We have discussed the demand for goods and it is now time to begin looking at their supply. The supply of total output changes when firms change the quantities of inputs they employ or the technology they use to combine the inputs. When inputs change, it could be labor, capital, or natural resources that are adjusted. Because we are more interested in the work and employment opportunities for people than we are in the similar opportunities for capital or raw materials, we begin our discussion by focusing on changes in the labor input.

So, in this chapter we turn to the study of the labor market. To some extent we began this task earlier with our discussion of unemployment. There we focused on definitions and measurement issues. Our concern now is more conceptual and we cast the analysis in terms of the demand and supply of labor. As usual, we start with an overview of the guiding facts. We then move to the basic model where the demand and supply of labor are discussed and equilibrium studied. Finally, we briefly cover some extensions of the model.

The Guiding Facts

The labor market focuses our attention on work effort, real wages, and labor productivity. Work effort can be measured in several different ways. The number of people employed full or part time can be counted up, or the total or average hours worked can be measured. Long term trends in these different measures may tell different stories. For example, a popular measure of work effort is the number of hours in the average workweek. The average workweek shortened from the latter part of the 19th century to the first half of the 20th century. In 1890 the average manufacturing worker put in 55 to 60 hours a week. By 1947 this shrunk to about 40.5 hours. Since the end of World War II this trend has abated. The average workweek has been nearly
constant, lasting 40.7 hours for the typical manufacturing worker in 1991. On the other hand, labor force participation rates and employment rates have risen in the post-war period. In the years immediately after the war about 56% of the adult population was employed in market activity. By the early 1990s this rate rose to nearly 62%.

Figure 10.1 shows a plot of the hours per week averaged over the entire population. This number varies when the average workweek, the participation rate, or the age distribution changes. The plot mimics the behavior of the average workweek in manufacturing in the sense that it declines sharply in the first half of the century and then levels off.

In contrast to its trend, the cyclical nature of work effort is clear. Whether we measure work effort by the number of workers, or by hours worked, work effort is strongly procyclical. It rises during expansions, and falls during recessions. This is shown in Figure 10.2 and 10.3.

Labor productivity is usually measured by the average product of labor which is defined as total output divided by

\[ \frac{\text{total output}}{\text{total population}} \]

\[ \frac{\text{total hours}}{52} \]

---

\[ \frac{\text{total hours total population}}{52} \]

\[ \frac{\text{total hours}}{\text{total population}} \times 52 \]

---

total hours worked. The Bureau of Labor Statistics measures the hourly wage in a similar way, dividing total real employee compensation by total hours. Over the long haul labor productivity and real wages move together. Figure 10.4 reveals this close relationship.

Movements in labor productivity over the long run are very important since they determine our standard of living. Figure 10.5 plots labor productivity for the United States and several other countries over the past 120 years. There are three points to note. First, for all of these countries labor productivity trends upward. This reflects the unprecedented growth in living standards over the past 120 years. Second, the rate of growth of labor productivity has declined since the early '70s. This is particularly clear in Figure 10.4 which also shows the marked fall in real wage growth. Though productivity continues to grow, so the next generation will be better off than their parents, it is growing noticeably slower. The slowdown has hit the entire developed world, not just the few representative countries pictured here. Finally, relative levels of productivity are apparently converging. The United States remains the most productive nation, but the gap between the U.S. and other developed nations has narrowed.

The cyclical behavior of labor productivity is also clear. Figure 10.6 shows that productivity growth rises as economic growth quickens, but slows when the economy slows. Cyclical movements in the real wage are more opaque. Figure 10.7 indicates that real
wages, like labor productivity, are procyclical, but the relationship is weaker, or looser, than it is for productivity.

We summarize the guiding facts as follows. Over the long run productivity and real wages have risen. Work effort first trended downward, but in the last fifty years or so has been relatively constant, or perhaps increasing somewhat. Work effort, real wages, and labor productivity are all procyclical. Of these, real wages show the weakest cyclical movement.

**The Production Function**

*a. basic concepts*

The production function underlies much of the analysis of labor demand. The production function relates the quantity of output produced to the quantity of inputs used. To think about the production function suppose that you can observe an ancient village near a river. From time to time the natives go to the banks of the river and dig out a gray, muddy clay, form the clay into bowls, set them in the sun, and let them dry. You can count the number of hours that the natives worked and the pounds of clay that they used. These are the inputs: work effort and natural resources or raw materials. The number of bowls
produced is the output. For example, it may take 40 hours of effort and 5 pounds of clay to make 20 bowls. Schematically,

\[
\text{produces}
\]
\[
(40 \text{ hours} , 5 \text{ lbs of clay}) \longrightarrow 20 \text{ bowls}
\]
work effort raw materials

Now, suppose you leave and return a century later. The village still thrives, but now the natives dig the clay with a crude wooden tool. The tool is a produced means of production and we call this type of input capital. Over the past hundred years the natives have added an input.

A century later you return again to find the villagers using a more sophisticated means of production. The descendant of the crude spades of a hundred years ago have better handles and are made from a stronger wood. Some of the workers set the clay on a wheel that rests on a pivot and spin the wheel to help mold the clay. They have also developed instruments that are used to carve decorative symbols and line on the bowl. The three types of inputs - work effort, raw materials, and capital - are the same; however, the technology or know-how used in bowl making has advanced.

The production of primitive bowls has much in common with the production of modern computers. To build a modern computer requires: the work effort of the people who assemble the parts, silicon and other raw materials, and precision machines. Moreover, a computer embodies a state of technology. In general, a production process, whether for bowls or PCs, can be described by the state of technology and the work effort, capital, and raw materials used to produce the output. The general feature of the production function can be summarized by

\[
Y = F(N, K, Z, \theta),
\]

where \( N \) is work effort, \( K \) is capital, \( Z \) is raw materials, and \( \theta \) represents the state of knowledge.

\[b. \quad \text{the production function}\]
The production function relates the quantity of inputs used to the quantity of output produced. You may think of it as a rule or recipe that shows how to get the maximum output from any given mix of inputs. It represents the available technology. Table 10.1 presents a production function in tabular form. The capital stock, technology, and the use of raw materials are held constant to keep things manageable. The only variable input is labor. A very important property of an input is its marginal product. The marginal product of labor (MPL) is the change in total output that is brought about by a unit change in labor. The marginal products of capital and of raw materials are defined in a similar fashion. In symbols, the marginal product of labor can be written down as

\[ MPL = \frac{\Delta Y}{\Delta N}. \]

It is calculated in column 5 of Table 10.1.

<table>
<thead>
<tr>
<th>output</th>
<th>work effort</th>
<th>capital</th>
<th>raw materials</th>
<th>MPL</th>
<th>APL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>5</td>
<td>10</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>40</td>
<td>1</td>
<td>5</td>
<td>10</td>
<td>40</td>
<td>40</td>
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<tr>
<td>60</td>
<td>2</td>
<td>5</td>
<td>10</td>
<td>20</td>
<td>30</td>
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<td>72</td>
<td>3</td>
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<td>80</td>
<td>4</td>
<td>5</td>
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<td>8</td>
<td>20</td>
</tr>
<tr>
<td>85</td>
<td>5</td>
<td>5</td>
<td>10</td>
<td>5</td>
<td>17</td>
</tr>
</tbody>
</table>

The marginal product of labor is positive. All this means is that as additional work effort is put forth output increases. However, the amount of the increase diminishes. Initially an additional unit of labor brings an increase of output of 40 units. The next unit of labor increases output by only 20 units, and so on. We say that the marginal product of labor diminishes.
The reason that the marginal product of labor diminishes is that some inputs are fixed. As additional labor is added to the fixed quantities of capital and raw materials each unit of labor has less and less of the fixed input with which to work. For example, the initial unit of labor can use all 5 units of capital and all 10 units of raw materials. The second unit of labor has only 2 1/2 units of capital and 5 units of raw materials available since he must share with the first. The last unit of labor can use but 1 unit of capital and 2 units of raw materials. Since an increase in labor usage reduces the availability of the fixed input per unit of labor, the additional output from the last hire falls.

c. the graphical representation

The production function may be represented graphically as well as in tabular form and this is done in Figure 10.8. The slope of the production function is the change in output divided by the change in the input, $\Delta Y/\Delta N$, which is just the marginal product of labor. In Figure 10.8 the slope changes at discrete intervals. Between 0 and 1 the slope is 40. From 1 to 2 the slope is 20, and so on. There are two features of the slope that deserve emphasis. First, it is positive which reflects the fact that adding workers increases total output. Second, the slope becomes flatter as the labor input increases which reflects the diminishing marginal product of labor.

Figure 10.9 shows a smooth production function. The slope of this production function is again the marginal product of labor. It is still positive, but now it diminishes gradually. The
smooth production function with the gradually diminishing marginal product is more convenient to work with than its kinky cousin because we do not have to worry about large and sudden changes in the MPL. Since it is easier, from now on we work exclusively with smooth production functions.

d. shifts in the production function

Along the production function, the capital stock, raw materials, and the available technology are held constant. To see how the production function reacts to changes in these factors, let us begin with the production function \( F_0 \) in Figure 10.10. On the original production function, work effort of \( N_0 \) produces an output of \( Y_0 \) units. Now, suppose that the capital stock increases. After the increase in the capital stock \( N_0 \) units of labor can produce more than \( Y_0 \) units of output, say \( Y_1 \) units, since labor has additional machines to help its effort. We could have started with any point on the production function \( F_0 \) and the effect would have been the same. So, we conclude that an increase in the capital stock shifts the production function upward and to the left to, say,
F₁. The story would be the same for increases in raw materials or improvements in technology. Any of these increases, shift the production function up and to the left.

The shift from F₀ to F₁ can be broken down into two steps. The first step rotates the production function around point A to get F₁'. This part of the shift increases the marginal product of labor because the slope of F₁' is greater than the slope of F₀ (F₁' is a steeper curve than F₀). The second step is the parallel shift upward from F₁' to F₁. This represents a pure improvement in production opportunities. In general, we expect shifts in the production function, whatever their cause, to change both the marginal product of labor as well as to alter the general opportunities for production.

The Demand for Labor

a. the hiring decision

The marginal product of labor is intimately related to the demand for labor. To see why, consider a firm trying to decide whether or not to hire another worker. Let P be the price of the good. The MPL tells the firm how many units of output the new worker will add to total output so that P • MPL is the additional revenue it can expect from a new hire. This new revenue is called the marginal revenue product of labor. Each new worker adds to total revenue, but workers don't come free. They must be paid a wage, call it W. So, there is a cost and a benefit to hiring a new worker and a firm must weigh the trade off.

When should the firm go ahead and hire? Clearly, they should hire when the benefits of a new worker exceed, or at least are not less than, the cost of a new worker; and fire if they find that the cost of the last worker was greater than the benefits that they brought. The decision rule is:

if \( P \cdot MPL > W \) then hire

if \( P \cdot MPL < W \) then fire (or don't hire in the first place).
A firm that is not following this rule cannot be maximizing its profit. Or, to put the point a bit differently, if this rule is violated, there would be adjustments in the work force that would leave the owner of the firm better off.

When is the firm just satisfied with its level of work effort and hence in a state of equilibrium? The answer is when the wage rate equals the marginal revenue product of labor. We write

\[ W = P \cdot MPL \]

in equilibrium. It is easy enough, and useful too, to express the same condition in terms of the real wage. Just divide both sides of the equilibrium relationship by \( P \) to get

\[ \frac{W}{P} = MPL. \]

In words, this says: in equilibrium firms employ the level of work effort that makes the real wage equal the marginal product of labor.

b. the labor demand curve

As you might suspect, it will be handy to have a graph of the demand for labor. To draw the graph first suppose that at the real wage \( (W/P)_0 \) firms hire \( N_0 \) units of work effort. The real wage \( (W/P)_0 \) also equals the marginal product of labor when \( N_0 \) units of labor are employed. This is shown in Figure 10.11. Now suppose that the real wage falls to \( (W/P)_1 \). Since the real wage has fallen, it is now less than the marginal product of labor at \( N_0 \). In symbols this means that

\[ (W/P)_1 < MPL_0. \]

It is now profitable to hire more workers and firms continue to hire until the MPL at the new profit maximizing work effort, call it \( MPL_1 \), equals \( (W/P)_1 \). In Figure 10.11 this occurs at the work effort \( N_1 \).
We have just traced out the labor demand curve and in the process you may have noted that this demand curve is also the marginal product of labor curve. In addition, we have found that the demand curve for labor is downward sloping. This is a simple and very reasonable conclusion. When the real wage falls, it is less expensive to hire workers, and firms respond by increasing the work effort they employed.

c. shifts in labor demand

Along any labor demand curve the stock of capital, the usage of raw materials, and technology are held constant. When any of these factors change, the labor demand curve shifts. This ought to sound familiar.

To see how labor demand shifts, suppose that there is an improvement in technology. This shifts the production function up and to the left. It is important to remember that the production function not only goes up, but also becomes steeper. The increased steepness reflects an increase in the marginal product of labor. The advent of a new technology makes labor more productive at the margin.

But we know that the marginal product of labor is closely tied to the demand for labor, so the demand for labor will surely react. Let's talk through this reaction with the aid of Figure 10.12. Initially, the labor demand curve is \( N^d \), the real wage is \( (W/P)_0 \), and work effort is \( N^d_0 \). Once technology improves, the marginal product of labor exceeds the original real wage. To see how the curve shifts suppose that the real wage stays at \( (W/P)_0 \). We are not saying that the real wage will stay there, but only asking what would happen if it did. If the real wage stayed the
same and the marginal product of labor increased, we would have a situation where the marginal product of labor exceeds the real wage. But this is just the hire condition. In symbols,

\[(W/P)_0 < MPL'_0\]

where the prime "'" reminds us that this is the marginal product of labor after the improvement in technology.

The technological change makes it profitable to hire more workers and firms do so. In Figure 10.12 the firm hires \(N_N^d\).

Nothing is special about the starting position. We could have started at any point on the labor demand curve and arrived at the same conclusion. This means that the labor demand curve shifts up and to the right.

Exactly the same analysis holds for an increase in the capital stock or an increase in the usage of raw materials. Both of these changes shift the production function up and to the left, and this induces the labor demand curve to move up and to the right. We conclude our discussion by saying that labor demand depends on: 1) the real wage rate, 2) the state of technology, 3) the capital stock, and 4) the usage of raw materials. In symbols

\[N^d = N^d(W/P, Z, K, \theta),\]

where the " - " under \(W/P\) reminds us that labor demand is inversely related to the real wage rate, and the " + " under the other determinants reminds us that these variables are positively related to labor demand.

**Labor Supply**
Each person decides how much she wants to work and how much leisure she want to enjoy. In doing so she must weigh the additional income from more work against the value of lost leisure. We want to know what are the main factors involved in the trade-off and what determines the household's choice.

a. *the real wage*

Each unit, say hour, of work effort is rewarded with pay. The real value of the pay is just the real wage, W/P, and it is the flip side of the firm's cost of work effort. We expect that when the real wage rises, the work effort households want to put forth increases also.

We can view this point from a slightly different perspective. When a person takes an hour of leisure, she foregoes an hour of work. The hour of work would have brought W/P units of income. Therefore, an hour of leisure costs the household W/P in terms of income foregone and we say that the real wage is the opportunity cost of leisure. A fundamental result of economics states that when the cost of an activity rises, less of that activity is undertaken. This result played an important role earlier in our discussion of consumption and plays a similar role here. When the real wage rises, the cost of leisure increases, and, according to the fundamental result, the household substitutes more work effort for less leisure. We call this a **substitution effect** and it is the conceptual kissin' cousin of the intertemporal substitution effect that we discussed in the context of the consumption decision.

b. *another wealth effect*

In our discussion of the effect on consumption of a change in the interest rate, we had a loose end. An increase in the interest rate, r, not only set off an intertemporal substitution effect, but also a wealth effect. Specifically, an increase in r made savers, or lenders, better off, and borrowers worse off. The wealth effect offset the intertemporal substitution effect for savers, but
reinforced it for borrowers. We argued that in the aggregate, or for the "average" consumer, the wealth effects cancel out, and only the intertemporal substitution effect remains.

A change in the real wage also sets off a wealth effect. After all, when your wage goes up you are better off. A little mental experiment will make this effect and its consequences clear. Suppose you earned $5 an hour mowing lawns. In the heat of the summer you work 40 hours a week. A series of lawsuits put your competitors out of business allowing you to raise your wage to $15 an hour. It is now possible for you to work fewer hours, but to earn more income. For example, you could cut back your hours to 30 per week and your income would still rise, from $200 to $450 per week. This opens up the possibility of working less in response to an increase in wages.

This reaction appears to be inconsistent with the substitution effect, but the inconsistency is only apparent. Instead, a change in the wage evokes two effects, a substitution effect and a wealth effect. The wealth effect acts to reduce work effort while the substitution effect acts to increase work effort. When the wage went to $15 an hour, and work effort fell to 30 hours, the wealth effect dominated the substitution effect, but this need not happen. In general, the effect on work effort from a change in the wage rate cannot be determined without knowledge of the relative magnitudes of the wealth and substitution effects.

Wealth effects can operate without any change in the real wage. Suppose, for example, that you won the lottery and it was the big one. Your wealth increases substantially. How would your choice of work effort respond? It is highly likely that most people would respond by working less and enjoying more leisure. Leisure is a good (think of it as recreational activities), similar to a consumption good, and when wealth increases we expect consumption of all types, leisure included, to rise; and the increase in leisure leaves less time for work.

It is convenient to separate wealth effects from substitution effects. To do this we lump together all wealth effects, regardless of their source. If the wealth effect from a change in the real wage is likely to be important, we will certainly discuss it; but as a general rule we act as if the only effect from a change in the wage rate is the substitution effect. With this understanding, we can now say that an increase in the real wage increases the supply of labor through a substitution effect. An increase in wealth, whatever its source, lowers work effort.

c. the interest rate
In our discussion of consumption and savings we said that when the interest rate increased it was a good time to save. This led us to conclude that higher interest rates induce households to save more and consume less. Consuming less is only one way to increase your savings. The other way is to earn more income. But, to earn more income, more work effort must be forthcoming. This chain of reasoning leads to the conclusion that an increase in the interest rate brings forth greater work effort.

All the details and qualifications that followed our conclusion about consumption and the interest rate hold here also. This effect is another example of an intertemporal substitution effect. More work effort is put forth, and less leisure enjoyed, today in exchange for less work effort, and more leisure, in the future. There are wealth effects at work on borrowers and lenders. But, as in the consumption case, they cancel out in the aggregate and for the average household, only the intertemporal substitution effect operates. Many economists believe that the effect of the interest rate on work effort is weak. We will return to this point in the chapter on sticky wage models. So, with these reminders and qualifications we conclude that an increase in the interest rate increases work effort.

d. the labor supply function

We can now gather together our results in the form of the labor supply function. This function summarizes the relationship between the supply of work effort and its determinants. The supply of work effort depends on: 1) the real wage rate, 2) wealth, and 3) the interest rate. In symbols we write

\[ N^s = N^s(W/P, \text{wealth, } r), \]

where, as before, the signs indicate the direction of the relationship.

A picture of the labor supply curve is plotted in Figure 10.13. At the real wage \((W/P)_0\) households want to put forth the effort \(N^s_0\). When the real wage increases to \((W/P)_1\), the
increased reward to work effort calls forth a greater labor supply of $N_1$. The substitution effect induces the positive slope of the labor supply curve.

Along any given labor supply curve, wealth and the interest rate are held constant. How does the curve shift when these variables change? Suppose that a hurricane blows by and does serious damage to homes, cars, and other things that aren't tied down. Households lose wealth. At the going real wage, our analysis suggests that households will want to work more to replace, at least in part, some of their losses. Prior to the hurricane, households were at the point A in Figure 10.14. After the hurricane work effort at the wage $(W/P)_0$ increases to $N_1$. This means that the entire curve shifts out and to the right.

An increase in the interest rate encourages work effort at the going real wage. The labor supply curve shifts out and to the right as households try to increase their income and savings to take advantage of the higher interest rates. This shift looks exactly like the one depicted in Figure 10.14.

**Labor Market Equilibrium**

*a. equilibrium work effort and real wages*

We can now put our analysis of labor demand together with our analysis of labor supply. The two curves are drawn in Figure
10.15. It won’t come as a surprise that equilibrium occurs where the two curves cross, but it is worthwhile checking to see if a plausible story lies behind this assertion.

Suppose the real wage is \((W/P)^h\). At this real wage the quantity of labor demanded exceeds the quantity supplied and an excess supply of workers characterizes the market. Many apply for each job opening, employers can be picky about new hires, and workers seldom quit. The difficulty finding a job at \((W/P)^h\) tempts firms to make lower real wage offers and workers are inclined to accept them. The real wage falls. So long as there is an excess supply of workers, there will be downward pressure on real wages and real wages continue to fall toward \((W/P)^*\).

At the real wage \((W/P)^l\) there is an excess demand for workers. Firms have a hard time filling positions and keeping workers. Under these conditions firms bid up wages in an effort to fill openings and retain employees. Needless to say, workers are happy to accept the higher wage. So, when the wage is below the equilibrium \((W/P)^*\), there is upward pressure on it. We conclude that market pressures move the real wage towards \((W/P)^*\). Once the real wage arrives at \((W/P)^*\), pressure for change ends, and employment settles down at \(N^*\).

\[ \text{Figure 10.15  Equilibrium in the Labor Market} \]

b. shocks to the labor market

Once in equilibrium the labor market will stay there until a shock of some sort occurs. A shock is any change that shifts the labor demand or supply curve. We have already gone through them, but a reminder here might be helpful. For labor demand, shocks can come from: 1) changes in technology, 2) changes in the capital stock, and 3) changes in raw materials. For labor supply, shocks arise from: 1) changes in wealth, and 2) changes in the interest rate. Let’s go through some examples that illustrate important principles and results.

Most economists agree that in developed countries technological
change drives economic growth. What is the effect of this type of change in the labor market? An increase in technology shifts the production function up and to the left. The marginal product of labor increases and this, in turn, shifts the labor demand curve out and to the right. This is pictured in Figure 10.16, and shows that the real wage increases as does work effort. So, technological change sets off a substitution effect that raises the real wage and work effort.

But, this isn't the only effect at work. A change in technology permanently increases income and since the increase is permanent, we expect wealth effects to arise. An increase in wealth shifts the labor supply curve up and to the left. This is one of the times it is important to realize that an increase in the wage rate evokes a wealth effect. The wealth induced shift in labor supply is also shown in Figure 10.16. The wealth effect reinforces the increase in real wages, but offsets the increase in employment. We can conclude with confidence that technological change raises real wage rates, but we cannot tell what happens to work effort. It depends on the relative sizes of the substitution and wealth effects.

We reviewed the historical record earlier. Over time real wages have risen at a bumpy, but, nevertheless, steady pace. The behavior of work effort over time is more interesting. From the late 1800s to the mid century the average workweek in manufacturing fell. However, since then it has stayed at about 40 to 41 hours per week. Average hours per capita, plotted in Figure 10.1, tells a similar story. Apparently, in the first half of the century the wealth effect dominated the substitution effect and work effort fell as technology progressed. In the latter half of the century, the two effects about offset and the work effort has been roughly constant.

To complete our analysis, we should consider the possible effects of technical change on the other factors that influence the labor market. Technological progress likely increases the productivity of capital as well as labor and the U.S. has experienced a rise in its capital stock relative to the work effort. In our model this means that K has increased, shifting the production function in the same direction as did the change in technology. This reinforces the above analysis. Over long periods of time the real interest rate has been relatively stable, so we don't expect technological change to have long-run effects on r. The remaining possible shock is changes in natural resources or raw materials. Though oil prices have been highly variable, on average the prices of raw materials have fallen over time. Like the increase in the capital stock, this reinforces our earlier analysis.

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18 chapter 10

19 See William Nordhaus' "Lethal Model 2: The Limits to Growth Revisted" Brookings Economic
We just mentioned that oil prices have been highly variable and this is especially so in the past twenty years. We expect oil prices, and energy prices more generally, to be important in a modern economy. Almost any production process you can imagine uses energy as an input. We would therefore suspect that changes in energy prices could have broad and substantial impacts over the entire economy. These are not just academic observations. We have experienced several sudden and large shocks to energy prices in the recent past. The first OPEC crises arrived in late 1973 and oil prices quadrupled by early 1974. OPEC sharply raised oil prices again beginning in 1979 and continuing into 1981. Our most recent oil price shock occurred in July of 1990 when oil prices sharply increased as a result of the Persian Gulf Crisis. Oil prices don't always rise. In 1985 and 1986 oil prices fell sharply as Iran and Iraq violated their OPEC quotas overproducing oil to finance their war efforts. In response, Saudi Arabia increased their output sharply driving oil prices down, punishing the OPEC mavericks, but benefiting most developed countries.

Each of the increases in oil prices, OPEC I and II, and the Gulf Crisis, coincided with recession when employment and real wages typically fall. In our model, an increase in the price of energy raises the cost of a raw material, and reduces its usage. So, we may think of increases in energy prices as inducing a decline in $Z$. A decline in $Z$ shifts the production function down, and to the left. The marginal product of labor declines and this shifts the labor demand curve down and to the left. There is an initial excess supply of workers and wages and work effort experience downward pressure. The result will be lower real wages and lower employment, and thus produces some of the usual symptoms of a recession. This is illustrated in Figure 10.16.

Figure 10.16 Impact of Technological Progress
Did any other of the determinants of labor supply or labor demand change in this example? Let’s check. There was no change in technology. The utilization of capital might be affected, however. Higher energy prices mean that it is more costly to run machines. As a result, firms may reduce the intensity with which they use their machinery, perhaps with fewer or shorter workshfits. If this occurs, it is equivalent to a decrease in $K$ and would reinforce the decline in labor demand.

There was no direct change in the interest rate and we will have to wait to study possible indirect effects. The only determinant left is wealth. If the increase in the price of oil was perceived to be permanent, wealth effects would have to be taken into account. A decrease in wealth, like in our hurricane example above, causes an increase in the supply of work effort. This pushes the real wage down even farther, but offsets to some extent the employment effect. By contrast, if the oil price shock was thought to be temporary, then any wealth effect would likely be small for the same reasons that temporary shocks to income have small effects on consumption. In this case there would be no change in the labor supply curve and our original analysis would go through unchanged.

**Extensions**

*a. unemployment*

We have not tied together our analysis here with our discussion of unemployment earlier. Indeed, it appears that the above model doesn't allow for unemployment. To remedy this omission let's reinterpret the meaning of labor supply and labor demand. Jobs that are currently filled represent labor demand since if the firm didn't want to have the position it could terminate it. But there may also be some unfulfilled labor demand in the form of job openings or...
vacancies. We may think of labor demand as the sum of current employment and job vacancies, and write

\[ N^d = \text{employed workers} + \text{vacancies}. \]

People who are currently employed are supplying labor, but there is also some unfulfilled supply. Unemployed workers are willing and able to supply work effort, but have not yet found a job. Just as job vacancies may be considered part of labor demand, unemployed workers may be thought of as part of labor supply. This means we may write

\[ N^s = \text{employed workers} + \text{unemployed workers}. \]

Equilibrium in the labor market requires that \( N^s \) equal \( N^d \). This, in turn, implies that

\[ \text{vacancies} = \text{unemployed workers}. \]

In equilibrium everyone need not be employed, but there must be a potential job match for everyone at the going wage.

**b. search theory**

Recall the constant flux in the labor market. At any given time some are leaving jobs to retire, return to school or home, or to look for other work. At the same time, new people enter the work force as their schooling, child rearing, or leisure days end. It takes time to match workers with jobs, so any snapshot of an economy, even one in equilibrium, will show some people unemployed and some job openings available.

The study of the matching process is called search theory. Workers search for jobs and employers search for workers. Whenever you are searching for something the subtle issue is when to quit. The questions always are: What's around the next corner?; Is it worthwhile to walk around it and look?
Suppose you are searching for a job and you get an offer of $10 per hour. Should you accept the offer and stop searching? The answer depends on what you believe is out there and how much it costs you to continue to look. For instance, if you were just laid off of a job that paid $25 an hour and have no reason to believe the value of your skills have deteriorated, you may very well think that there are much better jobs just around the corner. You would not be likely to stop. On the other hand, if you have 3 hungry mouths to feed at home and no income from any other source, this offer may be good enough to take. The lowest wage offer that a job searcher will accept is called the reservation wage. We have just touched on some of the things that determine the reservation wage - the expected real wage and non-wage income - but there are a few more.

Other factors to take into account are the frequency at which job offers arrive, the "spread" of the offers, and the interest rate. If job offers arrive frequently, the reservation wage will be higher. Even if you missed the last boat, another docks soon so there is little harm. The reservation wage will also be higher if there is a large diversity or spread in the offers. For example, if there are three possible offers, $9.75, $10.00, and $10.25, waiting for the $10.25 offer doesn't hold out much gain. On the other hand, if the possible offers are $5, $10, and $15; you may very well be willing to hold out for the $15 offer. Finally, the interest rate plays a role. The higher the interest, the better is the time to earn income and save. A higher interest rate also makes it more costly to borrow, perhaps by running up credit card balances, to tide you over until a job is found. A higher interest rate lowers the reservation wage and discourages search. We can summarize the discussion by writing

\[ w^{res} = w^{res}(\text{expected wage, other income, arrival rate, interest rate, spread}) \]

Other things the same, a higher reservation wage leads on average to a longer search. A longer search will, in turn, lead to both a higher rate and longer duration of unemployment. Some of our earlier discussion of unemployment may be cast in terms of search theory and the reservation wage.

Unemployment insurance, and public assistance programs more generally, are substitute sources of income. More generous or longer unemployment insurance increases the reservation wage and thereby lengthens the average spell of unemployment. This, in turn, tends to raise the
unemployment rate. Recall the plight of the structurally unemployed. A steel worker, say, is laid off. If another job in the steel industry can be found, he can enjoy the same high wage as before. However, the job skills learned making steel do not easily transfer to other occupations. The worker knows that the traditional steel industry is shrinking, but also realizes that there are still a few high paying jobs out there. A worker in this fix faces a large spread of potential offers and it may pay to wait for a high one. This produces higher and longer unemployment.

c. **unions**

Unions organize workers into bargaining units and act as representatives for these units. They negotiate with management to obtain the best deal that they can for their members. The typical union contract covers many aspects of the job and lasts for three years. In the U.S. roughly 10% of the private sector work force is unionized, while in many European countries three-quarters of the work force is covered by collective bargaining agreements. But, unions do not repeal the law of demand for labor, so when unions get higher wages for their employees they are likely to have to settle for fewer jobs. Union negotiators face a tricky trade off between wages and jobs. They would like more of both, but usually must trade one against the other.

Will the higher wages obtained by unions generate more unemployment in the aggregate? Suppose initially there are two industries, say, steel and education. One day union representatives convince steel workers to form a union. The union then negotiates higher wages for steel workers. Unfortunately, at the higher wage the steel industry hires fewer workers. What do the laid-off or shut-out workers do? They must shift over to the education industry. But, the increase in the supply of labor in the education industry lowers wages there. When all is said and done, wages in the steel industry rise while steel industry employment falls. Wages fall in the education industry and employment rises. However, the increase in employment in the education sector will not be large enough to fully offset the decline in steel industry, so aggregate employment falls. More to the point, there will be some workers who are not willing to accept the low wage employment in the education industry, but would accept the high wage in the steel industry. Indeed, they may be waiting to find employment there. These people will be classified as unemployed and may be unemployed for a long time. In this way unions may lead to more and longer unemployment, and less employment.
d. implicit contracts

Union contracts are explicit contracts. They are formally negotiated, reviewed, and signed by the two parties. In non-union settings there may be implicit contracts. Implicit contracts are agreements between employers and employees struck informally and enforced by tradition, trust, or threats of quits or fires. Such agreements may very well take a long view to the relationship. The employer may agree to pay the worker a stable wage in bad times, if the worker agrees to accept a stable wage in good times. Similarly, the worker may promise to work diligently in times of high demand if the firm promises to lay off workers only in low demand periods as a very last resort. If these types of agreements are widespread, an outside observer will see much more stability in wages and employment than the model in this chapter would suggest.

e. labor hoarding

The idea of implicit contracts and their implications leads to the notion of labor hoarding. Some economists argue that in a recession firms retain more workers than their current production justifies. That is, they hoard their labor. Hoarding may be profitable for both sides. Firms may not only extract from this act diligent work effort when they need it, but if they lay off a worker, that worker may take her talents, and any investment in training the firm put in, with her. Workers may be willing to trade intense effort in good times for more job security and stable wages.

Labor hoarding is a popular explanation of the procyclical behavior of productivity. The measured average product of labor is

\[ APL = \frac{\text{measured output}}{\text{measured work effort}}. \]

In a recession measured output falls, but, if labor hoarding occurs, measured work effort will not fall, or at least won't fall by very much. Workers put in the same number of hours, but fewer of the hours actually go toward producing goods or services. This makes the measured APL fall. When the recovery occurs, measured output increases, but measured work effort doesn't.
times are shorter and the production line moves faster. Workers are now busy all day producing goods, but the number of hours worked or the number of employees doesn't change by much. The observer sees a rapid increase in the APL. The apparent stability of wages and employment makes the average productivity of labor appear highly variable.

f. efficiency wages

In the basic model the productivity of labor depended only on the quantities of inputs. The marginal product of labor declined when more work effort was employed and rose when quantities of other inputs increased. Some economists have argued that the wage a worker receives affects her marginal product. Suppose the going wage elsewhere in the economy is $10 per hour. You are the manager of an office, but you have to be out of town often. You can't watch over or monitor your workers directly. One option open to you is to pay your workers more than the going wage, say $15 an hour. Workers are now less likely to shirk since, if they do and are caught, they will not be able to find another job that pays as well. There will also be sharks circling outside your personnel office ready to take the job of the next exposed shirker. It turns out to be efficient to pay the higher wage since it improves the quality of labor and substitutes for the inability to monitor. Relatively high wages may also improve the quality of labor by reducing turnover or improving the average ability of applicants. Wages set to affect the quality of labor are called efficiency wages.

Efficiency wage arguments can help explain persistent unemployment. Suppose a firm sets the efficiency wage at $15 an hour. At this wage there will be a line at the personnel office. In contrast to the basic theory of the labor market, this line will not induce the firm to offer lower wages. A lower wage doesn't profit the firm because it induces shirking from the existing workforce or perhaps excessive labor turnover. The firm is content to let the line persist and keep wages at the $15 mark. Those in line are counted as unemployed and they may be so for a good while.

Summary
The labor market plays a fundamental role in our model. The basic model attempts to isolate the main forces at work. The simplest way to think about the labor market is in terms of supply and demand. Real wages, wealth, and the interest rate determine the supply side of the market. Labor productivity, technology, the capital stock, and prices of raw materials determine the demand side.

We should not forget though that the basic model is a stripped down version of an actual labor market. We spent some time describing some of the intricacies of more elaborate models of this market. But even this coverage was limited. Labor economics is a subject all its own and we will leave to those who teach it to tell you about the economics of discrimination, of pensions, and more.

Review Questions

1) List three different interpretations of the marginal product of labor.

2) Consider the diagram on the previous page.
   a) What is the marginal product of labor when work effort is increased from:
      4 units to 5 units ______________________________
      5 units to 8 units _______________________________
   b) Suppose there is a change in technology, and at every level of work effort 10 more units of output can be produced. Draw the new production function. What kind of shift is this? What happens to the marginal product of labor?
   c) Suppose the real wage is 6 units. Will a firm with the above production function hire the 5th worker?

3) Suppose a worker wins the lottery. Then, work effort
   a) will fall because of a wealth effect
b) will fall because of a substitution effect  
c) will fall because of an intertemporal substitution effect  
d) may fall or rise depending on the strength of wealth and substitution effects

4) The workweek in the U.S. moved from about 55 to 60 hours per week for a manufacturing worker around the turn of the century to about 40 hours per week in 1947. This implies that over this period

a) the wealth effect dominated the intertemporal substitution effect  
b) the wealth effect dominated the substitution effect  
c) the substitution effect dominated the intertemporal substitution effect  
d) households grew lazy

5) Graphically analyze the effect of a temporary decline in oil prices on work effort and the real wage.