

## 2 AGGREGATE SUPPLY AND DEMAND: A SIMPLE FRAMEWORK FOR ANALYSIS

### Chapter 2 Contents

<b>A. Topics and Tools</b> .....	<b>1</b>
<b>B. Output and Prices</b> .....	<b>2</b>
<i>Levels or growth rates?</i> .....	3
<b>C. Aggregate Supply and Demand</b> .....	<b>4</b>
<i>Aggregate supply and the natural level of output</i> .....	4
<i>Upward-sloping aggregate supply</i> .....	6
<i>A fixed point on the short-run AS curve</i> .....	7
<i>Aggregate demand</i> .....	8
<i>Does the aggregate-demand curve slope downward?</i> .....	9
<i>Static equilibrium</i> .....	10
<i>Shocks to aggregate demand</i> .....	11
<i>Shocks to aggregate supply</i> .....	13
<b>D. Dynamic Equilibrium in the AS/AD Model</b> .....	<b>14</b>
<i>Why the AS curve shifts over time</i> .....	14
<i>Why the AD curve shifts over time</i> .....	15
<i>Equilibrium with growth and inflation</i> .....	16
<i>A “growth recession”</i> .....	18
<b>E. A Preview of Romer’s Text from the Perspective of AS/AD</b> .....	<b>19</b>
<i>Growth models</i> .....	19
<i>Real business cycles</i> .....	20
<i>The IS/LM and Mundell-Fleming models</i> .....	20
<i>Neoclassical and new Keynesian models</i> .....	21
<b>F. Suggestions for Further Reading</b> .....	<b>22</b>
<b>G. Works Cited in Text</b> .....	<b>22</b>

---

### A. Topics and Tools

Nearly every introductory and intermediate textbook on macroeconomics uses the framework of aggregate supply and aggregate demand to model the macroecon-

omy. Romer's text refers to this model occasionally, but never describes it in detail. This chapter presents a simple version of aggregate supply and aggregate demand that summarizes what most undergraduates learn about macroeconomics. The goal is not to cram a basic macroeconomics course into one chapter, but rather to describe a simple analytical framework that can be used to provide context for the detailed models we will study.

---

## B. Output and Prices

The central endogenous variables in aggregate supply-demand analysis are real output and the general price level. With the assignment of quantity to the horizontal axis and price to the vertical axis, the AS/AD model resembles the familiar supply-demand model of perfect competition. Indeed they are very similar in some ways, however it is extremely important not to push the parallels too far; some properties of the curves and models are very different.

The variables on the axes of the AS/AD model sound very much like the familiar quantity and price variables of microeconomics, but there are important differences. The quantity variable on the horizontal axis of the AS/AD model measures the total output of the economy (real GDP) rather than the physical output of some specific commodity. This leads to important differences in the interpretation of the curves. For example, the demand curve for zucchini slopes downward because consumers will substitute other foods as zucchini get expensive. In the macro model, GDP is *all* goods, so there is nothing obvious to substitute for GDP if it gets expensive.<sup>1</sup> Thus, in the macro context we cannot rely on the familiar logic of substitution to motivate the negative slope of the demand curve.

The price variable on the vertical axis is also fundamentally different. In the AS/AD model, price refers to the aggregate price of all goods and services—a price index like the GDP deflator—rather than the *relative* price of zucchini as in the micro model. Again, this has important implications for the behavior of the curves. An increase in *all* prices may not have any effect on either quantity supplied or quantity demanded if, along with the increase in prices, nominal wages and nominal stocks of assets such as money all increase in equal proportion. This is the familiar principle that the economy exhibits no *money illusion*—people care only about the real value of things, not about the number of dollars attached to them. If all dollar labels are redefined in a proportional way, nothing is more or less expensive than before and there is no reason for real purchases or sales to change.

---

<sup>1</sup> Future goods and foreign goods are possible substitutes. We'll have much more to say about such issues later on.

### *Levels or growth rates?*

The simplest form of the AS/AD model puts the *level* of GDP on the horizontal axis and the level of prices on the vertical axis. Putting the model in terms of levels has the advantage of simplicity: the unique point of intersection defines a unique equilibrium level of output and prices. This is the most common form of the model and is adequate as a momentary snapshot of the macroeconomy.

However, year-to-year growth of real output and inflation in the price level are the normal state in modern economies. We are often more interested in these rates of change than in the absolute level of GDP and prices. In order to capture this behavior, the “equilibrium point” in the levels version of the AS/AD model must be moving upward and to the right over time.<sup>2</sup> We can keep the model in terms of levels only if we are willing to discard the notion of a fixed point of long-run equilibrium and depict the long run as an equilibrium growth/inflation path involving a sequence of points of momentary equilibrium.

An alternative modeling strategy is to put the growth rate of output on the horizontal axis and/or the inflation rate on the vertical axis, modeling aggregate supply and aggregate demand in terms of percentage changes rather than levels of output and/or prices. By recasting the model in terms of rates of change, the economy may converge to a single point of long-run equilibrium on the graph: one where the growth rate of output and the rate of inflation are constant.

However, there are pitfalls with modeling rates of change as well. Putting the graphical analysis entirely in terms of growth rates means that there is no information on the graph about the *level* of output. Suppose that last year’s growth rate was unusually low, so the current level of output in the economy is below its long-run growth trend. Conventional macroeconomic theory suggests that such an economy would be expected to grow more quickly in the coming years to restore itself to the trend path. On the graph, this means that aggregate supply or aggregate demand (or both) must shift to the right when output is below trend in order to increase growth. In order to incorporate this into the graph, the position of the AD and AS curves must depend on the current *level* of GDP relative to a benchmark trend.

We shall model aggregate supply and demand in levels rather than growth rates. In the simple model that we introduce first, we ignore the tendency of output and prices to grow over the long run. Later in this chapter we will consider the nature of equilibrium with growth and inflation.

---

<sup>2</sup> Or downward in the case of deflation and to the left in the case of economic contraction.

---

## C. Aggregate Supply and Demand

We use the supply curve and the demand curve in competitive microeconomic markets to represent, respectively, the behavior of the producers and buyers of a commodity. By examining the interaction of the two curves and imposing an assumption of market clearing, we model the equilibrium levels of quantity exchanged and price at the intersection of the two curves.

The aggregate supply (AS) curve and aggregate demand (AD) curve perform similar roles for the aggregate macroeconomy. The AS curve summarizes the behavior of the production side of the market: the production decisions of firms and the activities in the markets for factor inputs. The AD curve summarizes desired purchases in the macroeconomy and the activities of asset markets that influence demand behavior.

Like microeconomic supply curves, the AS curve often slopes upward, though the underlying logic justifying its shape is quite different. The AS curve can be horizontal or vertical under some conditions. Unlike microeconomic supply curves, which tend to be more elastic in the long run than in the short run, the AS curve is perfectly inelastic (vertical) in the long run and may be highly elastic (flat) in the short run. The AD curve is generally downward-sloping, just as the microeconomic demand curve is, but again the reasons for the negative slope and the conditions under which it is elastic or inelastic are quite different.

### *Aggregate supply and the natural level of output*

In microeconomic markets, the positive slope of the supply curve is very natural. If a single good becomes more valuable relative to other goods (*i.e.*, its relative price increases) then firms will devote more of their productive activity to producing that good, taking resources away from production of other goods.

However, this logic does not work the same way in the aggregate macroeconomy. A price increase in the macroeconomy means that the prices of *all* goods have increased. Will this across-the-board price increase impel firms to use more resources to produce goods and services? Maybe, but not necessarily.

The benchmark model of neoclassical economics is the perfectly competitive general equilibrium (PCGE) model. This is the core model of most microeconomics courses; it is the model that most economists think of first when trying to answer questions about market economies.

In the PCGE model, the prices of all goods and inputs are perfectly flexible, all agents are perfectly informed, entry and exit are costless, and no one has any market power. Because buyers and sellers are price-takers, there are well-defined demand and supply curves relating quantities demanded and supplied to price. The quantity

of each good and service produced and sold is determined uniquely by the point of intersection of the supply and demand curves.

In competitive *general* equilibrium, every commodity in the economy has a perfectly competitive market. Relative prices adjust freely upward and downward in each market based on the relative scarcity of the commodity. Each commodity has a unique equilibrium quantity produced and sold.

If we were to add up the real value of all of the commodities produced in equilibrium of the PCGE model, we would obtain a unique value of GDP that reflects the equilibrium amount of production. This unique equilibrium quantity of aggregate output in the PCGE model is called the *natural level of output*, or sometimes capacity output or full-employment output. Theorems of welfare economics assure us that the competitive equilibrium allocation of resources (and therefore the amount produced) is Pareto-optimal, given the amounts of factors of production that are available and the optimal decisions by laborers about allocating their time between work and leisure.

Although natural output is crucially important for macroeconomic theory and policy, it cannot be directly observed. Policymakers must try to estimate the amount that could or should be produced with the current technology and resource endowments in order to know whether current actual output is too low or too high.

The natural level of output does not depend on the dollar value of prices in any way. PCGE determines an equilibrium *relative* price for each commodity. For example, equilibrium might require that apples be half as expensive as bananas and that the real wage of unskilled labor be 10 apples per hour of work. However, whether this is achieved by apples costing \$0.10, bananas \$0.20, and a nominal wage of \$1.00 or by apples costing \$500, bananas costing \$1,000, and a nominal wage of \$5,000 is completely irrelevant to PCGE model equilibrium. Any price level is consistent with production at the natural level of output.<sup>3</sup>

If the world behaved according to the PCGE model, real GDP would always equal the natural level of output ( $Y_n$ ) regardless of the nominal level of aggregate

---

<sup>3</sup> The aggregate dollar price level reflects (inversely) the relative price of the dollar. The PCGE model does not determine the aggregate price level unless we introduce money as one of the commodities. When money is a commodity that has traditional uses, such as gold, its price can be determined in a competitive market within the PCGE model. Modern monetary economies use fiat money, which has no intrinsic value and no use other than in exchange for commodities. PCGE models usually assume that exchange is costless, thus there is no need for agents to hold money in order to reduce transaction costs. If no one needs to hold money, then there is no demand for it—money will have a zero price and the aggregate dollar price level will be undefined. In order to establish an equilibrium price of money (and a finite aggregate dollar price level), we must examine the demand for money, which is a central feature of traditional macroeconomic models.

prices in the economy. Thus, the assumptions of the PCGE model lead to a vertical aggregate supply curve at  $Y = Y_n$ .

### ***Upward-sloping aggregate supply***

Most macroeconomists believe that the PCGE model provides a reasonable first approximation of macroeconomic behavior in the long run, so we usually take the long-run aggregate supply curve to be vertical. This implies that the economy will return to the natural level of output (full employment) in the long run as equilibrating forces pull it back to the vertical long-run AS curve.

However, from a macroeconomic perspective, a vertical AS curve eliminates a lot of interesting possibilities. With a vertical AS, the level of output is always at  $Y_n$  regardless of how the AD curve fluctuates: aggregate demand has no effect on output. Ever since Keynes's analysis of the Great Depression, most economists have been convinced that changes in aggregate demand *do* affect output, at least temporarily, thus the vertical AS curve seems like an inadequate description of macroeconomic supply behavior.

There are multitudes of theories explaining why the short-run AS curve might slope upward. We will study several of these theories in Romer's Chapter 6, so there is no need to elaborate the details now. A couple of examples should demonstrate the nature of elastic short-run supply.

One possibility is that firms face costs of changing their prices. These costs are often called "menu costs," as in the costs a restaurant faces when it is forced to re-print all of its menus to reflect changed prices. In that case, if there is upward pressure on nominal prices due to an increase in aggregate demand, some firms may choose not to raise their prices immediately. The relative prices charged by these firms will be lower and they will sell more output as a result. Thus, in the presence of menu costs, some firms will raise prices and others will increase production, so in the aggregate there will be an increase in both prices and output along an upward-sloping short-run AS curve.<sup>4</sup> Note that in this case we would expect all firms *eventually* to change their prices (once the old menus wear out), so the justification for an upward-sloping AS curve holds only in the short run. We still expect the long-run response to be an increase in all nominal prices with production back at  $Y_n$ , so the long-run AS curve is vertical.

Another possibility is that some of the firm's nominal costs fail to rise along with prices. For example, if wages are set in nominal contracts that last a year or more, an

---

<sup>4</sup> Note also that we have already strayed from one of the key assumptions of the PCGE model. Price-taking firms cannot defer their price change; they must charge the market-clearing price. If a few firms kept their prices low in a perfectly competitive market, all buyers would attempt to buy from them, forcing them to increase production dramatically, which would increase costs and force them to raise prices.

increase in prices would temporarily raise the firm's revenues relative to their (labor) costs. This would make it profitable to expand output in the short run while this gap between revenues and costs exists. Once again, production increases and prices rise in the short run, so the short-run AS curve slopes upward. However, as in the previous example, we would expect production eventually to return to  $Y_n$  at the higher price level. In this case, nominal wages would rise when contracts expire and workers whose cost of living has increased bargain for a compensating wage increase. Thus, again, the long-run AS curve is vertical.

### ***A fixed point on the short-run AS curve***

The two simple aggregate-supply theories sketched above have several characteristics in common. As we shall see later, these characteristics are shared by most short-run aggregate-supply models. Two important characteristics have been stressed above: (1) the short-run AS curve slopes upward and (2) the long-run AS curve is vertical at  $Y_n$ .

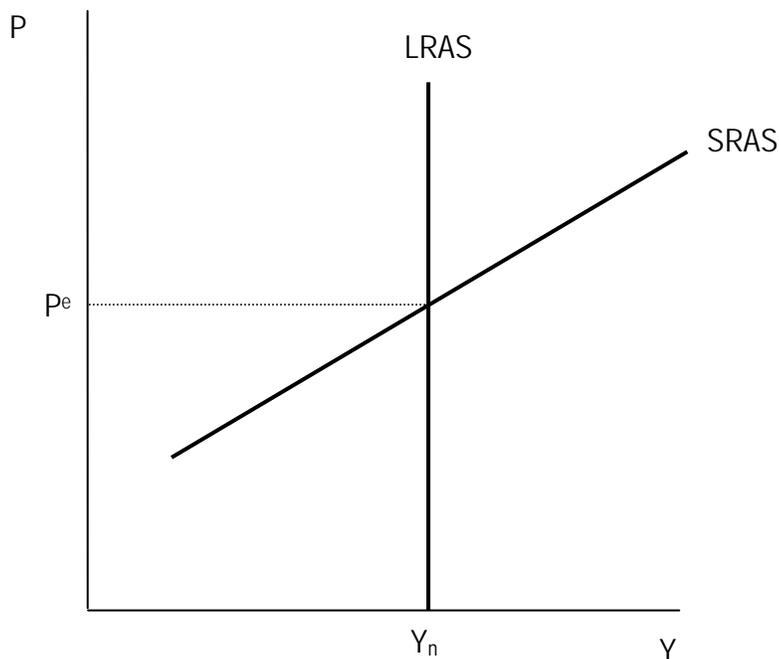
A third property that connects the short-run and long-run supply curves is less obvious: the short-run AS curve passes through the vertical long-run AS ( $Y = Y_n$ ) at the *expected price level*. Thus, the point  $(Y_n, P^e)$  always lies on the short-run AS curve.

We can explain the logic of this "fixed point" on the AS curve for the two simple models discussed above. With menu costs, we assume that the prices that firms have set for this period (and printed on their menus) are those that they expected to prevail at the time the menus were printed. Thus, if aggregate demand turns out to be as expected, firms will have set the appropriate prices and the economy will be in PCGE with  $P = P^e$  and  $Y = Y_n$ . When AD is higher than expected,  $P > P^e$  and  $Y > Y_n$ .

In the wage-contract model, we assume that firms and workers try to set the nominal wage in a way that leads to the PCGE real wage  $(W/P)^*$ . If they expect the price level to be  $P^e$ , then they set the nominal wage at  $\bar{W} = P^e \cdot (W/P)^*$ . If aggregate demand is as expected and the price level actually turns out to be  $P^e$ , then the actual real wage will be  $\bar{W} / P^e = (W/P)^*$  and the economy will be in PCGE. If aggregate demand is unexpectedly high and the price level exceeds  $P^e$  then the real wage will be lower than  $(W/P)^*$  and firms will expand production.

To summarize the conventional properties of aggregate supply, as depicted in Figure 1:

- The long-run AS curve is vertical at  $Y = Y_n$ . In the long run, changes in aggregate demand affect only the price level and not the level of real output.
- The short-run AS curve slopes upward and passes through the point where  $Y = Y_n$  and  $P = P^e$ . In the short run, increases in aggregate demand lead to increases in both price and real output.



**Figure 1. Short-run and long-run aggregate supply curves**

***Aggregate demand***

The aggregate-demand curve summarizes the desired spending behavior of consumers, firms buying durable plant and equipment, governments, and (in an open economy) foreigners. There are many ways to model aggregate demand—some simple and some very complex. We will spend some time looking at aggregate-demand models, although in many of our models we use a simple “place holder” for AD and focus on the details of aggregate supply. The closer focus on aggregate supply is because alternative aggregate-demand theories tend to have similar outcomes whereas the supply side has been highly controversial.

Aggregate demand rises when households, firms, and governments decide to increase their expenditures. There are many reasons why this could happen: increased optimism by households about their lifetime incomes, increased optimism by firms about their need for plant and equipment, stimulative fiscal policy that increases government purchases directly or lowers taxes to stimulate private spending, a depreciation of the dollar that makes domestic goods cheaper for foreign buyers, etc.

In macroeconomics, emphasis is often placed on the effects of monetary conditions and monetary policy on aggregate demand. As we shall discuss briefly later in

the course, an expansionary monetary policy involves the central bank (the Federal Reserve System in the United States) increasing the supply of monetary assets and, in the process, driving down nominal interest rates on very-short-term loans between financial institutions.

The combination of more plentiful monetary assets and lower interest rates tends to stimulate households' and firms' desire to spend. In the simplest sense, households that find that they hold additional wealth in the form of monetary assets may simply spend some of it. More subtly, lower (real) interest rates encourage spending by reducing the reward to saving and the cost of borrowing to finance expenditures on houses, cars, and college educations. For businesses, lower real interest rates reduce the cost of borrowing to invest in plant and equipment. If the reduction in the nominal interbank rate targeted by the central bank diffuses through the market to lower real rates on the interest-bearing assets bought and sold by households and firms, then monetary policy may act through an interest-rate channel.

### ***Does the aggregate-demand curve slope downward?***

We mentioned above that we cannot use the substitution logic of the microeconomic demand curve to justify the downward slope of the AD curve. So why should the AD curve slope downward at all? After all, when the PCGE assumptions are satisfied, the AS curve is perfectly inelastic: an increase in all nominal prices doesn't affect real production at all.

The fundamental reason why the AD curve slopes downward is that there are some assets whose value is fixed in nominal (dollar) terms, most notably money itself. If the prices of all goods and services increase with no change in the amount of money, then the real value (in terms of purchasing power) of people's money balances will decline, leaving them with less "liquidity" than they want. Another way of thinking of this is that if prices rise, people will need a greater number of dollars in order to finance their transactions. If the nominal supply of dollars doesn't change, they will be left short of liquid, monetary assets.

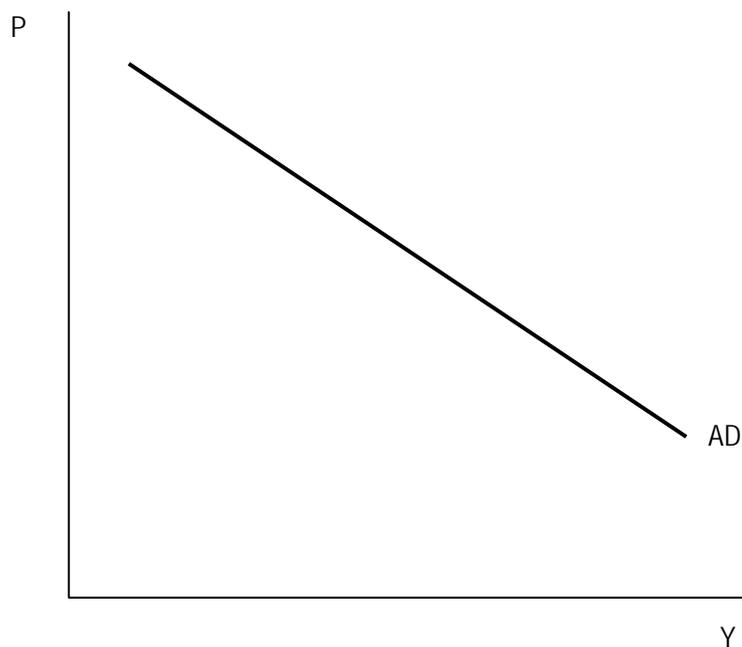
Households and firms may respond in several ways to a shortage in their money balances. One way of trying to get more money is to reduce expenditures, holding onto money instead of spending it. This would lower the quantity of real purchases demanded directly.

Another response would be to sell some non-monetary assets such as interest-bearing bonds in order to attempt to restore money holdings. But remember that the price increase applies to everyone in the economy, so everyone will be trying to augment their money balances at the same time. If everyone tries to sell bonds at the same time, there will be no buyers. Only by making the bonds more attractive will buyers emerge and the primary way of making bonds more attractive is to raise the interest rate. Thus, an excess demand for money balances is likely to lead to a rise in

interest rates, which encourages saving over spending and discourages firms from taking on debt in order to invest in real capital.

Through either or both of these mechanisms (or a couple of others), an increase in the aggregate price level lowers the desired spending by households and firms. Thus, the aggregate demand curve slopes downward as shown in Figure 2, although it is not necessarily a straight line as the figure suggests.

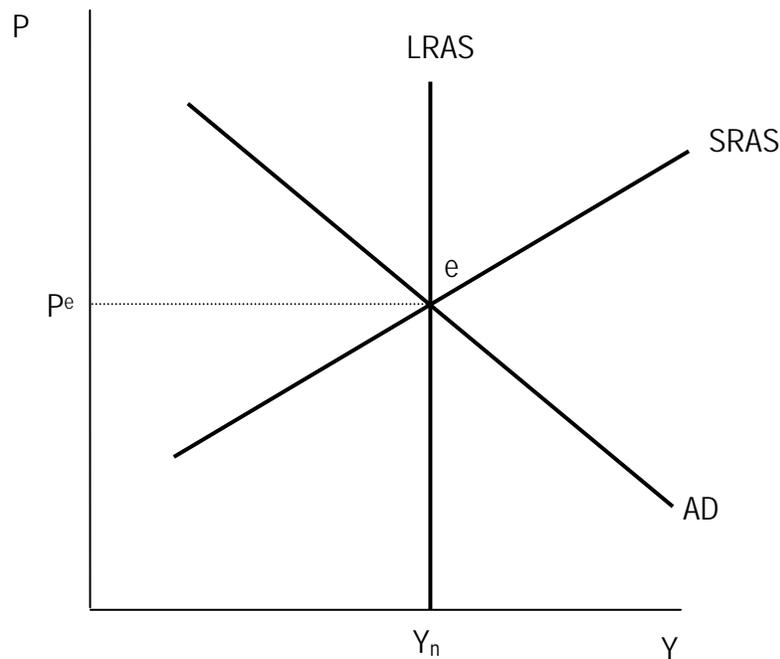
As noted above, changes in monetary or fiscal policy will shift the aggregate demand curve, as will anything that affects desired expenditures. For example, changes in optimism about the future, stock-market fluctuations, or changes in international conditions that affect imports and exports can all lead to shifts in the AD curve.



**Figure 2. Aggregate demand curve**

### ***Static equilibrium***

It is probably obvious that the short-run equilibrium of the economy occurs at the intersection of the aggregate demand and short-run aggregate supply curves and that the long-run equilibrium is where the aggregate demand curve intersects the long-run aggregate supply curve. The situation depicted in Figure 3 shows a state of long-run and short-run equilibrium at point  $e$ . If the aggregate demand curve and aggregate supply curves were to remain unchanged, the economy would continue to produce  $Y_n$  and have a price level of  $P^e$  indefinitely.



**Figure 3. Long-run equilibrium**

However, as noted above, there are many reasons why the AD and AS curves could shift. In the next section, we consider ongoing changes such as steady growth in natural output and sustained inflation. Here we examine one-time changes as perturbations from a static equilibrium such as a point  $e$ .

### ***Shocks to aggregate demand***

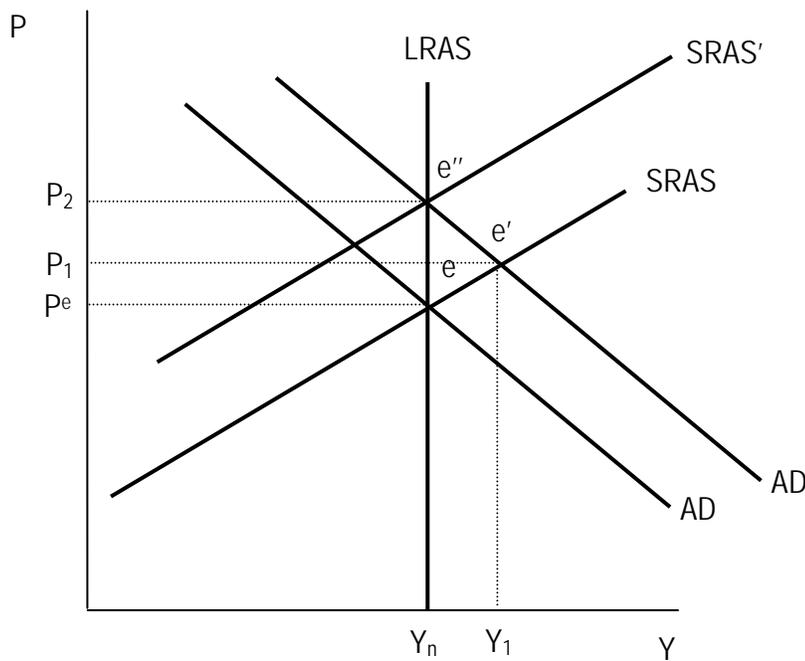
Consider first the effects of a one-time unexpected exogenous positive shock to aggregate demand. This could arise from an expansionary monetary policy action, an expansionary fiscal policy action, or an increase in desired expenditures from another source. An increase in aggregate demand shifts the AD curve to the right; more output is demanded at each level of the aggregate price index.<sup>5</sup>

---

<sup>5</sup> We begin all of our experiments from an initial point of long-run equilibrium. This allows us to examine the short-run and long-run effects of the shock without “interference.” If we were to begin from any other situation, two separate effects would be occurring at the same time: (1) the natural adjustment process from the initial situation to long-run equilibrium, which would have occurred in the absence of any shock, and (2) the effects of the shock. Beginning from full employment sometimes seems counterintuitive when the shock in question is a change in macroeconomic policy, since expansionary monetary and fiscal policy is usually used when the economy is believed to be operating below the natural level of output.

Since the change in AD is unexpected, the expected price level remains at  $P^e$  and since the natural level of output  $Y_n$  does not depend on aggregate demand, the aggregate supply curves do not shift. Point  $e'$  in Figure 4 shows the short-run effect of the aggregate demand increase. Output increases in the short run to  $Y_1$  and the price level rises to  $P_1$ .

Assuming that the change in aggregate demand is permanent, price expectations will adjust upward in the long run following the increase in actual prices. As the expected price rises, the short-run aggregate supply curve must move upward with it because the SRAS always passes through the point where  $Y = Y_n$  and price equals the expected price. The expected price and the SRAS will continue to shift upward until the economy reaches point  $e''$  in Figure 4, with the price level rising further to  $P_2$  and output returning to the unchanged natural level.



**Figure 4. Effects of an increase in aggregate demand**

Thus, a one-time change in aggregate demand affects both output and prices in the short run, but affects only prices in the long run. One application of this result is the concept of *monetary neutrality*. Since increases in the money supply are one cause of aggregate demand changes, this model shows that monetary expansion will have no effect on real output in the long run: money is neutral. Moreover, although it is not obvious from the graphs, the increase in price that re-establishes long-run equili-

Equilibrium is in exact proportion to the monetary expansion. A 10% increase in the money supply leads to a 10% increase in the long-run equilibrium price level, leaving the *real* quantity of money unchanged. There are 10% more dollars in circulation, but they buy the same amount of stuff because all goods cost 10% more.

### ***Shocks to aggregate supply***

The most important kinds of supply shocks are those that affect the natural level of output in the economy. For example, an improvement in production technology or an increase in the amount of labor or capital resources available would increase the aggregate amount produced in PCGE and thus shift both the long-run and the short-run AS curves to the right. A storm that destroyed agricultural crops or a sudden interruption in the availability of imported inputs such as oil might cause a reduction in  $Y_n$  and a shift to the left in the AS curves.<sup>6</sup>

Figure 5 shows the effects of a positive shock to aggregate supply that increases the natural level of output from  $Y_n$  to  $Y_n'$ . Assuming no change in the expected price level, both the LRAS and SRAS curves shift to the right so that the SRAS curve passed through  $(Y_n', P^e)$ . If aggregate demand does not change, the short-run equilibrium of the economy is at  $e'$ , with output increasing only to  $Y_1$  (by less than the full increase in natural output) and price falling to  $P_1$ . At  $e'$  the economy is actually below its natural output, but it is unlikely that policymakers or the general public would easily recognize this gap because  $Y_n$  is not directly observable and the absolute level of output has increased.

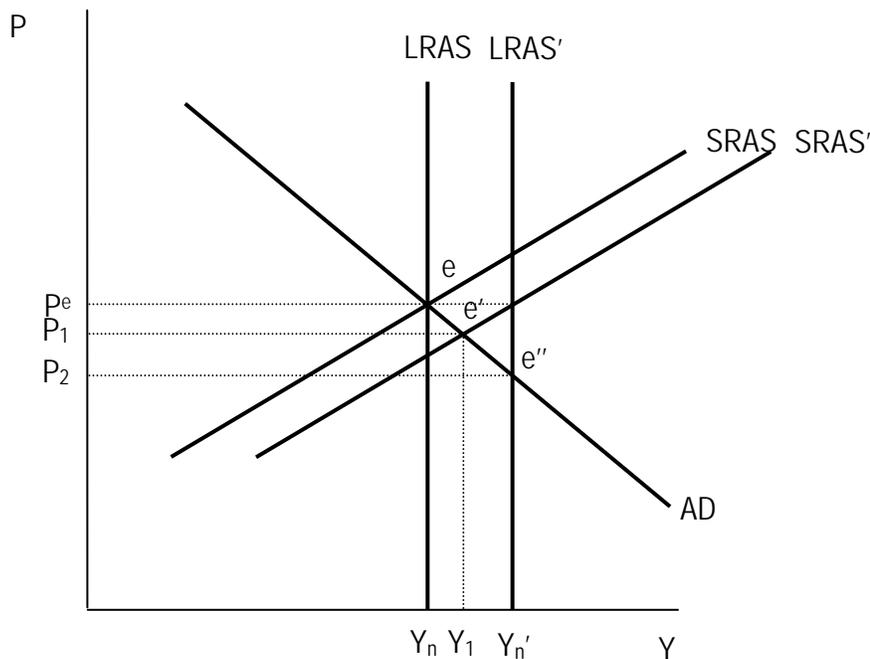
In the long run, the expected price level will adjust downward following the decline in prices. The eventual equilibrium of the economy will occur at  $e''$ , with price falling further to  $P_2$  and real output increasing to the new natural level.

The one-time shocks depicted in Figure 4 and Figure 5 are interesting and they illustrate the short-run and long-run effects of demand and supply shocks. However, they are unrealistic in one important way: the economy in which they occur has neither ongoing growth in natural real output nor inflation of the price level.

Since output in nearly all modern economies is growing over time and inflation is a common phenomenon in most, we should also examine how the AS/AD model can be used to demonstrate the equilibrium evolution of such economies. We now turn to that task.

---

<sup>6</sup> Was the 2008 financial-market disruption that curtailed many firms' access to financial capital a supply shock or a demand shock? The monetary and financial system is usually modeled as part of the demand side but constraints on the ability of firms to produce are supply shocks.



**Figure 5. Effects of an aggregate supply shock**

## D. Dynamic Equilibrium in the AS/AD Model

Modern economies grow; they don't stand still at a stationary point of equilibrium. If natural output and the determinants of aggregate demand (in particular, the money supply) are growing over time, then the economy does not remain perpetually in a static equilibrium such as the one depicted by point  $e$  in Figure 3. Instead, the whole system of AD and AS curves shifts over time, tracing out a dynamic time path of momentary equilibrium points. In this section, we first discuss why we would expect AS and AD curves to shift, then we examine the kind of equilibrium path that would result from steady growth in natural output and the money supply.

### *Why the AS curve shifts over time*

Economic growth theory, which will occupy us for the first third of the semester, explains how and why the natural level of output increases over time. We will preview the main factors here, then we dive into the details of growth theory in the next chapter.

Recall that the natural level of output is the amount produced at full employment under perfect competition. With labor and capital resources fully employed, an increase in the amount of labor or capital available leads to a rise in natural output. Similarly an increase in the technological efficiency of production would result in greater natural output. Thus, in simple terms, we can think of  $Y_n$  as reflecting the amount of output that can be produced by the available quantities of labor and capital using the best available technology.

The labor force in most countries increases from year to year. Investment by firms in new capital typically exceeds the amount of old capital depreciating, so the amount of capital input also usually grows over time. Finally, technological progress means that economies are able to get more output from their resource inputs. Through growth in labor and capital inputs and technological progress, the natural level of output tends to grow steadily over time, pushing the aggregate supply curves to the right. On a “steady-state growth path”—a concept to be defined more carefully in the next chapter—the annual percentage rate of growth in natural output would be constant, with the long-run aggregate-supply curve shifting to the right by a constant proportional amount each year.

### ***Why the AD curve shifts over time***

The rightward shift in the aggregate demand curve over time is somewhat more complicated to explain than aggregate supply without resorting to formal, mathematical analysis. To keep our initial exposition simple, we fall back on a simple demand model that affords a simple explanation that will suffice for most purposes.

The ***quantity theory of money*** is a classical proposition that held sway in the early 20<sup>th</sup> century. It asserts that people desire a stable, proportional relationship between the stock of liquid money they hold and the flow of expenditures they make. For example, someone might desire on average to keep one month’s worth of expenditures in the bank, so that their average holding of money was  $\frac{1}{12}$  of their annual expenditure. Thinking of this in another way, if everyone behaves this way the average dollar is spent 12 times per year, which we call the ***velocity of money***.

Money balances, expenditures, and velocity are linked by the ***equation of exchange***, which is a tautology:  $MV = PY =$  total nominal expenditures. If we take the velocity of money to be constant (which might not always be a reasonable thing to do), then we can solve the equation of exchange for real output  $Y$  as  $Y = MV/P$ . Taking the  $Y$  on the left-hand side to be the quantity of real output demanded, this becomes a very simple mathematical representation of an aggregate-demand curve, but it has several realistic properties: it slopes downward in price and responds proportionally to changes in the money supply. Although the constant-velocity behavior is very simplistic, we will find it convenient to use this simple AD curve frequently when we are not concerned with the details of aggregate demand.

This simple AD curve shows an important mechanism by which aggregate demand moves in the long run: growth in the money supply. Most central banks accommodate growth in the economy's transaction volume (as  $Y$  grows) by expanding the supply of money. The growth in  $M$  pushes the AD curve up and to the right in proportion to the monetary expansion. It looks from the equation of exchange that other factors such as fiscal policy and expenditure behavior of the public would not affect AD. This is not true; these kinds of shocks can enter the simple AD curve as changes in velocity.

You can see from the equation of exchange that if the central bank expands the money supply at the same rate that real output is growing (and if velocity is constant), then prices will be stable. The increases in  $M$  on the left and  $Y$  on the right will exactly balance with no change in  $V$  or  $P$ . If money growth exceeds real-output growth, then the quantity theory predicts that prices will rise to maintain the equation—there will be positive price inflation. If money growth falls short of output growth, then prices will tend to fall over time, which we call deflation.

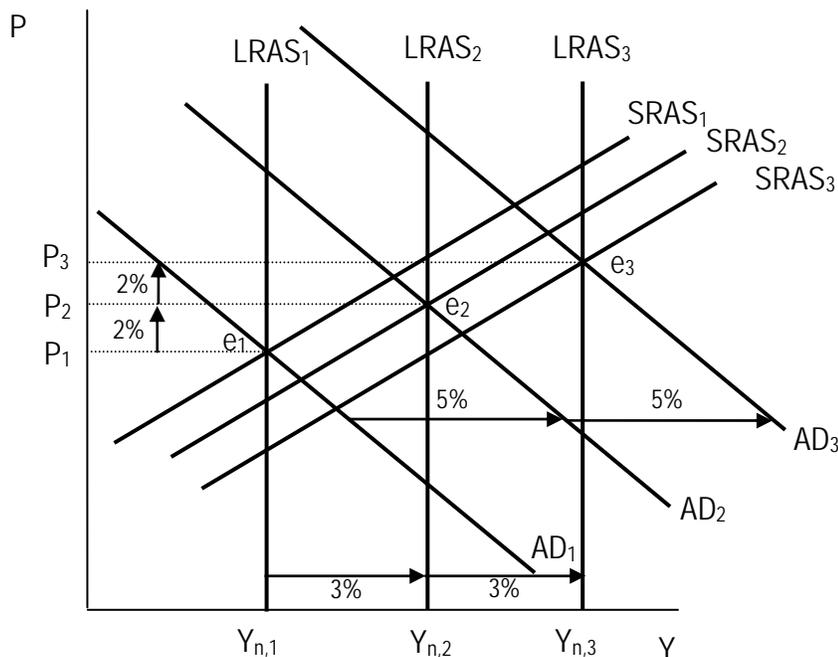
### ***Equilibrium with growth and inflation***

We have now established engines that can push the aggregate supply and aggregate demand curves to the right over time. Figure 6 shows a sequence of equilibria in an economy with both growth and inflation. Growth in labor, capital, and technological capability is increasing the natural level of output by 3 percent each year, from  $Y_{n,1}$  to  $Y_{n,2}$  to  $Y_{n,3}$  over the three years shown in Figure 6. This means that the LRAS curve is moving to the right as shown, by 3 percent per year.

The money supply is growing at 5 percent per year, which shifts the aggregate demand curve upward and to the right by 5 percent each year. This is shown as  $AD_1$ ,  $AD_2$ , and  $AD_3$  in Figure 6. (From the equation of exchange you can see that the AD curve should not be linear. It is drawn as a straight line in the figure to simplicity.)

We assume that the behavior of the money supply and aggregate demand are correctly predicted by everyone in the model—this is a smooth, ongoing process of growth and inflation with no shocks or surprises. Thus, price-setters and wage-setters would correctly anticipate that the price level would be  $P_1$  in the first period,  $P_2$  in the second period, and  $P_3$  in the third period. Since the SRAS curve always intersects the LRAS at the expected price level, it would move as shown by the  $SRAS_1$ ,  $SRAS_2$ , and  $SRAS_3$  curves in Figure 6.

Thus, the sequence of equilibrium will be traced out by the intersections of the AD and SRAS (and LRAS) curves at  $e_1$ ,  $e_2$ , and  $e_3$ . With AD shifting up 5 percent each year and AS shifting only 3 percent, the difference of 2 percent will be the increase in the price level. Thus, the economy pictured in Figure 6 would have a steady rate of inflation of 2 percent.



**Figure 6. Inflationary growth in the AS/AD model**

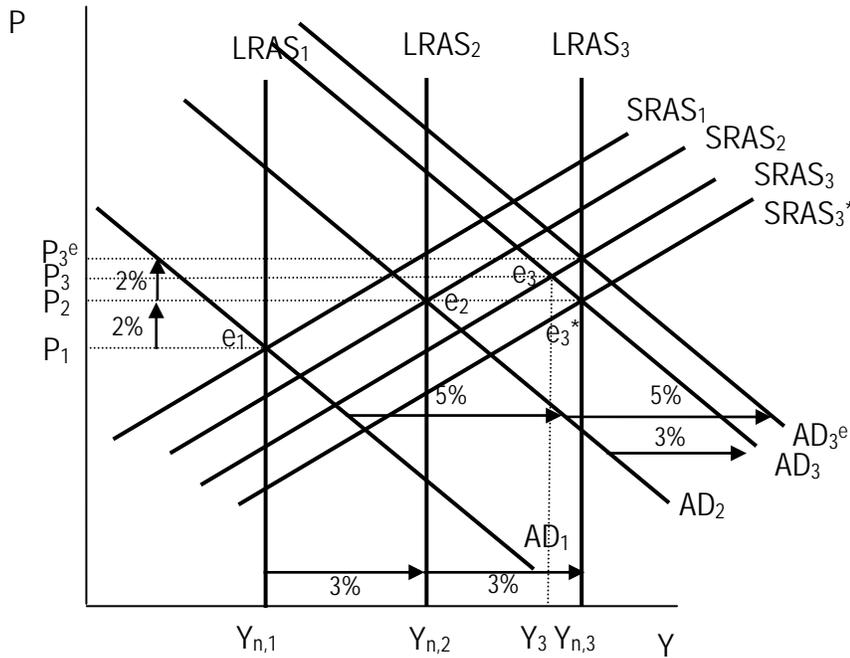
Are the points of equilibrium shown in Figure 6 short-run equilibria or long-run equilibria? They are certainly short-run equilibria because they are at the intersection of the AD and SRAS curves. They are also long-run equilibria in the same sense because they are intersections of the AD and LRAS curve. However, calling something a long-run equilibrium that is obviously changing from year to year seems awkward.

This is the difficulty we discussed at the beginning of the chapter with modeling aggregate demand and supply in terms of levels of  $Y$  and  $P$  rather than growth rates. On a diagram with the rate of inflation on the vertical axis and the rate of output growth on the horizontal axis, the sequence of  $e$  points in Figure 6 would be a single, stable point of equilibrium with output growth of 3 percent and inflation of 2 percent. Since we will not use the AS/AD apparatus formally in this course, it is not worth a detailed derivation of the alternative forms of the curves. As discussed just below, in growth models we ignore aggregate demand altogether while in our models of business cycles we will usually ignore the ongoing growth of natural output. This avoids the problem of combining growth and fluctuations around the natural growth path at the same time.

**A “growth recession”**

The dynamic equilibrium diagram of Figure 6 can also be used to show the effects of a slower-than-expected growth in aggregate demand. Suppose that the equilibria in periods one and two are as shown at  $e_1$  and  $e_2$  in Figure 6, which are replicated in Figure 7. Everyone expects that aggregate demand in period three will continue to grow at 5 percent, as shown by  $AD_3^e$  in Figure 7. However, suppose that in period three the central bank reduces money growth from 5 percent to 3 percent in an effort to eliminate inflation. This means that the actual aggregate demand curve in period three is at  $AD_3$ , below the expected level.

Since inflation expectations were formed based on the expected AD curve  $AD_3^e$ , expected inflation is still 2 percent and the expected price level is  $P_3^e$ . This means that the SRAS curve still shifts to  $SRAS_3$  based on the 2 percent expected inflation. However, since actual aggregate demand is  $AD_2$ , the equilibrium of the economy in period three is at  $e_3$  in Figure 7, with output  $Y_3$  lower than the natural level  $Y_{n,3}$  and prices still rising somewhat to  $P_3$ , but rising less than the expected inflation rate of 2 percent.



**Figure 7. A growth recession**

This situation is sometimes called a “growth recession.” It does not officially qualify as a recession because real output continues to grow. However, the growth rate of output in period three is less than the growth in natural output—real output falls below its growth trend—hence the term growth recession.

The situation shown in Figure 7 suggests that reducing the rate of inflation can be costly—it induces a temporary reduction in output growth. This change is temporary because once expectations adjust to the change in monetary growth, the SRAS curve will adjust downward to reflect lowered inflation expectations and output will return to its natural growth path. Depending on the size of the gap between  $Y_3$  and  $Y_{n,3}$  and the length of time required for expectations adjustment to occur, this cost of disinflation could be small or large.<sup>7</sup>

It is worth noting what would have happened if everyone had correctly anticipated the reduction in money growth in time to set wages and prices. In Figure 7, the expected price level for period three would have remained at  $P_2$  rather than rising to  $P_3^e$ , which would have shifted the SRAS curve further to the right to  $SRAS_3^*$ . In that case, equilibrium in period three would be at  $e_3^*$ , with output growing at the natural growth rate and inflation immediately jumping to the 0 percent rate that is consistent with the lowered rate of money growth.

This makes it clear that it is the delayed adjustment of wages and prices based on faulty inflation expectations that causes the growth recession in Figure 7. In the simple AS/AD model, a fully credible disinflation that is known about far enough in advance to allow wage and price setters to adjust will not lead to a reduction of output below its natural level. Disinflation can be costly, but in this model it need not be if monetary policy has sufficient credibility.

---

## E. A Preview of Romer’s Text from the Perspective of Aggregate Supply/Demand

### *Growth models*

Chapters 1 through 3 of Romer’s textbook describe the evolution of economic growth theory from the Solow model of the 1950s through the optimal growth models that Cass and Koopmans built on Ramsey’s framework in the 1960s to the endogenous growth models of Paul Romer and others since the 1980s. These growth

---

<sup>7</sup> In a famous article, Laurence Ball (1994) has estimated the “sacrifice ratio”—the amount of forgone output for each percentage-point reduction in inflation—for late 20<sup>th</sup> century disinflations.

models all describe the evolution over time in the natural level of output, ignoring any role of aggregate demand.

The emphasis in these models is on increases in aggregate supplies of labor and capital resources and on technological progress—*i.e.*, on the supply side of the macroeconomy. By focusing exclusively on aggregate supply, these models ignore any demand-related fluctuations of output relative to its long-run equilibrium growth path, such as those in Figure 7.

### ***Real business cycles***

Romer's Chapter 4 presents a stylized version of the real business cycle (RBC) model. This model is also entirely based on the supply side of the economy, but rather than looking exclusively at smooth trend movements in natural output it considers situations where the increase in natural output is subject to shocks. These supply shocks, which can be bursts of rapid or slow technological progress, cause the amount of rightward shift in the natural level of output and the LRAS curve to vary from year to year.

Like the growth models, the real business cycle model has no role for aggregate demand. It explains business cycles as fluctuations in supply-driven growth of  $Y_n$ , not as movements of  $Y$  around a smoothly growing  $Y_n$ . This difference is of critical importance for macroeconomic policy. Since  $Y_n$  is the level of output generated by the PCGE model, an appropriate goal of macro policy is to keep  $Y$  close to  $Y_n$ . If business cycles are fluctuations of  $Y$  around  $Y_n$ , then countercyclical policy to diminish these movements is desirable. If, as in the RBC model, it is the natural level of output itself that fluctuates, then the resulting cyclical movements in output are both “natural” and desirable. It would be inappropriate for monetary and fiscal policies to attempt to smooth them out. (And of course the RBC model predicts that monetary and fiscal policy, because they affect AD, would not affect output anyway.)

### ***The IS/LM and Mundell-Fleming models***

Traditional courses in “intermediate” macroeconomics devote a large share of their attention to a detailed model of aggregate demand called the *IS/LM* model. This model was first introduced by Hicks (1937) as a mathematical description of the system described by John Maynard Keynes (1936) in his seminal but cryptic *General Theory of Employment, Interest and Money*.

The *IS/LM* framework is a more detailed alternative to the simple quantity theory model developed in this chapter. It remains a popular way of thinking about how various kinds of shocks affect the aggregate demand curve, including changes in monetary and fiscal policy. However, the behavioral assumptions of the *IS/LM* model are not well grounded in microeconomic theory. They are simple descriptive relationships rather than manifestations of maximizing behavior and optimal market

interactions. As such, the *IS/LM* model has largely disappeared from the academic literature in the last three decades.

Romer introduces a variation of the *IS/LM* framework—the *IS/MP* model—in Chapter 5. This model is virtually identical to *IS/LM* except for the way in which monetary policy is assumed to be conducted. The *IS/MP* model assumes that the central bank sets an interest rate target (as most modern central banks do); the *IS/LM* model is based on the central bank setting a target for the quantity of money.

The traditional *IS/LM* model was developed for a closed economy—one with no trade or credit transactions with the rest of the world. The Mundell-Fleming model (also discussed in Romer’s Chapter 5) is an open-economy variant on the *IS/LM* approach, allowing for imports and exports of goods and for net borrowing and lending between countries.

The *IS/LM*, *IS/MP*, and Mundell-Fleming models are all models of aggregate demand. To the extent that they pretend, on their own, to be theories of real output determination, they are making the implicit assumption of fixed prices—a horizontal aggregate supply curve. This assumption is probably not very realistic even in the short run and is clearly inappropriate in the long run. A more appropriate characterization of the macroeconomy would use these models to explain the AD curve, then combine them with theories of aggregate supply.

### ***Neoclassical and new Keynesian models***

Chapter 6 is the most substantive and comprehensive chapter in Romer’s text. In this chapter, he describes a series of models that have been developed since the 1970s to explain the short-run behavior of aggregate supply. Earlier in this chapter, we discussed two simple models of aggregate supply, one based on menu costs and price stickiness and the other on wage contracts. Chapter 6 develops the detailed microeconomic foundations of several models, all of which share similar basic structural conclusions: the SRAS curve slopes upward and the LRAS curve is vertical.

We have argued that the perfectly competitive general-equilibrium model leads to a vertical AS curve. Thus, in order to motivate an upward-sloping AS curve we must introduce some kind of imperfection into the PCGE setup. In Chapter 6, we investigate models based on imperfect information, imperfect competition, menu costs, and wage stickiness. Because the emphasis on these models lies in the specification of short-run aggregate supply, we summarize the demand side of the economy by the simple quantity theory rather than a more complicated and realistic model.

---

## F. Suggestions for Further Reading

Much of the material discussed in this chapter is covered in standard introductory or intermediate macroeconomics texts. One of the best at each level is written by N. Gregory Mankiw: his *Macroeconomics* is an intermediate text and his *Introduction to Macroeconomics* is more basic. Other standard intermediate texts are those of Olivier Blanchard; Robert Hall and John Taylor; and Andrew Abel and Ben Bernanke. (All of these intermediate texts are called *Macroeconomics*.)

---

## G. Works Cited in Text

- Ball, Laurence. 1994. What Determines the Sacrifice Ratio? In *Monetary Policy*, edited by N. G. Mankiw. Chicago and London: University of Chicago Press.
- Hicks, John R. 1937. Mr. Keynes and the 'Classics'. *Econometrica* 5 (2):147-159.
- Keynes, John Maynard. 1936. *The General Theory of Employment, Interest and Money*. New York: Harcourt, Brace.