while so that wages and prices in labor and product markets have had time to adjust, or because the Federal Reserve has done a good job of neutralizing disturbances to total expenditure.)

But we cannot afford to keep the flexible-price assumption. We need to break it if we are to build a more useful model of the business cycle. Thus from this point on wages and prices will be “sticky”: They will not move freely and instantaneously in response to changes in demand and supply. Instead, prices will remain fixed at predetermined levels as businesses expand or contract production in response to changes in demand and costs. As you will see, such sticky prices make a big

flexible prices

When wages and prices in an economy are not sticky but move smoothly and rapidly to keep supply equal to demand in the labor market and in the goods market.

sticky prices

When wages and prices do not move smoothly and immediately to keep supply equal to demand in the labor and goods markets.

difference in economic analysis; they will drive a wedge between real GDP and potential output and between the supply of workers and the demand for labor. We will then be able to use this sticky-price model to account for business-cycle fluctuations.

Building this sticky-price model of the macroeconomy will take up all of Part 4. In this chapter, we will focus on how, when prices are sticky, firms hire or fire workers and expand or cut back production on the basis of whether their inventories are falling or rising. Inventory adjustment is the key to understanding how the level of real GDP can fluctuate around potential output. Chapter 10 focuses on how changes in the interest rate affect the levels of investment, exports, and real GDP in the sticky-price model.

Chapter 11 takes a deeper look at equilibrium in the money market: How are interest rates in the short run really determined? It is an optional chapter. You can simply say that the Federal Reserve — the Fed — sets interest rates, not inquire into how, and skip Chapter 11. But if you want to understand what happens when there is no interest rate–pegging central bank around, or how the Federal Reserve pegs interest rates, or what happens if the Federal Reserve pegs not interest rates but the money stock, then you need to study Chapter 11.

The last chapter of Part 4, Chapter 12, takes up the topics of expectations and inflation in an environment in which the Fed sets interest rates. By the end of Chapter 12 we will have linked up the sticky-price model of Part 4 with the flexible-price model of Part 3. We will understand the sorts of situations for which the sticky-price model is appropriate. And we will understand under what sets of circumstances wages and prices are flexible enough and have enough time to adjust for the flexible-price model to be the most useful way of analyzing the macroeconomy.

At each stage in the building of our sticky-price macroeconomic model, the preceding topic serves as a necessary foundation. The analysis of inflation and expectations in Chapter 12 rests on the analysis of how changes in interest rates affect investment, exports, and real GDP in Chapter 10. And the analysis of Chapter 10 in turn rests on the analysis of income, expenditure, and equilibrium in a sticky-price economy carried out here in Chapter 9. Chapter 11 also rests on Chapters 9 and 10, and it provides a fuller foundation for Chapter 12.

Up to this point, this book has not been cumulative. You could understand the long-run growth analysis in Chapters 4 and 5 without a firm grasp of the introductory material in Chapters 1 through 3. You could understand the flexible-price analysis in Chapters 6 and 7 without a firm grasp of either the introductory or the long-run-growth chapters. And you could understand Chapter 8 without having read anything earlier in the book. But from this point on, the chapters of this book become interdependent and very cumulative indeed.

Consequences of Sticky Prices

Flexible-Price Logic

To preview the difference between the flexible-price and the sticky-price models, let us analyze a decline in consumers' propensity to spend under both sets of assumptions. Suppose there is a sudden fall in the parameter C_0 that determines the baseline level of consumption in the consumption function

$$C = C_0 + C_y(1 - t)Y$$

where Y is GDP or national income, t is the tax rate, C is consumption spending, and C_0 and C_y are the parameters of the consumption function that determine

(1) the baseline level of consumption and (2) how much consumption increases for a \$1 increase in national income, respectively. When C_0 falls, then at any given level of national income Y , consumers wish to save more and spend less.

To make this concrete, consider what happens when baseline consumption spending falls. Suppose that the function for annual consumption spending (in billions of dollars) declines from

$$C = 2,000 + 0.5(1 - t)Y$$

to

$$C = 1,800 + 0.5(1 - t)Y$$

In the full-employment model of Chapters 6 through 8, such a \$200 billion fall in annual baseline consumption spending would have no impact on the level of real GDP. No matter what the flow of total expenditure, the labor market would still reach its full-employment equilibrium shown in Figure 9.2 because nominal wages and prices are flexible. And because the economy remains at full employment, real GDP would equal potential output.

The fall in consumption spending would have an effect on the economy — just not on the level of real GDP. As we saw in Chapters 6 and 7, a fall in consumption spending means an increase in saving. As consumption falls, the total saving curve shifts rightward on the flow-of-funds diagram, as Figure 9.3 on page 258 shows. The fall in consumption spending reduces the equilibrium real interest rate. The fall in the interest rate then leads to increases in the equilibrium level of investment and net exports. By how much does investment plus net exports increase? By \$200 billion, the amount necessary to offset the fall in consumption spending and keep real GDP equal to potential output.

Thus these are the flexible-price-model consequences of a fall in households' desired baseline consumption spending:

- Consumption falls.
- Household saving rises.

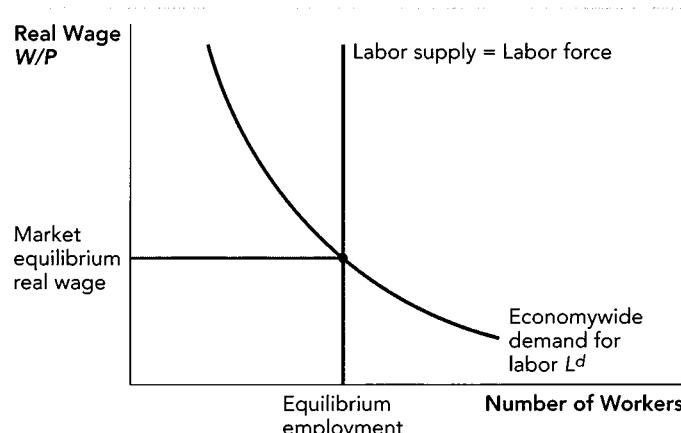


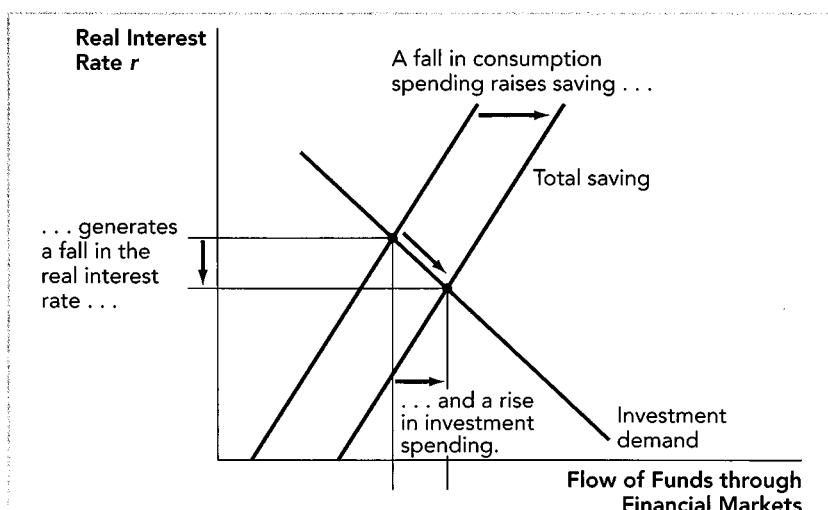
FIGURE 9.2
Flexible-Price Logic:
Labor-Market
Equilibrium

No matter what the flow of planned expenditure, flexible wages and prices mean that employment remains at full employment and the level of real GDP produced remains at potential output.

FIGURE 9.3

**Flexible-Price Logic:
The Effect on Saving of
a Fall in Consumption
Spending**

With flexible prices, a fall in consumption spending means a rise in household saving and an increase in the flow of saving through financial markets. Thus the real interest rate falls, and more investment projects are undertaken. The fall in the real interest rate also raises the value of the exchange rate and boosts net exports.



- The real interest rate falls.
- Investment rises.
- The value of foreign currency — the exchange rate — rises.
- Net exports rise; foreign saving falls.

Sticky-Price Logic

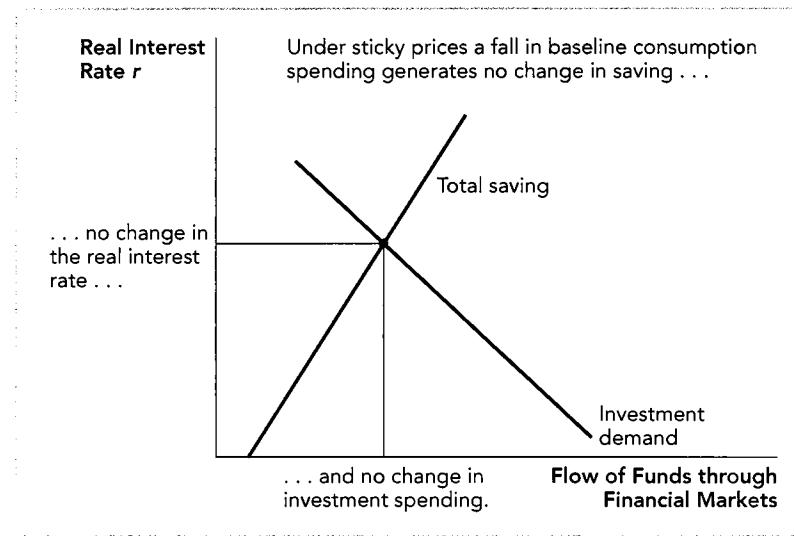
If wages and prices are sticky, the analysis is different. The first consequence of consumers' cutting back their spending will be a fall in expenditure for goods. Consumer spending has fallen, yet nothing has happened to change the flow of spending on investment goods, the flow of net exports, or the flow of government purchases.

As businesses see spending on their products begin to fall, they will not cut their nominal prices (remember, prices are sticky). Instead, they will respond to the fall in the quantity of their products demanded by reducing their production. They want to avoid accumulating unsold and unsellable inventory. As they reduce production, they will fire some of their workers, and the income of the fired workers will drop. By how much will total national income drop? Initially, it will fall by the amount of the fall in baseline consumption spending: \$200 billion a year. (Moreover, because the decline in income leads to a further decline in consumption as households that have lost income cut back on their spending, national income and real GDP will fall by more than the decline in C_0 . This *multiplier* process is discussed later on in the chapter.)

Thus the consequences of a fall in consumption spending under the sticky-price assumption are

- Consumption falls.
- Production and employment decline.
- National income declines.

In the flexible-price model, when consumption falls, investment and net exports rise. Why doesn't the same thing happen in the sticky-price model? Why doesn't a rise

**FIGURE 9.4**

Sticky-Price Logic: The Effect on Saving of a Fall in Consumption Spending

With sticky prices, a fall in baseline consumption spending carries with it a fall in income. Because both total consumption spending and ultimately income decline by the same amount, there is no change in total saving through financial markets. Thus the real interest rate remains unchanged. There is no change in investment spending or gross exports.

in investment spending keep GDP equal to potential output and keep employment full? What goes wrong with the flexible-price logic, according to which a fall in consumption spending generates an increase in saving that then boosts both investment spending and net exports?

The answer hinges on the fact that in the sticky-price model, firms respond to falling demand not by cutting prices but by cutting back production and employment, and so total income falls. A fall in total income reduces saving (if consumption is held constant) just as a fall in consumption raises saving (if income is held constant). Under the sticky-price assumption, the effect on total saving of the fall in consumption and the fall in income cancel each other out; there is no change in the flow of saving. Thus there is no rightward shift in the position of the total saving curve on the flow-of-funds diagram in Figure 9.4. There is no fall in interest rates to trigger higher investment (and a higher value of the exchange rate and expanded net exports). There is nothing to offset the fall in consumption spending and keep GDP from falling below potential output.

Why doesn't this sticky-price unemployment-generating logic work when prices are flexible? The answer is that when flexible-price firms see a fall in total spending, they respond not by cutting production and employment but by cutting the prices they charge and the wages they pay. Since prices and wages both fall, the real income households earn remains constant. Thus with flexible prices a fall in consumption spending does induce a rise in saving — hence a fall in the real interest rate, a rise in investment spending, an increase in the value of the exchange rate, and a rise in net exports.

Expectations and Price Stickiness

If managers, workers, consumers, and investors had time to foresee a fall in consumption and gradually adjust their wages and prices to it in advance, even

considerable stickiness in prices would not be a problem. With sufficient advance notice unions and businesses would strike wage bargains, and businesses could adjust their selling prices to make sure demand matched productive capacity. Both the stickiness of prices and the failure to accurately foresee changes far enough ahead to adjust to them in advance are needed if the sticky-price framework is to create business cycles in employment and output like the ones we see.

One way to think about this is that the analysis in Part 4 is a short-run analysis, and the analysis in Part 3 is a longer run analysis (although still not as long run as the truly long-run growth analysis of Part 2). In the Part 4 short run, prices are sticky; shifts in policy or in the economic environment that affect the components of planned total expenditure will affect real GDP and employment. In the Part 3 long run, prices are flexible and workers, bosses, and consumers have time to react and adjust to changes in policy or the economic environment. Thus in the long run, such shifts do not affect real GDP or employment.

Why do we need a sticky-price short-run model as well as the long-run flexible-price model? Why don't economists simply say that once wages and prices have fully adjusted (however long that takes), employment will be full and real GDP will be equal to potential output? The most famous and effective criticism of such let's-look-only-at-the-long-run analyses was made by John Maynard Keynes in his 1924 *Tract on Monetary Reform*. Criticizing one such long-run-only analysis, Keynes wrote:

In the long run [this] is probably true. . . . But this long run is a misleading guide to current affairs. In the long run we are all dead. Economists set themselves too easy, too useless a task if in tempestuous seasons they can only tell us that when the storm is long past the ocean will be flat once more.

Where is the line that divides the short run from the long run? Do we switch from living in the short run of Part 4 to the long run of Part 3 on June 19, 2006? No, we do not. The "long run" is an analytical construct. A change can be considered long run if enough people see it coming far enough in advance and have had time to adjust to it — to renegotiate their contracts and change their standard operating procedures accordingly. The length of the long run, and thus how many of us will be dead before it comes, depends in turn on the degree of price stickiness and the process by which people form their expectations — both hot topics for academic research in modern macroeconomics.

Why Are Prices Sticky?

Why don't prices adjust quickly and smoothly to maintain full employment? Why do businesses respond to fluctuations in demand first by hiring or firing workers and accelerating or shutting down their production lines? Why don't they respond first by raising or lowering their prices?

Economists have identified any number of reasons that prices could be sticky, but they are uncertain which are most important. Some likely explanations are:

- Managers and workers find that changing prices or renegotiating wages is costly and hence best delayed as long as possible.
- Managers and workers lack information and so confuse changes in total economywide spending with changes in demand for their specific products.
- The level of prices is as much a sociological as an economic variable — determined as much by what levels people think are "fair" as by the balance of supply and demand. Workers take a cut in their wages as an indication

that their employer does not value them; hence managers avoid wage cuts because they fear the consequences for worker morale.

- Managers and workers suffer from simple “money illusion”; they overlook the effect of price-level changes when assessing the impact of changes in wages or prices on their real income or sales.

Let's look more closely at each of these likely explanations. Economists call the costs associated with changing prices **menu costs**, a shorthand reference to the fact that when a restaurant changes its prices, it must print up a new menu. In general, changing prices or wages may be costly for any of a large number of reasons. Perhaps people want to stabilize their commercial relationships by signing long-term contracts. Perhaps reprinting a catalog is expensive. Perhaps customers find frequent price changes annoying. Perhaps other firms are not changing their prices and what matters most to a firm is its price relative to the prices of competitors. Hence managers and workers prefer to keep their prices and wages stable as long as the shocks that affect the economy are relatively small — or, rather, as long as the change they might want to make in their prices and wages is small.

A second source of price stickiness is **imperfect information**: a misperception of real and nominal price changes. If managers and workers lack full information about the state of the economy, they may be unsure whether a change in the flow of spending on their products reflects a change in overall aggregate demand or a change in demand for their particular products. If it is the latter, they should respond by changing how much they produce, not necessarily by changing the price. If it is the former, they should respond by changing their price in accord with overall inflation, not by changing how much they produce. If managers are uncertain which it is, they will split the difference. Hence firms will lower their prices less in response to a downward shift in total nominal demand than the flexible-price macroeconomic model would predict. If they keep their prices too high, they will have to fire workers and cut back production. Imperfect information is a possible source of sticky prices.

Yet a third reason why prices and wages are sticky is that workers and managers are really not the flinty-eyed rational maximizers of economic theories. In real life, work effort and work intensity depend on whether workers believe they are being treated fairly. A cut in nominal wages is almost universally perceived as unfair; wages depend on social norms that evolve slowly. Thus wages are by nature sticky. And if wages are sticky, firms will find that their best response to shifts in demand is to hire and fire workers rather than to change prices.

Last, workers, consumers, and managers suffer from **money illusion**: They confuse changes in nominal prices with changes in real (that is, inflation-adjusted) prices. Firms react to higher nominal prices by thinking falsely that it is more profitable to produce more — even though it isn't because their costs have risen in proportion. Workers react to higher nominal wages by searching more intensively for jobs and working more overtime hours, even though rises in prices have erased any increase in the real purchasing power of the wage paid for an hour's work. Such money illusion is a powerful generator of price stickiness and business-cycle fluctuations.

All these factors are potential sources of price stickiness. Your professor may have strong views about which is most important. We find ourselves more confused and agnostic. Our reading is that economists' knowledge is more limited. We are not sure the evidence is strong enough to provide clear and convincing support for any particular single explanation as the most important one. A safer

menu costs

The costs to a firm of changing the price(s) of a good(s) or service(s).

imperfect information

The information workers or managers have for decision making when they lack full information about the state of the economy.

money illusion

When managers, workers, and others fail to recognize that some of the change in their nominal income and revenue is a result of inflation and is not a change in their real income and revenue.

position is to remain agnostic about the causes of sticky wages and prices, and so in this book we will focus on analyzing not their causes but their effects.

RECAP STICKY PRICES

The full-employment model of Chapters 6 through 8 does not help explain business cycles because its assumption that prices are flexible guarantees that real GDP is always equal to potential output. To build a more useful model of the business cycle, we need to assume that prices are sticky. If prices are sticky, the first consequence of a shock like consumers cutting back their spending will be a reduction in production, not a cut in prices. Prices might be sticky for a number of reasons: menu costs, imperfect information, concerns of fairness, or simply money illusion. All seem plausible but no one explanation indisputably dominates the others.

9.2 INCOME AND EXPENDITURE

If prices are sticky, higher planned expenditure boosts production, and this boosts income. Higher income gives a further boost to consumption, and this in turn boosts planned expenditure some more. Thus any shift in a component of planned expenditure upward or downward leads to an amplified shift in total production because of the induced shift in consumption, as Figure 9.5 shows. The early-twentieth-century British economist John Maynard Keynes was one of the first to stress the importance of this multiplier process.

Whereas in booms the multiplier process induces an upward spiral in production, in bad times it is a source of misery. The downward shock is amplified as those who have been thrown out of work cut back on their consumption spending in turn.

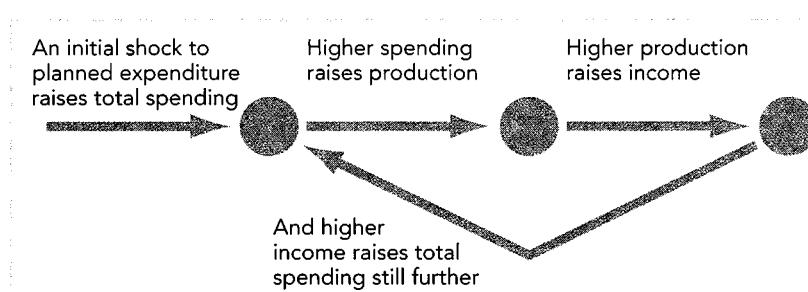
Because consumption spending is more than two-thirds of planned expenditure, this multiplier effect can be significant because the positive-feedback loop is so large — if the tax system has not been designed to provide the economy with so-called “automatic stabilizers,” and if the government does not take active steps to cushion the effects of shocks to planned expenditure.

Building Up Planned Total Expenditure

The rest of this chapter shows how the level of planned total expenditure, which we called *PE* back in Chapter 6, is determined in the sticky-price macroeconomic

FIGURE 9.5
The Multiplier Process

In the multiplier process, an increase in spending causes an increase in production and income, which leads to a further increase in spending. This positive-feedback loop amplifies the effect of any initial shift.



model. We will use a bottom-up approach, building planned total expenditure PE on domestically produced products up from the determinants of each of its components, consumption spending C , investment spending I , government purchases G , and net exports NX . The circular flow principle tells us that PE is the sum of C , I , G , and NX :

$$PE = C + I + G + NX$$

As long as prices are sticky, the level of real GDP is determined by the level of planned total expenditure

$$Y = PE$$

and not by the level of potential output Y^* .

Why? Recall our sticky-price assumption: Firms respond to falling spending by cutting back production and firing workers (and respond to rising spending by increasing production and hiring workers).

The Consumption Function

The two-thirds of GDP that is consumption spending is spending by households on things they find useful: services such as haircuts, nondurable goods such as food, and durable goods such as washing machines. As Figure 9.6 shows, when income rises consumption spending rises with it, increasing planned total expenditure and setting the multiplier process in motion. As we saw in Chapter 6, consumption spending does not rise dollar for dollar with total income. Economists call the share of an extra dollar of disposable income that is added to consumption spending the marginal propensity to consume (MPC), which is the parameter C_y in the consumption function equation that we saw in Chapter 6:

$$C = C_0 + C_y(1 - t)Y$$

The share of an extra dollar of national income that shows up as additional consumption spending is equal to the marginal propensity to consume times the share of income that escapes taxes: $C_y(1 - t)$.

marginal propensity to consume (MPC)

The increase in consumption spending resulting from a one-dollar increase in disposable income, C_y .

consumption function

The relationship between baseline consumption C_0 ; the marginal propensity to consume C_y ; and disposable income Y^D : $C = C_0 + C_y(Y^D) = C_0 + C_y(1 - t)Y$.

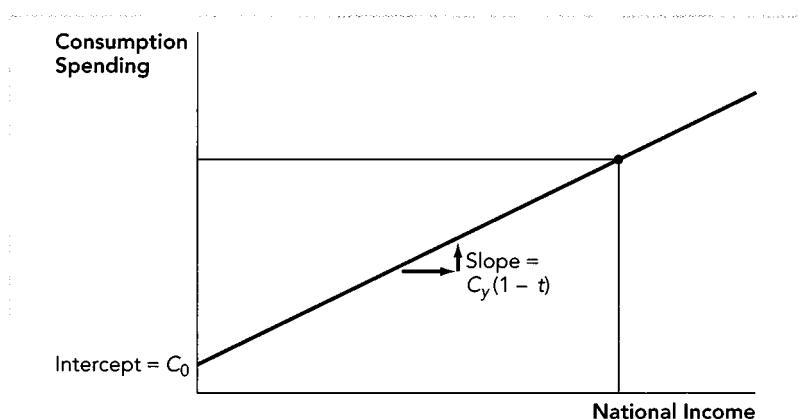


FIGURE 9.6
The Consumption Function and the Marginal Propensity to Consume

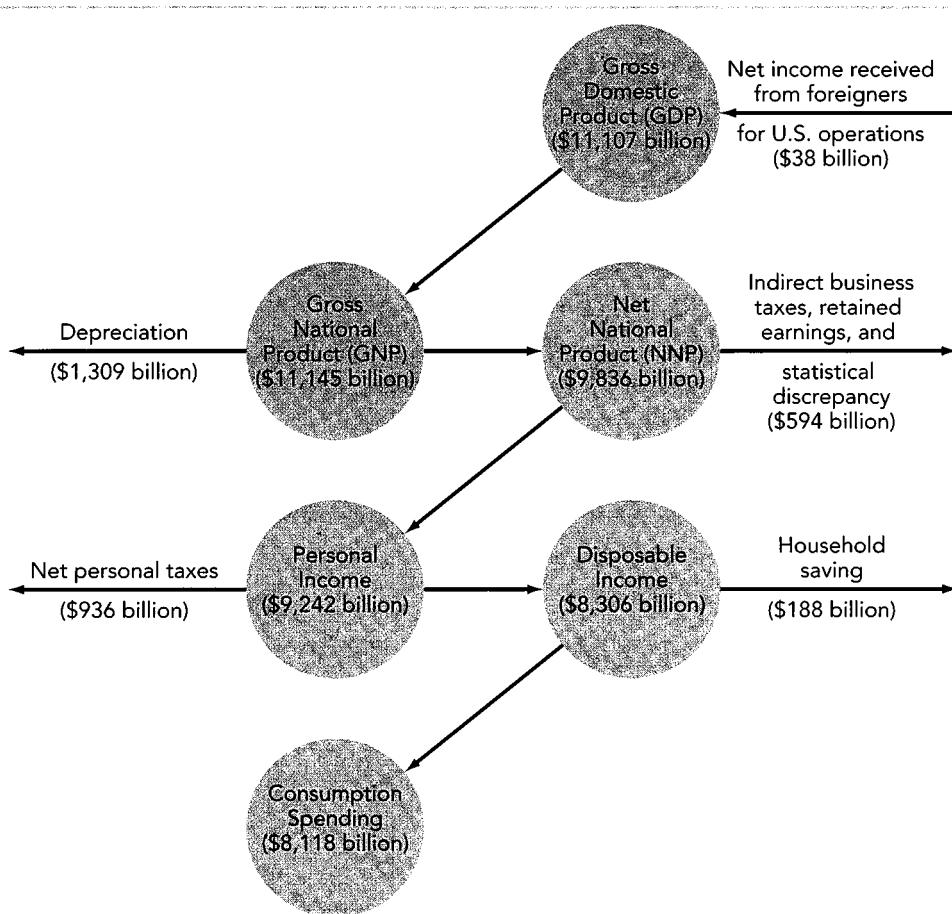
When drawn on a graph with economywide income on the horizontal axis and consumption spending on the vertical axis, the slope of the consumption function is the marginal propensity to consume times $(1 - t)$.

If changes in income are considered permanent, the MPC will be high: A \$1 increase in income will lead to an increase in consumption of as much as 80 cents. But if changes in income are considered transitory, the MPC will be low: A \$1 increase in income will lead to an increase in consumption of only 30 cents or so. Transitory increases in income have only a small effect on consumption because as we discussed in Appendix 6a people seek to smooth out their consumption spending over time.

For reasonably long-lasting shifts in the level of income, the MPC is roughly 0.6. That is, 60 cents of every extra dollar of disposable income shows up as higher consumption. Figure 9.7 shows how we get from the total flow of GDP down to the flow of consumption spending, which is GDP's largest component.

FIGURE 9.7

Consumption as a Function of After-Tax Disposable Income Three different factors drive the wedge between GDP and consumption spending. The first is depreciation: goods produced that merely replace obsolete and worn-out capital and so are a component of total cost rather than total income. The second is the tax system — both direct and indirect taxes. The third is household saving.



Box 9.1 shows how to use the consumption function and its parameters — baseline spending C_0 , the MPC C_y , and the tax rate t — to calculate consumption spending.

CALCULATING THE CONSUMPTION FUNCTION: AN EXAMPLE

Suppose statistical evidence tells us that the marginal propensity to consume out of disposable income C_y is 0.75. Suppose further that taxes amount to 40 percent of national income and that when real GDP — total national income — equals \$8 trillion, consumption equals \$5.5 trillion.

The fact that C_y is 0.75 and that the average tax rate t is 0.4 allows us to fill in some of the parameters in the consumption function:

$$\begin{aligned} C &= C_0 + C_y(1 - t)Y \\ &= C_0 + 0.75(1 - 0.4)Y \\ &= C_0 + 0.45Y \end{aligned}$$

We also know that when national income Y equals \$8 trillion, consumption C equals \$5.5 trillion:

$$\$5.5 \text{ trillion} = C_0 + 0.45 (\$8 \text{ trillion})$$

$$\$5.5 \text{ trillion} = C_0 + \$3.6 \text{ trillion}$$

$$\$1.9 \text{ trillion} = C_0$$

So the numerical form of the consumption function is

$$C = \$1.9 \text{ trillion} + 0.45 Y$$

Other Components of Total Expenditure

The determinants of the other components of planned total expenditure — investment spending, government purchases, and net exports — are familiar from Chapter 6. The level of investment spending is determined by the real interest rate and assessments of profitability made by business investment committees. In our model we represent these determinants by making investment spending I a function of the real interest rate r and of the parameters I_0 and I_r , the baseline level of investment spending and the interest sensitivity of investment.

$$I = I_0 - I_r r$$

The level of government purchases G is set by politics.

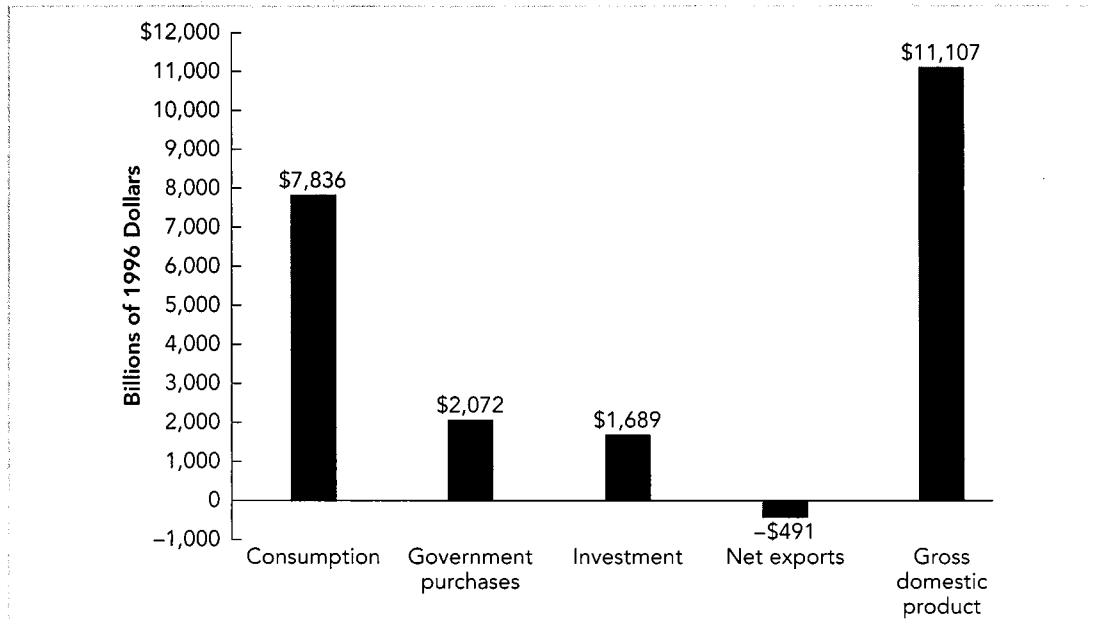
Net exports are equal to gross exports GX (a function of the real exchange rate ϵ and the level of foreign real GDP Y^f) minus imports. Imports IM are a function of national income Y :

$$NX = GX - IM = (X_f Y^f + X_\epsilon \epsilon) - IM_y Y$$

Figure 9.8 on page 266 shows the relative sizes of these four components of total expenditure.

FIGURE 9.8

Components of Total Expenditure By far the largest component of GDP is made up of consumption spending. Government purchases come second, and gross investment comes third. For the past two decades the United States has imported more than it has exported; hence net exports have been negative, not a contribution to but a subtraction from GDP.



Source: The 2004 edition of *The Economic Report of the President* (Washington, DC: Government Printing Office). Values do not sum exactly due to rounding.

Autonomous Spending and the Marginal Propensity to Expend

Let's take the equation for planned total expenditure

$$PE = C + I + G + NX$$

then separate net exports into its gross exports and imports components:

$$PE = C + I + G + (GX - IM)$$

and replace the two components of total expenditure that depend directly on national income Y — consumption spending C and imports IM — with their determinants:

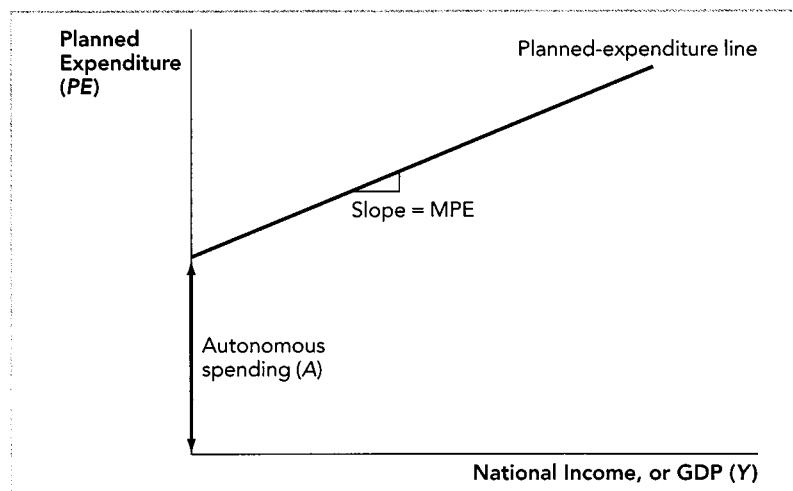
$$PE = [C_0 + C_y(1 - t)Y] + I + G + (GX - IM_y Y)$$

autonomous spending

Those components of planned expenditure that are independent of the level of national income.

We can now classify the components of planned total expenditure into two groups. The first group is so-called **autonomous spending**, which we will call A . Autonomous spending is made up of the components of planned total expenditure that do not depend directly on national income Y . Baseline consumption C_0 , investment spending I , government spending G , and gross exports GX are the components of autonomous spending A :

$$A = C_0 + I + G + GX$$

**FIGURE 9.9****The Income-Expenditure Diagram**

On the income-expenditure diagram, the line showing the relationship between total economy-wide income and total planned expenditure — the planned-expenditure line — is determined by two things: autonomous spending, the level at which the planned-expenditure line intercepts the vertical axis; and the marginal propensity to expend, the slope of the planned-expenditure line.

The second group includes the other two components of total expenditure — non-baseline consumption $C_y(1 - t)Y$ and a negative contribution from imports IM_yY :

$$C_y(1 - t)Y - IM_yY$$

Factor out income from this expression to get

$$[C_y(1 - t) - IM_y]Y$$

and let's call $C_y(1 - t) - IM_y$ the marginal propensity to expend on domestic goods: the MPE. Then we can write planned total expenditure PE in the simple form

$$PE = A + (MPE)(Y)$$

which Figure 9.9 shows, plotting planned total expenditure on the vertical axis and national income or real GDP on the horizontal axis of this version of what is called the income-expenditure diagram.

The vertical intercept of the planned-expenditure line is the level of autonomous spending A . The planned-expenditure line's slope is the marginal propensity to expend MPE. A change in the value of any determinant of any component of autonomous spending — the baseline levels of consumption C_0 , investment I_0 , or government purchases G ; the real interest rate r ; and foreign-determined variables that affect exports directly or indirectly (like foreign interest rates r^f , foreign levels of real income Y^f , or speculators' view of exchange rate fundamentals ε_0) — will shift the planned total expenditure line up or down. The higher the autonomous spending, the further from the horizontal axis the planned total expenditure line will be (see Figure 9.10 on page 268).

Changes in the marginal propensity to consume C_y , the tax rate t , or the propensity to spend on imports IM_y will change the MPE and the slope of the planned expenditure line. The higher the MPE, the steeper is the slope of the planned-expenditure line (see Figure 9.11 on page 268). Box 9.2 on page 269 provides an example of how to calculate the MPE.

marginal propensity to expend (MPE)

The increase in total spending — on consumption goods through the marginal propensity to consume and on net exports — from a one-dollar increase in national income.

income-expenditure diagram

The tool for figuring out what the equilibrium level of planned expenditure and gross domestic product is. Also known as the Keynesian cross diagram.

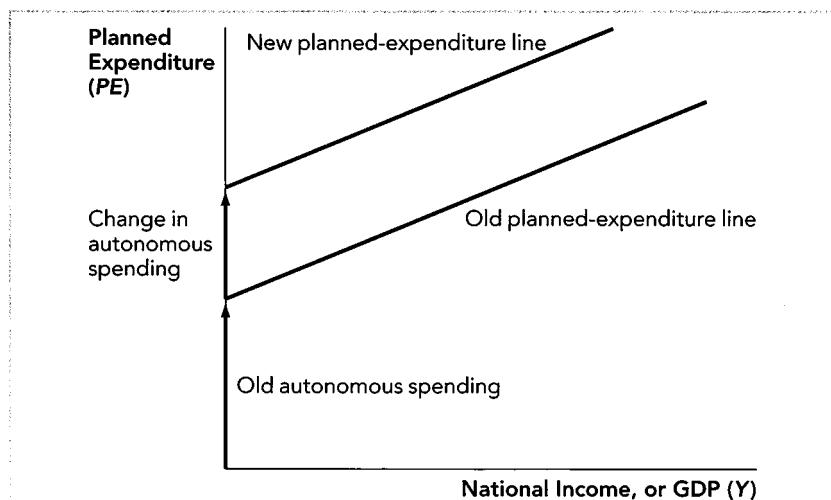
planned-expenditure line

Found on the income-expenditure (or Keynesian cross) diagram that shows planned expenditure on the vertical axis and national income on the horizontal axis. The planned-expenditure line shows planned total expenditure, $PE = C + I + G + NX$, as a function of the level of national income.

FIGURE 9.10

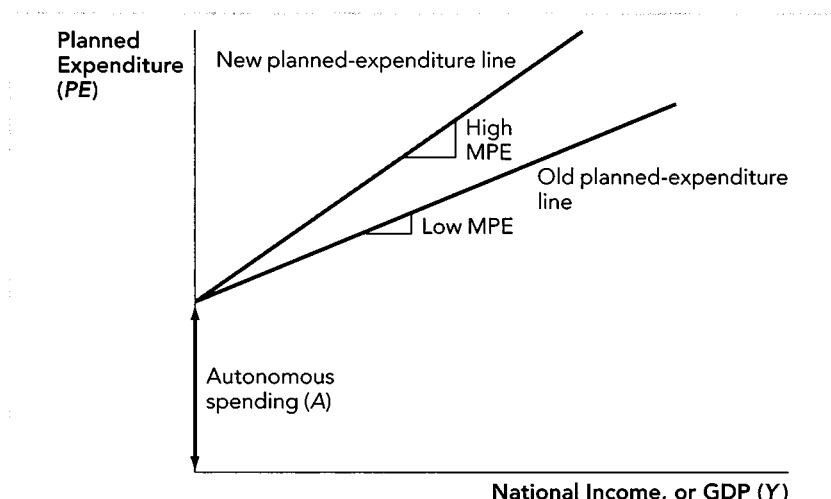
An Increase in Autonomous Spending

An increase in autonomous spending shifts the planned-expenditure line upward.

**FIGURE 9.11**

An Increase in the Marginal Propensity to Expend

A change in the marginal propensity to expend changes the slope of the planned-expenditure line.



Sticky-Price Equilibrium

The economy will be in equilibrium when planned total expenditure equals real GDP — which is, according to the circular-flow principle, the same as national income. Under these conditions there will be no short-run forces pushing for an immediate expansion or contraction of national income, real GDP, or total expenditure.

On the income-expenditure diagram, the points at which planned total expenditure equals national income are a line running up and to the right at a 45-degree angle with respect to the horizontal axis, as Figure 9.12 on page 270 shows. This

CALCULATING THE MPE: AN EXAMPLE

In the planned-expenditure function

$$PE = A + (MPE)(Y)$$

the marginal propensity to expend (MPE) will be less than the slope of the consumption function $C_y(1 - t)$ because of the effect on the economy of imports.

Thus if the marginal propensity to consume C_y is 0.75 and the tax rate is 40 percent, the 0.45 slope of the consumption function is an upper bound to the MPE. If imports are 15 percent of real GDP, then

$$\begin{aligned} MPE &= [C_y(1 - t) - IM_y] \\ &= [0.75(1 - 0.4) - 0.15] \\ &= 0.45 - 0.15 = 0.30 \end{aligned}$$

Such relatively small values of the MPE are typical for modern industrialized economies, which have substantial amounts of international trade (that is, relatively high values for IM_y), large social-democratic social-insurance states (that is, relatively high values for t), and deep and well-developed financial systems that provide ample room for household borrowing and lending to smooth out consumption (that is, relatively small values for C_y as well). However, in the past, in relatively closed economies, or in economies with undeveloped financial systems, the MPE can be significantly higher.

45-degree line shows all the possible points of equilibrium: all the points where planned expenditure equals national income. The actual equilibrium the economy will find in the sticky-price short run will be that point at which planned total expenditure is equal to actual national income; the point where this planned-expenditure line intersects the 45-degree equilibrium-condition line is the economy's equilibrium.

In algebra, the equilibrium values of planned total expenditure PE and real GDP or national income Y must satisfy both the planned-expenditure function:

$$PE = A + (MPE)(Y)$$

and the equilibrium condition

$$PE = Y$$

Substituting Y for PE in the first of these equations and regrouping, the solution is

$$Y = \frac{A}{1 - MPE}$$

If the numerical values of the parameters of the planned-expenditure function are $A = \$5,600$ billion and $MPE = 0.3$, then planned total expenditure as a function of real GDP is

$$PE = 5,600 + 0.3(Y)$$

The equilibrium level of real GDP and total expenditure is then

$$Y = \$8,000 \text{ billion}$$

What forces drive the economy to its short-run sticky-price *goods market equilibrium*? If the economy is not on the 45-degree line, then planned expenditure PE does not equal real GDP Y . If Y is greater than PE , there is excess supply of goods.



planned-expenditure function

The relationship $PE = C + I + G + NX$ used to build planned expenditure for domestically produced products from the determinants of each of its components: consumption spending C , investment spending I , government purchases G , and net exports NX .

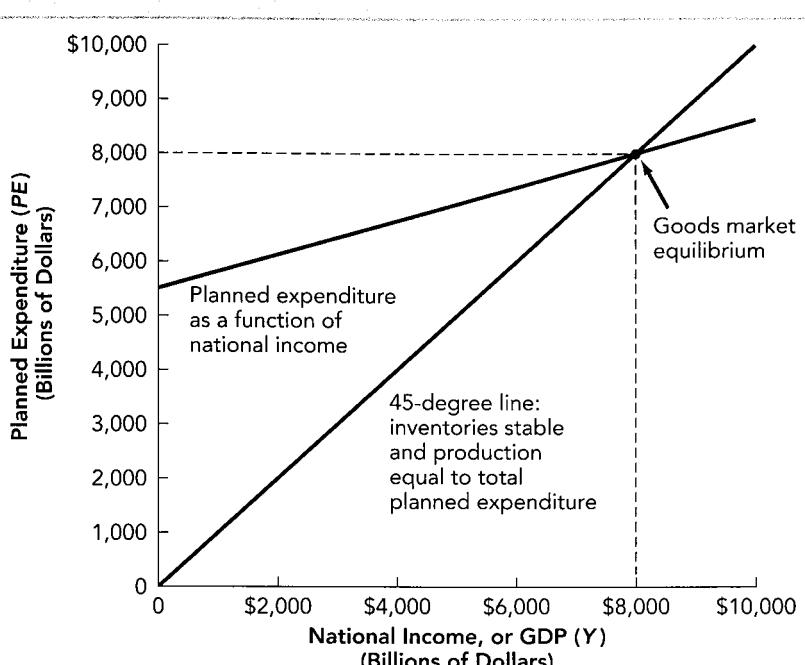


FIGURE 9.12
Equilibrium on the
Income-Expenditure
Diagram

On the income-expenditure diagram, the equilibrium point of the economy is that point where planned expenditure (as a function of national income) is equal to total product.

If PE is greater than Y , there is excess demand for goods. In neither case is the economy in equilibrium.

In the first case, in which production exceeds planned expenditure, inventories are rising rapidly, and firms unwilling to accumulate unsold and unsellable inventories are about to cut production and fire workers (see Figure 9.13). In the second case, in which planned expenditure exceeds production, inventories are falling rapidly. Businesses are selling more than they are making. Some businesses will respond to the fall in inventories by boosting prices, trying to earn more profit per good sold. But the bulk of businesses will respond to the fall in inventories by expanding production to match planned expenditure. They are about to hire more workers. Real GDP and national income are about to expand.

Now suppose that businesses see their inventories falling and respond by boosting their production to equal last month's planned expenditure. Will such an increase bring the economy into goods market equilibrium, with planned expenditure equal to total income and real GDP? The answer is that it will not. To boost production, firms must hire workers, paying more in wages and causing household income to rise. But when income rises, total spending rises as well. Thus the increase in production and income generates a further expansion in planned expenditure.

Even after production has increased to close the initial gap between planned expenditure and national income, the economy will still not be in equilibrium, as Figure 9.14 shows. Inventories will be falling even though hiring more workers has increased production. Because hiring more workers has also boosted total income and further increased planned expenditure, production will have to

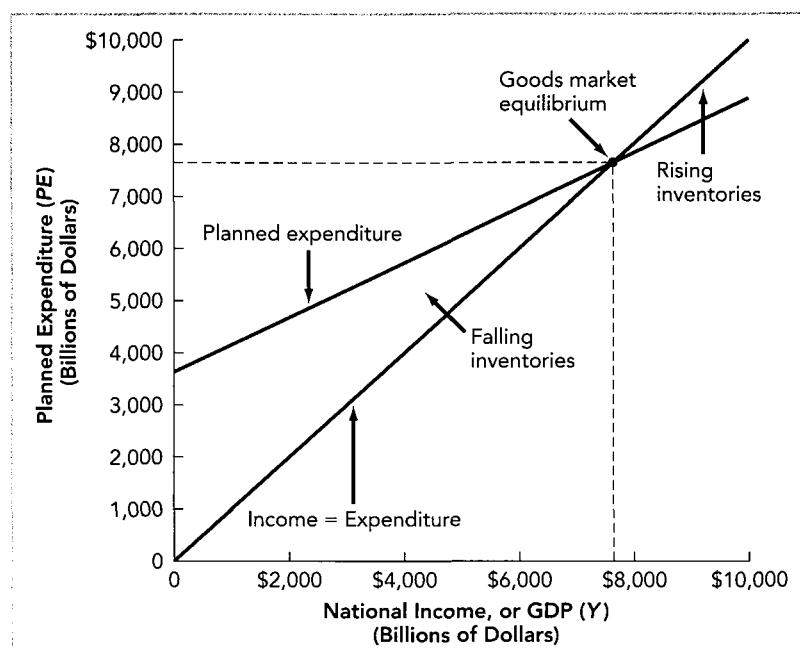


FIGURE 9.13
Inventory Adjustment
and Equilibrium: The
Income-Expenditure
Diagram

If the economy is not at its equilibrium point, then either actual production exceeds planned expenditure (in which case inventories are rising) or planned expenditure exceeds actual production (in which case inventories are falling).

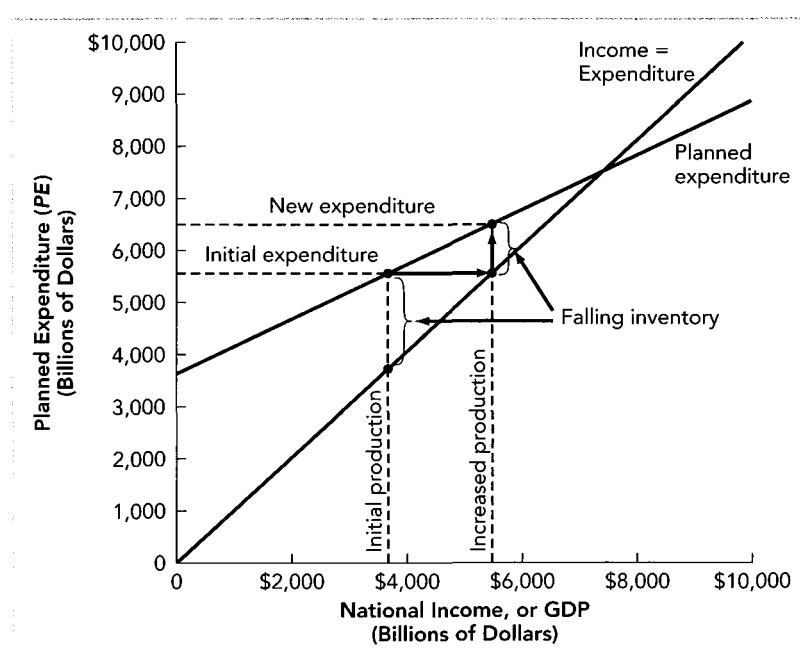


FIGURE 9.14
The Inventory-
Adjustment Process
If planned expenditure is
greater than total produc-
tion, inventories are
falling. Businesses will hire
more workers and
increase production. But
increasing production just
by the fall in inventory
won't bring the economy
to equilibrium because
planned expenditure rises
with production and
income.



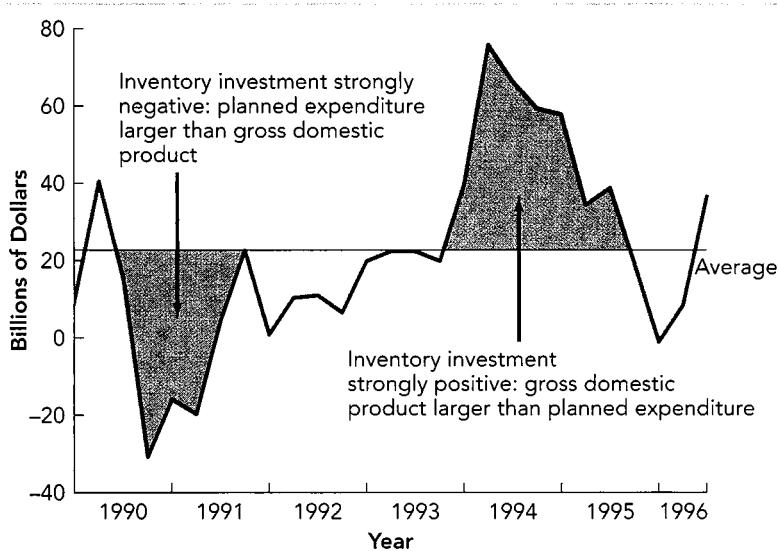
HOW FAST DOES THE ECONOMY MOVE TO EQUILIBRIUM? SOME DETAILS

At any one particular moment the economy does not have to be in short-run equilibrium. Planned expenditure can exceed real GDP and national income, and inventories can fall, for periods as long as a year. Strong forces are pushing the economy toward short-run equilibrium. Businesses do not like to lose money by producing things that they cannot sell or by not having things on hand that they could sell. But it takes at least months, usually quarters, and possibly more time for businesses to expand or cut back production.

For example, between the summer of 1990 and the summer of 1991 inventories fell for five straight quarters. Real GDP was less than planned expenditure as businesses decided that their high levels of inventories were too large given the economic uncertainties created by the Iraqi invasion of Kuwait and the subsequent recession. Between the winter of 1994 and the summer of 1995, for six quarters, inventories rose. For a year and a half GDP was greater than planned expenditure. (See Figure 9.15.)

FIGURE 9.15

Inventories as the Balancing Item: Inventory Investment in the Early and Mid-1990s



Source: The 2004 edition of *The Economic Report of the President* (Washington, DC: Government Printing Office).

expand by a multiple of the initial gap in order to stabilize inventories. The process will come to an end, with planned expenditure equal to national income, only when both have risen to the level at which the planned-expenditure line crosses the 45-degree income-equals-expenditure line. Box 9.5 provides a worked example. And the process works in reverse to lower production and expenditure if planned expenditure is initially below national income.

THE SEPTEMBER 11 TERRORIST ATTACK ON THE WORLD TRADE CENTER: AN EXAMPLE

The U.S. economy was already in recession in the summer of 2001 when the terrorist attack on the World Trade Center sent it into a further downward spiral. The attack on September 11, 2001, reduced autonomous spending through two different channels. First, the attack shook *consumer confidence*: The Conference Board's index fell from 114 in August 2001 to 85 in November. Baseline consumption spending, the parameter C_0 in the consumption function, is closely linked to consumer confidence. Second, the attack increased uncertainty. Would there be further attacks? What would the U.S. military response be? How would U.S. government spending shift in response to the attack?

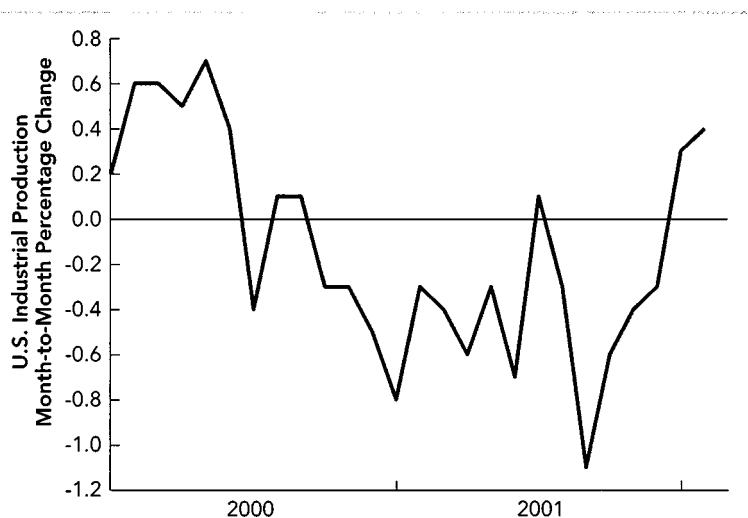
The first rule of planning for the future is that whenever uncertainty is unusually high, you are better off delaying whatever decisions you can until some of this uncertainty is resolved. Thus businesses undertaking investment projects adopted a wait-and-see approach. The result was that autonomous spending fell.

Had the terrorist attack been the only major shock to the U.S. economy, the recession would have been longer and deeper than turned out to be the case. However, three countervailing forces boosted planned expenditure. First, the Federal Reserve greatly reduced interest rates, and so stimulated investment. Second, the Bush tax cut of 2001 boosted consumers' incomes in 2002 by some \$80 billion

9.4

FIGURE 9.16

Month-to-Month Changes in U.S. Industrial Production, 2000–2002 Industrial production in the United States had been declining since late 2000 but was showing signs of recovery when the attack on the World Trade Center on September 11, 2001, shook consumer and business confidence. As consumers cut back on spending and as businesses adopted a wait-and-see attitude, U.S. industrial production dropped an additional 2.2 percent in the four months before recovery began.



and so boosted consumption spending. Most of this money went to high-income consumers with relatively low marginal propensities to consume, so it was not the most effective stimulus, but it was still welcome at the time. Third, the mobilization for the War against Terror boosted government purchases G .

Thus the economy began to rebound in 2002. But because the downward shock had been large and because the tax cut was not well designed to be the most effective employment-generating stimulus, the recovery from September 11 was slower than average as far as employment growth was concerned.



CALCULATING THE DIFFERENCE BETWEEN PLANNED EXPENDITURE AND REAL GDP: AN EXAMPLE

Suppose that our planned-expenditure function has numerical values for its coefficients, so that in trillions

$$\begin{aligned} PE &= A + (MPE)(Y) \\ &= \$5.6 + 0.3Y \end{aligned}$$

Suppose first that the current level of real GDP Y is \$7.5 trillion. Then *planned total expenditure* is

$$\begin{aligned} PE &= \$5.6 + (0.3)(\$7.5) \\ &= \$7.85 \text{ trillion} \end{aligned}$$

and business inventories are being drawn down at a rate

$$\frac{\Delta \text{ inventories}}{\Delta \text{ time}} = Y - PE = -\$0.35 \text{ trillion per year}$$

Suppose, instead, that the current level of total real GDP Y is \$8.5 trillion. Then *planned total expenditure* is

$$\begin{aligned} PE &= \$5.6 + (0.3)(\$8.5) \\ &= \$8.15 \text{ trillion} \end{aligned}$$

and business inventories are being added to at a rate

$$\frac{\Delta \text{ inventories}}{\Delta \text{ time}} = \$0.35 \text{ trillion per year}$$

However, if the current level of total national income (and of real GDP) Y is \$8.0 trillion, then *total planned expenditure* is

$$\begin{aligned} PE &= \$5.6 + (0.3)(\$8.0) \\ &= \$8.0 \text{ trillion} \end{aligned}$$

and business inventories are stable

$$\frac{\Delta \text{ inventories}}{\Delta \text{ time}} = \$0$$

RECAP INCOME AND EXPENDITURE

The force that pushes real GDP Y to equal planned total expenditure PE is the inventory-adjustment process. If real GDP exceeds planned expenditure, inventories are rising rapidly. Firms are unwilling to accumulate unsold and unsellable inventories, so they are about to cut production and fire workers to reduce real GDP. If real GDP is less than planned expenditure, inventories are falling rapidly as businesses are selling more than they are making. Businesses are about to expand production, hire more workers, and thus raise real GDP.

9.3 THE MULTIPLIER

Determining the Size of the Multiplier

Suppose something happens to change the level of planned total expenditure at every possible level of national income. Anything that affects the level of autonomous spending will do. What would then happen to the equilibrium level of total income and real GDP?

An upward shift in the planned-expenditure line would increase the equilibrium level of national income. At the prevailing level of national income, planned total expenditure would be larger than real GDP. Businesses would find themselves selling more than they were making, and their inventories would fall. In response, businesses would boost production to try to keep inventories from being exhausted, and production would expand.

How much production would expand depends on the magnitude of the change in autonomous spending and the value of the spending multiplier.

The value of this spending multiplier depends on the slope of the planned-expenditure line, the marginal propensity to expend (MPE). The higher the MPE, the steeper is the planned expenditure line and the greater is the multiplier. A large multiplier can amplify small shocks to spending patterns into large changes in total production and income, as Figure 9.17 on page 276 shows.

To calculate the multiplier, recall the equation for the short-run sticky-price equilibrium level of real GDP,

$$Y = \frac{A}{1 - MPE}$$

Suppose autonomous spending changes by an amount ΔA . Then the change ΔY in the equilibrium level of real GDP is

$$\Delta Y = \left(\frac{1}{1 - MPE} \right) \Delta A$$

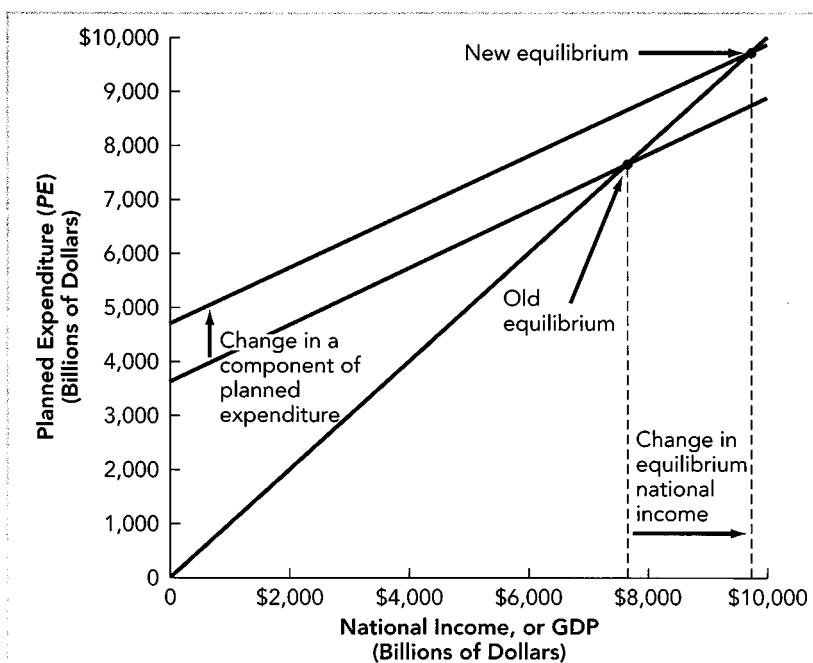
The factor $1/(1 - MPE)$ is the multiplier: It multiplies the upward shift in the planned-expenditure line as a result of the increase in autonomous spending into a change in the equilibrium level of real GDP, total income, and total expenditure.

Why the factor $1/(1 - MPE)$? Think of it this way: The MPE — the marginal propensity to expend — is the slope of the total-expenditure line. A \$1 increase in national income raises the equilibrium level of planned expenditure by \$1, because

spending multiplier

The change in national income and total expenditure that follows from a one-dollar change in any component of autonomous spending. Also known as the *Keynesian multiplier*.

FIGURE 9.17
The Multiplier Effect
 An increase in autonomous spending will generate an amplified increase in the equilibrium level of national income. Why? Because planned expenditure will rise not just by the increase in autonomous spending but by the increase in autonomous spending plus the marginal propensity to expend times the increase in the equilibrium level of national income.



expenditure has to go \$1 higher to balance income and production. It also raises the level of planned expenditure by $\$MPE$. Thus a \$1 increase in the level of total income closes $\$(1 - MPE)$ of the gap between planned expenditure and total income as Figure 9.17 shows. To close a full initial gap of $\$ΔA$ between planned expenditure and national income, the equilibrium level of national income must increase by $\$ΔA/(1 - MPE)$.

Because autonomous spending is influenced by a great many factors,

$$A = C_0 + (I_0 - I_r r) + G + (X_f Y^f + X_e \varepsilon_0 - X_e \varepsilon_r r + X_e \varepsilon_r r^f)$$

almost every change in economic policy or the economic environment will set this multiplier process in motion.

Changing the Size of the Multiplier

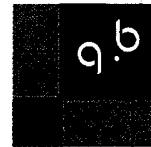
One factor that tends to minimize the multiplier is the tax system: whether the tax system has been designed to provide the government with *fiscal automatic stabilizers*. The government doesn't levy a total lump-sum tax independent of the state of the economy. Instead the government imposes roughly proportional (actually slightly progressive) taxes on the economy, so government tax collections are equal to a tax rate t times the level of GDP Y : the total tax take equals tY .

This means that when GDP is relatively high the government collects more in tax revenue than it would with a lump-sum tax. The collection of extra revenue

THE VALUE OF THE MULTIPLIER: AN EXAMPLE

Suppose that the planned-expenditure function has values for its parameters of $A = \$5.6$ trillion and $MPE = 0.3$, so that

$$\begin{aligned} PE &= A + (MPE)(Y) \\ &= \$5.6 \text{ trillion} + 0.3Y \end{aligned}$$



Then the equilibrium value of total income (and of real GDP) Y is \$8 trillion, for only at $Y = \$8$ trillion is planned expenditure equal to real GDP.

Now suppose that autonomous spending A increases by an amount of \$100 billion, or \$0.1 trillion:

$$\Delta A = \$0.1$$

Then the planned-expenditure function is

$$PE = \$5.7 + 0.3Y$$

and the equilibrium value of total income (and real GDP) Y is \$8.143.

The change in Y divided by the change in autonomous spending is

$$\frac{\Delta Y}{\Delta A} = 1.43$$

This is equal to

$$1.43 = \frac{1}{1 - 0.3} = \frac{1}{1 - MPE}$$

which we saw above is the definition of the multiplier.



dampens swings in after-tax income and thus reduces consumption. Similarly, the government collects less in tax revenue when GDP is relatively low; thus after-tax income is higher than that under lump-sum taxes, and this higher income boosts consumption. Because the fall in consumption is smaller with a proportional rather than a lump-sum tax, the multiplier is smaller. Disturbances to spending are not amplified as much as they would be with a lump-sum tax, and so shocks to the economy tend to cause smaller business cycles. The automatic working of the government's tax system (and, to a lesser extent, its social welfare programs) functions as an automatic stabilizer, reducing the magnitude of fluctuations in real GDP and unemployment.

Substituting our detailed expression for calculating the MPE,

$$MPE = C_y(1 - t) - IM_y$$

into our definition of the multiplier,

$$\text{Multiplier} = \frac{1}{1 - MPE}$$

tells us that under a proportional tax system the multiplier is

$$\frac{\Delta Y}{\Delta A} = \frac{1}{1 - MPE} = \frac{1}{1 - [C_y(1 - t) - IM_y]}$$

If the government levied lump-sum taxes, the multiplier would be

$$\frac{\Delta Y}{\Delta A} = \frac{1}{1 - MPE} = \frac{1}{1 - (C_y - IM_y)}$$

The difference is the $(1 - t)$ term that is missing from the denominator of the last expression in the equation above.

How important is this $(1 - t)$ term? How large are fiscal automatic stabilizers in the United States today? When national product and national income drop by a dollar, income tax and social security tax collections fall automatically by at least one-third of a dollar. Thus the fall in consumers' disposable income is only two-thirds as great as the fall in national income, and the fall in consumption is only two-thirds as large as it would be without fiscal automatic stabilizers.

A more globalized economy will also have a smaller multiplier. An economy that is more open to world trade will have a smaller multiplier than will a less open economy. The more open the economy, the greater is the marginal propensity to expend on imports. The more of every extra dollar of income spent on imports, the less is left to be devoted to planned expenditure on domestic products — and therefore the smaller is the multiplier. If the share of imports in GDP is large, the potential change in the multiplier from an *open economy*,

$$\frac{\Delta Y}{\Delta A} = \frac{1}{1 - MPE} = \frac{1}{1 - [C_y(1 - t) - IM_y]}$$

to that for a *closed economy*,

$$\frac{\Delta Y}{\Delta A} = \frac{1}{1 - MPE} = \frac{1}{1 - [C_y(1 - t)]}$$

can be considerable. The difference is the missing IM_y term in the denominator of the equation above. In modern industrialized economies where the share of imports in real GDP is certainly more than 10 percent, any calculation of the multiplier will be significantly off unless it takes account of the effects of world trade.

RECAP THE MULTIPLIER

If prices are sticky, higher planned expenditure boosts production, and this boosts income. Higher income gives a further boost to consumption, and this in turn boosts aggregate demand some more. Thus any shift in a component of planned expenditure upward or downward leads to a multiplied shift in total production. The early-twentieth-century British economist John Maynard Keynes was one of the first to stress the importance of this multiplier process. The multiplier arises because planned expenditure PE is equal to autonomous spending A plus the marginal propensity to expend MPE times national income Y : $PE = A + (MPE)(Y)$.

In equilibrium, planned expenditure PE equals national income Y , which is true if and only if $Y = A[1/(1 - MPE)]$. The term $1/(1 - MPE)$ is the value of the multiplier.

Chapter Summary

1. Business-cycle fluctuations can push real GDP away from potential output and push unemployment far away from its average rate.
2. If prices were perfectly and instantaneously flexible, there would be no such thing as business-cycle fluctuations. Hence macroeconomics must consist in large part of models in which prices are not flexible but sticky.
3. Prices might be sticky for a number of reasons: menu costs, imperfect information, concerns of fairness, or simple money illusion. All seem plausible. None has overwhelming evidence of importance vis-à-vis the others.
4. In the short run, while prices are sticky, the level of real GDP is determined by the level of planned total expenditure.
5. The short-run equilibrium level of real GDP is that level at which planned total expenditure as a function of national income is equal to the level of national income, or real GDP, itself.
6. Two quantities summarize planned total expenditure as a function of total income: the level of autonomous spending and the marginal propensity to expend (MPE).
7. The level of autonomous spending is the intercept of the planned-expenditure function on the income-expenditure diagram. It tells us what the level of planned expenditure would be if national income were zero.
8. The MPE is the slope of the planned-expenditure function on the income-expenditure diagram. It tells us how much planned expenditure increases for each \$1 increase in national income.
9. The value of the MPE depends on the tax rate t , the marginal propensity to consume C_y , and the share of spending on imports IM_y . Algebraically, $MPE = C_y(1 - t) - IM_y$.
10. In the simple macro models, an increase in any component of autonomous spending causes a more-than-proportional increase in real GDP. This is the result of the multiplier process.
11. The size of the multiplier depends on the marginal propensity to expend (MPE): the higher the MPE, the higher is the multiplier. The value of the multiplier is
$$\frac{\Delta Y}{\Delta A} = \frac{1}{(1 - MPE)}$$
.

Key Terms

flexible prices (p. 255)	marginal propensity to consume (MPC) (p. 263)	income-expenditure diagram (p. 267)
sticky prices (p. 256)	consumption function (p. 263)	planned expenditure line (p. 267)
menu costs (p. 261)	autonomous spending (p. 266)	planned-expenditure function (p. 269)
imperfect information (p. 261)	marginal propensity to expend (MPE) (p. 267)	spending multiplier (p. 275)
money illusion (p. 261)		

Analytical Exercises

1. Describe, in your own words, the factors that determine the slope of the planned-expenditure line.
2. Suppose that government purchases increase by \$100 billion but there are no other changes in economic policy or the economic environment.
 - a. What effect does this increase in government purchases have on the location of the planned-expenditure line?
 - b. What effect does this increase in government purchases have on the planned-expenditure function?
 - c. What effect does this increase in government purchases have on the equilibrium level of total expenditure, national income, and real GDP?
3. Consider an economy in which prices are sticky, the marginal propensity to consume out of disposable

- income C_y is 0.6, the tax rate t is 0.25, and the share of national income spent on imports IM_y is 20 percent.
- Suppose that total autonomous spending is \$6 trillion. Graph planned expenditure as a function of total national income.
 - Determine the equilibrium level of national income and real GDP.
 - What is the value of the multiplier?
 - Suppose that total autonomous spending increases by \$100 billion to \$6.1 trillion. What happens to the equilibrium level of national income and real GDP Y ?
 - Suppose that prices are sticky; the marginal propensity to consume out of disposable income C_y is 0.9. Suppose further that the economy is closed — the share of national income spent on imports is zero — and that the tax rate is 12.5 percent.
 - What is the marginal propensity to expend?
 - What is the value of the multiplier?

- What level of autonomous spending would be needed to attain a level of equilibrium total expenditure equal to \$10 trillion?
- Classify the following changes into two groups: those that increase equilibrium real GDP and those that decrease real GDP.
 - An increase in consumers' desire to spend today.
 - An increase in interest rates overseas.
 - A decline in foreign exchange speculators' confidence in the value of the home currency.
 - A fall in real GDP overseas.
 - An increase in government purchases.
 - An increase in managers' expectations of the future profitability of investments.
 - An increase in the tax rate.

Policy Exercises

- Suppose that the economy is at its full-employment level of output of \$8 trillion, with government purchases equal to \$1.6 trillion, the net tax rate equal to 20 percent, and the budget in balance.
 - Suppose that adverse shocks to consumption and investment lead real GDP to fall to \$7.5 trillion. What is the level of taxes collected? What is the government's budget deficit?
 - Suppose that favorable shocks to consumption and investment lead real GDP to rise to \$9.5 trillion. What is the level of taxes collected? What is the government's budget balance?
 - Most economists like to calculate a "full-employment budget balance," equal to government purchases minus what tax collections would be if the economy were at full employment, and to take that balance as their summary measure of the short-run effect of government taxes and spending on the level of real GDP. What advantages does such a full-employment budget measure have over the actual budget as a measure of economic policy? What disadvantages does it have?
- Suppose that the economy is short of its full-employment level of GDP, \$8 trillion, by \$500 billion, with the MPC out of disposable income equal to 0.6, the import share IM_y equal to 0.2, and the tax rate t equal to 25 percent.
 - Suppose the government wants to boost real GDP up to full employment by cutting taxes. How large a cut

- in the tax rate is required to do so? How large a cut in total tax collections is produced by this cut in the tax rate?
- Suppose the government wants to boost real GDP up to full employment by increasing government spending. How large an increase in government spending is required to do so?
 - Can you account for any asymmetry between the answers to *a* and *b*?
 - Think about the four possible sources of price stickiness mentioned in this chapter: money illusion, fairness considerations, imperfect information, and menu costs. What have you read or seen in the past two months that strike you as examples of any of these four phenomena? In your opinion, which of the four sources seems most likely to be the most important?
 - What changes in the economy's institutions can you think of that would diminish price stickiness and increase price flexibility? What advantage in terms of the size of the business cycle would you expect to follow from such changes in institutions? What disadvantages do you think that such institutional changes might have?
 - Suppose the government wants to increase real GDP by \$500 billion. How would you suggest the government go about accomplishing this goal?

CHAPTER

10

Investment, Net Exports, and Interest Rates: The IS Curve

QUESTIONS

How do the determinants of investment and net exports in the sticky-price model differ from those of the flexible-price model?

How do changes in interest rates affect the equilibrium level of real GDP and national income in the sticky-price model?

What is the IS curve? How do we use it?

How do we calculate the equilibrium level of real GDP in the sticky-price model when the central bank's policy is to peg the real interest rate?

If we can understand the causes and consequences of changes in investment spending, we will understand much of what we need to know in order to understand the causes of America's business cycles. We do so in this chapter by building an analytical tool called the *IS curve*, where "IS" stands for "investment-saving." The IS curve tells us the relationship between total expenditure or real GDP on the one hand and the long-term risky real interest rate on the other. Changes in the interest rate increase or depress investment and gross exports and so move the economy down or up along the IS curve. Changes in businesses' optimism or pessimism cause increases or decreases in investment unrelated to changes in interest rates, and so shift the entire IS curve itself either out or in.

10.1 INTEREST RATES AND PLANNED TOTAL EXPENDITURE

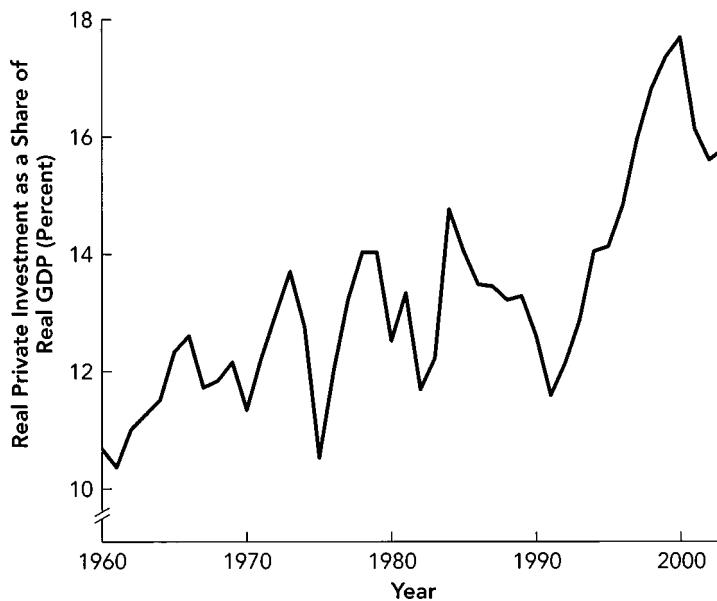
The Importance of Investment

The changes in investment spending shown in Figure 10.1 are the principal driving force behind the business cycle. Without exception, reductions in investment have played a powerful role in every single recession and depression. Falls in investment spending played an important role in generating the recessions of 1970, of 1974–1975, of 1979–1982, of 1990–1991, and of 2001–2002. Increases in investment have spurred every single *boom* — whether the late 1960s, the early 1970s, the late 1970s, the mid-1980s, or the late 1990s. Because of the multiplier, the swings in real GDP have invariably been larger than the swings in investment spending themselves.

FIGURE 10.1

Investment as a Share of Real GDP, 1960–2004

The substantial year-to-year swings in investment are one of the principal drivers of the business cycle. When investment booms, the economy as a whole booms too.



The Role of Investment

From this point our analysis of the role of investment spending will be the same but also different from the analysis carried out in the flexible-price model of Chapters 6 and 7. The determinants of investment are the same in both models: In both cases, investment is determined by (1) a baseline level of investment I_0 , (2) a sensitivity of investment to the real interest rate I_r , and (3) the level of the real interest rate r . But the kind of equilibrium the economy reaches and the process by which the economy reaches equilibrium are different. Hence the investment function plays a very different role in the two models.

In the flexible-price model in Chapters 6 and 7, the real interest rate was the market-clearing price. It was pushed up or down by supply and demand to equate the flow of saving into financial markets (from households and businesses, the government, and foreigners) to the flow of investment funding out of financial markets (to finance replacement of depreciated capital and increases in the capital stock). Supply and demand in the loanable funds market determined the interest rate. In the flexible-price model, the level of saving determined the level of investment, and the strength of investment demand determined the interest rate.

In the sticky-price model, the interest rate is not set in the loanable funds market. Instead, it is set directly by the central bank or indirectly by the combination of the stock of money and the liquidity preferences of households and businesses. The interest rate then determines the level of investment, which then plays a key role in autonomous spending. Together, autonomous spending and the multiplier determine the level of output.

“What happened to equilibrium in the loanable funds market?” you may ask. In a sticky-price model the fact that businesses match the quantity they produce to planned total expenditure automatically creates balance in the financial market, no matter what the interest rate. Any interest rate can be an equilibrium interest rate because the inventory-adjustment process has already made saving equal to investment.

Sources of Fluctuations in Investment

Fluctuations in investment have two sources. Some are triggered by changes in the real interest rate r . A lower real interest rate means higher investment spending, and a higher real interest rate means lower investment spending. Other fluctuations are triggered by shifts in investors’ expectations about future growth, profits, and risk. These two sources of fluctuations in investment correspond, respectively, to changes in investment spending I produced by (1) the interest sensitivity of investment parameter I_r , times changes in r , and (2) changes in the baseline level of investment I_0 in the investment function:

$$I = I_0 - I_r r$$

Both sources of fluctuation are important. Neither is clearly dominant.

Investment and the Real Interest Rate

A business that undertakes an investment project always has alternative uses for the money. One alternative would be to take the money that would have been spent building the factory or buying the machines and place it instead in the financial markets — that is, lending it out at the market real rate of interest. Thus the opportunity cost of an investment project is the real interest rate. The higher the

interest rate, the fewer the number and the smaller the value of investment projects that will return more than their current cost, and the lower the level of investment spending. But which interest rate is the relevant one? There are many different interest rates.

The Long-Term Interest Rate

long-term interest rate

The interest rate required if you are going to borrow money not for a short term of months but for a long term of decades.

short-term interest rate

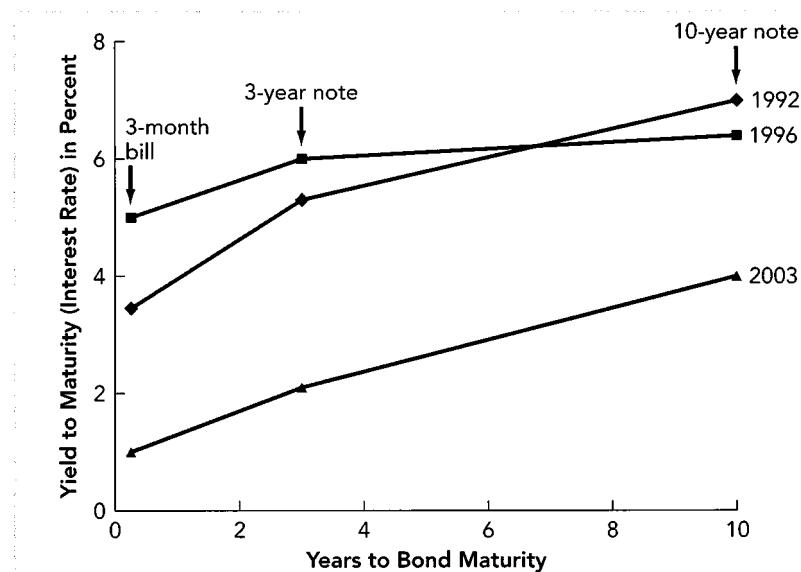
The interest rate paid to borrow money for the short term — three to six months.

This distinction matters because long- and short-term interest rates are different and do not always move in step. Figure 10.2 shows a standard yield curve chart, the *term structure* of interest rates, that plots the interest rate on safe U.S. government bonds of three different maturities — 3-month *Treasury bills*, 3-year *Treasury notes*, and 10-year *Treasury bonds* — at three different moments — 1992, 1996, and 2003. Looking at the shifts over time in such a yield curve chart shows that different interest rates do not always fluctuate together. The variable premium in the interest rate that the market charges on long-term loans vis-à-vis short-term loans is called the term premium. This creates the potential for problems for the Federal Reserve: What if it wants to lower interest rates to stimulate investment, and so buys three-month Treasury bills for cash to reduce the short-term interest

FIGURE 10.2

Bond Yield Curves

The interest rate the U.S. government must pay to borrow money depends on how long it wants to borrow the money. The same applies to private borrowers as well: Usually, the longer the term for which one wishes to borrow, the higher the interest rate one must pay.



rate, but finds the term premium rising and thus the long-term interest rate that matters for investment unchanged?

Long-term interest rates are usually higher than short-term rates because long-term assets are riskier, and investors demand a higher average return to compensate them for bearing this extra risk. As this chapter's appendix explains, when Wall Street bond traders expect short-term interest rates to rise in the future, the term premium is large. When they expect short-term interest rates to fall steeply, the term premium is negative, but such an inverted term premium is rare — the term structure of interest rates or yield curve is almost always upward sloping.

In 1992 and 2003 the yield curve was steep: long-term loans carried significantly higher interest rates than short-term loans; the term premium was high.¹ In 1996 the yield curve was nearly flat; the term premium was low. In 1992 and 1996 the general levels of interest rates were about the same. By 2003 the general level of interest rates had fallen all across the maturity structure; all three sets of Treasury assets paid lower returns than they had in 1992 or 1996.

The Real Interest Rate

The interest rate that is relevant for investment spending decisions is not the nominal but the real interest rate. The nominal price a business charges rises with inflation. If a business is willing to invest when the interest rate is 5 percent and inflation is 2 percent per year (and so the real interest rate is 3 percent per year), then the business should also be willing to invest when the interest rate is 10 percent and inflation is 7 percent per year (and so the real interest rate is still 3 percent per year). Figure 10.3 on page 286 shows both nominal and real interest rates in the United States. There is a big difference between the two.

The Risky Interest Rate

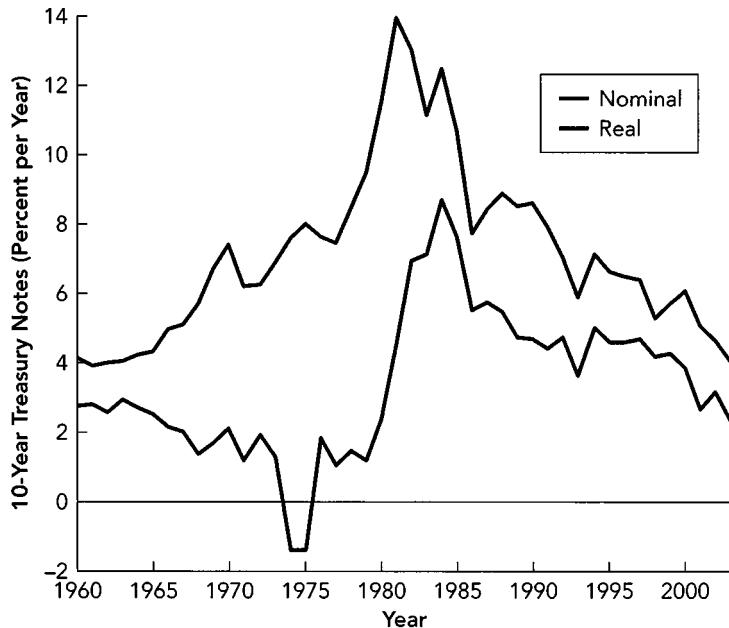
Lending money to a business always carries an element of risk. Perhaps the borrower will go bankrupt before the loan is due. Perhaps the creditors will find themselves last, or nearly last, in line as a small amount of leftover postbankruptcy assets are divided up. Financial institutions lending money are keenly interested in the financial health of those to whom they lend. The riskier they believe the loan is — the larger the possibility of a bankruptcy or a debt rescheduling appears to be — the higher is the interest rate that lenders will demand to compensate them for risk.

The interest rate that a firm faces is the interest rate charged to risky borrowers, not the interest rate charged to safe borrowers (like the U.S. government) to

¹Why was the term premium so high in 1992 and 2003? Two reasons. First, in both cases the Federal Reserve had aggressively pushed interest rates down in the recent past to try to boost investment and employment, so short-term interest rates were depressed below their normal levels, and markets were expecting the Federal Reserve to reverse itself as soon as employment returned to normal levels. As the appendix shows, the term premium is likely to be high when interest rates are expected to rise. Second, savers and investors in both 1992 and 2003 could look forward to a future in which there were large budget deficits that the government seemed to have no plans for reducing. In the flexible-price model, high budget deficits produce higher than normal interest rates. And so investors were expecting interest rates to soon be not just at normal but at higher than normal runaway-deficit levels.

FIGURE 10.3
Gaps between Real and Nominal Interest Rates, 1960–2003

Most borrowers and lenders care not about the nominal interest rate — the interest rate in terms of money — but about the real interest rate on loans — the interest rate in terms of goods. The difference between the nominal and the real interest rates is the inflation rate.



Source: Authors' calculations and 2004 edition of *The Economic Report of the President* (Washington, DC: Government Printing Office).

risky interest rate

The interest rate on assets where there is some chance the debtor will default.

safe interest rate

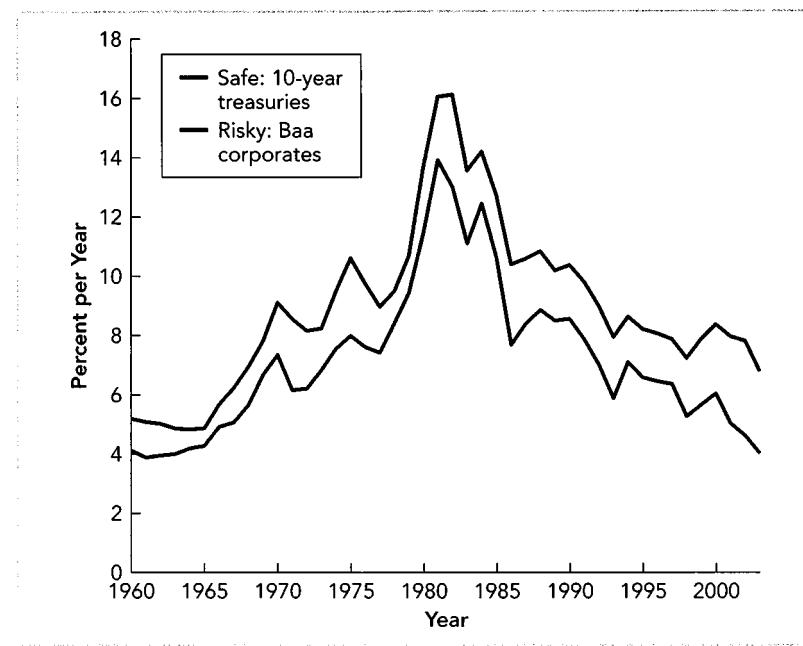
The interest rate on assets where there is no significant probability of default.

whom people lend when they want to sleep easily at night. The premium that lenders charge for loans to companies rather than to safe government borrowers is called the risk premium. (See Figure 10.4.) Financial and economic disturbances, like the default of the Russian government in August 1998, can cause large and swift moves in the risk premium. The risky interest rate does not always move in step with the safe interest rate.

Thus — bringing this all together — to determine the level of investment spending, take the baseline level of investment I_0 (determined by businesses' optimism, expected economic growth, and a bunch of other factors for which the level of the stock market serves as a convenient thermometer). Subtract from this baseline level the interest sensitivity of investment parameter I_r times the relevant interest rate r expressed in decimal form, so an interest rate of 3 percent is expressed as 0.03. The relevant interest rate must be long-term because most investments are long-term. The relevant interest rate must be real because investment projects are real assets: Their values rise with inflation. And the relevant interest rate must be risky because businesses borrowing to invest may go bankrupt. In the investment function

$$I = I_0 - I_r r$$

the relevant interest rate r is the long-term, real, risky interest rate, as is plotted in Figure 10.5. The nominal interest rate can be directly observed: It is what the newspapers print every day in their analyses of the *bond market*. The real interest rate is just the nominal interest rate minus the expected rate of



Source: The 2004 edition of *The Economic Report of the President* (Washington, DC: Government Printing Office).

FIGURE 10.4
The Risk Premium: Safe and Risky Interest Rates, 1960–2003

Loans that are not made to the U.S. government are risky: Lenders charge a risk premium that depends both on their tolerance for risk and on the amount of risk involved when they lend to other organizations. This risk premium is not constant but varies over time.

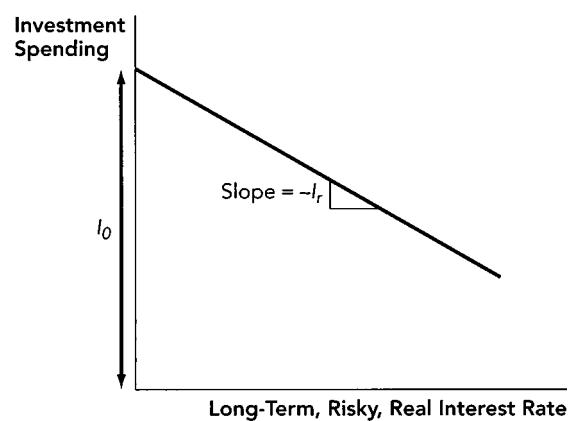


FIGURE 10.5
Investment as a Decreasing Function of the Long-Term, Real, Risky Interest Rate

The baseline level of investment I_0 tells us what the level of investment would be if the real interest rate were zero. The interest rate sensitivity parameter I_r tells us how much investment is discouraged by a 1-unit increase in the long-term, real, risky interest rate.

inflation. But can we find an easy way to observe the rest of the determinants of investment spending — all of those that are packed into the baseline level of investment spending I_0 ? Box 10.1 tells us that we can, by looking at the stock market.



THE STOCK MARKET AS AN INDICATOR OF FUTURE INVESTMENT: SOME TOOLS

Recall from Chapter 2 that if investors in the stock market are acting rationally, the level of the stock market P^s will be equal to

$$P^s = E^a \left(\frac{E^s}{E^a} \right) \left(\frac{1}{r + \sigma^s} \right)$$

where

- E^a is the accounting earnings corporations report.
- E^s/E^a is the ratio of the long-run “permanent” earnings investors expect to today’s accounting earnings. It is a measure of optimism, of expected future growth.
- r is the long-term real interest rate on bonds.
- σ^s is the risk premium investors require to invest in stocks rather than in less risky assets.

Thus the stock market sums up — in one easy-to-find number, reported daily — the real interest rate r plus the same important influences — profitability, expected growth, and attitudes toward risk — that determine the baseline level of investment I_0 .

Think of it this way: An investor deciding whether or not to commit his or her portfolio to stocks (rather than bonds) is making more or less the same decision as that made by a business’s investment committee deciding whether to build a factory. The purchase of a share of stock gives you title to a share in the ownership of past investments — factories, buildings, inventories, and organizations — that have been undertaken by one company. The same things that determine whether it is a good idea to undertake the construction of a new factory also determine whether it is a good idea to spend money to acquire title to a share of an old factory. And the conclusions reached by investors in the stock market, which we observe every day in stock price fluctuations, are likely to be much the same as the conclusions reached by businesses’ investment committees.

The higher the stock market, the higher is the likely future level of investment spending. 

Exports and Autonomous Spending

Investment spending is not the only component of autonomous spending that is affected by the real interest rate. In the total-expenditure function

$$PE = A + MPE \cdot Y$$

autonomous spending A — spending that does not depend upon income Y — includes not just baseline consumption, investment, and government purchases, but gross exports as well:

$$A = C_0 + I + G + GX$$

As we saw in Chapter 6, gross exports depend on foreign total income Y^f and the real exchange rate ϵ . So we can expand the determinants of gross exports in the

expression for autonomous spending:

$$A = C_0 + (I_0 - I_r r) + G + (X_f Y^f + X_e \varepsilon)$$

As we also saw in Chapter 6, the real exchange rate ε depends on the domestic real interest rate r as well as on foreign exchange speculators' opinions of fundamentals ε_0 and foreign interest rates r^f :

$$\varepsilon = \varepsilon_0 - \varepsilon_r(r - r^f)$$

Substituting this equation for the determinants of the exchange rate into the autonomous spending equation

$$A = C_0 + (I_0 - I_r r) + G + (X_f Y^f + X_e \varepsilon_0 - X_e \varepsilon_r r + X_e \varepsilon_r r^f)$$

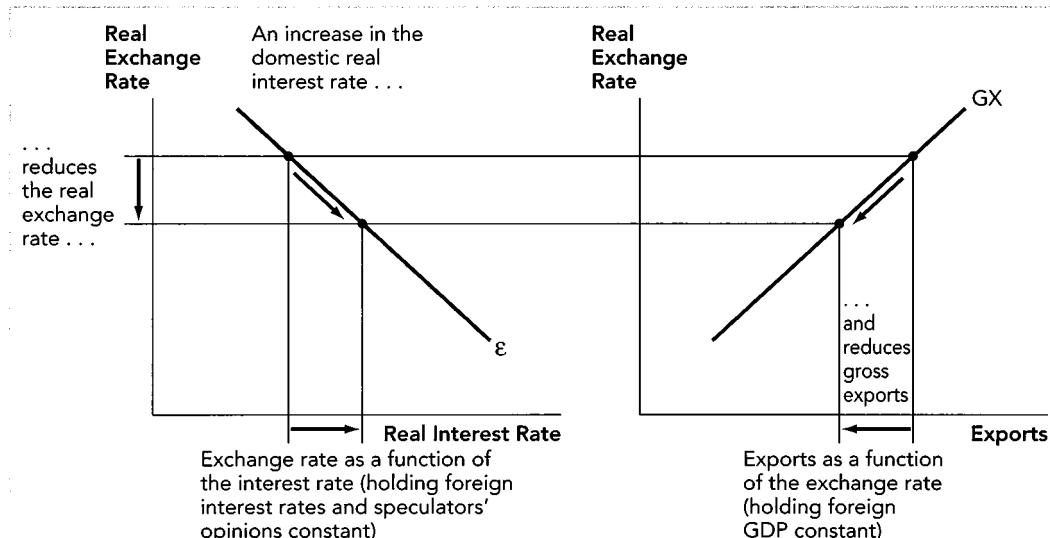
we can see that there are two components of autonomous spending affected by changes in the real interest rate. A higher real interest rate reduces autonomous spending by reducing exports (the $-X_e \varepsilon_r r$ term) as well as by reducing investment (the $-I_r r$ term). Figure 10.6 provides a graphical summary of how changes in the real interest rate affect exports and thus autonomous spending.

Why does a higher domestic interest rate reduce exports? A higher real interest rate makes purchasing financial assets in the home country more attractive: Foreign exchange speculators try to take advantage of this opportunity to earn higher returns by shifting their portfolio holdings to include more home-currency-denominated assets. This increase in demand for home-currency-denominated

FIGURE 10.6

From the Real Interest Rate to the Change in Exports

A change in the real interest rate changes the real exchange rate and thus changes gross exports as well.



assets and decrease in demand for foreign-currency-denominated assets drives down the exchange rate, which is the value of foreign currency.

A lower value of foreign currency makes our exports more expensive to foreigners: Their currency buys less here because it is less valuable. This diminishes their ability to purchase our exports. Since exports are a part of autonomous spending, a rise in the real interest rate diminishes autonomous spending through this channel as well. Thus a change in interest rates has a bigger effect on output than one would think from the effect of interest rates on investment alone.

RECAP INTEREST RATES AND PLANNED TOTAL EXPENDITURE

The investment function in the sticky-price model looks the same as it does in the flexible-price model, but it plays a very different role. In the flexible-price model the real interest rate is a market-clearing price. Supply and demand in the loanable funds market determine the interest rate. The level of saving determines the level of investment, and the strength of investment demand determines the interest rate. In the sticky-price model, the interest rate is not set in the loanable funds market but is set directly by the central bank or indirectly by the combination of the stock of money and the liquidity preferences of households and businesses. The interest rate then determines the level of investment, which plays a key role in autonomous spending. Together, autonomous spending and the multiplier determine the level of output. In a sticky-price model the fact that businesses match the quantity they produce to planned expenditure *automatically* creates balance in the financial market, no matter what the interest rate. Any interest rate can be an equilibrium interest rate because the inventory-adjustment process always forces saving equal to investment.

10.2 THE IS CURVE

Autonomous Spending and the Real Interest Rate

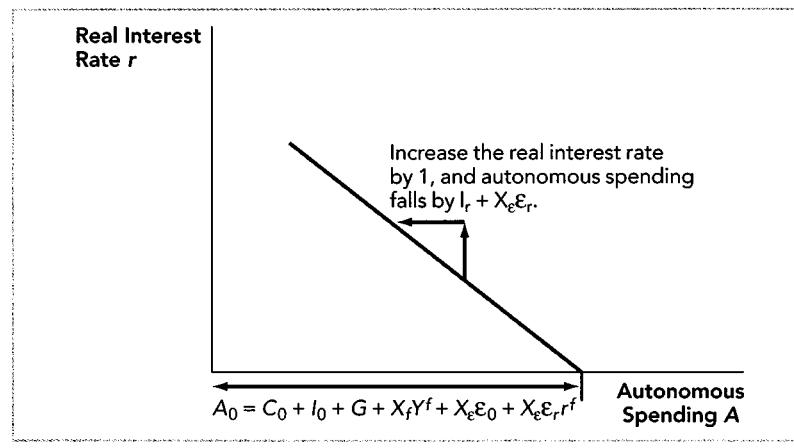
If we rearrange the equation for autonomous spending to put the two terms that depend on the interest rate together

$$A = [C_0 + I_0 + G + (X_f Y^f + X_e \varepsilon_0 + X_e \varepsilon_r r^f)] - (I_r + X_e \varepsilon_r) r$$

we see that an increase in interest rates of 1 (an increase of 100 percentage points) reduces autonomous spending by an amount $-(I_r + X_e \varepsilon_r)$. A 1 percentage-point increase in r ($\Delta r = 0.01$) will therefore decrease A by $0.01(I_r + X_e \varepsilon_r)$. Think back to the income-expenditure diagram of Chapter 9. Recall that the equilibrium level of real GDP depended on the level of autonomous spending:

$$Y = \frac{A}{1 - MPE}$$

Because a change in the real interest rate r changes autonomous spending A by changing investment I and exports GX , it will change the equilibrium level of real GDP. If we graph — as Figure 10.7 does — the real interest rate on the vertical axis and the level of autonomous spending on the horizontal axis, we see a downward-sloping relationship between interest rates and autonomous spending.

**FIGURE 10.7**

Autonomous Spending as a Function of the Real Interest Rate

The level of autonomous spending defined in Chapter 9 depends on the real interest rate: The higher the real interest rate, the lower is autonomous spending. The slope of the line depends not just on the interest sensitivity of investment spending but also on the interest rate sensitivity of exports — the sensitivity of exports to changes in the exchange rate times the sensitivity of the exchange rate to changes in the interest rate.

From the Interest Rate to Investment to Planned Total Expenditure

By how much does a change in the interest rate change equilibrium real GDP? By an amount equal to the change in r times the interest sensitivity of autonomous spending ($I_r + X_e \epsilon_r$) times the multiplier of Chapter 9. The change in the interest rate will change autonomous spending. And the whole point of the multiplier discussion in Chapter 9 was that changes in autonomous spending have multiplied effects on total expenditure. This relationship between the level of the real interest rate and the equilibrium level of real GDP has a name that was coined by economist John Hicks more than 60 years ago: the “IS curve,” where IS stands for “investment-saving.” The IS curve is a workhorse tool that macroeconomists and macroeconomics courses use very, very frequently.

To construct the IS curve, we must first draw a diagram with equilibrium real GDP on the horizontal axis and the real interest rate on the vertical axis, as in Figure 10.8 on page 292. We begin by picking a value for the real interest rate and then determine the level of autonomous spending at that real interest rate. Then we plug the corresponding level of autonomous spending into an income-expenditure diagram and draw the resulting planned-expenditure line. The point where the planned-expenditure line crosses the 45-degree line is the point at which planned expenditure equals national income. That is the value of equilibrium real GDP corresponding to our initial choice of the real interest rate.

The interest rate we started with and the real GDP level we ended with make up a single point on the IS curve. We repeat the process for as many different possible interest rates as we need. Plotting the points on the IS diagram and connecting them produces the IS curve.

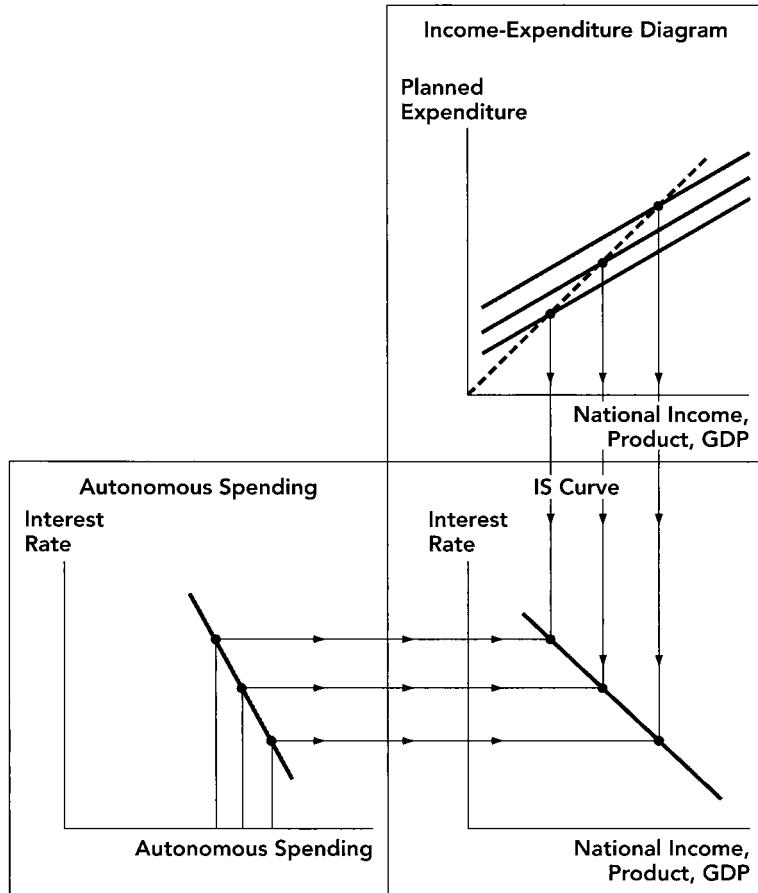
The algebra of the IS curve is straightforward, if a little crowded and complicated. We separate the determinants of autonomous spending into those that don’t

IS curve

The downward-sloping relationship between the (real, long-term) interest rate and the equilibrium level of national product and aggregate demand.

FIGURE 10.8**The IS Curve**

For each possible value of the real interest rate, there is a different level of autonomous spending. For each level of autonomous spending, the income-expenditure process generates a different equilibrium level of real GDP. The IS curve tells us what equilibrium level of real GDP corresponds to each possible value of the real interest rate.

**baseline autonomous spending**

Written A_0 . Those components of autonomous spending that are independent of the level of the interest rate.

depend on the interest rate and those that do, calling the first set of determinants “baseline autonomous spending,” or A_0 :

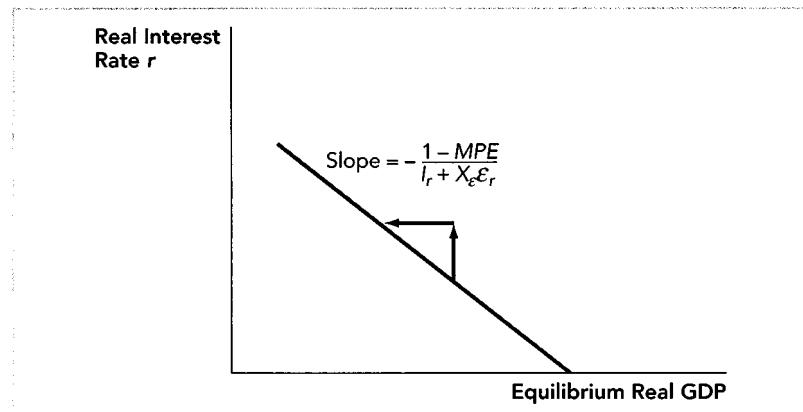
$$A_0 = C_0 + I_0 + G + (X_f Y^f + X_e \epsilon_0 + X_e \epsilon_r r^f)$$

And we write that total autonomous spending is equal to baseline autonomous spending A_0 minus the long-term risky real interest rate r times the sensitivity of autonomous spending to interest rates $I_r + X_e \epsilon_r$:

$$A = A_0 - (I_r + X_e \epsilon_r)r$$

We then turn back to the income-expenditure analysis in Chapter 9, and remember that real GDP is equal to autonomous spending A divided by 1 minus the MPE, or autonomous spending times the multiplier:

$$Y = \frac{A}{1 - MPE}$$

**FIGURE 10.9****The IS Curve**

The position of the IS curve summarizes all the determinants of equilibrium real GDP and how the level of equilibrium real GDP changes in response to changes in the interest rate.

And we get our expression for the IS curve: Real GDP Y is

$$Y = \frac{A_0}{1 - MPE} - \left(\frac{I_r + X_e \epsilon_r}{1 - MPE} \right) r$$

where baseline autonomous spending A_0 is equal to

$$A_0 = C_0 + I_0 + G + (X_f Y^f + X_e \epsilon_0 + X_e \epsilon_r r^f)$$

and, from Chapter 9, the marginal propensity to expend, the MPE, is

$$MPE = C_y(1 - t) - IM_y$$

In this IS curve equation, the first set of terms gives the horizontal intercept of the IS curve: the value that real GDP would attain if the real interest rate were zero. The second set of terms determines the slope of the IS curve: the responsiveness of equilibrium real GDP to changes in the long-term, risky, real interest rate, as in Figure 10.9.

The Slope and Position of the IS Curve

The Slope of the IS Curve

The slope of the IS curve depends on four factors. Anything that affects the multiplier will change the slope of the IS curve. Anything that affects the responsiveness of investment to a change in real interest rates will change the slope of the IS curve. Anything that affects how sensitive exports are to the real exchange rate will change the slope of the IS curve. And anything that changes how large a swing in real exchange rates is induced by a change in interest rates will change the slope of the IS curve.

These changes are all clearly visible in the term that multiplies the interest rate in the IS curve equation (which is the reciprocal of the slope of the IS curve):

$$-\left(\frac{1}{1 - MPE}\right)(I_r + X_e \epsilon_r)$$

The first of these factors is the multiplier: $1/(1 - MPE)$. The larger the multiplier, the larger is the impact on planned expenditure set in motion by a given change in investment spending and gross exports, and so the flatter is the IS curve. The second factor is the interest sensitivity of investment: the I_r term. The larger is I_r , the larger is the impact on investment due to a change in the real interest rate, and so the flatter is the IS curve. The third factor is how large a change in exports is generated by a change in the real interest rate: the $X_e \varepsilon_r$ term, which is the product of the exchange rate sensitivity of exports and the interest rate sensitivity of the exchange rate. The larger is $X_e \varepsilon_r$, the larger is the impact on gross exports due to a change in the real interest rate, and so the flatter is the IS curve.

All this means that a great many shocks to the economy change the slope of the IS curve. Thus in analyzing events, the correct calculation of the slope of the IS curve is important. Box 10.2 shows how to do this.

The Position of the IS Curve

The position of the IS curve depends on the baseline level of autonomous spending A_0 times the multiplier $1/(1 - MPE)$. To see how many factors can change the position of the IS curve, let's for the moment expand A_0 and MPE and write them



CALCULATING THE DEPENDENCE OF PLANNED EXPENDITURE ON THE INTEREST RATE: AN EXAMPLE

To calculate how much a change in the interest rate will shift the equilibrium level of planned expenditure, you need to know four things:

- The marginal propensity to spend (MPE), and thus the multiplier $1/(1 - MPE)$.
- The interest sensitivity of investment I_r .
- How much a change in the interest rate will affect the real exchange rate ε_r .
- How much a change in the exchange rate will affect exports X_r .

Suppose that you know that the marginal propensity to expend is 0.5 and the interest sensitivity of investment is 10,000, that is, a 1-percentage-point rise in the annual interest rate ($\Delta r = 0.01$) decreases annual investment by \$100 billion. Then the direct effects of interest rates on investment coupled with the multiplier would lead you to conclude that a 1-percentage-point increase in the interest rate would decrease equilibrium planned expenditure by \$200 billion, acting through the investment channel alone.

However, there is another channel through which interest rates affect planned expenditure — the export channel. If a 1-percentage-point increase in the interest rate ($\Delta r = 0.01$) reduces the value of the exchange rate by 1,000 units, and if each 1-unit reduction in the exchange rate reduces exports by \$5 billion, then there would be an additional decrease of $2 \cdot (5) \cdot (10) = \100 billion in planned expenditure through the exports channel.

Thus the total decline in equilibrium annual planned expenditure from a 1-percentage-point increase in the interest rate ($\Delta r = 0.01$) would be \$300 billion. The slope of the IS curve would be $\Delta r / \Delta Y$ or $-1/30,000$.

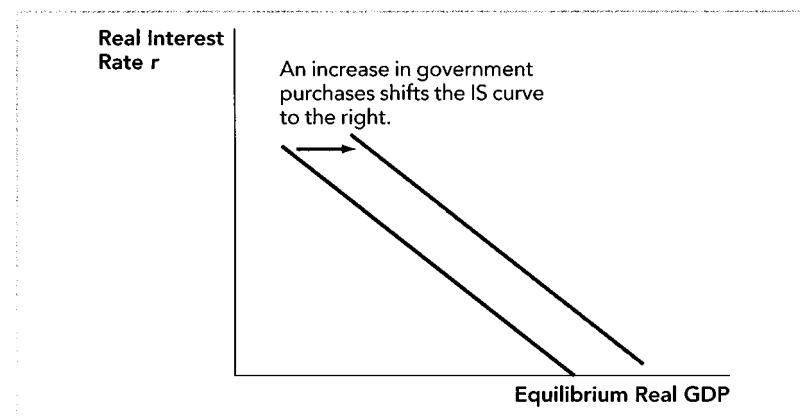


FIGURE 10.10
A Change in Fiscal Policy and the Position of the IS Curve

Practically any shift in policy or in the economic environment will change the position of the IS curve. In this case an increase in government purchases shifts the IS curve to the right.

in terms of their more fundamental determinants:

$$\frac{A_0}{1 - MPE} = \frac{C_0 + I_0 + G + (X_f Y^f + X_e \varepsilon_0 + X_e \varepsilon_r r^f)}{1 - [C_y(1 - t) - IM_y]}$$

Anything that changes any of the non-interest-dependent components of autonomous spending will shift the position of the IS curve. An increase in government spending G will shift the IS curve to the right and raise the equilibrium level of real GDP for any fixed value of the real interest rate, as Figure 10.10 shows. An increase in the baseline level of investment spending I_0 or consumption spending C_0 will do the same. Other events that shift the IS curve to the right include increases in foreign income Y^f , increases in foreign exchange speculators' expectations ε_0 , and increases in foreign interest rates r^f . In analyzing almost any change in the economic environment or in the government's *fiscal policy*, the position of the IS curve will shift.

Moving the Economy to the IS Curve

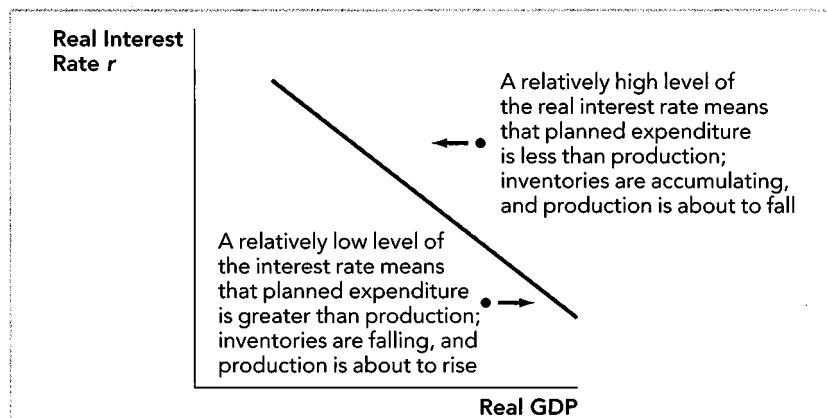
What happens if the current level of real GDP and the interest rate is not on the IS curve? If the economy is above the IS curve on the diagram, then real GDP is higher than planned expenditure. Inventories are rising rapidly and unexpectedly. So businesses cut back production. Employment, real GDP, and national income fall. If the economy is below the IS curve, planned expenditure is higher than total production. Inventories fall. Firms try to expand production in order to meet unexpectedly high demand. As they do, real GDP, employment, and national income rise, as Figure 10.11 on page 296 shows.

The process that pulls the economy back to the IS curve works relatively slowly, over months and quarters. Firms respond to increases in inventories by contracting (and to decreases in inventories by raising) production. As was noted in Chapter 9, the economy can stay away from its equilibrium on the income-expenditure diagram for a substantial time, all the while with inventories building up or falling. And if the economy is away from its equilibrium level of real GDP on the income-expenditure diagram, it is not on the IS curve either.

FIGURE 10.11

Off of the IS Curve

The economy's position does not have to correspond to a point on the IS curve. But if the economy is not on the IS curve, then powerful forces will push it toward the IS curve.



RECAP THE IS CURVE

The higher the real interest rate, the lower are the investment spending and exports components of autonomous spending and the lower is real GDP in the sticky-price model. The relationship between the real interest rate and real GDP is called the IS relationship. When plotted on a graph with real GDP on the horizontal axis and the real interest rate on the vertical axis, it is called the IS curve. The IS curve is downward-sloping. Its horizontal intercept is equal to baseline autonomous spending — what autonomous spending A would be if the real interest rate were zero — times the multiplier. Its slope is equal to the reciprocal of the multiplier $1/(1 - MPE)$ times the sum of two terms: (1) the interest sensitivity of investment spending I_r , and (2) the product of the exchange rate sensitivity of gross exports and the interest sensitivity of the exchange rate $X_e \epsilon_r$.

The slope of the IS curve is $\frac{-(1 - MPE)}{I_r + X_e \epsilon_r}$.

10.3 USING THE IS CURVE TO UNDERSTAND THE ECONOMY

Shifting the IS Curve

We have seen that anything that affects the non-interest-dependent components of autonomous spending shifts the position of the IS curve. Changes that increase baseline autonomous spending shift the IS curve to the right and raise equilibrium real GDP (if interest rates are constant). Changes that reduce baseline autonomous spending shift the IS curve to the left and reduce equilibrium real GDP (if interest rates are held constant).

For example, two kinds of changes in government fiscal policy directly affect the position of the IS curve. A shift in tax rates changes both the position and the

A GOVERNMENT SPENDING INCREASE AND THE IS CURVE: AN EXAMPLE

Calculating the effect on the equilibrium level of real GDP of an increase in a component of baseline autonomous spending such as government purchases is straightforward. For example, suppose that in the economy the initial MPE is equal to 0.5, the baseline level of autonomous spending is \$5,000 billion, a 1-percentage-point decline in the real interest rate ($\Delta r = -0.01$) raises investment spending by \$110 billion and exports by \$15 billion, and the real interest rate is fixed at 4 percent ($r = 0.04$). Then the initial equilibrium level of annual real GDP is

$$\begin{aligned} Y &= \frac{A_0}{1 - MPE} - \frac{I_r + X_e \epsilon_r}{1 - MPE}(r) = \frac{\$5,000}{1 - 0.5} - \frac{\$11,000 + \$1,500}{1 - 0.5}(0.04) \\ &= \$10,000 - \$25,000(0.04) = \$9,000 \text{ billion} \end{aligned}$$

And suppose that annual government purchases are then raised by $\Delta G = \$200$ billion.

Since government purchases are a component of baseline autonomous spending A_0 , the increase in the equilibrium level of real GDP is straightforward to calculate as long as the central bank does not change the real interest rate r :

$$\begin{aligned} \Delta Y &= \frac{\Delta A_0}{1 - MPE} - \frac{I_r + X_e \epsilon_r}{1 - MPE}(\Delta r) \\ &= \frac{\$200}{1 - 0.5} - \frac{\$11,000 + \$1,500}{1 - 0.5}(0) = \$400 \text{ billion} \end{aligned}$$

Real equilibrium aggregate demand rises by \$400 billion.

slope of the IS curve. And a change in the level of government purchases changes the position but not the slope of the IS curve; it shifts the IS curve to the right or the left. The government's fiscal policy thus increases or decreases the equilibrium level of real GDP associated with each possible level of the real interest rate. (See Box 10.3.)

Moving along the IS Curve

Changes in the level of the real interest rate r will move the economy either left and upward or right and downward along the IS curve. A higher real interest rate will produce a lower level of planned expenditure. A lower real interest rate will produce a higher level of planned expenditure and equilibrium real GDP. The Federal Reserve can control — target — interest rates to a considerable degree. Such an interest-rate-targeting central bank can stimulate the economy by cutting interest rates (see Box 10.4 and Figure 10.12 on page 298) and can contract the economy by raising interest rates.

How does the Federal Reserve control interest rates? It does so by buying and selling short-term government bonds for cash in open-market operations, so called because they are carried out in the “open market” and the Federal Reserve really does not care whom it buys from or sells to. Whenever the Federal Reserve buys government bonds in return for cash, it increases the total amount of cash in the hands of the public and reserves in the hands of the banking system, as

10.3



interest rate targeting

A process whereby a central bank focuses its policies on controlling — i.e., targeting — interest rates.

10.4

MOVING ALONG THE IS CURVE: AN EXAMPLE

Suppose that the staff projections of the Federal Reserve predict that if current policies are continued, real GDP will be only \$9 trillion at a time for which estimates of potential output are \$9.5 trillion. The Federal Open Market Committee (FOMC) might well decide that it is time to lower interest rates to close such a “deflationary gap.”

Suppose further that the staff estimates that the marginal propensity to spend is 0.5, that a 1-percentage-point fall in the real interest rate ($\Delta r = -0.01$) generates an extra \$110 billion in annual investment spending and a 5-point rise in the real exchange rate. And that each 1-point rise in the real exchange rate — the value of foreign currency — raises exports by \$3 billion.

Such estimates of the structure of the economy imply that the slope of the IS curve is

$$\text{IS slope} = -\frac{(1 - MPE)}{I_r + X_e \varepsilon_r} = -\frac{1 - 0.5}{\$11,000 + (500)(\$3)} = -\frac{1}{\$25,000}$$

So to boost equilibrium real GDP by \$500 billion by moving the economy along the IS curve, the real interest rate has to be reduced by 0.02 — by 2 percentage points.

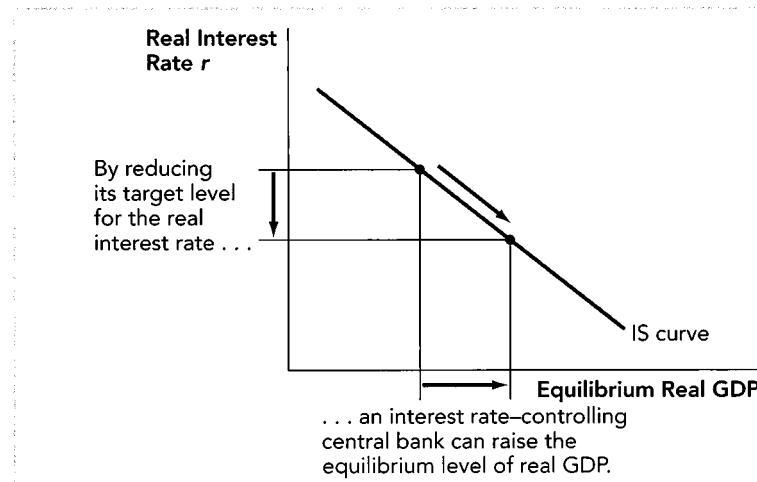


Figure 10.13 shows. Banks with the extra reserves use them to try to increase their deposits. Thus such an expansionary open-market operation increases the economy's stock of money: It increases the quantity of assets — checking account deposits and cash — that are readily spendable purchasing power.

Banks, businesses, and households take a look at the larger quantity of money — wealth in the form of readily spendable purchasing power — that they hold. At the previous level of interest rates this is more money than they want to hold in their

FIGURE 10.12
Cutting Target Interest
Rates and Raising
Real GDP

The IS curve shows us what happens to real GDP when the central bank changes the real interest rate.



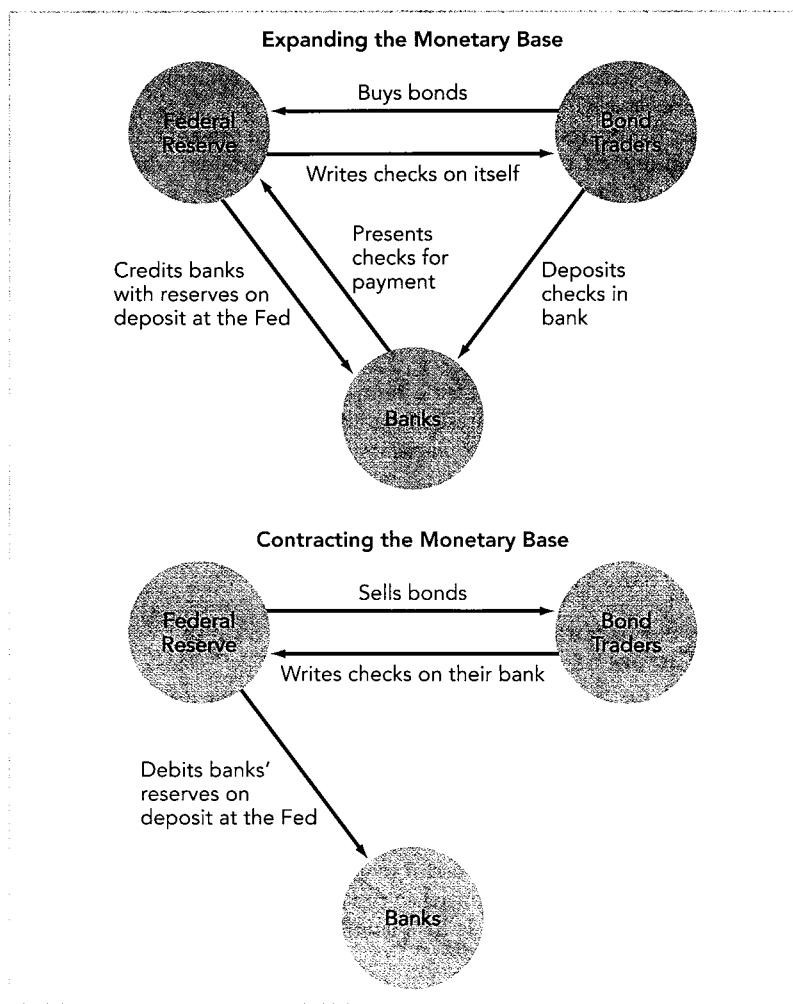


FIGURE 10.13
Open-Market Operations

The Federal Reserve changes interest rates by changing the quantity of liquid money in the economy through open-market operations: purchases or sales of U.S. government bills, notes, and bonds for cash on the open market.

portfolios. So households, businesses, and banks try to use this money to buy assets, such as bonds, that pay higher yields than cash. As they do so, they push the price of bonds up and the interest rate down. Thus an expansionary open-market operation reduces interest rates in the economy. The same process works in reverse to push interest rates up when the Federal Reserve sells bonds for cash on the open market. Box 10.4 shows how central bankers would go about trying to calculate the size of the change in interest rates needed to properly manage the economy.

Difficulties

Attempts to control planned expenditure by manipulating interest rates encounter certain difficulties. First, our knowledge of the structure of the economy is imperfect.

Perhaps at any particular moment the slope of the IS curve is half what the Federal Reserve staff believes or is twice what the Federal Reserve staff believes. Second, even when policies do have their expected effects, these effects do not necessarily arrive on schedule. As economist Milton Friedman often says, economic policy works with long and *variable lags*.

Moreover, the interest rates that the Federal Reserve can control are short-term, nominal, safe interest rates. The interest rate that determines where the economy is in equilibrium on the IS curve is the long-term, real, risky interest rate. Even if the government and central bank attain their target interest rate and even if the effects of changes in the interest rate are exactly as predicted and arrive exactly on schedule, there is a lot of potential slippage: Changes in the term premium between short and long interest rates, changes in the rate of inflation, and changes in the risk premium will each carry the economy to a point on the IS curve other than the point that the Federal Reserve wanted.

What determines the value of the term premium — the gap between short-term and long-term interest rates? Appendix 10a shows that the major determinant is expectations of future *monetary policy*. Long-term interest rates will be high relative to short-term interest rates if people expect short-term interest rates to be raised in the future; long-term interest rates will be low relative to short-term interest rates if people expect short-term rates to be lowered in the future.

Economic Fluctuations in the United States: The IS Curve as a Lens

How useful is the IS curve in understanding economic fluctuations in the United States over the past generation or so? If we plot on a graph the points corresponding to the long-term real interest rate and output relative to potential attained by the U.S. economy since 1960, we see that the economy has been all over the map — or at least all over the diagram (see Figure 10.14). Yet we can make sense of what has happened using shifts in and movements along the IS curve. That in fact is what the IS curve is for. It is a useful tool, which is why we have spent so many pages developing it. In the following five subsections we will apply the IS curve to gain insight into business-cycle fluctuations in each of the past four decades as well as the current decade.

The 1960s

The 1960s saw a substantial rightward shift of the IS curve. Increased optimism on the part of businesses, the Kennedy-Johnson cut in income taxes, and the extra government expenditures needed to fight the Vietnam War all increased planned expenditure. The IS curve shifted rightward by perhaps 3 percent of potential output in the 1960s, as Figure 10.15 shows.

The late 1960s also saw a movement downward and to the right along the IS curve, as real interest rates declined. In large part real interest rates declined by accident. The Federal Reserve did not fully gauge the amount by which inflation was rising. Rising inflation increased the gap between the nominal interest rates directly controlled by monetary policy and the real interest rates that determine planned expenditure. The Federal Reserve did not recognize this as it was happening and thus allowed real interest rates to drift downward.

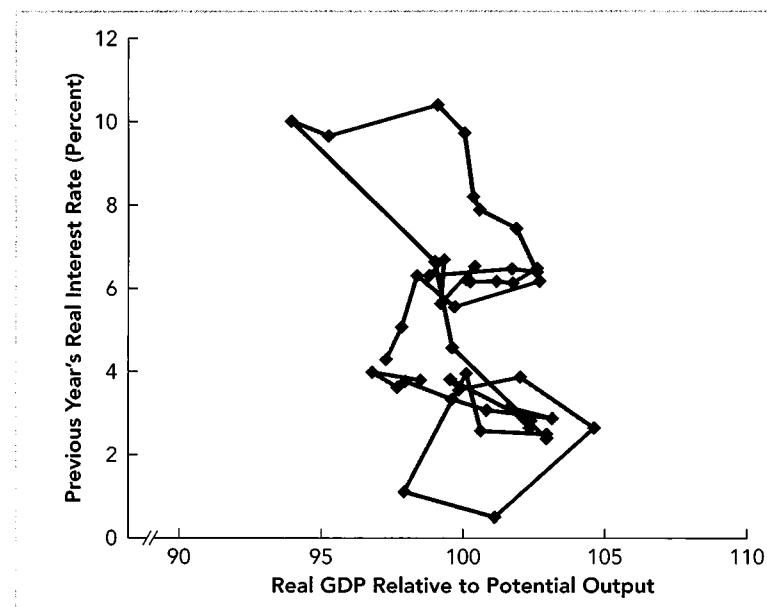


FIGURE 10.14
Real GDP and the
Interest Rate,
1960–2004

Much of what has happened to the U.S. economy since 1960 can be understood by thinking of events as either shifts of or movements along the IS curve, though you can't tell by looking at one graph with all 45 years of data.

Source: Authors' calculations and 2004 edition of *The Economic Report of the President* (Washington, DC: Government Printing Office).

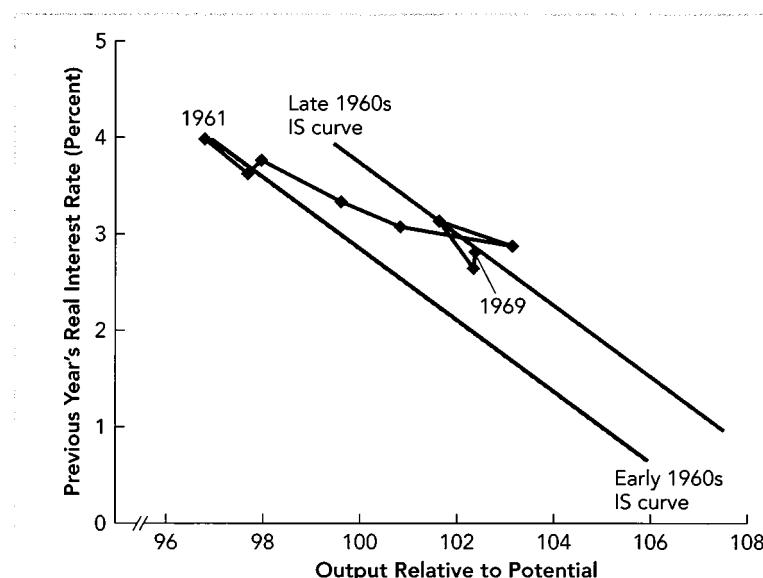


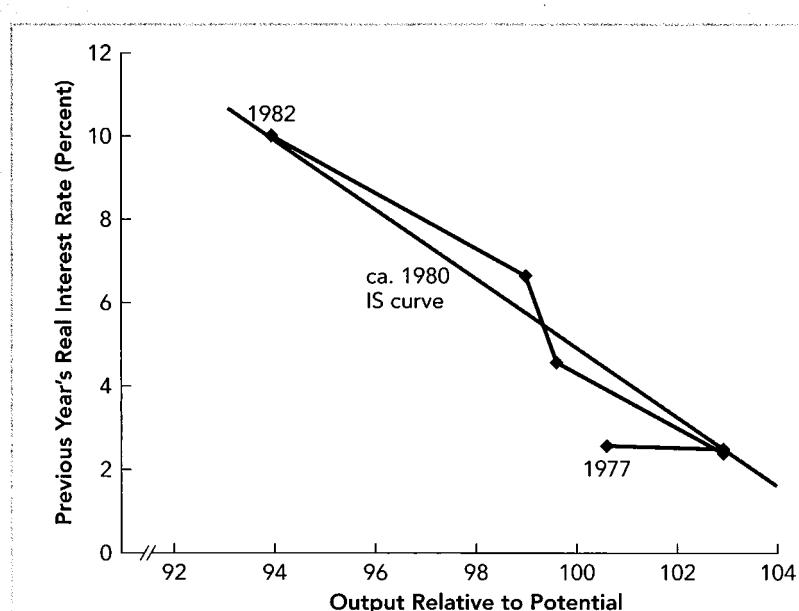
FIGURE 10.15
Shifting Out and
Moving along
the IS Curve, 1960s

The Vietnam War, the Kennedy-Johnson tax cut, and an increase in business optimism about the future all shifted the IS curve to the right between the start of the 1960s and the second half of the decade.

Source: Authors' calculations and 2004 edition of *The Economic Report of the President* (Washington, DC: Government Printing Office).

FIGURE 10.16

Moving along the IS Curve, Late 1970s
 Sharp rises in real interest rates at the end of the 1970s after Paul Volcker became Chair of the Federal Reserve pushed the U.S. economy up and to the left along the IS curve.



Source: Authors' calculations and 2004 edition of *The Economic Report of the President* (Washington, DC: Government Printing Office).

The 1970s

The end of the 1970s saw the level of real GDP in the United States near the level of potential output. As Figure 10.16 shows, from 1977 to 1979 the U.S. economy moved down and to the right along the IS curve. However, the expansion of output beyond potential was accompanied by unexpectedly high and rising inflation. This rise in inflation was further fueled by a supply shock: the sudden rise in oil prices triggered by the Iranian revolution.

A sudden shift in Federal Reserve policy occurred in 1979 when Paul Volcker became chair of the Federal Reserve, replacing G. William Miller. Under Miller fighting inflation had been a relatively low priority. Under Volcker fighting inflation became the highest priority of all. The Federal Reserve raised annual real interest rates step-by-step from 1979 to 1982 up to over 10 percent. The increase in real interest rates moved the economy up and to the left along the end-of-the-1970s position of the IS curve: The unemployment rate reached nearly 10 percent in 1982, and real GDP fell to only 94 percent of the economy's potential output.

The 1980s

The election of Ronald Reagan in 1980 was followed by a massive fiscal expansion. Military spending was increased and income taxes were cut in a series of steps that became effective between 1982 and 1985. The result of these increases in government purchases and cuts in taxes was an enormous government deficit and an outward shift in the IS curve. A simultaneous increase in *investor optimism* triggered by falling inflation combined with the government's fiscal stimulus to

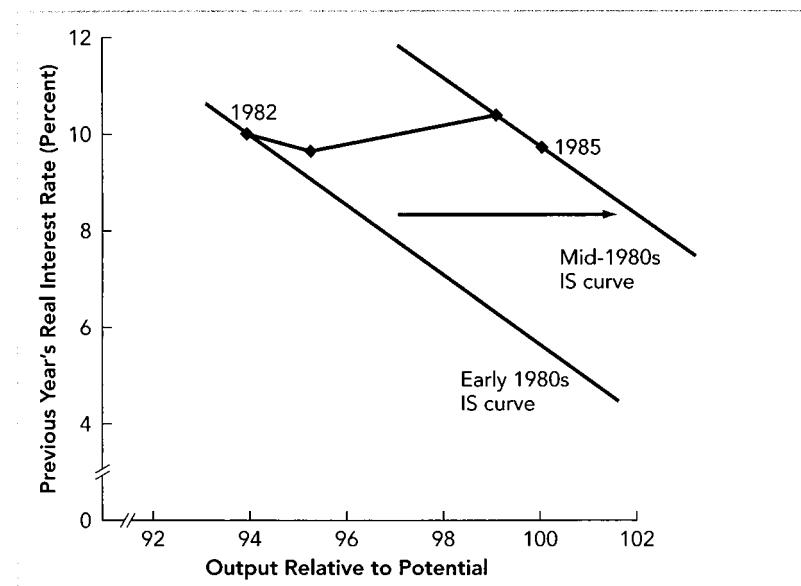


FIGURE 10.17
Shifting the IS Curve
Out, Early 1980s

The Reagan budget deficits of the 1980s shifted the economy's IS curve to the right.

Source: Authors' calculations and 2004 edition of *The Economic Report of the President* (Washington, DC: Government Printing Office).

shift the IS curve outward relative to potential output by at least 4 percent. (See Figure 10.17.)

The Federal Reserve responded to this outward shift in the IS curve by maintaining high real interest rates. It sought in the first half of the 1980s to ensure that the success it had achieved in reducing inflation did not unravel. The Federal Reserve feared that a rapid return of real GDP to potential GDP would put upward pressure on inflation once more — hence the maintenance of high real interest rates to make sure that the large Reagan-era fiscal expansion did not have too great an effect.

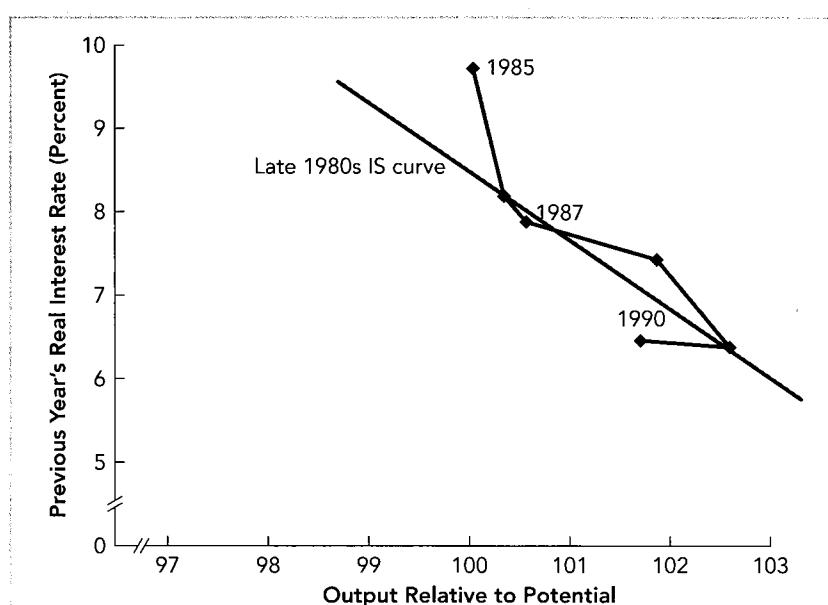
As inflation remained low throughout the mid and late 1980s, Federal Reserve policy makers gained confidence. They became increasingly optimistic that higher real GDP levels relative to potential would not reignite inflation. Between 1985 and 1990 successive step-by-step reductions in real interest rates carried the U.S. economy back to full employment, and carried it down and to the right along the IS curve. (See Figure 10.18 on page 304.)

The 1990s

The principal maker of economic policy since the late 1980s has been Federal Reserve Chair Alan Greenspan, appointed and reappointed by four successive presidents: Reagan, George H. W. Bush, Clinton, and George W. Bush. Greenspan is somewhat of a paradox: a Federal Reserve chair whom all trust to be a ferocious inflation fighter, yet one who — in the policies that he has chosen — frequently seemed willing to risk higher inflation in order to achieve higher economic growth or to avoid a recession.

FIGURE 10.18**Moving along the IS Curve, Late 1980s**

With the inflation of the 1970s broken and no longer a threat, the Federal Reserve gradually reduced interest rates in the late 1980s. As it did so, the economy moved down and to the right along its IS curve.

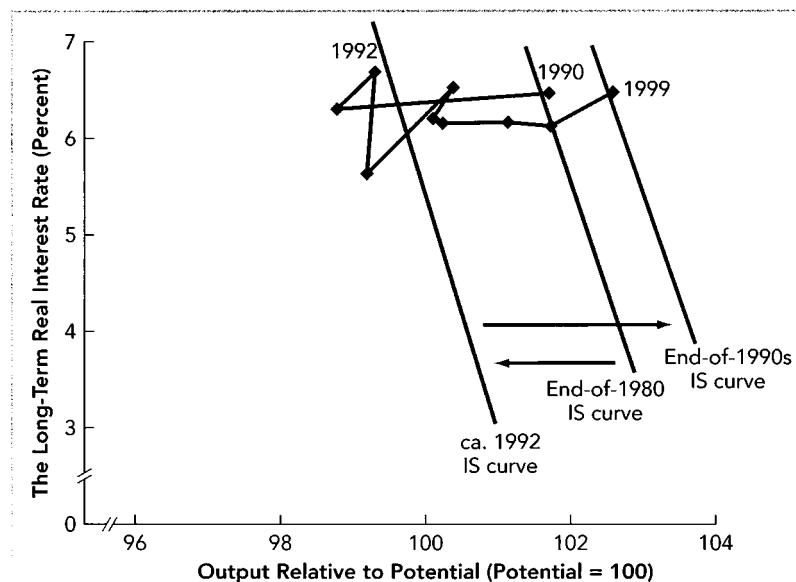


Source: Authors' calculations and 2004 edition of *The Economic Report of the President* (Washington, DC: Government Printing Office).

Immediately after taking office Greenspan faced a challenge: the sudden stock market crash of October 1987. How large an effect would this crash have on planned expenditure? What would it do to investment spending? Would a leftward shift in the IS curve be generated by the sudden change in investors' expectations about the future that triggered the stock market crash? No one knew. If the crash turned out to be the harbinger of a large leftward shift in the IS curve, then an unchanging monetary policy would lead to a significant recession. So the Greenspan-led FOMC lowered interest rates and expanded the monetary base, hoping that this shift in monetary policy would offset any leftward shift in the IS curve and avoid a recession.

In point of fact, the stock market crash of 1987 had next to no effect on investment spending or planned expenditure. Economists have still not come up with a convincing story for why its effects were so small. The two years after 1987 saw higher output relative to potential and saw lower unemployment rates. The years between 1987 and 1990 did not see real interest rates rising — as they usually do in the latter stages of an expansion — but real interest rates that were stable or falling.

As the unemployment rate fell, inflation accelerated. In 1988 and 1989, inflation moved up from 3 to 4 percent. The Federal Reserve found that it had successfully avoided any chance of a (big) recession in 1988 in the aftermath of the stock market crash, but only at the price of letting inflation rise above 4 percent per year. In the second half of 1990 there came a sudden leftward shift in the IS curve: The Iraqi invasion of Kuwait served as a trigger for firms to reduce investment, as they waited to see whether the world economy was about to experience another

**FIGURE 10.19****The 1990s**

A sharp inward shift in the IS curve triggered a recession at the beginning of the 1990s. Subsequent increases in autonomous investment shifted the IS curve to the right again.

Source: Authors' calculations from the 2004 edition of the *Economic Report of the President* (Washington, DC: Government Printing Office).

long-run upward spike in oil prices. The U.S. economy slid into recession at the end of 1990. The Federal Reserve, worried about the upward creep in inflation in the late 1980s, took no steps to reduce real interest rates as the economy slid into the recession. (See Figure 10.19.)

During the recession, inflation fell to $2\frac{1}{2}$ percent. Unemployment rose to a peak of 7.6 percent — in the late spring of 1992, just in time to be salient for the 1992 presidential election. Recovery began in mid-1992.

Soon thereafter Greenspan made another decision to risk higher inflation in order to accomplish other goals. In 1993 he signaled that if Congress and the president took significant steps to reduce the budget deficit, then the Federal Reserve would try as best as it could to maintain lower interest rates — a shift in the policy mix that would keep the target level of production and employment unchanged but that with lower interest rates would promise higher investment and faster productivity growth: an “investment-led recovery.”

This time the gamble turned out extremely well. As fiscal policy tightened in 1994 and beyond, interest rates remained significantly lower than they had been in the 1980s even though output recovered to potential. Moreover, this time there was no significant acceleration of inflation, even though by the end of the 1990s unemployment had fallen to the lowest level in a generation.

The 2000s

The end of the 1990s saw the end of the dot-com bubble. The crash of the stock market in 2000 was both cause and consequence of the recognition that investors and businesses had been overly optimistic not about the technology and productivity benefits of the computer revolution, but about the ability of businesses to

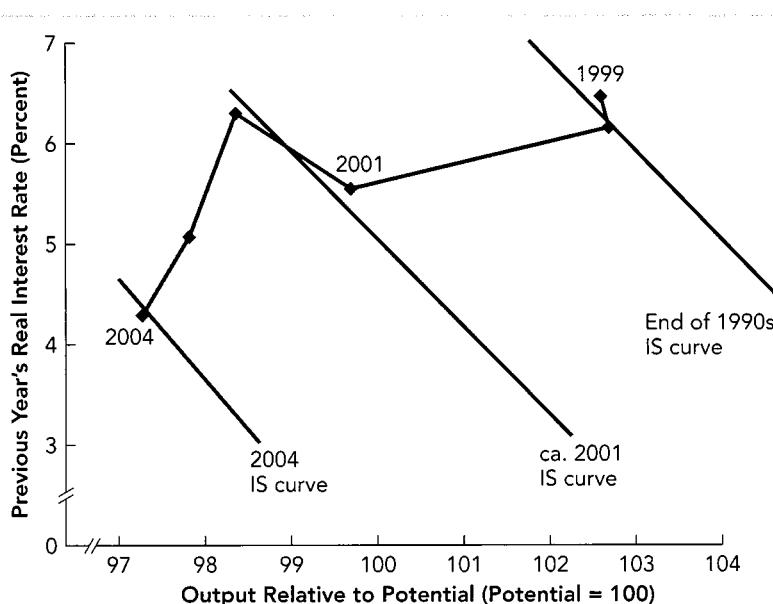
make profits off of the computer boom. Investment fell sharply in 2000 and 2001, carrying real GDP relative to potential down with it. The recession was given a further impetus by the uncertainty created by the terror attack of September 11, 2001. While real GDP had been some 3 percent *above* potential output in 1999, by 2001 it was 1 percent *below* potential.

The executive branch — the administration of George W. Bush — responded by proposing tax cuts that were poorly crafted to stimulate demand: The bulk of the money went to households for which the marginal propensity to consume was low. Fiscal policy thus did little to move the IS curve back to the right and expand output. The Federal Reserve responded by cutting interest rates severely. Observers even began to fear that the Federal Reserve would run out of room to cut interest rates further, since short-term nominal interest rates cannot fall below zero. But during 2002 and 2003 the Federal Reserve's easy-money policies were neutralized by further falls in business and investor confidence and a further move to the left in the IS curve. In spite of remarkably expansionary monetary policy, it was only after 2004 that there were signs that the economy was beginning to close the output gap. (See Figure 10.20.)

FIGURE 10.20

The 2000s

The collapse of the dot-com stock-market bubble in 2000 and the September 11, 2001, attacks were large shocks to the U.S. economy: Output fell from about 3 percent above to perhaps 1 percent below potential in response. The Federal Reserve waited to respond, believing that the economy in 2000 had been running at a rate unsustainable without rising inflation. But when the Federal Reserve did move, it moved rapidly to reduce interest rates. Before 2004, however, few signs suggested that the reduction in interest rates and concomitant stimulative budget deficits had done much to keep output from falling even further below potential.



Source: Authors' calculations from the 2005 edition of the *Economic Report of the President* (Washington, DC: Government Printing Office).

RECAP USING THE IS CURVE TO UNDERSTAND THE ECONOMY

We have seen that anything that affects the non-interest-dependent components of autonomous spending shifts the position of the IS curve. Changes that increase baseline autonomous spending shift the IS curve to the right and raise equilibrium real GDP. Changes that reduce baseline autonomous spending shift the IS curve to the left and reduce real GDP.

Changes in the size of the multiplier, the interest sensitivity of investment or gross exports, and the responsiveness of the real exchange rate to changes in the interest rate change the slope of the IS curve. Changes in the level of the real interest rate will move the economy either left and upward or right and downward along the IS curve. A higher real interest rate will produce a lower level of planned expenditure. A lower real interest rate will produce a higher level of planned expenditure and equilibrium real GDP. The Federal Reserve can control—target—interest rates to a considerable degree. Such an interest rate-targeting central bank can stimulate the economy by cutting interest rates and can contract the economy by raising interest rates.

Chapter Summary

1. In the sticky-price model the investment function is the same as in the flexible-price model. But in the flexible-price model the level of saving determines investment, and the investment function determines the real interest rate. In the sticky-price model the real interest rate is determined outside the IS framework, and the level of the real interest rate powerfully affects the level of real GDP.
2. The international sector of the sticky-price model is essentially the same as the international sector of the flexible-price model.
3. The income-expenditure diagram takes autonomous spending as given and then determines the equilibrium level of real GDP, planned expenditure, and national income as functions of autonomous spending and the marginal propensity to spend.
4. The IS curve incorporates the effect of changing interest rates on autonomous spending and adds this effect to the income-expenditure diagram.
5. The IS curve slopes downward because a higher interest rate lowers both investment and exports, and these reductions in autonomous spending in turn lower planned expenditure and equilibrium real GDP.
6. When the central bank targets the real interest rate, then the position of the IS curve and the central bank's interest rate target together determine the equilibrium level of planned expenditure and real GDP.

Key Terms

long-term interest rate (p. 284)

short-term interest rate (p. 284)

risky interest rate (p. 286)

safe interest rate (p. 286)

IS curve (p. 291)

baseline autonomous spending (p. 292)

interest rate targeting (p. 297)

Analytical Exercises

1. Why does an expansion of government purchases have an amplified impact on the equilibrium level of real GDP? Suppose that the central bank does not target interest rates but instead keeps the money stock constant. Is it still the case that an expansion of government purchases will cause a greater than one-for-one increase in the equilibrium level of real GDP?
 2. Explain why the IS curve slopes downward. Is its slope steeper in a closed economy with no international trade, or in an open economy?
 3. For each of the following, decide whether the IS curve shifts in and to the left, shifts out and to the right, or stays unchanged:
 - a. The tax rate decreases.
 - b. Foreign interest rates rise.
 - c. Businesses become more optimistic about future demand.
 - d. Consumers desire to save a greater proportion of their income for the future.
 - e. The central bank lowers the short-term nominal interest rate it controls.
 - f. The term premium rises.
 - g. Foreign exchange speculators become more pessimistic about the long-run value of domestic currency.
4. Suppose that the government and central bank together want to keep GDP constant but raise the rate of investment. What policies can they follow to achieve this?
 5. Suppose that the level of investment spending does not depend at all on the interest rate. Does this mean that the IS curve is vertical? If not, how can it be that central-bank changes in the real interest rate affect the equilibrium level of real GDP?

Policy Exercises

1. Suppose that the consumption, investment, net exports, and exchange rate functions are

$$C = C_0 + C_y(1 - t)Y = \$3,000 + 0.5(1 - 0.4)Y$$

$$I = I_0 - I_r r = \$1,200 - \$10,000r$$

$$GX = X_f Y^f + X_e \epsilon = 0.1Y^f + \$4\epsilon$$

$$IM = IM_y Y = 0.2Y$$

$$NX = GX - IM$$

$$\epsilon = 100 - 1,000(r - r^f)$$

Derive the IS curve for this economy: real GDP as a function of all the unspecified variables in the economy. Suppose that the foreign interest rate r^f is 5 percent ($r^f = 0.05$), that total foreign income Y^f is \$10,000, and that government spending G is \$3,000. What then is equilibrium annual real GDP if the central bank sets the real interest rate at 3 percent ($r = 0.03$)? At 5 percent? At 7 percent?

2. Suppose that the economy is the same as in problem 1 except for the fact that it is a closed economy. There are no imports and no exports: $IM_y = 0$, $X_f = 0$, and $X_e = 0$. Derive the IS curve for this economy. What is equilibrium annual real GDP if the central bank

sets the interest rate at 3 percent? At 5 percent? At 7 percent?

3. In which of the two economies — the open economy of problem 1 or the closed economy of problem 2 — do you think that changes in interest rates have larger effects on the equilibrium level of real GDP? Explain your answer.
4. Suppose that the short-term nominal interest rate — the one the central bank actually controls — is 3 percent. But also suppose that the inflation rate is zero, that the term premium is 4 percent, and that the risk premium is 3 percent.
 - a. What is the real interest rate relevant for the IS curve?
 - b. Suppose that the IS equation of the economy is $Y = \$10,000 - 30,000r$. What is the equilibrium level of real GDP?
 - c. Suppose that the central bank wants to use monetary policy to raise Y to \$9,000. Can it do so by open-market operations that lower the short-term nominal interest rate? Explain why or why not. What other policy steps can you think of that the government and central bank could take to raise equilibrium real GDP to \$9,000?

5. Suppose that the consumption, investment, net exports, and exchange rate functions are

$$C = C_0 + C_y(1 - t)Y = \$3,000 + 0.5(1 - 0.4)Y$$

$$I = I_0 - I_r r = \$1,200 - \$10,000r$$

$$GX = X_f Y^f + X_e \varepsilon = 0.1Y^f + \$4\varepsilon$$

$$IM = IM_y Y = 0.2Y$$

$$NX = GX - IM$$

$$\varepsilon = 100 - 1,000(r - r^f)$$

Suppose further that the government follows a balanced-budget rule: Government purchases G are equal to government tax collections tY . Derive the IS for this economy: real GDP as a function of all the unspecified variables in the economy. Is the level of real GDP along the IS curve more or less sensitive to changes in interest rates than it was in problem 1? Why?

The Term Premium and Expected Future Interest Rates

APPENDIX 10a

What determines the value of the *term premium* — the gap between short-term and long-term interest rates? To start thinking about this question, consider once again a simple two-period model in which the periods are “now” and “the future.” Bankers make long-term loans that fall due in two periods. Bond traders buy and sell long-term bonds that fall due in two periods. The real interest rate paid on these long-term loans and bonds is the long-term real interest rate r . Bankers also make short-term loans (and bond traders also buy and sell short-term bonds) that mature in just one period.

Someone thinking about buying a long-term bond (or making a long-term loan) knows that for each real dollar invested in such financial instruments today, he or she will after two periods have

$$\text{Gross return} = 1 + r + r$$

Each period they will receive the long-term real interest rate on their investment, r .

Someone thinking about buying a short-term bond today (or making a short-term loan) knows that for each real dollar invested in such financial instruments today, she or he will after the end of the first period (the one that is going on “now”) have $1 + r_n^s$: r for the real interest rate, s because it is the rate paid on a short-term loan, and n because it is the interest rate paid in the “now” period. But the person’s capital will then, at the start of the second period (the one that will happen in the future), be lying idle. The natural thing to do then will be to invest it again in another short-term bond (or make another short-term loan — this time at the short-term interest rate that will prevail in the future, r_f^s).

So after two periods someone who chooses today to invest money in short-term securities will have

$$\text{Gross return} = 1 + r_n^s + r_f^s$$

for each real dollar that she or he invested at the start of the first period.

What will a flint-eyed money-maximizing rational bond trader do? The first complication is that he or she doesn’t know today what the future short-term real

interest rate r_f^s will be when the time to reinvest the principal arrives. The best he or she can do is form an expectation now — E_n — of what the future short-term real interest rate will be: $E_n(r_f^s)$.

Thus the bond trader has to decide whether to invest for the long term or for the short term (and then, later, to reinvest). The returns from investing for the long term will be greater if

$$\text{Long-term gross return} = 1 + 2r > 1 + r_n^s + E_n(r_f^s) = \text{short-term return}$$

Or, defining $E_n(\Delta r^s)$, the expected change in the short-term real interest rate, as the difference between expected future short rates $E_n(r_f^s)$ and current short rates r_n^s

$$\text{Expected change in short rates, } E_n(\Delta r^s) = E_n(r_f^s) - r_n^s$$

The returns from investing for the long term will be greater if

$$r - r_n^s > \frac{E_n(\Delta r^s)}{2}$$

and the bond trader will probably decide to invest for the long term. If

$$r - r_n^s < \frac{E_n(\Delta r^s)}{2}$$

then the returns from investing for the short term will be greater, and the trader will probably decide to invest for the short term.

In equilibrium there are *both* short-term and long-term bonds held and short-term and long-term loans made. So in equilibrium the typical bond trader and bank loan officer must think that the expected returns from long-term and short-term financial investments are roughly equal. In equilibrium,

$$r - r_n^s = \frac{E_n(\Delta r^s)}{2}$$

The term premium $r - r_n^s$ is equal to the expected change in short-term interest rates over the life span of the loan, weighted by the proportion of the loan's time span over which the changed short-term interest rate will apply. In other words, *the term premium tells you how bond traders expect short-term interest rates to move in the future*.

If financiers are buying two-year bonds at, say, 5.75 percent — when they could instead buy three-month T-bills every quarter for two years — then they must believe that either portfolio strategy will average out to about 5.75 percent over two years, or else they would all be crowding into one security or the other. Demand for the one would rise; demand for the other would fall. And the interest rates on them and on loans of that duration would change until once more it looked to bond traders that the two strategies were equally attractive. Similarly, if bond traders are buying three-month T-bills at, say, 4 percent when they could instead buy two-year bonds at 5.75 percent, then they must expect that higher short-term rates a year and a half in the future — say, 7.5 percent — will balance out today's low rates to average out to 5.75 percent.

This is the *expectations theory of the term structure*: The long-term interest rate is the average of what bond traders expect future short-term rates to be for the duration of the long-term loan. The term premium tells us how much bond traders are expecting the average short-term interest rate to rise (or fall) over the duration of the long-term loan.

Chapter 10 Investment, Net Exports, and Interest Rates: The IS Curve

From the standpoint of governments that seek to control interest rates, this dependence of today's long-term interest rate on expectations of what the short-term interest rate will be tomorrow is very inconvenient. All the changes in today's interest rate that the central bank can undertake today will have only a limited effect on long-term interest rates unless bond traders are convinced that policies once adopted will be continued. Thus central banks guard their reputation for credibility and consistency above everything else. They can preserve their ability to move the economy along the IS curve by changing interest rates only if bond traders' expectations of the future, and thus today's long-term interest rates, react predictably to changes in interest rate policy.

CHAPTER

The Money Market and the LM Curve

QUESTIONS

What do we mean by "money-market equilibrium"?

What is the LM — liquidity-money — curve?

What is the IS-LM framework?

How is the equilibrium level of real GDP determined when the money stock is constant?

What is an IS shock to the economy? An LM shock?

What is the aggregate demand — AD — curve? The aggregate supply — AS — curve?

The IS curve we built up in Chapter 10 gives us enough theory to think about business cycles — as long as the central bank uses open-market operations to control the real interest rate and keep it pegged to its preferred chosen value. But not all central banks peg interest rates. Not all central banks that peg interest rates today pegged them in the past. And not all economies even today have central banks with the power to peg interest rates.

Thus the analysis of Chapter 10 is fine, comprehensive, and complete only as long as we restrict our view to large postindustrial economies — the United States, western Europe, and Japan — today. If you are willing to do that, fine; stop reading this chapter now, and go to the start of Chapter 12. This is an optional chapter for those with the time and inclination to dig a little deeper into the operations of the money market.

But if you do have time, and if your professor does want to dig deeper into the operations of the money market, then keep reading. For you, extending the analysis in a different direction to consider how the economy behaves when what is fixed is not the real interest rate but instead the economy's money stock — the amount of liquid assets, of wealth held in the form of readily spendable purchasing power — is worthwhile.

In this chapter we derive what economists John Hicks and Alvin Hansen were the first to call an LM — a liquidity-money — curve. The LM curve serves as a sibling to the IS curve, and tells us how interest rates adjust when the stock of liquid money is fixed. The LM curve joins the IS curve in what is called the IS-LM model, which provides our analysis of the determinants of real GDP and the interest rate when the money stock is fixed.

The very end of this chapter begins the process of understanding what determines the price level and the inflation rate in the sticky-price macroeconomic model. We use all the previous chapters of Part 4 to construct the aggregate demand (AD) relationship, which tells how planned expenditure varies in the short run as the price level changes. We combine this with a simple model of short-run aggregate supply (AS). Putting these two together generates the AS-AD framework, which allows us not just to analyze what the level of real GDP is but also to begin to analyze how changes in real GDP affect the price level.

11.1 THE MONEY MARKET AND THE MONEY STOCK

Wealth, Bonds, and the Demand for Money

Think about a household or a business trying to figure out in what form to hold its wealth. The household can hold its wealth in the form of interest-bearing or other return-earning assets like real estate, stocks, and bonds — let's lump all of these together and call them "bonds," for bonds are a very typical way that wealth is held. Or the household can hold its wealth in the form of "money," which we call M — where money is shorthand for assets that are liquid, can be readily spent, can be easily used to buy things. Households and businesses can and do move their wealth back and forth between these two forms of assets.

Wealth held in the form of money earns little or no interest. Wealth held in the form of bonds earns interest at the nominal interest rate i . Wealth held in the form of bonds cannot be readily spent: To transform it into a form in which you can

use it to buy things takes some time, and so if too great a proportion of wealth is held in bonds, you may miss opportunities to buy goods and services. Wealth held in the form of money is liquid, and it can be easily spent — that's the defining characteristic of money.

There are three important facts about the quantity of money that businesses and households demand to hold, which we will call M^d , with the d superscript there to remind ourselves that this is a demand:

- **Money demand** has a time trend, the result of slow changes in banking-sector structure and technology.
- Money demand is proportional to total income, which by the circular flow principle is the same as total spending and the same as GDP.
- Money demand is inversely related to the nominal interest rate — when nominal interest rates go up, demand for money goes down.

Why does the quantity of money demanded M^d go up when total income — or total spending, or GDP, for they are synonymous — Y goes up? Think of it this way: How much wealth you want to hold in readily spendable form depends on how large are the purchases you typically make in a unit of time. And the higher the flow of total income, the greater the flow of purchases an average household or business wants to make.

Why does the quantity of money demanded M^d go down when the nominal interest rate i goes up? Think of it this way: The nominal interest rate is the opportunity cost of holding money. That part of your wealth which you hold as money — in the form of deposits in your checking account or cash in your pocket — earns zero nominal interest. By contrast, if you were to shift the wealth you hold in the form of money into less liquid but more lucrative investments like bonds, it would earn the prevailing market nominal interest rate i . The difference between the expected return on holding wealth in the liquid form of money and on holding wealth in bonds is thus the nominal interest rate. The nominal interest rate i is the opportunity cost of holding money. You want to hold money because not having liquid assets you can use to buy commodities is very inconvenient. But holding wealth in the form of money means that you are giving up the interest you could otherwise earn. Hence the quantity of money demanded falls when the nominal interest rate i rises.

Notice that money demand depends *not* on the real interest rate r but on the nominal interest rate i . The difference between them is the expected inflation rate π^e : $i = r + \pi^e$.

Economists try to fit these insights into their model by writing down a demand-for-money function:

$$\frac{M^d}{P} = M_y Y - M_i i$$

where M^d is the nominal quantity of money that households and businesses want to hold. It is divided by the overall price level P because what households and businesses really care about is not how many pieces of paper with George Washington's face they have, but how much in the way of goods and services their money holdings can buy. The parameter M_y tells how much in the way of extra real money balances people demand when total income — which, you remember, the circular flow principle tells us we can also think of as total spending or GDP — Y goes up. Over long periods of time M_y tends to fall as

money demand

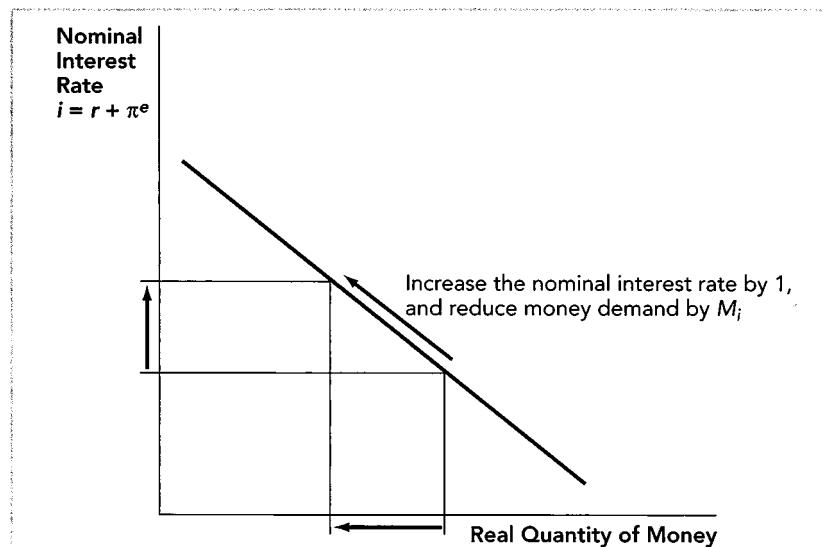
How much wealth in the form of readily spendable purchasing power — money — households and businesses wish to hold at the given levels of national income and nominal interest rates.

real money balances

The total stock of nominal money balances in the economy divided by the price level.

FIGURE 11.1**The Interest Rate and the Demand for Money**

Because the opportunity cost of holding wealth in the liquid, readily spendable form of money depends on the nominal interest rate, demand for money falls when the nominal interest rate rises.



the financial system becomes more sophisticated, the time required for checks to clear falls, and credit card balance limits rise. The parameter M_i tells how much households and businesses shrink the amount of wealth they want to hold in the liquid form of money when the nominal interest rate i goes up, as is shown in Figure 11.1. Box 11.1 explains why we are not using the money demand model of Chapter 8: to keep things simple.

Money Supply and Money Demand

In a sticky-price model — and this is the sticky-price section of this textbook — the price level P is predetermined. In a sticky-price model, the price level cannot jump instantly and substantially. Back in the flexible-price model covered in Chapter 8, the price level could and did jump instantly and substantially. Back in Chapter 8, the level of *bank reserves* and the banking system together determined the supply of money: the amount of liquid readily spendable assets in the economy. Given this supply of money M , the price level back in Chapter 8 jumped to make the economy's level of real money balances M/P such that the money market was in equilibrium and to make the real *money supply* equal to the real money demand.

But this is not flexible-price Chapter 8; this is sticky-price Chapter 11. In this chapter, the price level cannot move instantly to keep the money market in equilibrium. What, then, makes money supply equal to money demand? The answer is that the nominal interest rate must adjust instead.

The price level P is predetermined. As we saw back in Chapter 8, the nominal money supply M is the result of the interaction of the level of reserves in the economy with the structure of the banking system. For the moment let's assume

money market equilibrium

When the money demand by consumers and firms equals the money supply which the Federal Reserve has allowed the banking system to make available.

MONEY DEMAND AND THE QUANTITY THEORY: DETAILS

Back in Chapter 8 we had a different model of money demand. There the key equation was the so-called quantity theory of money equation:

$$MV = PY$$

which, if you solve for M/P , is

$$\frac{M}{P} = \frac{Y}{V}$$

instead of

$$\frac{M^d}{P} = M_y Y - M_i i$$

The two equations are the same if $M_i = 0$ and if $M_y = 1/V$, and not otherwise. Why start over with this new and different money demand equation, rather than building on the quantity equation taught in Chapter 8? The answer is that we seek simplicity: The equations and formulas later in this chapter are simpler this way, and the equations and formulas in Chapter 8 were simpler with the quantity theory equation. After all, the differences between the two approaches are not that great; no important points of theory depend on them. And so in each case we take whatever starting point makes the end of the argument clearest and simplest.

that we know the level of total income Y . We know that when the money market is in equilibrium, the quantity of money M supplied by the banking system will be equal to the quantity of money demanded M^d by households and businesses:

$$M = M^d$$

And we know the money demand equation

$$\frac{M^d}{P} = M_y Y - M_i i$$

We can solve these two by substituting M for M^d and subtracting $M_y Y$ from both sides:

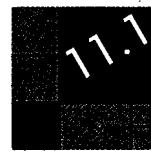
$$\frac{M}{P} - M_y Y = -M_i i$$

Then we divide by $-M_i$ to solve for i :

$$i = \frac{M_y Y - \left(\frac{M}{P}\right)}{M_i}$$

This level of the nominal interest rate i is the equilibrium level of the interest rate. It is the level at which the *money supply* and *money demand* curves cross.

A higher level of total spending and income Y increases the equilibrium interest rate i : With more spending, people find it more urgent to hold wealth in the form of money and are willing to pay a higher opportunity cost to do so. A higher



real money stock M/P reduces the equilibrium value of i : With more money in the economy people are happy holding the larger quantity of liquid assets in their portfolios only if the opportunity cost of doing so is lower.

Note that a higher level of M_i — more sensitivity of money demand to the interest rate — means that changes in M/P and in Y would have smaller effects on the equilibrium interest rate i . Note also that a smaller value of M_y — and M_y does tend to shrink over time — also means that changes in Y will have smaller effects on the equilibrium interest rate i .

Adjustment to Equilibrium

Suppose money supply is less than money demand, so that households and businesses want to hold more liquid money balances than exist. Businesses and households sell bonds to boost their cash holdings. The price of bonds falls — and, as is explained in Box 11.2, a fall in the price of bonds is equivalent to a rise in the nominal interest rate. And as the nominal interest rate rises, the quantity of money demanded by households and businesses falls as well: The opportunity cost of holding money has risen.

When the nominal interest rate has risen far enough that the quantity of money demanded has fallen until it equals the money supply, and households and businesses are no longer trying to increase their liquid money balances, there is no more upward pressure on the nominal interest rate.

Now suppose instead that money supply is greater than money demand, so that businesses and households are holding more liquid money balances than they want. They take these extra liquid money balances and buy bonds with them. The price of bonds rises, which means that the nominal interest rate falls. As the nominal interest rate falls, the quantity of money demanded rises because the opportunity cost of holding money has fallen. When the nominal interest rate has fallen enough so that the quantity of money demanded is equal to the money supply, there is no more downward pressure on the nominal interest rate.



BOND PRICES AND INTEREST RATES: DETAILS

Suppose that we have a very long lived bond that pays its holder \$1 in interest every year. The interest rate earned by the bondholder depends on the price of the bond. Suppose the price of the bond is \$10. Then the bondholder is earning \$1 per year on a financial asset whose price is \$10, for a rate of return — an interest rate — of 10 percent. Now, what happens if the price of the bond rises? Suppose the price of the bond goes up to \$20. Then the rate of return — the interest rate — earned by the bondholder will be just 5 percent, because \$1 in interest income is 5 percent of the bond's \$20 value. The bond's price is

$$\text{Price of bond} = \frac{1}{i}$$

Thus we see that the nominal interest rate i moves inversely with the price of bonds: The higher the price of bonds, the lower the nominal interest rate; the lower the price of bonds, the higher the nominal interest rate. ◆

RECAP THE MONEY MARKET AND THE MONEY STOCK

Households and businesses want to hold some of their wealth in the form of money: a liquid form in which they can easily spend it. Wealth held in the form of money earns little or no interest, hence the higher the nominal interest rate i , the lower is the demand for money. And the value of holding wealth in readily spendable form depends on the flow of income, hence the higher total income Y , the greater is the demand for money. For given values of the real supply of money M/P and the level of total income Y , supply and demand in the money market produce an equilibrium value of the nominal interest rate i . The higher the real supply of money M/P , the lower is the interest rate i . The higher the flow of total income Y , the higher is the interest rate i .

11.2 THE LM CURVE

Interest Rates and Total Income

We have assumed that the money supply M and the price level P are constant. And we have found that under this assumption the equilibrium nominal interest rate i depends on three other things: the parameter M_y , which tells us how much in the way of money balances households and businesses typically demand per dollar of income (and which is a function of the sophistication of the banking and payments system); the parameter M_i , which tells us how sensitive consumers' and businesses' demand for money is to changes in the interest rate; and the level of total income Y .

This dependence on total income Y means that fully capturing the money market in a single diagram with the quantity of money on the horizontal axis and the nominal interest rate on the vertical axis is impossible. We try to draw such a diagram in Figure 11.2 on page 320, but we find that there is a different curve for real money demand M/P as a function of the nominal interest rate i for each different possible value of income Y . And each of these different curves for each different value of Y generates a different equilibrium nominal interest rate i .

When total income and spending Y rises and the money supply M does not, the nominal interest rate i will rise to keep the money market in equilibrium. With higher incomes, households and businesses want to hold more money. But if the money supply does not increase, then in aggregate their money holdings cannot grow. Households and businesses sell bonds as they try to increase their money holdings — efforts that are futile in the aggregate but successful for individual households and businesses — and these bond sales push down the price of bonds, which is the same thing as pushing up the nominal interest rate i . As the interest rate i rises, the opportunity cost of holding money increases, so money demand M^d falls. The nominal interest rate will rise until the resulting drop in money demand has fully offset the increase in money demand that resulted from the higher income and spending.

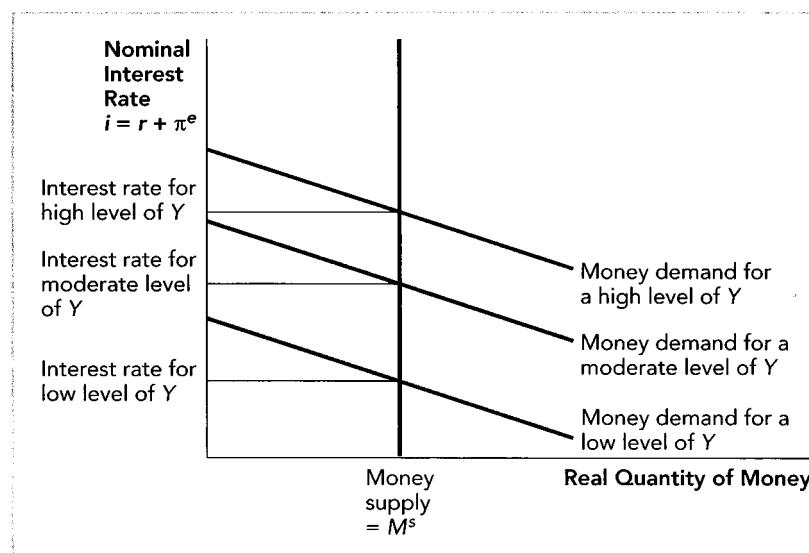
Drawing the LM Curve

How are we going to capture these complexities and still manage to draw simple diagrams? Consider placing the nominal interest rate i on the vertical axis and total

FIGURE 11.2

Money Demand Varies as Total Income Varies

The higher the level of total income Y , the higher the quantity of money demanded for any given interest rate, and (for a fixed money stock) the higher the equilibrium interest rate.



LM curve

The positive relationship between real GDP or total income and the real interest rate that emerges from considering a whole family of money demand-money supply diagrams.

income Y on the horizontal axis. For each possible value of Y on the horizontal axis, plot the point whose vertical axis value is the interest rate that produces equilibrium in the money market. The result is shown in Figure 11.3. This result is called the “LM curve”—the combinations of total income Y and nominal interest rates i that produce money market equilibrium. The LM curve slopes upward: At a higher level of real GDP Y , the equilibrium nominal interest rate is higher.

The equation for the LM curve is one step removed from the money demand function:

$$i = \frac{M_y Y - \left(\frac{M}{P}\right)}{M_i}$$

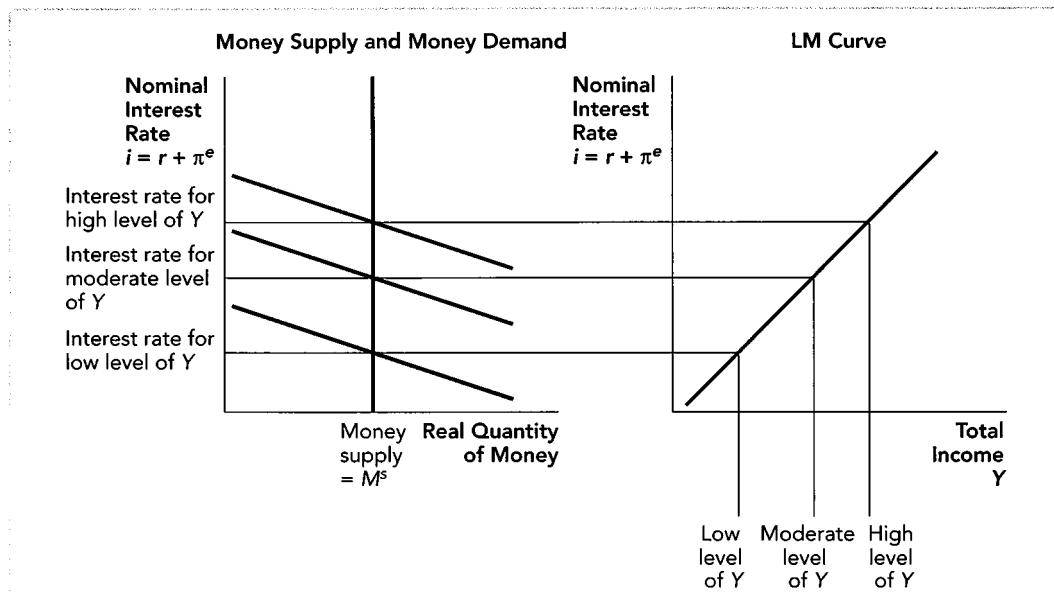
We simply rewrite and transform this equation to put the level of total income Y all by itself on the left side:

$$Y = \frac{\left(\frac{M}{P}\right) + M_i i}{M_y}$$

The location of the LM curve depends on the economy's current level of the real money stock M/P . Change M/P , and you change the position of the LM curve. Thus a change in monetary policy that increased the money supply M would shift the LM curve to the right in Figure 11.3: The same equilibrium nominal interest rate i would then correspond to a higher level of total income Y . A shift in monetary policy that decreased the nominal money supply M would shift the LM curve to the left. Similarly, a decline in the price level P would boost the real money supply (M/P), and so shift the LM curve to the right in Figure 11.3. A rise in the

FIGURE 11.3

From Money Demand to the LM Curve The LM curve on the right tells us what the nominal interest rate will be for each value of total income Y .



price level P would decrease the real money supply (M/P) and shift the LM curve to the left.

RECAP THE LM CURVE

Money demand depends positively on total income Y and negatively on the nominal interest rate i . For a fixed value of the real money stock M/P , there is therefore a positive relationship between Y and i . We call this relationship the LM curve — an upward-sloping relationship between total income or real GDP Y and the nominal interest rate i .

11.3 THE IS-LM FRAMEWORK

The IS-LM Diagram

If we knew the level of total income Y , we could use the LM curve to figure out the nominal interest rate i . If we knew the level of the real interest rate r , we could use the IS curve from Chapter 10 to figure out the level of real GDP Y . The Y that is total income in the LM curve is the same as the Y that is real GDP in the

IS curve — the circular flow principle guarantees it. But we can't figure out Y without knowing r , and can't figure out r without knowing i , and we can't figure out i without knowing Y .

But we are not at an impasse. The level of total income Y and the nominal interest rate i appear in the LM curve. Total income Y is the same thing as real GDP Y . The nominal interest rate i is equal to the real interest rate r plus the expected inflation rate π^e . The real interest rate r and real GDP Y appear in the IS curve.

Since the nominal interest rate is equal to the real interest rate plus the expected inflation rate, we can plot the IS and LM curves on the same set of axes as long as we know what the expected inflation rate is. And if the inflation rate is and has been constant for some time, we can reasonably assume the expected inflation rate π^e equals the actual inflation rate π . If the inflation rate is 2 percent, then a 3 percent real interest rate is a 5 percent nominal interest rate and a 6 percent real interest rate is an 8 percent nominal interest rate. If the inflation rate is 4 percent, then a 3 percent real interest rate is a 7 percent nominal interest rate and a 6 percent real interest rate is a 10 percent nominal interest rate. As long as we know what the expected inflation rate is, there is no problem with using the vertical axis for both the IS curve's real interest rate r and the LM curve's nominal interest rate i .

Figure 11.4 is called the **IS-LM diagram**. It allows us to figure out what the equilibrium levels of real GDP and of the interest rate are: The equilibrium values are at the point where the IS and LM curves cross. At that level of real GDP and total income Y and the real interest rate r , the economy is in equilibrium in both the goods market and the money market. Planned expenditure is equal to total production, so inventories are stable (that's what the IS curve indicates); and money demand is equal to money supply (that's what the LM curve indicates).

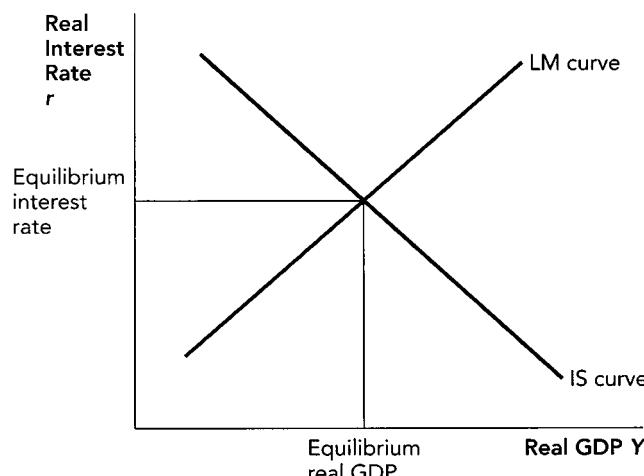
IS-LM diagram

A diagram used to determine what values of the interest rate and of total income together produce equilibrium in the money market — supply of money equal to money demand — and equilibrium in the goods market — planned expenditure equal to real GDP.

FIGURE 11.4

The IS-LM Diagram

What is the economy's equilibrium? It is the point at which the IS and LM curves cross. Along the IS curve, total production is equal to planned expenditure. Along the LM curve, the quantity of money demanded by households and businesses is equal to the money stock. Where the curves cross, both the goods market and the money market are in balance.



Box 11.3 shows how to calculate the economy's equilibrium position for some specific parameter values of the sticky-price model.

IS Shocks

Any change in economic policy or the economic environment that increases autonomous spending, such as an increase in government purchases, shifts the IS curve to the right. If the money stock is constant, it moves the economy up and to the right along the LM curve on the IS-LM diagram, as Figure 11.6 at the bottom of page 324 shows. The new equilibrium will have both a higher level of real interest rates and a higher equilibrium level of real GDP.

Exactly how the total effect of an expansionary shift in the IS curve is divided between increased interest rates and increased real GDP depends on the slopes of

IS-LM EQUILIBRIUM: AN EXAMPLE

Suppose that the economy's marginal propensity to expend (MPE) is 0.5, that the initial baseline level of autonomous spending A_0 is \$5,000 billion, and that a 1-percentage-point increase in the real interest rate r (an increase, say, from 4 percent to 5 percent — from $r = 0.04$ to $r = 0.05$) will reduce the sum of investment and gross exports by \$100 billion. Then, from Chapter 10, the economy's IS curve is (in billions)

$$Y = \frac{A_0}{1 - MPE} - \left(\frac{I_r + X_e \epsilon_r}{1 - MPE} \right) r = \frac{\$5,000}{1 - 0.5} - \left(\frac{\$10,000}{1 - 0.5} \right) r = \$10,000 - \$20,000r$$

Suppose further that the inflation rate π is constant at 3 percent per year — $\pi = \pi^e = 0.03$ — and that the economy's initial LM curve is (in billions)

$$Y = \$1,000 + \$100,000i$$

where i is the economy's nominal interest rate, the sum of the real interest rate r and the expected inflation rate π^e .

The equilibrium point for this economy will be the point at which total income and real GDP Y and the real interest rate r and the nominal interest rate i are at their values where the IS and LM curves cross. Remember that the nominal interest rate i is the real interest rate r plus the expected inflation rate π^e .

$$Y = \$1,000 + \$100,000(r + \pi^e)$$

Set the right-hand sides of the LM and IS curve equations equal to each other:

$$\$1,000 + \$100,000(r + \pi^e) = \$10,000 - \$20,000r$$

Substitute in 0.03 for the expected inflation rate π^e :

$$\$1,000 + \$100,000(r + 0.03) = \$10,000 - \$20,000r$$

And solve for the real interest rate r :

$$\$120,000r = \$6,000$$

$$r = 0.05 = 5\%$$

The equilibrium real interest rate r is 5 percent per year. And from this it is straightforward to solve that real GDP Y is \$9,000 billion, as Figure 11.5 shows.

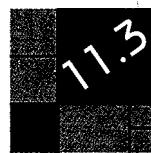


FIGURE 11.5
IS-LM Equilibrium Example

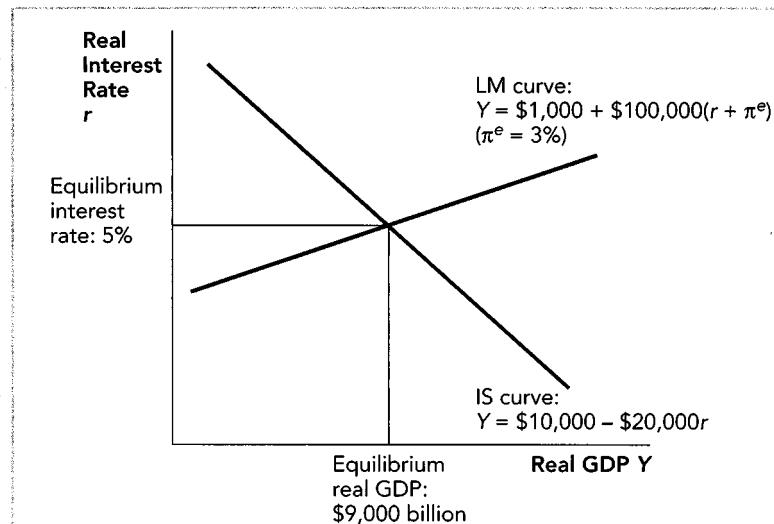
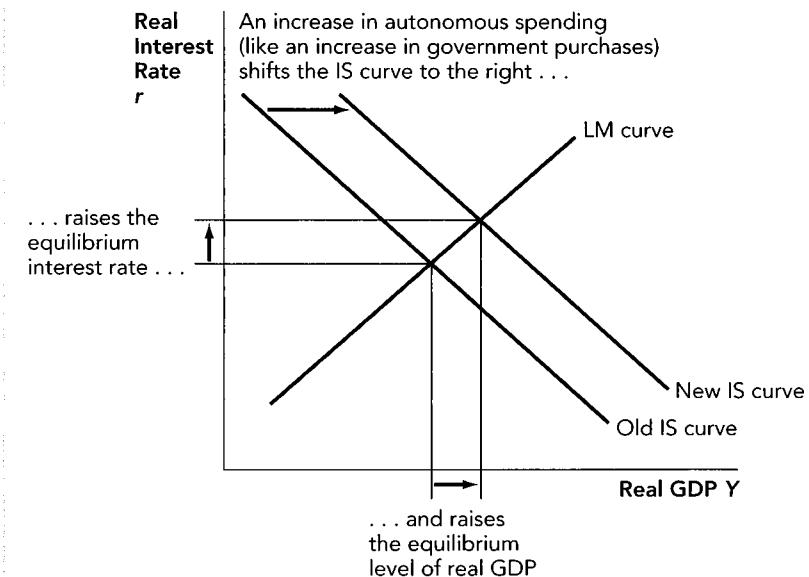


FIGURE 11.6
Effect of a Positive IS Shock
An expansionary shift in the IS curve raises both real GDP Y and the real interest rate r .



the IS and LM curves. Box 11.4 provides an example of how to calculate exactly what the effects are.

AN INVESTMENT SHOCK IN THE IS-LM MODEL: AN EXAMPLE

Suppose that, as in Box 11.3, the economy's marginal propensity to expend (MPE) is 0.5, that the initial level of baseline autonomous spending A_0 is \$5,000 billion, and that a 1-percentage-point increase in the real interest rate r (an increase, say, from 4 percent to 5 percent — from $r = 0.04$ to $r = 0.05$) will reduce the sum of investment and gross exports by \$100 billion. Then, as in Box 11.3, the economy's IS curve is (in billions)

$$Y = \frac{A_0}{1 - MPE} - \left(\frac{I_r + X_e \varepsilon_r}{1 - MPE} \right) r = \frac{\$5,000}{1 - 0.5} - \left(\frac{\$10,000}{1 - 0.5} \right) r = \$10,000 - \$20,000r$$

And suppose further, as in Box 11.3, that the inflation rate π is constant at 3 percent per year so $\pi = \pi^e = 0.03$, and that the economy's initial LM curve is (in billions)

$$Y = \$1,000 + \$100,000i = \$1,000 + \$100,000(r + \pi^e)$$

where i is the economy's nominal interest rate, the sum of the real interest rate r and the expected inflation rate π^e .

Then the initial equilibrium point for this economy is

$$r = 0.05 = 5\% \text{ per year}$$

and

$$Y = \$9,000 \text{ billion}$$

Now suppose there is a positive real shock to demand: Enthusiasm about new technologies leads to an increase in baseline investment I_0 (and thus also in baseline autonomous spending A_0) of \$150 billion. What is the economy's new equilibrium?

The answer is that the IS curve now, because of the increase in baseline autonomous spending, is

$$Y = \frac{A_0 + \Delta I_0}{1 - MPE} - \left(\frac{I_r + X_e \varepsilon_r}{1 - MPE} \right) r = \frac{\$5,150}{1 - 0.5} - \left(\frac{\$10,000}{1 - 0.5} \right) r = \$10,300 - \$20,000r$$

The IS curve shifts out and to the right by \$300 billion — the value of the increase in autonomous spending \$150 billion times the multiplier $1/(1 - MPE)$, which in this economy is equal to 2. The LM curve remains unchanged.

Set the right-hand sides of the LM and the new IS curve equal to each other:

$$\$1,000 + \$100,000(r + \pi^e) = \$10,300 - \$20,000r$$

Substitute 0.03 for the expected inflation rate π^e :

$$\$1,000 + \$100,000(r + 0.03) = \$10,300 - \$20,000r$$

and solve for the real interest rate r :

$$\$120,000r = \$6,300$$

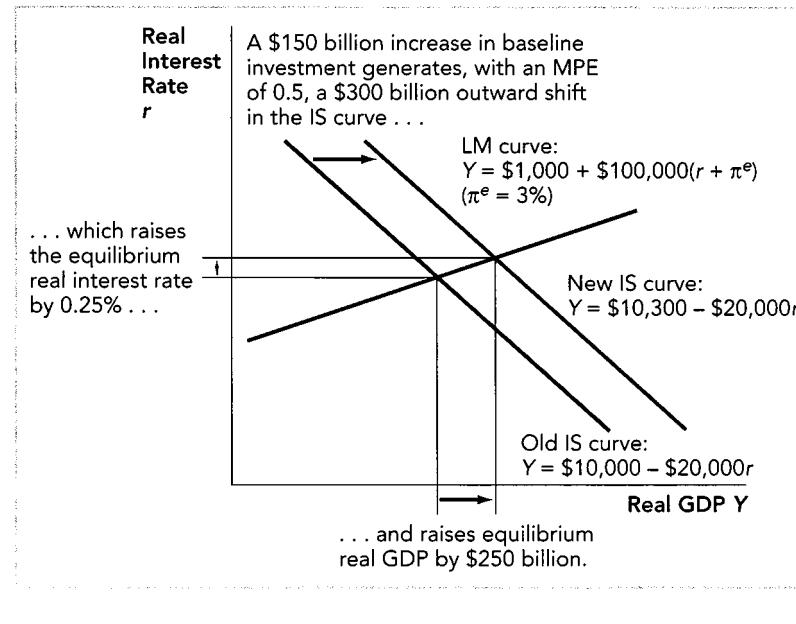
$$r = 0.0525 = 5.25\%$$



The equilibrium real interest rate r is 5.25 percent per year. And from this it is straightforward to solve that real GDP Y is \$9,250 billion, as Figure 11.7 shows.

Although the IS curve has shifted outward by \$300 billion, real GDP has risen by only \$250 billion. Why? Higher income has increased the demand for money. Stronger demand for money has pushed the real interest rate r up to 5.25 percent per year (and has pushed the nominal interest rate i up to 8.25 percent per year). And the increase in interest rates has had a depressing effect on investment, which has crowded out some \$50 billion of real GDP that would have been present had interest rates remained unchanged. Figure 11.7 shows how these curves shift.

FIGURE 11.7
Calculating the Effect of an IS Shift



If the LM curve is nearly horizontal, interest rates will show little increase. The increase in equilibrium real GDP will be nearly the same magnitude as the outward shift in the IS curve. If the LM curve is very steeply sloped, there will be a big effect on interest rates and little effect on real GDP. The LM curve will be steeply sloped when M_i is very small — when, that is, demand for money is extremely interest-inelastic. When M_i is small, a large change in interest rates is needed to cause a small change in households' and businesses' desired holdings of money. The LM curve will also be steeply sloped when M_y is large — when, that is, demand for money is extremely income-elastic. Here again, only a large change in interest rates will offset the effects of a small change in income.

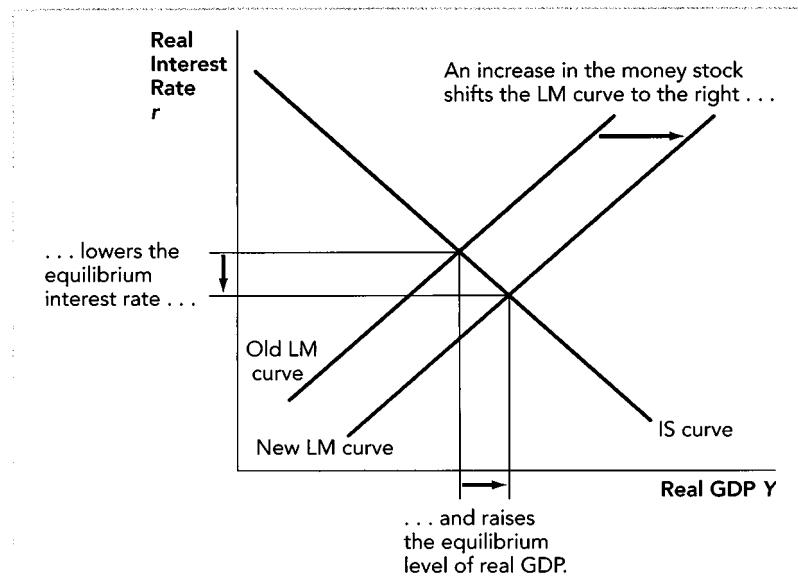


FIGURE 11.8
Effect of an
Expansionary LM
Shock

An expansionary shift in the LM curve raises real GDP Y and lowers the equilibrium interest rate r .

LM Shocks

An increase in the nominal money stock M will shift the LM curve to the right. The larger money supply means that any given level of real GDP will be associated with a lower equilibrium nominal interest rate. Such an expansionary LM shift will shift the equilibrium position of the economy down and to the right along the IS curve, as Figure 11.8 shows. The new equilibrium position will have a higher level of equilibrium real GDP and a lower interest rate. Box 11.5 provides an illustrative example of such an expansionary LM shift.

CALCULATING THE EFFECTS OF AN LM SHOCK: AN EXAMPLE

Suppose that, as in Boxes 11.3 and 11.4, the economy's IS curve is

$$Y = \frac{A_0}{1 - MPE} - \left(\frac{I_r + X_e \varepsilon_r}{1 - MPE} \right) r = \frac{\$5,000}{1 - 0.5} - \left(\frac{\$10,000}{1 - 0.5} \right) r = \$10,000 - \$20,000r$$

that the inflation rate π is constant at 3 percent per year — $\pi = \pi^e = 0.03$ — and that the economy's initial LM curve is (in billions)

$$Y = \$1,000 + \$100,000i$$

where i is the economy's nominal interest rate, the sum of the real interest rate r and the expected inflation rate π^e .

Now suppose that the central bank buys bonds for cash, expanding the economy's money supply, and shifting the LM curve to

$$Y = \$2,200 + 100,000i$$



shifting the LM curve to the right by \$1,200 billion. What will be the new equilibrium for the economy?

Substitute the sum of the real interest rate r and the expected inflation rate π^e for the nominal interest rate i in the LM curve equation, and set the right-hand sides of the LM and IS equations equal to each other:

$$\$2,200 + \$100,000(r + \pi^e) = \$10,000 - \$20,000r$$

Substitute in 0.03 for the expected inflation rate π^e , and solve for r :

$$\$120,000r = \$4,800$$

$$r = 0.04 = 4\% \text{ per year}$$

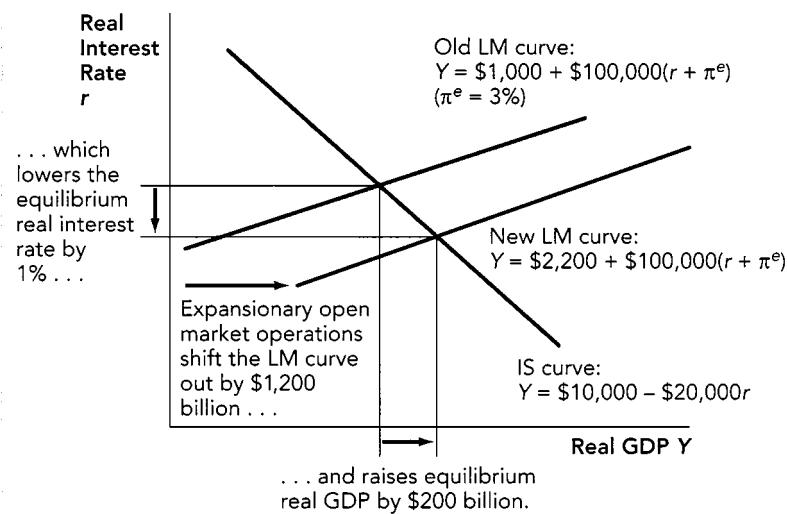
The real interest rate falls to 4 percent per year (and, with constant expected inflation, the nominal interest rate falls to 7 percent per year). We can then use the IS curve to calculate that total income and output must be

$$Y = \$9,200 \text{ billion}$$

The expansionary monetary policy has succeeded in raising output and incomes.

Figure 11.9 shows, graphically, how the LM curve shifts in this example.

FIGURE 11.9
An Expansionary Shift in the LM Curve



Conversely, a decrease in the money supply or any other contractionary LM shock that shifts the LM curve in and to the left will shift the economy up and to the left along the IS curve, resulting in higher equilibrium interest rates and a lower equilibrium value of real GDP.

Note the difference between how the money market works in this sticky-price model and in the flexible-price model presented in Part 3. In the flexible-price model, the real interest rate balanced the supply and demand for loanable funds flowing through the financial markets. Changes in the money stock had no effect on either the real interest rate or real GDP. Instead, the price level adjusted upward or downward to keep the quantity of money demanded equal to the money supply.

Here in the sticky-price model the price level is . . . sticky. It cannot adjust instantly upward or downward. So an imbalance in money demand and money supply does not cause an immediate change in the price level. Instead, it causes an immediate change in the nominal interest rate.

Classifying Economic Disturbances

The IS-LM framework allows economists to classify shifts in the economic environment and changes in economic policy into four basic categories, two that affect the LM curve and two that affect the IS curve. A surprisingly large number of economic disturbances can be fitted into the IS-LM framework.

Changes That Affect the LM Curve

The LM curve is a relationship between the short-run nominal interest rate i and the level of total income and real GDP Y at a given, fixed level of the real money supply for given, fixed parameters of the money demand function. This means, first, that any change in the nominal money stock or in the price level will shift the LM curve. Second, any change in the parameters of the money demand function — in how sensitive money demand is to changes in the nominal interest rate i or in total income Y — will shift the LM curve.

Moreover, the IS-LM diagram is drawn with the real interest rate — the long-term, risky, real interest rate — on the vertical axis. This has important consequences. As long as the spread between the short-term, safe, nominal interest rate i in the LM equation and the long-term, risky, real interest rate r in the IS equation is constant, the LM curve can be drawn on the same diagram as the IS curve with no complications. But what if the expected rate of inflation π^e , the risk premium, or the term premium between short- and long-term interest rates changes? Then the position of the LM curve on the IS-LM diagram shifts either upward (if expected inflation falls, or if the risk premium rises, or if the term premium rises) or downward (if expected inflation rises, or if the risk premium falls, or if the term premium falls). Figure 11.10 on page 330 illustrates what happens to the position of the LM curve if the expected inflation rate rises.

Thus changes in financial market expectations of future Federal Reserve policy or of future inflation rates or simply changes in the risk tolerance of bond traders shift the LM curve. The IS-LM equilibrium is affected not only by disturbances in the money market but by broader shifts in the financial markets that alter the relationship between the nominal interest rates on short-term safe bonds and the real interest rate paid by corporations undertaking long-term risky investments.

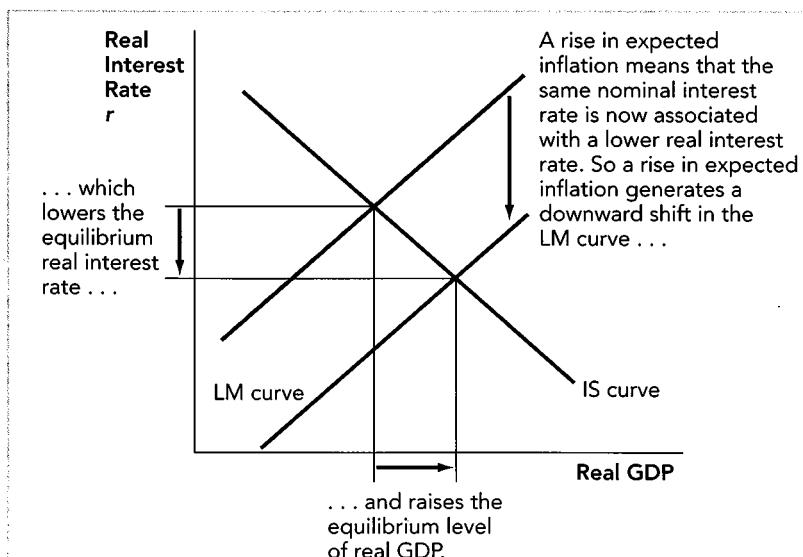
Changes That Affect the IS Curve

Shifts in the IS curve are probably more frequent than shifts in the LM curve, for more types of changes in the economic environment and economic policy affect planned expenditure than affect the supply and demand for money. Any change in the sensitivity of investment to the real interest rate changes the slope of the IS curve.

FIGURE 11.10

An Increase in Expected Inflation Moves the LM Curve Downward

The fact that the interest rate relevant to the IS curve is a real rate and the interest rate relevant to the LM curve is a nominal rate is a source of complications: A rise in expected inflation lowers the real interest rate that corresponds to any given nominal interest rate, and so shifts the LM curve down on the IS-LM diagram.



So will any change in either the sensitivity of exports to the exchange rate or the sensitivity of the level of the exchange rate to the level of domestic interest rates.

Furthermore, anything that affects the marginal propensity to spend — the MPE — will change the slope of the IS curve and the position of the IS curve as well. Any shift in the marginal propensity to consume C_y will change the MPE. Thus if households decide that income changes are more likely to be permanent (raising the marginal propensity to consume) or more likely to be transitory (lowering the marginal propensity to consume), that will raise or lower the MPE. Changes in tax rates have a direct effect on the MPE. So do changes in the propensity to import. Thus, for example, the imposition (or removal) of a tariff on imports to discourage (or encourage) imports will affect the position and slope of the IS curve.

Finally, changes in the economic environment and in economic policy that shift the level of baseline autonomous spending shift the IS curve. Anything that affects the baseline level of consumption C_0 affects autonomous spending — whether it is a change in demography that changes desired saving behavior, a change in optimism about future levels of income, or any other cause of a shift in consumer behavior. Anything that affects the baseline level of investment I_0 affects autonomous spending — whether it is a wave of innovation that increases expected future profits and desired investment, a wave of irrational overoptimism or overessimism, a change in tax policy that affects not the level of revenue collected but the incentives to invest, or any other cause. Changes in government purchases affect autonomous spending.

In sum, almost anything can affect the equilibrium level of planned expenditure on the IS-LM diagram. Pretty much everything does affect it at one time or another. One of the principal merits of the IS-LM diagram is its use in sorting and classifying the determinants of equilibrium output and interest rates.

RECAP THE IS-LM FRAMEWORK

For a constant value of inflation π and thus of the expected inflation rate π^e , we can think of the LM curve as a relationship between real GDP Y and the real interest rate r , and we can draw it on the same axes as the IS curve to make the IS-LM diagram. The IS-LM diagram shows us how to analyze any of a huge number of shocks to the economy when the central bank sets the money supply. In general, shocks to the IS curve cause real GDP Y and interest rates r to move in the same direction, whereas shocks to the LM curve cause real GDP Y and interest rates r to move in opposite directions.

11.4 AGGREGATE DEMAND AND AGGREGATE SUPPLY

The Price Level and Aggregate Demand

What happens to real GDP as the price level rises? If the nominal money supply is fixed, then an increase in the price level reduces real money balances and shifts the LM curve to the left. The equilibrium real interest rate rises, and the equilibrium level of real GDP falls, as the top panel of Figure 11.11 shows.

Suppose we draw a second diagram, this time with the price level on the vertical axis and the level of real GDP on the horizontal axis. We use this second diagram to plot what the equilibrium level of real GDP is for each possible value of the price level. For each value of the price level, we calculate the LM curve and use the IS-LM diagram to calculate the equilibrium level of real GDP. As the bottom panel of Figure 11.11 shows, we find — if the nominal money supply is fixed — a downward-sloping relationship between the price level and real GDP. With the nominal money stock held fixed, a rise in the price level decreases the real money stock and shifts the LM curve to the left because the position of the LM curve depends on the value of the real money stock.

A leftward shift in the LM curve reduces the equilibrium level of real GDP and increases the interest rate. The lower the price level, the higher real money balances are, the lower the interest rate is, the higher aggregate demand is, and the higher the equilibrium level of real GDP is. Economists call this curve — according to which a lower price level means higher aggregate demand — the aggregate demand (AD) curve.

The Price Level and Aggregate Supply

Inflation is an increase in the general, overall price level. An increase in the price of any one particular good — even a large increase in the price of any one particular good — is not inflation. Inflation, then, is an increase in the price of just about everything. Together, the prices of all or nearly all goods and incomes rise by approximately the same proportional amount.

Note — and this is important — that in the sticky-price model prices are sticky, not stuck. They do move over time. They just don't move fast enough to get us to the flexible-price model situation of Chapters 6–8 immediately. (See Box 11.6 on page 333.) Up until this point, paying little or no attention to the fact that prices are not stuck fast in the sticky-price model has been convenient. But from this point on, we

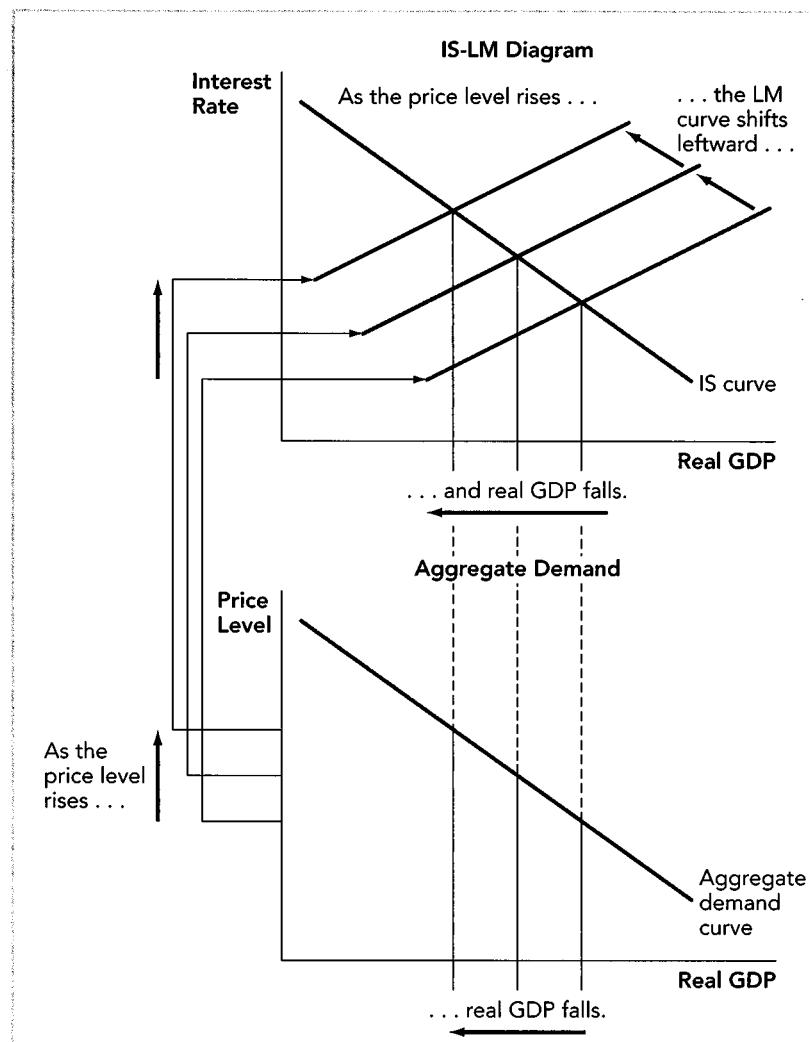
aggregate demand (AD) curve

A downward-sloping relationship between planned expenditure and the price level, produced because a higher price level means a lower real money stock, higher real interest rates, lower investment spending, and lower planned expenditure.

FIGURE 11.11

From the IS-LM Diagram to the Aggregate Demand Curve

For a fixed value of the nominal money stock, an increase in the price level is a contractionary shift in the economy. The higher the price level, the lower is the real money stock and the further left the LM curve moves. Plot the equilibrium value of real GDP for that LM curve on the horizontal axis and the price level on the vertical axis. The result is the aggregate demand curve.



do need to pay attention to how prices change and what the inflation rate is in the sticky-price model.

aggregate supply (AS) curve

The curve that shows the dependence of firms' production on the inflation rate (and thus on the price level): The higher the inflation rate, the more goods and services are produced.

In the short run of the sticky-price model, whenever real GDP is greater than potential output, inflation and the price level are likely to be higher than people had previously anticipated. Conversely, whenever the level of real GDP is below potential output, inflation and the price level are likely to be lower than people had previously anticipated. The inflation rate is likely to fall toward zero — and perhaps prices will begin to fall in deflation. Economists call the correlation between real GDP (relative to potential output) and the price level or the rate of inflation (relative to their previously expected values) the short-run aggregate supply (AS) curve.

PRICES: STUCK? STICKY? FLEXIBLE? AN EXAMPLE

Remember our example from Chapter 7 about prices of coffee drinks at off-campus cafés? If prices were flexible, the price of the coffee drinks served to students who rush into the café just before class on a chilly morning would rise between the time the last student got in line and the time she reached the counter. And then when student demand for espresso drinks fell just minutes later as classes began, the price of the drink would fall. Anyone who has stood at the end of a long line waiting for a morning caffeine fix should be grateful that prices are not fully flexible in the very short run.

Instead, what does happen? There's a long line, you're going to be late for class, there aren't enough people working the counter . . . it's a shortage. But prices are sticky; Strada can't change prices between the time you walk in the door and the time you reach the counter. Instead, the café tries to increase output to respond to this unexpected shortage by hollering for the kitchen staff to help take orders and by making those lattes as fast as humanly (and machinely!) possible. Prices are sticky, so output is the first thing to adjust to the unexpected shortage.

Prices are sticky, but they are not stuck. Given enough time — which for Caffè Strada might be as little as a week — the café can surely change its prices in response to shifts in supply and demand. Prices are not stuck. If the shortage persists — if Strada is never able to hire additional workers at the old wage, if the increase in demand is permanent and not just associated with the time of day or the weather — then ultimately Strada will probably increase the price somewhat. No one will jack up prices by the time you reach the counter, but maybe by the time you get back for classes next term. Or perhaps as soon as next week. Prices are sticky but they are not stuck; they will eventually change in response to an unexpected shortage or surplus.

High levels of real GDP should be associated with higher inflation and a higher price level for many possible reasons, but we briefly consider only two. First, when demand for products is stronger than anticipated, firms raise their prices higher than they had previously planned. When aggregate demand is higher than potential output, demand is strong in nearly every single industry. Nearly all firms raise prices and hire more workers. Employment expands beyond its average proportion of the adult population and the unemployment rate falls below the “natural” rate of unemployment — the rate at which the rate of inflation is stable. High demand gives workers extra bargaining power, and they use it to bargain for higher wage levels than they had previously planned. Unions threaten to strike, knowing that firms will have a hard time finding replacement workers. Individuals quit, knowing they can find better jobs elsewhere. Such a high-pressure economy generates wages that rise faster than anticipated. Rapid wage growth is passed along to consumers in higher prices and accelerating inflation. Thus high real GDP generates a higher price level and inflation rate.

Second, when aggregate demand is higher than potential output, individual economic sectors and industries in the economy quickly reach the limits of capacity. Now bottlenecks emerge. Confronted with a bottleneck — a vital item, part, or process where production cannot be increased quickly — potential purchasers bid up the price of the bottlenecked item. Since a car is useless without brakes, car



manufacturers will pay any price for brake assemblies if they are in short supply. Such high prices signal to the market that the bottleneck industry should expand and trigger investment that in the end boosts productive capacity. But developing bottlenecks lead to prices that increase faster than expected, thus to accelerating inflation and a higher price level.

Note that here it is not important to distinguish between inflation and the price level. Inflation is, after all, the proportional change between last year's price level and this year's price level. Thus a high price level relative to what was previously expected is a high inflation rate (relative to what was previously expected), and vice versa. When we draw aggregate supply curves on graphs, we won't care too much about whether what is on the vertical axis of the graph is the price level or the inflation rate: They move together.

Note also that expectations play a key role. What calls forth higher (or lower) production is that prices and inflation are higher (or lower) than people had been expecting.

The AS-AD Diagram

AS-AD diagram

A diagram that plots real GDP (relative to potential output) on the horizontal axis and the price level (or the inflation rate) on the vertical axis and shows the aggregate demand curve and the aggregate supply curve.

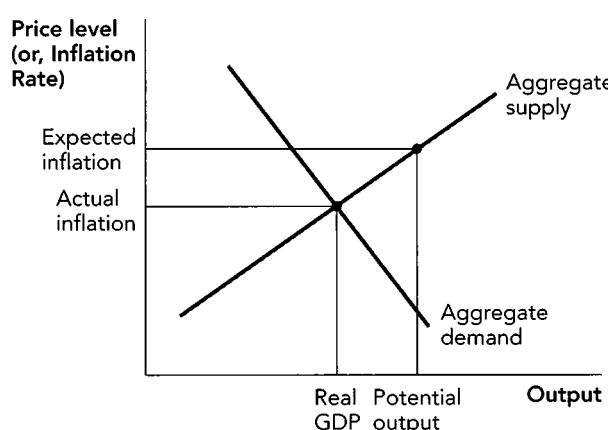
We combine the aggregate supply curve with the aggregate demand curve by drawing them both on the same set of axes — the AS-AD diagram. Now we can see not just the equilibrium level of real GDP but also the equilibrium price level (and inflation rate), as shown in Figure 11.12. The AS curve slopes upward because an unexpectedly high price level — a relatively high inflation rate between last year and this year — calls forth the more intensive use of resources and thus a higher level of production. A higher price level reduces the real money stock (if the nominal money supply is constant) and thus increases interest rates. Where aggregate supply and aggregate demand are equal — where the two curves cross — is the current level of real GDP and the price level (and inflation rate).

Now for the first time we have an integrated story of business-cycle fluctuations not just in production but in the overall level of prices as well. Suppose the

FIGURE 11.12

Aggregate Supply and Aggregate Demand

Where aggregate supply equals aggregate demand determines not just real GDP but also the price level and the inflation rate.



A SHOCK TO AGGREGATE DEMAND: DETAILS

In late 1987, newly inaugurated Federal Reserve Chair Alan Greenspan and the rest of the Board of Governors, Federal Reserve Bank presidents, and staff of the Federal Reserve system faced a dilemma. The stock market had just crashed. Did this mean that investors were getting discouraged — that their baseline level of investment spending I_0 was about to fall and that recession was on the way? They weren't sure, but they did not want to take the chance. Late 1988 and 1989 saw low interest rates and expansionary monetary policy to try to keep production from declining.

The policies were successful. Real GDP rose by a healthy 4.1 percent in 1988 and 3.5 percent in 1989. But inflation, which had been under 4 percent between 1983 and 1987, began to rise. Between December 1989 and December 1990 consumer prices rose by 6.1 percent.

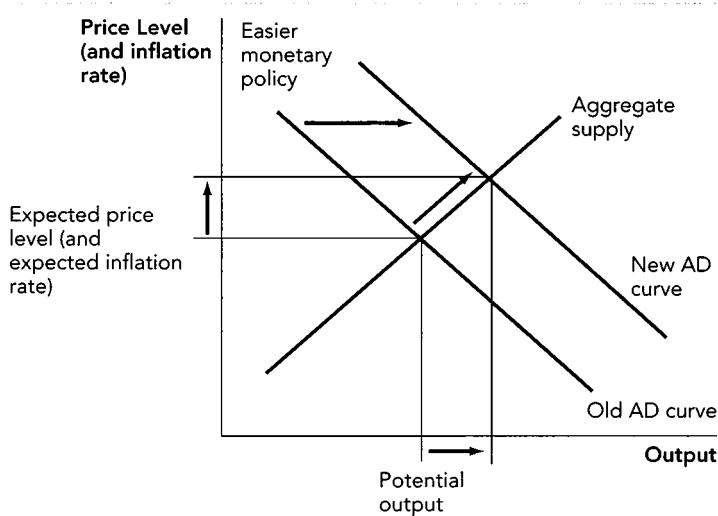
The best way to understand this uses the AS-AD diagram. (See Figure 11.13.) The Federal Reserve's late 1987 resort to expansionary monetary policy shifted the AD curve up and to the right. Production rose, and prices and inflation rates rose too as higher-than-expected demand produced higher-than-anticipated price levels and inflation rates.

The Federal Reserve thus guarded against the possibility of a recession in 1988 and 1989, but at the price of stirring up a different kind of macroeconomic trouble for the future.



FIGURE 11.13

Using the AS-AD Diagram The late 1980s shift to more expansionary monetary policy brought higher output, but also higher prices and inflation as expanding demand pushed the economy up and to the right along the AS curve.



government enacts a tax cut — something that shifts the IS curve out to the right and shifts the point of intersection of the IS and LM curves up and to the right, producing higher equilibrium values of real GDP and interest rates for each possible value of the price level. In the AS-AD framework, such a tax cut shifts the AD curve out and to the right as well. The result in the AS-AD framework sees output expand — real GDP rise — and the price level rise as well.

The AS-AD framework allows us to see why the rapid oil price rises of the 1970s caused recessions. The oil price shocks shifted the AS curve upward, and so moved the economy's AS-AD equilibrium up and to the left: a lower value of real GDP accompanied by a higher price level, which in the 1970s was called "stagflation."

RECAP AGGREGATE DEMAND AND AGGREGATE SUPPLY

As the price level rises, the real value of a fixed money stock falls, interest rates rise, and so planned expenditure falls; the aggregate demand curve slopes downward. As the amount of output produced rises relative to potential, prices and inflation rise above their anticipated levels; the aggregate supply curve slopes upward. Combining the AD and AS curves gives us the AS-AD diagram. For an economy with a fixed money stock, the AS-AD diagram is useful for analyzing the effects on the aggregate price level and output of changes in monetary policy, changes in fiscal policy, and supply shocks such as the 1970s rise of oil prices.

Chapter Summary

1. The money market is in equilibrium when the level of total income and of the short-term nominal interest rate makes households and businesses want to hold all the real money balances that exist in the economy.
2. When the central bank's policy keeps the money stock fixed — or when there is no central bank — the LM curve consists of those combinations of interest rates and real GDP levels at which money demand equals money supply.
3. When the central bank's policy keeps the money stock fixed — or when there is no central bank — the point at which the IS and LM curves cross determines the equilibrium level of real GDP and the real interest rate r .
4. The IS-LM framework consists of two equilibrium conditions: The IS curve shows those combinations of interest rates and real GDP levels at which planned expenditure is equal to total production; the LM curve shows those combinations of interest rates and real GDP levels at which money demand is equal to money supply. Both equilibrium conditions must be satisfied.
5. An IS shock is any shock to the level of total spending as a function of the domestic real interest rate. An IS shock shifts the position of the IS curve. An expansionary IS shock raises real GDP and the real interest rate.
6. An LM shock is a shock to money demand or money supply. An LM shock shifts the position of the LM curve. An expansionary LM shock raises real GDP and lowers the interest rate.
7. The aggregate demand relationship arises because changes in the price level and inflation rate cause shifts in the level of planned expenditure as changes in the price level change the real money stock and thus interest rates.
8. The aggregate supply curve captures the relationship between aggregate supply and the price level. The higher real GDP, the higher the price level and the inflation rate are likely to be and vice versa: The higher the price level and the inflation rate, the higher real GDP is likely to be.
9. Together the aggregate supply and aggregate demand curves make up the AS-AD framework, which allows us to analyze the impact of changes in economic policy and the economic environment not just on real GDP but also on the price level and the inflation rate.

Key Terms

money demand (p. 315)
 real money balances (p. 315)
 money market equilibrium (p. 316)

LM curve (p. 320)
 IS-LM diagram (p. 322)
 aggregate demand (AD) curve (p. 331)

aggregate supply (AS) curve (p. 332)
 AS-AD diagram (p. 334)

Analytical Exercises

1. What are the qualitative effects, in the IS-LM model, of each of the following changes?
 - a. An increase in firms' optimism about future profits.
 - b. A sudden improvement in banking technology that makes checks clear two days faster.
 - c. A wave of credit card fraud that leads people to use cash for purchases more often.
 - d. A banking crisis that diminishes banks' willingness to accept deposits.
 - e. A sudden increase in military spending.
2. What are the qualitative effects of an increase in real GDP on the rate of inflation?
3. Suppose that the expected rate of inflation suddenly jumped. What would happen — with no other changes

in the economic environment — to the IS-LM equilibrium? Would equilibrium real GDP go up or down? Would the equilibrium real interest rate go up or down?

4. Suppose that the *term premium* — the gap between short-term and long-term interest rates — suddenly went up. With no other changes in the economic environment, what would happen to the IS-LM equilibrium? Would equilibrium real GDP go up or down? Would the equilibrium real interest rate in the IS curve go up or down?
5. In what directions would you advise a government to change its fiscal and monetary policies if it wanted to make sure that net exports were positive — that it was running a trade surplus?

Policy Exercises

1. Between 1980 and 1986 U.S. net exports shifted from +\$10 billion (in 1992 dollars) to -\$164 billion. The unemployment rates in 1980 and 1986 were almost identical. Almost all observers agreed that this shift in the trade deficit was driven by shifts in the U.S. domestic condition. Which of the following do you think happened between 1980 and 1986? Why?
 - a. The LM curve shifted right and the IS curve shifted right.
 - b. The LM curve shifted right and the IS curve shifted left.
 - c. The LM curve shifted left and the IS curve shifted right.
 - d. The LM curve shifted left and the IS curve shifted left.
2. Rank each of the following pairs by which is likely to have large, medium, or small positive or negative effects on equilibrium output:
 - a. A substantial increase in the money stock when demand for money is interest-inelastic versus a substantial increase in the money stock when demand for money is very interest-elastic.

- b. A jump in business willingness to invest when the LM curve is steep versus a jump in business willingness to invest when the LM curve is flat.
- c. A sudden cutback in consumer spending when investment and exports vary little with changes in the interest rate versus a sudden cutback in consumer spending when investment and exports vary a lot with changes in the interest rate.
- d. A sudden increase in the velocity of money when investment is responsive to the interest rate versus a sudden increase in the velocity of money when investment is unresponsive to the interest rate.
- e. A jump in businesses' willingness to invest when money demand does not depend on the interest rate versus a jump in businesses' willingness to invest when the LM curve is flat.
- f. A boost to government spending when the IS curve is flat versus a boost to government spending when the IS curve is steep.

3. Suppose that money demand is interest-insensitive. That is, suppose that the money demand function is

$$\frac{M^d}{P} = M_y Y - M_i i$$

with M_i equal to 0 so that there is no dependence on the interest rate at all. What, then, is the LM curve for this economy? What effect does an increase in government purchases have on the level of real interest rates and the equilibrium level of annual real GDP?

4. Suppose that the economy's LM curve is given by the equation

$$Y = \$1,000 + \$100,000(r + \pi^e)$$

and that the expected inflation rate π^e is constant at 3 percent per year. Suppose further that the economy's marginal propensity to expend (MPE) is 0.6, that the marginal propensity to import IM_y is 0.25, that the initial level of baseline autonomous spending A_0 is \$5,000 billion, that a 1-percentage-point increase in the real interest rate reduces investment spending by \$40 billion and reduces the value of the exchange rate by 10 percent, and that each 1 percent increase in the exchange rate increases net exports by \$6 billion.

What is the effect on the domestic economy's equilibrium of a sudden 30 percent increase in the exchange rate as foreign exchange speculators lose confidence in the economy?

The Phillips Curve, Expectations, and Monetary Policy

QUESTIONS

What can shift the Phillips curve?

What is the Monetary Policy Reaction Function? What determines its slope?

What is the natural rate of unemployment? How has its value changed?

What are static expectations of inflation? Adaptive? Rational?

How has the expected rate of inflation changed?

How do we use the Phillips curve, the Monetary Policy Reaction Function, and the way in which expectations of inflation are determined to analyze the economy?

How do we connect the sticky-price model of Part 4 with the flexible-price model of Part 3?

This is the most important chapter in the book. It draws together the flexible-price business cycle model of Part 3 and the sticky-price business cycle model of Part 4. It provides a bird's-eye overview of demand, monetary policy, and inflation. Chapter 9 analyzed demand and the multiplier. Chapter 10 added interest rates and their effect on investment and exports. In this chapter we build on those two and add unemployment, inflation, and monetary policy — how the Federal Reserve makes its decisions.

When you finish this chapter, you will have a comprehensive view of how business cycles and demand management work. The Federal Reserve responds to unemployment and inflation by choosing a monetary policy that aims at *price stability* and full employment with the first goal taking priority. That monetary policy then — through the mechanisms of Chapter 10 — determines investment and exports and — through the mechanisms of Chapter 9 — the level of production. The level of production relative to potential output itself feeds back and generates unexpected rises and declines in inflation relative to what was previously anticipated.

But that is not all this chapter does. It also analyzes expectations — how the previous anticipations of prices and inflation are formed. Expectations are key, for they provide the linkage between the sticky-price model of Part 4 and the flexible-price model of Part 3.

That is how this chapter accomplishes its two major goals: to complete the construction of the sticky-price model begun in Chapter 9 and to link the sticky-price macroeconomic model analysis of Part 4 with the flexible-price macroeconomic model analysis of Part 3. The key to accomplishing both of these is an analytical tool called the Phillips curve. The Phillips curve describes the relationship between inflation and unemployment, according to which a higher rate of unemployment is associated with a lower rate of inflation.

The plan of this chapter is to first examine aggregate supply and the Phillips curve: Why is there — in the short run of our sticky-price model — a positive relationship between production Y on the one hand and the price level P and the inflation rate π on the other (and thus also a negative relationship between unemployment and inflation)? This leads into an analysis of how the existence of the aggregate supply relationship and the Phillips curve affects modern central banks' conduct of monetary policy and the important concept of the Monetary Policy Reaction Function. Then it is time to put all the pieces together by bringing into the picture the key elements of the determinants of the natural rate of unemployment and the three kinds of expectations — static, adaptive, and rational — that play an overwhelmingly important role in determining how modern economies behave.

12.1 AGGREGATE SUPPLY AND THE PHILLIPS CURVE

Unemployment

So far in this book one of our six key economic variables, the unemployment rate, has been largely absent. In Part 2, the long-run growth section, unemployment was not a significant factor. In Part 3, the flexible-price macroeconomic model section, there were no fluctuations in unemployment. Wages and prices were flexible, and so labor supply balanced labor demand.

Now it is time to bring unemployment to center stage. Back in Chapter 2 we showed that there is generally an inverse relationship between the unemployment rate u and the **output gap** — the level of real GDP relative to potential output Y^* . This relationship is called **Okun's law** (see Box 12.1). Because of Okun's law, we do not have to conduct separate analyses of real GDP and unemployment: We know that when one is high the other is low, and vice versa.

When output Y is equal to potential output Y^* , then the unemployment rate is equal to what Milton Friedman in 1966 was among the first to call the **natural rate of unemployment** — let's call it u^* — and the labor market is putting neither upward nor downward pressure on the rate of inflation. When output Y is above potential output Y^* , the unemployment rate u is below the natural rate of unemployment u^* and there is upward pressure on the rate of inflation. When output Y is below potential output Y^* , the unemployment rate u is above u^* and there is typically downward pressure on the rate of inflation.

In this chapter we spend most of our time analyzing the behavior of the unemployment rate. The unemployment rate is of special interest because a high unemployment rate means low social welfare (see Box 12.2). But with only one additional step we could turn that analysis into an analysis of the output gap — of real GDP relative to potential output.

output gap

The difference between the actual and potential levels of output, $Y - Y^*$.

Okun's law

Periods of low (or high) national production relative to potential output correspond to periods of high (or low) unemployment relative to the natural rate.

natural rate of unemployment

The rate of unemployment where actual and expected inflation are equal, and there is no downward or upward pressure on inflation.

FORMS OF OKUN'S LAW: DETAILS

Okun's law relates the unemployment rate u (relative to the natural rate of unemployment u^*) to real GDP Y (relative to potential output Y^*). When Y is equal to Y^* , then the unemployment rate u is equal to the natural rate of unemployment u^* . When real GDP Y is different from Y^* , the unemployment rate u will be different from the natural rate of unemployment u^* by an amount described by the equation

$$u - u^* = -0.4 \left(\frac{Y - Y^*}{Y^*} \right)$$



When real GDP is above potential output, unemployment will be below the natural rate of unemployment. When real GDP is below potential output, unemployment will be above the natural rate. And the percentage-point gap between unemployment and its natural rate is two-fifths the magnitude of the percentage gap between real GDP and potential output. For example, if real GDP is 10 percent below potential output [$(Y - Y^*)/Y^* = -0.10$], then the unemployment rate will be 4 percentage points above the natural rate of unemployment: If the natural rate of unemployment u^* is 5 percent ($u^* = 0.05$), then the unemployment rate u will be 9 percent [$u = 0.05 + 0.4(-0.10) = 0.09$].

Since 2000 the quantitative form of Okun's law has shifted. Between 2000 and 2004, a 1-percentage-point gap between real GDP and potential output generated a much smaller gap between unemployment and the natural rate of unemployment than we had seen in previous decades. We are not yet sure whether Okun's law will return to its old pattern, or, if it does not, whether the new quantitative relationship between unemployment and the output gap will remain at its 2000–2004 level. Many economists think that the relatively stagnant employment levels seen between 2000 and 2004 have led a great many people who would seek jobs in normal times to drop out of the labor force, and so artificially and temporarily lowered the unemployment rate. If they are right, then Okun's law will once again return

to its traditional level soon, with a 1-percentage-point gap between output and potential output corresponding to a 0.4-percentage-point gap between the unemployment rate and the natural rate of unemployment.

But whatever happens with the quantitative relationship, we are still sure about the qualitative relationship: Higher real GDP Y (relative to potential output Y^*) means lower unemployment u (relative to the natural rate u^*) and vice versa.



COSTS OF HIGH UNEMPLOYMENT: POLICY

In a typical U.S. recession, unemployment rises by 2 percentage points. By Okun's law, that means that the output gap — real GDP relative to potential output — falls by some 5 percent. Five percent is about four years' worth of growth in output per worker. Moreover, recessions are not permanent; with rare exceptions, they are over in a year or two and are followed by periods of rapid growth that return real GDP to its prerecession growth trend. Even the steepest post–World War II recession raised the unemployment rate by only 4 percentage points, and it took only three years after the recession trough for unemployment to fall back to a normal level.

These considerations make it somewhat of a puzzle that people fear recessions so much. People fear a deep recession much more than they appear to value an extra four years' worth of economic growth. For example, the memory of the 1982 recession substantially altered Americans' perceptions of how the economy works, how much they dare risk in the search for higher wages, and how confident they can be that their jobs are secure.

Why do episodes of recession and high unemployment have such a large psychological impact? The most likely answer is that recessions are feared because their impact is not distributed equally. Workers who keep their jobs are only lightly affected, whereas those who lose their jobs suffer a near-total loss of income. People fear a 2 percent chance of losing *half* of their income much more than they fear a *certain* loss of just 1 percent of income. So it is much worse for 2 percent of the people to each lose half of their income than for everyone to lose 1 percent. Thus the unequal distribution of the costs of recessions is what makes them so feared — and makes voters so anxious to elect economic policy makers who will successfully avoid them.

Aggregate Supply

sticky prices

When wages and prices do not move smoothly and immediately to keep supply equal to demand in the labor and goods markets.

In our sticky-price model prices are sticky, not stuck. (Forget the difference? See Box 11.6 for an example.) They do move over time. They just don't move fast enough to get us to the flexible-price situation of Chapters 6–8 immediately. Up until now we have paid next to no attention to the fact that prices are not stuck fast in the sticky-price model. But now this will change as we start to analyze what the price level P and the inflation rate π are in our sticky-price model.

In the short run, we find that whenever real GDP Y is higher than potential output Y^* , the inflation rate π and the price level P are likely to be higher than people had previously anticipated. There are many reasons for this. One is that whenever demand for products is stronger than anticipated, firms raise their prices higher than they had previously planned. When planned expenditure is higher than

potential output, demand is strong in nearly every industry. Nearly all firms raise prices and hire more workers. High demand gives workers extra bargaining power. Unions threaten to strike, knowing that firms will have a hard time finding replacement workers. Individuals quit, knowing they can find better jobs elsewhere. Such a high-pressure economy generates wages that rise faster than anticipated. Rapid wage growth is passed along to consumers in higher prices and accelerating inflation. Thus high real GDP Y relative to potential output Y^* generates a higher price level P and a higher inflation rate π than people had previously expected.

A second reason is that when planned expenditure is higher than potential output, individual economic sectors and industries in the economy quickly reach the limits of capacity: Bottlenecks emerge. Since a building cannot be built without cement, construction companies will pay nearly any price for cement if it is in short supply. Such high prices signal to the market that the bottleneck industry should expand and eventually trigger investment that in the end boosts productive capacity. But in the meantime, developing bottlenecks lead to prices that increase faster than expected, thus to accelerating inflation and a higher price level.

Note that expectations play a key role. What calls forth higher (or lower) production in the bottleneck industries is that prices and inflation turn out to be higher (or lower) than people had been counting on because demand is so high. It's not high prices but higher-than-expected prices and inflation that are associated with high output. Economists call this correlation between real GDP Y (relative to potential output Y^*) and the price level P and the rate of inflation π (relative to their previously expected values) the short-run Aggregate Supply (AS) curve.

Note also that there is little reason to distinguish between inflation and the price level. Inflation is the change between last year's and this year's price level. A high price level relative to what was previously expected is a high inflation rate (relative to what was previously expected), and vice versa. So we can think of Aggregate Supply as an upward-sloping positive relationship between the price level P (relative to the previously expected price level) and the level of real GDP Y (relative to potential output). Or we can think of it as an upward-sloping positive relationship between the inflation rate π (relative to the previously expected inflation rate) and the level of real GDP Y (relative to potential output). Or we can think of it in yet a third way, using Okun's law. Because high real GDP Y means low unemployment u , we can think of aggregate supply as a relationship between the inflation rate π (relative to the value that people had previously expected inflation to be π^e) and the unemployment rate u (relative to the natural rate u^*).

This third form of the relationship is the modern Phillips curve:

$$\pi = \pi^e - \beta(u - u^*)$$

where we once again use π^e to stand for previously expected inflation, with the e reminding us that it is an expectation. This equation tells us that inflation π is higher than it was previously expected to be when unemployment u is lower than its natural rate u^* . By how much? That depends on the parameter β , the slope of this relationship. And it is this relationship that is called the Phillips curve, after the New Zealand economist A. W. Phillips, who first wrote back in the 1950s of the relationship between unemployment and the rate of change of prices.

Phillips curve

The downward-sloping relationship between unemployment and inflation: The higher expected inflation, the higher the unemployment rate needed to keep inflation at any particular level.

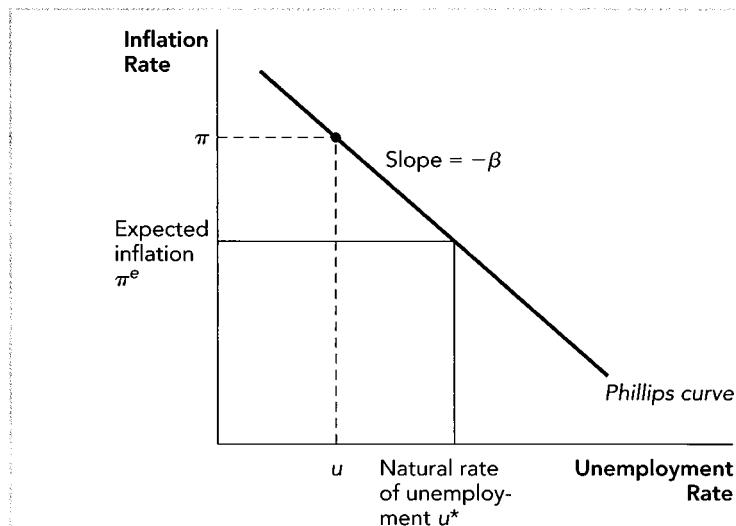
expected inflation

The rate at which the inflation rate was expected to increase. Today's expected inflation rate is yesterday's guess about today's inflation rate.

FIGURE 12.1**The Phillips Curve**

When inflation π is higher than expected inflation and production is higher than potential output, the unemployment rate u will be lower than the natural rate of unemployment. There is an inverse relationship in the short run between inflation and unemployment.

When inflation π is higher than expected inflation and production is higher than potential output, the unemployment rate u will be lower than the natural rate of unemployment. There is an inverse relationship in the short run between inflation and unemployment.



Since Phillips's time, economic events have led economists to change the Phillips curve slightly to take account of shocks that can affect the inflation rate. So we add an extra term to the Phillips curve:

$$\pi = \pi^e - \beta(u - u^*) + ss$$

where ss stands for large sudden "supply shocks" — like the 1973 oil price increase — that can affect the rate of inflation by changing prices directly, without first changing the unemployment rate and so putting pressure on wage levels.

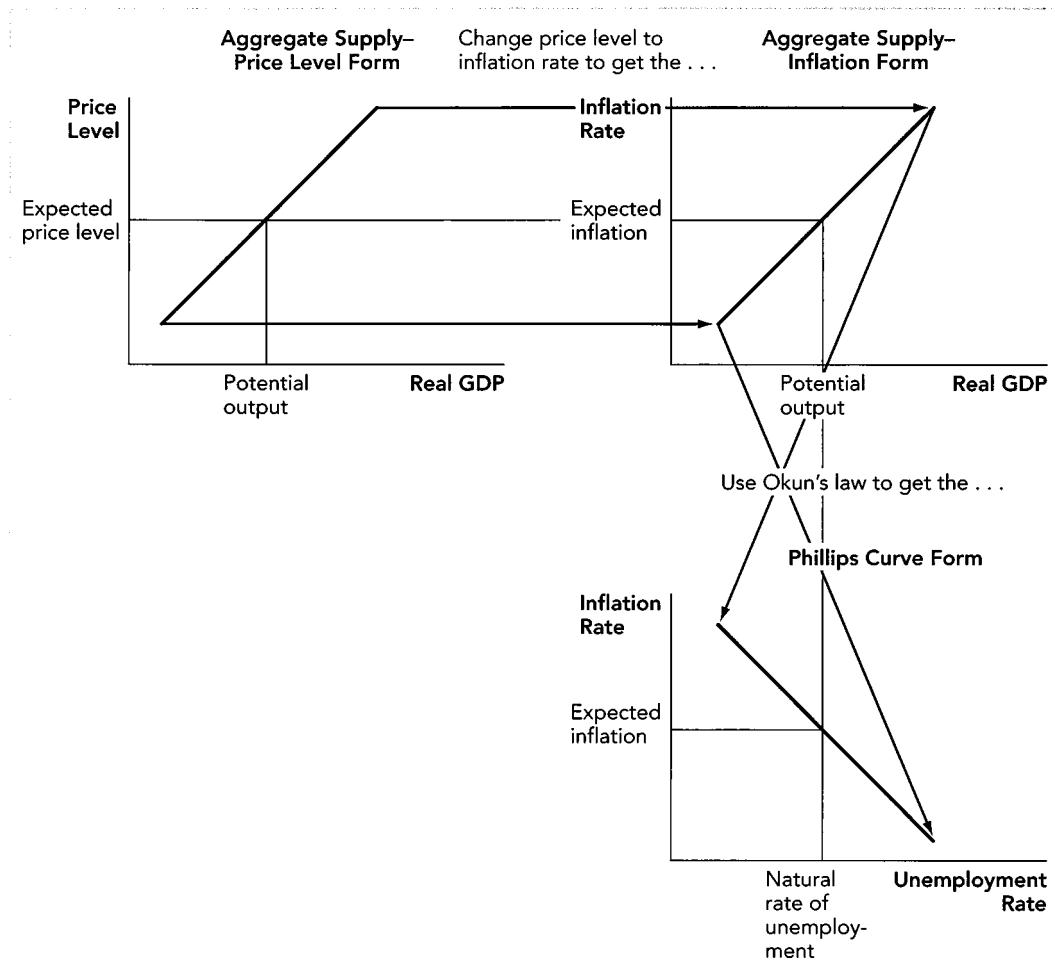
Figure 12.1 sketches the Phillips curve on a graph with the unemployment rate on the horizontal axis and the inflation rate on the vertical axis. Figure 12.2 shows the Phillips curve along with the other two possible ways of thinking about aggregate supply. The underlying economic meaning is the same no matter which form — real GDP–price level, real GDP–inflation, or unemployment–inflation — you use. From this point on, however, we will always use the unemployment–inflation Phillips curve form simply for convenience.

The Phillips Curve Examined

The slope of the Phillips curve depends on how sticky wages and prices are. The stickier are wages and prices, the smaller is the parameter β and the flatter is the Phillips curve. The parameter β varies widely from country to country and era to era. In the United States today it is about 0.5. When the Phillips curve is flat, even large movements in the unemployment rate have little effect on the inflation rate. When wages and prices are less sticky, the Phillips curve is nearly vertical. Then even small movements in the unemployment

FIGURE 12.2

Three Faces of Aggregate Supply You can think of aggregate supply as a relationship between production (relative to potential output) and the price level, between production (relative to potential output) and the inflation rate, or between unemployment (relative to the natural rate of unemployment) and the inflation rate. These are three different views of what remains the same single relationship.

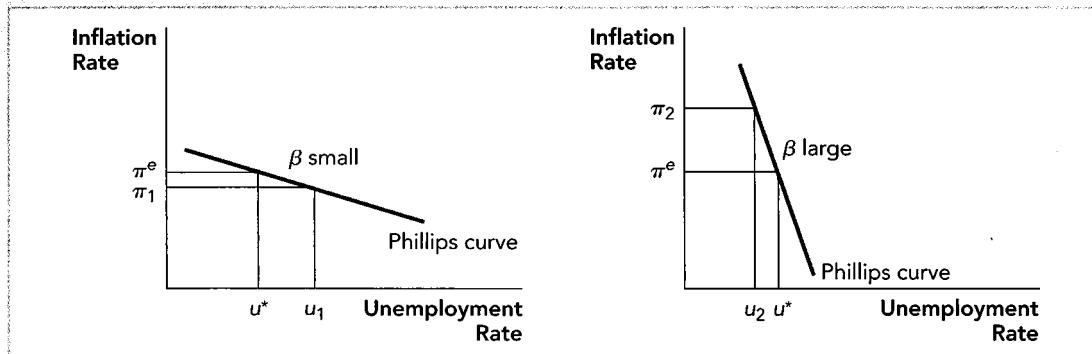


rate have the potential to cause large changes in the inflation rate, as seen in Figure 12.3 on page 346.

Whenever unemployment is equal to its natural rate u^* and there are no supply shocks, inflation is equal to expected inflation π^e . Thus we can determine the position of the Phillips curve if we know the natural rate of unemployment and

FIGURE 12.3

The Slope of the Phillips Curve When wages and prices are very sticky, β is small and the Phillips curve is flat, so a large change in the unemployment rate — say, from u^* to u_1 in the left panel — results in a relatively small change in the inflation rate. But when wages and prices are less sticky, β is large and the Phillips curve is steep, so even a small change in the unemployment rate — say, from u^* to u_2 in the right panel — results in a relatively large change in the inflation rate.

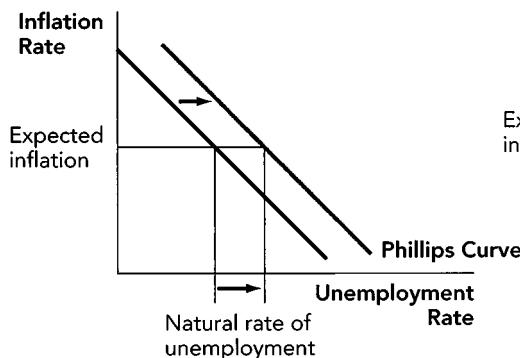
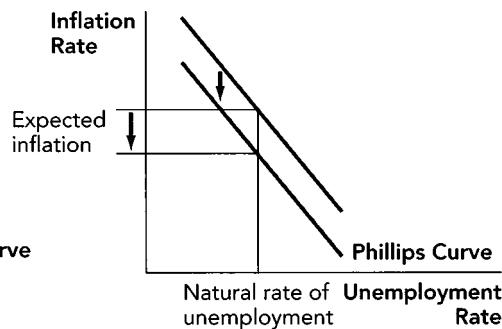


the expected rate of inflation. A higher natural rate shifts the Phillips curve right. Lower expected inflation shifts the Phillips curve down.

If the past 45 years have made anything clear, it is, as Figure 12.4 shows, that the Phillips curve shifts around substantially as both expected inflation and the natural rate change. Neither is a constant. Neither is known precisely. That is one of the things that makes the Federal Reserve's job of trying to stabilize the macroeconomy

FIGURE 12.4

Shifts in the Phillips Curve When the natural rate of unemployment or expected inflation changes, the position of the Phillips curve changes too.

A Rise in the Natural Rate of Unemployment**A Fall in Expected Inflation**

so hard, and so interesting. In America today the current natural rate of unemployment u^* is thought to be near 5 percent. The current rate of expected inflation π^e is about 2 or 2.5 percent per year. But both have been different in the past and will be different in the future.

RECAP THE PHILLIPS CURVE

The Phillips curve is an inverse relationship between inflation and unemployment. It is the most convenient form of the aggregate supply relationship, so it is the one that we use. The Phillips curve tells us that when unemployment is below its natural rate, inflation is higher than expected inflation; conversely, when unemployment is above its natural rate, inflation is lower than expected inflation. The stickier wages and prices are, the flatter the Phillips curve is. When the Phillips curve is flat, even large movements in the unemployment rate have little effect on the inflation rate. When wages and prices are less sticky, the Phillips curve is nearly vertical. Then even small movements in the unemployment rate have the potential to cause large changes in the inflation rate. When the natural rate of unemployment rises (falls), the Phillips curve shifts to the right (left). When the expected inflation rate falls (rises), the Phillips curve shifts down (up).

12.2 MONETARY POLICY, AGGREGATE DEMAND, AND INFLATION

The Reaction of Monetary Policy to Inflation

Modern central banks do not sit by and passively watch the business cycle. They play a very active role in managing the macroeconomy. Monetary policy of modern central banks reacts to the macroeconomy's condition. And when the central bank reacts to the economy's condition, the action it takes is to change the real interest rate.

How do central banks decide what value the interest rate should be? Stanford University and Treasury Department economist John Taylor proposed a simple model of how central banks act. Modern central banks pay a great deal of attention to the inflation rate. So Taylor said: think of the central bank as having a target value for the inflation rate π^t (t for "target") and having a belief about the "normal" baseline value r_0 of the real interest rate.¹ If inflation is higher than the central bank's target value, the central bank raises the real interest rate r above what it considers to be the real interest rate's "normal" baseline value r_0 . If inflation is lower than its target value, the central bank reduces the real interest rate r below r_0 . We write the Taylor rule in the form of an equation as

$$r = r_0 + r_\pi (\pi - \pi^t)$$

where the parameter r_π tells us how much the central bank changes the real interest rate r in reaction to a gap between the actual and target inflation rates. If the central

"normal" baseline real rate of interest

The real interest rate that the central bank would set if the inflation rate were equal to the central bank's target inflation rate.

Taylor rule

A description of how the real interest rate that the central bank sets depends on the gap between the current inflation rate and the central bank's target inflation rate.

¹A more complete version of the Taylor rule would have the central bank responding not just to inflation but also to deviations of the actual unemployment rate from the bank's target unemployment rate.

bankers believe the cost of fighting inflation — increased unemployment due to the higher real interest rate — is too great, r_π will be low and little will be done to fight inflation. If they believe the costs of inflation outweigh the cost of increased unemployment, r_π will be high. Social, political, and economic factors all influence the central bankers' value of r_π .

Unless r_π equals zero, inflation above the central bank's target level of inflation prompts the central bank to raise the real interest rate. A higher real interest rate leads, through the IS curve relationship, to a lower level of real GDP Y relative to potential output Y^* . Chapter 10 showed us the steps: A higher real interest rate dampens planned expenditure — particularly investment and gross export spending — and, through the multiplier, lowers total demand. Real GDP, relative to potential output Y^* , falls. And Okun's law reminds us that reducing output Y relative to potential output Y^* raises the unemployment rate. So the Taylor rule describing how the central bank's monetary policy reacts to inflation, together with the behavior of planned expenditure, and the Okun's law relationship between unemployment and output produce a direct relationship between the inflation rate π and the unemployment rate u . When the inflation rate rises, the central bank raises the real interest rate, which increases unemployment. When the inflation rate falls, the central bank lowers the real interest rate, which decreases unemployment. We call this relationship the **Monetary Policy Reaction Function (MPRF)**. Its derivation is shown in Figure 12.5. A numerical example is in Box 12.3.

The MPRF captures all of the linkages — from inflation to the real interest rate to planned expenditure to output to unemployment — at once. It tells us how the central bank's reactions to inflation π will affect unemployment. We write this monetary policy reaction function — this MPRF — as the equation

$$u = u_0 + \phi(\pi - \pi^t)$$

where

- u_0 is the value of the unemployment rate when the central bank has set the real interest rate to what the central bank thinks is the “normal” baseline value r_0 .
- π^t is the central bank's target value for inflation.
- π is the current inflation rate to which the central bank is reacting.
- u is the resulting unemployment rate.
- And ϕ is a parameter that tells us how much unemployment rises when the central bank raises the real interest rate r because it thinks that inflation is too high and needs to be reduced.

This parameter ϕ is itself determined by three different factors:

- The extent of the central bank's distaste for inflation — how much the central bank typically raises interest rates in response to an acceleration in inflation.
- The slope of the IS curve — how much real GDP changes in response to a change in the real interest rate.
- The Okun's law coefficient — how large a change in unemployment is produced by a change in real GDP.

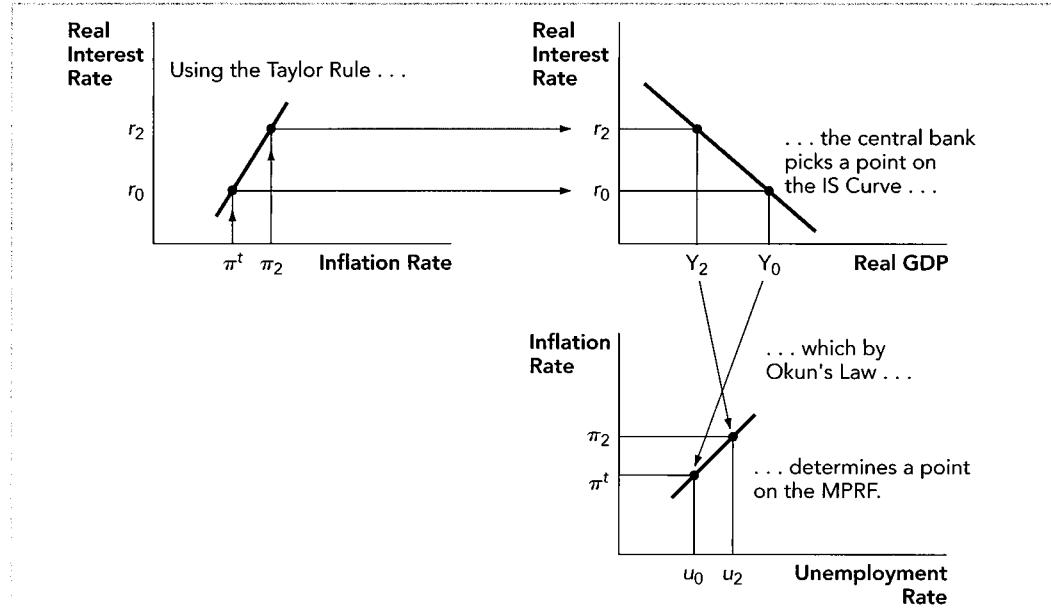
When will the parameter ϕ be large: When will a small increase in inflation above its target level call forth a reaction from the central bank that will push

monetary policy reaction function (MPRF)

An upward-sloping relationship between the inflation rate and the unemployment rate. When the inflation rate rises, a central bank wishing to fight inflation will raise interest rates to reduce output and thus increase the unemployment rate.

FIGURE 12.5

The Monetary Policy Reaction Function (MPRF) The MPRF summarizes a great deal of information in one curve. Inflation π_2 above the central bank's target level π^t leads the central bank to increase the real interest rate above r_0 (Taylor rule), which decreases planned expenditure and real output (IS curve), increasing unemployment (Okun's law).



THE MONETARY POLICY REACTION FUNCTION: AN EXAMPLE

The monetary policy reaction function brings together three relationships at once:

1. Taylor rule:

$$r = r_0 + r_\pi (\pi - \pi^t)$$

2. IS curve:

$$Y = \frac{A_0}{1 - MPE} - \left(\frac{I_r + X_e e_r}{1 - MPE} \right) r$$

3. Okun's law:

$$u = u^* - 0.4 \left(\frac{Y - Y^*}{Y^*} \right)$$



Suppose

$$\pi^t = 2\%$$

$$\pi = 5\%$$

$$r_\pi = 1/3$$

$$r_0 = 2.5\%$$

Then by the Taylor rule

$$r = 0.025 + \frac{1}{3}(0.05 - 0.02)$$

$$r = 0.025 + \frac{1}{3}(0.03) = 0.025 + 0.01 = 0.035$$

The central bank will conduct monetary policy so that the real interest rate equals 3.5 percent.

Suppose further that

$$MPE = 0.5$$

$$A_0 = \$2,150 \text{ billion}$$

$$I_r = 8,000$$

$$X_e \varepsilon_r = 2,000$$

Then the IS curve tells us that with an interest rate of 3.5 percent

$$Y = \frac{2,150}{1 - 0.5} - \left(\frac{8,000 + 2,000}{1 - 0.5} \right)(0.035)$$

$$Y = 4,300 - 20,000(0.035) = 4,300 - 700 = \$3,600 \text{ billion}$$

Planned expenditure will equal real GDP when total output is \$3,600 billion.

Finally, suppose that

$$u^* = 5\%$$

$$Y^* = \$4,000 \text{ billion}$$

Then Okun's law tells us that when output is \$3,600 billion

$$u = 0.05 - 0.4 \left(\frac{3,600 - 4,000}{4,000} \right)$$

$$u = 0.05 - 0.4 \left(\frac{-400}{4,000} \right) = 0.05 + 0.04 = 0.09$$

The unemployment rate will be 9 percent.

When the inflation rate is 5 percent rather than the central bank's target of 2 percent, the central bank will raise the real interest rate from its normal baseline rate of 2.5 percent to 3.5 percent, which will cause output to fall to \$3,600 billion and generate an unemployment rate of 9 percent.

What is the unemployment rate when the inflation rate π equals the central bank's target inflation rate π^t ? In this case, the central bank will set the real interest rate to its normal baseline level r_0 , which in this example is 2.5 percent. Using the IS curve, we find that output Y is \$3,800 billion:

$$Y = \frac{2,150}{1 - 0.5} - \left(\frac{8,000 + 2,000}{1 - 0.5} \right)(0.025)$$

$$Y = 4,300 - 20,000(0.025) = 4,300 - 500 = \$3,800 \text{ billion}$$

From Okun's law, we then see that when the interest rate is 2.5 percent, the unemployment rate equals 7 percent:

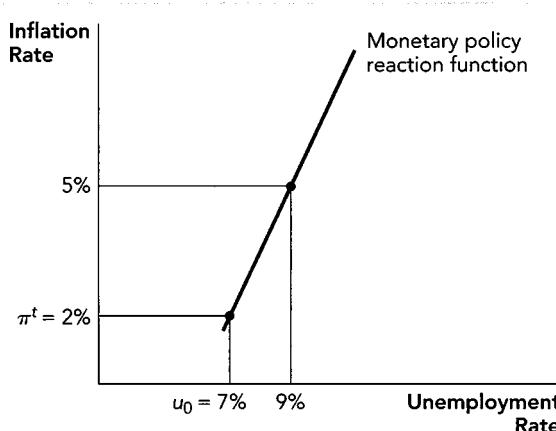
$$u = 0.05 - 0.4 \left(\frac{-200}{4,000} \right) = 0.05 + 0.02 = 0.07$$

We use u_0 to stand for the rate of unemployment when $r = r_0$.

The MPRF for this economy is illustrated in Figure 12.6.

FIGURE 12.6

The MPRF



unemployment up significantly? The parameter will be large — and the MPRF will be relatively flat — if the central bank cares strongly about keeping inflation close to its target, or if investment and export spending are very sensitive to the interest rate, or if the multiplier is relatively large, or if the Okun's law coefficient is large. The parameter will be small — and the MPRF will be steep — if the central bank is not that concerned about keeping inflation close to its target all the time, and if investment and export spending are not very sensitive to the interest rate, and if the multiplier is small, and if the Okun's law coefficient is small. (See Figure 12.7.) Boxes 12.4 and 12.5 illustrate two ways to determine the value of the parameter ϕ and the slope of the MPRF.

Equilibrium: The MPRF and the Phillips Curve

Together, the MPRF relationship

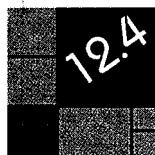
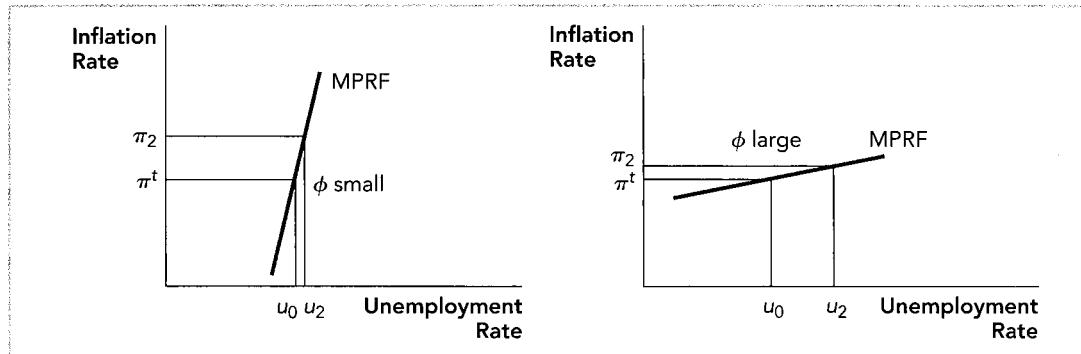
$$u = u_0 + \phi(\pi - \pi^t)$$

and the Phillips curve equation

$$\pi = \pi^e - \beta(u - u^*) + ss$$

FIGURE 12.7

The Slope of the Monetary Policy Reaction Function The slope of the MPRF is $1/\phi$. When the central bank's reaction to a high inflation rate results in very little change in the unemployment rate, as in the left panel, the MPRF is steep. When the central bank's reaction to inflation results in a relatively large change in the unemployment rate, as in the right panel, the MPRF is flat.



THE SLOPE OF THE MPRF: AN EXAMPLE

In Box 12.3 we found two combinations of inflation and unemployment that were on the MPRF: (1) when the inflation rate was 5 percent, the central bank set the real interest rate at 3.5 percent and the resulting unemployment rate was 9 percent; and (2) when the inflation rate was at its target level of 2 percent and the real interest rate was set at its “normal” baseline rate of 2.5 percent, the resulting unemployment rate was 7 percent.

The equation for the MPRF is $u = u_0 + \phi(\pi - \pi^t)$. The value of the parameter ϕ is simply the change in unemployment for a 1-unit change in the inflation rate. In our example, then

$$\phi = \frac{\Delta u}{\Delta \pi} = \frac{0.09 - 0.07}{0.05 - 0.02} = \frac{2}{3} = 0.67$$

The slope of the MPRF line — where the inflation rate is on the vertical axis (the rise) and the unemployment rate is on the horizontal axis (the run) — is “rise over run,” or the change in inflation over the change in the unemployment rate. So the slope of the MPRF is $\Delta\pi/\Delta u$, which is simply $1/\phi$, or, in our example, 1.5. 



FROM INCOME EXPENDITURE TO THE MPRF: SOME DETAILS

Whole chapters’ worth of detail underpin the parameter ϕ that governs the slope of the MPRF:

$$u = u_0 + \phi(\pi - \pi^t)$$

If we want to look at these details, we can do so by writing the determinants of ϕ as four different factors multiplied together:

$$\phi = r_\pi(I_r + X_e \varepsilon_r) \left(\frac{1}{1 - MPE} \right) \left(\frac{0.4}{Y^*} \right)$$

The first term

$$r_\pi$$

comes from central bankers' distaste for inflation. It is the amount by which central bankers raise the real interest rate when inflation is 1 unit higher.

The second term

$$I_r + X_e \varepsilon_r$$

comes from Chapter 10. It is the interest sensitivity of autonomous spending. It incorporates both the effect of interest rates on investment spending and the effect of interest rates on the exchange rate and hence on exports spending too.

The third term

$$\frac{1}{1 - MPE}$$

comes from Chapter 9. It is the multiplier, which tells us how much real GDP changes when there is a change in autonomous spending.

The last term

$$\frac{0.4}{Y^*}$$

comes from Okun's law. It tells us the change in the unemployment rate produced by a change in real GDP relative to potential output Y^* .

Thus there is a sense in which much of the work of Chapters 9 and 10 is encapsulated in this single parameter ϕ .

In the example in Box 12.3, we had

$$r_\pi = \frac{1}{3}$$

$$I_r + X_e \varepsilon_r = 8,000 + 2,000 = 10,000$$

$$MPE = 0.5$$

$$Y^* = 4,000$$

So in that example, our parameter ϕ equals

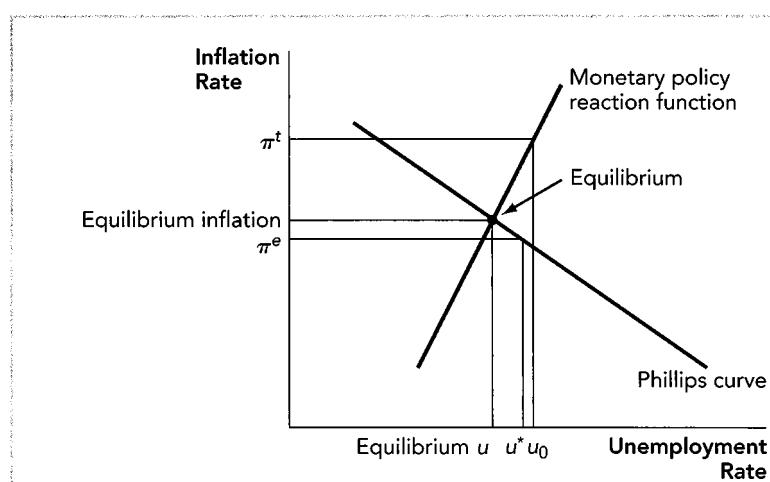
$$\begin{aligned} \phi &= r_\pi (I_r + X_e \varepsilon_r) \left(\frac{1}{1 - MPE} \right) \left(\frac{0.4}{Y^*} \right) = \left(\frac{1}{3} \right) (10,000) \left(\frac{1}{1 - 0.5} \right) \left(\frac{0.4}{4,000} \right) \\ &= \frac{4,000}{6,000} = \frac{2}{3} = 0.67 \end{aligned}$$

The same result we obtained in Box 12.4!

let us find out what the inflation rate π and the unemployment rate u will be in the economy. The MPRF determines the unemployment rate as a function of the inflation rate as the central bank reacts to changes in inflation by using its monetary policy control over interest rates to manipulate planned expenditure. The Phillips curve determines inflation as a function of the unemployment rate. Both must be satisfied for this system of equations to be in equilibrium. The

FIGURE 12.8
**Equilibrium Levels
of Unemployment
and Inflation**

The equilibrium levels of unemployment and inflation occur where the MPRF and Phillips curve cross. In the short run, equilibrium inflation can be different from the central bank's target inflation rate π^t and from the expected rate of inflation π^e . In the short run, equilibrium unemployment can be different from the natural rate of unemployment u^* and from the unemployment rate when the central bank sets the interest rate at its normal baseline value u_0 .



economy's equilibrium is where the curves cross, as Figure 12.8 shows. Box 12.6 shows how to determine the values of the unemployment and inflation rates in equilibrium.

Equilibrium occurs when the unemployment and inflation rates are not changing. Why is the point where the curves cross the only equilibrium? To see the answer, let's choose any unemployment rate along the horizontal axis. The Phillips curve tells us what inflation rate the resulting wage and price bargaining in input markets will generate. But unless that unemployment rate and inflation rate combination from the Phillips curve is also on the MPRF, the central bank will react to that inflation rate by changing the real interest rate. And a change in the real interest rate will ultimately change the unemployment rate, moving us to yet another point on the Phillips curve!

At what combination of unemployment and inflation rates will the supply-side forces that determine inflation be in concert with the central bank's monetary policy and resulting demand for output? Only a combination of unemployment and inflation rates that is on *both* the Phillips curve and the MPRF will accomplish this. Any other combination of u and π is not an equilibrium combination because the central bank's reaction to inflation will change the unemployment rate (move us along the MPRF), which in turn will change the inflation rate (move us along the Phillips curve). The economy will be in equilibrium at that unemployment rate and inflation rate where the Phillips curve and the MPRF cross.

How can the level of inflation be different in the short run from both expected inflation π^e and the central bank's target inflation rate π^t ? And how can this equilibrium level of unemployment u be different in the short run from both the natural rate of unemployment u^* and from the level of unemployment u_0 when the

SOLVING FOR EQUILIBRIUM: AN EXAMPLE

How do we actually figure out what the economy's inflation and unemployment rates are? If we have the equations for the Phillips curve and the MPRF, we can solve those equations jointly to determine the equilibrium inflation and unemployment rates.

In our example in Boxes 12.3 and 12.4, we derived the MPRF

$$\text{MPRF: } u = u_0 + \phi(\pi - \pi^t) = 0.07 + \frac{2}{3}(\pi - 0.02)$$

Suppose the parameter β in the Phillips curve equation is $\frac{1}{2}$, that expected inflation π^e is 4 percent, there are no supply shocks, and as in Boxes 12.3 and 12.4 the natural rate of unemployment u^* is 5 percent. Then the Phillips curve is

$$\text{Phillips curve: } \pi = \pi^e - \beta(u - u^*) = 0.04 - \frac{1}{2}(u - 0.05)$$

To solve for the equilibrium value of the unemployment rate we can substitute the Phillips curve equation for π into the MPRF equation and solve for the unemployment rate:

$$u = 0.07 + \frac{2}{3}(\pi - 0.02) = 0.07 + \frac{2}{3}\left\{\left[0.04 - \frac{1}{2}(u - 0.05)\right] - 0.02\right\}$$

$$u = 0.07 + \frac{2}{3}\left(0.045 - \frac{1}{2}u\right) = 0.10 - \frac{1}{3}u$$

$$\frac{4}{3}u = 0.10$$

$$u = 0.075$$

Now to solve for the equilibrium value of the inflation rate, we just substitute $u = 0.075$ into the Phillips curve equation:

$$\pi = 0.04 - \frac{1}{2}(u - 0.05) = 0.04 - \frac{1}{2}(0.075 - 0.05) = 0.0275$$

In equilibrium in our example from Box 12.3, the unemployment rate will be 7.5 percent and the inflation rate will be 2.75 percent.

central bank sets the interest rate at what it thinks is the interest rate's normal baseline value r_0 ?

Actual inflation π can be different from expected inflation π^e because economic decisions have to be made in advance, and people update their expectations only with a time lag. Workers, firms, investors, and financiers would have to have super-human powers of observation and analysis for actual inflation to be — except occasionally and luckily — exactly equal to expected inflation.

Actual inflation π can be different from the central bank's target π^t because the central bank has other things to worry about as well as inflation. If all the central bank worried about was keeping inflation at its target, it could do so: The MPRF would then be flat, at the target level π^t . But the parameter r_π is not infinitely



large, which it would need to be to create a completely flat MPRF. Central banks do not want to cause the financial upset that would result from the large rapid swings in interest rates needed to create a flat MPRF.

Unemployment will in general not be equal to the central bank's view of normal unemployment u_0 because inflation will rarely be exactly equal to its target. Unemployment is the central bank's inflation-fighting tool. So the central bank will want to push unemployment above or below its view of normal in order to reduce or increase inflation.

In a good world, with a perfect central bank, the central bank's idea of what the normal unemployment is would be equal to the natural rate of unemployment, and the central bank's target inflation rate would be equal to expected inflation. Then inflation and unemployment would be stable, and the business cycle would be a nonevent. But changes and shocks to the economy — and misperceptions by the central bank and by the economy's workers, firms, investors, and financiers — will keep that from being the case except for moments of exceptional good luck.

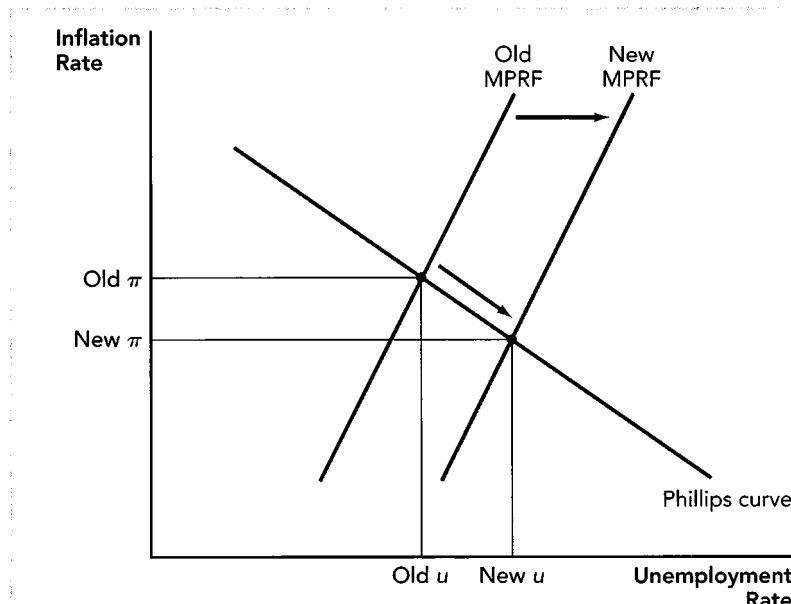
Using the MPRF–Phillips Curve Model

We can use this framework to analyze the effects of a shift in policy on the economy's equilibrium. For example, consider a depression abroad that lowers demand for exports. This change in the economic environment causes a decrease in planned expenditure — a shift left of the IS curve — and leads to a rise in the unemployment rate. The Monetary Policy Reaction Function has shifted to the right, as Figure 12.9 shows, and the economy's equilibrium has moved down and

FIGURE 12.9

Effects of a Fall in Exports

A fall in exports with no countervailing change in the central bank's view of the normal interest rate r_0 shifts the MPRF right, raises the equilibrium unemployment rate, and lowers the inflation rate.



to the right along the Phillips curve. The unemployment rate rises. The inflation rate falls.

Consider instead an expansion of government purchases at home. We would show this as a shift to the right of the IS curve of Chapter 10, which shifts the MPRF curve in and to the left. If the central bank does not change its notion of the normal baseline interest rate r_0 , and expected inflation does not change, the unemployment rate will fall and the inflation rate will rise.

What if there is no aggressive central bank acting to stabilize the economy by raising interest rates when inflation rises? Does the economy spin out of control? No. Those curious about why not need to look to Chapter 11, which analyzes how the money market works in the sticky-price model when there is no central bank actively managing the economy. It provides the answer to this question in the discussion of aggregate demand and aggregate supply that comes at its end. Without a central bank to control interest rates, inflation itself sets in motion forces that raise interest rates and so “cool off” the economy and raise unemployment. Inflation raises the price level. A higher price level makes the nominal money supply in the economy worth less. A smaller real money stock means higher interest rates. With a fixed money stock, the aggregate demand curve of Chapter 11 can perform the same economy-stabilizing function automatically that modern central banks accomplish through their active control over interest rates.

What about a negative — costly — supply shock such as the oil price hikes in the 1970s? We would show this as a rightward shift in the Phillips curve. The unemployment rate would rise and the inflation rate would rise as well. The MPRF-Phillips curve model is deceptively simple but satisfyingly powerful. It can help us to understand the short-run effects on inflation and unemployment of any number of macroeconomic events.

RECAP MONETARY POLICY REACTION FUNCTION AND THE PHILLIPS CURVE

Central banks respond to higher-than-desired inflation rates by raising interest rates to “cool off” the economy, thus lowering real GDP Y and raising the unemployment rate u . We model this facet of central bank behavior by a monetary policy reaction function — MPRF — that is an upward-sloping relationship between inflation π and unemployment u . We combine this with our Phillips curve — a downward-sloping relationship between inflation π and unemployment u — to determine the equilibrium levels of the unemployment rate and inflation rate in our sticky-price economy. We can use the MPRF and the Phillips curve to analyze the effects of economic policy.

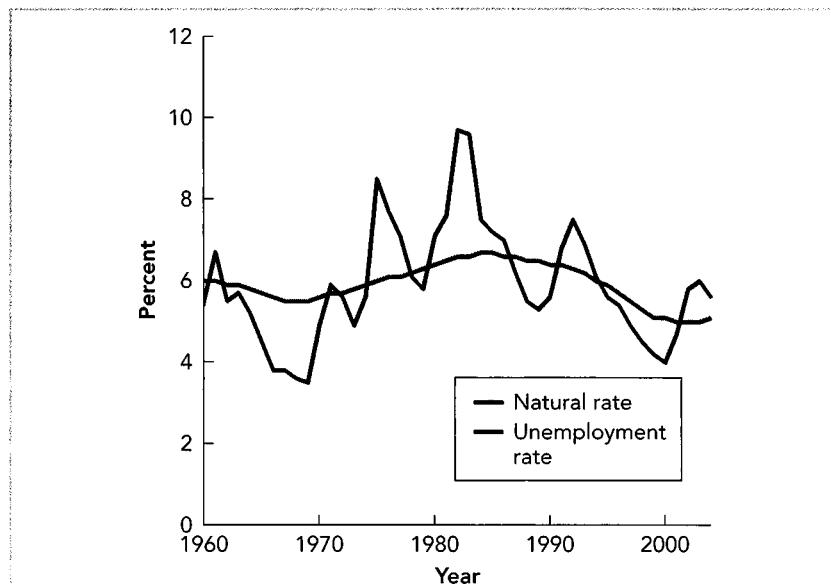
12.3 THE NATURAL RATE OF UNEMPLOYMENT

In English, the word “natural” carries strong positive connotations of normal and desirable, but a high natural rate of unemployment u^* is a bad thing. Unemployment cannot be reduced below its natural rate without accelerating inflation, so a high natural rate means that expansionary fiscal policy and expansionary monetary policy are largely ineffective as tools to reduce unemployment.

FIGURE 12.10

Fluctuations in Unemployment and the Natural Rate

The natural rate of unemployment is not fixed. It varies substantially from decade to decade. Moreover, variations in the natural rate in the United States have been much smaller than variations in the natural rate in other countries.



Source: Authors' calculations and 2004 edition of *The Economic Report of the President* (Washington, DC: Government Printing Office).

Today, most estimates of the current U.S. "natural" rate of unemployment are around 5 percent, although uncertainty about the level of the natural rate is substantial. And the natural rate has fluctuated substantially over the past two generations, as shown in Figure 12.10. Broadly, four sets of factors have powerful influence over the natural rate.

Demography and the Natural Rate

First, the natural rate changes as the relative age and educational distribution of the labor force changes. Teenagers have higher unemployment rates than adults; thus an economy with a lot of teenagers will have a higher natural rate. Looking for a job is easier for more experienced and more skilled workers. They need less time to find a new job when they leave an old one, so the natural rate of unemployment will fall when the labor force becomes more experienced and more skilled. Women formerly had higher unemployment rates than men, although this is no longer true in the United States. The more educated tend to have lower rates of unemployment than the less well educated. African-Americans and Hispanic-Americans have higher unemployment rates than whites.

A large part of the estimated rise in the natural rate from 5 percent or so in the 1960s to 6 or 7 percent by the end of the 1970s was due to changing demography. Some component of the decline in the natural rate since then derives from the increasing experience at searching for jobs of the very large baby-boom cohort. But the exact, quantitative relationship between demography and the natural rate is not well understood.

Institutions and the Natural Rate

Second, institutions have a powerful influence over the natural rate. Some economies have strong *labor unions*; other economies have weak ones. Some unions sacrifice employment in their industry for higher wages; others settle for lower wages in return for employment guarantees. Some economies lack apprenticeship programs that make the transition from education to employment relatively straightforward; others make the school-to-work transition easy. In each pair, the first increases and the second reduces the natural rate of unemployment. Barriers to worker mobility raise the natural rate, whether the barrier be subsidized housing that workers lose if they move (as in Britain in the 1970s and the 1980s), or high taxes that a firm must pay to hire a worker (as in France from the 1970s to today).

However, the link between economic institutions and the natural rate is neither simple nor straightforward. The institutional features many observers today point to as a source of high European unemployment now were also present in the European economies in the 1970s — when European unemployment was low. Once again the quantitative relationships are not well understood.

Productivity Growth and the Natural Rate

Third, in recent years the rate of productivity growth has become increasingly implicated as a major determinant of the natural rate. The era of slow productivity growth from the mid-1970s to the mid-1990s saw a relatively high natural rate. By contrast, rapid productivity growth before 1973 and after 1995 seems to have generated a relatively low natural rate.

Why should a productivity growth slowdown generate a high natural rate? A higher rate of productivity growth allows firms to pay higher real wage increases and still remain profitable. If workers' aspirations for real wage growth depend on the rate of unemployment, then a slowdown in productivity growth will increase the natural rate as indicated in Figure 12.11. If real wages grow faster than productivity for an extended period of time, profits will disappear. Long before that point is reached businesses will begin to fire workers, and unemployment will rise. Thus if productivity growth slows, unemployment will rise. Unemployment will keep rising until workers' real wage aspirations fall to a rate consistent with current productivity growth.

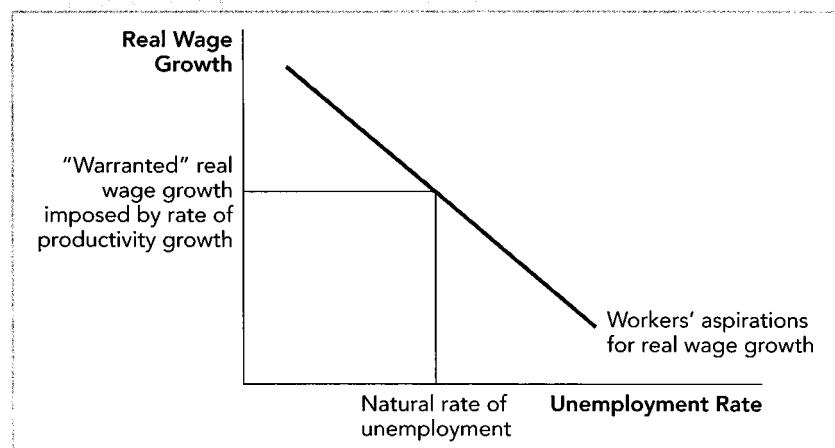
The Past Level of Unemployment and the Natural Rate

Fourth and last, the natural rate will be high if unemployment has been high. Before 1980 western European economies had unemployment rates lower than the 5 percent to 6 percent that the United States averaged back then. But the mid-1970s brought recessions. European unemployment rose, but it did not fall back much in subsequent recoveries. Workers unemployed for two or three years lost their skills, lost their willingness to show up on time, and became so discouraged that they lost their interest in even looking for new jobs. Thus the natural rate rose sharply in Europe with each business cycle. By the late-1990s European unemployment averaged 8 percent, as depicted in Figure 12.12, and inflation was stable.

FIGURE 12.11

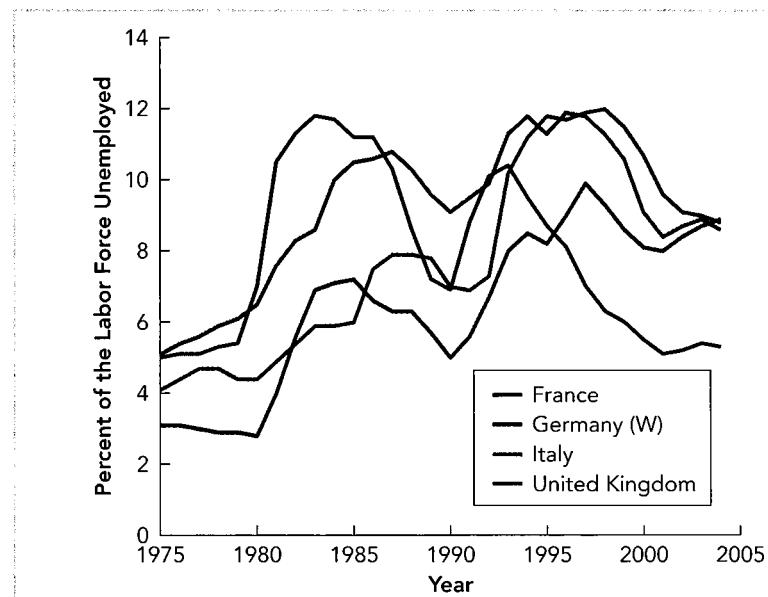
Real Wage Growth Aspirations and Productivity

Workers aspire to earn higher real wages. How much workers demand in the way of increases in the average real wage is a function of unemployment: The higher unemployment is, the lower workers' aspirations for real wage growth are. But in the long run real wages can grow no faster than productivity. Hence the natural rate of unemployment is whatever rate of unemployment curbs real wage demands so that they are consistent with productivity growth.

**FIGURE 12.12**

The Rise in European Unemployment

Unemployment in western European countries grew between 1975 and 2004 as their natural rates of unemployment increased.



Conclusion: The Fluctuating Natural Rate

This laundry list of factors affecting the natural rate is incomplete. Do not think that economists understand much about why the natural rate is what it is. Almost every economist was surprised by the large rise in the natural rate in western Europe over the past quarter century. Almost every economist was surprised by the sharp fall in America's natural rate in the 1990s. And economists cannot confidently account for these shifts even in retrospect.

RECAP THE NATURAL RATE OF UNEMPLOYMENT

The natural rate of unemployment is not a constant. It has fluctuated substantially over the past two generations, and it will continue to fluctuate. Four sets of factors drive fluctuations in the natural rate of unemployment. First, the natural rate changes as the relative age and educational distribution of the labor force changes. Second, countries with inflexible labor markets are likely to have high natural rates of unemployment. Third, faster productivity growth brings a lower natural rate with it. Fourth, the natural rate will be high if unemployment has been high in the past and large numbers of workers have become discouraged.

12.4 EXPECTED INFLATION

The natural rate of unemployment and expected inflation together determine the location of the Phillips curve because it passes through the point where inflation is equal to expected inflation and unemployment is equal to its natural rate. This is how the Phillips curve is defined: When inflation π is equal to its expected value π^e , then that tells us that the labor market is in rough balance — that unemployment u is equal to its natural rate u^* . Thus higher expected inflation shifts the Phillips curve upward. But who does the expecting? And when do people form expectations relevant for this year's Phillips curve?

Economists work with three basic scenarios for how managers, workers, and investors go about forecasting the future and forming their expectations:

- Static expectations of inflation prevail when people ignore the fact that inflation can change.
- Adaptive expectations prevail when people assume the future will be like the recent past.
- Rational expectations prevail when people use all the information they have as best they can.

The Phillips curve behaves very differently under each of these three scenarios.

The Phillips Curve under Static Expectations

If inflation expectations are static, expected inflation never changes. People just don't think about inflation. There will be some years in which unemployment is relatively low; in those years inflation will be relatively high. There will be other

static expectations

Visions of the future that do not change at all in response to changes in the current economic situation.

adaptive expectations

Expectations of the future formed by assuming the future will be like the past.

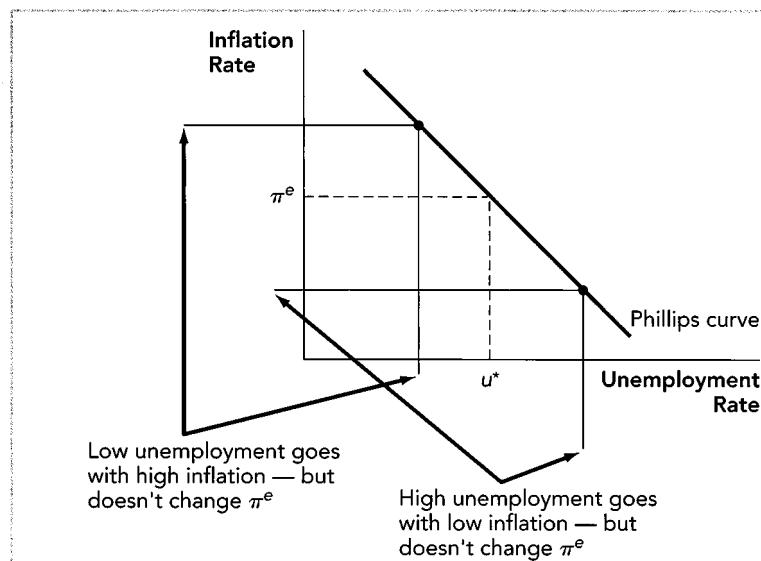
rational expectations

Expectations about the future formed by using all information about the structure of the economy and the likely course of government policy.

FIGURE 12.13

Static Expectations of Inflation

If inflation expectations are static, the economy moves up and to the left and down and to the right along a Phillips curve that does not change its position so long as there are no supply shocks and the natural rate of unemployment is constant.



years in which unemployment is higher, and then inflation will be lower. But as long as expectations of inflation remain static (and there are no supply shocks, and the natural rate of unemployment is unchanged), the trade-off between inflation and unemployment — the position of the Phillips curve — will not change from year to year. (See Figure 12.13.)

If inflation has been low and stable, businesses will probably hold static inflation expectations. Why? Because the art of managing a business is complex enough as it is. Managers have a lot of things to worry about: what their customers are doing, what their competitors are doing, whether their technology is adequate, and how applicable technology is changing. When inflation has been low or stable, everyone has better things to focus their attention on than the rate of inflation. The 1960s were an era of static expectations (see Box 12.7).

The Phillips Curve under Adaptive Expectations

Suppose that the inflation rate varies too much for workers and businesses to ignore it completely. What then? As long as inflation last year is a good guide to inflation this year, workers, investors, and managers are likely to hold *adaptive* expectations and forecast inflation by assuming that this year will be like last year. Adaptive forecasts are good forecasts as long as inflation changes only slowly and adaptive expectations do not absorb a lot of time and energy that can be better used thinking about other issues.

Under such adaptive inflation expectations, the Phillips curve can be written with t subscripts to denote time (not “target”):

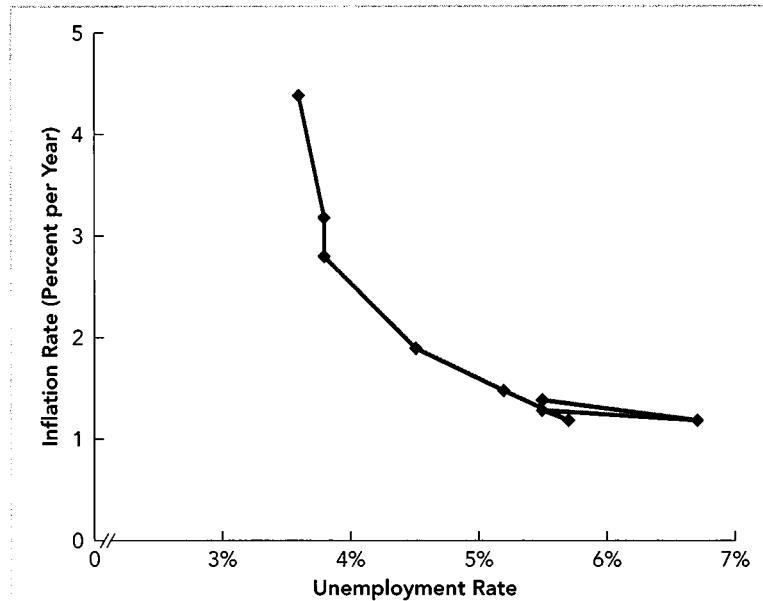
$$\pi_t = \pi_{t-1} - \beta(u_t - u_t^*) + ss_t$$

STATIC EXPECTATIONS OF INFLATION IN THE 1960s: AN EXAMPLE

The standard example of static expectations is expectations of inflation in the 1960s. When unemployment was above 5.5 percent, inflation was below 1.5 percent. When unemployment was below 4 percent, inflation was above 2.5 percent. This Phillips curve, shown in Figure 12.14, did not shift up or down in response to changes in expected inflation during the decade. Instead, the economy moved along a stable Phillips curve.



FIGURE 12.14
Static Expectations and the Phillips Curve, 1960–1968



Source: The 2004 edition of *The Economic Report of the President* (Washington, DC: Government Printing Office).

where π_{t-1} , which is just what inflation was last year, stands in place for π_t^e . Why? Because we have assumed that expected inflation is just equal to last year's inflation rate. Under such a set of *adaptive expectations*, the Phillips curve will shift up or down depending on whether last year's inflation was higher or lower than the previous year's (see Box 12.8). Under adaptive expectations, inflation accelerates when unemployment is less than the natural unemployment rate and decelerates when unemployment is more than the natural rate. The 1980s were such an era (see Box 12.9).

The Phillips Curve under Rational Expectations

What happens when government policy and the economic environment are changing rapidly enough that adaptive expectations lead to significant errors and are no



A HIGH-PRESSURE ECONOMY UNDER ADAPTIVE EXPECTATIONS: AN EXAMPLE

Suppose the central bank tries to keep unemployment below the natural rate for a long time in an economy with adaptive expectations. Then year after year inflation will be higher than expected inflation, and so year after year expected inflation will rise. Suppose that the government pushes the economy's unemployment rate down 2 percentage points below the natural rate, that the β parameter in the Phillips curve is $1/2$, that last year's inflation rate was 4 percent, and that there are no supply shocks. Then, because each year's expected inflation rate is last year's actual inflation rate, and because

$$\pi_t = \pi_{t-1} - \frac{1}{2}(-0.02) + 0$$

this year's inflation will be

$$0.04 - \frac{1}{2}(-0.02) = 0.05$$

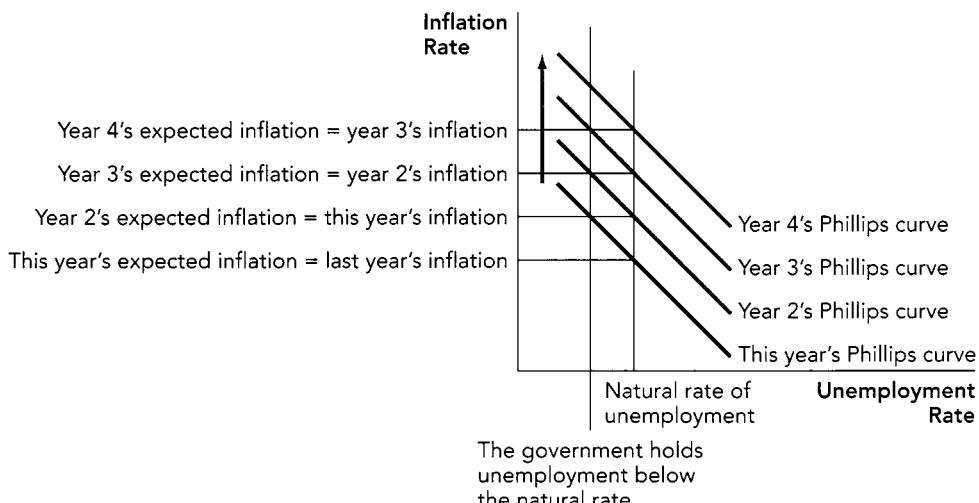
next year's inflation rate will be

$$0.05 - \frac{1}{2}(-0.02) = 0.06$$

the following year's inflation rate will be

$$0.06 - \frac{1}{2}(-0.02) = 0.07$$

FIGURE 12.15
Accelerating Inflation



and the year after that's inflation rate will be

$$0.07 - \frac{1}{2}(-0.02) = 0.08$$

as shown in Figure 12.15.

When inflation increases, expected inflation increases. And as expected inflation increases, the Phillips curve shifts up.

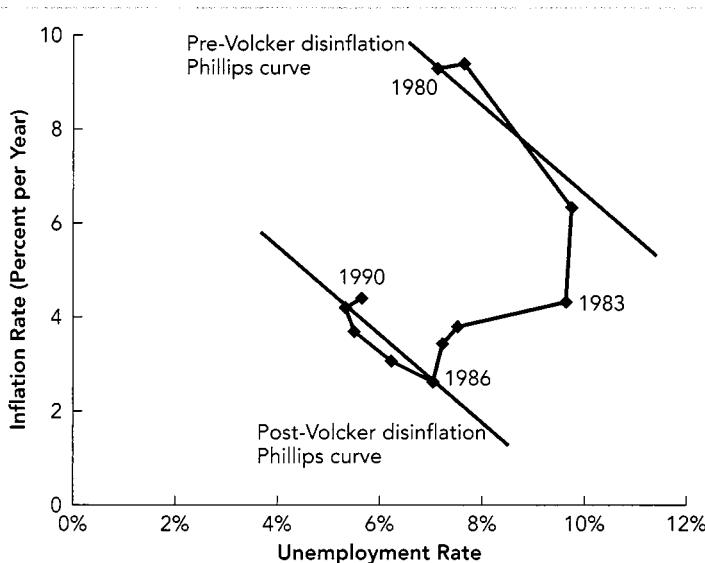
ADAPTIVE EXPECTATIONS AND THE VOLCKER DISINFLATION: ECONOMIC POLICY

At the end of the 1970s the high level of expected inflation gave the United States an unfavorable short-run Phillips curve trade-off. Between 1979 and the mid-1980s, the Federal Reserve under Chair Paul Volcker reduced inflation in the United States from 9 percent per year to about 3 percent.

Because inflation expectations were adaptive, the fall in actual inflation in the early 1980s triggered a fall in expected inflation as well. The early 1980s therefore saw a downward shift in the short-run Phillips curve, a downward shift that gave the United States a much more favorable short-run inflation-unemployment trade-off by the mid-1980s than it had had in the late 1970s, as shown in Figure 12.16.



FIGURE 12.16
The Phillips Curve before and after the Volcker Disinflation



To accomplish this goal of reducing expected inflation, the Federal Reserve raised interest rates sharply, discouraging investment, reducing aggregate demand, and pushing the economy to the right along the Phillips curve. Unemployment rose, and inflation fell. Reducing annual inflation by 6 percentage points required “sacrifice”: During the disinflation, unemployment averaged some 1.5 percentage points above the natural rate for the seven years between 1980 and 1986. Ten percentage-point-years of excess unemployment above the natural rate — that was the cost of reducing inflation from near 10 percent to below 5 percent.

longer good enough for managers or workers? Then the economy will shift to *rational* expectations. Under rational expectations, people form their forecasts of future inflation not by looking backward at what inflation was, but by looking forward. They look at what current and expected future government policies tell us about what inflation will be.

Economic Policy under Rational Expectations

Under rational expectations the Phillips curve shifts as rapidly as, or faster than, changes in economic policy that affect the level of aggregate demand. This has an interesting consequence: Anticipated changes in economic policy turn out to have no effect on the level of production or employment.

Consider an economy where the central bank's target inflation π^t rate is equal to the current value of expected inflation π^e and where u_0 , the unemployment rate when the real interest rate is at its normal value, is equal to the natural rate of unemployment u^* . In such an economy, the initial equilibrium has unemployment equal to its natural rate and inflation equal to expected inflation.

Suppose that workers, managers, savers, and investors have rational expectations. Suppose further that the government takes steps to stimulate the economy: It cuts taxes and increases government spending in order to reduce unemployment below the natural rate, and so reduces the value of u_0 . What is likely to happen to the economy?

If the government's policy comes as a *surprise* — if the expectations of inflation that matter for this year's Phillips curve have already been set, in the sense that the contracts have been written, the orders have been made, and the standard operating procedures have been identified — then the economy moves up and to the left along the Phillips curve in response to the shift in aggregate demand produced by the change in government policy: Unemployment falls and the inflation rate rises, as shown in Figure 12.17.

But if the government's policy is *anticipated* — if the expectations of inflation that matter for this year's Phillips curve are formed after the decision to stimulate the economy is made and becomes public — then workers, managers, savers, and investors will take the stimulative policy into account when they form their expectations of inflation. The inward shift in the MPRF will be accompanied, under rational expectations, by an upward shift in the Phillips curve as well. (See Figure 12.18.) How large is the upward shift? The increase in expected inflation has to be large enough to keep expected inflation after the demand shift equal to actual inflation. Otherwise people are not forming their expectations rationally.

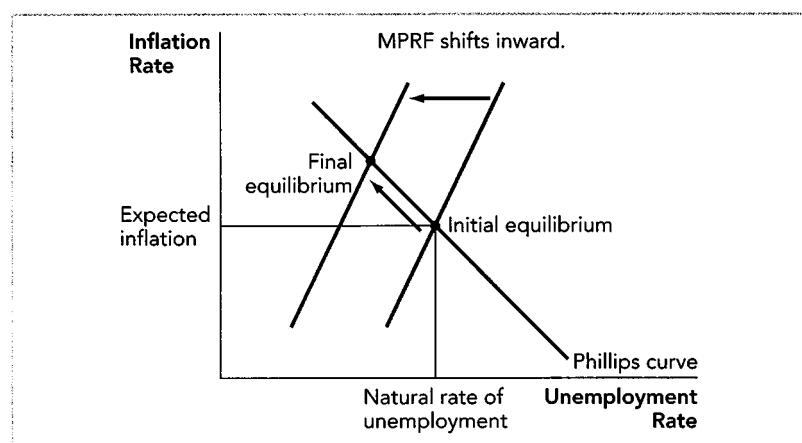


FIGURE 12.17
Results if the Shift in Policy Comes as a Surprise

A government pursuing an expansionary economic policy shifts the MPRF. An increase in production is associated with a reduction in unemployment, so an expansionary shift is a shift to the left in the MPRF. A surprise expansionary policy moves the economy along the Phillips curve, raising inflation and lowering unemployment (and raising production) in the short run.

Thus an anticipated increase in aggregate demand has, under rational expectations, no effect on the unemployment rate or on real GDP. Unemployment does not change; it remains at the natural rate of unemployment because the shift in the Phillips curve has neutralized in advance any impact of changing inflation on unemployment. It will, however, have a large effect on the rate of inflation. Economists will sometimes say that under rational expectations “anticipated policy is irrelevant.” But this is not the best way to express it. Policy is very relevant indeed for the inflation rate. It is only the effects of policy on real GDP and the unemployment rate — effects that are associated with a divergence between expected inflation and actual inflation — that are “irrelevant.”

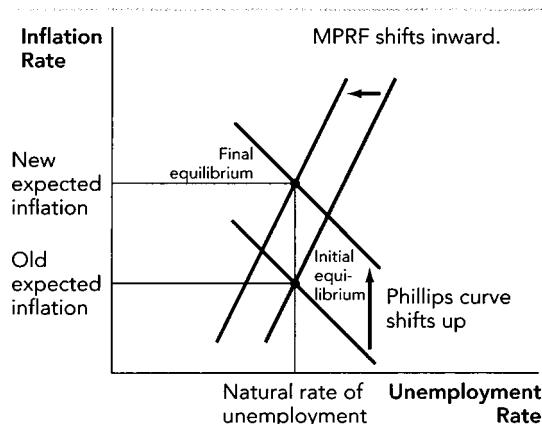


FIGURE 12.18
Results if the Shift in Policy Is Anticipated

If the expansionary policy is anticipated, workers, consumers, and managers will build the policy effects into their expectations: The Phillips curve will shift up as the MPRF shifts in, and so the expansionary policy will raise inflation without having any impact on unemployment (or production).

When have we seen examples of rational inflation expectations? The standard case is that of France immediately after the election of Socialist President François Mitterrand in 1981. Throughout his campaign Mitterand had promised a rapid expansion of demand and production to reduce unemployment. Thus when he took office French businesses and unions were ready to mark up their prices and wages in anticipation of the expansionary policies they expected. The result? From mid-1981 to mid-1983 France saw a significant acceleration of inflation, but no reduction in unemployment. The Phillips curve had shifted upward fast enough to keep expansionary policies from having any effect on production and employment.

What Kind of Expectations Do We Have?

If inflation is low and stable, expectations are probably static: Even thinking about what one's expectations should be is not worth anyone's while. If inflation is moderate and fluctuates, but slowly, expectations are probably adaptive: To assume that the future will be like the recent past — which is what adaptive expectations are — is likely to be a good, simple to implement, rule of thumb.

When shifts in inflation are clearly related to changes in monetary policy, swift to occur, and are large enough to seriously affect profitability, then people are likely to have rational expectations. When the stakes are high — when people think, “Had I known inflation was going to jump, I would not have taken that contract” — then every economic decision becomes a speculation on the future of monetary policy. Because their bottom lines and their livelihoods are at risk, people will turn all their skill and insight into generating inflation forecasts.

Thus the kind of expectations likely to be found in the economy at any moment depends on what has been and is going on. A period during which inflation is low and stable will lead people to stop consciously making, and stop paying attention to, inflation forecasts — and tend to cause expectations of inflation to revert to static expectations. A period during which inflation is high, volatile, and linked to visible shifts in economic policy will see expectations of inflation become more rational. An intermediate period of substantial but slow variability is likely to see many managers and workers adopt the rule of thumb of adaptive expectations.

Persistent Contracts

The ways that people make contracts and form and execute plans for their economic activity are likely to make an economy behave *as if* expectations are less “rational” than expectations in fact are. People do not wait until December 31 to factor next year's expected inflation into their decisions and contracts. They make decisions about the future, sign contracts, and undertake projects all the time. Some of those steps govern what the company does for a day. Others govern decisions for years or even for a decade or more.

Thus the “expected inflation” that determines the location of the short-run Phillips curve has components that were formed just as the old year ended, but also components that were formed two, three, five, ten, or more years ago. People buying houses form forecasts of what inflation will be over the next 30 years — but once the house is bought, that decision is a piece of economic activity (imputed rent on owner-occupied housing) as long as they own the house, no

matter what they subsequently learn about future inflation. Such lags in decision making tend to produce “*price inertia*.” They tend to make the economy behave as if inflation expectations were more adaptive than they in fact are. There will always be a large number of projects and commitments already under way that cannot easily adjust to changing prices. It is important to take this price inertia into account when thinking about the dynamics of inflation, output, and unemployment.

RECAP EXPECTED INFLATION

The dynamics of how expectations evolve are key to understanding the economy. Economists work with three basic scenarios for how managers, workers, and investors go about forecasting the future and forming their expectations: *Static expectations* of inflation prevail when people ignore the fact that inflation can change. *Adaptive expectations* prevail when people assume the future will be like the recent past. *Rational expectations* prevail when people use all the information they have as best they can.

The Phillips curve behaves very differently under each of these three scenarios. Under static expectations the Phillips curve doesn’t shift, so changes in policy have powerful effects on unemployment and real GDP. Under rational expectations the Phillips curve shifts immediately and drastically in response to policies so that anticipated changes in policy have powerful effects on inflation, but not on unemployment and real GDP. And adaptive expectations are in the middle.

12.5 FROM THE SHORT RUN TO THE LONG RUN

Rational Expectations

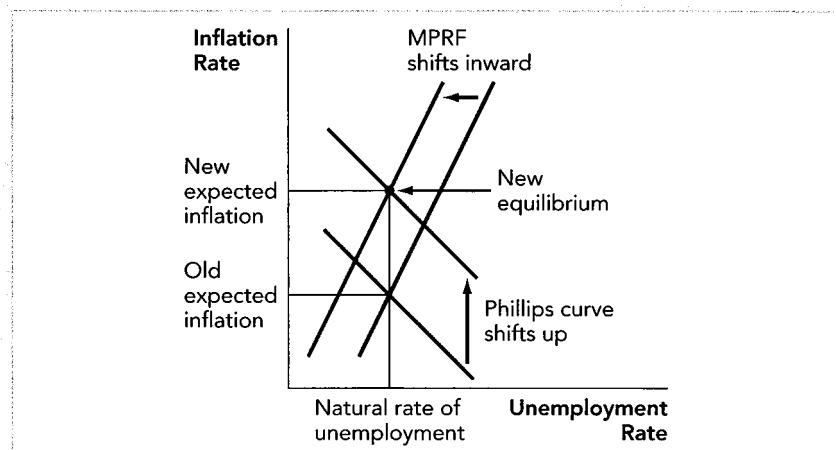
Our picture of the determination of real GDP and unemployment under sticky prices is now complete. We have a comprehensive framework to understand how the aggregate price level and inflation rate move and adjust over time in response to changes in aggregate demand, production relative to potential output, and unemployment relative to its natural rate. There is, however, one loose end. How does one get from the short-run sticky-price patterns of behavior covered in Part 4 to the long-run flexible-price patterns of behavior that were laid out in Part 3? How do you get from the short run to the long run?

In the case of an anticipated shift in economic policy under rational expectations, the answer is straightforward: You don’t have to get from the short run to the long run; the long run is now. An inward (or outward) shift in the monetary policy reaction function on the Phillips curve diagram caused by an *expansionary* (or *contractionary*) change in economic policy or the economic environment sets in motion an offsetting shift in the Phillips curve. If expectations are rational, if changes in economic policy are foreseen, and if there are no supply shocks, then expected inflation will be equal to actual inflation:

$$\pi = \pi^e$$

FIGURE 12.19

Rational Expectations: The Long Run Is Now
 Under rational expectations there simply is no short run, unless changes in policy come as a complete surprise.



which means that the unemployment rate is equal to the natural rate, as shown in Figure 12.19. The economy is at full employment. All the analysis of Chapters 6, 7, and 8 holds immediately.

Back in the early 1920s the British economist John Maynard Keynes wrote that it was not enough to do just a long-run analysis, because by the time the long run rolled around we would all be dead. But if everyone in the economy has rational expectations, then Keynes was wrong: The long run comes immediately.

Adaptive Expectations

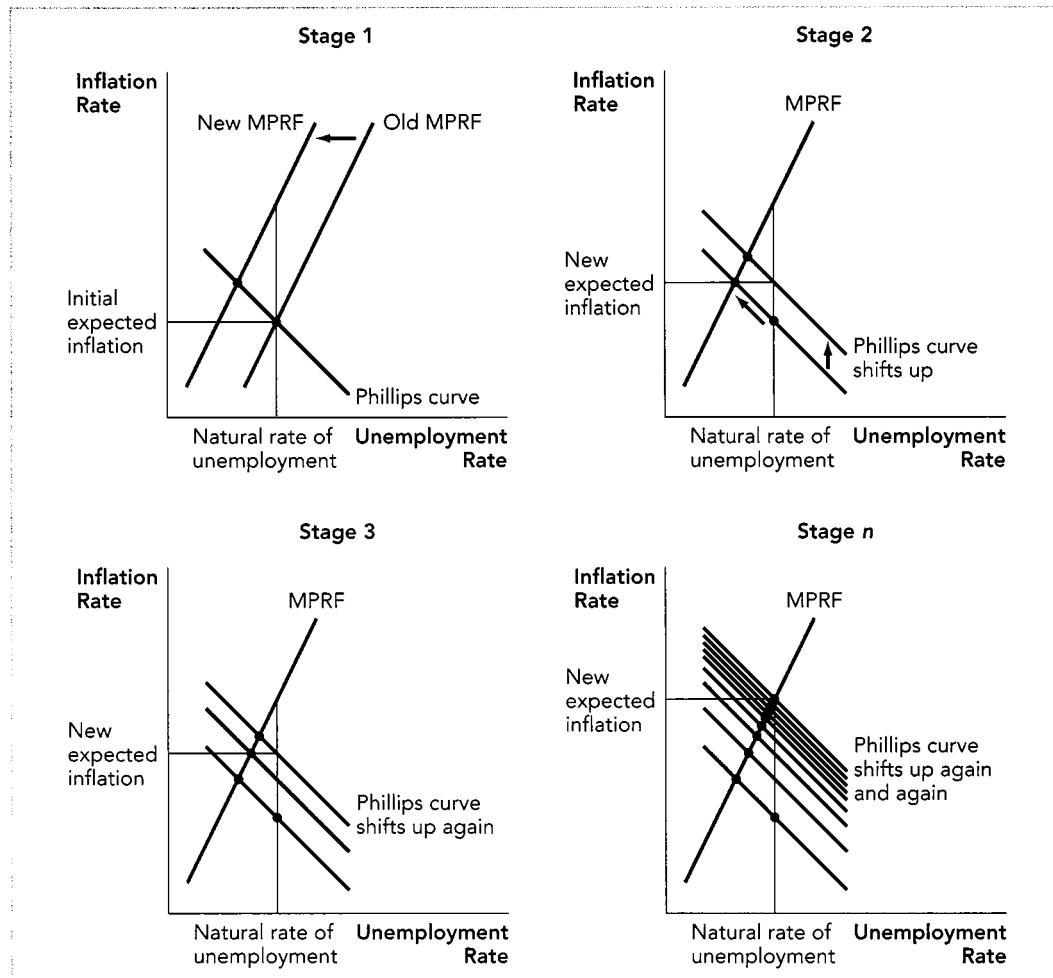
If expectations are and remain adaptive, then the economy approaches the long-run equilibrium laid out in Chapter 7 gradually, as is shown in Figure 12.20. An expansionary initial shock increases planned expenditure and shifts the monetary policy reaction function inward, generating a fall in unemployment, an increase in real GDP, and a rise in inflation. Call this stage 1. Stage 1 takes place before anyone has had any chance to adjust his or her expectations of inflation.

Then comes stage 2. Workers, managers, investors, and others look at what inflation was in stage 1 and raise their expectations of inflation. The Phillips curve shifts up by the difference between actual and expected inflation in stage 1. The central bank begins to fight inflation by increasing the real interest rate, which increases unemployment. Between stage 1 and stage 2 unemployment rises, real GDP falls, and inflation rises.

Then comes stage 3. Workers, managers, investors, and others look at what inflation was in stage 2 and raise their expectations of inflation again. The Phillips curve shifts up by the difference between actual and expected inflation in stage 2. As inflation rises further, the central bank ratchets up its fight against inflation, increasing the real interest rate yet again and thus increasing unemployment. Between stage 2 and stage 3 unemployment rises further, real GDP falls again, and inflation again rises. As time passes the gaps between actual and expected inflation, between real GDP and potential output, and between unemployment and its

FIGURE 12.20

Adaptive Expectations Converge to the Long Run Under adaptive expectations, shifts in policy have strong initial effects on unemployment and production, but those effects slowly die off.



natural rate shrink toward zero. Eventually unemployment returns to the natural rate of unemployment and the only lasting effect of the increase in spending is an increase in the inflation rate.

Under adaptive expectations, people's forecasts become closer and closer to being accurate as more and more time passes. Thus the "long run" arrives gradually. Each year the portion of the change in demand that is not implicitly incorporated in people's adaptive forecasts becomes smaller and smaller. Thus a larger and larger proportion of the shift is "long run," and a smaller and smaller proportion is "short run."

Static Expectations

Under static expectations, the long run never arrives, and thus the flexible-price analysis of Chapters 6 to 8 never becomes relevant. Under static expectations, the gap between expected inflation and actual inflation can grow arbitrarily large as different shocks affect the economy. And if the gap between expected inflation and actual inflation becomes large, workers, managers, investors, and consumers will not remain so foolish as to retain static expectations.

Under rational expectations, the long run is now. The analysis we did in Chapters 6 to 8 is always relevant. Adaptive expectations provide an intermediate case; as time passes, the analysis of Chapters 9 and 10 becomes less relevant and that of Chapters 6 to 8 becomes more relevant.

RECAP FROM THE SHORT RUN TO THE LONG RUN

The amount of time that must pass before the relevant framework shifts from the sticky-price models of Part 4 to the flexible-price models of Part 3 depends on the kind of inflation expectations held in the economy. If workers, bosses, savers, and investors hold static expectations and never update them, then the flexible-price models never become relevant. If the expectations are adaptive, the shift from Part 4 to Part 3 takes place slowly and gradually. But if expectations are rational, then the shift to Part 3 takes place very quickly indeed — as soon as policy changes are announced or recognized.

Chapter Summary

1. The location of the Phillips curve is determined by the expected rate of inflation and the natural rate of unemployment (and possibly by current, active supply shocks). In the absence of supply shocks, the Phillips curve passes through the point at which inflation is its expected value and unemployment is its natural rate.
2. The slope of the Phillips curve is determined by the degree of price stickiness in the economy. The more sticky are prices, the flatter is the Phillips curve.
3. Modern central banks respond to higher-than-desired inflation by raising interest rates, thus reducing output and raising unemployment. This monetary policy reaction function (MPRF) is a powerful stabilizing factor in modern economies.
4. The MPRF and Phillips curve can be used to analyze the effect of changes in economic policy on the economy's inflation and unemployment rates.
5. The natural rate of unemployment in the United States has exhibited moderate swings in the past two generations, from perhaps 4.5 percent at the end of the 1950s

to perhaps 7 percent at the start of the 1980s, and now down to about 5 percent. Changes in the natural rate of unemployment shift the Phillips curve to the left or right.

6. The principal determinant of the expected rate of inflation is the past behavior of inflation. If inflation has been low and steady, expectations are probably static and the expected inflation rate is very low and unchanging. If inflation has been variable but moderate, expectations are probably adaptive and expected inflation is probably simply equal to last year's inflation. If inflation has been high or moderate but has varied extremely rapidly, then expectations are probably rational and expected inflation is likely to be households' and businesses' best guesses of where economic policy is taking the economy. Changes in inflation expectations shift the Phillips curve up or down.
7. The best way to gauge how expectations of inflation are formed is to consider the past history of inflation. Would adaptive expectations have provided a significant edge

over static ones? If yes, then inflation expectations are probably adaptive. Would rational expectations have provided a significant edge over adaptive ones? If yes, then inflation expectations are probably rational.

- How fast the flexible-price model becomes relevant depends on the type of inflation expectations in the

economy. Under static expectations, the flexible-price model never becomes relevant. Under adaptive expectations, the flexible-price model becomes relevant gradually, in the long run. Under rational expectations the long run is now; the flexible-price model analysis is relevant always and immediately.

Key Terms

output gap (p. 341)	"normal" baseline real rate of interest (p. 347)	static expectations (p. 361)
Okun's law (p. 341)	Taylor rule (p. 347)	adaptive expectations (p. 361)
natural rate of unemployment (p. 341)	monetary policy reaction function (p. 348)	rational expectations (p. 361)
sticky prices (p. 342)		
Phillips curve (p. 343)		
expected inflation (p. 343)		

Analytical Exercises

- What is the relationship between the three views of aggregate supply? Why do economists tend to focus on the Phillips curve to the exclusion of the other two views?
- Under what circumstances will a government expansionary fiscal or monetary policy do nothing to raise GDP or lower unemployment?
- Under the circumstances in which an expansionary government policy fails to raise GDP or lower unemployment, what would the policy manager do?
- If expectations of inflation are adaptive, is there any way to reduce inflation without suffering unemployment higher than the natural rate? What would you advise a central bank that sought to reduce inflation without provoking high unemployment to do?
- What do you think a central bank should do in response to an adverse supply shock? How does your answer depend on the way in which expectations of inflation are being formed in the economy?

Policy Exercises

- In 2004 the unemployment rate averaged 5.6 percent. Back in 2000 it averaged 4.1 percent. Real GDP in 2004 stood some 10.3 percent above real GDP in 2000. Assuming that the natural rate of unemployment remained unchanged between 2000 and 2004, how much growth in real GDP over those 4 years was due to increases in potential output? What was the effect of "cyclical" factors — fluctuations in unemployment?
- What factors do you think have led the natural rate of unemployment to be so low in the United States today?
- Do you think that inflation expectations in the United States today are static, adaptive, or rational? Why?
- Suppose that the economy has a Phillips curve

$$\pi = \pi^e - \beta(u - u^*)$$

with the parameter $\beta = 0.5$ and the natural rate of unemployment u^* equal to 6 percent. And suppose that the central bank's reaction to inflation, the IS curve, and Okun's

law together mean that the unemployment rate is given by

$$u = u_0 + \phi(\pi - \pi^t)$$

with the central bank's target level of inflation π^t equal to 2 percent, with the parameter ϕ equal to 0.4, and with the normal baseline real interest rate level of aggregate demand corresponding to a value of u_0 of 6 percent. Suppose that initially — this year, in the year 0 — expected inflation is equal to actual inflation.

- a. What is the initial level of unemployment?
- b. Suppose that the government announces that in year 1 and in every year thereafter its expansionary policies will reduce u_0 to 4 percent, that this announcement is credible, and that the economy has *rational expectations* of inflation. What will unemployment and inflation be in year 1? What will they be thereafter?
- c. Suppose that the government announces that in year 1 and in every year thereafter its expansionary policies will reduce u_0 to 4 percent, that this announcement is credible, and that the economy has *adaptive expectations* of inflation. What will unemployment and inflation be in year 1? What will they be thereafter?
- d. Suppose that the government announces that in year 1 and in every year thereafter its expansionary policies will reduce u_0 to 4 percent, that this announcement is credible, and that the economy has *static expectations* of inflation. What will unemployment and inflation be in year 1? What will they be thereafter?

6. Suppose that the economy has a Phillips curve

$$\pi = \pi^e - \beta(u - u^*)$$

with the parameter $\beta = 0.5$ and the natural rate of unemployment u^* equal to 6 percent. And suppose that the central bank's reaction to inflation, the IS curve, and Okun's law together mean that the unemployment rate is given by

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with the central bank's target level of inflation π^t equal to 2 percent, with the parameter ϕ equal to 0.4, and with the normal baseline real interest rate level of aggregate demand corresponding to a value of u_0 of 6 percent. Suppose that initially — this year, in the year 0 — expected inflation is equal to actual inflation.

- a. What is the initial level of unemployment?
- b. Suppose that the central bank raises its target inflation rate for next year — year 1 — to 4 percent, and announces this change. Suppose the economy has *rational expectations* of inflation. What will happen to unemployment and inflation in year 1? What will happen thereafter?

c. Suppose that the central bank raises its target inflation rate for next year — year 1 — to 4 percent, and announces this change. Suppose the economy has *adaptive expectations* of inflation. What will happen to unemployment and inflation in year 1? What will happen thereafter?

d. Suppose that the central bank raises its target inflation rate for next year — year 1 — to 4 percent, and announces this change. Suppose the economy has *static expectations* of inflation. What will happen to unemployment and inflation in year one? What will happen thereafter?

7. Suppose that the economy has a Phillips curve

$$\pi = \pi^e - \beta(u - u^*)$$

with the parameter $\beta = 0.5$ and the natural rate of unemployment u^* equal to 6 percent. And suppose that the central bank's reaction to inflation, the IS curve, and Okun's law together mean that the unemployment rate is given by

$$u = u_0 + \phi(\pi - \pi^t)$$

with the central bank's target level of inflation π^t equal to 2 percent, with the parameter ϕ equal to 0.4, and with the normal baseline real interest rate level of aggregate demand corresponding to a value of u_0 of 6 percent. Suppose that initially — this year, in the year 0 — expected inflation is equal to actual inflation.

- a. What is the initial level of unemployment?
- b. Suppose that the natural rate of unemployment u^* falls to 4 percent in year 1 and remains at that level indefinitely. And suppose that this fall in the natural rate of unemployment does not come as a surprise. Suppose the economy has *rational expectations* of inflation. What will happen to unemployment and inflation in year 1? What will happen thereafter?
- c. Suppose that the natural rate of unemployment u^* falls to 4 percent in year 1 and remains at that level indefinitely. And suppose that this fall in the natural rate of unemployment does not come as a surprise. Suppose the economy has *adaptive expectations* of inflation. What will happen to unemployment and inflation in year 1? What will happen thereafter?
- d. Suppose that the natural rate of unemployment u^* falls to 4 percent in year 1 and remains at that level indefinitely. And suppose that this fall in the natural rate of unemployment does not come as a surprise. Suppose the economy has *static expectations* of inflation. What will happen to unemployment and inflation in year 1? What will happen thereafter?

Equilibrium Inflation and Unemployment: Some Details

APPENDIX 12a

The position of the Phillips curve depends on the natural rate of unemployment u^* , the expected rate of inflation π^e , and whether there are any current supply shocks affecting inflation, ss . The position of the MPRF depends on the level of unemployment u_0 when the real interest rate r is at what the central bank thinks of as its normal baseline rate r_0 , and the central bank's target level of inflation π^t . All five of these factors together, along with the parameters ϕ and β — the slopes of the monetary policy reaction function and of the Phillips curve — determine the economy's equilibrium inflation and unemployment rates.

From our MPRF

$$u = u_0 + \phi(\pi - \pi^t)$$

and our Phillips curve

$$\pi = \pi^e - \beta(u - u^*) + ss$$

it is straightforward but tedious to obtain an algebraic solution for what the economy's unemployment rate and inflation rate are. Simply substitute the Phillips curve equation into the monetary policy reaction function and solve for the unemployment rate:

$$u = \left(\frac{1}{1 + \phi\beta}u_0 + \frac{\phi\beta}{1 + \phi\beta}u^* \right) + \frac{\phi}{1 + \phi\beta}(\pi^e - \pi^t) + \frac{\phi}{1 + \phi\beta}ss$$

and substitute the monetary policy reaction function equation into the Phillips curve equation and solve for the inflation rate:

$$\pi = \left(\frac{1}{1 + \phi\beta}\pi^e + \frac{\phi\beta}{1 + \phi\beta}\pi^t \right) + \frac{\beta}{1 + \phi\beta}(u^* - u_0) + \frac{1}{1 + \phi\beta}ss$$

We could use these equations together with the values from Boxes 12.3 and 12.6 to again determine that in equilibrium in our example, the unemployment rate u is 7.5 percent and the inflation rate π is 2.75 percent.

In general, we see that the unemployment rate is equal to

- A weighted average of the unemployment rate u_0 when the central bank has set the real interest rate to its normal baseline value r_0 and the natural rate of unemployment u^* (the greater the product of the slope parameters ϕ and β , the higher the relative weight on the natural rate u^*).
- A term that depends on the difference between the expected rate of inflation π^e and the central bank's target rate of inflation π^t (when the expected inflation rate is higher than the central bank's target rate, unemployment is higher because the central bank has raised interest rates to fight inflation).
- A term that depends on current supply shocks ss .

We see that the inflation rate is equal to

- A weighted average of the expected rate of inflation π^e and the central bank's target rate of inflation π^t (the greater the product of the slope parameters ϕ and β , the higher the relative weight on the target rate π^t).
- A term that depends on the difference between the natural rate of unemployment u^* and unemployment rate u_0 when the central bank has set the real interest rate to its normal baseline value r_0 . When the natural rate of unemployment is higher than u_0 , inflation is higher because there is an inflationary bias to demand.
- A term that depends on current supply shocks ss .

We can use this framework to analyze the effects of a shift in policy on the economy's equilibrium. For example, consider a depression abroad that lowers demand for exports. This change in the economic environment causes a decrease in planned expenditure, which leads to a rise in u_0 , the unemployment rate when the real interest rate is at its normal baseline value r_0 , by an amount Δu_0 . Since none of the other parameters of the inflation-unemployment framework change, the effect on the equilibrium levels of unemployment and inflation can be calculated immediately as

$$\Delta u = \frac{1}{1 + \phi\beta} \Delta u_0$$

and

$$\Delta \pi = \frac{-\beta}{1 + \phi\beta} \Delta u_0$$