It is now time to put together our analyses of consumption, investment, and the labor market into a simple model of the economy. This simple model focuses attention on shocks to the economy's production function and shocks to investment demand. The model is often called a real business cycle model, or RBC model for short, because it does not include the money market. We will, of course, include money in the model later, but first we will see how far we can go without it.

Most economists consider these models to be important building blocks toward a more complete theory. A thorough understanding of how certain "shocks" alter the equilibrium of real business cycle models will provide you with the intuition to form "educated guesses" about how similar shocks might affect real world economies. For example, how changes in the availability of foreign oil influence U.S. interest rates. Many interactions between economic variables would be difficult to identify if one proceeded immediately to more realistic (complex!) settings.

Some economists believe real business cycle models drastically over-simplify to the point of being misleading. Others believe the models, as they are, can explain a great deal about how actual economies work. Our view is that these models are an essential starting point for learning how to use economic theory to make sense of the real world, whether or not they are capturing the whole story.

We begin the model building by summing together consumption demand and investment demand to make so-called aggregate demand. **Aggregate demand** is the total quantity of goods and services that the people, both consumers and producers, want to buy. This provides one side of the market. The next step extends the study of the labor market to derive the aggregate supply
Aggregate supply is the total quantity of output that producers want to supply to the market. This is the other side of the market.

With these parts we can establish equilibrium in the goods market. This equilibrium determines the interest rate, the level of output, and, through the labor market, the real wage, and the level of work effort. We are then in a position to study the response of these key macroeconomic variables to changes in the environment. Of particular interest to us will be the response of the economy's equilibrium to technological progress, oil price shocks, and shocks to the productivity of investment projects. We end the chapter with an overview and some extensions of the model.

Aggregate Demand

As we just mentioned, aggregate demand is the just the sum of investment demand and consumption demand. Let's start by writing it down in symbols and then discuss it. Aggregate demand, \( Y^d \), can be written as

\[
Y^d = C^d + I^d
\]

\[
= C(r_t, Y_t, Y_{t+1}, ...) + I(r_t, A_{t+1}, ...)
\]

Aggregate demand depends on the same variables that determine consumption and investment demand. Both investment and consumption demand depend on the interest rate and so also will aggregate demand. Consumption depends on the expected income stream and the response of consumption to a change in current income depends critically on whether households perceive the change in income to be permanent or temporary. The same holds true for aggregate demand. Finally, investment depends on the expected profit stream from investment projects and the expected profit stream carries over as a determinant of aggregate demand. Moreover, the potential reasons for volatile investment now apply as potential explanations for volatile aggregate demand.

As usual, it proves convenient to have a picture, so we now derive the aggregate demand curve plotted against the real interest rate. Both consumption and investment demand share the real interest rate as a determining variable and both decline when the interest rate increases. This
means that aggregate demand must also
decline when the interest rate increases. For
example, suppose that the interest rate is
initially 3%. At this interest rate suppose
that consumption demand is 16,200 and
investment demand is 6,000. This makes
aggregate demand 22,200. This initial
position is shown in Figure 11.1. Now
suppose the interest rate rises to 5%.
Consumption falls by, say, 1,600 to 14,600,
and investment follows, declining by 1,000
units to 5,000. This means that aggregate
demand declines by 2,600 (= 1,600 + 1,000)
to 19,600 (= 14,600 + 5,000). This second point is also shown in Figure 11.1. When we trace
out all such points we have the aggregate demand curve, labeled \( Y_d \).

Along any \( Y_d \) curve the stream of income and the profitability of investment projects are
held constant. We need to know how the \( Y_d \) curve responds when these variables change. First,
consider a permanent change in income of
200 units. Earlier we argued that the
marginal propensity to consume out of a
permanent change in income equaled one.
When income increases permanently there
is no need to smooth the consumption from
it and as a result households consume the
entire increase. Since consumption
increases by 200 so also does aggregate
demand. This is shown in Figure 11.2 by a
200 unit shift to the right in the aggregate
demand curve.

What happens if the increase in income
is only thought to be temporary? In this
case we argued that households smooth their consumption, and the marginal propensity to consume out of temporary changes in income was approximated by 1/planning horizon. If generations are linked, because parents care about their kids, grandkids, and so on, then the planning horizon will be very long. The long planning horizon makes the MPC out of temporary change in income very small, and we take it to equal zero. This is convenient graphically because it implies that consumption demand, and hence aggregate demand do not shift when the change in income is perceived to be temporary.

Now suppose that computer technology makes investment projects more productive, or profitable. Computers may aid in the design of more efficient machines, or, perhaps, current generation machines may be monitored more effectively with the assistance of computers. This raises the stream of expected profits \((A_{t+1}, A_{t+2}, \ldots)\), and makes some projects acceptable that were earlier rejected. At the original rate of interest investment demand increases from, say, 6,000 to 7,200. This, in turn, increases aggregate demand to 23,400 at the going 3% rate of interest. This means that the \(Y^d\) curve shifts out and to the right, and this shift is pictured in Figure 11.3.

These are the basics of aggregate demand, and the aggregate demand curve. They are basic in the sense that they are first principles, or, more to the point, implications of first principles. They are also basic in the sense that they play an important role in just about all that follows. It is therefore worthwhile to review, perhaps traveling to earlier chapters, and to mull over the above analysis so that you become comfortable with it.

**Aggregate Supply**

We now link the aggregate supply of output, which we call \(Y^s\), to the interest rate. They are connected through the labor market, and the connection is

![Figure 11.3 Effect of an Increase in the Profitability of Investment Projects]
straightforward. Suppose that the interest rate is initially 2%, and at this interest rate producers supply 15,000 units of output. This gives one point, point A in Figure 11.4, on the aggregate supply curve. Now, suppose the interest rises to 4%. At the higher interest rate it is a good time to save. One way to increase savings is to increase income, but to do so requires additional work effort. This motivates an increase in the supply of labor, and equilibrium work effort increases as well. With more work effort greater output is produced, and aggregate supply increases to, say, 15,500. These two points allow us to draw the aggregate supply curve in Figure 11.4.

Though this connection is simple, it takes three graphs to make it. In Figure 11.5 the graphs of labor market equilibrium, the production function, and the aggregate supply curve formalize the above connection. At the interest rate of 2% the supply curve of labor is \( N_s(r=2\%) \) and equilibrium employment is 120. The 120 units of work effort translates through the production function into an output of 15,000 units. When the interest rate increases to 4%, the labor supply shifts out to \( N_s(r=4\%) \), and work effort rises to 130 units. This increases output to 15,500 and gives us the upward sloping \( Y_s \) curve. Note also that the real wage falls.

 Movements along an aggregate supply curve represent movements along a production function. In Figure 11.5 the movement from point a to point b along the \( Y_s \) curve corresponds to the movement from point a’ to point b’ along the production function. Shifts in the production, whatever their cause, will shift the aggregate supply curve. Let’s look at a few examples.

Suppose an improved technology comes on line. This shifts the production function up and to the left. At the current rate of interest more output will be supplied, say an increase from 15,000 units to 16,500. This means that the aggregate supply curve shifts out and to the right to \( Y' \). This is shown in Figure 11.6. There are two loose ends here. First, the increase in technology increases the marginal product of labor and hence labor demand. This causes an increase in employment, which adds to the increase in output, and reinforces the direct effect from the
change in the production function. Second, since technical progress is permanent, wealth increases. Higher wealth reduces work effort so yet another effect operates. This works in the opposite direction from the other two effects. However, it is very unlikely that this wealth effect changes our conclusions. We expect an increase in wealth to reduce work effort so that more leisure can be enjoyed, but we do not expect leisure to increase by so much that total output falls. Indeed, we expect that as household incomes rise more of both consumption and leisure will be enjoyed. From now on we assume, very safely, that a permanent increase in the production function, from whatever source, shifts the aggregate supply curve out and to the right, and we say that the \( Y' \) curve has increased.

Now let's consider a temporary shock to the production function. Suppose a Middle East dictator invades a small neighboring oil producing country. The rest of the world protests and militarily engages the dictator. As one of the consequences, oil production in the region declines, the specter of future shortages appears, and oil prices rise sharply. Oil, and energy more generally, is a ubiquitous input, and the higher energy prices discourage production of goods and services broadly across the economy. In the context of our model, we interpret these events as causing a decline in the production function. Since production opportunities have deteriorated, the supply of output falls. In Figure 11.7, we again begin with an
interest rate of 2% and an output of 15,000, but the oil price shock causes output to decline at the original rate of interest to 13,500. The marginal product of labor also falls, shrinking labor demand and work effort, and reinforcing the decline in output. There is no wealth effect to worry about since the change is temporary. The aggregate supply curve shifts back and to the left, and we say that the Y curve has decreased.

In late 1985 and into 1986 the price of oil fell. For the case of falling oil prices the reverse analysis holds. The production function shifts up and to the left, and the aggregate supply curve shifts out and to the right. A picture of this shift would look exactly like the picture for the permanent technology shock in Figure 11.6. Indeed, if you were shown Figure 11.6 without its title, you could tell that production opportunities improved, but you could not tell whether the shock was temporary or permanent. In general, shocks that increase the production function increase aggregate supply and shocks that decrease the production function decrease aggregate supply. This relationship does not depend on whether the shock is temporary or permanent.

**Equilibrium in the Goods Market**

With the aggregate demand and supply of goods in hand, we are now ready to study equilibrium in the goods market. By definition equilibrium occurs when the quantity of goods that producers want to supply equals the
quantity of goods that consumers and producers demand. In symbols we write that equilibrium occurs when

\[ Y^s = Y^d, \]

or

\[ Y^s = C^d + I^d. \]

It is very useful to have another interpretation of equilibrium. We define desired savings, or we could say the supply of savings, as the difference between desired income, \( Y^s \), and desired consumption, \( C^d \). In symbols we write desired savings, \( S^d \), as

\[ S^d = Y^s - C^d. \]

It is easy to see, by simple subtraction, that in equilibrium we must have

\[ Y^s - C^d = I^d, \]

or

\[ S^d = I^d. \]

In other words, equilibrium requires that desired savings equals investment demand.

This alternative interpretation helps us understand the state of the economy outside of equilibrium. For example, suppose that the aggregate supply of goods exceeds the aggregate demand for goods. In symbols, this means that \( Y^s > Y^d \) and we say that there is an excess supply of goods. Our alternative interpretation implies that this is also a situation where desired savings is greater than desired investment. In a sense, there is too much savings.

This excess of savings causes interest rates to fall. To see why, remember that households who want to save want to buy bonds. Those bonds may come in the form of CDs at their local bank, U.S. treasury bonds, or some other financial instrument. Whatever the form, there are many household who want to buy bonds, and relatively few households and firms that want to sell them. This excess demand for bonds causes bond prices to rise. But we know that higher bond prices mean lower interest rates. In this way an excess supply in the goods market reduces
the interest rate. We could construct an analogous argument, and you should, that an excess demand for goods causes the interest rate to rise. We are now in a position to find the goods market equilibrium.

In Figure 11.8 we have drawn the aggregate supply and demand for goods. It comes as no surprise that equilibrium occurs at the intersection of the two curves. The equilibrium rate of interest is \( r^* \) and equilibrium output is \( Y^* \). It is, however, important to convince ourselves that there are forces at work that will move the economy towards this point. After all, we are interested in equilibrium only because we believe the economy moves toward it, and, once there, stays there.

Consider the interest rate \( r_h \) in Figure 11.8. At \( r_h \) there is an excess supply of goods. This corresponds to an excess of desired savings over investment demand. There is thus an excess demand for bonds, bond prices rise, and the interest rate falls toward equilibrium. At the interest rate \( r_l \) there is an excess demand for goods. This translates into an excess of desired investment over desired savings. This implies that there is an excess supply of bonds, bond prices fall, and the interest rate rises toward equilibrium. We can now conclude that if the economy is away from equilibrium, there are forces at work that drive it back toward equilibrium.

Applications of the Model

a. technical change

In the first 10,000 years or so of civilization technical change occurred, but it was painfully slow. Sometimes methods were forgotten and hundreds of years passed until they were reinvented. In the past 200 years, technology has progressed rapidly. Water- and
steam-powered engines replaced human and animal effort. These power sources were then supplanted by the more efficient gas and electric engines, and now work goes on to develop solar and other energy sources. The advance of power technology had effects on almost all aspects of production. For example, in transportation the average speed on the nation's highways 150 years ago was about 5 miles an hour. The roads were rough, and intemperate weather often made travel impossible. Today, laws hold down the legal speed on our highways to 55 miles per hour; and trains and planes move two to ten times that fast. To take another example, the efficiency of transforming cotton into thread, and hence a crop into clothes, multiplied by factors in the thousands as the water frame and jenny replaced the spindle. These two examples of technological progress could be increased many fold without difficulty.

Technological improvements allow more goods to be produced from a given set of resources and this means that the production function shifts up. This, in turn, shifts the aggregate supply curve out and to the right. The shift from $Y^*$ to $Y^\prime$ in Figure 11.9 depicts this change. The improvement in technology raises income permanently. Since the change is permanent, there is no incentive for households to smooth the consumption of their additional income. Consumption demand, and hence aggregate demand, shifts out and to the right by the same distance as the shift in the $Y^*$ curve. Here we are putting to work our result that the marginal propensity to consume out of permanent changes in income is one. There is no initial excess supply or demand for goods, and so no disturbance to the original equilibrium interest rate. The new equilibrium occurs at $r^\prime$ and $Y^{**}$. The model thus predicts that improvements to technology do not affect the equilibrium interest rate. Equilibrium output increases as we would expect.

This analysis assumes that the profitability of investment projects is unaffected by the technical change. This may not be plausible since new technology is often embodied in new machines, or other types of capital. Electricity required electric motors; you couldn't just plug in a steam engine. We will deal with this complication later. For now it is best to take our shocks one at a time

\[ b. \quad \textit{temporary fall in the price of oil} \]

We now analyze a fall in the price of oil that is perceived to be temporary. Recall from our earlier discussion that oil prices both rise and fall; and that a sharp fall occurred in late 1985. To
finance their war effort, Iran and Iraq produced more oil than allowed by their OPEC quotas and Saudi Arabia, the largest producer in the cartel, punished them by increasing its production. Over this period the price producers paid for processed fuels and lubricants fell by 25%. Cheaper energy shifts the production function up and to the left, aggregate supply increases, and \( Y^s \) shifts to \( Y^{s'} \) in Figure 11.10.

The consumption demand curve will not shift. This is because the shock is temporary, and the consumption from any change in income will be spread over a long planning horizon. Here we are using the result that the marginal propensity to consume out of temporary changes in income is negligible. There is also no direct impact on investment since the productivity, or profitability of potential projects, has not changed.

The increase in aggregate supply coupled with no change to aggregate demand leaves an initial excess supply of goods. This means that there is an excess supply of savings as people attempt to save in order to spread out the consumption of their temporary gain over their planning horizon. So, there are many people trying to buy bonds and relatively few trying to sell them. Bond prices rise and interest rates fall. The new equilibrium in Figure 11.10 has a lower interest rate and higher output.

Although there is no direct effect on either consumption or investment, there is an indirect one. The temporary decrease in the price of oil lowers interest rates, and lower interest rates motivate more consumption and investment. We add to our predictions that in the new equilibrium both consumption and investment will be higher.

Let's contrast the results here with the effects of a permanent increase in the production function. When oil prices fall temporarily, the production function increases, and the interest rate falls. An improvement in technology also increases the production function, but there is no change in the interest rate. What explains the difference? When technology improves things are
better today and they will be better tomorrow as well. There is no change in the opportunities today relative to the opportunities in the future. On the other hand, oil prices will return to their original level next period. When oil prices fall temporarily, opportunities today improve relative to tomorrow. It is this change in relative opportunities that influences savings behavior, and is responsible for the fall in interest rates.

c. increase in the profitability of investment

Now let's suppose that investment projects, new plants and equipment, become more profitable. For example, computers now aid in the design of machines and the organization of factories. Through simulations of various possibilities, too expensive to actually try out in practice, designers may see alternatives that would otherwise be missed and develop new plant configurations or equipment designs that are more efficient.

An increase in the profitability of investment projects increases investment demand, shifting the investment demand curve out and to the right. The aggregate demand curve shifts out in the same direction by the same amount. This is shown in Figure 11.11.

The current production function does not shift since the plant or equipment does not come on line until the next period. It takes time to deliver and install new equipment, or to construct new plants. This implies that the current $Y^*$ curve stays put.

The increase in aggregate demand together with no change in aggregate supply produces an initial excess demand for goods and an excess of investment demand over desired savings. Firms eagerly try to sell bonds to raise funds to invest in the now more productive projects. The resulting excess supply of bonds causes bond prices to fall and so interest rates rise. The higher
interest rate induces greater work effort and this causes a movement along the aggregate supply curve. The equilibrium interest rate and output increase in Figure 11.11.

The model predicts that an increase in investment demand results in higher output and a higher interest rate. Let's assume that there is no direct effect on consumption; an assumption that we will drop later, but is useful now. Nevertheless, the increase in investment demand causes consumption to decline because of its effect on the interest rate. The higher interest rate encourages saving, savings that is needed to take advantage of the more productive investment opportunities, and consumption falls.

Often times, perhaps even most of the time, higher interest rates are viewed by the media as a bad thing. In the present case the interest rate rises, but the higher rate reflects something good going on in the economy. Plants and equipment are more productive, and when they come on line in the future we will enjoy greater output and consumption. The higher interest rates should be cheered, not jeered. In general, just looking at a price change will not be informative on whether things are looking up or down. To decide if a change in a price portends good or ill, you must look deeper into matters to find the cause of the change. This task is much harder than just reporting the change.

**Examples of Shocks**

Shocks to the economy may originate from many different sources. There are many different types of technology shocks ranging from new supersonic airplanes flown by computers to new strains of wheat that resist cold weather and pests. We may also think of certain institutional changes as constituting permanent shocks. For example, the creation of computer viruses may be interpreted as causing a permanent decrease in the production function since resources...
must be siphoned off from the production of goods to the defense from viruses. On the other hand, if an economy is able to shed old prejudices, resources are likely to be better allocated. Talents better matched with opportunities. This would increase efficiency and we may think of it as shifting out the production function. To take another example, the judiciary may be reorganized so that cases run more smoothly through it. In some areas this has already occurred as certain courts specialize in certain types of cases, for example patent cases. When courts adjudicate cases more rapidly, fewer resources need be expended on lawyers, expert witnesses, and so forth; and instead these resources may go into the production of goods and services. Again, we may think of this institutional change as a permanent positive shock to the production function.

Oil price shocks served as our example of a temporary shock to the economy and this is no accident. The economist James Hamilton pointed out that of the eight recessions between World War II and 1983 six have coincided or been immediately preceded by sharp increases in the price of oil.\(^\text{20}\) If, as some economists have argued, the recessions in 1980 and 1982 are considered as one, then the number rises to seven of the last eight. Hamilton published his paper in 1983, long before the last recession in July of 1990. It is interesting to recall that this recession also coincided with a sharp increase in the price of oil as a result of Iraq's invasion of Kuwait. The earlier oil price shocks were also associated with similar political events. In 1952-53 Iran nationalized oil companies and there were strikes by oil and coal workers. The recession that began in the third quarter of 1957 was preceded by a spike in oil prices caused by the Suez Canal crisis. The behavior of the relative price of oil from 1947 through 1972, measured by the ratio of the price of crude petroleum to the CPI, is plotted in Figure 11.12. Shaded parts of the diagram indicate recessions.

The relative price of oil has been extraordinarily volatile since 1973. This can be seen by comparing the scales in Figures 11.12 and 11.13. For the 1973-1992 period the upper bound is higher and the lower bound is smaller than they are for the earlier period. The first oil price shock in the later period occurred in late 1973. The OPEC embargo, caused at least in part by the U.S. support for Israel in the Yom Kippur war, produced a sharp increase in the price of crude, and a sharp and long recession ensued. The Iranian revolution fueled the shock in the late

\(^{20}\) See James Hamilton's "Oil and the Macroeconomy since World War II" in the *Journal of Political Economy* 91, April, 1983.
1970s. Some economists do not believe that these oil price shocks were large enough to cause recessions, but it seems clear that, at least, they are contributors to the economic downturns.

There are other important examples of temporary shocks. Floods, droughts, hurricanes, earthquakes, and tornadoes all disrupt production temporarily. Even less dramatic variations in the weather can have important effects on agriculture, construction, and other weather dependent activities.

Structural change in the economy may also result in a temporary deterioration in production opportunities. For example, suppose there are 2 sectors in the economy and initially they both produce 100 units of output. Now, assume that tastes in the economy shift away from output of sector 1 toward the output of sector 2 so that people want 60 units of sector 1 output and 140 units of sector 2 output. If the transition from one structure of production to the other were costless, no shift in aggregate production would occur. Output in sector 1 would fall by 40 units, output in sector
2 would rise by the same amount, and total output would stay at 200. However, it is unlikely that the structural change doesn't involve costs. Workers and capital may have to move or be modified, contraction in the one industry is likely to proceed faster than expansion in the other as the changes involved may be costly and time consuming to implement. Output in sector 1 may fall rapidly to 60 units, while output in sector 2 rises only to 120 units. Aggregate production would decline, from 200 units to 180 units, as some resources are used to carry out the transition.

Disruptions or advances in production may have many sources. Some may be readily identifiable, like sharp increases in the price of oil. Some may be hard to pin down, like structural change that occurs slowly and across many sectors. This list of permanent and temporary shocks is not meant to be exhaustive, only illustrative.

**Overview and Extensions**

*a. demand and supply: macro vs. micro*

You may have already recognized one feature of macroeconomic demand and supply analysis that makes it more difficult than standard microeconomics. A macroeconomic shock may well cause both demand and supply curves to shift (think back to our examples). When both curves shift it is harder to make clear predictions about movements in both r and Y. In macroeconomics knowing something about the relative sizes of the shifts is crucial in allowing for unambiguous predictions.

For example, a temporary decrease in production shifts the Y* curve leftward. Lower current period income decreases wealth and this puts downward pressure on consumption. But since the change is temporary, consumption will only decline by a small fraction of the change in Y*. To make comparisons easier we have assumed that there is no shift in Y^d. Whether or not we make this simplification, a temporary negative shock to the production function results in an excess demand for goods and this causes interest rates to rise. Without knowing something about relative shifts, we would not have been able to make these predictions. The key piece of information was that the change was viewed as temporary. In studying any event, it is then very important to ask whether it is temporary or permanent in nature.
b. role of investment

An initial equilibrium with an interest rate of 10% and output of 500 units is drawn in Figure 11.14. Let's suppose that 100 units of aggregate output are devoted to investment and the other 400 units are consumed. Now suppose a temporary negative shock to output occurs, like a temporary increase in the price of oil, and the \( Y^s \) curve shifts 150 units to the left. The interest rate rises to 15% and output settles at 425 units.

There are three important points here. First, recall that the increase in the interest rate calls forth greater work effort so the net decline in output is only 75 units instead of the initial 150 units. Second, because the interest rate increases investment falls to, say, 70 units and consumption falls to 355 units. The decline in investment acts as a buffer for consumption and allows households to keep their consumption closer to its normal (original) level. Third, output declines by 15%, consumption by 12.5%, and investment by 30%. In proportional terms, the fall in investment is much larger than the fall in output, while the change in consumption is small relative to the change in income.

Here it is important to remember the argument that if investment is a small fraction of the capital stock, it may react very strongly to a change in the demand for capital. So, a change in the interest rate has to alter the desired capital stock by only a small amount to change investment demand by a lot. This makes investment much more sensitive to changes in the interest rate than consumption, and as a result investment will be the more volatile of the two aggregates.

c. shifts in investment and consumption demand

With capital in the model you must always ask: "Will the shock change the
future profitability of capital?" If the answer is no, then you have to worry only about the response of consumption. Recall the effects of a permanent technological advance, which does not make capital more productive. The $Y^*$ curve shifts out, and the $Y^d$ curve shifts out one-for-one with it, as consumption responds to a permanently higher level of income. Since investment demand does not change, the interest rate stays the same.

Suppose the technological advance does increase the productivity of new capital and hence increases investment demand. In this case, the demand for new plant and equipment will rise at the going interest rate. This creates an additional increase in aggregate demand and the total increase in demand now exceeds the increase in supply. This creates an excess demand for goods, the cost of funds, $r$, is bid up, and the new equilibrium occurs at a higher rate of interest and a higher level of income.

We can address the issue of simultaneous shocks in another way. The outcome of two simultaneous shocks is shown in Table 11.1. In the first row of this table the effects of a permanent increase in the production function are summarized. These are the results we obtained in our analysis of an improvement in technology. In the second row the effects of an increase in investment are shown. The combined effects of these two shocks occupy the third row. It shows a certain increase in the interest rate, output, and investment; but consumption may either fall or rise.

| Table 11.1 |
| The Effects of a Simultaneous Technical Progress and an Increase in the Productivity of Capital |

<table>
<thead>
<tr>
<th>technical progress</th>
<th>$Y$</th>
<th>$r$</th>
<th>$C$</th>
<th>$I$</th>
</tr>
</thead>
<tbody>
<tr>
<td>increase in investment demand</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>combined effect</td>
<td>+</td>
<td>+</td>
<td>?</td>
<td>+</td>
</tr>
</tbody>
</table>

d. capacity utilization and the interest rate

We have already mentioned that many economists do not believe that the work effort responds much at all to changes in the interest rate. This would mean that the $Y^*$ curve is vertical.
and would change several of our earlier results. Most importantly, if the $Y^*$ curve is vertical, an increase in investment demand only results in a higher interest rate. Equilibrium output would not change. Some economists have suggested that a strong response by households to a change in the interest rate is not essential. If we allow the capacity utilization of capital to change, we do not have to rely solely on the response of work effort to give $Y^*$ a positive slope. Variations in the usage of existing capital may be enough.

To begin the story, we first need to know why there may be existing slack. Why don't firms operate their plants and equipment at 100% capacity? The reason hinges on the depreciation of capital. The more intensively a firm uses its capital stock, the faster the capital stock wears out. Or, to put it in a slightly different way, the greater is the capacity utilization rate, the greater is the depreciation rate of capital. For example, if a firm keeps its capital in use all the time, three shifts a day with no down time, the capital may wear out very fast, say in 3 years. On the other hand, if the capital is used only two shifts a day and experiences some down time for routine maintenance checks, it may be able to last quite a bit longer, say 10 years. Because of this relationship it may not be in the firm's best interest to use its capital at full capacity. The output produced over the longer period of time may well compensate the firm for not running the capital continuously at full capacity.

| Table 11.2 |
| Changing Capacity Utilization |
| period 1 | period 2 | present values |
| shifts | y1 | shifts | y2 | pv (10%) | pv (20%) |
| strategy A | 0 | 0 | 2 | 13 | 11.8 | 10.8 |
| strategy B | 1 | 7 | 1 | 7 | 13.4 | 12.8 |
| strategy C | 2 | 13 | 0 | 0 | 13 | 13 |

A simple numerical example may help clarify this point. Suppose a firm makes plans over a two-period horizon and has a machine with a lifetime of two shifts. The firm may run the machine for two shifts in the first period, or two shifts in the second period, or the firm may run the machine for one shift in each of the two periods. If the machine is used for one shift in a
period it produces 7 units of output in that period. If capital is employed two shifts in a period, it yields only 13 units of output in that period, because the more intense utilization causes the machine to wear down faster.

Table 11.2 gives the choices available to the firm. If it chooses strategy A, it produces no output today and 13 units of output in the second period. Strategy B yields 7 units of output in each period. Strategy C calls for 13 units of current output, but nothing in the second period. Since output is realized in different periods, the three possible streams of output are not directly comparable. We must calculate the present value of the output stream generated by each strategy to compare the choices and to find out which one the firm will choose.

To calculate a present value an interest rate is needed. Let’s first suppose that the interest rate is 10%. The present value of each output stream when the interest rate is 10% is given in column 5. The calculation is straightforward. For example, the present value of the output stream generated by strategy B is

$$13.4 = 7 + 7/(1+.1)$$

When the interest rate is 10% strategy B gives the highest present value and the firm will produce 7 units of output in each of the two periods. Now suppose the interest rate rises to 20%. The higher interest rate means that we are discounting future output at a higher rate. The present value of strategy B falls to 12.8 and it is now below the present value for strategy C. The firm chooses strategy C, so in response to the increase in the interest rate, the firm increases the use of its capital stock and current output goes up.

In short, we do not have to rely solely on a labor supply effect to have a positively sloped supply curve. Instead, we can explain a positive relationship between output and the interest rate by an appeal to greater capacity utilization. There is, however, a close connection between the labor supply explanation and the capacity utilization. An increase in the interest rate means it is a good time to increase your earnings. In a world with capital, there are two ways that this can be done. First, you can increase work effort and this is the labor supply effect. Second, you can work machines harder. This is the capacity utilization explanation. The general argument is that when the interest rate increases, there is an incentive for inputs (labor and capital) to work harder and longer, and this causes an increase in current output.
e. shocks to a small open economy

We can extend the analysis to small open economies in a fairly straightforward way. An open economy is one that can engage in international trade and we want to know how the current account balance for such a country will change when the economy is shocked. A small economy is defined here as economy small enough so that the behavior of its citizens does not affect the world interest rate. The U.S. is probably not a small economy, Sweden is.

We now recognize that aggregate demand includes the demand for goods and services produced abroad as well as those produced at home and some of aggregate supply is now sold to foreigners. The $Y^d$ and $Y^s$ curves still look the same and still shift for the same reasons as before. However, it is no longer true that aggregate demand must equal aggregate supply in equilibrium. In any particular period $Y^d$ may exceed $Y^s$. In this case the country's consumption and investment exceeds its production, which means it must be borrowing from foreigners (or drawing down its claims on foreigners) and running a current account deficit. If, on the other hand, $Y^s$ exceeds $Y^d$, then the country produces more than it demands; and the remainder is lent to foreigners (or used to repay earlier debts).

To simplify matters, we begin with a country whose current account is in balance. This means that $Y^s$ equals $Y^d$ at, say, 7,000 units. Now suppose the country suffers a spell of poor weather. This is a temporary negative shock. The $Y^s$ curve will shift back and to the left, but, because the shock is temporary, the $Y^d$ curve will not shift. This is shown in Figure 11.15. We know from our earlier analysis that the households in this country will try to borrow in order to maintain their current living standards. In our earlier model, this led to an increase in the interest rate. However, in a small open economy this is not the case. The interest rate is set in world markets at $r_{world}$ and our country is, by assumption, too small to affect this rate.

In a closed economy one household can borrow only by inducing another one to lend. In an open economy this is no longer true. All of the households in one country can simultaneously increase their borrowing by seeking loans from abroad. As households borrow from foreigners, the country will experience a capital inflow, their capital account balance will be positive, and their current account will be in deficit. The size of the deficit in Figure 11.15 is the difference between $Y^s$ and $Y^d$, 600 units.
To study another type shock, suppose that investment projects in this country become more popular. In this case the $Y^d$ curve shifts out and to the right, but, since the capital will not come on line until the next period, the $Y^s$ curve will not shift. This means that there is an excess demand for goods; that is, $Y^s$ is less than $Y^d$. Again, in a closed economy this would result in higher interest rates. In a small open economy the interest rate is not affected, and, instead, the country experiences a capital inflow, and a current account deficit. This is shown in Figure 11.16 where the current account deficit is 200 units.

The shocks that cause an initial excess demand for goods raise interest rates in a closed economy and produce current account deficits in a small open economy. Shocks that cause an initial excess supply of goods, such as a spell of very good weather, lower interest rates in a closed economy and create current account surpluses in a open economy. What happens if no initial excess demand or supply is created? For example, a permanent shock to the production function, say from an invention, creates neither a shortage or a surplus. In this case, we can therefore conclude that such a shock will not affect the current account balance.

We have not addressed two questions. First, what happens if a country is large? In this case we would expect some combination of the two results. For example, if there is an investment boom in the U.S., we would expect that the world interest rate would rise and the U.S. would experience a current account deficit. The second question we have left open is what happens to exchange rates? A discussion of this issue will have to wait until the extensions section of chapter 14.

**Summary**
In this chapter we developed a model of the goods market. We first found the equilibrium and then subjected it to shocks. There are three types of shocks: permanent shifts in the production function, temporary shifts in the production function, and changes in the productivity of capital. Of course, in an actual economy two or more shocks may occur at once and we learned how to deal with this situation. Even though the model was kept simple, it can be used to study a broad array of events that can have important effects on the economy.

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**Review Questions**

1) To practice using the model analyze the impact of the following events on r, C, and I, and Y. Remember to ask two questions:

1. Is the event permanent or temporary in nature?
2. If permanent, is it likely to affect the profitability of investment?

   a. An OPEC decision to produce more oil lowers oil prices. Most analysts believe the decision is tied to financial problems in the OPEC countries and will not last.

   b. The U.S. increases aid to those suffering from the drought in Africa.

   c. A shift in demand away from U.S. manufacturing goods toward the service sector leaves some workers and capital unemployed.

   d. A new computer is developed to help detect minor breakdowns in manufacturing processes. Which results would be altered if aggregate supply does not respond to interest rates?
2) Often times economists are presented with data and asked to guess what shock caused the movements. Below describe a shock or set of shocks that can explain the data.

a. an increase in the interest rate and lower output
b. no change in the interest rate and higher consumption
c. higher consumption, investment, and interest rate
d. a lower interest rate and higher investment