SHORT-RUN FLUCTUATIONS

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August 1999
This revision: January 2006

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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 material here can take the place of the material in Mankiw starting with Section 10-2 and ending with Chapter 13. 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.

In a separate paper, I compare the new approach with the usual one and explain why I believe it is preferable.[2] This document, however, simply presents the new approach and

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[1] N. Gregory Mankiw, *Macroeconomics*, fifth edition (New York: Worth Publishers, 2003).

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

shows how to use it. In addition, the presentation here is more skeletal than that in standard textbooks. The document 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, and to numerous correspondents for helpful suggestions. I am especially grateful to my students for their encouragement, patience, and feedback.

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:

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[1] See Mankiw, Section 10-1.

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

We can express this characteristic 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.

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. 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.

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.

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 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.

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 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

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

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 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 diagram 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 the composition of output. With income unchanged and taxes higher than before, 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.[3]

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 the enormous downturn that became known as the Great Depression.[4]

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[3] See Section 14-1 of Mankiw for more on why policymakers' control of the economy is not immediate or perfect.

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

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 existence of the MP curve. In this section, we will investigate how the central bank is able to do this. We will see that 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.[5]

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

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[5] See Section 4-5 of Mankiw.

be equal is

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

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 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

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

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

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

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

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

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:

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

The money market is no longer in equilibrium. One way for it to get back to an 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 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.[6] 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.

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, 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

[6] See Section 4-2 of Mankiw.

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

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

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

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 all of the response of prices occurs immediately after the increase in the money supply 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.

There is a second case where the central bank cannot influence the real interest rate. Suppose there is a situation where our usual assumption that the demand for real money balances is increasing in income and decreasing in the nominal interest rate is wrong. Specifically, suppose that people are willing to hold a greater quantity of real balances at the current levels of the interest rate and income. Suppose also that increases in the money supply do not raise expected inflation. In a situation like this, an increase in the money supply does not throw the money market out of equilibrium: although the increase raises the supply of real balances, people are wiling to hold the greater supply without any change in the real interest rate or output.

This case is certainly not a good description of the money market most of the time. But it may apply in situations where the nominal interest rate is very close to zero. In such situations, there is almost no opportunity cost to holding money, and so people may be perfectly willing to hold more real balances. And because they are willing to hold more real balances, an increase in the money supply need not cause prices to rise in the long run; as a result, it may not increase expected inflation.

A situation where monetary policy is powerless for these reasons is known as a *liquidity trap*. The great British macroeconomist John Maynard Keynes argued that the major world economies were in such a liquidity trap in the Great Depression. Until recently, most macroeconomists believed that the possibility of a liquidity trap was of little relevance today. But in Japan's depressed economy, nominal interest rates have been virtually zero since the late 1990s. Some economists therefore argue that Japan is in a liquidity trap. Others, however, believe that despite the very low nominal interest rates, increases in the money supply, if they were only tried, would increase expected inflation and thereby lower the real interest rate and stimulate Japan's economy.

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 Federal Reserve 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 Federal Reserve 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. 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 Federal Reserve 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 Federal Reserve 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 Federal Reserve keeps the money supply unchanged.

i. Does the interest rate rise or fall?

ii. What happens to consumption and investment?

3. Suppose the Federal Reserve 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).

4. 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 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

$$NX = NX(\varepsilon).$$

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:

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

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

$$E = Y.$$

[1] See Mankiw, Section 5-3.

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

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

[2] See Mankiw, Section 5-1.

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

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

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:

$$\boldsymbol{NX = CF,}$$

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,

$$\boldsymbol{CF = CF(r).}$$

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 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, $E = C(Y\text{-}T) + I(r) + G + NX(\varepsilon)$. The resulting expression is

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[3] See the appendix to Chapter 5 of Mankiw.

$$E = C(Y-T) + I(r) + G + CF(r).$$

We can use this expression to obtain the IS curve for this model. As before, we start with the Keynesian cross diagram 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 the interest rate rises. The increase in the interest rate 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 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 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]

[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.

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, 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 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

[5] See Mankiw, Section 5-1.

$$S = I + CF.$$

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 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 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 the surprising result that trade policies do not affect net exports 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.

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. Of course, a government cannot fix the exchange rate by fiat. Instead, it must participate in the foreign exchange market in a way that keeps its exchange rate 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 yens 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

$$CF = PCF + RG.$$

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

$$RG = NX - PCF.$$

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

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

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

$$RG \geq 0.$$

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[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:

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

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 simply 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 it 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 $\widetilde{MP}$ 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 $\widetilde{MP}$ 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 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.

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 shortly, a change in the fixed exchange rate). Those policies, unlike protection, do not create 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 $\bar{\mathbf{r}}$ and cause output to fall. The intersection of the new IS and $\widetilde{MP}$ curves is at point 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 an attractive 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 the following:

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, $\bar{Y}$, 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 work. 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 1982-1983, 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.

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[1] See Mankiw, Chapter 3.

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, say, 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 1982-1983 recession. Instead, below-normal output causes firms to raise their prices by less than before. Although inflation remained positive in the 1982-1983 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 in the late 1990s is a prominent example of such

[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.

exceptions. Output was well above its natural rate, but inflation did not increase at all. We will incorporate such exceptions into our analysis by allowing for the possibility of *inflation shocks*. The causes and consequences of such shocks are discussed in 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.

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. The higher is inflation, the higher is the real interest rate that the central bank sets. 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).

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 $Y = \bar{Y}$ line. In the case shown, it is to the right; that is, output is above its natural rate. According to our

[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 not realistic. We will therefore devote little attention to the case of fixed exchange rates in this section.

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 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

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[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 any important additional insights.

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. Remember that 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.[5] 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 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.

[5] See Mankiw, Section 10-1.

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. 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 curved 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 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 E^1_{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 E^1_{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 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 an increase in government purchases.[6]

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 (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.[7] 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

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[6] See Mankiw, Section 3-4.

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

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 would show 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 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 $\bar{Y}$, inflation continues to fall. All of this is shown in Figure III-12. The 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 $\bar{Y}$, 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).[8]

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 the end of 1982. Inflation fell rapidly. As it fell, the Federal Reserve

[8] See Mankiw, Chapter 4.

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

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

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

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

Solving this equation for π_{LR} gives us

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

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.[9] Because many different interest rate polices 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 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 decade central banks in many countries have succeeded in bringing inflation down to low levels and keeping it there.[10]

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[9] 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.

[10] 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 4). The way these two conclusions are related involves how the central bank controls the real interest rate. Recall

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 rate at which firms raise their prices -- that is, the inflation rate -- rises when

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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.

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, $\bar{Y}$. 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 $\bar{Y}$. 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 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 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 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 between five and six 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

Our final topic in this section is a 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 that 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 important 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 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.[11]

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[11] 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.

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. Sketch the AD curve when exchange rates are fixed.

6. 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.

7. Suppose the Federal Reserve, 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 Federal Reserve's target level of inflation, and b is some positive parameter. This rule states that the Federal Reserve 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 Federal Reserve reduces its inflation target, π^*.

8. 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. Do you agree or disagree with each of the following statements? Defend your answers.

a. "In the absence of inflation shocks, times of falling output cannot be times of falling inflation."

b. "In the absence of inflation shocks, times when output is below its natural rate cannot be times of falling inflation."