SHORT-RUN FLUCTUATIONS

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PREFACE

This document presents a model of the determination of output, unemployment, inflation, and other macroeconomic variables in the short run at a level suitable for students taking intermediate macroeconomics. The model is based on an assumption about how central banks conduct monetary policy that differs from the one made in most intermediate macroeconomics textbooks. The document is designed to be used in conjunction with standard textbooks by instructors and students who believe that the new approach provides a more realistic and powerful way of analyzing short-run fluctuations.

I have designed the document to work most closely with N. Gregory Mankiw's textbook, which I refer to simply as "Mankiw."[1] The notation is the same as Mankiw's, and I refer to other parts of Mankiw when they are relevant. But I believe the document can be used with other intermediate macroeconomics textbooks without great difficulty.

Sections I to III can take the place of the material in Mankiw starting with Section 11-2 and ending with Chapter 15. Sections IV and V extend the analysis to two topics that are not considered in depth in Mankiw: the zero lower bound on nominal interest rates, and credit market disruptions. One of the strengths of the new approach is that it is straightforward to extend it to incorporate the zero lower bound. The extension to consider credit market disruptions, in contrast, does not involve monetary policy, and so does not provide an additional reason to favor the new approach. However, credit market disruptions are so central to recent and current macroeconomic

[1] N. Gregory Mankiw, *Macroeconomics*, eighth edition (New York: Worth Publishers, 2013).

events that it seems essential to include them.

In a separate paper, I compare the new approach with the usual one and explain why I believe it is preferable.[2] The material here, however, simply presents the new approach and shows how to use it. In addition, the presentation here is more skeletal than that in standard textbooks. It covers the basics, but contains relatively few applications, summaries, and problems.

I am indebted to Christina Romer and Patrick McCabe for helpful comments and discussions, to Claire Wang for help in preparing the manuscript, and to numerous correspondents for helpful suggestions. I am especially grateful to my students for their encouragement, patience, and feedback.

[2] David Romer, "Keynesian Macroeconomics without the LM Curve," *Journal of Economic Perspectives* 14 (Spring 2000), pp. 149–169.

I The IS-MP Model

I-1 Monetary Policy and the MP Curve

You have already learned about the IS curve, shown in Figure I-1.[1] The curve shows the relationship between the real interest rate and equilibrium output in the goods market. An increase in the interest rate reduces planned investment. As a result, it reduces planned expenditure at a given level of output. Thus the planned expenditure line in the Keynesian cross diagram shifts down, and so the level of output at which planned expenditure equals output falls. This negative relationship between the interest rate and output is known as the IS curve.

The IS curve by itself does not tell us what either the interest rate or output is. We know that the economy must be somewhere on the curve, but we do not know where. To pin down where, we need a second relationship between the interest rate and output.

This second relationship comes from the conduct of monetary policy. Monetary policy is conducted by the economy's central bank (the Federal Reserve in the case of the United States). A key feature of how the central bank conducts monetary policy is how it responds to changes in output:

> *When output rises, the central bank raises the real interest rate. When output falls, the central bank lowers the real interest rate.*

[1] See Mankiw, Section 11-1.

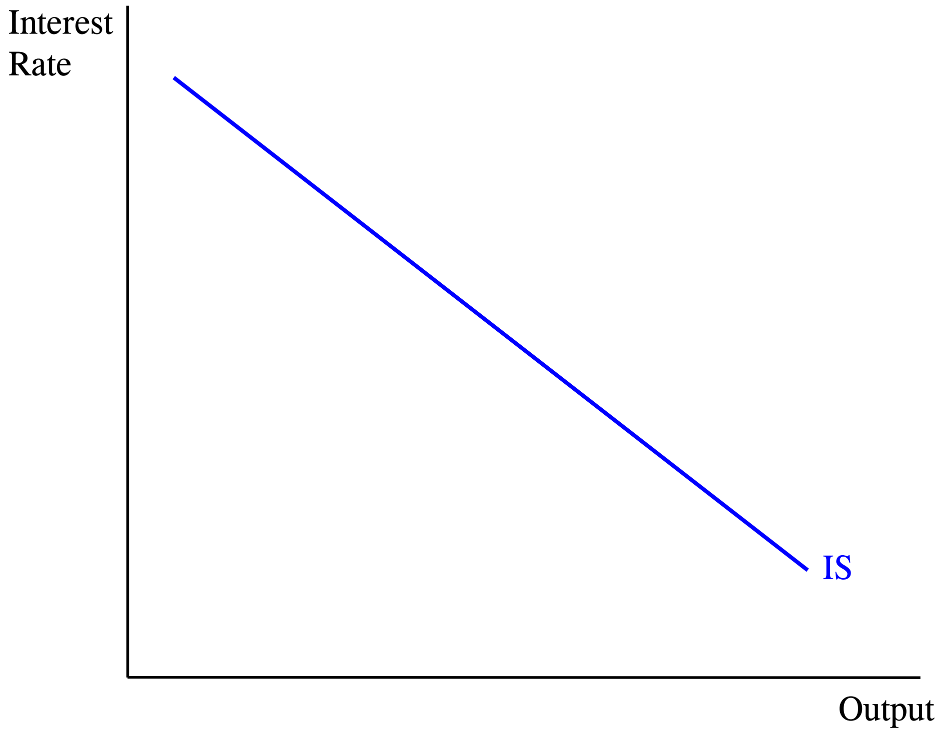

Figure I-1. The IS Curve

We can express this property of monetary policy in the form of an equation:

$$\boldsymbol{r = r(Y).} \tag{I-1}$$

When output, Y, rises, the central bank raises the real interest rate, r. Thus r(Y) is an increasing function.

We can also depict this relationship using a diagram. The fact that the central bank raises the real interest rate when output rises means that there is an upward-sloping relationship between output and the interest rate. This curve is known as the MP curve. It is shown in Figure I-2.

Figure I-2. The MP Curve

Ultimately, the fact that the central bank raises the interest rate when output rises and lowers it when output falls stems from policymakers' goals for output and inflation. All else equal, central bankers prefer that output be higher. Thus when output declines, they reduce the interest rate in order to increase the demand for goods and thereby stem the fall in output. But the central bank cannot just keep cutting the interest rate and raising the demand for goods further and further. As we will see in Section III, when output is above its natural rate, so that firms are operating at above their usual capacities, inflation usually begins to rise. Since central bankers want to keep inflation from becoming too high, they raise the interest rate when output rises. It is these twin concerns about output and inflation that cause the central bank to make the real interest rate an increasing function of output.

This description of how the central bank conducts monetary policy leaves two issues unresolved. The first issue is *how* the central bank controls the real interest rate. Central banks do not set the interest rate by decree. Instead they adjust the money supply to cause the interest rate behave in the way they want. We will discuss the specifics of how they do this in Section I-3, and Section IV will consider an important limitation on central banks' ability to control the interest rate. For most of our analysis, however, we will simply take as given that the central bank can control the interest rate, and that it does so in a way that makes it an increasing function of output.

The second unresolved issue concerns shifts of the MP curve. In Section III, we will see that the central bank adjusts the real interest rate in response not only to output, but also to inflation. An increase in inflation causes the central bank to choose a higher interest rate at a given level of output than before. That is, it causes the MP curve to shift up. Thus, the MP curve shows the relationship between output and the interest rate at a given time, but changes in inflation cause the curve to shift over time.

I-2 Using the IS-MP Model to Understand Short-Run Fluctuations

The next step is to bring the IS and MP curves together. They are shown in the IS-MP diagram in Figure I-3. The point where the two curves intersect shows the real interest rate and output in the economy. At this point, planned expenditure equals output, and the central bank is choosing the interest rate according to its policy rule. The IS-MP diagram is our basic tool for analyzing how the interest rate and output are determined in the short run. We can therefore use it to analyze how various economic developments affect these two variables.

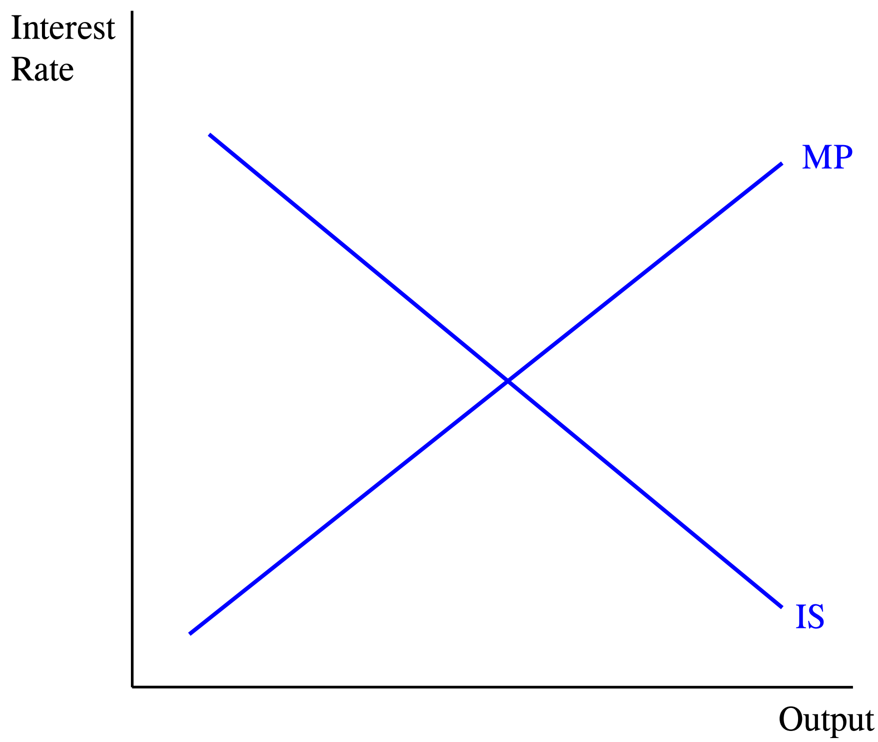

Figure I-3. The IS-MP Diagram

An Increase in Government Purchases

Suppose that government purchases increase. Government purchases are a component of planned expenditure. Thus the rise in purchases affects the IS curve. To see how, we use the Keynesian cross diagram shown in Figure I-4. Recall that the Keynesian cross shows planned expenditure as a function of output for a given level of the real interest rate. Thus the intersection of the planned expenditure line and the 45-degree line shows equilibrium output for a given interest rate. That is, it determines a point on the IS curve.

The increase in government purchases raises planned expenditure at a given level of income. Thus, as the figure shows, it shifts the planned expenditure line up. This increases the equilibrium level of income at the interest rate assumed in drawing the diagram.

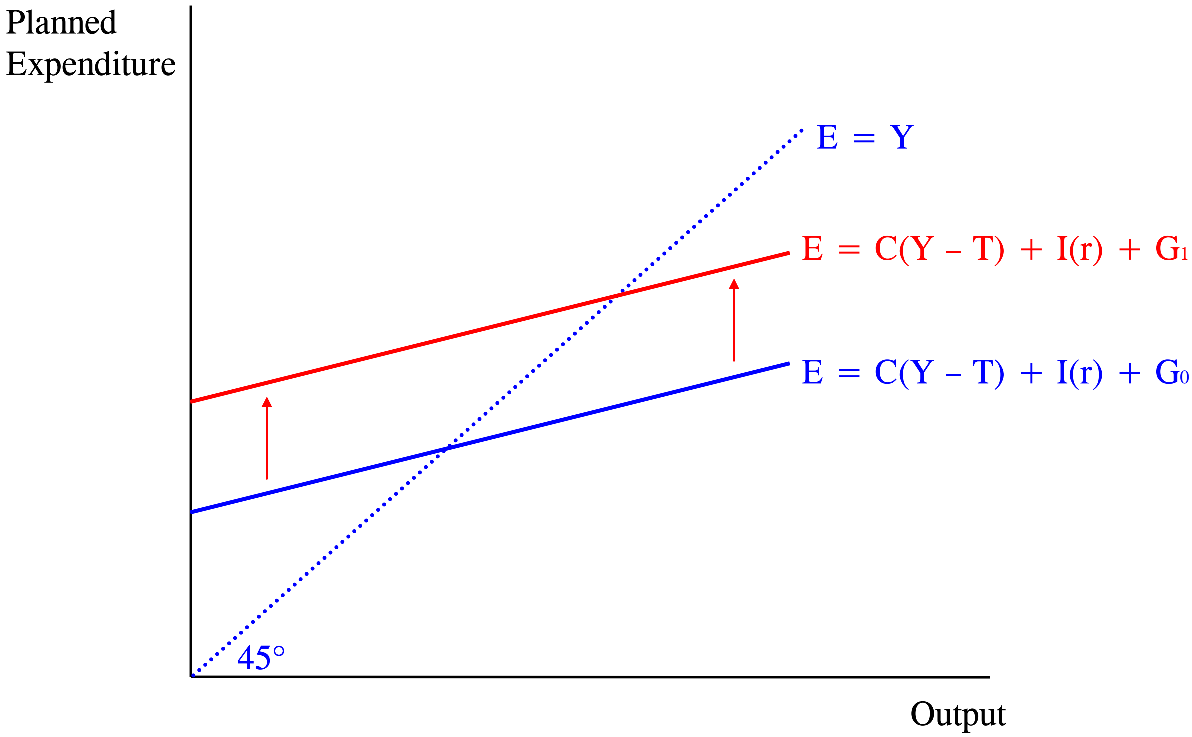

Figure I-4. The Effect of an Increase in Government Purchases on Output at a Given Interest Rate

In terms of the IS-MP diagram, this analysis shows us that at a given interest rate, equilibrium income is higher than before. That is, the IS curve shifts to the right. The central bank's rule for choosing the interest rate as a function of output is unchanged. Thus the MP curve does not shift. This information is summarized in Figure I-5.

The figure shows that at the intersection of the new IS curve and the MP curve, both the interest rate and output are higher than before. Thus the figure shows that an increase in government purchases raises both the interest rate and output in the short run.

We can also determine how the increase in government purchases affects the other components of output. The increase in the interest rate reduces investment. Thus government

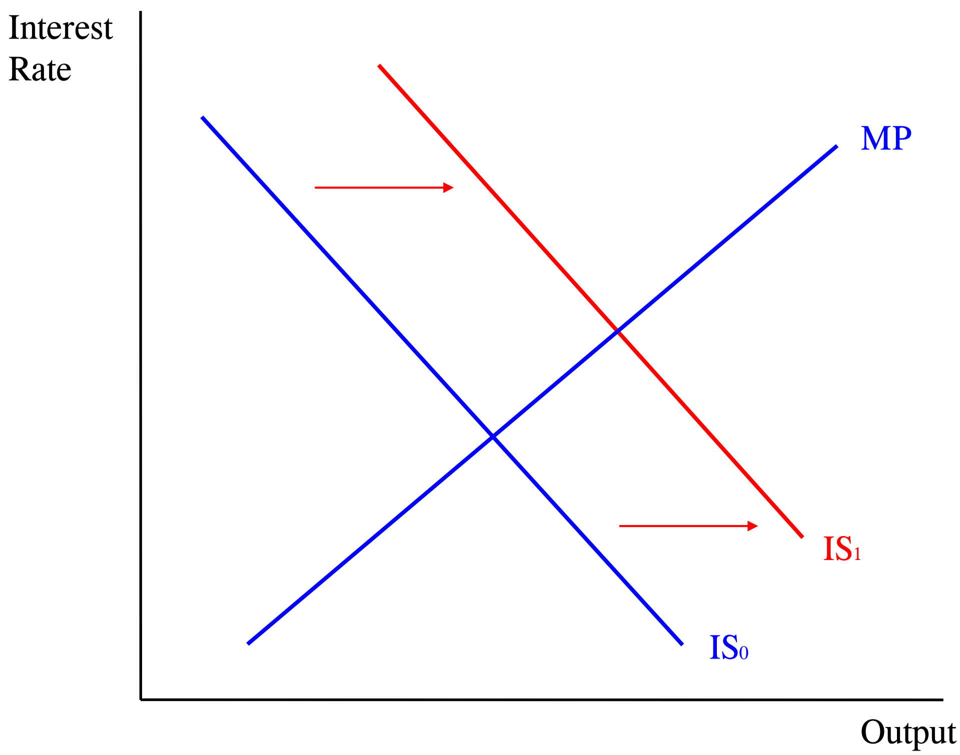

Figure I-5. The Effects of an Increase in Government Purchases on Output and the Interest Rate

purchases crowd out investment in the short run, just as they do in the long run.[2] Since consumption is an increasing function of disposable income, on the other hand, the increase in income resulting from the rise in government purchases raises consumption.[3]

A Shift to Tighter Monetary Policy

We can also analyze a change in monetary policy. Specifically, suppose the central bank changes its monetary policy rule so that it chooses a higher level of the real interest rate at a given level of output than before. This move to tighter monetary policy corresponds to an upward shift of

[2] See Section 3-4 of Mankiw for the long-run effects of a change in government purchases.

[3] This is based on Mankiw's assumptions about how the components of output are determined: $C = C(Y - T)$, $I = I(r)$, with C an increasing function of $Y - T$ and I a decreasing function of r. See Problem 2 at the end of this section for the implications of some other assumptions.

the MP curve. The IS curve is not affected: equilibrium output at a given interest rate is unchanged. This information is summarized in Figure I-6. The figure shows that the shift to tighter monetary policy raises the interest rate and lowers output in the short run.

We can again determine the effects of the policy change on the components of output. The increase in the interest rate reduces investment, and the decline in income reduces consumption. Since government purchases are an exogenous variable of our model, they are unchanged.

Fiscal and Monetary Policy Together: The Policy Mix

Changes in fiscal and monetary policy need not occur in isolation. There are many cases when both policies change at the same time. There can be deliberate coordination between the two sets of policymakers, one can react to the other’s actions, or outside developments can prompt independent responses by both.

When fiscal and monetary policies both change, the IS and MP curves both move. Depending on such factors as the directions and sizes of moves, there can be almost any combination of changes in the interest rate and output. One interesting case is when the two policies change in a way that leaves output unchanged. For concreteness, suppose that Congress and the President raise taxes, and at the same time the Federal Reserve changes its rule for setting the interest rate as a function of output by enough to keep output at its initial level.

These assumptions provide a reasonably good description of some developments in the U.S. economy in the early 1990s under Presidents Bush and Clinton. Motivated by a desire to reduce the budget deficit, Congress and the President made various changes to the budget to increase taxes and to reduce transfer payments and government purchases. The Federal Reserve did not want these changes to reduce output. It therefore lowered the interest rate at a given level of

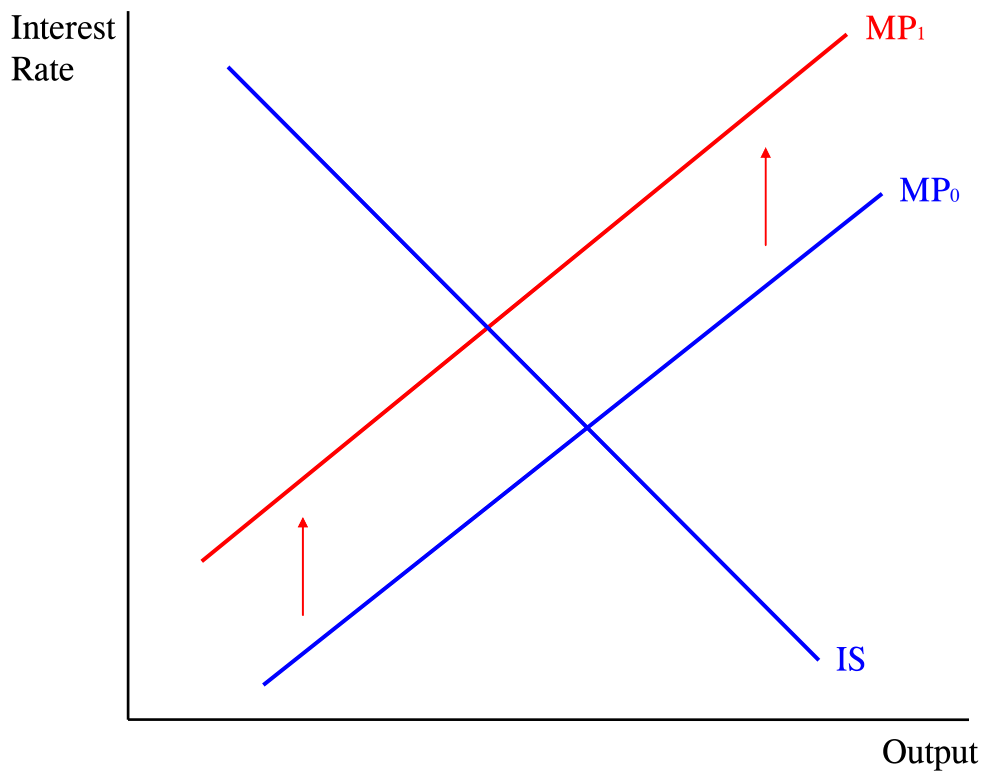

Figure I-6. The Effects of a Shift to Tighter Monetary Policy

output to keep output at roughly the same level as before.

Figure I-7 shows the effects of these developments. The increase in taxes shifts the IS curve to the left. The reasoning is essentially the reverse of our earlier analysis of a rise in government purchases. Since consumption depends on disposable income, Y − T, the increase in T reduces consumption at a given Y. Thus it shifts the planned expenditure line in the Keynesian cross down, and so reduces equilibrium output at a given interest rate. And the Federal Reserve's decision to reduce the interest rate at a given level of output causes the MP curve to shift down. By assumption, the new IS and MP curves cross at the same level of output as before.

Although this simultaneous change in fiscal and monetary policy does not change overall output, it does change its composition. With income unchanged and taxes higher than before,

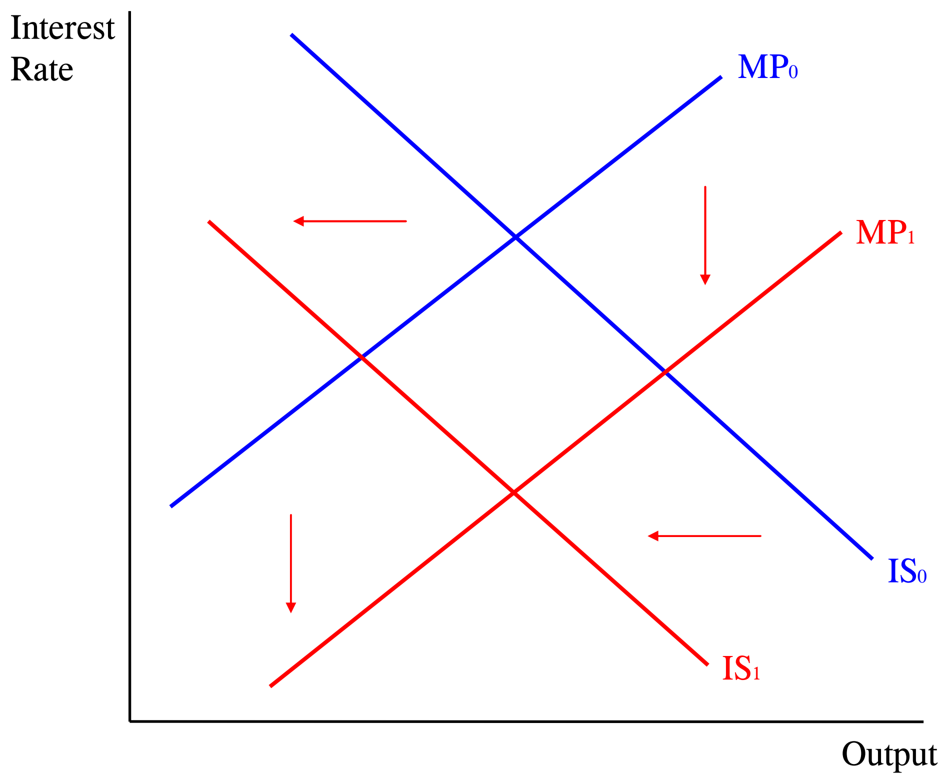

Figure I-7. The Effects of Simultaneous Changes in Fiscal and Monetary Policy that Leave Output Unchanged

disposable income is lower than before; thus consumption is lower than before. And as Figure I-7 shows, the combination of contractionary fiscal policy and expansionary monetary policy lowers the interest rate. Thus investment rises. Finally, government purchases are again unchanged by assumption.

This analysis shows how the coordinated use of fiscal and monetary policy can keep policies to lower the budget deficit from reducing aggregate output. It also shows how policy coordination can shift the composition of output away from consumption and toward investment.

A Fall in Consumer Confidence

So far, the only sources of short-run economic fluctuations we have considered are changes in government policies. But developments in the private economy can also cause fluctuations. For our final example, we consider the effects of a decline in consumer confidence. That is, we suppose that for some reason consumers become more worried about the future, and that they therefore consume less and save more at a given level of disposable income than before.

This fall in consumer confidence shifts the IS curve; the analysis is similar to the analysis of a tax increase. Figure I-8 shows the effects of the shift. The economy moves down along the MP curve. Thus the real interest rate and output both fall.

Shifts in consumer confidence are an important source of short-run fluctuations. To give one example, Iraq's invasion of Kuwait and other developments caused a sharp fall in consumer confidence in the United States in the summer of 1990. This fall in confidence shifted the IS curve to the left. In principle, a rapid response by monetary policymakers could have shifted the MP curve down and kept output from falling. Alternatively, rapid increases in government purchases or decreases in taxes could have kept the IS curve from shifting at all. In practice, however, policymakers did not become aware of the fall in consumer confidence quickly enough to take corrective action. The result was that the United States entered a recession.[4]

A more important example of a downward shift in the consumption function occurred in the United States in 1929. The stock market crash of October 1929, coming after almost a decade of rapidly rising stock prices and enormous increases in participation in the stock market, created tremendous uncertainty among consumers. As a result, they put off making major purchases to see what developed. Thus, consumption at a given level of income fell sharply. The resulting shift of the IS curve was an important factor in changing what was at that point only a mild recession into

[4] See Section 18-1 of Mankiw for more on why policymakers' control of the economy is not immediate or perfect.

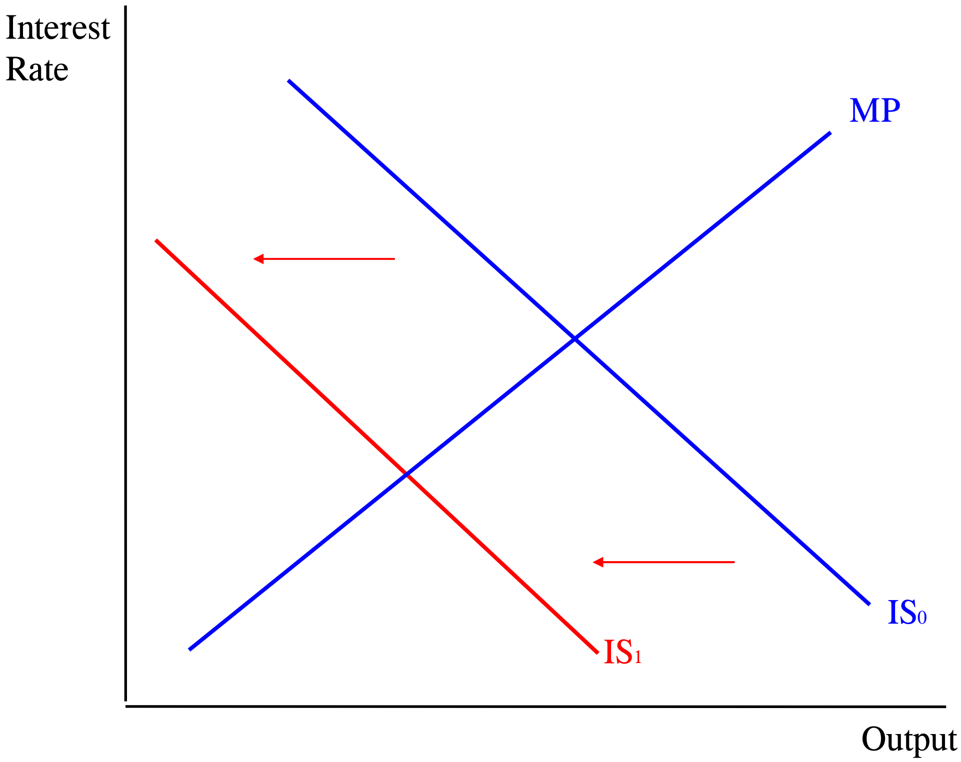

Figure I-8. The Effects of a Fall in Consumer Confidence

the enormous downturn that became known as the Great Depression.[5]

I-3 The Money Market and the Central Bank's Control of the Real Interest Rate

The Money Market

The assumption that the central bank can change the real interest rate is crucial to the MP curve. In this section, we will investigate how the central bank is able to do this. We will see that

[5] Christina D. Romer, "The Great Crash and the Onset of the Great Depression," *Quarterly Journal of Economics* 105 (May 1990), pp. 597–624.

what gives it this ability is its control of the money supply. Thus, we will examine the market for money.

Equilibrium in the money market occurs when the supply of real money balances equals the demand. The supply of real balances is simply the quantity of money measured in terms of the amount of goods it can buy. That is, it equals the dollar amount of money, M, divided by the price of goods in terms of dollars, P: the supply of real money balances is M/P.

Recall from your earlier analysis of money and inflation that there are two key determinants of the demand for real balances. The first is income, Y. When income is higher, people make more transactions, and so they want to hold a greater quantity of real balances. The second is the nominal interest rate, i. Money does not earn any interest, while other assets earn the nominal interest rate. The opportunity cost of holding money is thus the nominal interest rate. When the nominal interest rate is higher, individuals want to hold a smaller quantity of real balances.[6]

This discussion shows that the condition for the supply and demand of real balances to be equal is

$$\boldsymbol{\frac{M}{P} = L(i, Y)},$$

where L is a function that tells us the demand for real balances given the nominal interest rate and income. The function is decreasing in the interest rate and increasing in income.

We want to know whether the central bank can influence the *real* interest rate. To address this question, it helps to use the fact that, by definition, the real interest rate is the difference

[6] See Section 5-4 of Mankiw.

between the nominal interest rate and expected inflation: $r = i - \pi^e$, where π^e denotes expected inflation. This equation implies that the nominal rate equals the real rate plus expected inflation: $i = r + \pi^e$. Substituting this expression for the nominal rate into the condition for equilibrium in the money market gives us

$$\frac{\boldsymbol{M}}{\boldsymbol{P}} = \boldsymbol{L}(\boldsymbol{r} + \boldsymbol{\pi}^{\boldsymbol{e}}, \boldsymbol{Y}) \tag{I-2}$$

Equation (I-2) is the equation we will use to see how the central bank influences the real interest rate.

The central bank controls the nominal money supply directly. But when it changes the nominal money supply, the price level and expected inflation may also change. Thus it is not obvious how a change in the nominal money supply affects supply and demand in the money market. Our strategy will be to tackle this question in two steps. We will first consider what happens if prices are completely sticky. Although this assumption is not realistic, it is a useful starting point. We will then consider what happens when prices respond to changes in the money supply.

The Money Supply and the Real Interest Rate with Completely Sticky Prices

For the moment, assume complete price stickiness: prices are fixed, both now and in the future. This means that the price level is equal to some exogenous value, $\bar{P},$ that does not change when the money supply changes. It also means that expected inflation is always zero: if prices are completely fixed, there is no reason for anyone ever to expect inflation.

Thus with completely sticky prices, we can rewrite the condition for equilibrium in the market for money, equation (I-2), as

$$\frac{\boldsymbol{M}}{\overline{\boldsymbol{P}}} = \boldsymbol{L}(\boldsymbol{r}, \boldsymbol{Y}).$$

This equation differs from equation (I-2) in two ways: P has been replaced by $\bar{P}$, and π^e has been eliminated.

Suppose that the economy starts in a situation where the interest rate and output are on the IS curve, and where the money market is in equilibrium. Let r_0 denote the real interest rate in this situation, Y_0 output, and M_0 the nominal money supply. Thus, the situation in the money market is described by

$$\frac{\boldsymbol{M_0}}{\overline{\boldsymbol{P}}} = \boldsymbol{L}(\boldsymbol{r_0}, \boldsymbol{Y_0}).$$

Now suppose the central bank raises the nominal money supply from M_0 to some higher value, M_1. Since prices are fixed, the supply of real money balances, M/P, increases. Thus the supply of real balances now exceeds the demand at the initial values of the real interest rate and income:

$$\frac{\boldsymbol{M_1}}{\overline{\boldsymbol{P}}} > \boldsymbol{L}(\boldsymbol{r_0}, \boldsymbol{Y_0}).$$

The money market is no longer in equilibrium. One way for it to get back to equilibrium would be for the real interest rate to fall: since individuals want to hold more real money balances when the interest rate is lower, a big enough fall in the interest rate would raise the quantity of real balances demanded to match the increase in the real money supply. Alternatively, income could rise: a rise in income, like a fall in the interest rate, increases the amount of real balances people want to hold. Or a combination of a fall in the real interest rate and a rise in income could bring the money market back into equilibrium.

What determines whether it is a fall in the real interest rate, a rise in income, or a combination that restores equilibrium in the money market? The answer is the IS curve. This is shown in Figure I-9. Initially the economy is at point E_0 on the IS curve, with the money market in equilibrium. When the central bank raises the money supply from M_0 to M_1, it throws the money market out of equilibrium. A fall in the interest rate, with no change in income, could restore equilibrium. This is shown as point A in the figure. But at this point the goods market is not in equilibrium: planned expenditure is greater than output. Likewise, the increase in the money supply cannot cause only a rise in income. At point B in the figure, the money market is in equilibrium, but again the goods market is not. In this case, the problem is that planned expenditure is less than output.

What happens instead is that the increase in the money supply causes both a fall in the interest rate and an increase in income. Specifically, the economy moves down along the IS curve. Since the interest rate is falling and income rising as we move down the curve, the quantity of real balances demanded is rising. Thus the economy moves down the IS curve until the quantity of real balances demanded rises to match the increase in supply. The new equilibrium is shown as point E_1 in the figure.

This analysis shows that under complete price rigidity, a change in the nominal money supply changes the prevailing real interest rate. Thus the central bank can control the real interest

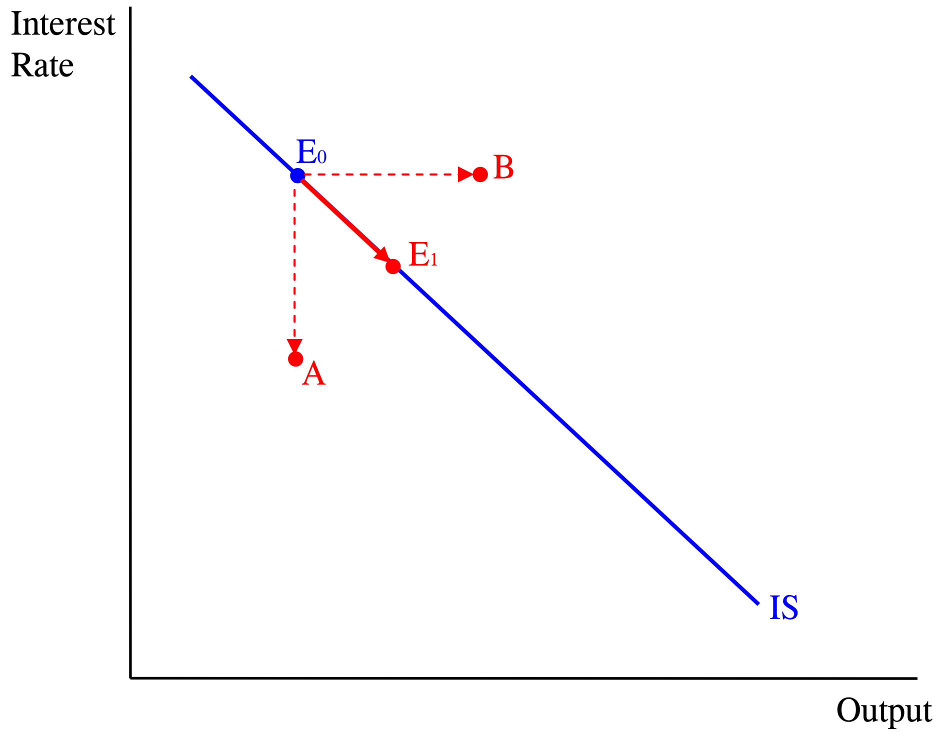

Figure I-9. The Effects of an Increase in the Money Supply

rate. By adjusting the money supply appropriately, it can therefore set the interest rate following a rule like the one described in Sections I-1 and I-2.

The Money Supply and the Real Interest Rate with Price Adjustment

Of course, prices are not completely and permanently fixed. We know that in the long run, an increase in the money supply raises the price level by the same proportion as the increase in the money supply.[7] Prices can adjust in two different ways. Prices that are completely flexible jump up immediately at the time of the increase in the money supply. Prices that are sluggish, on the other hand, rise slowly to their new long-run equilibrium level after the money supply increases.

[7] See Section 5-1 of Mankiw.

Because there are two ways that prices adjust, price adjustment has two effects on how a change in the money supply influences the money market. First, the fact that some prices jump at the time of the increase in the money stock lessens the rise in the real money supply. Since not all prices are completely flexible, however, the price level does not immediately jump all the way to its long-run equilibrium level. That is, at the time of the increase in M, P rises by a smaller proportion than M. Thus, the increase in the nominal money supply, M, still increases the supply of real money balances, M/P.

Second, the fact that some prices are sluggish causes the increase in the money supply to generate expected inflation. When the money supply rises and the price level has not yet adjusted fully to this, people know that prices must continue to rise until they have increased by the same proportion as the money supply. Thus the increase in the money supply raises expected inflation.

To see how these two forces affect the money market, consider again the condition for demand and supply to be equal. As before, we start in a position where the economy is on the IS curve and the money market is in equilibrium. Since we are no longer assuming that prices are completely fixed, we want to allow for the possibility that there is some expected inflation. Thus the initial situation in the money market is described by

$$\boldsymbol{\frac{M_0}{P_0} = L(r_0 + \pi_0^e \,, Y_0).}$$

When the nominal money supply rises from M_0 to M_1, the price level jumps from its initial value, P_0 to some higher level, P_1. As described above, the price level rises by a smaller proportion than the nominal money supply; thus M_1/P_1 is greater than M_0/P_0. In addition, expected inflation rises from π_0^e to some higher level, π_1^e. The increase in expected inflation means that at a given real interest rate, the nominal interest rate is higher than before. Since people want to hold a smaller quantity of real balances when the nominal interest rate is higher, this means that the amount of real balances they want to hold at a given real interest rate and level of income is smaller than before. That is, $L(r_0 + \pi_1^e, Y_0)$ is less than $L(r_0 + \pi_0^e, Y_0)$.

Together, this discussion implies

$$\frac{\boldsymbol{M_1}}{\boldsymbol{P_1}} > L(\boldsymbol{r_0} + \boldsymbol{\pi_1^e}, \boldsymbol{Y_0}).$$

That is, with gradual price adjustment, an increase in the nominal money supply creates an imbalance between the supply and demand of real balances at the initial values of the real interest rate and income, just as it does in the case of completely sticky prices.

From this point, the analysis is the same as it is in the case of completely sticky price. Restoring equilibrium in the money market requires a fall in the real interest rate, a rise in income, or a combination. A fall in the interest rate alone, or a rise in income alone, would move the economy off the IS curve, and thus cannot occur. Instead the economy moves down along the IS curve, with the interest rate falling and income rising, until the quantity of real money balances demanded rises to the point where it equals the supply.

Finally, this analysis shows us when the central bank cannot control the real interest rate. If all prices are completely and instantaneously flexible, the price level jumps when the money stock rises by the same proportion as the increase in the money supply. Thus the supply of real balances, M/P, does not change. In addition, the fact that the entire response of prices occurs immediately when the money supply increases means that prices are not going to adjust any more. Thus expected inflation does not change. That is, when all prices are completely flexible, a change in the nominal money supply does not affect either the supply or the demand for real balances at a given real interest rate and output. Thus the money market remains in equilibrium at the old levels of the real interest rate and output. In this case, there is no movement along the IS curve, and the central bank is powerless to affect the real interest rate. Since the assumption that all prices adjust completely and instantaneously to changes in the money supply is not realistic, however, this case is not relevant in practice.

Section IV is devoted to a second, and much more important, case where the issue of whether the central bank can influence the real interest rate arises. Suppose the nominal interest rate is very close to zero. As we will discuss, the nominal rate cannot be negative. As a result, the only way for the central bank to reduce the real interest rate is by increasing expected inflation. The issues of how the central bank can do this when the nominal rate is zero, and of whether there are cases when it is powerless to do so, are complicated – and extremely relevant to current policy.

A situation where the nominal interest rate is virtually zero is known as a *liquidity trap*.

PROBLEMS

1. Describe how, if at all, each of the following developments affects the IS and/or MP curves:

a. The central bank changes its monetary policy rule so that it sets a lower level of the real interest rate at a given level of output than before.

b. Government purchases fall, and at the same time the central bank changes its policy rule to set a higher real interest rate at a given level of output than before.

c. The demand for money increases (that is, consumers' preferences change so that at a given level of i and Y they want to hold more real balances than before).

d. The government decides to vary its purchases in response to the state of the economy, decreasing G when Y rises and increasing it when Y falls.

e. The central bank changes its policy rule to be more aggressive in responding to changes in output. Specifically, it decides that it will increase the real interest rate by more than before if output rises, and cut it by more than before if output falls.

2. Our analysis so far follows Mankiw in assuming that consumption is determined by

disposable income ($C = C(Y - T)$, with the function increasing) and investment is determined by the real interest rate ($I = I(r)$, with the function decreasing). But the real interest rate may affect households' choice between consumption and saving, and firms' sales or cash flow may influence their investment. This problem therefore asks you to consider the implications of some alternative assumptions.

a. Suppose $C = C(Y - T, r)$, with C a decreasing function of r. With this change in the model, does an increase in G increase C, decrease it, or leave it unchanged, or is it not possible to tell?

b. Suppose $I = I(Y - T, r)$, with I an increasing function of $Y - T$ (and suppose that C is given by $C(Y - T)$). Does an increase in G increase I, decrease it, leave it unchanged, or is it not possible to tell?

c. Suppose there are two types of investment. One (for example, the investment of large, mature firms) is determined by the real interest rate, and the other (for example, the investment of start-ups) is determined by consumer demand. Thus we write $I = I^A(r) + I^B(Y - T)$, where I^A and I^B are the two types of investment. Similarly, assume $C = C^A(r) + C^B(Y - T)$; the first type of consumption might include cars and other long-lived goods, and the second might include shorter-lived goods such as restaurant meals and vacations. The "A" functions are assumed to be decreasing and the "B" functions are assumed to be increasing. With this change in the model, how does an increase in G affect each type of investment and each type of consumption?

3. Suppose that prices are completely rigid, so that the nominal and the real interest rate are necessarily equal. Money-market equilibrium is therefore given by $M/\bar{P} = L(r, Y)$.

a. Suppose that government purchases increase, and that the central bank adjusts the money supply to keep the interest rate unchanged.

i. Does the money supply rise or fall?

ii. What happens to consumption and investment?

b. Suppose that government purchases increase, and that the central bank adjusts the money supply to keep output unchanged.

i. Does the money supply rise or fall?

ii. What happens to consumption and investment?

c. Suppose that government purchases increase, and that the central bank keeps the money supply unchanged.

i. Does the interest rate rise or fall?

ii. What happens to consumption and investment?

4. Suppose the central bank wants to keep the real interest rate constant at some level, $\bar{r}$. Describe whether it needs to increase, decrease, or not change the money supply to do this in response to each of the following developments. Except in part (d), assume that P is permanently fixed at some exogenous level, $\bar{P}$.

a. The demand for money at a given P, i, and Y increases.

b. There is an upward shift of the consumption function.

c. The exogenous price level, $\bar{P}$, increases permanently.

d. Expected inflation increases (with no change in the current price level).

5. Suppose that instead of following the interest rate rule $r = r(Y)$, the central bank keeps

the money supply constant. That is, suppose $M = \bar{M}$. In addition, suppose that prices are completely rigid, so that the nominal and the real interest rate are necessarily equal; money-market equilibrium is therefore given by $\bar{M}/\bar{P} = L(r, Y)$.

a. Suppose that the money market is in equilibrium when r = r_0 and Y_0. Now suppose Y rises to Y_1. For the money market to remain in equilibrium at the initial values of $\bar{M}$ and $\bar{P}$, does r have to rise, fall, or stay the same?

b. Suppose we want to show, in the same diagram as the IS curve, the combinations of r and Y that cause the money market to be in equilibrium at a given $\bar{M}$ and $\bar{P}$. In light of your answer to part (a), is this curve upward-sloping, downward-sloping, or horizontal?

c. Using your answer to part (b), describe how each of the following developments affects the interest rate and output when the central bank is setting $M = \bar{M}$ and prices are completely rigid:

i. Government purchases rise.

ii. The central bank reduces the money supply, $\bar{M}$.

iii. The demand for money increases. That is, consumers' preferences change so that at a given level of i and Y they want to hold more real balances than before.

II The Open Economy

The analysis in Section I assumed that economies are closed. But actual economies are open. This section therefore extends our analysis of short-run fluctuations to include international trade, foreign investment, and the exchange rate.

We will investigate two sets of issues. The first concern how openness affects the analysis we have done so far. For example, we will analyze how international trade alters the effects of fiscal and monetary policy. We will also explore how open-economy forces introduce new sources of macroeconomic fluctuations. The second set of issues concern the determinants of net exports and the exchange rate in the short run. We will analyze how fiscal and monetary policy and other factors affect these variables.

Before we start, it is crucial to distinguish between two ways that the exchange rate can be determined. The first is for it to be floating. In a floating exchange rate system, the exchange rate is determined in the market. As a result, if there is a change in the economy, the exchange rate is free to change in response. The United States and most other industrialized countries have floating exchange rates.

The alternative is for the exchange rate to be fixed. Under this system, the government keeps the exchange rate constant at some level. Most economies had fixed exchange rates until 1973, and many less developed countries still have them today. We will discuss the mechanics of how governments fix exchange rates later. But first we will investigate short-run fluctuations in open economies under floating exchange rates.

II-1 Short-Run Fluctuations with Floating Exchange Rates

Planned Expenditure in an Open Economy

The assumption that the central bank raises the real interest rate when output rises is just as reasonable for an open economy with floating exchange rates as it is for one that does not engage in international trade. When output is low, the central bank wants to stimulate the economy; when it is high, the central bank wants to dampen it in order to restrain inflation. Thus, we can write $r = r(Y)$ as before. There is therefore still an upward-sloping MP curve. Where international trade and floating exchange rates alter our analysis involves the IS curve.

The first step in our analysis of the open-economy IS curve is to modify our analysis of planned expenditure to include net exports. Before, we considered only planned expenditure coming from consumption, investment, and government purchases; thus planned expenditure was $E = C(Y-T) + I(r) + G$. But foreign demand for our goods – that is, our exports – is also a component of planned expenditure on domestically produced output. And the portion of our consumption, investment, and government purchases that is obtained from abroad – that is, our imports – is not part of planned expenditure on domestically produced output. Thus total planned expenditure is consumption, planned investment, government purchases, and exports, minus imports. That is, it is the sum of consumption, planned investment, government purchases, and net exports.

The key determinant of net exports is the real exchange rate, ε. Recall that the real exchange rate is the relative price of domestic and foreign goods.[1] Specifically, ε is the number of units of foreign output an American can obtain by buying one less unit of domestic output. When

[1] See Mankiw, Section 6-3.

the real exchange rate increases, foreign goods become cheaper relative to domestic goods. A rise in the real exchange rate therefore causes foreigners to buy fewer American goods, and Americans to buy more foreign goods. That is, a rise in ε reduces our exports and increases our imports. Both of these changes reduce our net exports. Thus we write

$$\boldsymbol{NX = NX(\varepsilon).}$$

Net exports are a decreasing function of the real exchange rate.

Adding this expression to our usual expression for planned expenditure gives us an equation for planned expenditure in an open economy:

$$\boldsymbol{E = C(Y-T) + I(r) + G + NX(\varepsilon).}$$

As in a closed economy, equilibrium requires that planned expenditure equals output:

$$\boldsymbol{E = Y.}$$

If planned expenditure is less than output, firms sell less than they produce, so they accumulate unwanted inventories. They therefore cut back on production. Similarly, if planned expenditure exceeds output, firms' inventories are depleted. They therefore increase production. Equilibrium occurs only when E and Y are equal.

Net Exports and the Net Capital Outflow

We are not yet in a position where we can determine equilibrium output in the goods market at a given interest rate. The problem is that we do not know the level of the exchange rate, and so we do not know the quantity of net exports. To solve this problem, we bring the net capital outflow into our analysis.

Recall that our transactions with foreign countries involve not only goods and services, but also assets.[2] As a result, our demand for foreign currency in exchange for dollars arises both from our demand for foreign goods and services and from our demand for foreign assets; likewise, foreigners' demand for dollars in exchange for their currency arises from their demand both for American goods and services and for American assets. Thus for the foreign-exchange market to be in equilibrium, our demand for foreign goods, services, and assets must equal foreigners' demand for American goods, services, and assets.

We can write the condition for equilibrium in the foreign-exchange market as

$$\boldsymbol{M + CO = X + CI.}$$

Here M and X are imports and exports, CO is the capital outflow (that is, our purchases of foreign assets), and CI is the capital inflow (that is, foreign purchases of American assets). If $M + CO$ were less than $X + CI$, for example, the supply of dollars would be less than the demand, and so the exchange rate would be bid up. The exchange rate therefore adjusts so that $M + CO$ and $X + CI$ are equal.

We can rewrite the condition for equilibrium in the foreign-exchange market as

[2] See Mankiw, Section 6-1.

$$X - M = CO - CI.$$

The left-hand side is the difference between our exports and imports – that is, our net exports. The right-hand side is the capital outflow minus the capital inflow – that is, the net capital outflow. Thus we have a critical relationship:

$$NX = CF,$$

where CF is the net capital outflow.

The key determinant of the net capital outflow is the real interest rate. The real interest rate is the real rate of return that wealthholders obtain on domestic assets. Thus when it rises, Americans buy fewer foreign assets and foreigners buy more American assets. In other words, the net capital outflow falls. Thus,

$$CF = CF(r).$$

The net capital outflow is a decreasing function of the real interest rate.

Note that this assumption about the net capital outflow corresponds to the assumption of imperfect capital mobility or of a large open economy.[3] That is, we are *not* assuming that the domestic interest rate, r, must equal the world interest rate, r*. The assumption that r must equal r* is reasonable if a small gap between the two interest rates causes domestic and foreign

[3] See the appendix to Chapter 6 of Mankiw.

wealthholders to sell vast quantities of assets in the country where the interest rate is lower and buy vast quantities in the country where the interest rate is higher. In this case, the net capital outflow is enormously positive if r* exceeds r by even a small amount, and enormously negative if r* falls short of r by even a small amount. Equilibrium can only occur if r equals r*. This is often a good first approximation for the long run. But it is usually not a good first approximation for the short run. Short-run differences in interest rates among countries are common. Such differences cause wealthholders to sell assets in the country where the interest rate is low and buy in the country where it is high; this is our assumption that CF is a decreasing function of r. But they do not cause it to occur so rapidly that the only possible outcome is for the two interest rates to be equal.

The IS Curve with Floating Exchange Rates

What we have found is that equilibrium in the foreign-exchange market requires that net exports and the net capital outflow be equal. We can therefore substitute the net capital outflow for net exports in the expression for planned expenditure, $E = C(Y-T) + I(r) + G + NX(\varepsilon)$. The resulting expression is

$$\boldsymbol{E = C(Y-T) + I(r) + G + CF(r).}$$

We can use this expression to obtain the IS curve for this model. As usual when we are interested in the IS curve, we start with the Keynesian cross; it is shown in Figure II-1. The diagram is drawn for a given value of the interest rate. The point where the planned expenditure line crosses the 45-degree line shows equilibrium income in the goods market given the interest rate. To derive the IS curve, we suppose that the interest rate rises. The increase in the interest rate

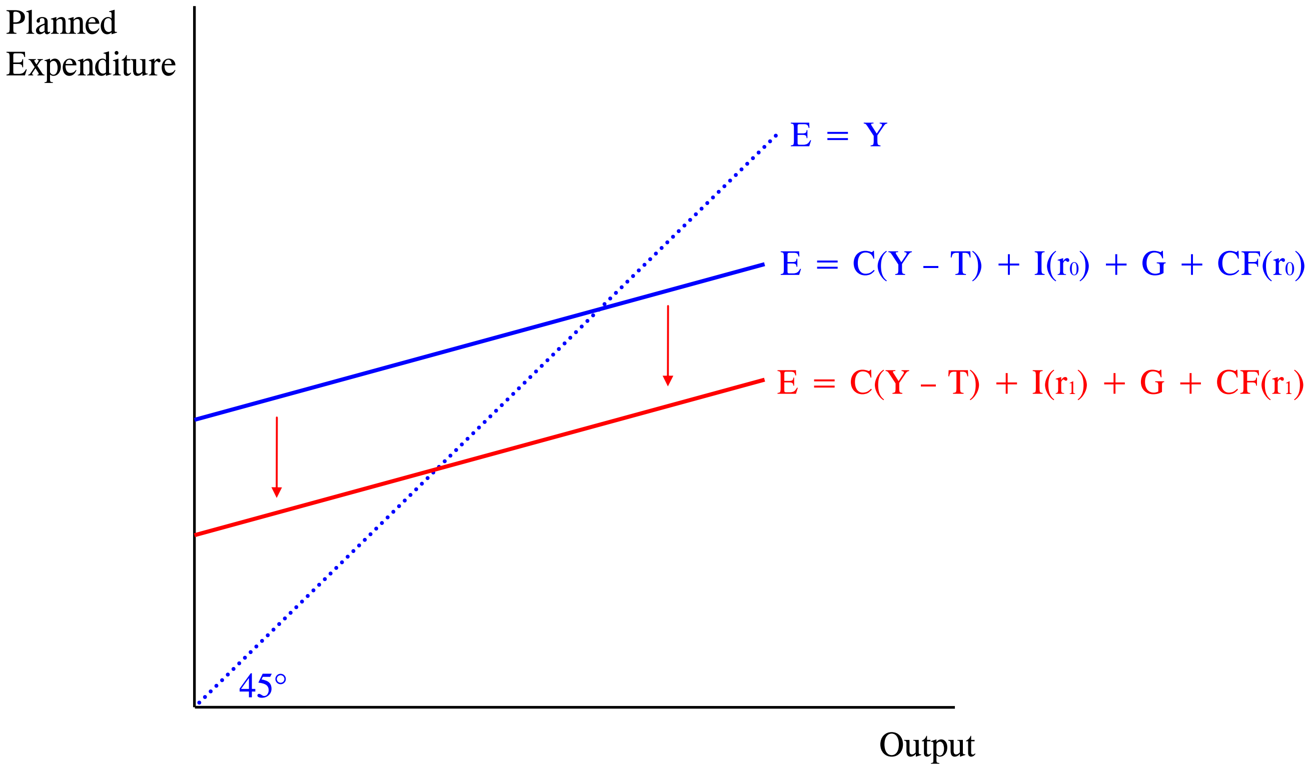

Figure II-1. The Effects of a Rise in the Interest Rate on Equilibrium Output in the Goods Market with Floating Exchange Rates

decreases two components of planned expenditure, investment and the net capital outflow. As the figure shows, the planned expenditure line shifts down, and so equilibrium income falls. Thus, there is a negative relationship between the interest rate and equilibrium income. That is, there is a downward-sloping IS curve, just as there is in a closed economy. It is shown together with the MP curve in Figure II-2. As before, the IS and MP curves determine the interest rate and output.

It is important to keep in mind that the IS curve is *not* drawn for a given level of the exchange rate. As we move down the curve, the interest rate is falling, and so the net capital outflow is rising. Since net exports must equal the net capital outflow, net exports are also rising. But remember that net exports depend on the exchange rate: $NX = NX(\varepsilon)$. Since net exports are a

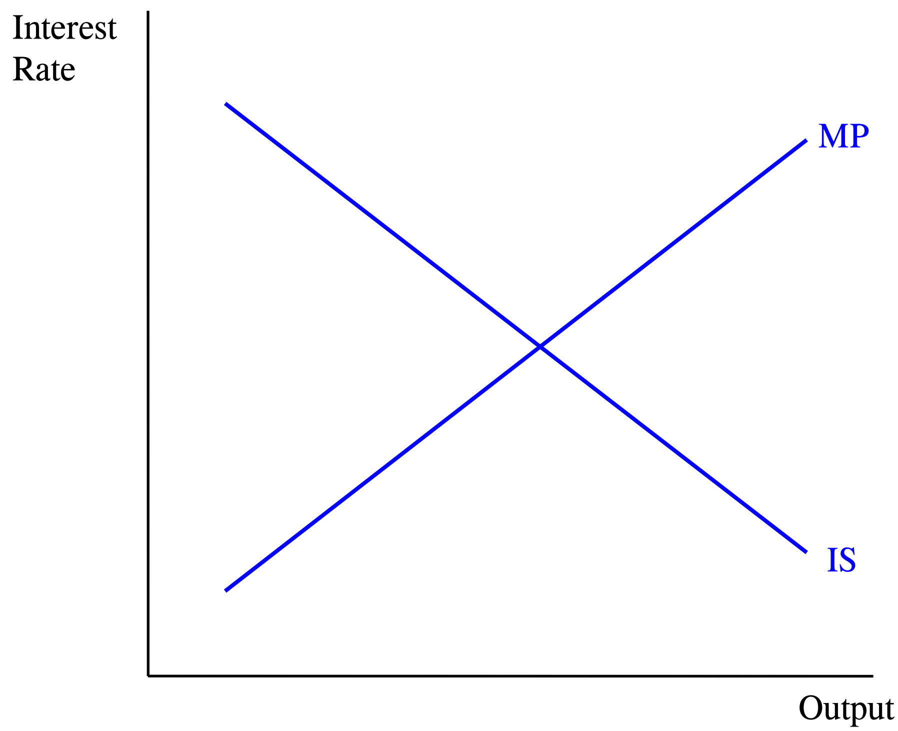

Figure II-2. The IS-MP Diagram for an Open Economy with Floating Exchange Rates

decreasing function of the exchange rate, the exchange rate must be falling for net exports to be rising. That is, the exchange rate is falling as we move down the IS curve.

The economics of why this occurs is straightforward. Suppose the interest rate in the United States falls. This increases Americans' desire to trade dollars for foreign currencies to buy foreign assets, and reduces foreigners' desire to trade their currencies for dollars to buy American assets. These changes cause the value of the dollar in terms of foreign currencies to fall; that is, they cause the exchange rate to depreciate. This depreciation makes American goods cheaper relative to foreign goods, and thus raises our net exports.

This discussion implies that a fall in the interest rate affects planned expenditure through two channels. As in a closed economy, it increases investment. But it also increases the net capital outflow; equivalently, it causes the exchange rate to depreciate and thereby increases net exports. As a result, a change in the interest rate is likely to have a larger effect on equilibrium income than in a closed economy. It is for this reason that the open-economy IS curve in Figure II-2 is fairly flat.

The Determination of Net Exports and the Exchange Rate

The IS-MP diagram does not provide an easy way for us to tell how various developments affect net exports and the exchange rate. To see how these two variables are determined, we add two diagrams to the IS-MP diagram. The three diagrams are shown together in Figure II-3.

The first new diagram shows the net capital outflow as a function of the interest rate. This diagram is placed directly to the right of the IS-MP diagram. The vertical scales of both the new diagram and the IS-MP diagram measure the real interest rate. The intersection of the IS and MP curves determines the real interest rate. The dotted horizontal line connecting the two diagrams brings the real interest rate determined by this intersection over to the net capital outflow diagram. We can then use the CF schedule to see the level of the net capital outflow.

The second new diagram shows net exports as a function of the real exchange rate. It is placed directly below the net capital outflow diagram. The horizontal axis of this diagram measures net exports, while the horizontal axis of the diagram above measures the net capital outflow. Net exports must equal the net capital outflow. Thus we can bring the level of the net capital outflow from the top diagram down to show the level of net exports. This is shown by the dotted vertical line connecting the net capital outflow and net exports diagrams.

Finally, we can use the net exports schedule to find the exchange rate. We know the level

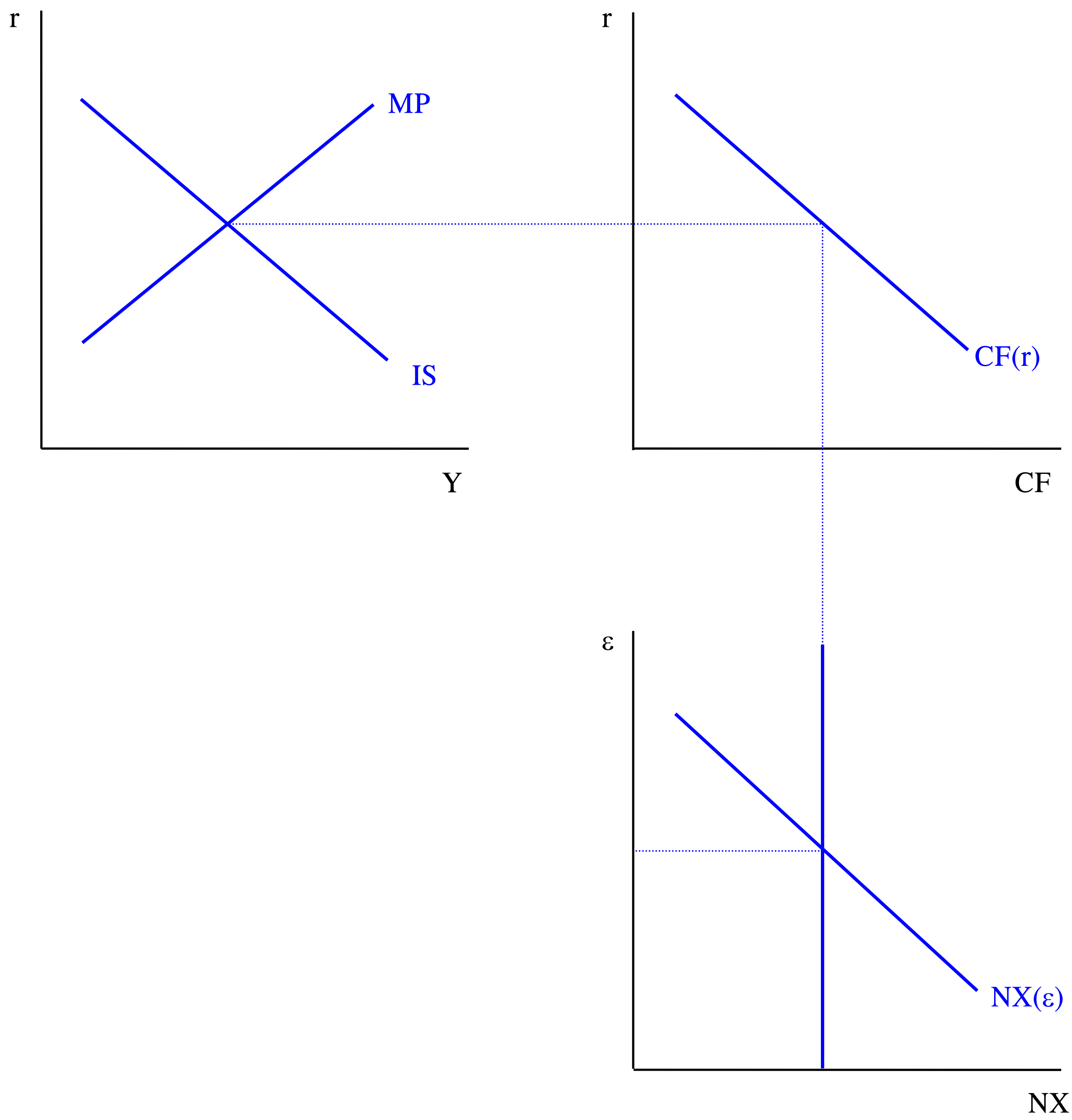

Figure II-3. The Determination of Net Exports and the Exchange Rate under Floating Exchange Rates of net exports from the fact that they must equal the net capital outflow. But the amounts of American goods that foreigners want to purchase, and of foreign goods that Americans want to purchase, depend on the exchange rate. Thus the exchange rate adjusts so that net exports equal the level of the net capital outflow determined by the interest rate. That is, ε adjusts so that $NX(\varepsilon) = CF(r)$. This is shown by the dotted horizontal line in the net exports diagram.

The key rule in using the three diagrams is always to start with the IS-MP diagram, then proceed to the net capital outflow diagram, and finally to use the net exports diagram. The IS and MP curves determine the interest rate and output. This interest rate and the CF schedule then determine the net capital outflow. Finally, the net capital outflow determines the level of net exports, and the level of net exports and the NX schedule determine the exchange rate. Changes in the later diagrams do not affect the earlier ones.[4]

II-2 Using the Model of Floating Exchange Rates

Fiscal Policy

Let us begin by considering the effects of fiscal policy. Specifically, as in Section I-2, suppose there is a rise in government purchases. This development is analyzed in Figure II-4.

Government purchases are a component of planned expenditure. As a result, an increase in government purchases shifts the IS curve to the right. The reasoning is the same as for a closed economy. The rise in government purchases increases planned expenditure at a given interest rate and output; that is, it shifts the planned expenditure line in the Keynesian cross diagram up. Thus

[4] Note, however, that CF(r) appears both in the IS curve in the first diagram and in the CF schedule in the second. Thus a development that changes the net capital outflow at a given real interest rate changes both the first and second diagrams.

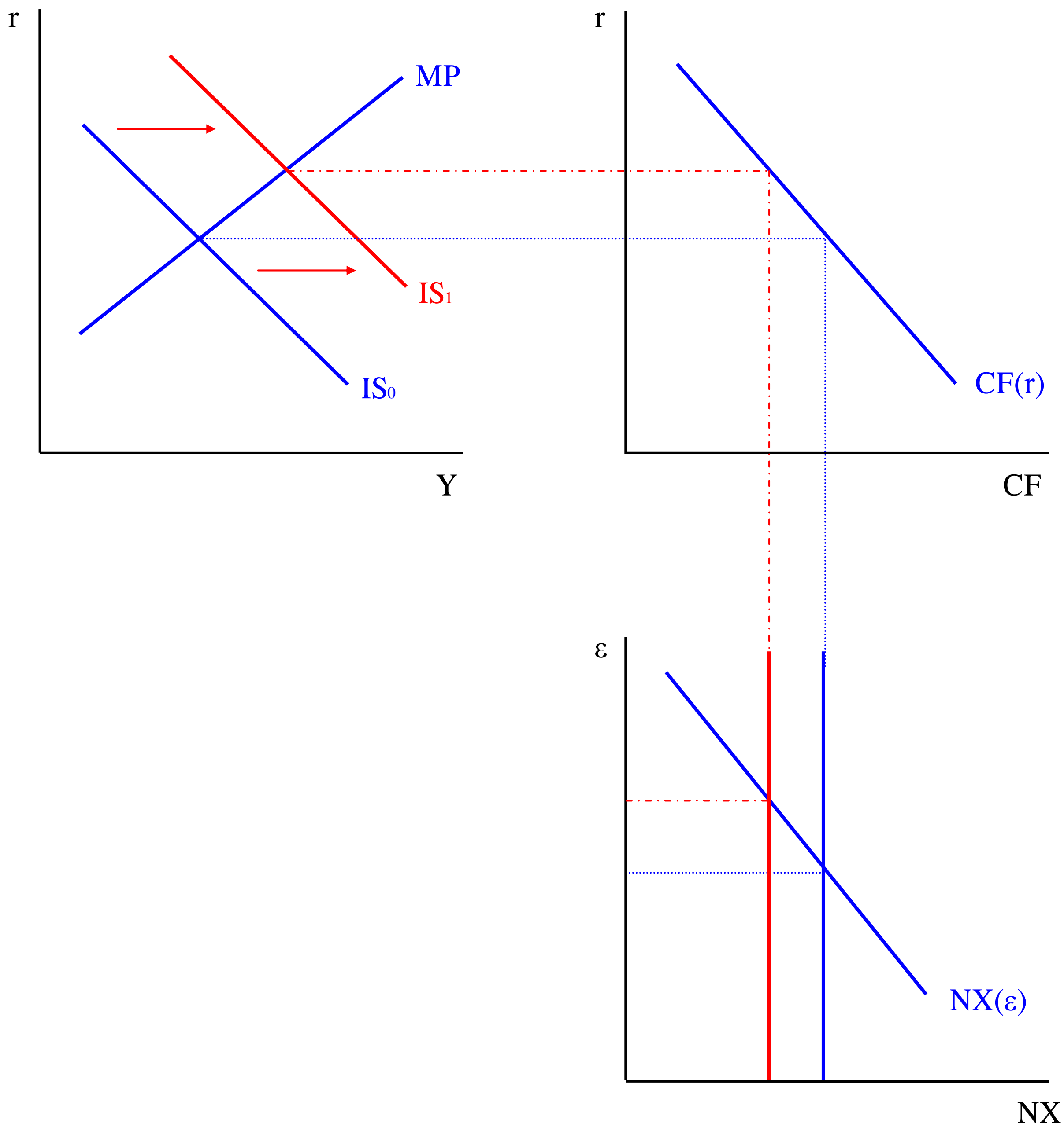

Figure II-4. The Effects of an Increase in Government Purchases with Floating Exchange Rates equilibrium income at a given interest rate is higher than before. The rightward shift of the IS curve moves the economy up along the MP curve. Thus, just as in a closed economy, the increase in government purchases raises both output and the interest rate. And the fact that the interest rate rises means that government purchases again crowd out investment.

To see how the rise in government purchases affects the net capital outflow, we draw a horizontal line from the new level of the interest rate in the IS-MP diagram over to the net capital outflow diagram. As that diagram shows, because the net capital outflow is a decreasing function of the interest rate and the interest rate rises, the net capital outflow falls.

One way to think about this result is to remember that the net capital outflow necessarily equals the difference between saving and investment.[5] Equivalently, we can write

$$\boldsymbol{S = I + CF.}$$

This equation tells is that there are two possible uses of national saving: it can be used to finance domestic investment, and it can be used to purchase foreign assets. When government purchases rise, national saving falls. This fall in national saving leads to falls in both uses of saving, investment and the net capital outflow.

The final step is to see what happens to net exports and the exchange rate. To do this, we draw a vertical line down from the new level of the net capital outflow to the net exports diagram. Since the net capital outflow falls, net exports fall too. That is, government purchases crowd out not just investment, but also net exports. And, as the net exports diagram shows, for net exports to fall the exchange rate must rise. That is, expansionary fiscal policy causes the exchange rate to

[5] See Mankiw, Section 6-1.

appreciate. In terms of the foreign-exchange market, the rise in the interest rate makes foreigners more willing to trade their currencies for dollars to buy American assets, and Americans less willing to trade dollars for foreign currencies to buy foreign assets. Thus the value of the dollar in terms of foreign currencies rises. This appreciation reduces net exports.

Monetary Policy

Figure II-5 analyzes the effects of a decision by the central bank to adopt a tighter monetary policy rule. That is, the central bank sets a higher real interest rate at a given level of output than before.

This change in monetary policy corresponds to an upward shift of the MP curve. Thus, as the IS-MP diagram in the figure shows, the interest rate rises and output falls. These effects of tighter monetary policy are the same as in a closed economy.

The net capital outflow diagram shows that the rise in the interest rate reduces the net capital outflow. The net exports diagram then shows that because the net capital outflow is lower, net exports are lower as well. Finally, the fact that the NX schedule is downward-sloping means that when net exports fall, the exchange rate rises.

This analysis shows us that monetary policy works through two channels in an open economy. First, as in a closed economy, an increase in the interest rate reduces investment. Second, the increase raises the value of the dollar, and thus reduces net exports.

Trade Policy

It is often proposed that governments adopt various types of protectionist policies – policies that restrict imports through tariffs, quotas, and other means. It is therefore natural to

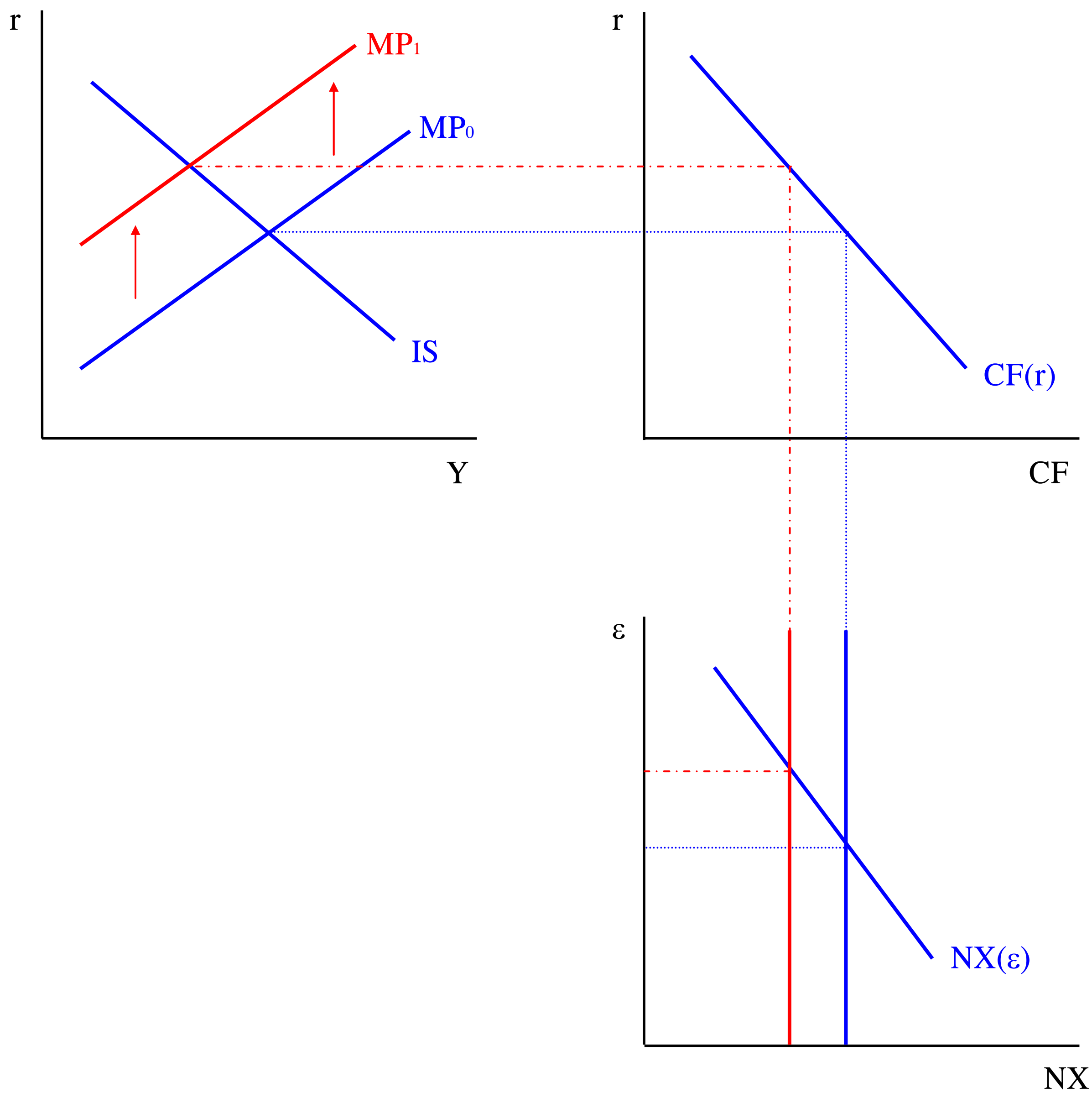

Figure II-5. The Effects of a Shift to Tighter Monetary Policy
with Floating Exchange Rates

examine the macroeconomic effects of such policies. Of course, this will not be a complete analysis of protection: as you have no doubt learned in other economics courses, protection has important microeconomic effects as well.

Suppose that the government restricts imports of certain types of goods. This means that at a given exchange rate, imports are lower than before. Since net exports equal exports minus imports, it follows that net exports are higher than before at a given exchange rate. That is, the net exports schedule shifts to the right. This is shown in the net exports diagram in Figure II-6.

The figure shows that the only effect of the protection is to cause the exchange rate to appreciate. Output, the interest rate, and even net exports are unaffected. In terms of the mechanics of the model, this is an illustration of the rule that changes in the later diagrams of our three-diagram analysis do not affect the earlier ones. In terms of the economics, what lies behind this surprising result is the fact that net exports must equal the difference between saving and investment. Trade policies do not change either saving or investment, and so they do not affect net exports. Instead, they affect the exchange rate. At the old exchange rate, foreigners' desire to trade their currencies for American dollars is the same as before, since American goods and assets are just as attractive as before. But the amount of dollars Americans want to exchange for foreign currencies is lower, since there are now restrictions on their ability to buy certain foreign goods. Thus the value of the dollar in terms of foreign currencies increases. It rises to the point where the downward impact of the higher exchange rate on net exports just offsets the upward effect from the protection. Net exports remain at their initial level.

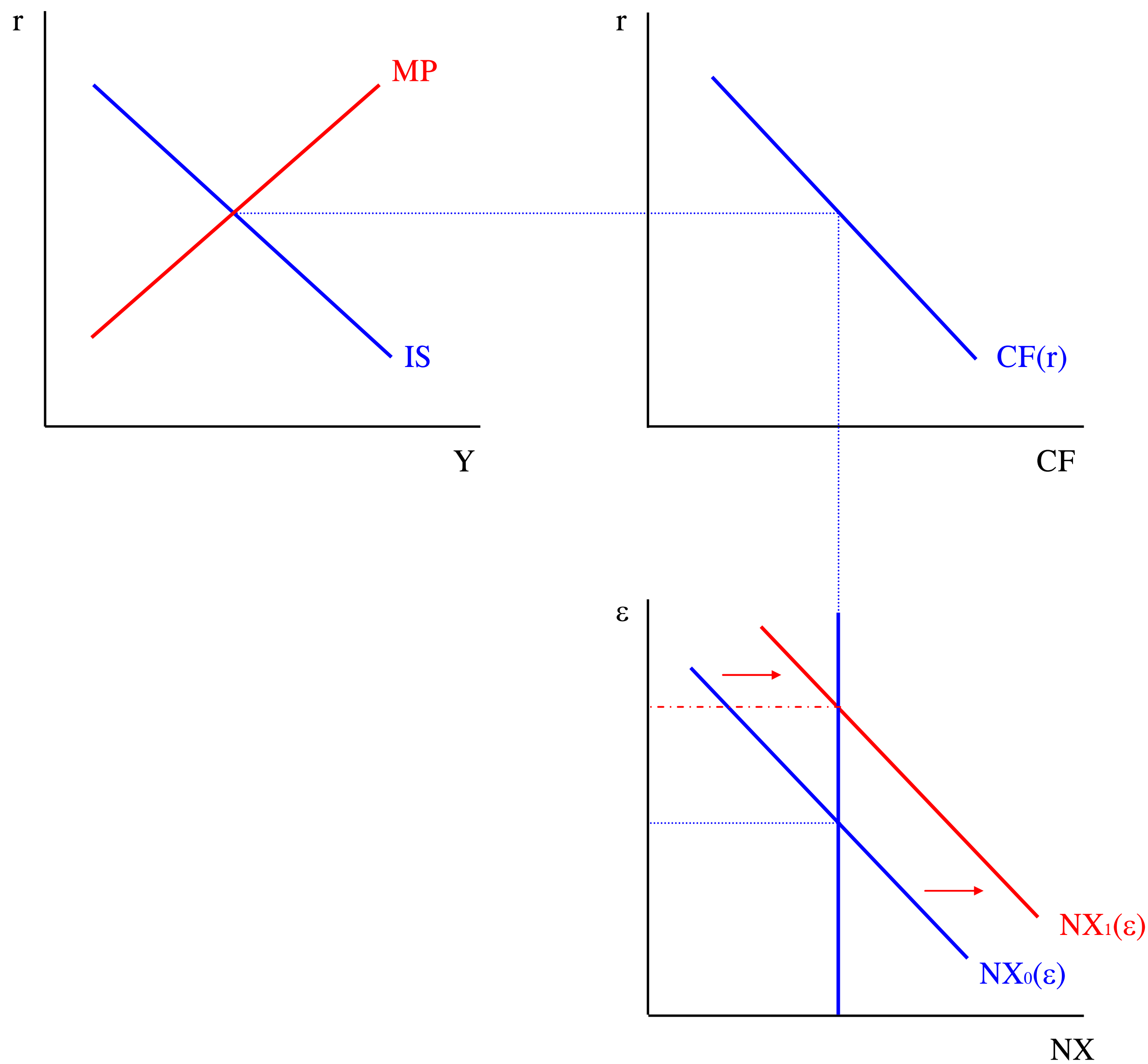

Figure II-6. The Effects of Protectionist Policies with Floating Exchange Rates

II-3 Short-Run Fluctuations with Fixed Exchange Rates

The Mechanics of Fixing the Exchange Rate

Some countries choose to keep their exchange rates constant rather than letting them adjust in response to economic developments. Governments do not fix their exchange rates by fiat. Instead, they participate in the foreign exchange market in a way that keeps their exchange rates at the desired level.

Specifically, the way a country fixes its exchange rate is by having its central bank stand ready to either buy or sell domestic for foreign currency at the desired exchange rate. For example, suppose the United States wants to fix its exchange rate with Japan at 100 yen per dollar. To do this, the Federal Reserve must be willing to trade dollars for yen at this exchange rate. The Federal Reserve's willingness to trade at this rate would keep the exchange rate at this level. No one would pay more than 100 yen for a dollar, since the Federal Reserve would sell dollars at this rate. And no one would sell a dollar for less than 100 yen, since the Federal Reserve would buy at this rate.

When a currency trader wants to trade yen for dollars with the Federal Reserve under this system, the Federal Reserve has no difficulty in providing the dollars. Since the Federal Reserve controls the U.S. money supply, it can just issue new dollars to meet the trader's demand. But the Federal Reserve cannot issue Japanese yen. Thus if the currency trader wants to trade dollars for yen, the Federal Reserve must have reserves of yen available (or be able to borrow yen). If traders' desire for yen becomes too great, the Federal Reserve is unable to meet it, and so must abandon the fixed exchange rate. We will see in a moment how the fact that a central bank cannot supply unlimited amounts of foreign currency limits its choices under fixed exchange rates.

The difference between the central bank's purchases and sales of foreign currency is called the *reserve gain*, which we denote RG. If the bank is selling more reserves than it is purchasing, RG is negative – that is, the central bank is losing reserves of foreign currency.

The central bank's purchases and sales of foreign currency are purchases and sales of foreign assets. Thus they enter into the overall net capital outflow. Specifically, since the net capital outflow equals our purchases of foreign assets minus our sales of assets to foreigners, and since RG equals the central bank's purchases of foreign currency minus sales, RG enters into the overall net capital outflow positively.

Because the reserve gain is a part of the net capital outflow, it is useful to divide the overall net capital outflow into two components. The first component is all of the net capital outflow other than the reserve gain. For simplicity, we will refer to this as the "private" net capital outflow (although it includes some transactions in foreign assets involving governments), and denote it PCF. As discussed before, the private net capital outflow depends negatively on the real interest rate. That is, PCF = PCF(r) – the private net capital outflow is a decreasing function of the real interest rate.

The second component of the net capital outflow is the reserve gain. Thus the overall net capital outflow is

$$\boldsymbol{CF = PCF + RG.}$$

We know from our earlier analysis that the overall net capital outflow equals net exports. Since the overall net capital outflow is $PCF + RG$, it follows that

$$\boldsymbol{RG = NX - PCF.}$$

This relationship is easiest to understand by starting with the case where PCF is zero and net exports are negative. The combination of negative net exports and no PCF means that the amount of dollars Americans are trading to obtain foreign currency exceeds the amount of dollars foreigners are obtaining in exchange for their currency. The only way this can come about is if some of the foreign currency Americans are obtaining for their dollars is coming from the central bank. That is, when PCF is zero and net exports are negative, the central bank is losing reserves, and so RG is negative.

More generally, $NX - PCF$ equals the difference between total sales to foreigners (not only goods and services, but also assets) and total purchases from foreigners (again, of goods, services, and assets). If this difference is positive, the central bank must be gaining reserves. If it is negative, the central bank must be losing reserves.

The IS Curve with Fixed Exchange Rates

With the exchange rate fixed, our expression for planned expenditures becomes

$$\boldsymbol{E = C(Y-T) + I(r) + G + NX(\bar{\varepsilon}),}$$

where $\bar{\varepsilon}$ denotes the fixed level of the exchange rate. Since the reserve gain need not be zero, net exports need not equal PCF. Thus we can no longer substitute for net exports in the equation for planned expenditure and have the exchange rate change as we move along the IS curve. Instead, we now draw the IS curve for the fixed value of the exchange rate.

To see how equilibrium output in the goods market depends on the interest rate, we again consider the effects of a rise in the interest rate. This change lowers investment, and therefore reduces planned expenditure at a given level of income. Thus equilibrium output falls. That is, there is again a negative relation between the interest rate and equilibrium output – a downward-sloping IS curve.

The fact that the exchange rate is fixed eliminates one of the two channels through which the interest rate influences equilibrium output under flexible exchange rates: a rise in the interest rate no longer leads to an appreciation of the exchange rate and a fall in net exports. Thus, moving to fixed exchange rates makes the IS curve steeper.[6]

Monetary Policy with Fixed Exchange Rates

As always, the central bank would like to raise the real interest rate when output rises and lower it when output falls. With a fixed exchange rate, however, there are limits on its ability to do this: the desire to keep the exchange rate fixed limits its choices. In particular, there is some limit to the reserve losses a central bank can sustain. It simplifies the analysis to assume that the central bank starts with no reserves at all, and thus that its reserve gain cannot be negative. That is, it faces the constraint

$$\boldsymbol{RG \geq 0.}$$

[6] Note that we have implicitly assumed that the central bank is holding the *real* exchange rate fixed. (We did this by writing the real exchange rate, ε, as $\bar{\varepsilon}$ in the expression for planned expenditure.) Like all assumptions in our models, this one is not completely accurate. Most countries that have a fixed exchange rate hold the nominal rather than the real exchange rate fixed. But assuming that they fix the real exchange rate captures the essence of the difference between fixed and floating exchange rates: both nominal and real exchange rates are dramatically less volatile under fixed exchange rates. The alternative assumption that the central bank holds the nominal exchange rate fixed makes the model very hard to use. Every time the price level changes, the real exchange rate changes, and so net exports change and the IS curve shifts. Thus for most questions, the assumption that it is the real exchange rate that is fixed is preferable: it simplifies the analysis greatly without affecting the model's main messages.

Recall that $RG = NX - PCF$, and that PCF is a decreasing function of the real interest rate. Thus as the real interest rate falls, the reserve gain falls. Intuitively, a fall in the interest rate makes domestic assets less attractive relative to foreign assets. Thus domestic residents want to trade more domestic currency for foreign currency in order to buy foreign assets, and foreign residents want to trade less of their countries' currencies for the domestic currency to buy domestic assets. To prevent these changes from causing the exchange rate to depreciate, the central bank must provide foreign currency in exchange for domestic currency – that is, its reserve gain must fall.

At some point, the interest rate becomes sufficiently low that the reserve gain reaches zero. Once this point is reached, the central bank cannot lower the real interest rate further. We let $\bar{r}$ denote the interest rate that results in a reserve gain of zero.

Because the central bank cannot set the interest rate freely under a fixed exchange rate, our assumption about how it conducts monetary policy has two parts. First, if the central bank can set the real interest rate according to the usual MP relationship, $r = r(Y)$, it does so. Second, if following its usual rule is not feasible – that is, if it would lead to RG < 0 – the central bank sets the real interest rate to the lowest feasible level, $\bar{r}$. We can express this as:

$$\boldsymbol{r} = \begin{cases} \boldsymbol{r}(\boldsymbol{Y}) & \text{if } \boldsymbol{NX}(\bar{\boldsymbol{\varepsilon}}) - \mathbf{PCF}\big(\mathbf{r}(\mathbf{Y})\big) \geq \mathbf{0} \\ \bar{\boldsymbol{r}} & \text{otherwise.} \end{cases}$$

This discussion shows how fixing the exchange rate constrains monetary policy. The central bank is free to set a high interest rate, since this only leads foreigners to want to purchase domestic currency to obtain high-yielding domestic assets, and it can meet this demand by printing money. But it faces a limit to its ability to lower interest rates. When domestic interest rates are low, people want to convert domestic to foreign currency. And since the central bank cannot print foreign currency, it has a limited ability to meet this demand.

Figure II-7 shows the derivation of the modified MP curve. The left-hand diagram plots the reserve gain as a function of the real interest rate; we refer to this as the RG curve. Recall that the reserve gain equals NX minus PCF. Thus

$$\boldsymbol{RG(r) = NX(\bar{\varepsilon}) - PCF(r).}$$

Since PCF is a decreasing function of r, the RG curve slopes up. $\bar{r}$ is the interest rate that leads to a reserve gain of zero.

The right-hand panel of the figure shows how the central bank sets the real interest rate as a function of real output. When Y is very low, the central bank would like to set the real interest rate below $\bar{r}$; this is shown by the dashed line in the figure. It cannot do this, however, because this would lead to RG < 0. It therefore sets the real interest rate to $\bar{r}$. This is the flat portion of the function. Once Y becomes high enough, however, the central bank would like to set r above $\bar{r}$, and it is free to do so; thus in this case it follows its usual rule. This is the upward-sloping portion of the function. We call the curve showing the central bank's entire rule – first flat, then upward-sloping – the $\widetilde{\text{MP}}$ curve.

The Determination of Output and the Interest Rate

Figure II-8 brings the IS curve back into the analysis by adding it to the diagram with the $\widetilde{\text{MP}}$ curve. As before, the key rule in using the diagrams is to begin with the diagram on the left. The point where RG is zero determines $\bar{r}$. We can then bring $\bar{r}$ over the right-hand diagram to find

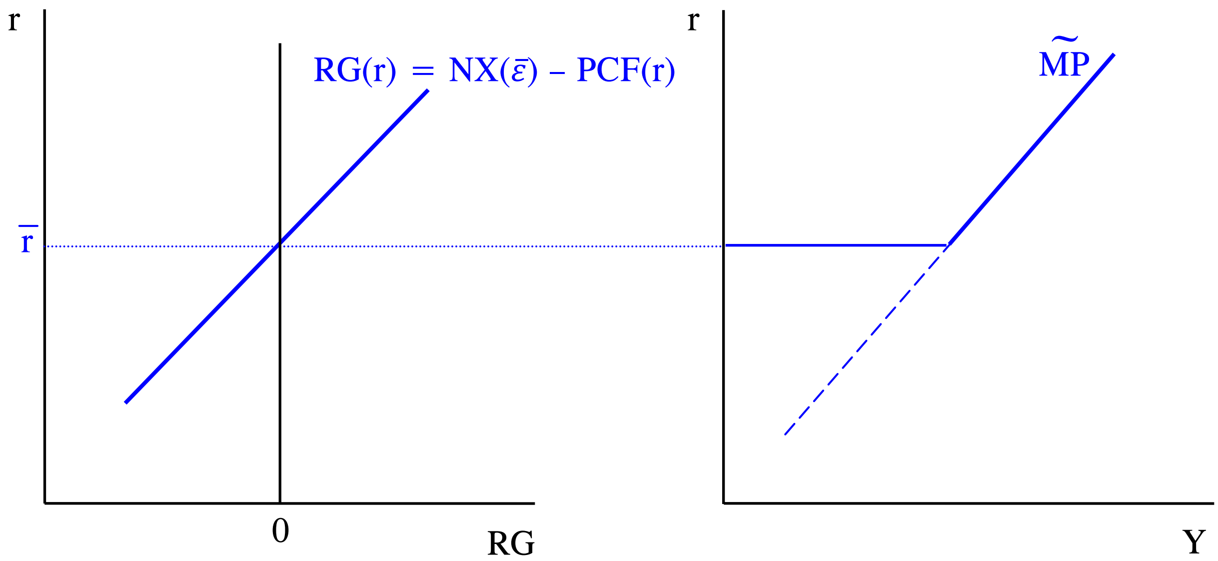

Figure II-7. Monetary Policy with Fixed Exchange Rates

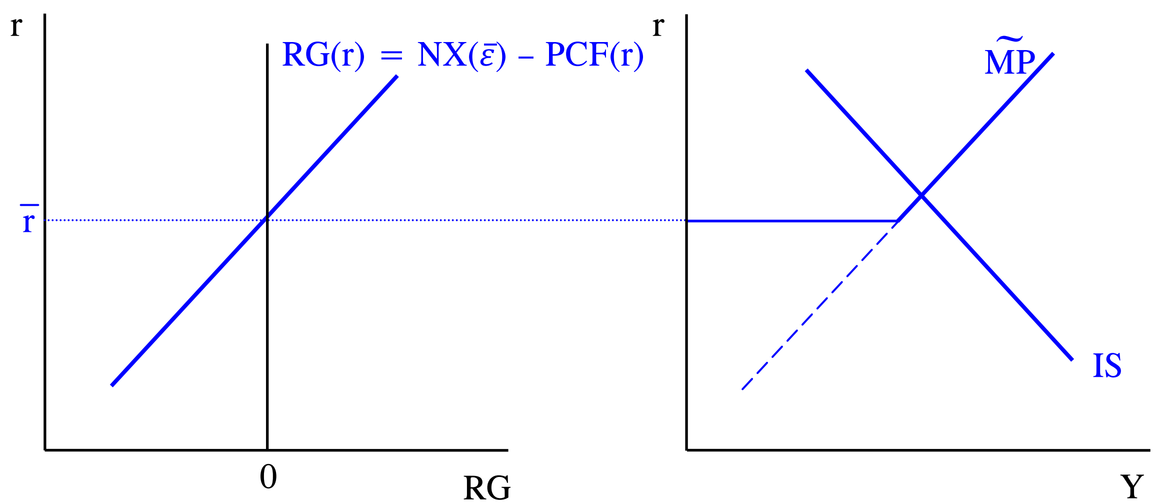

Figure II-8. The Determination of Output and the Interest Rate in an Open Economy with Fixed Exchange Rates the position of the $\widetilde{MP}$ curve. The intersection of the IS and $\widetilde{MP}$ curves determines r and Y. If the intersection is in the flat part of the $\widetilde{MP}$ curve, the interest rate is $\bar{r}$ and the reserve gain is zero. If the intersection is in the upward-sloping part, the interest rate is above $\bar{r}$ and the reserve gain is positive. In the case shown in Figure II-8, the intersection is in the upward-sloping part.

II-4 Using the Model of Fixed Exchange Rates

Fiscal Policy

To see how the model works, we begin with our standard example of an increase in government purchases. The effects of this change are shown in Figure II-9. The rise in purchases has no effect on the reserve gain for a given r; that is, it does not affect the RG curve, and so it does not affect $\bar{r}$. It does, however, shift the IS curve to the right for the usual reasons. Thus, as the IS-$\widetilde{MP}$ diagram in the figure shows, output and the interest rate rise. The rise in the interest rate increases the central bank's reserve gain; thus the desire to keep the exchange rate fixed is not a barrier to expansionary fiscal policy.

Monetary Policy

The next change we consider is a fall in the interest rate the central bank desires to set for a given level of output. That is, we consider a downward shift of the r(Y) function. This change is analyzed in Figure II-10. The change corresponds to a downward shift of the upward-sloping portion of the $\widetilde{MP}$ curve. For values of Y where the central bank wanted to set an interest rate above $\bar{r}$, it can now set a lower interest rate than before. But the central bank still cannot set the interest rate below $\bar{r}$. Thus the flat portion of the curve is unchanged.

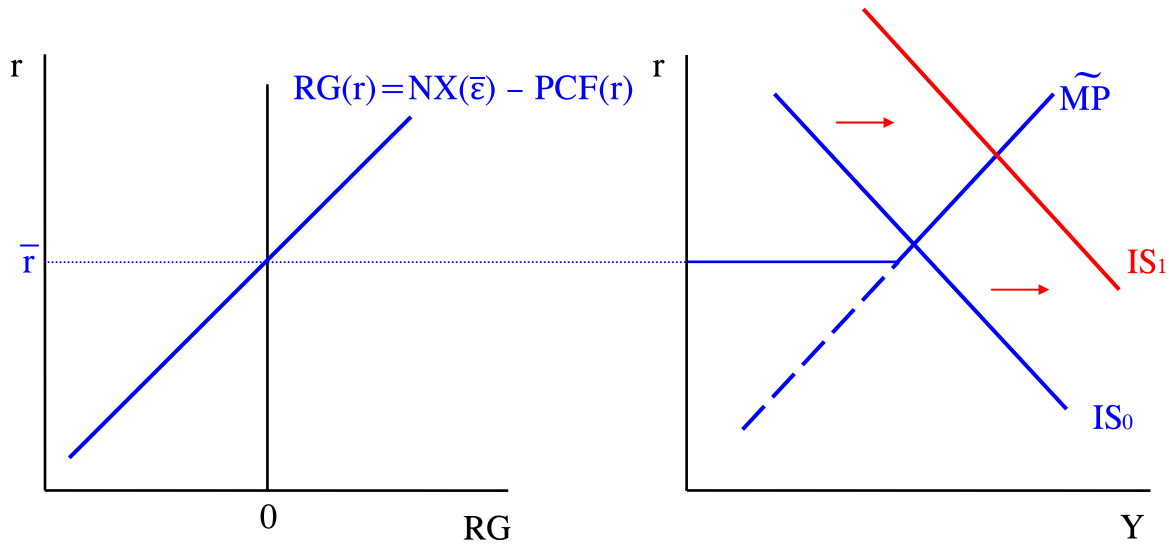

Figure II-9. The Effects of an Increase in Government Purchases with Fixed Exchange Rates

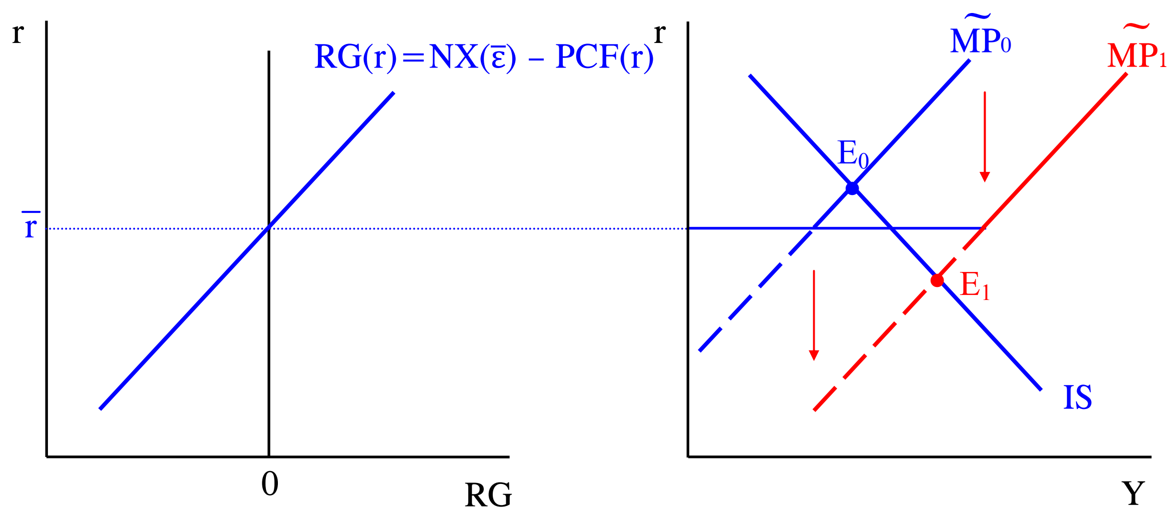

Figure II-10. The Effects of Expansionary Monetary Policy with Fixed Exchange Rates

If the central bank is starting from a situation where it is gaining reserves, the change lowers the interest rate and increases output. As the interest rate falls, however, so does the reserve gain. Thus there is a limit on the central bank's ability to conduct expansionary monetary policy: it can expand only to the point where the reserve gain equals zero. This is the case shown in the figure.

Trade Policy

We saw in Section II-2 that protection shifts the demand for net exports: if the government limits imports, net exports at a given exchange rate increase. With floating exchange rates, the exchange rate rises to offset this, and output, the interest rate, and net exports are unaffected. But with fixed exchange rates, the exchange rate cannot change. As a result, protection has macroeconomic effects.

These effects are shown in Figure II-11. With net exports higher at a given exchange rate and the exchange rate fixed, the reserve gain, $NX(\bar{\varepsilon}) - PCF(r)$, is higher than before at a given interest rate. Thus the RG curve in the first diagram shifts to the right, and so $\bar{r}$ falls. In addition, the rise in net exports shifts the IS curve to the right. The result is that output rises. What happens to the interest rate is unclear. In the case shown in the figure, r is initially above $\bar{r}$; in this case r unambiguously rises. In the case where the central bank is initially constrained by the need to fix the exchange rate, however, it is possible for r to fall.

The fact that protection increases output in the short run does not imply that it is desirable. As you will see in Section III, there are disadvantages as well as advantages to raising output. And if policymakers do want to raise output, they can use monetary and fiscal policy (or, as we will see momentarily, a change in the fixed exchange rate). Those policies, unlike protection, do not create

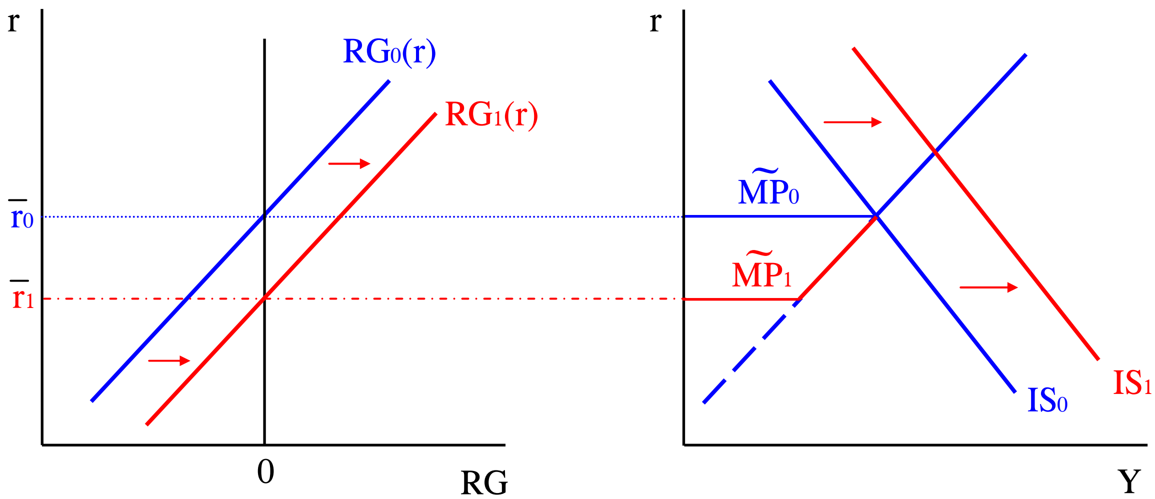

Figure II-11. The Effects of Protectionist Policies with Fixed Exchange Rates

Note: $RG_0(r) = NX_0(\bar{\varepsilon}) - PCF(r)$; $RG_1(r) = NX_1(\bar{\varepsilon}) - PCF(r)$

microeconomic distortions.

A Fall in Export Demand

In many third world countries, most exports consist of just a few commodities. Bolivia exports mainly tin, for example, and Venezuela exports mainly oil. As a result, developments in the market for a single commodity can have a large effect on the demand for a country's exports. Thus our next example is a decline in the demand for a country's exports.

This development is analyzed in Figure II-12. Initially, the IS and $\widetilde{MP}$ curves intersect at point E_0. The fall in export demand means that exports are lower at a given exchange rate. Both the RG curve in the first diagram and the IS curve in the second diagram shift to the left. These changes raise $\bar{r}$ and cause output to fall. The intersection of the new IS and $\widetilde{MP}$ curves is at point

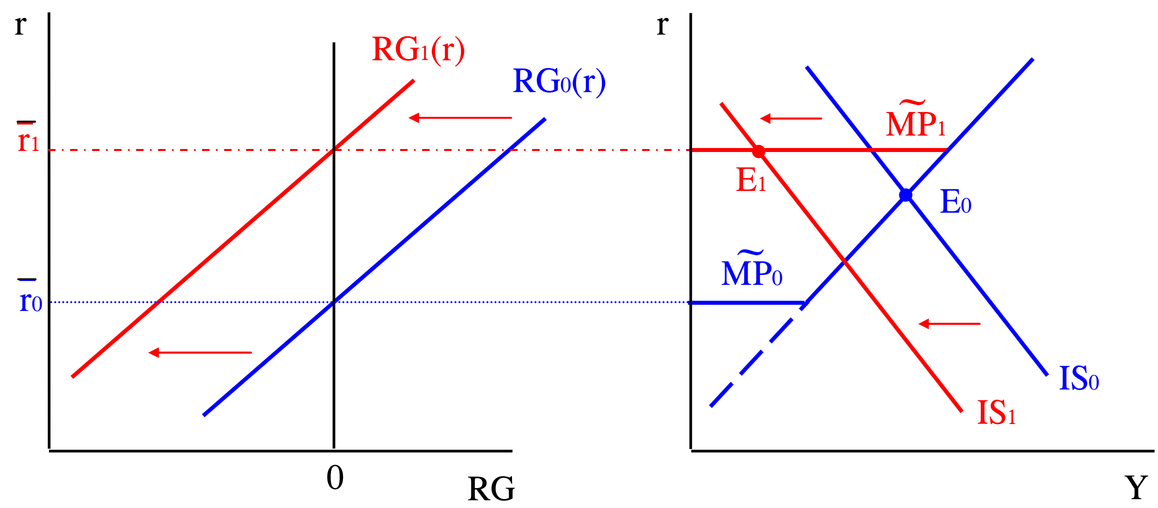

Figure II-12. The Effects of a Fall in Export Demand with Fixed Exchange Rates

Note: $RG_0(r) = NX_0(\bar{\varepsilon}) - PCF(r)$; $RG_1(r) = NX_1(\bar{\varepsilon}) - PCF(r)$

E_1. In the case considered in the figure, the rise in $\bar{r}$ forces the central bank to raise the real interest rate. This preserves the fixed exchange rate, but makes the decline in output greater.

Devaluation

With a fixed exchange rate, the government has another type of macroeconomic policy available: it can change the exchange rate. Figure II-13 shows the effects of a *devaluation* – that is, a reduction in the fixed exchange rate. The reduction in $\bar{\varepsilon}$ increases net exports. Thus both the RG curve and the IS curve shift to the right. Output rises, and the interest rate can either rise or fall.

In situations where a government wants to expand the economy, devaluation is often a reasonable policy. For example, if a country faces a fall in demand for its net exports and must raise the interest rate if it is to maintain its exchange rate, devaluation is often a highly attractive

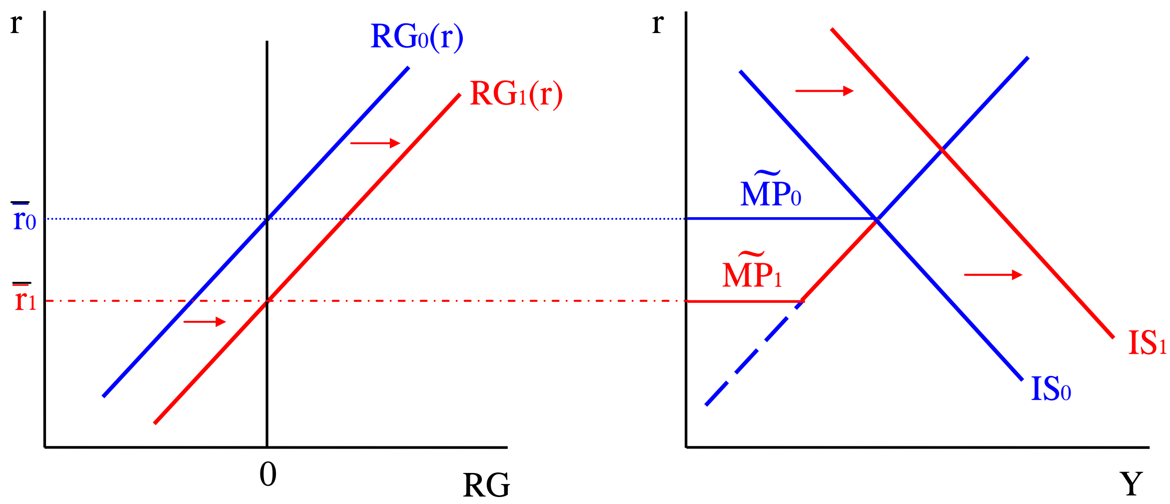

Figure II-13. The Effects of a Devaluation

Note: $RG_0(r) = NX(\bar{\varepsilon}_0) - PCF(r)$; $RG_1(r) = NX(\bar{\varepsilon}_1) - PCF(r)$

alternative. Such a policy dampens rather than magnifies the fall in output stemming from the decline in export demand. Likewise, devaluation has macroeconomic effects that are similar to protection, but without the microeconomic costs.

Devaluation does have a cost, however. A lower real exchange rate means that the country's residents must give up more domestically produced goods in order to buy foreign goods. This effect of devaluation acts to reduce standards of living.

An increase in the fixed exchange rate is known as *revaluation*. Its effects are the opposite of a devaluation's.

PROBLEMS

1. Describe how, if at all, each of the following developments affects income, the exchange rate, and net exports in an open economy with floating exchange rates:

a. The discovery of new investment opportunities causes investment demand to be higher at a given interest rate than before.

b. The central bank changes its monetary policy rule so that it sets a lower real interest rate at a given level of output than before.

c. Foreign goods become more fashionable – that is, American demand for foreign goods at a given exchange rate increases.

d. Foreigners become more confident about America's future. Specifically, the CF function changes so that CF is lower at a given r than before.

e. The demand for money decreases (that is, consumers' preferences change so that at a given level of i and Y they want to hold fewer real balances than before).

2. Suppose the government wishes to lower the exchange rate, ε, but not to change real output, Y. What monetary or fiscal policy, or combination of the two, does it need to use to do this? Assume that exchange rates are floating.

3. Suppose that capital mobility increases (that is, that a given change in r has a larger impact on CF than before). Does this change increase, decrease, or not affect the power of monetary policy – that is, does it cause a given change in r to have a larger, smaller, or the same impact on Y than before? Assume that exchange rates are floating.

4. We found in Section II-2 that protection does not affect net exports under floating exchange rates. Can you determine how it affects each of the two components of net exports, exports and imports?

5. In many third world countries, foreign investors are concerned about whether the country's government and firms will repay their debts. As a result, foreign purchases of domestic assets depend not just on the domestic interest rate (r), but also on the government's budget deficit (G − T). Specifically, a higher budget deficit reduces foreign purchases of domestic assets. Suppose the government in such an economy reduces government purchases. Assume that exchange rates are floating.

a. What happens to output, consumption, and investment?

b. Can you tell what happens to the net capital outflow, net exports, and the exchange rate?

6. Describe how, if at all, each of the following developments affects the IS and/or $\widetilde{MP}$ curves in an open economy with fixed exchange rates:

a. The discovery of new investment opportunities causes investment demand to be higher at a given interest rate than before.

b. The central bank's preferences change so that it wants to set a higher interest rate at a given level of output than before.

c. Foreigners become more confident about the country's future. Specifically, the CF function changes so that CF is lower at a given r than before.

7. Consider an open economy with fixed exchange rates. Suppose that foreign goods become more fashionable – that is, the demand for foreign goods at a given exchange rate increases. Describe how this change affects output and the interest rate if:

a. The reserve gain is initially zero.

b. The reserve gain is initially substantially positive.

III Aggregate Supply

So far, our analysis of short-run fluctuations has focused on the factors that determine output, the interest rate, the exchange rate, and net exports at a point in time. This analysis goes under the heading of *aggregate demand*, since it is based on the idea that output is determined by the overall demand for goods and services.

We now want to extend the analysis to incorporate inflation. The behavior of inflation stems from how firms respond to the demand for their goods and services. This behavior therefore goes under the heading of *aggregate supply*. Together, aggregate demand and aggregate supply determine not only output and inflation at a point in time, but how they change over time.

III-1 Extending the Model to Include Aggregate Supply

The Behavior of Inflation

Our basic assumption about the behavior of inflation is:

At a point in time, the rate of inflation is given. When output is above its natural rate, inflation rises. When output is below its natural rate, inflation falls. When output equals its natural rate, inflation is constant.

Recall that the natural rate of output, $\overline{Y}$, is the level of output that prevails when prices are completely flexible; it is the level of output that is produced when the unemployment rate is at its natural rate, $\bar{u}$.[1] In the short run, however, prices are not completely flexible. As a result, output does not always equal its natural rate. But prices are not completely rigid either. When output is below its natural rate, firms have idle capacity and little trouble finding new workers and retaining their current ones. As a result, they raise their prices by less than they were raising them before. Similarly, when output is above its natural rate, firms must run extra shifts and have difficulty finding and retaining workers. As a result, they raise their prices by more than before.

This description of how inflation behaves is not only intuitively appealing, but a good description of how actual economies usually function. In the United States, inflation has generally fallen when output has been below its natural rate and risen when output has been above its natural rate. During the severe recession of 1981–1982, for example, when unemployment rose to almost 11 percent and output was far below its natural rate, inflation fell from close to 10 percent to under 4 percent. During the boom of the 1960s, when unemployment fell below 4 percent, inflation rose from around 1 percent to over 4 percent.

This pattern does not just hold in the United States. Laurence Ball identified 65 episodes in 19 industrialized countries in which inflation fell substantially. He found that in a large majority of the episodes, output was below its natural rate. That is, periods of below-normal output are associated with falling inflation.[2]

Two aspects of our assumption about aggregate supply are very important. First, inflation at a point in time is given – that is, inflation does not respond immediately to disturbances. If, for

[1] See Mankiw, Chapter 3.

[2] Laurence M. Ball, "What Determines the Sacrifice Ratio?" in N. Gregory Mankiw, editor, *Monetary Policy* (Chicago: University of Chicago Press, 1994), pp. 155–182.

example, the government uses fiscal policy to increase aggregate demand, the immediate effect of the policy is to raise output with no change in inflation. Only later does the above-normal output cause inflation to rise. This process will be clearer shortly, when we consider the rest of the model and some examples.

Second, our assumption concerns the behavior of inflation, not prices. Below-normal output does not cause most firms to actually reduce their prices. For example, inflation remained positive – that is, the price level continued to rise – during the 1981–1982 recession. Instead, below-normal output causes firms to raise their prices by less than before. Although inflation remained positive in the 1981–1982 recession, it fell substantially from what it had been before the recession.

Of course, like all of our assumptions, our assumption about inflation is not a perfect description of what actually happens. Sometimes inflation does not fall when output is below its natural rate, and sometimes it does not rise when output is above the natural rate. The behavior of inflation in the United States from 2009 to 2012 is a prominent example of such exceptions. Output was far below its natural rate, but inflation barely fell. We will incorporate such exceptions into our analysis by allowing for *inflation shocks* and *anchored expectations*. These possibilities are the subject of Section III-3.

The Effect of Inflation on Monetary Policy

The analysis in Sections I and II concerned the economy at a point in time. Thus it was reasonable to take inflation as given, and not to concern ourselves with how the central bank responds to inflation. But now we want to incorporate inflation into our analysis. We do not have a complete understanding of inflation's effects. But there is some evidence that it may have substantial harms. It appears to lower investment of all kinds by creating uncertainty and reducing confidence in future government policies, to divert some of the economy's productive capacity into such activities as forecasting inflation and trying to offset its effects, and to magnify the microeconomic distortions created by the tax system. Because of these harms, central bankers dislike inflation. When it rises, they raise the real interest rate to reduce output and thereby control it. When it falls, their need to restrain output is smaller, and so they cut the real interest rate. In terms of the IS-MP diagram, this means that the MP curve shifts up when inflation rises and shifts down when it falls.

This discussion implies that we must extend our assumption about monetary policy:

> *The central bank's choice of the real interest rate depends not only on output, but also on inflation. When inflation rises, the central bank raises the real interest rate. When inflation falls, the central bank lowers the real interest rate.*

We can state this assumption in terms of an equation:

$$\boldsymbol{r = r(Y,\pi).}$$

The function $r(Y,\pi)$ is increasing in both Y and π.

The AD-IA Diagram

The two key variables in our analysis are output and inflation. It is therefore useful to summarize our model using a diagram in terms of these variables.

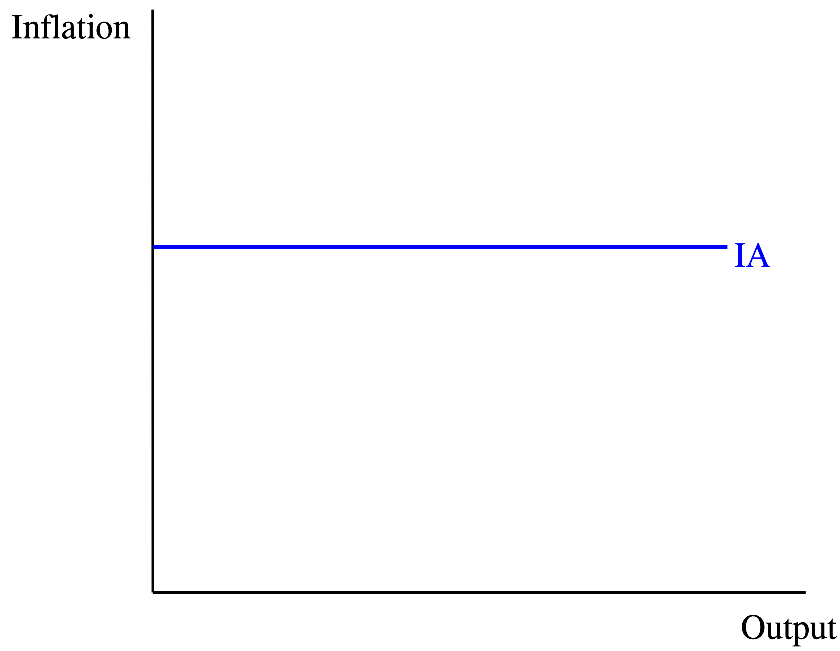

Figure III-1. The Inflation Adjustment Line

We start with aggregate supply. Inflation at a point in time is given. This is shown by the horizontal line in Figure III-1. This line shows that inflation at a point in time does not depend on output at that time.

Instead, output affects inflation by causing it to rise or fall gradually over time. That is, the line shifts up or down depending on whether output is above or below its natural rate. Because the line determines how inflation behaves over time, we call it the inflation adjustment, or IA, line.

Now consider aggregate demand. When inflation is higher, the real interest rate that the central bank sets at a given level of output is higher. That is, a rise in inflation shifts the MP curve up. This is shown in the top diagram of Figure III-2. When inflation rises from π_0 to π_1, the MP shifts up from MP_0 to MP_1. The economy moves up along the IS curve, and so output falls. Thus, as the bottom diagram in the figure shows, there is a downward-sloping relationship between inflation and output. It is labeled AD (for aggregate demand).

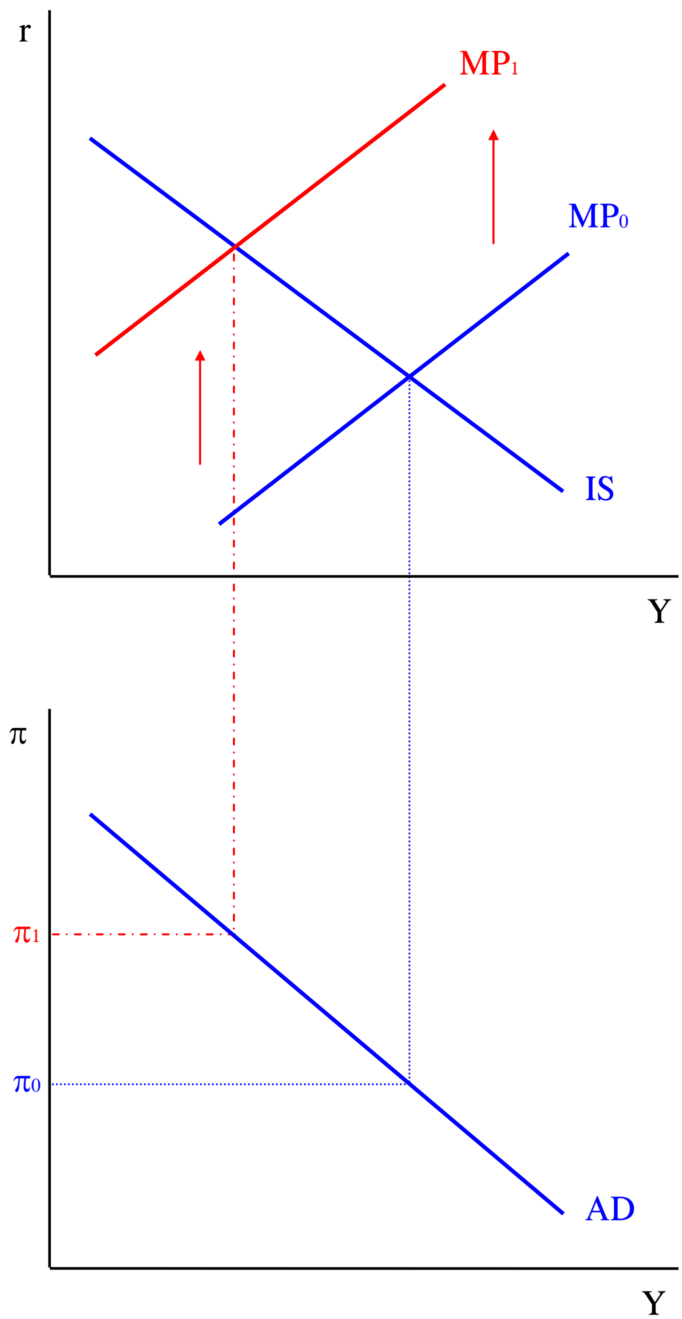

Figure III-2. The Aggregate Demand Curve

The AD and IA curves are shown together in Figure III-3. The curves determine output and inflation at a point in time. The AD curve tells us what output is given inflation, and the IA curve tells us what inflation is. Notice that we can use the AD-IA diagram both for a closed economy and for an open economy with floating exchange rates. In both cases, the AD curve is downward-sloping, and the IA curve is horizontal and moves up or down depending on whether output is above or below its natural rate.[3]

The Behavior of Output and Inflation over Time

The final step in our analysis is to describe how inflation and output change. To address this issue, we must bring in the rest of our assumption about aggregate supply: although inflation at a point in time is given, it rises if output is above its natural rate and falls if it is below. This is shown in Figure III-4, which adds a dashed vertical line at the natural rate of output to the AD-IA diagram. Output is determined by the intersection of the AD and IA curves (point A in the diagram). Thus to see if output is above or below its natural rate, we need to look at whether this intersection is to the right or the left of the $Y = \overline{Y}$ line. In the case shown, it is to the right; that is, output is above its natural rate. According to our assumption about aggregate supply, this means that inflation is rising. This is shown by the arrows above the IA line.[4]

As the IA line shifts up, inflation and output move along the AD curve. Thus inflation is

[3] The case of fixed exchange rates is slightly more complicated, because the central bank cannot set the real interest rate freely. But analyzing the long-run equilibrium of an open economy with fixed exchange rates is not very interesting. If the economy's reserve gain in the long run is zero, this means the long-run equilibrium is the same as it would be if the central bank were letting exchange rates float. And if the economy's long-run reserve gain is positive, this means that the central bank is accumulating reserves of foreign currencies indefinitely, which is rarely realistic. We will therefore devote little attention to the case of fixed exchange rates in this section.

[4] Throughout our analysis of the short run, we will neglect the fact that technological progress and increases in the labor force and the capital stock cause the natural rate of output to be rising over time. Thus we will keep the $\bar{Y}$ line fixed rather than showing it as shifting gradually to the right. Accounting for changes in $\bar{Y}$ makes the analysis more complicated without giving us important additional insights.

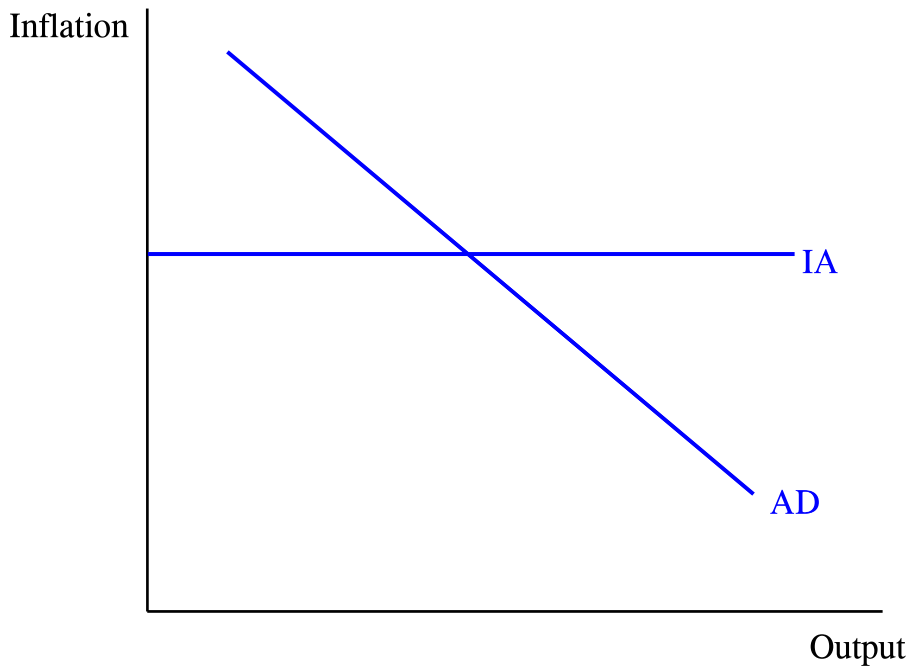

Figure III-3. The AD-IA Diagram

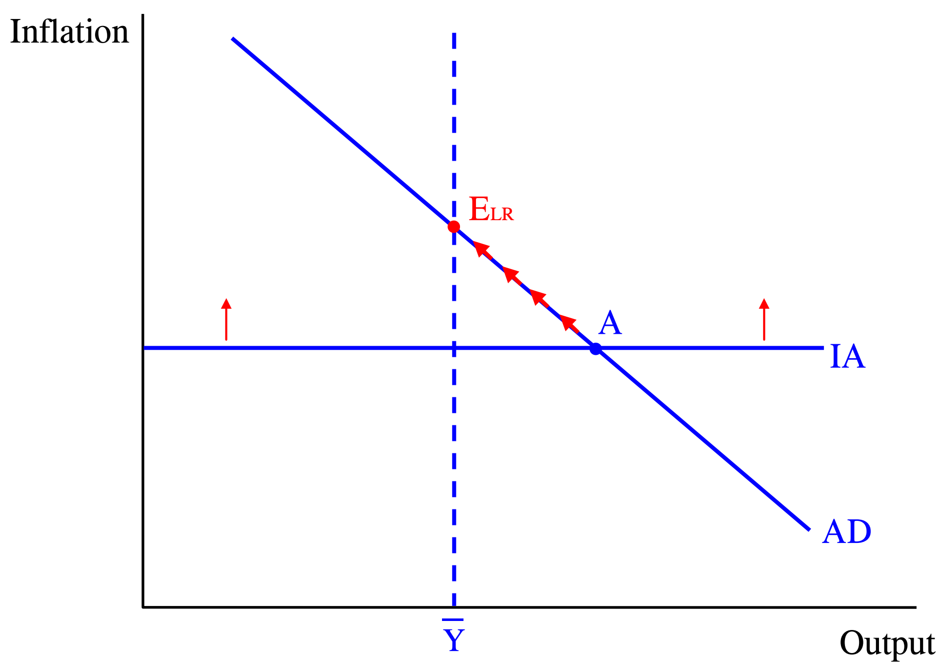

Figure III-4. Adjusting to Long-Run Equilibrium rising and output falling. This is shown by the arrows on the AD curve. In the background, the increases in inflation are causing the central bank to raise the real interest rate for a given level of output, and these changes in monetary policy are causing output to fall. These *shifts of* the MP curve in response to changes in inflation in the IS-MP diagram correspond to *movements along* the AD curve in the AD-IA diagram.

Since output was initially greater than its natural rate, it remains above even after it has fallen somewhat. Thus inflation continues to rise. The process continues until output reaches its natural rate. This is the point labeled E_{LR} (for long run) in the diagram. Once the economy reaches that point, our assumption about inflation implies that inflation remains steady. Thus, there is no further change in inflation or output until some type of disturbance occurs.

Figure III-5 shows the long-run equilibrium. The IA curve comes to rest at the point where it intersects the AD curve at $Y = \bar{Y}$. Since output is at its natural rate, inflation is steady – that is, the IA curve is no longer shifting.

Finally, one can use the IS-MP diagram to see what the real interest rate is at the long-run equilibrium. Output equals its natural rate. Thus the IS and MP curves must intersect at $Y = \bar{Y}$. This is shown in Figure III-6. As that diagram shows, the real interest rate in a long-run equilibrium is the value of r on the IS curve at $Y = \bar{Y}$. This is labeled r_{LR} in the diagram.

As one would expect, the level of the real interest rate in the long run implied by the analysis is the same as the level we would find if we just assumed that prices are flexible, and that output therefore equals its natural rate. Another way of thinking about the IS curve is that it shows, as a function of output, the real interest rate at which the market for loans is in equilibrium. That is, if we are considering a closed economy, the IS curve shows the real interest rate at which saving and investment are equal as a function of output. If we are considering an open economy with

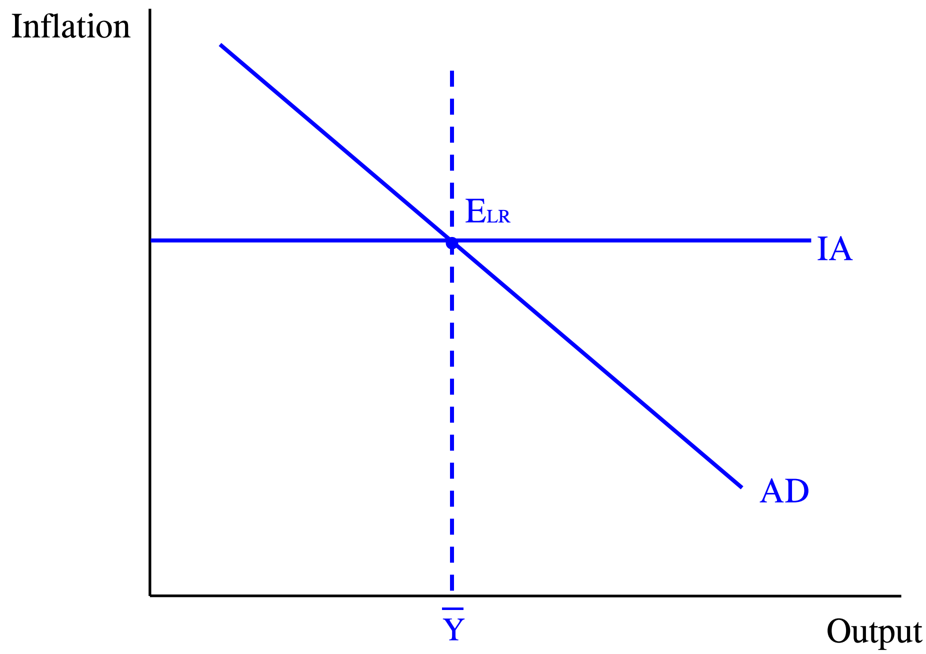

Figure III-5. Long-Run Equilibrium

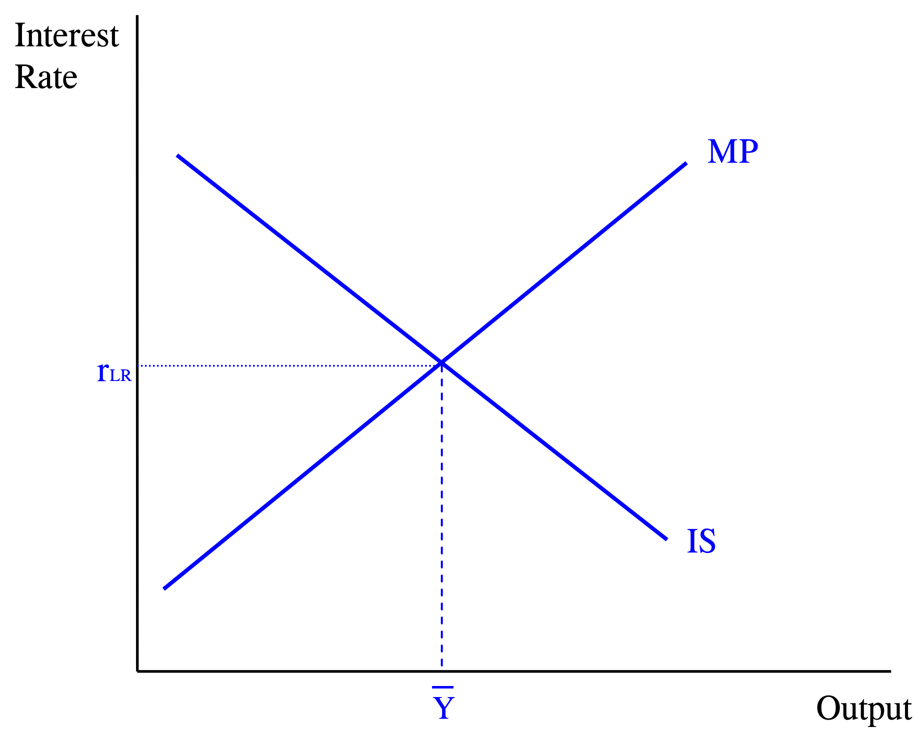

Figure III-6. The Real Interest Rate When the Economy is in Long-Run Equilibrium floating exchange rates, the curve shows, as a function of output, the real interest rate at which saving equals the sum of investment and the net capital outflow. Thus, the long-run real interest rate shown in Figure III-6 is simply the real interest rate that equilibrates the market for loans when output is at its natural rate.

III-2 Changes on the Aggregate Demand Side of the Economy

Now that we have developed our model, we can use it to understand how various developments affect the economy. This section considers changes involving aggregate demand. The next section considers changes involving aggregate supply.

Fiscal Policy

Our first example is the one we usually start with: an increase in government purchases. Specifically, consider a situation where the economy starts in a long-run equilibrium. That is, output equals its natural rate, and as a result inflation is steady at some level. There is then an increase in government purchases. Specifically, government purchases rise from their initial level to a higher level, and then remain at that higher level. Because this is our first example, we will work through it in detail.

We begin by considering the immediate effects of the increases – that is, the effects before inflation starts to change. To do this, we use the IS-MP model from Section I. The increase in government purchases shifts the IS curve to the right. The result, as Figure III-7 shows, is that output and the interest rate both rise.

The IS-MP diagram shows that at the initial level of inflation, output is higher than before.

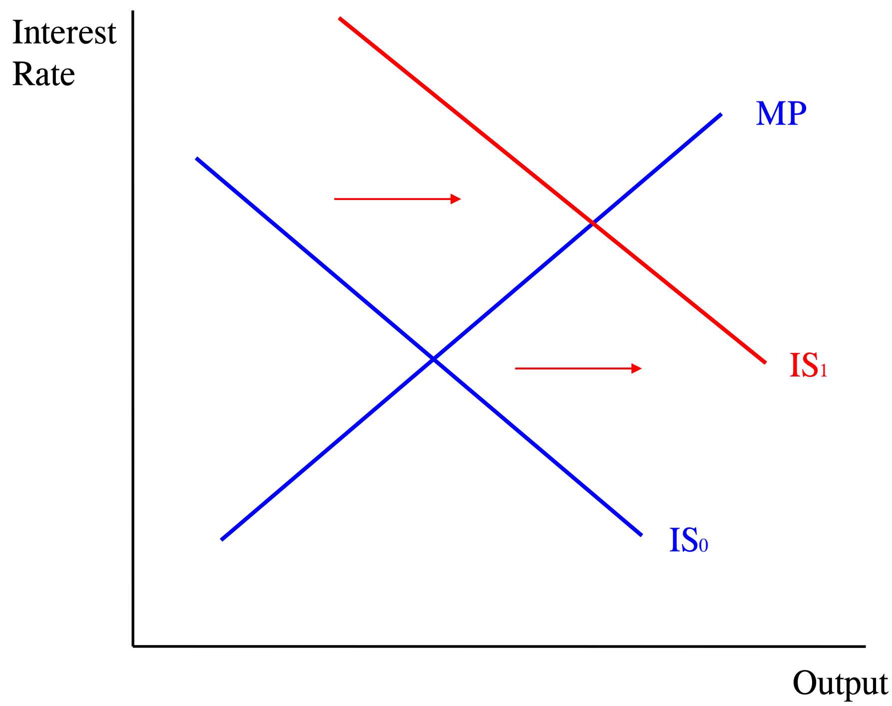

Figure III-7. The Immediate Effects of an Increase in Government Purchases

We could repeat this analysis for other inflation rates. Our choice of the inflation rate would affect where we drew the MP curve, because inflation affects the real interest rate the central bank sets for a given level of output. But each time, the increase in government purchases would shift the IS curve to the right, and so output would be higher at that inflation rate than before.

What this analysis is telling us is that the rise in government purchases shifts the AD curve to the right: at a given inflation rate, output is higher than before. This is shown together with the IA line in Figure III-8. The figure confirms what we already know from the IS-MP diagram and the fact that inflation does not respond immediately to economic developments: the immediate effect of the increase in government purchases is to raise output and leave inflation unchanged.

The importance of the AD-IA diagram is that it allows us to trace out the effects of the

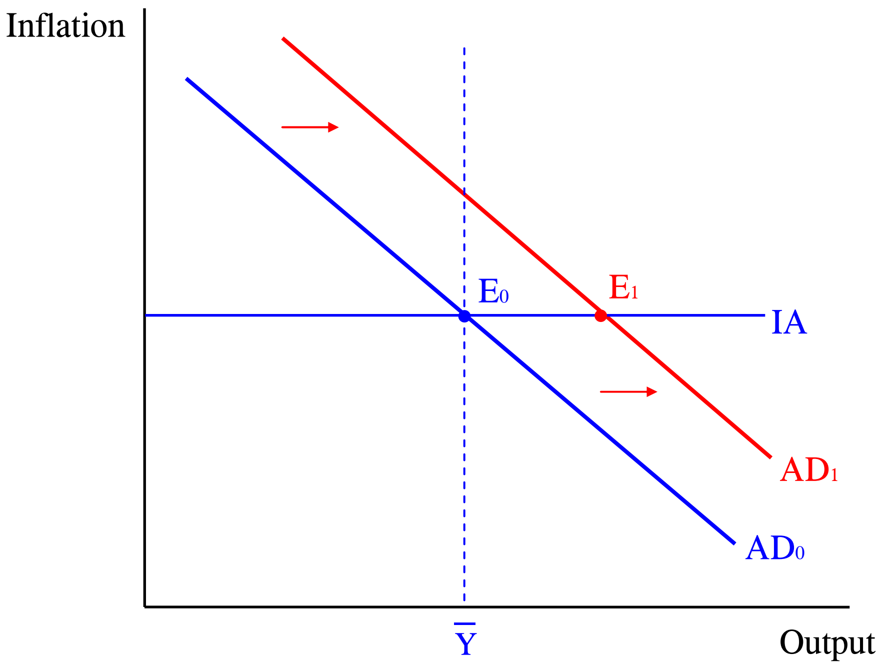

Figure III-8. The Immediate Effects of an Increase in Government Purchases in Terms of the AD-IA Diagram

increase in government purchases after its immediate impact. Since government purchases remain at their higher level, there are no additional shifts of the AD curve. But output is now above its natural rate. Thus inflation rises; that is, the IA curve begins to shift up. Output falls back toward the natural rate and inflation increases as the economy moves up along the AD curve. This process is depicted in Figure III-9.

The process continues until output returns to its natural rate; this is shown as point $\mathrm{E}^1_{\mathrm{LR}}$ in the figure. At that point, there are no further changes in inflation. Thus inflation is steady at a higher level than it began. That is, the IA curve stops moving when it intersects the new AD curve at $Y = \bar{Y}$ (point $\mathrm{E}^1_{\mathrm{LR}}$).

In the background, the increases in inflation are causing the central bank to raise the real interest rate at a given level of output. That is, the MP curve is shifting up. The economy moves up

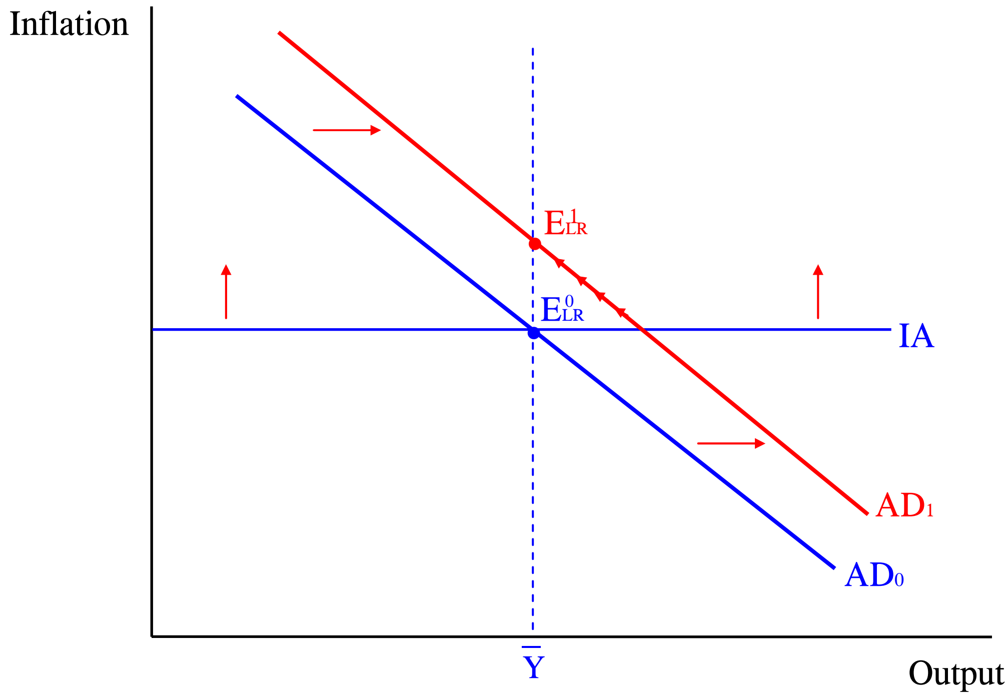

Figure III-9. The Effects of an Increase in Government Purchases over Time

along the downward-sloping IS curve, so the real interest rate rises and output falls. The process continues until output returns to its natural rate. Thus, the real interest rate increases immediately because of the increase in government purchases, and then rises gradually further as the economy is moves to its new long-run equilibrium because inflation rises.

Figure III-10 shows the positions of the IS and MP curves in the new long-run equilibrium. The IS curve is to the right of where it was initially because of the increase in government purchases. The MP curve is above where it was initially because of the rise in inflation. Thus the diagram also shows us that the increase in government purchases raises the real interest rate in the long run. This result is consistent with what you have already learned about the long-run effects of

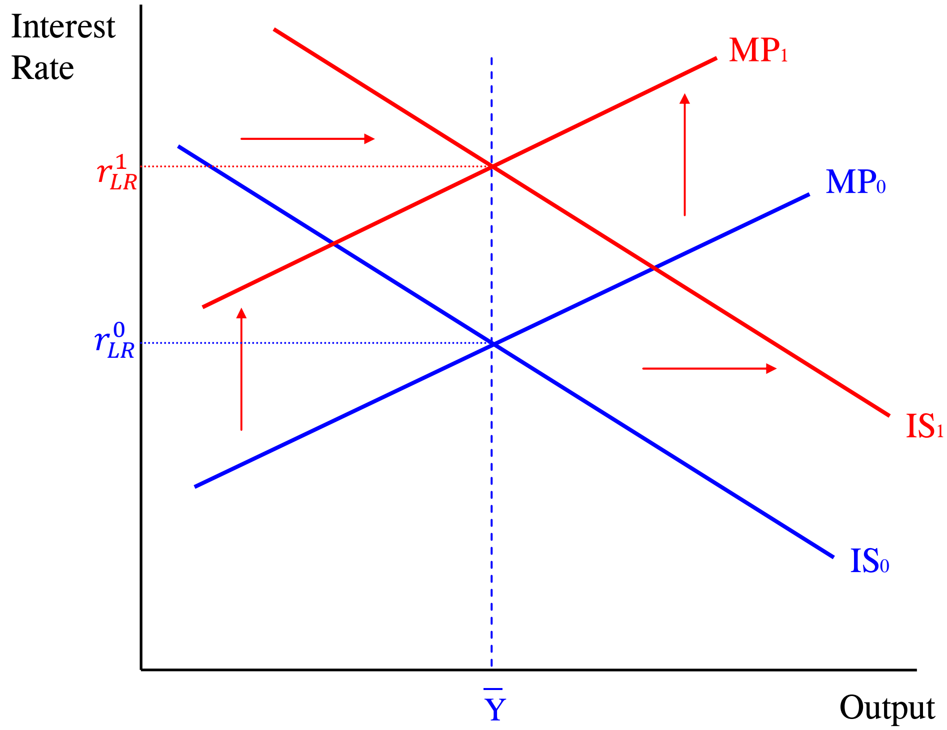

Figure III-10. The Long-Run Effects of an Increase in Government Purchases in Terms of the IS-MP Diagram

an increase in government purchases.[5]

We can also see how the increase in government purchases affects the different components of output. Consumption depends on disposable income, Y − T. Since the event we are considering does not involve any changes in taxes, the behavior of consumption is similar to the behavior of output. Consumption rises at the time of the increase in government purchases because of the increase in output, and then declines gradually back to its initial level as output returns to its natural rate.

Investment is determined by the real interest rate; the higher is the real interest rate, the lower is investment. Thus investment falls at the time of the increase in government purchases

[5] See Mankiw, Section 3-4.

(because of the initial rise in the interest rate), and then falls more as the economy adjusts to its new long-run equilibrium (because of the additional increases in the interest rate).

We can also find the behavior of net exports exchange rates if exchange rates are floating.[6] The key is to use the fact that net exports must equal the net capital outflow (see Section II-1). The net capital outflow is a decreasing function of the real interest rate. Thus the net capital outflow – and hence net exports – falls at the time of the increase in government purchases, and falls further as the economy moves to its new long-run equilibrium. In the background, the exchange rate is adjusting so that net exports equal the level of the net capital outflow determined by the real interest rate at each point in time. Thus the exchange rate appreciates at the time of the increase in government purchases, and increases more after that. If we wanted to, we could show all of this using a three-diagram figure like that in Figure II-3.

In practice, of course, the economy is never exactly in a long-run equilibrium when a change occurs, and there are always other developments as the economy is adjusting to the change. The reason for making the unrealistic assumption that the increase in government purchases is the only force influencing the economy is that it allows us to see the effects of the increase clearly. If the economy begins away from a long-run equilibrium or there are other shocks while the economy is adjusting to the increase in government purchases, the analysis we have done shows how an increase in purchases would cause the path of the economy to differ from what it would have been otherwise. Suppose, for example, that the rise in government purchases occurs when output is already above its natural rate. In the absence of the increase, inflation would have risen gradually and output would have returned gradually to its natural rate. In this case, the increase in government purchases causes output to rise farther above its natural rate and to take longer to

[6] As discussed above, for the most part we are not considering the case of fixed exchange rates in this section. See n. 3.

return to the natural rate than it would have otherwise, and causes inflation to rise by more than it would have otherwise. To avoid cluttering up the discussion with endless references to what would have happened otherwise, we focus on the case where the only development affecting the economy is the increase in government purchases.

Monetary Policy

The government's other major tool for influencing the macroeconomy in the short run is monetary policy. To see how monetary policy affects the economy, suppose there is a shift to a tighter monetary policy rule. That is, suppose the central bank changes its rule so that at a given level of output and inflation, it sets a higher real interest rate than before. Its reason for doing this might be to reduce inflation. Again, to see the effects of this development clearly, we assume that the economy is initially in a long-run equilibrium and that there are no additional disturbances while the economy is moving to its new long-run equilibrium.

As before, we use the IS-MP diagram to find the immediate effects of the change. At the initial inflation rate, the central bank is setting a higher interest rate at a given level of output than before. Thus the MP curve shifts up. The interest rate rises and output falls. This is shown in Figure III-11.

This analysis tells us that at a given level of inflation, output is lower than before. That is, the AD curve shifts to the left. Since output started at its natural rate, it is now below. Thus inflation starts to fall; that is, the IA line begins to shift down. Since the central bank makes no additional changes in its rule for setting the interest rate, the AD curve does not shift again. The economy moves down along the new AD curve, with output rising back towards its natural rate. As long as output is below $\overline{Y}$, inflation continues to fall. All of this is shown in Figure III-12. The

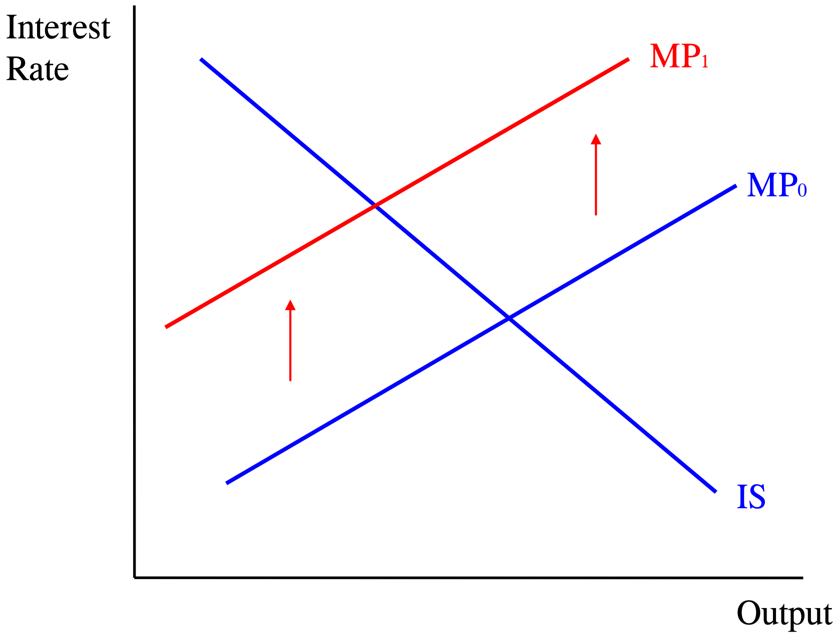

Figure III-11. The Immediate Effects of a Shift to Tighter Monetary Policy

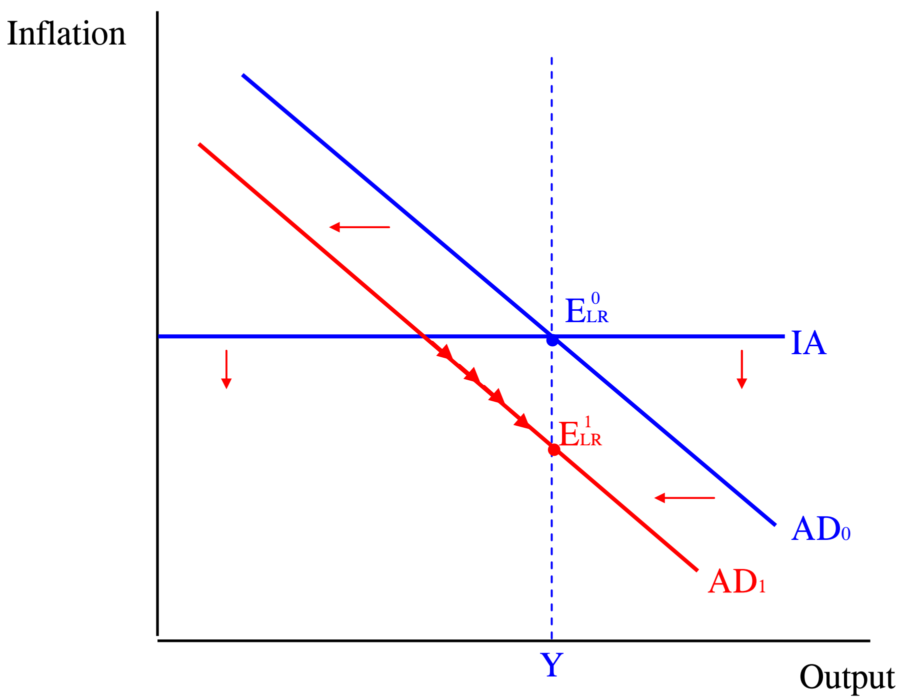

Figure III-12. The Effects of a Shift to Tighter Monetary Policy over Time economy comes to rest at point E^1_{LR}. Once it is there, inflation is steady at a lower level than it began. Thus the central bank has succeeded in reducing inflation – though at the cost of putting the economy through a period when output is below its natural rate.

We can again use IS-MP analysis to find the long-run effect of the change on the interest rate. The change in the monetary policy rule corresponded to an upward shift of the MP curve. This is shown as the move from MP_0 to MP_1 in Figure III-13. This change produced the *shift* of the AD curve. Then as inflation fell, the MP curve shifted down. These changes corresponded to the *movements along* the AD curve: the reason the AD curve slopes down is that when inflation is lower, the central bank sets a lower real interest rate at a given level of output. Throughout the process, there is no change in the IS curve. Thus when Y returns to $\overline{Y}$, the MP curve must be back in its original position. This is shown by the fact that MP_{LR} is in the same place as MP_0 in the diagram. It follows that in the new long-run equilibrium, the real interest rate is the same as it was before the change in policy.

Notice that the change in monetary policy does not affect any real variables in the long run. Output and the real interest rate both return to their initial values; only inflation changes permanently. This is consistent with what you have already learned: in the long run, monetary changes do not affect real variables (like output), only nominal ones (like inflation).[7]

There have been many actual episodes like this one. In the United States, the clearest example is the "Volcker disinflation" of the early 1980s. In October 1979, under the leadership of Paul Volcker, the Federal Reserve made a major shift to tighter monetary policy because it believed that inflation was much too high. The result was a period of very high interest rates, below-normal output, and high unemployment. The unemployment rate peaked at 10.8 percent at

[7] See Mankiw, Chapter 5.

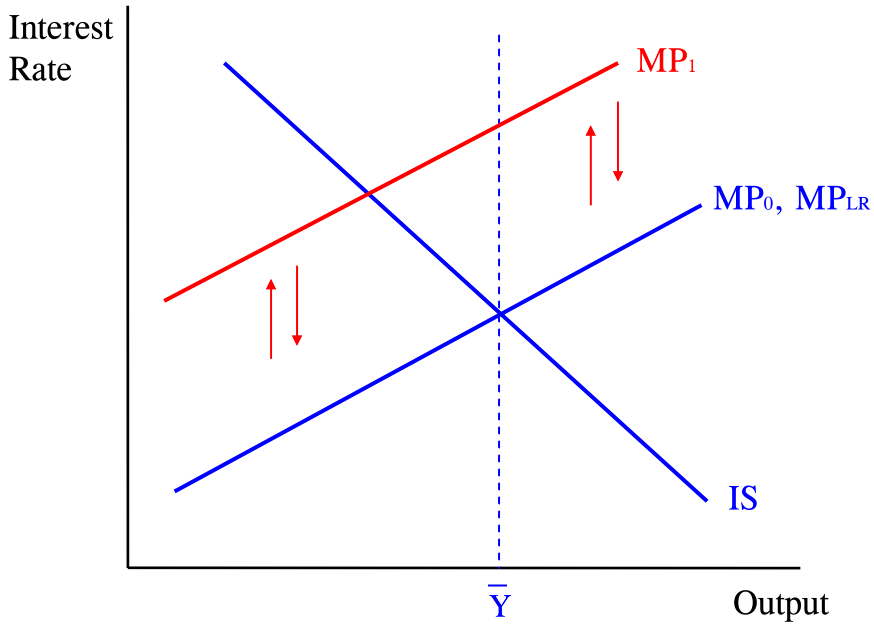

Figure III-13. The Long-Run Effects of a Shift to Tighter Monetary Policy in Terms of the IS-MP Diagram

the end of 1982. Inflation fell rapidly. As it fell, the Federal Reserve reduced the real interest rate. By 1986, output and unemployment had returned to roughly their natural rates, and inflation had fallen from almost 10 percent to below 4 percent.

Monetary Policy and Inflation in the Long Run

This analysis shows that monetary policy is a critical determinant of inflation in the long run. Suppose the central bank follows a fairly loose monetary policy rule – that is, a rule that sets a relatively low real interest rate when inflation is low or moderate unless output is well above its natural rate. With such a rule, monetary policy tends to push output above the natural rate when inflation is low or moderate. The result is that inflation rises, and thus that it is high in the long run. If the central bank follows a fairly tight policy rule, on the other hand, inflation is low in the long run.

We can be more specific about the relation between the central bank's rule and inflation in the long run. Monetary policy does not affect either output or the real interest rate in the long run. Output equals its natural rate, and the real interest rate equals the value that brings the loan market into equilibrium when output is at that level. The inflation rate in the long run is therefore the inflation rate that causes the central bank to set the real interest rate to the level that equilibrates the loan market when output equals its natural rate. In other words, the inflation rate in the long run is the rate that causes the MP curve to cross the IS curve at $Y = \bar{Y}$.

An example may clarify this point. Suppose the central bank's rule for the real interest rate is linear. Specifically, suppose the function $r = r(Y,\pi)$ takes the form

$$\boldsymbol{r = a + b\pi + c[Y - \bar{Y}].}$$

Here b is a parameter showing how the central bank responds to inflation: if inflation rises by a percentage point, the central bank raises the real interest rate by b percentage points. Similarly, c shows how it responds to departures of output from normal. If $Y - \bar{Y}$ rises by one unit, the central bank raises r by c percentage points. Both b and c are positive. Finally, a is the intercept term of this linear rule. It shows what real interest rate the central bank would set if inflation were zero and output equaled its natural rate.

Let r_{LR} denote the value of the real interest rate given by the IS curve when output equals its natural rate. We know that in the long run, $Y = \bar{Y}$ and $r = r_{LR}$. Thus if the central bank follows the rule given above, inflation in the long run, which we will call π_{LR}, is the solution to the equation

$$\boldsymbol{r_{LR} = a + b\pi_{LR} + c[0].}$$

Solving this equation for π_{LR} gives us

$$\boldsymbol{\pi_{LR} = \frac{r_{LR} - a}{b}}.$$

A higher value of a – which corresponds to a rule that sets a higher real interest rate at a given level of inflation and output – produces lower inflation in the long run. Likewise, suppose that $r_{LR} - a$ is positive; this is what is needed for inflation to be positive in the long run. Then a rule that responds more to increases in inflation (that is, that has a higher b) produces lower inflation in the long run. Finally, because output equals its natural rate in the long run, inflation is not affected in the long run by how the central bank responds to departures of output from its natural rate (that is, it is not affected by the parameter c).

Because of monetary policy's crucial role in determining inflation in the long run, most central banks today design their policies with a focus on their implications for inflation. In some countries, such as the United Kingdom and Canada, this is done through formal *inflation targeting*. The central bank begins by choosing a long-run goal for inflation. It then adjusts the real interest rate in response to output and inflation with that goal in mind.[8] Because many different interest rate policies produce the same level of inflation in the long run, inflation targeting takes many forms. The central bank can change the real interest rate more or less aggressively in response to departures of inflation from the target, and more or less aggressively in response to departures of output from its natural rate. In terms of our example of a linear rule, the level of inflation in the

[8] Of course this is not done by mechanically following a rule like those we have discussed. Instead the central bank adjusts the interest rate in response to economic developments in a way that is intended to keep inflation close to the long-run goal. One consequence is that policy is well described by a rule of the sort we have been discussing.

long run, π_{LR}, does not dictate the exact values the parameters a, b, and c must take. But by conducting policy with a focus on the level of inflation in the long run, over the last few decades central banks in many countries have succeeded in bringing inflation down to low levels and keeping it there.[9]

III-3 Changes on the Aggregate Supply Side of the Economy

Inflation Shocks and Supply Shocks

We now turn to the effects of changes in aggregate supply. There are two main types of changes: inflation shocks and supply shocks. Since the distinction between them is important, the first step is to define them:

An inflation shock is a disturbance to the usual behavior of inflation that shifts the inflation adjustment line. A supply shock is a change in the natural rate of output.

Let us consider each of these in turn. An inflation shock occurs when some development causes firms to set their prices in a way that differs from the usual pattern. Recall that normally the

[9] This analysis shows that the central bank's real interest rate rule is a crucial determinant of inflation in the long run. You learned earlier that the growth rate of the money stock is a crucial determinant of inflation in the long run (see Mankiw, Chapter 5). The way these two conclusions are related involves how the central bank controls the real interest rate. Recall from Section I-3 that it does this by adjusting the money supply. Thus when it sets the real interest rate, in the background it is choosing the money growth rate. Since the condition for equilibrium in the money market – $M/P = L(i,Y)$ – is the same here as in your earlier analysis of inflation in the long run, the same long-run relationship between money growth and inflation holds here as in your earlier analysis. For example, suppose the central bank is following a real interest rate rule that produces low inflation in the long run. To carry out such a rule, the central bank needs to keep money growth low. When inflation is low and output equals its natural rate, for example, high money growth would raise the supply of real money balances, and thus lower the real interest rate; this in turn would raise output above normal and hence cause inflation to start to rise. As in Section I-3, the details of how the central bank adjusts the money supply to carry out its rule are not important. The important point is simply that the earlier conclusions about money growth and inflation in the long run continue to hold.

rate at which firms raise their prices – that is, the inflation rate – rises when output is above its natural rate and falls when output is below its natural rate. An unfavorable inflation shock is an event that causes inflation to jump to a higher level; a favorable inflation shock is an event that causes it to jump to a lower level. The classic example of an inflation shock is an oil shock – a sudden change in oil prices. In the winter of 1973–1974 and again in 1979, the Organization of Petroleum Exporting Countries (OPEC) raised the price of oil dramatically. Since oil prices are a component of firms' costs, these increases caused firms to raise the prices of their products by more than before. That is, they caused inflation to jump to a higher level. In terms of our model, they caused an upward shift of the IA line. And these increases in inflation had nothing to do with the level of output; they were a result of the increases in oil prices.

To think about inflation shocks more systematically, it is helpful to list the ingredients that go into firms' choices of their prices:

○ The first ingredient is the wages that firms pay. All else equal, the higher are wages, the higher are firms' costs, and thus the higher are the prices they charge.

○ The second ingredient is labor costs other than wages. Employing workers involves not just the wages they are paid, but payroll taxes, fringe benefits like health insurance, and so on.

○ The third ingredient is the costs of inputs other than labor, such as oil, other raw materials, and goods purchased from other firms.

○ The fourth ingredient is productivity. When firms can produce more using a given amount of labor and a given quantity of other inputs, their costs are lower, and so (all else equal) their prices are lower.

○ The final ingredient is the relationship between prices and costs. In a perfectly competitive market, firms set their prices equal to their marginal costs. But actual markets are not perfectly competitive; prices usually exceed marginal costs. The greater is this gap, the higher are prices (again, all else equal).

This list of ingredients allows us to see what kinds of developments cause inflation shocks. An inflation shock can arise from any of these ingredients. For example, wages might rise unusually fast because of a change in labor laws that increases unions' bargaining power; this would cause an unfavorable inflation shock stemming from the first ingredient of firms' pricing decisions. Rises in the cost of health insurance are an important example of unfavorable inflation shocks involving the costs of hiring labor other than wages. Increases in oil prices are a type of unfavorable inflation shock involving the costs of inputs other than labor. And declines in productivity (which lead to higher costs) and increases in monopoly power (which increase the gap between prices and costs) are also potential sources of unfavorable inflation shocks.

Of course, inflation shocks can be favorable as well. In the United States, inflation failed to rise over the second half of the 1990s despite the fact that output was almost certainly well above its natural rate. The reason is that there were a series of favorable inflation shocks. The prices of oil and other raw materials plummeted. Rises in health insurance costs were less than the overall inflation rate. And increased competition from foreign firms appears to have reduced the average gap between firms' prices and their marginal costs.

It is also important to remember that not all changes in inflation are inflation shocks. If firms raise wages, and thus prices, more than before because unemployment is very low, this is the usual response of inflation to above-normal output, not an inflation shock. The same is true if firms find that their costs are high because they are operating close to maximum capacity.

Supply shocks are easier to describe that inflation shocks. A supply shock is a change in the natural rate of output, $\overline{Y}$. There are two sources of supply shocks. The first is changes in the inputs that would be available if the economy were operating at its natural rate. Two examples of this type of supply shock are a change in the labor force and a change in the natural rate of unemployment. Both of these changes affect the number of workers when the economy is operating at its normal level, and thus affect $\overline{Y}$. The second source of supply shocks is changes in output for a given level of inputs – that is, a change in productivity. Notice that this means that a change in productivity leads to both an inflation shock and a supply shock. That is, it both shifts the inflation adjustment line and alters the natural rate of output.

The Effects of an Inflation Shock

Now that we have described possible sources of disturbances on the supply side of the economy, we can analyze their effects. We begin with an unfavorable inflation shock. For concreteness, suppose that initially the economy is in a long-run equilibrium, and that there is a sudden rise in oil prices.

The immediate effects of this change are shown in Figure III-14. The inflation shock shifts the inflation adjustment line up. In terms of the figure, at the time of the shock the IA line shifts from IA_0 to IA_1. The economy moves up along the aggregate demand curve. Output falls and inflation rises – a combination that was dubbed "stagflation" in the 1970s. In the background, the central bank is raising the real interest rate in response to the rise in inflation.

Changes in oil prices have little impact on the economy's natural rate of output. Thus output is now below its natural rate. And since the event we are considering is a one-time rise in oil

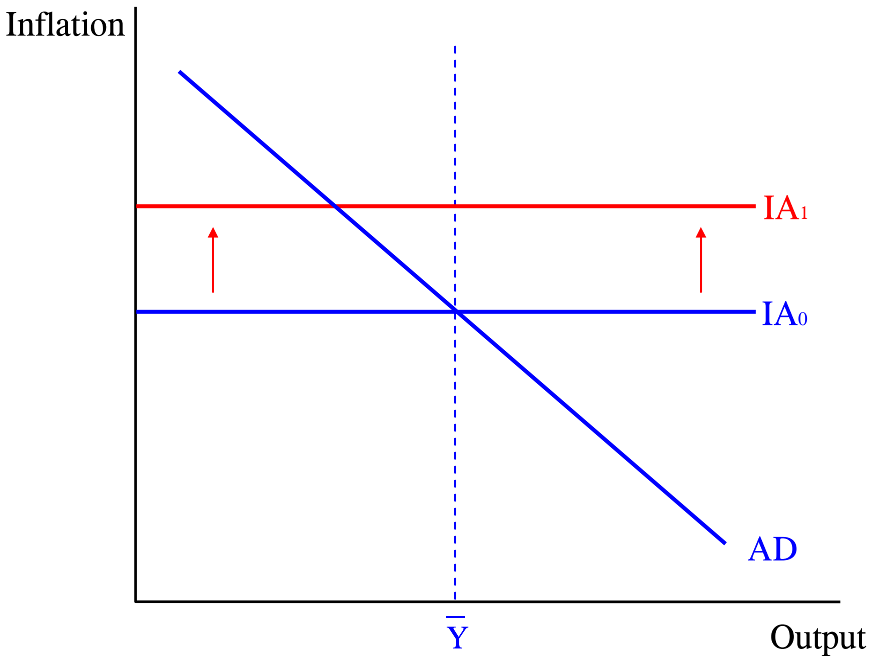

Figure III-14. The Immediate Effects of an Unfavorable Inflation Shock

prices, there are no further inflation shocks. Thus inflation begins to fall; that is, as Figure III-15 shows, the IA line begins to move down. Inflation falls and output rises. The process continues until output returns to its natural rate. When it does, inflation is back at its initial level. Thus, the unfavorable inflation shock causes a period of high inflation and below-normal output.

The Effects of a Supply Shock

Our second example is a fall in the natural rate of unemployment, $\bar{u}$. With a lower natural rate of unemployment, the economy's normal level of employment is higher, and so its natural rate of output is higher. Again, we assume that the economy begins in a long-run equilibrium.

The immediate effect of this development is a little surprising: neither output nor inflation change. In the absence of an inflation shock, inflation at a point in time is given. Thus inflation

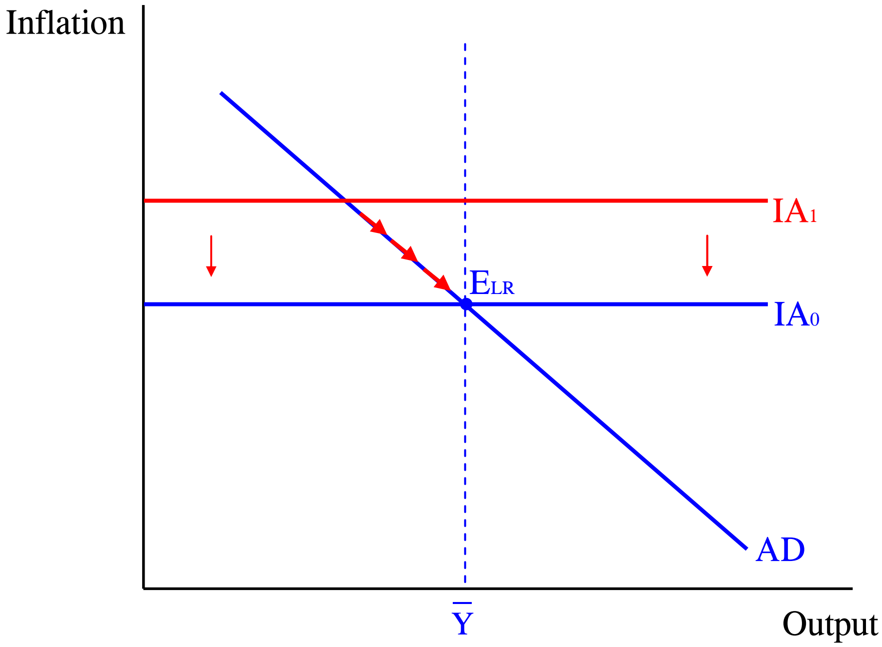

Figure III-15. The Effects of an Unfavorable Inflation Shock over Time

does not change immediately. And since neither the IS nor the MP curve is affected by the change, output does not change either.

Nonetheless, the fall in the natural rate of unemployment does matter. Because the natural rate of output is higher than before and actual output is unchanged, output is now below its natural rate. Thus inflation begins to fall. As it falls, output rises. This continues until output equals its new natural rate. At that point, inflation is steady at a lower level than it began, and there are no further changes in output. Figure III-16 summarizes this analysis. It shows the gradual downward shift of the IA line and the economy's movement down along the AD curve from its initial position (point E^0_{LR}) to the new long-run equilibrium (point E^1_{LR}).

A fall in the natural rate of unemployment appears to be another reason for the U.S. economy's excellent performance over the second half of the 1990s. In the early 1990s, the natural

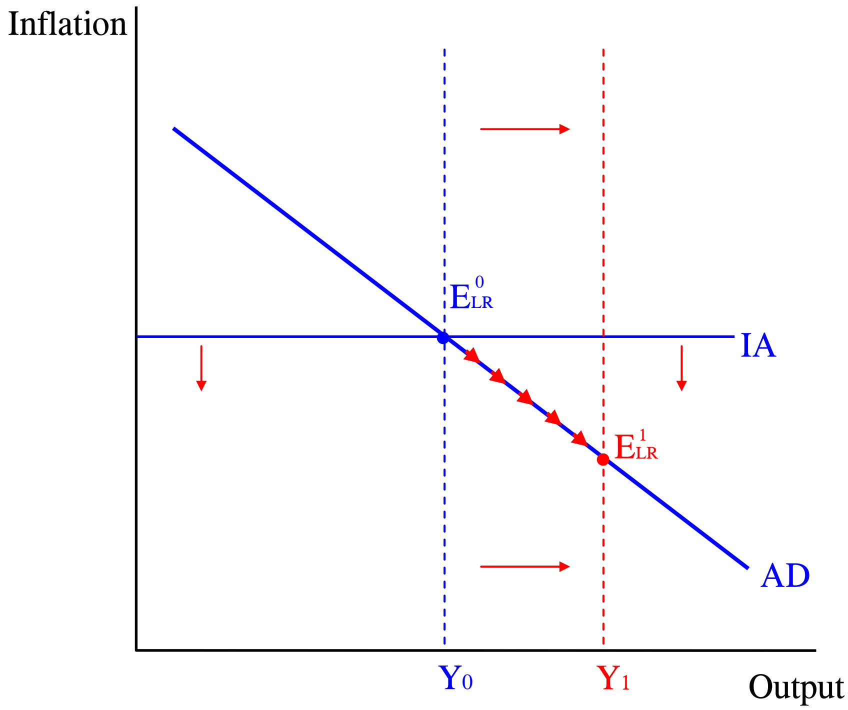

Figure III-16. The Effects of a Fall in the Natural Rate of Unemployment

rate of unemployment appears to have been slightly over six percent. But various developments, including changes in the demographic composition of the labor force, appear to have reduced it to around five percent. This decline in the natural rate was accompanied by rising output and falling inflation, just as our model predicts.

Inflation Expectations and Inflation Shocks

One possible source of inflation shocks that is somewhat different from the others we have considered. Think about a firm deciding what wage to pay for the coming year. One factor it will consider is the amount of inflation it expects during the year. If, for example, it expects a great deal of inflation, it will want to set a fairly high wage to make sure that it is paying an adequate amount at the end of year. And when the firm sets a higher wage, it will charge a higher price for its product. The same analysis applies to a firm and a union bargaining over what wage the firm will pay over the next few years, or to a firm deciding what price to charge for its product for the next year: the higher is expected inflation, the higher are the wages and prices that are set now. What this analysis is telling us is that changes in expected inflation cause inflation shocks: they cause a change in the behavior of prices that is not simply a response to whether output is above or below its natural rate.

One implication of this discussion is that the *credibility* of a policy to reduce inflation can have important effects on the costs of getting inflation down. Consider first a central bank with a poor record of fighting inflation and of carrying out its announced policies. Suppose this central bank announces that it is changing its policy rule to set a higher interest rate at a given level of output and inflation than it did before in order to bring inflation down. Given the bank's track record, firms and workers are not likely to expect it to stick with the new policy for long. Thus their expectations of inflation change little. If the bank then carries through with its plan, the resulting shift of the AD curve leads to a fall in output. The central bank succeeds in reducing inflation, but only at the cost of a recession. That is, the analysis we did in Section III-2 applies.

Now consider a central bank with a strong record of fighting inflation and of sticking with its announced policies. When this central bank announces a shift to a tighter rule, expected inflation is likely to fall. Thus the announcement of the policy change generates a favorable inflation shock. This development is analyzed in Figure III-17. The bank's policy shift causes a leftward shift of the AD curve, as before; this is shown as the shift from AD_0 to AD_1. But the favorable inflation shock shifts the IA curve; this is shown as the shift from IA_0 to IA_1. The result is an immediate fall in inflation and a smaller fall in output. In terms of the diagram, the immediate effect of the change is to move the economy from point E^0_{LR} to point A. In contrast, without

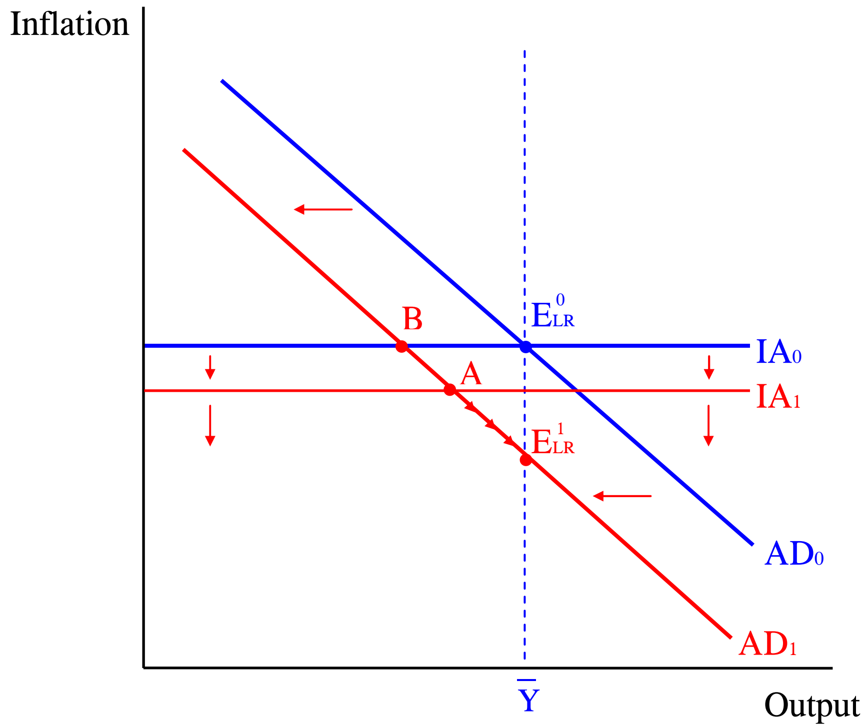

Figure III-17. The Effects of a Credible Shift to Tighter Monetary Policy

credibility there is no immediate effect on inflation, and so the economy moves to point B. After the initial move, the economy moves down the new AD curve to the new long-run equilibrium (point E^1_{LR}). Thus credibility reduces the cost of getting inflation down.

The importance of changes in expected inflation in causing inflation shocks is controversial. As a result, there is disagreement about how important credibility is to the costs of reducing inflation. One view is that expected inflation is a crucial determinant of the behavior of actual inflation. In this case, a fully credible policy can reduce inflation at almost no cost in terms of lost output: when a credible central bank announces its plan to bring inflation down, actual inflation drops almost immediately to the level it will attain in the new long-run equilibrium. The opposing view is that firms and workers rely mainly on past inflation and the current state of the economy in setting prices and wages. In this view, even a very credible policy change has little immediate impact on how prices and wages are set, and so our usual assumption that inflation falls only when output is below normal is still a good first approximation.[10]

Anchored Expectations

The United States entered into a prolonged period of below-normal output in 2008. As of this writing (January 2013), the unemployment rate has been over 7 percent for more than 4 years. Nonetheless, inflation has not fallen sharply. Excluding the effects of food and energy prices, which are volatile in the short run, it fell from around 2.5 percent in 2008 to between 1.5 and 2 percent in 2009 and has remained around that level.

From the perspective of our model, this behavior is puzzling. Output is far below its natural rate and there have been no evident large inflation shocks. Thus the model implies that inflation should have fallen greatly.

The leading candidate resolution of this puzzle is based on the importance of inflation expectations. In the quarter century before 2008, the Federal Reserve kept inflation low and stable. And by 2008, keeping inflation close to 2 percent was a central and highly visible focus of its policy. Thus when firms were setting wages and prices over the past few years, they likely expected that the Federal Reserve would conduct policy in a way that would bring inflation back to around 2 percent.

We saw above that inflation expectations affect price-setting and wage-setting – that is, that they affect actual inflation. Thus when output is less than its natural rate but inflation is below a target that the central bank is strongly and publicly committed to, there are two competing forces

[10] For some evidence on the merits of the two positions, see Thomas J. Sargent, "The Ends of Four Big Inflations," in Robert E. Hall, ed., *Inflation* (Chicago: University of Chicago Press, 1982), pp. 41–98; and Guy Debelle, "The Ends of Three Small Inflations: Australia, New Zealand, and Canada," *Canadian Public Policy* 22 (March 1996), pp. 56–78.

affecting inflation. On the one hand, the below-normal output makes firms want to raise wages and prices by less than before. This acts to push inflation down. On the other, the fact that firms expect that inflation will eventually rise makes them want to raise prices by more than before. This acts to push inflation up. The end result may be that inflation can stabilize at a level somewhat below the central bank's target, at least for a while.

It may be helpful to express these ideas mathematically. What we are saying is that the rate of change of inflation – that is, the rate at which inflation is rising or falling – depends on two factors: the departure of output from normal, and the departure of inflation from the central bank's target. We can express this as:

$$\textbf{Rate of change of inflation} = \boldsymbol{\lambda}[\boldsymbol{Y} - \overline{\boldsymbol{Y}}] + \boldsymbol{\theta}[\boldsymbol{\pi}^* - \boldsymbol{\pi}]. \tag{III-1}$$

Here π^* is the central bank's target level of inflation, and λ and θ are parameters that are positive. The two terms of this expression capture the two factors influencing inflation.

Suppose that for some reason, output is persistently below normal. For concreteness, suppose that $\mathrm{Y} - \overline{\mathrm{Y}}$ is constant at some level, which we will denote $[\mathrm{Y} - \overline{\mathrm{Y}}]_{\mathrm{STEADY}}$. Our assumption is that $[\mathrm{Y} - \overline{\mathrm{Y}}]_{\mathrm{STEADY}}$ is negative. Thus, this force will be tending to cause inflation to fall. For inflation to not fall, we need the other term of expression (III-1) to offset this influence; that is, we need $\theta[\pi^* - \pi]$ to be equal and opposite to $\lambda\,[\mathrm{Y} - \overline{\mathrm{Y}}]_{\mathrm{STEADY}}$. Let us denote the inflation rate that does this π_{STEADY}. That is, π_{STEADY} is the inflation rate for which

$$\boldsymbol{\lambda}[\boldsymbol{Y} - \overline{\boldsymbol{Y}}]_{\boldsymbol{STEADY}} + \boldsymbol{\theta}[\boldsymbol{\pi}^* - \boldsymbol{\pi}_{\boldsymbol{STEADY}}] = \boldsymbol{0}.$$

To find π_{STEADY}, first subtract $\lambda[Y-\overline{Y}]_{STEADY}$ from both sides, and then divide by θ. This gives us:

$$\pi^* - \pi_{STEADY} = -\frac{\lambda}{\theta}[Y-\overline{Y}]_{STEADY}.$$

Now multiply by –1 and add π* to both sides. The result is:

$$\pi_{STEADY} = \pi^* + \frac{\lambda}{\theta}[Y-\overline{Y}]_{STEADY}.$$

Since our assumption is that $[Y-\overline{Y}]_{STEADY}$ is negative (and that λ and θ are positive), π_{STEADY} is less than π*. That is, inflation stabilizes at a level below the central bank's target. That appears to be what happened in the United States in the past few years. A situation where beliefs about the central bank's inflation target influence actual inflation is known as one of *anchored expectations.*

It seems unlikely that such a situation can continue indefinitely, however. The reason that π* influences the behavior of inflation is that firms believe that the central bank will return inflation to π*. If output is persistently below normal and inflation is consistently less than π*, those beliefs are being repeatedly proven wrong. Thus at some point, firms would likely abandon those beliefs. When that happened, the usual dynamics of inflation would take over, and so the below-normal output would cause inflation to start to fall. An important question about the United States going forward from 2012 is how long output can remain less than its natural rate before that happens.

PROBLEMS

1. Describe how, if at all, each of the following developments affects the AD and/or IA curves:

a. Individuals become more optimistic about their future incomes, and therefore consume more out of a given amount of disposable income than before.

b. Exchange rates are floating, and American goods become more fashionable – that is, foreign demand for American goods at a given real exchange rate increases.

c. Anti-trust laws are relaxed, so firms charge higher prices for a given level of costs.

d. The demand for money increases (that is, consumers' preferences change so that at a given level of i and Y they want to hold more real balances than before).

e. Investment demand becomes less sensitive to changes in the interest rate.

f. Oil prices increase, and at the same time consumption for a given level of disposable income falls.

2. Suppose that output is initially at its natural rate, and that there is a tax cut. Describe how output, inflation, the real interest rate, consumption, and investment respond to the tax cut, both immediately and over time.

3. Consider the shift to a tighter monetary policy rule analyzed in Section III-2. What are the immediate effects of the shift on consumption and investment? How do consumption and investment behave as the economy is moving to its new long-run equilibrium?

4. Again consider the shift to a tighter monetary policy rule analyzed in Section III-2. Assume that exchange rates are floating.

a. What is the immediate effect of the shift to a tighter monetary policy rule on net exports and the exchange rate?

b. How do net exports and the exchange rate behave as the economy is moving toward its new long-run equilibrium?

5. Suppose that there is a technological disaster that makes workers less productive than before. Assume that initially output is at its natural rate.

a. How, if at all, does this affect the IA curve?

b. How, if at all, does this affect $\bar{Y}$?

c. In light of your answers to (a) and (b), what is the immediate effect of the disaster on output and the real interest rate?

d. Can you tell how the long-run effect of the disaster on output compares with the short-run effect? Explain.

6. Suppose the central bank, instead of following the rule $r = r(Y,\pi)$, has a target level of inflation. Specifically, it sets r according to $r = r_{LR} + b[\pi - \pi^*]$. Here r_{LR} is the real interest rate when the economy is in long-run equilibrium; that is, it is the real interest rate that causes the loan market to be in equilibrium when $Y = \bar{Y}$. In addition, π^* is the central bank's target level of inflation, and b is some positive parameter. This rule states that the central bank raises the real interest rate above its long-run level when inflation is above its target and lowers it below its

long-run level when inflation is below its target.

a. With this monetary policy rule, is the MP curve upward-sloping, flat, or downward-sloping? Explain.

b. Is the AD curve upward-sloping, flat, or downward-sloping? On the AD curve, what level of Y is associated with $\pi = \pi^*$? Explain.

c. Suppose some development raises r_{LR} but does not change $\bar{Y}$. How, if at all, does this affect the AD curve?

d. Assume the economy starts in a situation where $\pi = \pi^*$ and $Y = \bar{Y}$. Describe the immediate effects of each of the following developments on output, inflation, and the real interest rate:

i. Government purchases rise.
ii. There is an unfavorable inflation shock.
iii. The central bank reduces its inflation target, π^*.

7. Suppose that initially output equals its natural rate, and that inflation is therefore steady. Now suppose that there is a sudden loss of investor confidence in a country, so that there is a large increase in the net capital outflow at a given real interest rate. Further, suppose that, in addition to our usual assumptions, the real exchange rate matters for aggregate supply. Specifically, suppose that a rise in the real exchange rate (because it lowers the costs of firms that import some of their inputs) is a favorable inflation shock, and that a fall is an unfavorable shock. Finally, assume that exchange rates are floating.

a. How, if at all, does the loss of confidence affect the AD curve?
b. How, if at all, does the loss of confidence affect the IA line?

9. Multiple choice: Our baseline assumption about the behavior of inflation is:
a. When output is above normal, inflation is rising.
b. When output is rising, inflation is rising.
c. When output is above normal, inflation is positive.
d. When output is rising, inflation is positive.

10. Multiple choice: When the economy is in long-run equilibrium:
a. Output is equal to potential output.
b. Inflation is steady.
c. The real interest rate is given by the point on the IS curve where $Y = \bar{Y}$.
d. (a) and (b) only.
e. All of the above.

IV The Liquidity Trap

The central bank's ability to control the real interest rate plays a critical role in the model of Section III. Actions by the central bank to raise the real interest rate when output is above its natural rate restrain demand, and so bring output back in line with its normal capacity. As a result, inflation does not rise to higher and higher levels. Likewise, moves by the central bank to stimulate the economy by cutting the real interest rate when output is below normal prevent the economy from spiraling off to depression and deflation.

We saw in Section I-3 that the usual way the central bank affects the real interest rate is by changing the money supply. We also saw that the most straightforward channel through which changes in the money supply affect the real interest rate is by changing the nominal interest rate. An increase in the money supply generally leads to a lower nominal rate. And since monetary expansion does not lower expected inflation, the real interest rate falls as well.

But the nominal interest rate cannot be negative. Thus if the nominal rate is zero, the first and most direct step in the process through which increases in the money supply lower the real interest rate is gone. Such a situation is known as a *liquidity trap*.

The liquidity trap was long thought to be an unusual possibility that was important mainly for understanding the Great Depression. But nominal interest rates have been close to zero in Japan since the late 1990s. And, crucially, from late 2008 to the present writing (January 2013), they have been close to zero in many of the world's advanced economies – including the United States, the United Kingdom, and the Euro area, as well as Japan. Thus the liquidity trap is no longer a historical curiosity. As we will see, it raises complicated issues and is essential to understanding the prolonged and severe slump we are currently experiencing.

IV-1 A Model of the Liquidity Trap

The Zero Lower Bound on Nominal Interest Rates

Think about what would happen if every bank was offering a nominal interest rate on deposits of negative 5 percent. If you deposited $1000 and left it untouched, at the end of the year, your balance would be $950. Since no bank was offering a higher return, would you go ahead and make the deposit? The answer is almost surely no, because you have a way of earning a zero nominal return for sure: instead of making the deposit, you could hold onto your assets in the form of currency. A year from now, the nominal value (that is, the value measured in dollars) of a thousand dollars of currency will still be a thousand dollars. Thus you would not make the deposit. It follows that the prevailing nominal interest rate cannot be negative 5 percent.

This discussion suggests that, realistically, nominal interest rates could be *slightly* negative: you might be willing to accept a small negative return to avoid the costs of keeping your currency holdings safe (such as buying a safe or renting a safety deposit box) and for the convenience of easy access to your assets. The key implication of this discussion, however, is that there is *some* lower bound on the nominal interest rate.

To analyze the consequences of this lower bound, it is easiest to model the lower bound as being at exactly zero. Making the more realistic assumption that it is a small negative number would complicate the analysis without generating any important additional insights.

Thus, we have a key assumption:

The nominal interest rate cannot be negative.

The zero lower bound on the nominal interest rate affects the behavior of the real interest rate. Recall that our baseline assumption is that the central bank sets the real interest rate as an increasing function of output and inflation: $r = r(Y,\pi)$. By definition, the real interest rate is the nominal rate minus expected inflation: $r = i - \pi^e$. Since the nominal rate cannot be negative, it follows that the real rate cannot be less than $0 - \pi^e$. If the central bank wants to set the real interest rate below this level, it will not be able to. In short, the zero lower bound on the nominal interest rate may prevent the central bank from setting the real interest rate at the level it desires.

It is natural to assume that if the central bank's desired real interest rate is below the lowest possible level, the central bank will make the real rate as low as it can. That is, we assume that if the central bank's real interest rate rule calls for a negative nominal interest rate, it will set the nominal rate to zero.

Thus we have:

If the central bank is able to set the real interest rate according to its rule, $r = r(Y, \pi)$, it will do so. But if achieving the desired real interest rate would require a negative nominal interest rate, it will set the nominal interest rate to zero, and so set the real interest rate to $0 - \pi^e$.

We can express this mathematically as:

$$\mathbf{r} = \begin{cases} \mathbf{r(Y,\pi)} & \text{if } \mathbf{r(Y,\pi) + \pi^e \geq 0} \\ \mathbf{0 - \pi^e} & \text{otherwise.} \end{cases}$$

The Behavior of Expected Inflation

This discussion implies that when monetary policy is constrained by the zero lower bound, the real interest rate is determined by expected inflation. Thus we need to consider the determination of expected inflation.

One factor that is likely to have a large effect on expected inflation is actual inflation. Our basic assumption about actual inflation is that it is fixed at a point in time, and that it rises, falls, or holds steady over time depending on whether output is above, below, or equal to its natural rate. Thus at any point in time, the current inflation rate is a major determinant of inflation in the near future. Our starting point in analyzing expected inflation is therefore to assume that it depends on actual inflation:

> *When inflation is higher, expected inflation is higher. When it is lower, expected inflation is lower.*

We can express this assumption in the form of an equation:

$$\pi^e = \pi^e(\pi).$$

$\pi^e(\pi)$ is an increasing function.

The MP Curve in the Presence of the Zero Lower Bound

We are now in a position to analyze the effects of the zero lower bound. Since the bound affects the central bank's control of the real interest rate, the place it will enter the model is the MP curve, and from there the AD curve. Thus we will start by considering the MP curve.

The effect of the zero lower bound is shown in Figure IV-1. Recall that the MP curve is drawn for a given inflation rate. The dashed line in the figure shows the real interest rate the central bank would like to set at the given inflation rate as a function of output. It has its usual upward-sloping form. The zero lower bound, however, means that there is a lower limit to the real interest rate at the given inflation rate: because the nominal interest rate cannot be negative, the real rate cannot be less than $0 - \pi^e$. Given our assumption about expected inflation, this means that it cannot be less than $0 - \pi^e(\pi)$. This lower limit is shown by the dotted line in the figure.

When the real rate the central bank would like to set is above $0 - \pi^e(\pi)$, the zero lower bound causes no problems. In this case the central bank sets the real rate to the desired level. Thus for higher values of Y, the real interest rate is given by the point on the dashed line. But when the central bank's desired real rate would require a negative nominal rate, it cannot do this, and so it sets the nominal rate to zero. Thus for lower values of Y, the real interest rate is given by the point on the dotted line. The information is summarized in Figure IV-2. It shows that the zero lower bound makes the MP curve flat for low values of Y, then upward-sloping as usual.

Notice the strong resemblance between the MP curve here and the $\widetilde{\text{MP}}$ curve in the model of fixed exchange rates in Section II-4. Both curves are first flat, then upward-sloping. And in both cases, the reason is that there is a lower bound on the real interest rate. Here, it comes from the fact the nominal interest rate cannot be negative and expected inflation is given; in Section II-4, it comes from the fact that too low a real interest rate would cause reserve losses for the central bank, and so make maintaining the fixed exchange rate impossible.

There is, however, a crucial difference between the two cases. Under fixed exchange rates,

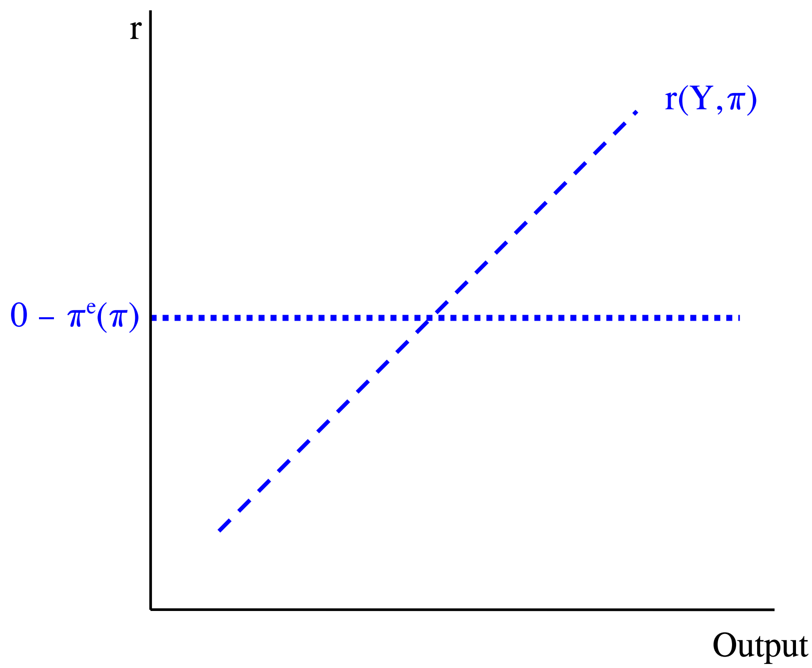

Figure IV-1. The Derivation of the MP Curve in the Presence of the Zero Lower Bound

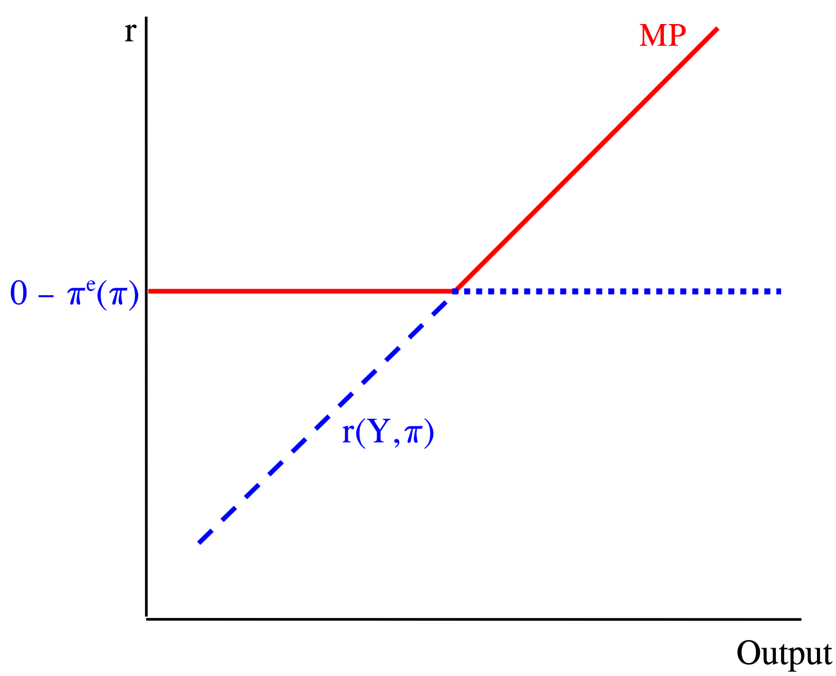

Figure IV-2. The MP Curve in the Presence of the Zero Lower Bound the central bank can eliminate the lower bound on the real interest rate by abandoning its exchange rate peg. But the central bank cannot eliminate the lower bound on the nominal interest rate. As a result, the zero lower bound raises much more challenging issues.

The AD Curve in the Presence of the Zero Lower Bound

The AD curve comes from considering the IS and MP curves for different inflation rates. Specifically, it shows the level of Y at the intersection of the IS and MP curves as a function of the inflation rate. Thus to figure out how the zero lower bound on the nominal interest rate affects the AD curve, we need to bring in the IS curve and consider different inflation rates.

The zero lower bound affects how the real interest rate is determined, but it does not affect the demand for goods at a given real rate. Thus it does not affect the IS curve, and so that curve retains its usual downward-sloping form.

Suppose that the first inflation rate we consider, which we will call π_0, implies that the IS and MP curves intersect in the upward-sloping part of the MP curve. This is shown in the upper panel of Figure IV-3. We denote the MP curve corresponding to this inflation rate by MP(π_0). (The IS curve, in contrast, is unaffected by inflation, and so does not need a special label.) The intersection of the IS and MP curves determines output at the assumed inflation rate, which we will call Y_0. The fact that output equals Y_0 when $\pi = \pi_0$ is shown in the bottom panel of the figure.

Now consider what happens with a slightly lower inflation rate, π_1. This affects the IS-MP diagram via the MP curve. To see how, consider each part of the MP curve separately. The lower inflation rate means, as usual, that the real interest rate the central bank *wants* to set at a given level when inflation is lower than before. Thus the upward-sloping portion of the MP curve shifts down. But, expected inflation is lower – and so $0 - \pi^e(\pi)$ is higher. Thus the lowest possible interest rate

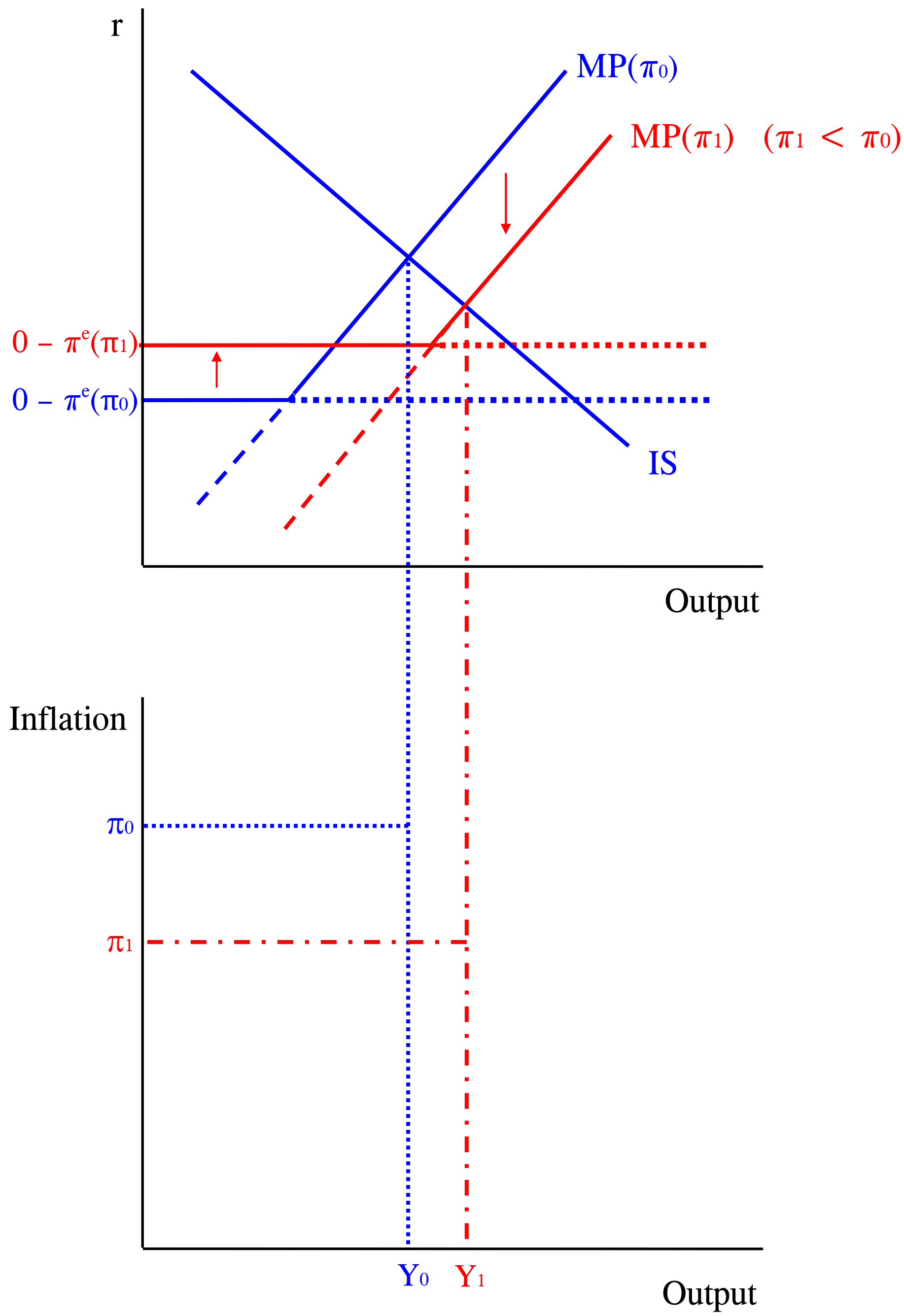

Figure IV-3. The Derivation of the AD Curve in the Presence of the Zero Lower Bound rises, and so the flat portion of the MP curve shifts up. Intuitively, when inflation is lower, the real interest rate corresponding to a zero nominal rate is less negative – that is, it is higher.

The MP curve corresponding to an inflation rate of π_1 is shown as MP(π_1) in Figure IV-3. MP(π_1) and the IS curve (which is unaffected by inflation) intersect on the upward-sloping portion of the MP curve. The resulting level of output, Y_1, is greater than Y_0. All of this is shown in the figure.

As the level of inflation we consider falls, the upward-sloping part of the MP curve continues to shift down and the flat part continues to shift up. Eventually we reach an inflation rate, which we call π_2, such that the IS and MP curve meet at the kink of the MP curve. This is shown in Figure IV-4. The corresponding level of output is Y_2. For all inflation rates above π_2, the zero lower bound does not prevent the central bank from doing what it wants, and so we have the conventional downward-sloping relationship between inflation and output. This is shown in the bottom panel of Figure IV-4.

But now consider an inflation rate that is less than π_2, which we will call π_3. Figure IV-5 shows what happens. Again, the lower level of inflation means that the upward-sloping part of the MP curve shifts down and the flat part shifts up. But now this means that the IS and MP curves intersect on the flat part of the MP curve. As a result, output when inflation is π_3 is less than when inflation is π_2. This is shown in the bottom panel of the figure. It shows that once the inflation rate we consider falls below π_2, the AD curve slopes up. And if we considered an inflation rate less than π_3, the flat portion of the MP curve would be even higher, and so output at the intersection of the IS and MP curves would be even lower.

Figure IV-6 summarizes what we have found about the AD curve when we account for the fact that the nominal interest rate cannot be negative. For higher levels of inflation, it has its usual

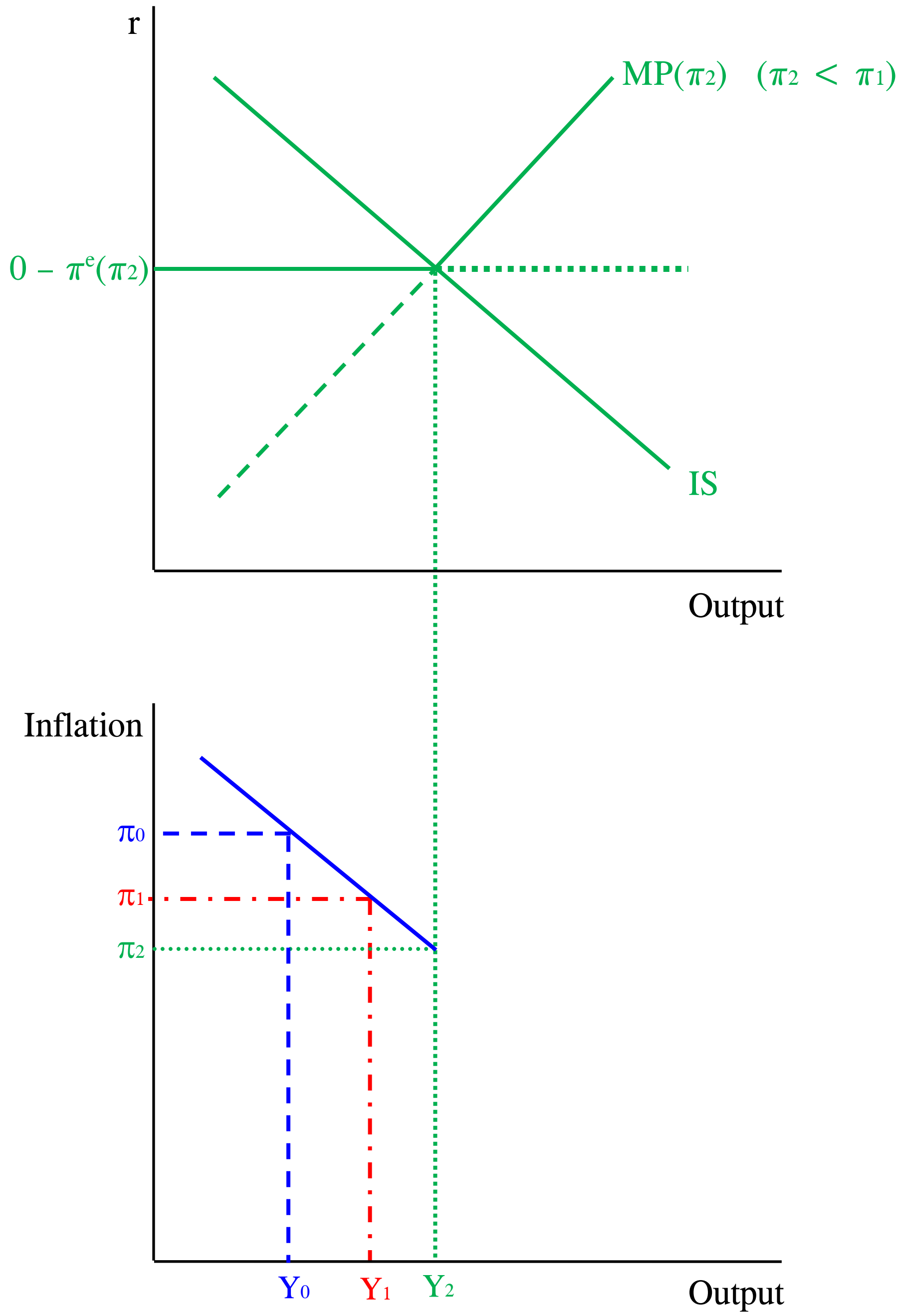

Figure IV-4. The Derivation of the AD Curve in the Presence of the Zero Lower Bound (Continued)

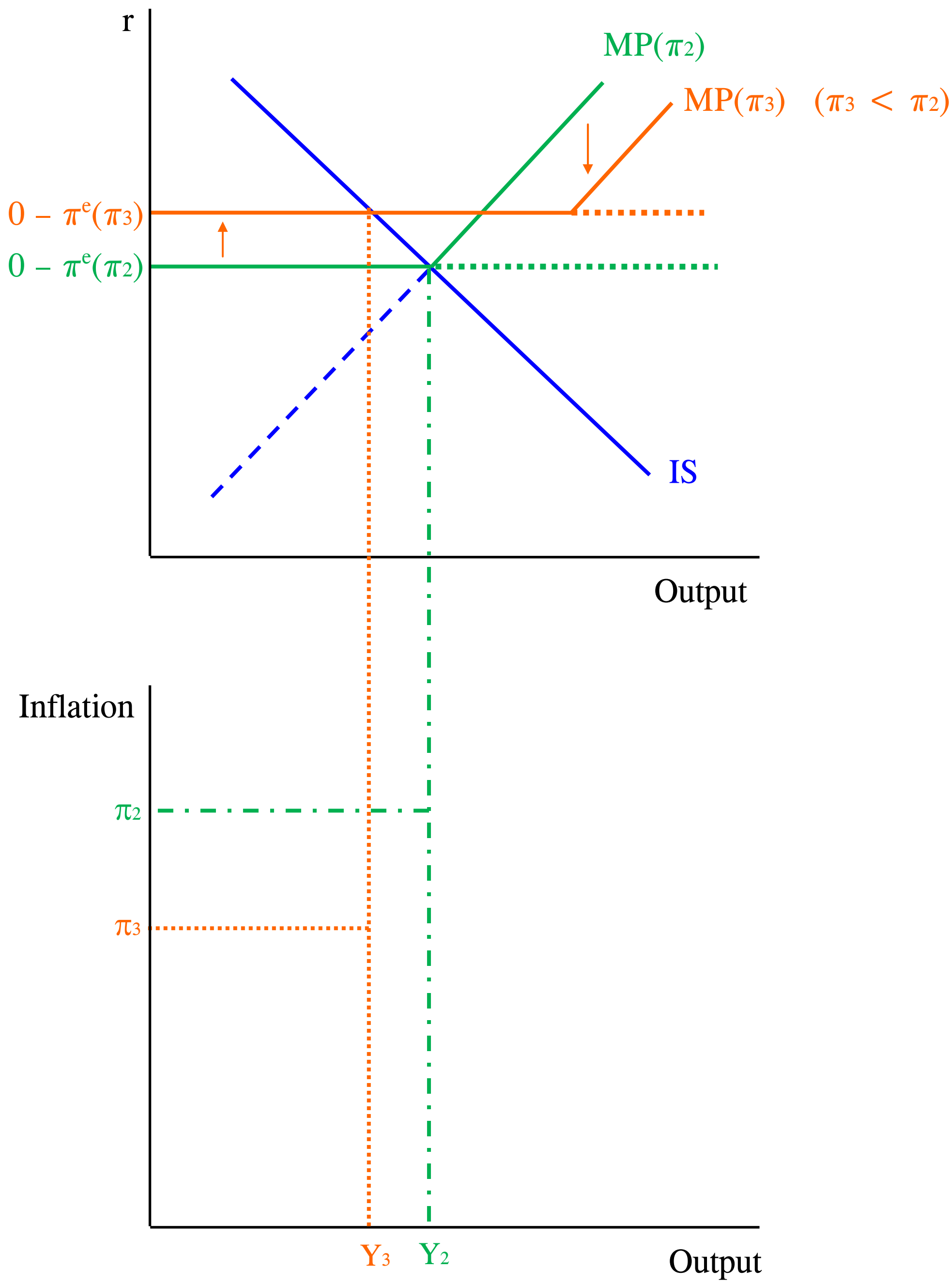

Figure IV-5. The Derivation of the AD Curve in the Presence of the Zero Lower Bound (Concluded)

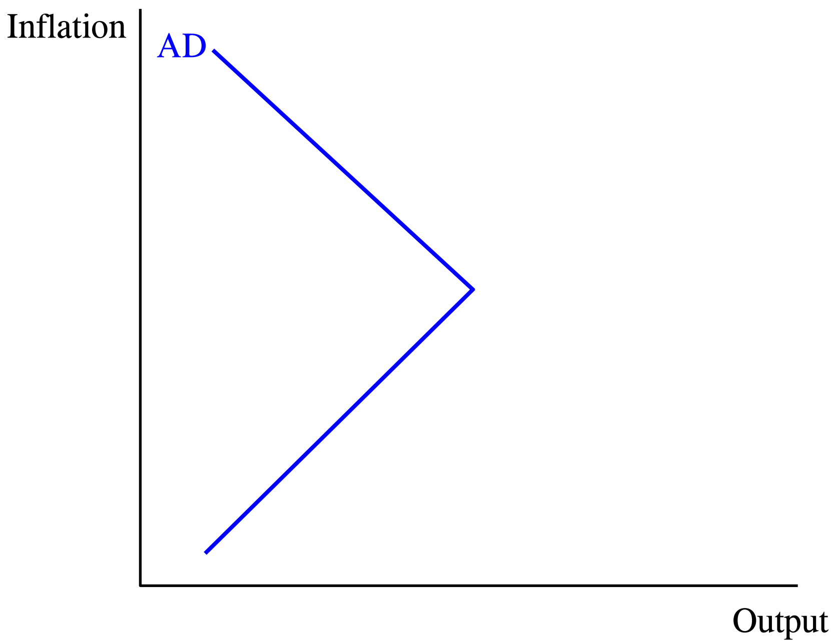

Figure IV-6. The AD Curve in the Presence of the Zero Lower Bound

downward-sloping form. But at some level of inflation, it turns and becomes upward-sloping. Intuitively, as long as inflation is not too low, the real interest rate is determined by the central bank's usual rule for its desired interest rate, and so the real interest rate falls when inflation falls. But when inflation is sufficiently low, the zero lower bound prevents the central bank from following its rule. Instead, it sets the real interest rate at the lowest level it can, which is minus the expected rate of inflation. As a result, a fall in the inflation rate (which lowers expected inflation, and so raises minus the expected rate of inflation) forces the central bank to raise the real interest rate, and thus to reduce demand.

Aggregate Supply

The zero lower bound affects how the central bank conducts monetary policy, and so it affects the aggregate demand side of the economy. But it does not affect aggregate supply. Thus the behavior of inflation and of the IA curve is the same as before: inflation at a point in time is given, and it rises, falls, or stays the same over time depending on whether output is above, below, or equal to its natural rate.

IV-2 The Effects of a Large, Long-Lasting Fall in Aggregate Demand

We are now ready to put our model to work. We will focus on an example that is essential to understanding the economic downturns of the Great Depression, Japan in the 1990s and 2000s, and many countries in the past few years.

Suppose that initially the economy is in a conventional long-run equilibrium. Output is equal to its natural rate, and so inflation is steady. And, by assumption, at that combination of output and inflation the zero lower bound is not a binding constraint. This situation is shown in Figure IV-7. The fact that the initial situation is conventional implies that the economy is on the upward-sloping part of the MP curve and the downward-sloping part of the AD curve.

Notice that the diagram shows the flat portions of the MP curve and the upward-sloping portion of the AD curve. Since the zero lower bound always exists (even when it is not constraining monetary policy), those portions of the curves always exist. For most issues we are interested in (such as those that we discussed in Sections I through III), however, we are not concerned about the effects of the zero lower bound, and so for simplicity we do not show those parts of the curves. But here we want to know how the zero lower bound will affect the economy, and so we show those portions of the curves from the outset

In this situation, suppose there is a large leftward shift of the IS curve – so large that it now

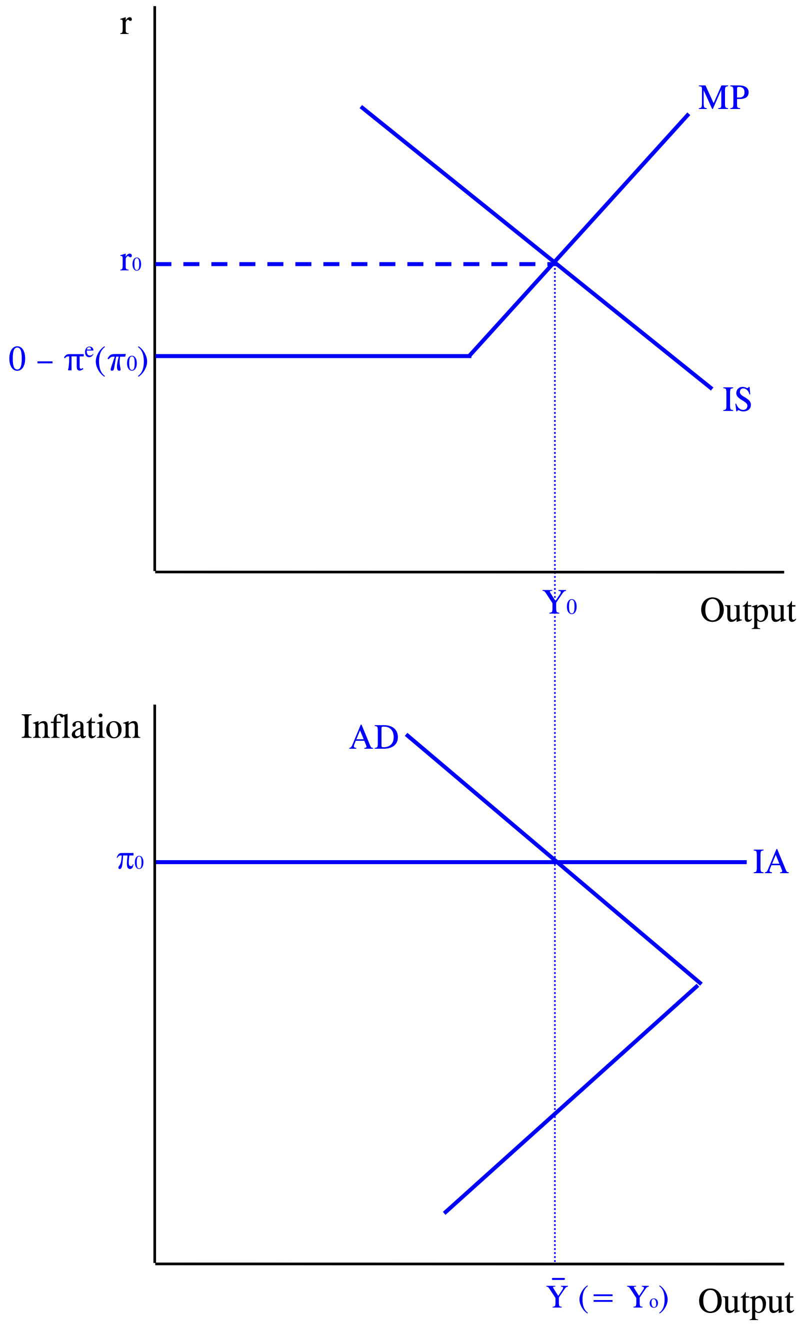

Figure IV-7. A Conventional Long-Run Equilibrium in the Presence of the Zero Lower Bound intersects the MP curve in its flat portion. In the United States, such a shift occurred as a result of a series of events over the course of 2007 and 2008. A sharp fall in house prices put large strains on financial institutions that had invested heavily in mortgage-backed securities and other housing-related assets, culminating in the bankruptcy of Lehman Brothers in September 2008. The resulting disruptions of credit markets, loss of credit availability, and the collapses of confidence led to very large falls in consumption at a given level of disposable income and in investment at a given level of the real interest rate – that is, to a very large leftward shift of the IS curve. By December, the Federal Reserve had cut its target for the nominal interest rate to essentially zero, where it remains four years later.

For reasons that will become clear, we will focus on the case where the shift of the IS curve lasts for a substantial time but is not permanent. That is, we will assume that at some point the curve shifts back to the right by a substantial amount (the specifics of which we will discuss below).

The Short Run

Figure IV-8 shows the short-run effects of the large shift of the IS curve. The top part of the diagram shows two things. First, output at the initial inflation rate is lower than before; and second, for that inflation rate, the two curves now intersect in the flat part of the MP curve.

If we considered other inflation rates, we would find that at each rate, the leftward shift of the IS curve leads to lower output at that inflation rate. We would also find that if we considered high enough inflation rates, $0 - \pi^e$ was sufficiently low, and the central bank's desired real interest rate for a given level of output was sufficiently high, that the new IS curve crossed the MP curve in its upward-sloping position.

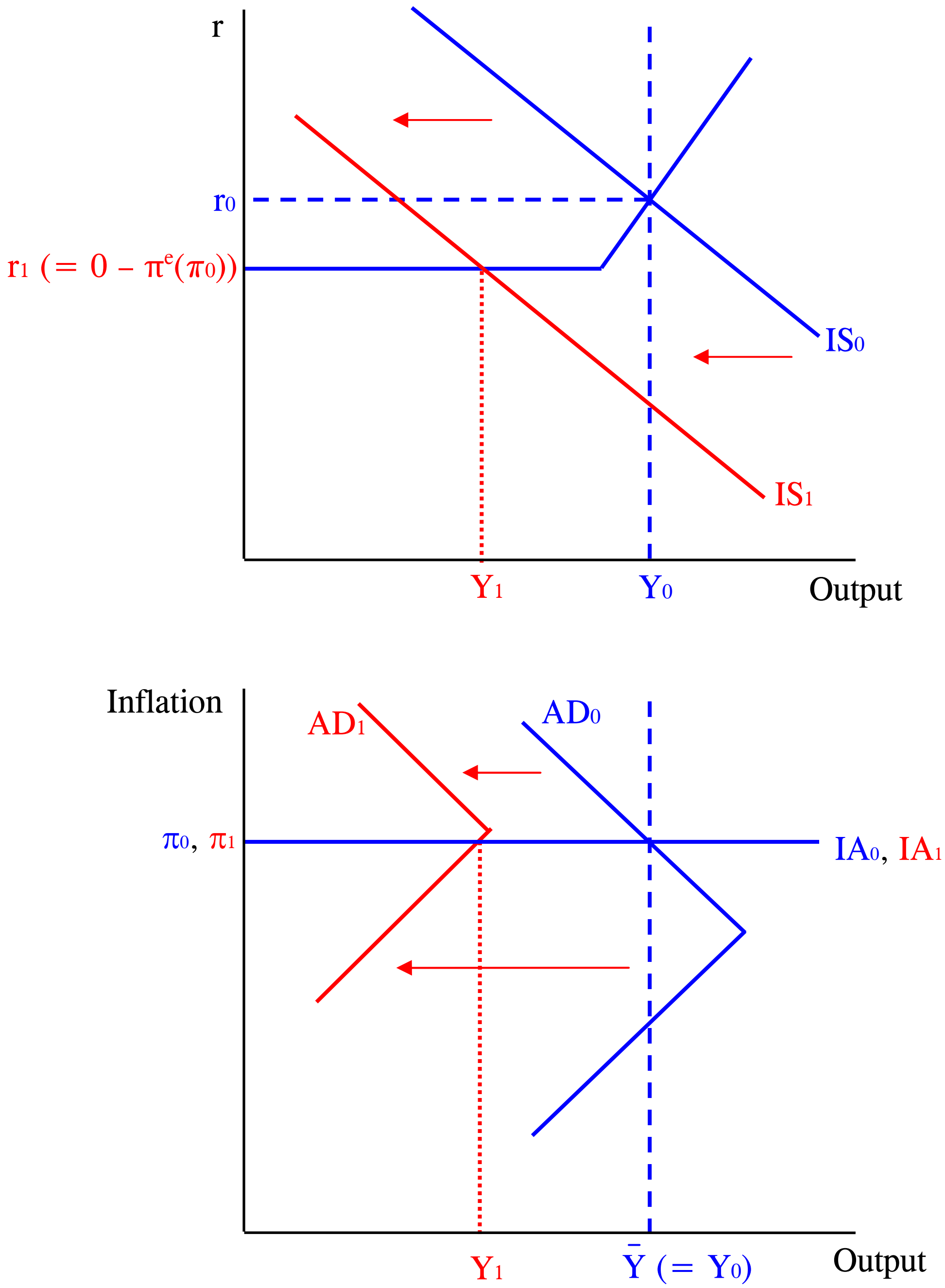

Figure IV-8. The Effects of a Large Shift of the IS Curve that Causes Monetary Policy to Hit the Zero Lower Bound

The bottom panel of the figure shows the implications of this discussion for the AD curve and for output and inflation. First, the fact that output is lower at a given inflation rate means that the AD curve shifts to the left. Second, the fact that at the initial inflation rate the IS and MP curves cross on the flat position of the MP curve means that at that inflation rate, the AD curve is upward-sloping. Finally, the fact that for high enough inflation, the IS and MP curves intersect in the upward-sloping part of the MP curve means that the AD curve still has a downward-sloping piece.

Notice that the AD curve does not shift evenly to the left. Instead, the upward-sloping portion shifts more than the downward-sloping portion, and so the kink in the curve is now at a higher inflation rate. This follows from the fact that at the initial inflation rate, the initial IS curve crosses the MP curve in its upward-sloping part, but the new IS curve crosses in the flat part.

Another way to see why the leftward shift of the AD curve is not uniform is to consider the upward-sloping and downward-sloping parts of the curve separately. In the upward-sloping part, the zero lower bound constrains monetary policy. Thus when the IS curve shifts, it moves along the flat part of the MP curve, and so output at the given inflation rate falls by the full amount of the leftward shift of the IS curve. In the upward-sloping part of the AD curve, in contrast, the central bank cuts the real interest rate when output falls. Thus output at a given inflation rate falls by less than the full amount of the shift in the IS curve. This analysis tells us that the upward-sloping piece of the AD curve shifts by more than the downward-sloping piece does. The result, as Figure IV-8 shows, is that the inflation rate where the two pieces meet is higher than before.

The bottom panel of Figure IV-8 shows what happens to output and inflation in the short-run. As usual, because inflation at a point in time is given, inflation is not affected in the short-run. The leftward shift of the AD curve, however, causes output to fall.

Recall that the top panel of the figure shows the situation at the initial level of inflation. Since inflation does not change in the short-run, it too shows the short-run fall in output. That panel shows that the zero lower bound makes the negative output effects of the shock larger. In the absence of the bound, the central bank would have cut the real interest rate by more, and so the output decline would have been smaller.

The critical importance of the zero lower bound, however, involves not the short-run impact of the shock, but the economy's behavior over time. We now turn to that subject.

The Behavior of the Economy over Time

Figure IV-9 shows what happens to the economy after the initial shock. Recall from Section III that our main tool for analyzing the dynamics of the economy is the AD-IA diagram. Thus the figure shows that diagram, leaving the IS-MP curve in the background.

The key fact about the adjustment of the economy is that the behavior of inflation is determined by whether output is above, below, or equal to normal. Here, output is below normal, and so inflation starts to fall. In terms of the diagram, the IA curve begins to shift down – for example, from IA_1 to IA_2. But because we are on the upward-sloping part of the AD curve, the fall in inflation does not help to return output to normal. Instead, as the diagram shows, it causes output to fall further. The reason is that the real interest rate is no longer determined by what the central bank would like it to be. Instead, it is determined by the combination of expected inflation and the zero lower bound on the nominal interest rate. With the real interest rate equal to $0 - \pi^e$, and with π^e lower when inflation is lower, a fall in inflation raises the real interest rate, and so causes output to fall further.

And, unfortunately, the process continues. With output still below normal, the IA curve

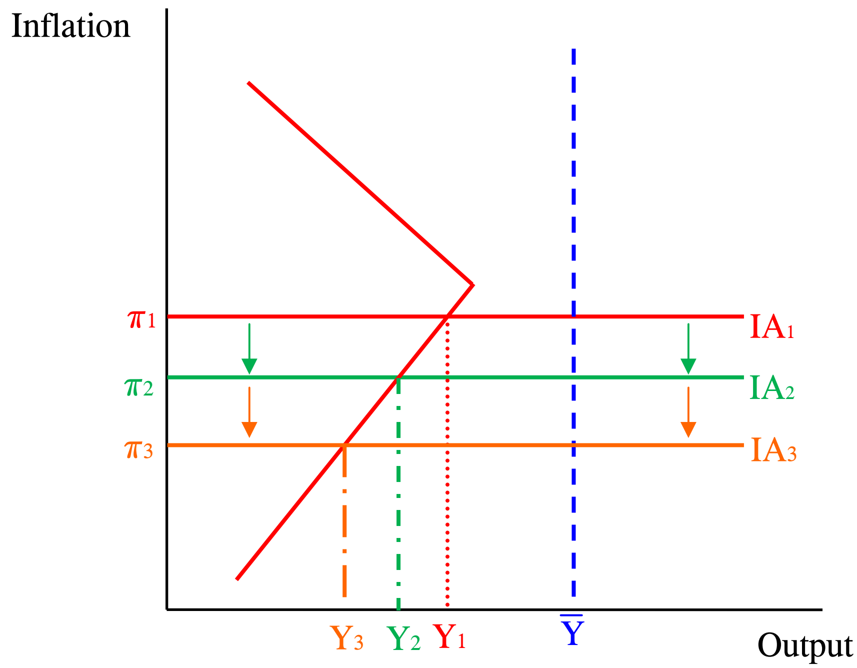

Figure IV-9. The Behavior of the Economy over Time When Monetary Policy is Constrained by the Zero Lower Bound

shifts down further – for example, to IA_3. The resulting fall in inflation moves the economy further down the upward-sloping part of the AD curve, and so output falls more. The process continues from there.

Thus, we have a crucial result. The zero lower bound eliminates a key force that usually helps to keep the economy stable. When the economy is functioning normally, below-normal output causes inflation to fall, leading the central bank to cut the real interest rate and push output back toward normal. At the zero lower bound, however, falls in inflation lead not to cuts but to rises in the real interest rate. As a result, they are destabilizing rather than stabilizing.

A premise of our example is that the shift of the IS curve is not permanent. At some point, it shifts back to the right. In particular, we assume that it shifts to the right by enough that at the current level of inflation, the economy is once again on the upward-sloping portion of the AD curve, and that some portion of the new AD curve has $Y > \bar{Y}$.

The effects if this development are shown in Figure IV-10. To pick up where the previous figure left off, the inflation rate prevailing at the time of the bounceback of the IS curve is denoted π_3. Before the IS curve shifts to the right, output is below normal, monetary policy is constrained by the zero lower bound, and the economy is in a deflationary spiral. But the large rightward shift of the IS curve pulls the economy out of the spiral. In the case shown in the diagram, the shift is large enough that output is above natural.

From that point, the dynamics of the economy are conventional. The above-normal output causes inflation to rise, moving the economy up along the downward-sloping part of the AD curve. Long-run equilibrium occurs when the IA curve has shifted up by enough that it intersects the AD curve at $\bar{Y}$. Since this part of the story should be familiar from Section III, it is not shown in the diagram.[1]

Discussion

This example captures a central feature of what happened to many of the major world economies starting in 2008. A series of events led to a large fall in investment and consumption demand – so large that central banks cut interest rates to virtually zero. But those interest rate cuts were not enough to return output to normal. And once that happened, the key force that usually

[1] It is natural to wonder why we made the assumption that at some point there is a large outward shift of the IS curve. The reason is that it captures something realistic. Taken literally, our model implies that if the leftward shift of the IS curve were permanent, the deflationary spiral would continue forever. Output would fall without limit – leading, presumably, to the eventual death by starvation of the entire population. This is surely not right. At some point, other forces would help to restore the economy to normal. For example, the simple fact that factories, cars, and durable goods were wearing out would eventually lead to higher demand at given r and Y – that is, to a rightward shift of the IS curve. More exotically, with the market economy breaking down, at some point individuals and firms would likely turn to other arrangements, such as barter or transacting in a foreign currency. In other words, in our model the central bank's real interest rate policy is the only force stabilizing the economy, and so when the zero lower bound vitiates it, the economy becomes completely unstable. In reality, however, there are other forces that would prevent complete instability. Rather than trying to incorporate those forces into the model (which would be difficult), we focus on an example where, by assumption, the economy eventually returns to normal conditions.

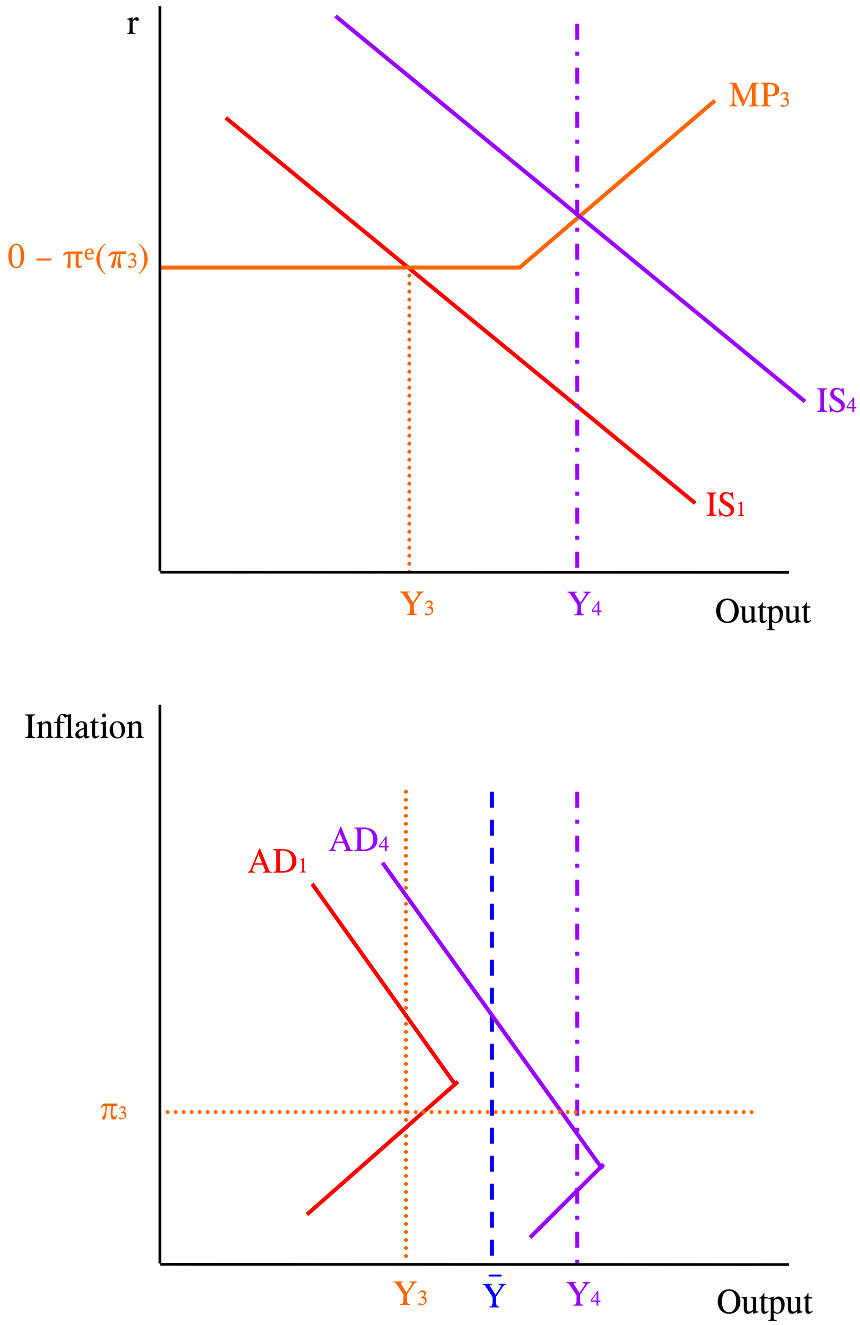

Figure IV-10. The Effects of a Large Rebound of the IS Curve pushes output back to normal was gone: falls in inflation would no longer lead to reductions in the real interest rate. With that stabilizing factor absent, output languished far below its normal level for years.

While our example captures much of the essence of the disastrous economic outcomes in the wake of the 2008 financial crisis, in one key aspect it is off the mark. The major economies did not experience continually falling inflation and output. Instead, inflation tended to vary irregularly around some fairly low level. As described in Section III-3, for example, inflation in the United States for the most part stayed between 1 and 2 percent from 2009 to 2012. And output, rather than falling farther and farther below potential output, stayed a fairly steady amount below potential output starting in late 2009.

The reason for the divergence between the predictions of our model and actual behavior appears to lie in the anchoring of inflation expectations, which we discussed at the end of Section III. With anchored expectations, the combination of below-normal output and below-target inflation creates countervailing influences on inflation: the fact that output is less than normal tends to push inflation down, but the fact that inflation is below the central bank's target tends to push inflation up. This can be enough to prevent a deflationary spiral. Problem 3 at the end of this section asks you to work out the implications of anchored expectations for the zero lower bound in more detail.

Despite this difference between the predictions of the model and actual developments, the model captures a central feature of the crisis: the zero lower bound eliminates the force that usually works to return output to normal when a shock pushes it below. As a result, a period when output is below normal can last a very long time. Sadly, that is exactly what is happening today.

IV-3 Policy in a Liquidity Trap

An economy where the nominal interest rate is zero poses severe challenges for policymakers. If output is less than its natural rate, inflation will tend to fall. With the nominal interest rate stuck at zero, this will raise the real interest, and so depress the output further. Policymakers therefore face the risk of the economy spiraling off on a path of continually falling inflation and output, like what we just analyzed.

What can policymakers do to avoid such a disaster? This section discusses the main possibilities.

Fiscal Policy

The obvious alternative to monetary policy is fiscal policy. And, fortunately, fiscal policy continues to be effective in a liquidity trap.

This is shown in Figure IV-11. Initially, the economy is in a liquidity trap with $\mathrm{Y} < \overline{\mathrm{Y}}$. Thus, the IS and MP curves intersect on the flat portion of the MP curve, and the IA and AD curves intersect on the upward-sloping portion of the AD curve at a point where output is less than its natural rate.

Now suppose the government undertakes expansionary fiscal policy by cutting taxes or increasing its purchases. Fiscal policy works through the IS curve, and the fact that the economy is in a liquidity trap does not affect that curve. Thus the policy shifts the IS curve to the right as usual. If the shift is large enough, it gets the economy out of the liquidity trap. In the case shown in the figure, the shift causes the new IS curve to intersect the MP curve on its upward-sloping part. Thus the nominal interest rate is now positive, and the economy is on the upward-sloping portion of the

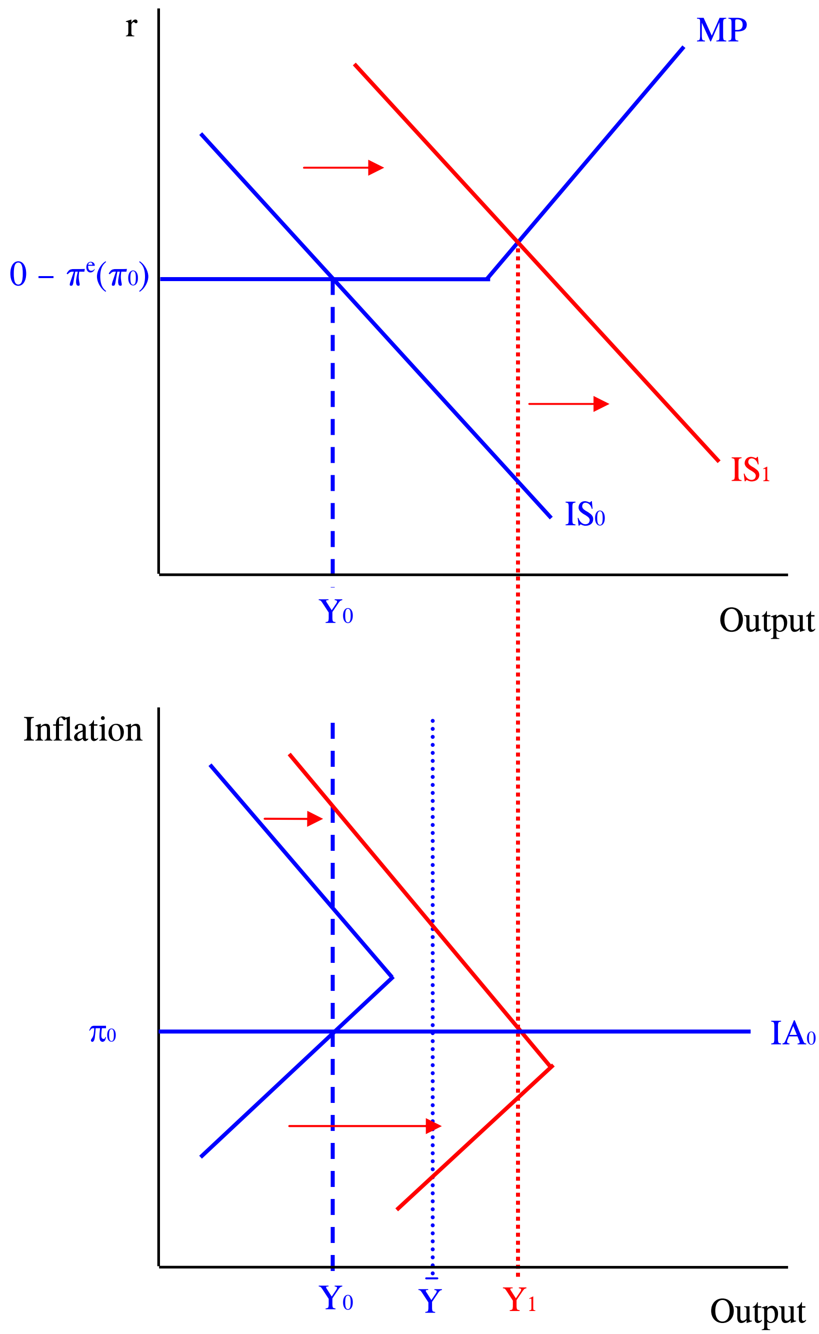

Figure IV-11. The Effects of an Expansionary Fiscal Policy in a Liquidity Trap

AD curve. The shift is also assumed to be large enough to push output above potential. That is, expansionary fiscal policy has moved the economy to a normal situation.

Unfortunately, expansionary fiscal policy is not a costless or surefire way to escape a liquidity trap. It increases the government's budget deficit, and so leaves the government with more debt than if it had been able to find some other way out of its predicament. This will eventually require higher taxes or lower government spending, or some combination of the two.

In extreme cases, concerns about government debt may prevent attempts at fiscal stimulus from being expansionary at all. Consider a country in a situation like that of Greece over the past few years. Households and firms had severe doubts about whether the government would repay its debt, and they were worried about the possibilities of default, financial crisis, and widespread economic disruptions. In such an extreme situation, tax cuts and increases in government spending might reduce consumption at a given level of disposable income and investment at a given real interest rate. In such a case, fiscal policy might fail to move the IS curve in the desired direction.

In addition, even in situations where fiscal stimulus could free the economy from a liquidity trap, it may not be politically feasible. In a deep recession, many individuals and households have little choice other than to cut back on their own spending. Often, they are paying off high levels of debt. Our model shows that in this situation, for the government to do exactly the opposite – increasing its spending and accumulating more debt – helps to heal the economy. But, not surprisingly, such policies are counterintuitive. Indeed, the recommendation that the government should be spending more and borrowing more when ordinary people have little choice but to reduce their spending and borrowing makes many voters angry.

For all of these reasons, it is important to consider alternatives to fiscal policy.

Actions to Lower Other Interest Rates

In all of our analysis, we have been acting as if there is only one interest rate in the economy. But, of course, there are many interest rates – rates on assets of many different maturities, and on loans to borrowers with different degrees of financial soundness and reputations.

In conducting monetary policy, central banks usually focus on a safe, short-term interest rate. The Federal Reserve, for example, normally conducts policy in terms of its target for the federal funds rate, which is the interest rate on very short-term loans between banks where the risk of default are very small. When the interest rate reaches zero, most other interest rates are still positive. For example, interest rates on very safe long-term assets (such as long-term U.S. government debt) were well above zero even after the federal funds rate fell to almost zero in late 2008. And interest rates on risky short-term loans (such as credit card debt) and risky long-term loans (such as mortgages and corporate bonds) were generally even higher.

Each of these interest rates affects someone's spending. The mortgage interest rate is relevant to someone thinking of taking out a mortgage to buy a new home; the corporate bond rate is relevant to a firm thinking of issuing debt to build a factory; and for a firm that is flush with cash thinking of undertaking an investment project, the opportunity cost of the funds that would finance the project may be the interest rate on long-term government debt.

Thus, one type of policy available when the short-term safe nominal interest rate is zero is actions that lower other interest rates. If, for example, the interest rate on 10-year government bonds is 2 percent, the central bank can adopt a target of 1 percent and buy long-term government debt until that interest rate is driven down to the target. Or, instead of targeting other interest rates, the central bank can buy various bonds and other debt-related assets, which will drive down their interest rates. This is what the Federal Reserve did with its policies of "quantitative easing" starting in 2009. By purchasing large amounts of long-term government debt and mortgage-backed securities, it reduced interest rates on those assets, and on assets that are close substitutes for them.

Fiscal policymakers can also take steps to reduce other interest rates. For example, they can provide various types of subsidies (such as tax benefits, guarantees, and direct subsidies) to particular types of loans.

Once we recognize that there are many different interest rates, we have to take a stand about which interest rate we are showing on the vertical axis of the IS-MP diagram. The natural choice is the real, safe, short-term interest rate, since that is the interest rate that monetary policy usually emphasizes and the rate for which the zero lower bound on nominal interest rates becomes relevant first.

Given the choice of what interest rate to show on the diagram, policies that lower other interest rates shift the IS curve to the right. Such policies mean that for a given real, safe, short-term interest rate, some other real interest rates are lower than they otherwise would be. These lower interest rates lead to higher investment. As a result, output for a given real, safe, short-term rate is higher than before – that is, the IS curve has shifted to the right.

In terms of our diagrams, the effects of these policies are therefore like those of expansionary fiscal policy. This is shown in Figure IV-12; for simplicity, only the IS-MP diagram is shown. It follows that these policies can raise output in a liquidity trap; and if they shift the IS curve by enough, they can move the economy out of the liquidity trap altogether.

Section V will explore the implications of the multiplicity of interest rates further.

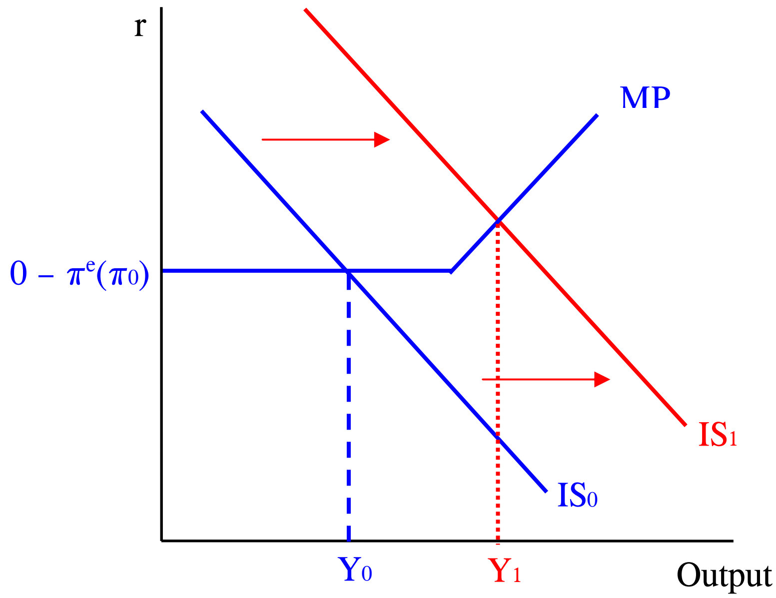

Figure IV-12. The Effects of Policies that Lower Other Interest Rates in a Liquidity Trap

Raising Expected Inflation: General Considerations

The real interest rates that are relevant to investment decisions are nominal interest rates minus *expected* inflation. So far, we have assumed that expected inflation is a function of actual inflation. But other factors are likely to also influence expected inflation. Individuals and firms making decisions about various types of spending have a lot of information about future inflation in addition to its current level. For example, they may observe whether inflation is rising or falling, and they can observe how the central bank is conducting policy and what central bank officials are saying about how they plan to conduct policy in the future.

The fact that expected inflation depends on more than actual inflation gives policymakers another way of influencing an economy in a liquidity trap. And since monetary policy determines inflation in the long run, this is especially true of monetary policymakers.

Let us ignore for a moment the issue of *how* monetary policymakers can influence expected inflation, and assume that they can. For concreteness, assume that they are able to bring about an upward shift of the $\pi^e(\pi)$ function, so that expected inflation at a given level of actual inflation is higher than before.

Figure IV-13 shows the effects of this change in the IS-MP diagram. As always, the diagram is drawn for a given level of inflation; let us call that inflation rate π_0. When expected inflation at π_0 is higher, the real interest rate corresponding to a nominal rate of zero is lower than before. Thus the flat portion of the MP curve shifts down. The economy moves down along the IS curve, and so output rises. That is, the increase in expected inflation stimulates the economy in a liquidity trap.

Intuitively, what is going on is that the increase in expected inflation is reducing the *real* cost of borrowing: the fact that expected inflation is higher means that businesses and household believe that the dollars with which they will repay loans will be less valuable. And this reduction in the real interest rate stimulates demand.

Policies to raise expected inflation create an important tension. What matters for behavior today is expectations of future inflation. Thus when the central bank finds itself in a liquidity trap, it may want firms and households to believe that inflation will be higher in the future. But when the future arrives, what inflation actually turns out to be cannot influence decisions that were made earlier. Thus if the central bank dislikes inflation, it will be tempted to not produce the high inflation it had said it would. But if firms and households recognize this temptation, they may not believe the central bank's original statements that future inflation will be high. In other words, statements about future inflation may not be *credible*, and so may be ineffective.

At a broad level, central bank policies that will be effective in raising expected inflation all

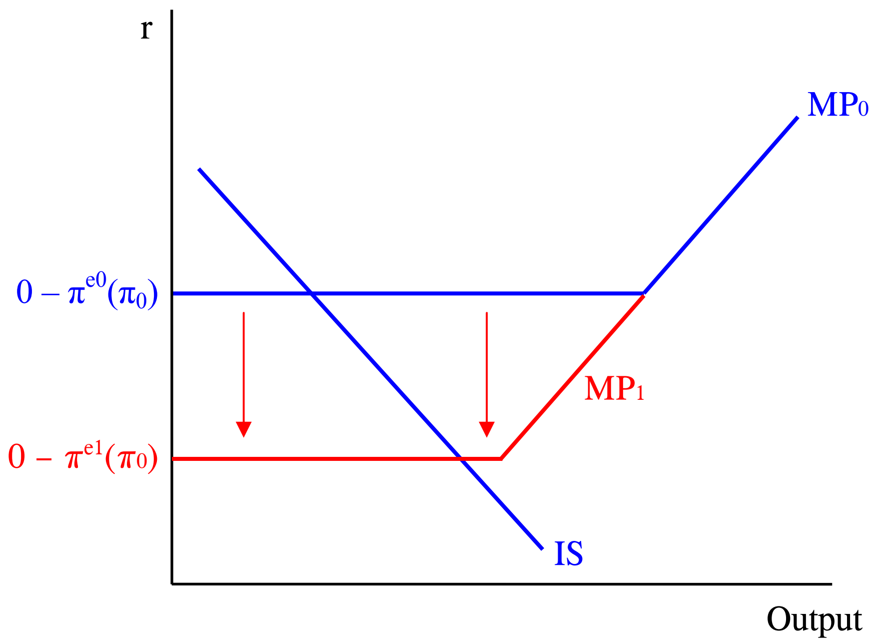

Figure IV-13. The Effects of Increasing Expected Inflation in a Liquidity Trap

share important features. They start with a presumption that at some point, the economy will be back in a situation where the nominal interest rate is positive and monetary policy can affect the economy in the usual way.[2] Suppose the central bank can persuade people that once that occurs, it will follow more expansionary policy than it otherwise would, at least for a while. Setting a lower real interest rate than it otherwise would will cause output to be higher than it otherwise would be. And since inflation responds to the difference between actual and potential output, inflation will be higher than it otherwise would be. Thus, beliefs that monetary policy will be more expansionary once the economy returns to normal raise current expectations of inflation. All the specific policies to raise expected inflation we will consider work through this same basic channel.

[2] The case where the liquidity trap is potentially permanent raises hard issues. We will not consider this case.

Note that keeping interest rates lower once the economy has returned to normal not only makes future inflation higher than it otherwise would be, but also makes future output higher: the channel through which lower interest rates raise inflation is by raising output. And although it is not true in our model, it is likely that in practice, expectations of higher future output increase current demand. A business is more likely to undertake an investment project if it believes that incomes (and hence demand for its product) will be higher in the future. And households are likely to consume more today if they expect their incomes will be higher in the future.[3] This is another channel by which expectations about future monetary policy can stimulate an economy in a liquidity trap. Interestingly, when his channel is at work, the expectations about monetary policy are working partly through the IS curve rather than the MP curve.

We can now turn to specific policies central banks may try to use to credibly affect expectations of policy once the economy has returned to normal, and thus affect expected inflation.

Statements about Future Interest Rates

Since ultimately the central bank influences expectations by changing people's views about future interest rates, a straightforward way to try to affect expectations is by making statements about future interest rates. This was central to the Federal Reserve's strategy once it brought the short-term, safe interest rate down to almost zero late 2008.

For example, in December 2008, the Federal Reserve stated that it "anticipates that weak economic conditions are likely to warrant exceptionally low levels of the federal funds rate for some time." In August 2011, it adopted more specific language, saying that it expected that

[3] See Mankiw, Chapter 16.

conditions were likely to warrant "exceptionally low levels for the federal funds rate at least through mid-2013." And in December 2012, it changed from giving an estimate of the time when it might raise the funds rate to describing the economic conditions that might lead it to do so.

Unfortunately, such statements may have little impact on expected inflation. There are two problems. First, the various statements seem to say that if the Federal Reserve followed its usual policies, it would want low interest rates for a long time. In terms of our model, this seems to describe not a change in its interest rate rule in the future, but a prediction about what its existing rule would call for in the future. There is no evident reason that such a prediction would raise expected inflation. Indeed, the Federal Reserve's pessimistic predictions about future economic conditions could lead economic actors to lower their expectations of inflation.

The second problem is that because the statements only make predictions and offer no commitments, they do little to overcome the credibility problem. That is, they create no noticeable cost to raising interest rates in the future, and thus provide businesses and households with little reason to be confident that the Federal Reserve will actually change its behavior once the economy recovers.

Adopting a Higher Inflation Target

A more dramatic approach is to adopt a new target or policy framework. For example, currently the Federal Reserve identifies 2 percent as its most preferred inflation rate. Adopting a higher target, such as 3 or 4 percent, would be a way to try to affect expected inflation. The way the central bank would get to the higher inflation rate would be by adopting an interest rate rule that implied a lower real interest rate for a given combination of output and inflation than before. Thus the basic mechanism would be the same as with statements about future interest rates. But announcing a new inflation target would be more dramatic than making statements about expectations of future interest rates. And the public would be able to tell whether the central bank was hitting its stated target, which would presumably increase the central bank's incentives to produce the outcome it had announced it was aiming for. As a result, such a policy might have a strong impact on expected inflation.

Targeting a Price Level Path or a Nominal GDP Path

An obvious disadvantage to a higher inflation target is that the central bank is permanently raising inflation to address a temporary problem. If the higher inflation rate is undesirable on other grounds, this seems wasteful.[4] If the central bank could credibly convey that it was aiming for higher inflation, but doing so only temporarily, that would be even better.

One concrete proposal along these lines is for the central bank to target a *price-level path*. Figure IV-14 illustrates the idea. Suppose the central bank is targeting some low inflation rate, such as 2 percent. Thus in normal times, the price level will be rising slowly. Now suppose that at some point – time t_0 in the diagram – the economy goes into a recession, and so inflation starts to fall. Prices continue to rise, but they rise more slowly than before. Thus the price level falls gradually below the path it was following before.

Now consider the economy at some point after inflation has been low for a while – time t_1 in the figure. Under traditional inflation target with a 2 percent target, the central bank's goal is always 2 percent inflation. Thus given the price level at time t_1, the central bank's most preferred path for the price level is shown by the dotted line in the figure. And if inflation continues below 2 percent longer, the central bank's preferred price-level path shifts down further.

[4] The issues of the costs of inflation and of the best long-run inflation rate are complicated. See Mankiw, Section 5-5.

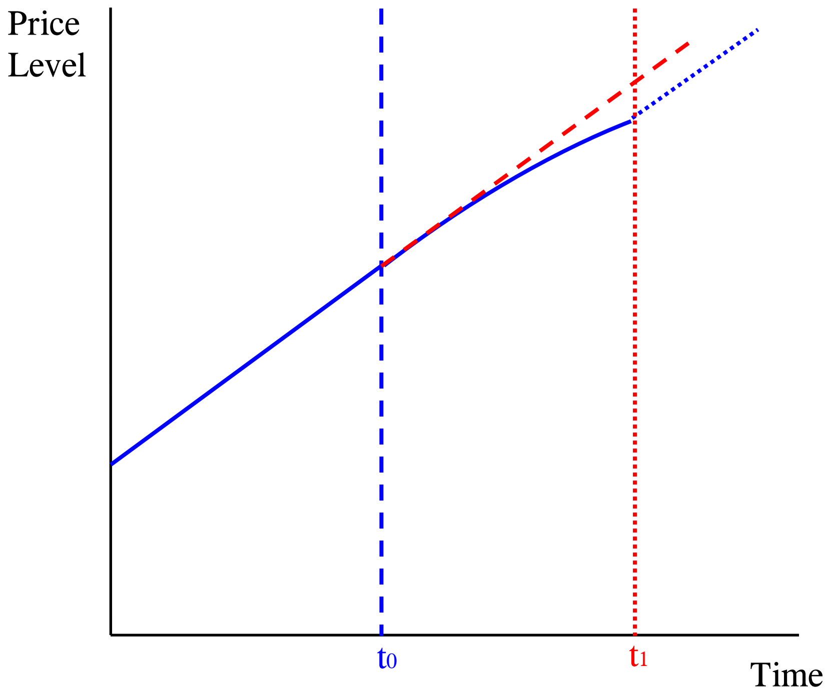

Figure IV-14. Targeting an Inflation Rate versus Targeting a Price-Level Path

If the central bank is targeting a path for the price level, in contrast, its goal is always to have average inflation from some fixed starting point be 2 percent per year. Thus, at time t_1, its goal is to get the price level back to its old path – that is, back to the dashed line in the figure. And that remains its goal regardless of what happens to inflation in the short run. Notice that this accomplishes what we want: the central bank's goal when a recession and a liquidity trap cause inflation to be below normal for a while is a period of temporarily high inflation (to get the price level path to its old path); but its long-run inflation goal is unchanged. And, as with an inflation target, the central bank's success in achieving its target path for the price level is easy to judge.

Although targeting a price-level path has desirable qualitative properties, its quantitative effects may be small. Five years after the U.S. economy entered into a recession in late 2007, for example, the price level was only a few percent lower than it would have been if it had continued to grow by 2 percent per year. Thus the amount of additional expected inflation created by targeting a price-level path would have been small.

Some economists have therefore suggested that central banks should target a *nominal GDP path*. Recall that nominal GDP is the product of real GDP and the price level. When the economy goes into a recession, both ingredients are likely to fall below their pre-recession paths. Thus a policy of trying to get nominal GDP back to its pre-recession path would likely involve keeping interest rates lower for longer, and so raising inflation by more, than a policy of trying to get the price level back to its old path. In the United States, for example, nominal GDP fell almost 10 percent below its pre-recession path in the five years after the 2007 business cycle peak. Qualitatively, however, targeting a nominal GDP path is similar to targeting a price-level path: it provides a framework through which the central bank can create expectations of future expansionary policy in a liquidity trap without changing its long-run goals.

Increasing the Money Supply

This discussion leaves out what might appear to be a simple way of increasing expected inflation: since the ultimate driver of inflation in the long run is money growth, why not just increase the money supply? The issue turns out to be far from simple, and it is closely related to the issue of credibility that we discussed above.

Raising the money supply today will raise the price level in the long run only if it raises the money supply in the long run. And there is no guarantee that this will happen. Suppose, for example, that the central bank increases the money supply in a liquidity trap, but that it does not change its rule for how it would like to set the real interest rate. Then when the economy recovers, the money supply will be determined not by what it was in the liquidity trap, but by what is needed to yield the real interest rate called for by the central bank's rule.[5] Thus whether an increase in the money supply in a liquidity trap raises expected inflation depends on how it affects expectations of the future money supply, and it is possible that it will not affect those expectations.

Exchange Rate Policy

We have discussed central bank policies that can help an economy in a liquidity trap by changing the prices of certain kinds of assets, and policies that can help by changing expected inflation. The final policy we will discuss involves elements of both. Recall from Section II that exchange rate depreciation increases exports and reduces imports, and so raises the demand for domestically produced goods and services. Thus one possible way for the central bank to stimulate an economy in a liquidity trap is by bringing about depreciation. In particular, it can announce that it is willing to sell domestic currency at a low price in terms of foreign currency. As always with a policy of fixing the exchange rate, this will drive the exchange rate down to the announced rate (see Section II-3). And because the central bank can issue domestic currency, it will be able to meet the resulting demand. Thus, a central bank can use exchange rate policy to stimulate an economy in a liquidity trap.

What does this have to do with expected inflation? Suppose people believe that the exchange-rate policy was isolated and temporary, and thus that it had no implications for future inflation. Then they would expect the exchange rate to return to roughly its old level once the economy recovered. But then buying domestic currency with foreign currency is enormously profitable, since people expect that when the economy has recovered, they will be able to sell the domestic currency for foreign currency at a much higher price. The only way there would not be

[5] See Section I-3.

almost unlimited demand for domestic currency at the low price is if people expect its price to remain low. And that in turn requires that they expect inflation. Thus a policy of driving down the exchange rate either needs to be part of a broader policy package that raises expected inflation or needs to be interpreted by firms and households as a sign that future inflation will be higher. Either way, it involves higher expected inflation.[6]

PROBLEMS

1. Suppose the IS and MP curves intersect on the flat part of the MP curve. Describe how each of the following developments affects the two curves, and thus how it affects the real interest rate and output in the short run:

a. Investment demand at a given real interest rate falls.

b. The central bank adopts a more expansionary real interest rate rule. That is, the real interest rate it wants to set for a given combination of output and inflation is lower than before.

c. Expected inflation rises.

d. The demand for money increases (that is, consumers' preferences change so that at a given level of i and Y, they want to hold more real balances than before).

2. Consider the situation shown in Figure IV-5. At the intersection of MP(π_2) and IS, what nominal interest rate does the central bank *desire* to set? What is the actual nominal interest rate? Explain your answer.

3. Recall from Section III-3 that an alternative assumption about the behavior of inflation behavior is that inflation expectations are anchored. This problem asks you to analyze the implications of anchored inflation expectations for the 1iquidity trap.

a. Suppose that expected inflation equals π^* regardless of the current level of inflation.

i. Describe the MP curve for a given actual inflation rate. Does it still have a flat portion? If so, what is r on the flat portion? If not, why not?

ii. How, if at all, does a fall in actual inflation affect the MP curve?

iii. Use your answers to (i) and (ii) to show the shape of the AD curve.

b. Suppose that the economy is initially in long-run equilibrium with $\pi = \pi^*$ and $i > 0$. Now suppose there is a permanent backward shift of the IS curve such that when $\pi = \pi^*$, the IS and MP curves intersect on the flat part of the MP curve. Assume also that the behavior of inflation is described by our assumptions for the case of anchored expectations at the end of Section III.

i. How, if at all, will this shift affect the AD curve?

ii. What will happen to this economy over time? Will output ever return to $\overline{Y}$? Will output and inflation fall without bound? (Hint: see the discussion of π_{STEADY} at the end of Section

[6] For more on these issues, see Lars E. O. Svensson, "Escaping from a Liquidity Trap and Deflation: The Foolproof Way and Others," *Journal of Economic Perspectives* 17 (Fall 2003), pp. 145–166.

III.)

4. Suppose the economy is in the situation shown in Figure IV-15. Output is below normal and the nominal interest rate is positive. In addition, as the figure shows, the kink in the AD curve occurs at $Y < \overline{Y}$, and an extension of the upward-sloping portion of the AD curve crosses the IA line at $Y > \overline{Y}$. This problem asks you to consider the effects of two possible strategies for the central bank.

a. Saving your ammunition: Suppose the central bank does not want to cut the nominal interest quickly to zero, since at that point it would lose the ability to cut the nominal rate further. It therefore continues to follow its usual interest rate rule (subject to the zero lower bound). What will be the behavior of output and inflation over time?

b. Using your ammunition: Suppose that the central bank immediately changes its interest rate rule so that its desired real interest rate at a given combination of output and inflation is lower than before. Suppose the change is large enough that it immediately reduces the nominal interest rate to zero. What will be the behavior of output and inflation over time?

c. Which policy would you recommend?

5. Consider the fiscal expansion analyzed in Figure IV-11. What will be the behavior of output and inflation over time? What is the economy's long-run equilibrium?

6. Suppose that the economy is in a situation where $i = 0$ and $Y < \overline{Y}$. Is it possible for the initial situation to be such that some fiscal expansions will result in $i = 0$ and $Y > \overline{Y}$ in the short run? Why or why not? If the answer is yes, what will be the behavior of output and inflation over time?

7. Suppose that there are two simultaneous developments. First, government purchases are reduced. Second, the central bank changes its interest rate rule so that its desired real interest rate for a given level of output and inflation is lower than before.

Describe whether the combined effect of these two developments will be to raise, lower, or have no effect (or whether it is not possible to determine the effect) on output and the real interest rate in the short run if:

a. Monetary policy is not constrained by the zero lower bound on the nominal interest rate.

b. Monetary policy is constrained by the zero lower bound before the developments occur.

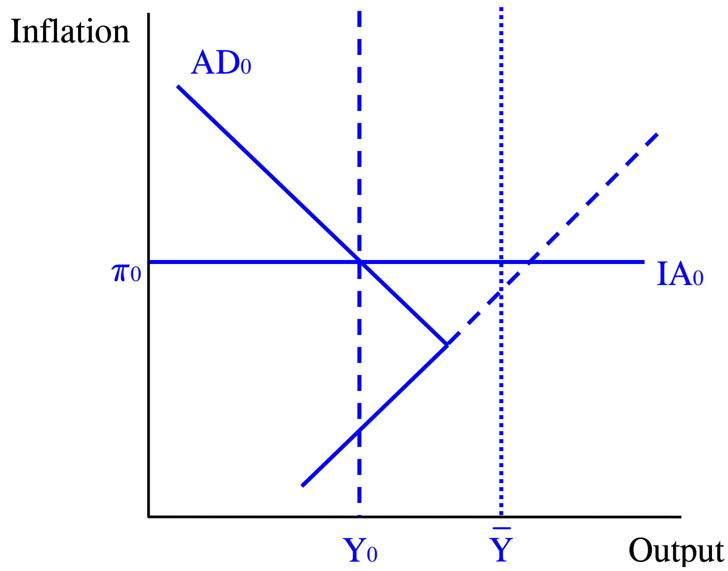

Figure IV-15. Saving versus Using Your Ammunition:
The Initial Situation

V Credit Market Disruptions

One of the simplifications in almost all of the analysis so far is that all saving and borrowing is done at the same interest rate. This has allowed us to talk about "the" nominal interest rate, or "the" real interest rate.

Like all of our assumptions, this one is not completely correct. There are in fact many different interest rates. For example, the rate the U.S. federal government pays to borrow is less than the rate paid by an established corporation; the established corporation's rate is less than that paid by a corporation with a shorter track record; and the young corporation's rate is in turn less than the rate paid by an entrepreneur financing a new business by borrowing on his or her personal credit card.

For most purposes, ignoring the multiplicity of interest rates simplifies our analysis without obscuring its main messages – which is precisely why we made the assumption. In response to many developments, such as changes in monetary and fiscal policy, most interest rates generally move together, and the modest variations in their relative movements do not have large effects on the economy.

Sometimes, however, the fact that there are multiple interest rates is critical to behavior of the economy. This is especially true in periods when there are large changes in how well financial markets are functioning. As U.S. and world financial markets started to undergo stress in 2007 and the first part of 2008, for example, interest rates for very safe borrowers, such as the U.S. government, fell, while interest rates for riskier borrowers, such as small firms, rose. And when the world entered a full-blown financial crisis in late 2008, safe interest rates plummeted and risky interest rates skyrocketed. Analyzing such developments in a model where all interest rates move together is almost impossible.

This section therefore extends our analysis to allow for more than one interest rate and for the possibility of disruptions of credit markets.[1] In many ways, the material is analogous to our analysis of the open economy in Section II. As in that section, we will consider two sets of issues. The first concern is how the new ingredient of our model (in this case, allowing for more than one interest rate) affects our earlier analysis. For example, we can ask how the new ingredient affects the impact of changes in monetary and fiscal policy on output. The second group of issues concerns the new ingredient itself. The most important issues here involve the effects of credit market disruptions. But we can also ask how changes in monetary and fiscal policy and other developments affect various interest rates differently.

As with the open economy, the important effects of recognizing that there are multiple interest rates are on the aggregate demand side of the model, not on aggregate supply. We will therefore focus on how this extension of the model changes our IS-MP analysis. Since the extension does not affect aggregate supply, we would learn little new by bringing in the IA line and the IA-AD diagram.

V-1 Modeling Multiple Interest Rates and Credit Market Disruptions

The Saving and Borrowing Real Interest Rates

As we have just discussed, there are many interest rates. But trying to build a model that

[1] The model presented is a simplified version of the model developed in Michael Woodford, "Financial Intermediation and Macroeconomic Analysis," *Journal of Economic Perspectives* 24 (Fall 2010), pp. 21–44.

captured the multitude of interest rates for borrowers of different degrees of riskiness – from ones that are virtually riskless to one that are on the brink of default – and borrowing for different lengths of time – from less than a day to decades – would produce a morass.

It turns out that we can learn a great deal about the consequences of the fact that there is more than one interest rate by taking the smallest possible step in the direction of realism and assuming that there are two rates. That is therefore the approach we will take.

Because the IS-MP model focuses on the real interest rate, our extension considers two real rates. Of course, each of these real rates has a corresponding nominal rate; it equals the relevant real rate plus expected inflation.

The first real interest rate in our model is the rate that households and firms earn on their saving. It is natural to think of this as the interest rate on a quite safe asset, such as a bank account or government debt. We will call this rate the "saving" interest rate, and we will denote it by r^s.

The second real interest rate is the rate that households and firms pay when they borrow. We will call this the "borrowing" interest rate, and denote it by r^b.

The borrowing real interest rate will generally be higher than the saving real interest rate, for two reasons. The first is risk. Although households and firms usually do their saving in relatively safe assets, loans to individual firms and households are often risky. The interest rates that borrowers pay reflect this additional risk.

The second source of the gap between the borrowing and saving interest rates is the costs of screening and monitoring individual borrowers. Savers rarely make loans directly to the ultimate borrowers. Instead, they hold their assets through banks, money market mutual funds, pension funds, and other *financial intermediaries*. These intermediaries devote considerable resources to investigating possible uses of their deposits and, often, to making sure that their borrowers are using the funds they have obtained well. The interest rates that borrowers pay must compensate the intermediaries not only for the riskiness of their loans, but also for the intermediaries' costs of selecting and managing the loans.

How the Two Interest Rates Enter the Model

The saving and borrowing real interest rates, r^s and r^b, enter our model in different places. In conducting monetary policy, central banks generally focus on quite safe interest rates. For example, in normal times the Federal Reserve puts the most emphasis on the federal funds rate, which is the interest rate on very short-term, very safe loans between banks.

Thus it is reasonable to assume that the central bank's interest rate rule is a rule for the saving interest rate. That is, we assume that the rule takes the form

$$\boldsymbol{r^s = r^s(Y, \pi)}.$$

As before, the function is increasing in both Y and π.

In contrast, a very large number of firms and households finance their purchases by borrowing. We will therefore assume that it is the borrowing real interest rate that affects the demand for goods. Thus our expression for planned expenditure becomes:

$$\boldsymbol{PE = C(Y - T) + I(r^b) + G.}$$

(Note that we are omitting net exports for simplicity.) As usual, investment demand is a decreasing function of the real interest rate – in this case, of the real borrowing interest rate.

Like all assumptions, the assumptions that only r^s enters that MP curve and that only r^b enters the equation that underlies the IS curve are simplifications. Central banks pay some attention to borrowing interest rates in conducting monetary policy. Likewise, at the margin, many firms and households pay for their purchases not by borrowing more, but by saving less. For these buyers, it is the saving interest rate that is most relevant. The advantage of our assumptions is that they keep the analysis relatively manageable while allowing us to see some of the key ways that the existence of multiple interest rates affects the macroeconomy.

The Determination of the Interest Rate Differential

We will refer to the gap between the borrowing interest rate and the saving interest rate, $r^b - r^s$, as the *interest rate differential*. The key feature of the model is that this differential is not constant. Our assumption about what determines it has two components.

First, when aggregate output is higher, the interest rate differential is lower. The idea behind this assumption is that when the economy is booming – that is, when output is higher – loans are less risky, and so financial intermediaries and other lenders charge borrowers lower interest rates given their costs of obtaining funds.

We can express this assumption about the interest rate differential as

$$\boldsymbol{r^b - r^s = d(Y).}$$

The function d(Y) is a decreasing function.

The second feature of our assumption about what determines the interest rate differential is that the differential for a given level of output can change in response to factors affecting the financial system. In particular, the way we will model a disruption in credit or financial markets is as a rise in the differential for a given level of output – that is, as an upward shift of the d(Y) function. For example, in the United States in 2007, as lenders' doubts about the soundness of loans related to real estate increased, the spread between the interest rate paid by a typical borrower and the rate received by a typical saver rose even though output was continuing to grow more or less normally.

We will think of a full-blown financial crisis as a very large credit market disruption – that is, as a very large upward shift of the d(Y) function. When Lehman Brothers collapsed in September 2008, the interest rates paid by many borrowers skyrocketed, while the rates on traditional forms of saving, such as bank deposits, held steady or fell. One reason was that concerns about the riskiness of many loans rose even further than they had in 2007 and early 2008. Another was disruptions of financial intermediaries. For example, firms that had been obtaining funds from Lehman had to turn to lenders who were less familiar with them, and so charged them higher rates.

The IS and MP Curves

In previous sections, there was only a single real interest rate. Now, however, there are two: the saving interest rate, r^s, and the borrowing interest rate, r^b. We therefore have to choose which one to put on the vertical axis of the IS-MP curve.

It is possible to do the analysis with either choice. The analysis is somewhat easier, however, using the saving real interest rate. We will therefore make that choice.

Recall that we are assuming that the central bank's rule is for the saving real interest rate. Thus the MP curve in the model of this section has exactly the same form as before. When output rises, the central bank acts to raise the real interest rate that it focuses on. It follows that in a diagram with output on the horizontal axis and the saving real interest rate on the vertical axis, the MP curve slopes up. This is shown in Figure V-1.

To derive the IS curve in the presence of an interest rate differential, it is easiest to think of the curve as showing the real interest rate that causes saving to equal investment as a function of the level of output. (In a moment, we will consider a second way of deriving the IS curve in this model.) As output rises, saving rises.[2] This is just another interpretation of the condition that output and planned expenditure must be equal – that is, it is another interpretation of the IS curve.

The real interest rate that affects planned expenditure is the borrowing rate, r^b. Thus *if* we put r^b on the vertical axis of the IS-MP diagram, we would just have a conventional IS curve. This is shown by the dashed line in Figure V-2. It shows the *borrowing* interest rate that would cause the loan market to be in equilibrium as a function of output. Equivalently, it shows the *saving* interest rate that would cause the loan market to be in equilibrium *if there were no interest rate differential.*

To find the actual saving real interest rate when the loan market is in equilibrium, we use the fact that the saving interest rate equals the borrowing real interest rate minus the interest rate differential:

$$\begin{aligned} r^s &= r^b - (r^b - r^s) \\ &= r^b - d(Y). \end{aligned}$$

This expression tells us that to find the saving real interest rate when the loan market is in equilibrium, we need to subtract the interest rate differential from the borrowing real interest rate. This is shown by the vertical distance labeled d(Y) in the diagram. Subtracting d(Y) at each level

[2] Recall from Section 3-4 of Mankiw that national saving is Y – C – G. Since the marginal propensity to consume is less than one, an increase in Y increases saving.

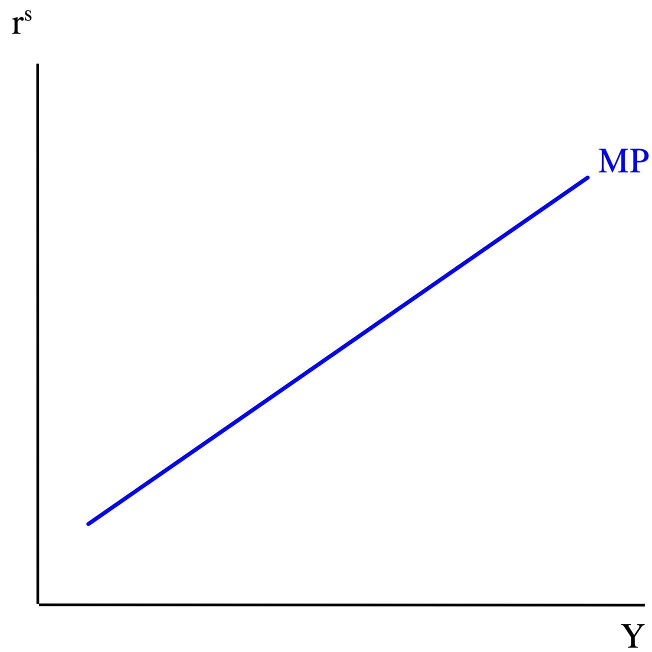

Figure V-1. The MP Curve in the Presence of an Interest Rate Differential

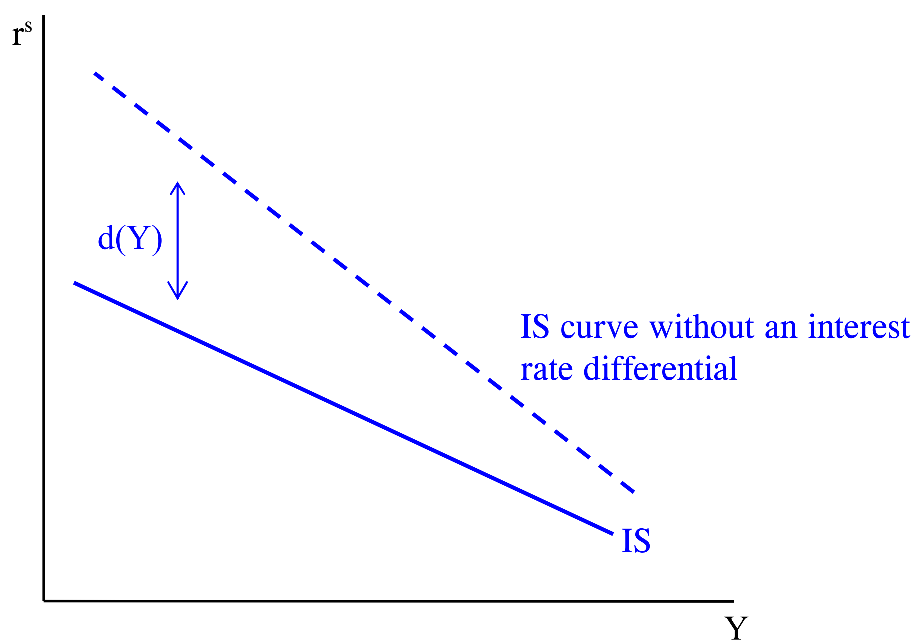

Figure V-2. The IS Curve in the Presence of an Interest Rate Differential of Y gives us the IS curve in the presence of an interest rate differential.

Notice that the interest rate differential has two effects on the IS curve. First, the new IS curve lies below the IS curve without interest rate differentials. Intuitively, the r^b that causes saving to equal investment is the same as before. But with an interest rate differential, r^s is less than r^b.

Second, as output rises, the IS curve with an interest rate differential gets closer to the curve without the differential. This too makes sense. As output rises, credit markets function better – that is, the spread between the borrowing and saving interest rates gets smaller. With the interest rate differential smaller, the two curves are closer together.

Figure V-3 brings the IS and MP curves together. It shows that the diagram has the same form as in the baseline model: the MP curve slopes up, and the IS curve slopes down. Their intersection determines output, Y, and the saving real interest rate, r^s. If we need to find the borrowing real interest rate, r^b, we can find it as the saving real interest rate at the intersection of the two curves plus the interest rate differential at the level of output where the two curves intersect. That is, we can find r^b as r^s plus d(Y).

Another Way of Deriving the IS Curve

We normally think of the IS curve as showing, as a function of the real interest rate, the level of output at which the demand for goods equals the amount produced. Thus it may be helpful to think about what happens if we use this way of thinking about the IS curve to describe how introducing an interest rate differential affects the curve.

Recall that in the usual approach, we find the IS curve using the Keynesian cross diagram.[3] We draw the diagram for a given level of the real interest rate to find output at that interest rate. We

[3] See Mankiw, Section 11-1.

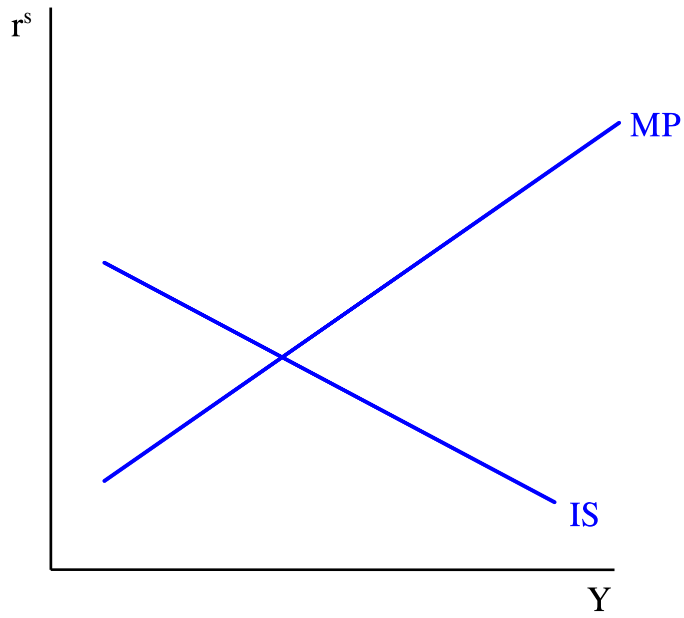

Figure V-3. The IS-MP Diagram in the Presence of an Interest Rate Differential

then consider different values of the interest rate and see how output varies. This gives us the IS curve.

Here, our goal is to find the IS curve in a diagram with output, Y, on the horizontal axis and the saving real interest rate, r^s, on the vertical one. Thus we need to find output for a given value of r^s.

To do this, we have to face a complication. Planned expenditure depends not on r^s, but on the borrowing real interest rate, r^b:

$$PE = C(Y - T) + I(r^b) + G.$$

To deal with this problem, write the borrowing real interest rate as the saving real interest rate plus the differential: $r^b = r^s + (r^b - r^s)$. We know that the differential is a function of output: $r^b - r^s =$

$d(Y)$. Combining these two expressions lets us express the r^b in terms of r^s and Y: $r^b = r^s + d(Y)$. The final step is to substitute this expression for r^b in the equation for planned expenditure. This gives us:

$$\boldsymbol{PE = C(Y - T) + I(r^s + d(Y)) + G.}$$

We can now draw the Keynesian cross for a given level of r^s. It is shown in Figure V-4. Notice that output enters the expression for planned expenditure in two ways. As in the baseline model, it affects consumption. But it also affects investment. When Y rises, the interest rate differential, d(Y), falls. This means that given the assumed value of r^s, r^b is lower. Since investment is a decreasing function of r^b, this in turn means that investment is higher. In other words, the planned expenditure line now slopes up for two reasons rather than just one: both consumption and investment rise as output rises. As a result, the planned expenditure line is steeper than in the baseline model.[4]

We can now see the two ways that introducing an interest rate differential affects the IS curve. First, with an interest rate differential, r^b is greater than r^s. As a result, for whatever level of r^s is assumed in drawing the Keynesian cross, investment at a given Y is lower than it would be without the differential. That is, introducing the interest rate differential shifts the planned expenditure line down. Thus it reduces output at any given r^s – it shifts the IS curve to the left.

Second, consider what happens if we assume a different level of r^s when we draw the Keynesian cross. For concreteness, suppose we assume a lower value than before. The effects of this change are shown in Figure V-5. Since r^b equals r^s + d(Y), r^b at a given level of Y falls by the

[4] If these effects were very strong, the planned expenditure line could be steeper than the 45-degree line, which would complicate the analysis greatly. Since that case is not realistic, we do not consider it.

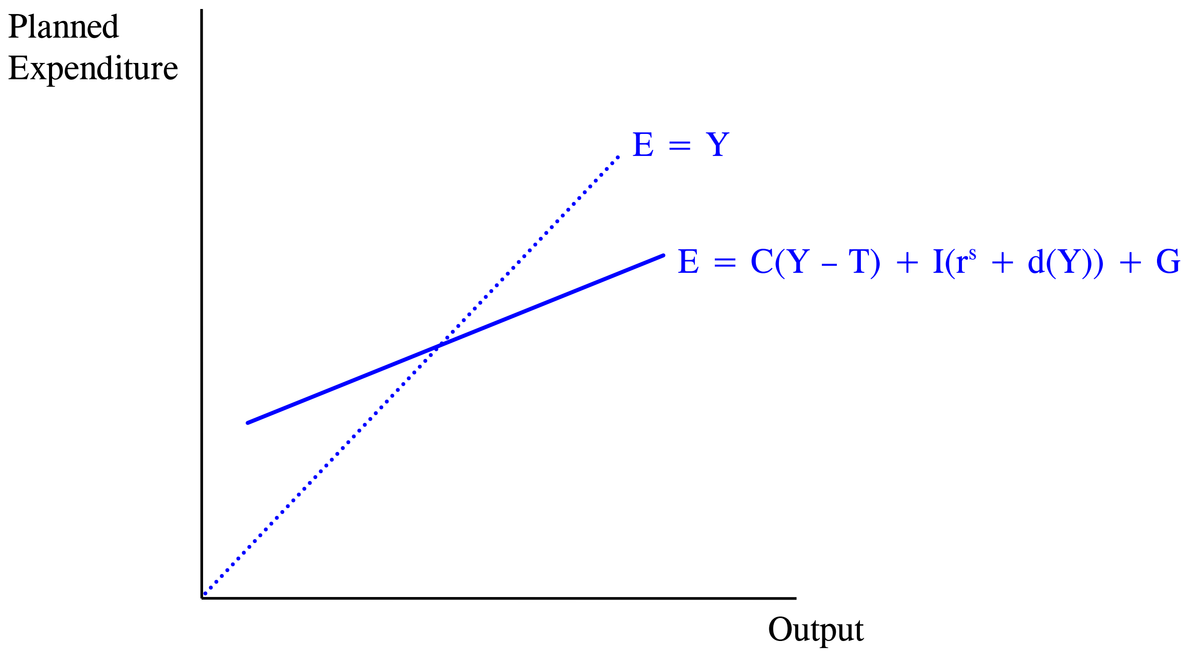

Figure V-4. The Keynesian Cross in the Presence of an Interest Rate Differential

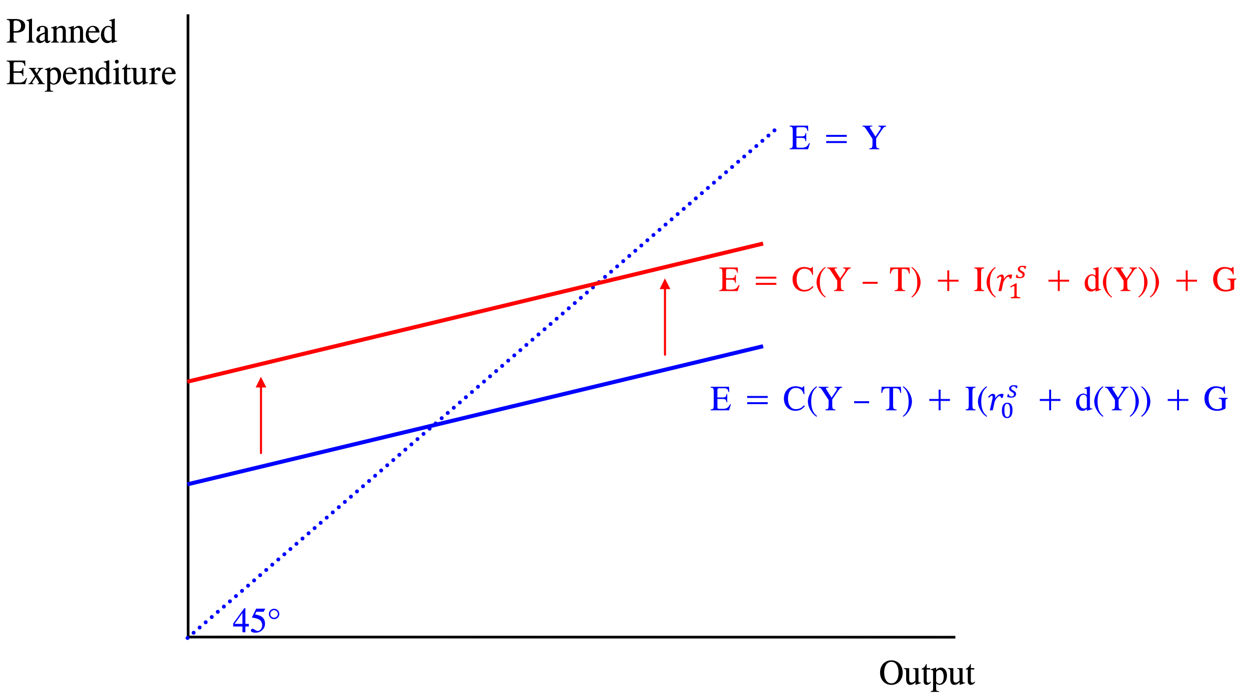

Figure V-5. The Effect of a Lower Saving Real Interest Rate in the Presence of an Interest Rate Differential amount of the fall in r^s. Since investment is a decreasing function of r^b, investment rises – that is, the planned expenditure line shifts up. And since the interest rate differential at a given Y is not affected, the fact that there is an interest rate differential does not affect the amount that the planned expenditure line shifts. But recall that the presence of the differential makes the planned expenditure line steeper than it otherwise would be. This means that a given upward shift of the planned expenditure line has a larger impact on the level of output where the planned expenditure line crosses the 45-degree line. Thus, the presence of an interest rate differential causes a change in r^s to have a bigger impact on Y – it makes the IS curve flatter.

V-2 Using the Model

We can now put our model to work. This section considers two applications. The first illustrates how the presence of an interest rate differential affects the impact of other shocks to the economy. The second looks at the effects of a disruption to financial markets.

A Change in Consumer Confidence and the "Financial Accelerator"

For a concrete example of a change in the economy that is not a direct shock to the financial system, consider a fall in consumer confidence. That is, suppose that consumption at a given level of disposable income is lower than before.

As we know from Section I-1, the decline in C at a given Y – T shifts the planned expenditure line in the Keynesian cross down, and so reduces output at a given interest rate. Thus the IS curve shifts to the left. Figure V-6 shows the results: both output and the saving real interest rate fall.

Crucially, the interest rate differential magnifies these effects. As output falls, the interest

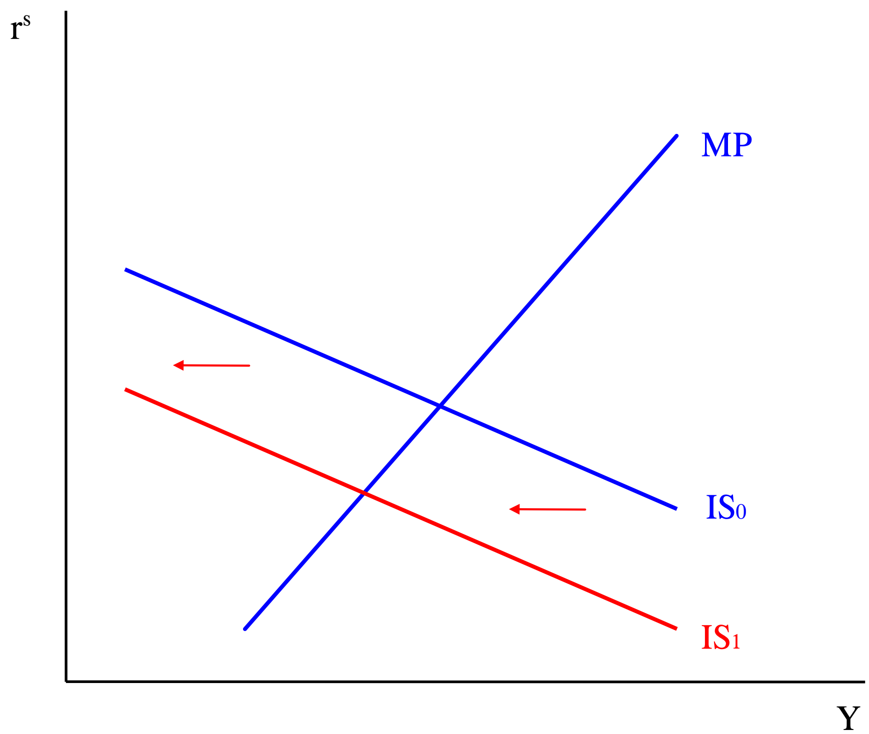

Figure V-6. The Effects of a Fall in Consumer Confidence

rate differential, $r^b - r^s$, rises. For a given r^s, a higher differential reduces output. Thus the rise in the differential is an additional force pushing output down.

The fact that the presence of interest rate differentials magnifies the effects of other forces that affect output is known as the "financial accelerator."[5] The intuition for the accelerator is easiest to see for the case of something that acts to raise output. As output rises, the financial health of firms and households is likely to improve, and the values of any assets they use as collateral for their loans are likely to rise. These developments make loans to firms and households less risky, and thus lower the interest rate on loans for a given rate on saving. This increases investment

[5] A more accurate term might be "financial amplifier". But "financial accelerator" is standard, so we will use that.

demand, and so raises output further.[6]

Finally, notice that there are two competing effects on the borrowing interest rate, r^b. The fact that r^s falls tends to decrease r^b, but the fact that $r^b - r^s$ rises tends to increase it. The overall effect can go either way. If the interest rate differential is quite responsive to output – that is, if the d(Y) function is fairly steep – and if the MP curve is fairly flat, r^b rises. But in the opposite case (a flat d(Y) function and a steep MP curve), r^b falls.

A Disruption to Credit Markets

Our second example is a disruption to credit markets. That is, suppose that for some reason – such as a decline in asset prices, the revelation of new information about risks, or the failure of some financial intermediaries – it is harder for borrowers to obtain loans *at a given level of output and of the saving real interest rate*.

In our model, this development corresponds to an upward shift of the d(Y) function. That is, the interest rate differential, $r^b - r^s$, is higher at a given level of Y than before.

To trace through the effect of the disruption, we start with the Keynesian cross, which is shown in Figure V-7. Recall that the Keynesian cross is drawn for a given value of the saving real interest rate, r^s, while investment depends on the borrowing real interest rate, r^b. As a result, the rise in the interest rate spread for a given Y means that r^b for a given Y is higher than before, and so

[6] Although the idea that changes in the differential magnify the impact of other factors affecting output is intuitive, it may not be immediately clear how to see this in the IS-MP diagram for IS shocks. Consider the fall in consumer confidence. The change in the interest rate differential makes the leftward shift of the IS curve larger, which tends to make the output effect larger. But we also know that the presence of the differential makes the IS curve flatter. For a given leftward shift of the curve, this acts to make the output effect smaller.

The best way to see that the overall effect is to make the output effect larger is to consider not the leftward shift of the IS curve, but the downward shift. At a given Y, there is no change in the interest rate differential. As a result, the presence of the differential has no effect on the amount that the fall in consumer confidence causes the IS curve to shift down. And for a given downward shift, a flatter IS curve makes the output effect larger. Thus the overall effect of the fact that the interest rate differential rises when output falls is to magnify the output effects of factors that shift the IS curve.

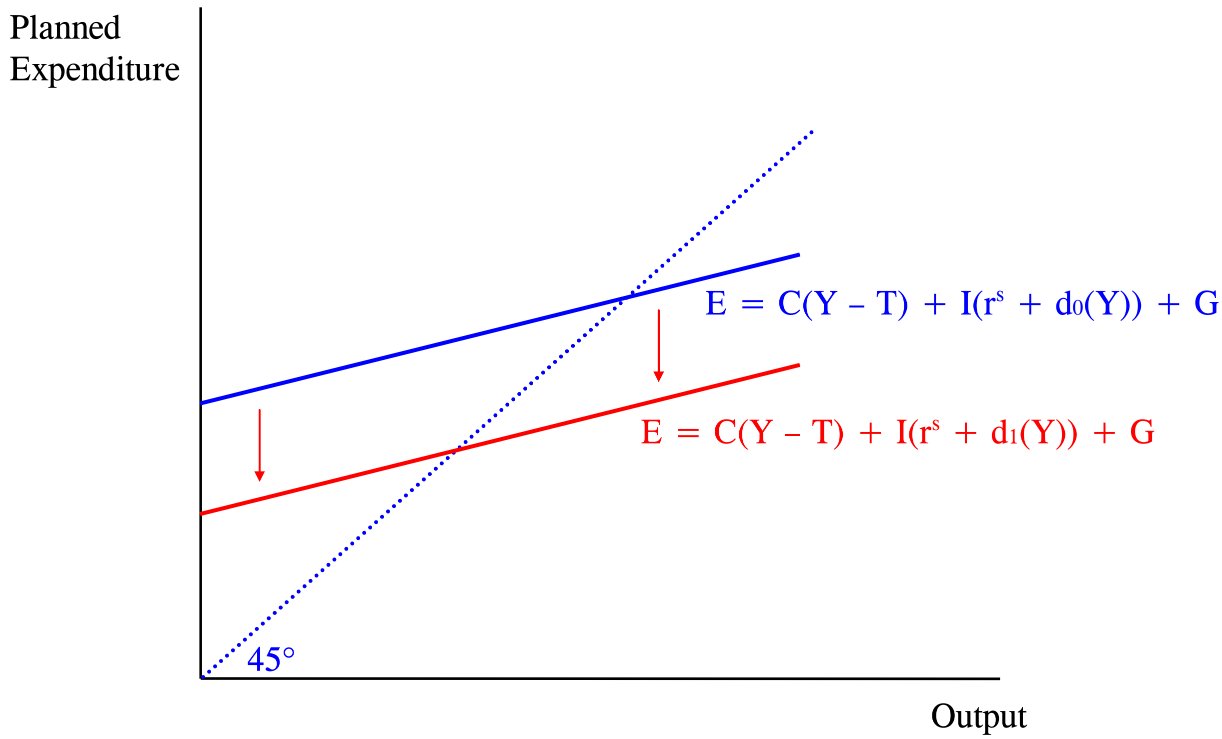

Figure V-7. The Effects of a Financial Market Disruption on the Keynesian Cross

investment is lower. Thus, as the figure shows, the planned expenditure line shifts down. From the Keynesian cross, we see that output at a given level of r^s is lower than before. This corresponds to a leftward shift of the IS curve in the IS-MP diagram. This is shown in Figure V-8.

The figure shows the effects of the financial disruption on the macroeconomy. The leftward shift of the IS curve reduces output, Y, and causes the central bank to cut the saving real interest rate, r^s. The bottom line is that a disruption of financial market can cause an economic downturn.

In our model, a full-blown financial crisis is just a very large increase in the interest rate differential at a given level of output – that is, it is a very large upward shift of the d(Y) function. Of course, financial crises have many different effects. But a crucial one is that for a given interest

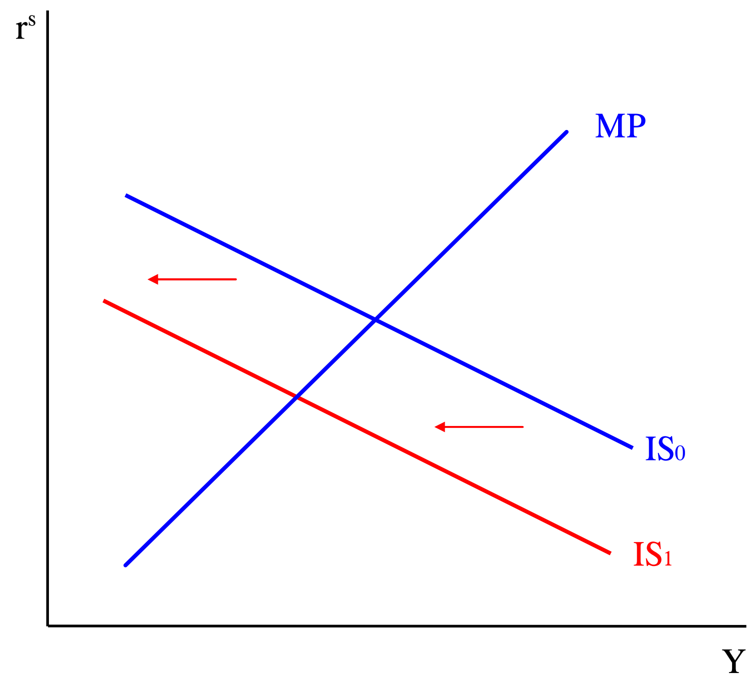

Figure V-8. The Effects of a Financial Market Disruption on the IS-MP Diagram

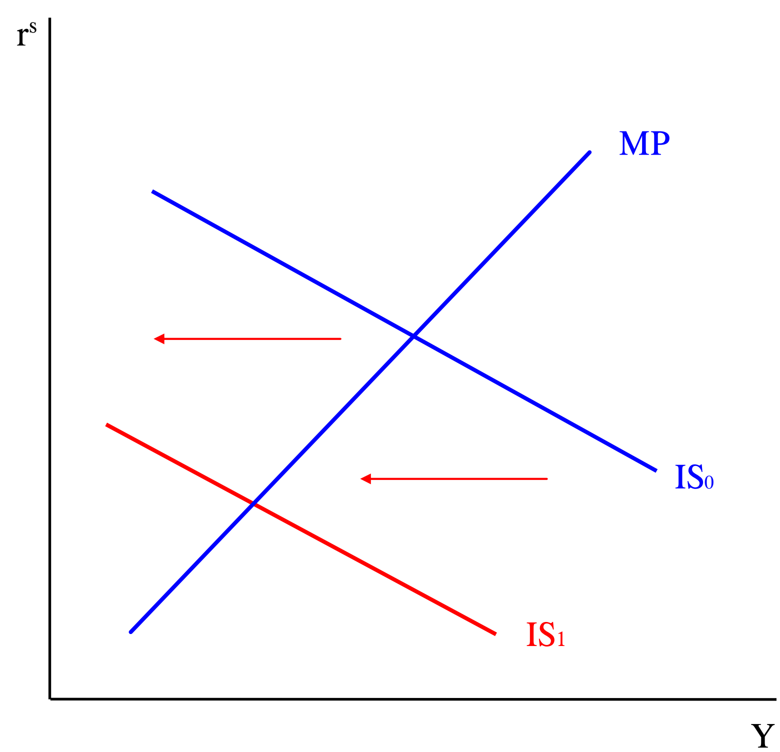

Figure V-9. The Effects of a Financial Crisis on the IS-MP Diagram rate received by savers, borrowers' costs and difficulty of obtaining loans are much greater.

The effects of a crisis are shown in Figure V-9. Qualitatively, they are like those of a credit market disruption shown in Figure V-8: the IS curve shifts to the left and output and the saving real interest rate both fall. The difference is that the effects are larger. In the extreme, financial crises can lead to depression (as occurred in the 1930s) or to the most severe recession in postwar U.S. history (as occurred in 2007–2009).

PROBLEMS

1. Suppose the central bank changes its interest rate rule to set a higher value of the saving real interest rate for a given level of output.

a. Show the effects of this change in the IS-MP diagram.

b. Describe whether this change increases, decreases, or has no effect on the following variables (or whether it is not possible to tell):

i. Output.

ii. The saving real interest rate.

iii. The borrowing real interest rate.

iv. The interest rate differential.

2. Describe how each of the following developments affects the IS and/or MP curves in the model of this section:

a. Government purchases increase.

b. The interest rate differential is no longer a function of output. Instead, it becomes constant at its level at the point where the IS and MP curves intersected before the change.

3. Consider a combination of a tax increase and a change in the central bank's interest rate rule that leaves output unchanged. We found in Section I-2 that in the basic IS-MP model, the combined effect of these changes was necessarily to lower consumption and raise investment. Does that conclusion continue to hold in the model with an interest rate differential?

4. Suppose financial innovations reduce the interest rate differential at a given level of output.

a. How, if at all, does this development affect output, Y, and the saving real interest rate, r^s? How does it affect the borrowing real interest rate, r^b?

b. Suppose we draw the IS and MP curves with the *borrowing* real interest rate, r^b, on the vertical axis (rather than with the saving real interest rate, r^s). With this way of presenting the model, how, if at all, do financial innovations that reduce the interest rate differential at a given level of output affect the IS and/or MP curves? How do they affect output, Y, and the borrowing real interest rate, r^b?

5. In Section V-1, we found that introducing an interest rate differential makes the IS curve steeper than it otherwise would be. How, if at all, does introducing an interest rate differential affect the slope of the AD curve?

6. Suppose monetary policy is constrained by the zero lower bound. Show the effects of a credit market disruption in this situation in the IS-MP diagram. Is the effect on output larger, smaller, or the same as it would be if monetary policy were not constrained (or is it not possible to tell)?

7. Suppose a credit market disruption causes the interest rate differential at a given level of output to rise. Suppose, however, that at the same time the central bank changes its interest rate rule in such a way that the borrowing interest rate, r^b, at a given level of output is the same as before the credit market disruption.

a. In order to do this, how, if at all, does the central bank need to change the saving interest rate, r^s, at a given level of output?

b. What, if anything, is the combined effect of the credit market disruption and the change in the interest rate rule on output and the saving real interest rate?