6 The Costs of Production

LEARNING OBJECTIVES

After reading this chapter, you should know:

LO1. What the production function reveals.

LO2. The law of diminishing returns.

LO3. How the various measures of cost are related.

Last year U.S. consumers bought more than $2 *trillion* worth of imported goods, including Japanese cars, Italian shoes, and toys from China. As you might expect, this angers domestic producers, who frequently end up with unsold goods, half-empty factories, and unemployed workers. They rage against the "unfair" competition from abroad, asserting that producers in Korea, Brazil, and China can undersell U.S. producers because workers in these countries are paid dirt-poor wages.

But lower wages don't necessarily imply lower costs. You could pay me $2 per hour to type and still end up paying a lot for typing. Truth is, I type only about 10 words a minute, with lots of misteaks. The cost of producing goods depends not only on the price of inputs (e.g., labor) but also on how much they produce.

In this chapter we begin looking at the costs of producing the goods and services that market participants demand. We confront the following questions:

- **How much output *can* a firm produce?**
- **How do the *costs* of production vary with the rate of output?**
- **Do larger firms have a cost advantage over smaller firms?**

The answers to these questions are important not only to producers faced with foreign competition but to consumers as well. The costs of producing a good have a direct impact on the prices consumers pay.

THE PRODUCTION FUNCTION

No matter how large a business is or who owns it, all businesses confront one central fact: It costs something to produce goods. To produce corn, a farmer needs land, water, seed, equipment, and labor. To produce fillings, a dentist needs a chair, a drill, some space, and labor. Even the "production" of educational services such as this economics class requires the use of labor (your teacher), land (on which the school is built), and capital (the building, blackboard, computers). In short, unless you're producing unrefined, unpackaged air, you need **factors of production**—that is, resources that can be used to produce a good or service. These factors of production provide the basic measure of economic cost. The costs of your economics class, for example, are measured by the amounts of land, labor, and capital it requires. These are *resource* costs of production.

factors of production: Resource inputs used to produce goods and services, such as land, labor, capital, and entrepreneurship.

To assess the costs of production, we must first determine how many resources are actually needed to produce a given product. You could use a lot of resources to produce a product or use just a few. What we really want to know is how *best* to produce. What's the *smallest* amount of resources needed to produce a specific product? Or we could ask the same question from a different perspective: What's the *maximum* amount of output attainable from a given quantity of resources.

The answers to these questions are reflected in the **production function,** which tells us the maximum amount of good *X* producible from various combinations of factor inputs. With one chair and one drill, a dentist can fill a *maximum* of 32 cavities per day. With two chairs, a drill, and an assistant, a dentist can fill up to 55 cavities per day.

production function: A technological relationship expressing the maximum quantity of a good attainable from different combinations of factor inputs.

A production function is a technological summary of our ability to produce a particular good.[1] Table 6.1 provides a partial glimpse of one such function. In this case, the output is designer jeans, as produced by Low-Rider Jeans Corporation. The essential inputs in the production of jeans are land, labor (garment workers), and capital (a factory and sewing machines). With these inputs, Low-Rider Jeans Corporation can produce and sell hip-hugging jeans to style-conscious consumers.

Varying Input Levels

As in all production endeavors, we want to know how much output we can produce with available resources. To make things easy, we'll assume that the factory is already built, with fixed space dimensions. The only inputs we can vary are labor (the number of garment workers per day) and additional capital (the number of sewing machines we lease per day).

Capital Input (sewing machines per day)	Labor Input (workers per day)								
	0	1	2	3	4	5	6	7	8
	Jeans Output (pairs per day)								
0	0	0	0	0	0	0	0	0	0
1	0	15	34	44	48	50	51	51	47
2	0	20	46	64	72	78	81	82	80
3	0	21	50	73	83	92	99	103	103

TABLE 6.1
A Production Function

A production function tells us the maximum amount of output attainable from alternative combinations of factor inputs. This particular function tells us how many pairs of jeans we can produce in a day with a given factory and varying quantities of capital and labor. With one sewing machine, and one operator, we can produce a maximum of 15 pairs of jeans per day, as indicated in the second column of the second row. To produce more jeans, we need more labor or more capital.

[1]By contrast, the production possibilities curve discussed in Chapter 1 expresses our ability to produce various *combinations* of goods, given the use of *all* our resources. The production possibilities curve summarizes the output capacity of the entire economy. A production function describes the capacity of a single firm.

In these circumstances, the quantity of jeans we can produce depends on the amount of labor and capital we employ. ***The purpose of a production function is to tell us just how much output we can produce with varying amounts of factor inputs.*** Table 6.1 provides such information for jeans production.

Consider the simplest option, that of employing no labor or capital (the upper-left corner in Table 6.1). An empty factory can't produce any jeans; maximum output is zero per day. Even though land, capital (an empty factory), and even denim are available, some essential labor and capital inputs are missing, and jeans production is impossible.

Suppose now we employ some labor (a machine operator) but don't lease any sewing machines. Will output increase? Not according to the production function. The first row in Table 6.1 illustrates the consequences of employing labor without any capital equipment. Without sewing machines (or even needles, another form of capital), the operators can't make jeans. Maximum output remains at zero, no matter how much labor is employed in this case.

The dilemma of machine operators without sewing machines illustrates a general principle of production: ***The* productivity *of any factor of production depends on the amount of other resources available to it.*** Industrious, hardworking machine operators can't make designer jeans without sewing machines.

productivity: Output per unit of input, for example, output per labor-hour.

We can increase the productivity of garment workers by providing them with machines. The production function again tells us by *how much* jeans output could increase. Suppose we leased just one machine per day. Now the second row in Table 6.1 is the relevant one. It says jeans output will remain at zero if we lease one machine but employ no labor. If we employ one machine *and* one worker, however, the jeans will start rolling out the front door. Maximum output under these circumstances (row 2, column 2) is 15 pairs of jeans per day. Now we're in business!

The remaining columns in row 2 tell us how many additional jeans we can produce if we hire more workers, still leasing only one sewing machine. With one machine and two workers, maximum output rises to 34 pairs per day. If a third worker is hired, output could increase to 44 pairs.

Table 6.1 also indicates how production would increase with additional sewing machines (capital). By reading down any column of the table, you can see how more machines increase potential jeans output.

Efficiency

The production function summarized in Table 6.1 underscores the essential relationship between resource *inputs* and product *outputs*. It's also a basic introduction to economic costs. To produce 15 pairs of jeans per day, we need one sewing machine, an operator, a factory, and some denim. All these inputs comprise the *resource cost* of producing jeans.

Another feature of Table 6.1 is that it conveys the *maximum* output of jeans producible from particular input combinations. The standard garment worker and sewing machine, when brought together at Low-Rider Jeans Corporation, can produce *at most* 15 pairs of jeans per day. They could also produce a lot less. Indeed, a careless cutter can waste a lot of denim. A lazy or inattentive one won't keep the sewing machines humming. As many a producer has learned, actual output can fall far short of the limits described in the production function. Indeed, jeans output will reach the levels in Table 6.1 only if the jeans factory operates with relative **efficiency.** This requires getting maximum output from the resources used in the production process. ***The production function represents maximum technical efficiency—that is, the most output attainable from any given level of factor inputs.***

efficiency (technical): Maximum output of a good from the resources used in production.

We can always be inefficient, of course. This merely means getting less output than possible for the inputs we use. But this isn't a desirable situation. To a factory manager, it means less output for a given amount of input (cost). To society as a whole, inefficiency implies a waste of resources. If Low-Rider Jeans isn't producing efficiently, we're being denied some potential output. It's not only a question of having fewer jeans. We could also use the labor and capital now employed by Low-Rider Jeans to produce something else. Specifically, the **opportunity cost** of a product is measured by the most desired goods and services that could have been produced with the same resources. Hence, if jeans production isn't up to par, society is either (1) getting fewer jeans than it should for the resources

opportunity cost: The most desired goods or services that are forgone in order to obtain something else.

devoted to jeans production or (2) giving up too many other goods and services in order to get a desired quantity of jeans.

Although we can always do worse than the production function suggests, we can't do better, at least in the short run. The production function represents the *best* we can do with our current technological know-how. For the moment, at least, there's no better way to produce a specific good. As our technological and managerial capabilities increase, however, we'll attain higher levels of future productivity. These advances in our productive capability will be represented by new production functions.

Short-Run Constraints

Let's step back from the threshold of scientific advance for a moment and return to Low-Rider Jeans. Forget about possible technological breakthroughs in jeans production (e.g., electronic sewing machines or robot operators) and concentrate on the economic realities of our modest endeavor. For the present we're stuck with existing technology. In fact, all the output figures in Table 6.1 are based on the use of a specific factory. Once we've purchased or leased that factory, we've set a limit to current jeans production. When such commitments to fixed inputs (e.g., the factory) exist, we're dealing with a **short-run** production problem. If no land or capital were in place—if we could build or lease any-sized factory—we'd be dealing with a *long-run* decision.

short run: The period in which the quantity (and quality) of some inputs can't be changed.

Our short-run objective is to make the best possible use of the factory we've acquired. This entails selecting the right combination of labor and capital inputs to produce jeans. To simplify the decision, we'll limit the number of sewing machines in use. If we lease only one sewing machine, then the second row in Table 6.1 is the only one we have to consider. In this case, the single sewing machine (capital) becomes another short-run constraint on the production of jeans. With a given factory and one sewing machine, the short-run rate of output depends entirely on how many workers are hired.

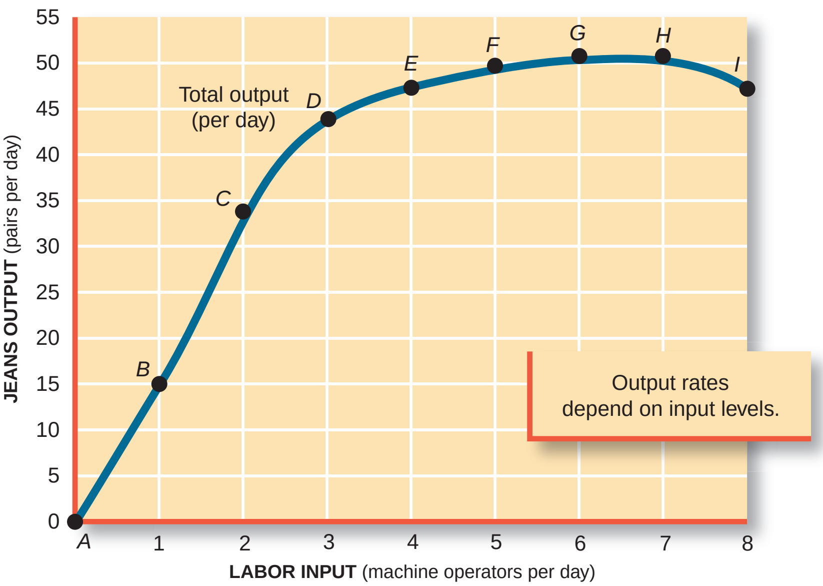


FIGURE 6.1
Short-Run Production Function

In the short run some inputs (e.g., land and capital) are fixed in quantity. Output then depends on how much of a variable input (e.g., labor) is used. The short-run production function shows how output changes when more labor is used. This figure and the table below are based on the second (one-machine) row in Table 6.1.

	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*
Number of workers	0	1	2	3	4	5	6	7	8
Total output	0	15	34	44	48	50	51	51	47
Marginal physical product	—	15	19	10	4	2	1	0	−4

Figure 6.1 illustrates the short-run production function applicable to the factory with one sewing machine. As noted before, a factory with a sewing machine but no machine operators produces no jeans. This was observed in Table 6.1 (row 1, column 0) and is now illustrated by point *A* in Figure 6.1. To get any jeans output, we need to hire some labor. In this simplified example, ***labor is the variable input that determines how much output we get from our fixed inputs (land and capital).*** By placing one worker in the factory, we can produce 15 pairs of jeans per day. This possibility is represented by point *B*. The remainder of the production function shows how jeans output changes as we employ more workers in our single-machine factory.

MARGINAL PRODUCTIVITY

The short-run production function not only defines the *limit* to output but also shows how much each worker contributes to that limit. Notice again that jeans output increases from zero (point *A* in Figure 6.2) to 15 pairs (point *B*) when the first machine operator is hired. In other words, total output *increases* by 15 pairs when we employ the first worker. This increase is called the **marginal physical product (MPP)** of that first worker—that is, the *change* in total output that results from employment of one more unit of (labor) input, or

marginal physical product (MPP): The change in total output associated with one additional unit of input.

$$\text{Marginal physical product (MPP)} = \frac{\text{change in total output}}{\text{change in input quantity}}$$

With zero workers, total output was zero. With the first worker, total output increases to 15 pairs of jeans per day. The MPP of the first worker is 15 pairs of jeans.

If we employ a second operator, jeans output more than doubles, to 34 pairs per day (point *C*). The 19-pair *increase* in output represents the marginal physical product of the *second* worker.

The higher MPP of the second worker raises a question about the first. Why was the first's MPP lower? Laziness? Is the second worker faster, less distracted, or harder working?

The second worker's higher MPP isn't explained by superior talents or effort. We assume, in fact, that all "units of labor" are equal—that is, one worker is just as good as another.[2] Their different marginal products are explained by the structure of the production process,

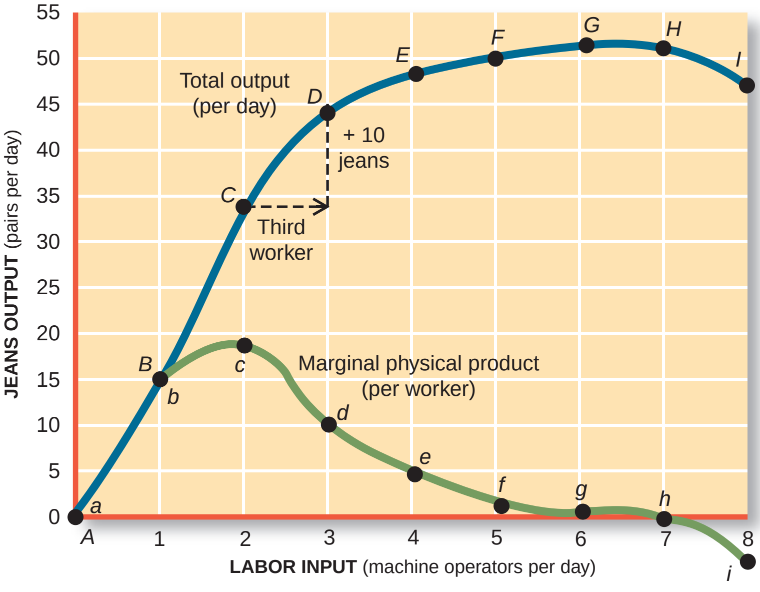


FIGURE 6.2
Marginal Physical Product (MPP)

Marginal physical product is the *change* in total output that results from employing one more unit of input. The *third* unit of labor, for example, increases *total output* from 34 (point *C*) to 44 (point *D*). Hence the *marginal* output of the third worker is 10 pairs of jeans (point *d*). What's the MPP of the fourth worker? What happens to *total* output when this worker is hired?

[2] In reality, garment workers do differ greatly in energy, talent, and diligence. These differences can be eliminated by measuring units of labor in *constant-quality* units. A person who works twice as hard as everyone else would count as two *quality-adjusted* units of labor.

not by their respective abilities. The first garment worker not only had to sew jeans but also to unfold bolts of denim, measure the jeans, sketch out the patterns, and cut them to approximate size. A lot of time was spent going from one task to another. Despite the worker's best efforts, this person simply couldn't do everything at once.

A second worker alleviates this situation. With two workers, less time is spent running from one task to another. While one worker is measuring and cutting, the other can continue sewing. This improved *ratio* of labor to other factors of production results in the large jump in total output. The second worker's superior MPP isn't unique to this person: It would have occurred even if we'd hired the workers in the reverse order.

Diminishing Marginal Returns

Unfortunately, total output won't keep rising so sharply if still more workers are hired. Look what happens when a third worker is hired. Total jeans production continues to increase. But the increase from point *C* to point *D* in Figure 6.2 is only 10 pairs per day. Hence, the third worker's MPP (10 pairs) is *less* than that of the second (19 pairs). Marginal physical product is *diminishing.* This concept is illustrated by point *d* in Figure 6.2.

What accounts for this decline in MPP? The answer lies in the ratio of labor to other factors of production. A third worker begins to crowd our facilities. We still have only one sewing machine. Two people can't sew at the same time. As a result, some time is wasted as the operators wait for their turns at the machine. Even if they split up the various jobs, there will still be some "downtime," since measuring and cutting aren't as time-consuming as sewing. Consequently, we can't make full use of a third worker. The relative scarcity of other inputs (capital and land) constrains the third worker's marginal physical product.

Resource constraints are even more evident when a fourth worker is hired. Total output increases again, but the increase this time is very small. With three workers, we got 44 pairs of jeans per day (point *D*); with four workers, we get a maximum of 48 pairs (point *E*). Thus the fourth worker's MPP is only 4 pairs of jeans. There simply aren't enough machines to make productive use of so much labor.

If a seventh worker is hired, the operators get in one another's way, argue, and waste denim. Notice in Figure 6.1 that total output doesn't increase at all when a seventh worker is hired (point *H*). The MPP of the seventh worker is zero (point *h*). Were an eighth worker hired, total output would actually *decline*, from 51 pairs (point *H*) to 47 pairs (point *I*). The eighth worker has a *negative* MPP (point *i* in Figure 6.2).

Law of Diminishing Returns. The problems of crowded facilities apply to most production processes. In the short run, a production process is characterized by a fixed amount of available land and capital. Typically, the only factor that can be varied in the short run is labor. Yet, ***as more labor is hired, each unit of labor has less capital and land to work with.*** This is simple division: The available facilities are being shared by more and more workers. At some point, this constraint begins to pinch. When it does, marginal physical product declines. This situation is so common that it's the basis for the **law of diminishing returns,** which says that the marginal physical product of any factor of production, such as labor, will diminish at some point, as more of it is used in a given production setting. Notice in Figure 6.2 how diminishing returns set in when the third worker was hired.

law of diminishing returns: The marginal physical product of a variable input declines as more of it is employed with a given quantity of other (fixed) inputs.

RESOURCE COSTS

A production function tells us how much output a firm *can* produce with its existing plant and equipment. It doesn't tell us how much the firm will *want* to produce. A firm *might* want to produce at capacity if the profit picture were bright enough. On the other hand, a firm might not produce *any* output if costs always exceeded sales revenue. The most desirable rate of output is the one that maximizes total **profit**—the difference between total revenue and total costs.

profit: The difference between total revenue and total cost.

The production function therefore is just a starting point for supply decisions. To decide how much output to produce with that function, a firm must next examine the costs of production. How fast do costs rise when output increases?

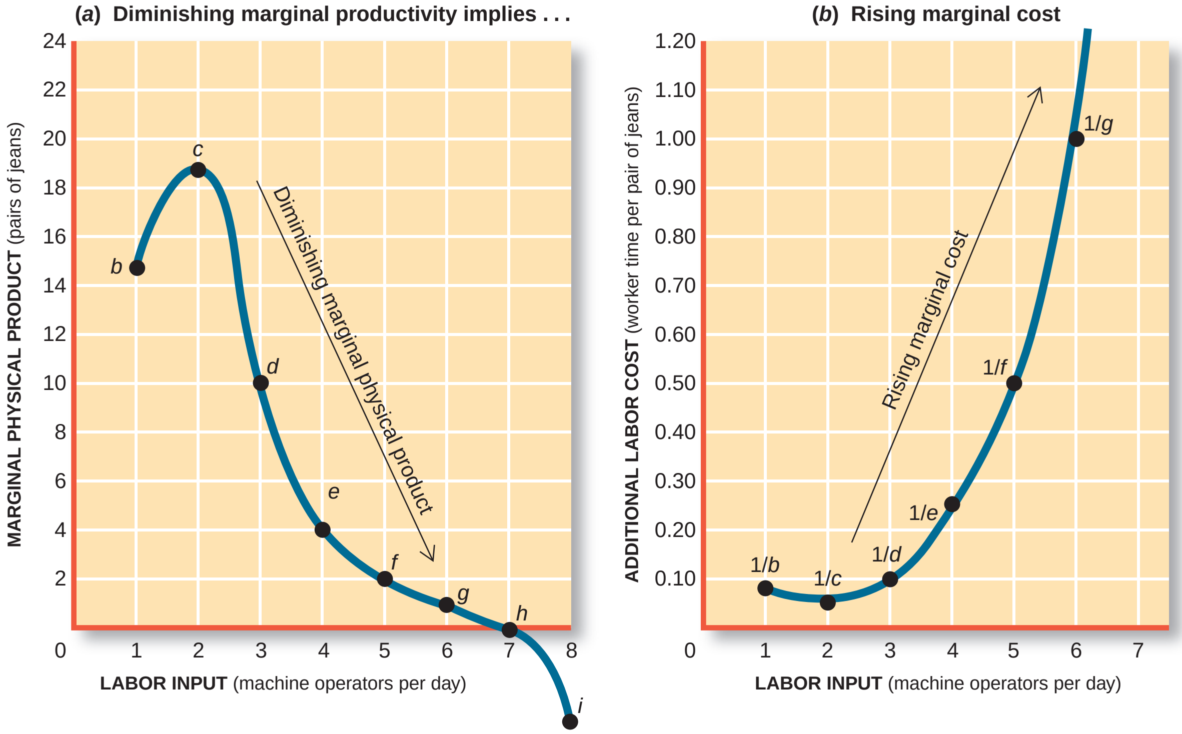


FIGURE 6.3
Falling MPP Implies Rising Marginal Cost

Marginal physical product (MPP) is the additional output obtained by employing one more unit of input. If MPP is falling, each additional unit of input is producing less additional output, which means that the input cost of each unit of output is rising. The third worker's MPP is 10 pairs (point *d* in part *a*). Therefore, the labor cost of these additional jeans is approximately 1/10 unit of labor per pair (point 1/*d* in part *b*).

The law of diminishing returns provides a clue to how fast costs rise. ***The economic cost of a product is measured by the value of the resources needed to produce it.*** What we've seen here is that those resource requirements eventually increase. Each additional sewing machine operator produces fewer and fewer jeans. In effect, then, each additional pair of jeans produced uses more and more labor.

Suppose we employ one sewing machine and one operator again, for a total output of 15 pairs of jeans per day; see point *b* in Figure 6.3*a*. Now look at production from another perspective, that of *costs*. How much labor cost are we using at point *b* to produce one pair of jeans? The answer is simple. Since one worker is producing 15 pairs of jeans, the labor input per pair of jeans must be one-fifteenth of a worker's day, that is, 0.067 unit of labor; see point 1/*b* in Figure 6.3*b*. All we're doing here is translating *output* data into related *input* (cost) data.

Marginal Resource Cost

The next question is, How do input costs change when output increases. As point *c* in Figure 6.3*a* reminds us, total output increases by 19 pairs when we hire a second worker. What's the implied labor cost of those *additional* 19 pairs? By dividing one worker by 19 pairs of jeans, we observe that the labor cost of that extra output is one-nineteenth, or 0.053 of a worker's day; see point 1/*c* in Figure 6.3*b*.

When we focus on the *additional* costs incurred from increasing production, we're talking about *marginal* costs. Specifically, **marginal cost (MC)** refers to the *increase* in total costs required to get one additional unit of output. More generally,

marginal cost (MC): The increase in total cost associated with a one-unit increase in production.

$$\text{Marginal cost (MC)} = \frac{\text{change in total cost}}{\text{change in output}}$$

In our simple case where labor is the only variable input, the marginal cost of the added jeans is

$$\text{Marginal cost} = \frac{\text{1 additional worker}}{\text{19 additional pairs}}$$

$$= 0.053 \text{ workers per pair}$$

Topic Podcast: Why Marginal Costs Rise

The amount 0.053 of labor represents the *change* in total resource cost when we produce one *additional* pair of jeans.

Notice in Figure 6.3*b* that the marginal labor cost of jeans production declines when the second worker is hired. Marginal cost falls from 0.067 unit of labor (plus denim) per pair (point 1/*b* in Figure 6.3*b*) to only 0.053 unit of labor per pair (point 1/*c*). It costs less labor *per pair* to use two workers rather than only one. This is a reflection of the second worker's increased MPP. ***Whenever MPP is increasing, the marginal cost of producing a good must be falling.*** This is illustrated in Figure 6.3 by the upward move from *b* to *c* in part *a* and the corresponding downward move from 1/*b* to 1/*c* in part *b*.

Unfortunately, marginal physical product typically declines at some point. As it does, the marginal costs of production rise. In this sense, each additional pair of jeans becomes more expensive—it uses more and more labor per pair. Figure 6.3 illustrates this inverse relationship between MPP and marginal cost. The third worker has an MPP of 10 pairs, as illustrated by point *d*. The marginal labor input of these extra 10 pairs is thus 1 ÷ 10, or 0.10 unit of labor. In other words, one-tenth of a third worker's daily effort goes into each pair of jeans. This additional labor cost *per unit* is illustrated by 1/*d* in part *b* of the figure.

Note in Figure 6.3 how marginal physical product declines after point *c* and how marginal costs rise after point 1/*c*. This is no accident. ***If marginal physical product declines, marginal cost increases.*** Thus, increasing marginal cost is as common as—and the direct result of—diminishing returns. These increasing marginal costs aren't the fault of any person or factor, simply a reflection of the resource constraints found in any established production setting (i.e., existing and limited plant and equipment). In the short run, the quantity and quality of land and capital are fixed, and we can vary only their intensity of use, such as with more or fewer workers. It's in this short-run context that we keep running into diminishing marginal returns and rising marginal costs.

DOLLAR COSTS

This entire discussion of diminishing returns and marginal costs may seem a bit alien. After all, we're interested in the costs of production, and costs are typically measured in *dollars*, not such technical notions as MPP. Jeans producers need to know how many dollars it costs to keep jeans flowing; they don't want a lecture on marginal physical product.

Jeans manufacturers don't have to study marginal physical products, or even the production function. They can confine their attention to dollar costs. The dollar costs observed, however, are directly related to the underlying production function. To understand *why* costs rise—and how they might be reduced—some understanding of the production function is necessary. In this section we translate production functions into dollar costs.

Total Cost

total cost: The market value of all resources used to produce a good or service.

The **total cost** of producing a product includes the market value of all the resources used in its production. To determine this cost we simply identify all the resources used in production, determine their value, and then add up everything.

In the production of jeans, these resources included land, labor, and capital. Table 6.2 identifies these resources, their unit values, and the total dollar cost associated with their use. This table is based on an assumed output of 15 pairs of jeans per day, with the use of one worker and one sewing machine (point *B* in Figure 6.2). The rent on the factory is $100 per day, a sewing machine rents for $20 per day, the wages of a garment worker are $80 per day. We'll assume Low-Rider Jeans Corporation can purchase bolts of denim for $30 apiece, with each bolt providing enough denim for 10 pairs of jeans. In other words, one-tenth of a bolt ($3 worth of material) is required for one pair of jeans. We'll ignore any other

Resource Input	×	Unit Price	=	Total Cost
1 factory		$100 per day		$100
1 sewing machine		20 per day		20
1 operator		80 per day		80
1.5 bolts of denim		30 per bolt		45
Total cost				$245

TABLE 6.2
The Total Costs of Production (total cost of producing 15 pairs of jeans per day)

The total cost of producing a good equals the market value of all the resources used in its production. In this case, the production of 15 pairs of jeans per day requires resources worth $245.

potential expenses. With these assumptions, the total cost of producing 15 pairs of jeans per day amounts to $245, as shown in Table 6.2.

Fixed Costs. Total costs will change of course as we alter the rate of production. But not all costs increase. In the short run, some costs don't increase at all when output is increased. These are **fixed costs,** in the sense that they don't vary with the rate of output. The factory lease is an example. Once you lease a factory, you're obligated to pay for it, whether or not you use it. The person who owns the factory wants $100 per day. Even if you produce no jeans, you still have to pay that rent. That's the essence of fixed costs.

The leased sewing machine is another fixed cost. When you rent a sewing machine, you must pay the rental charge. It doesn't matter whether you use it for a few minutes or all day long—the rental charge is fixed at $20 per day.

fixed costs: Costs of production that don't change when the rate of output is altered (e.g., the cost of basic plant and equipment).

Variable Costs. Labor costs are another story altogether. The amount of labor employed in jeans production can be varied easily. If we decide not to open the factory tomorrow, we can just tell our only worker to take the day off without pay. We'll still have to pay rent, but we can cut back on wages. On the other hand, if we want to increase daily output, we can also get additional workers easily and quickly. Labor is regarded as a **variable cost** in this line of work—that is, a cost that *varies* with the rate of output.

The denim itself is another variable cost. Denim not used today can be saved for tomorrow. Hence, how much we "spend" on denim today is directly related to how many jeans we produce. In this sense, the cost of denim input varies with the rate of jeans output.

Figure 6.4 illustrates how these various costs are affected by the rate of production. On the vertical axis are the costs of production, in dollars per day. Notice that the total cost

variable costs: Costs of production that change when the rate of output is altered (e.g., labor and material costs).

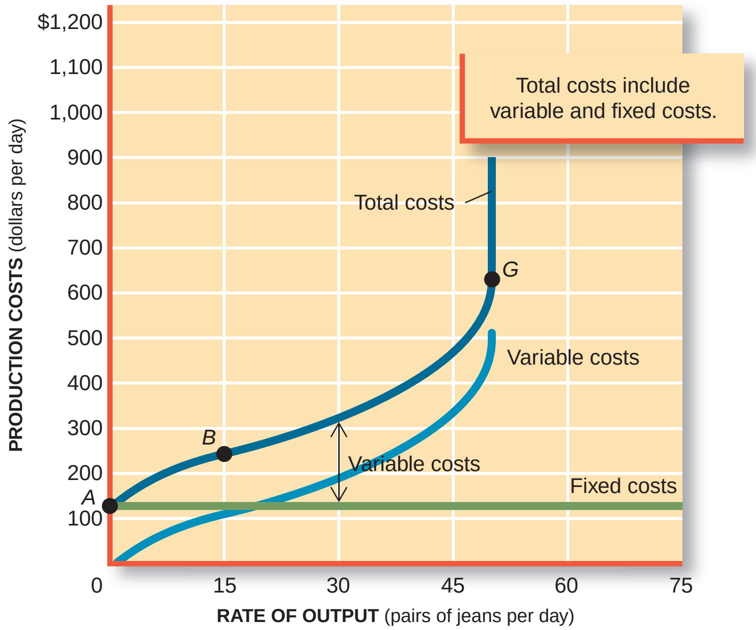


FIGURE 6.4
The Cost of Jeans Production

Total cost includes both fixed and variable costs. Fixed costs must be paid even if no output is produced (point *A*). Variable costs start at zero and increase with the rate of output. The total cost of producing 15 pairs of jeans (point *B*) includes $120 in fixed costs (rent on the factory and sewing machines) and $125 in variable costs (denim and wages). Total cost rises as output increases, because additional variable costs must be incurred.

In this example, the short-run capacity is equal to 51 pairs (point *G*). If still more inputs are employed, costs will rise but not total output.

of producing 15 pairs per day is still $245, as indicated by point *B*. This cost figure consists of

Dollar Cost of Producing 15 Pairs

Fixed costs:		
Factory rent	$100	
Sewing machine rent	20	
Subtotal		$120
Variable costs:		
Wages to labor	$80	
Denim	45	
Subtotal		$125
Total costs		$245

If we increase the rate of output, total costs will rise. ***How fast total costs rise depends on variable costs only,*** however, since fixed costs remain at $120 per day. (Notice the horizontal fixed-cost curve in Figure 6.4.)

With one sewing machine and one factory, there's an absolute limit to daily jeans production. According to the production function in Figure 6.1, the capacity of a factory with one machine is roughly 51 pairs of jeans per day. If we try to produce more jeans than this by hiring additional workers, our total costs will rise, but our output won't. Recall that the seventh worker had a *zero* marginal physical product (Figure 6.2). In fact, we could fill the factory with garment workers and drive total costs sky-high. But the limits of space and one sewing machine don't permit output in excess of 51 pairs per day. This limit to productive capacity is represented by point *G* on the total cost curve. Further expenditure on inputs will increase production *costs* but not *output.*

Although there's no upper limit to costs, there is a lower limit. If output is reduced to zero, total costs fall only to $120 per day, the level of fixed costs, as illustrated by point *A* in Figure 6.4. As before, ***there's no way to avoid fixed costs in the short run.*** Indeed, those fixed costs define the short run.

Average Costs

average total cost (ATC): Total cost divided by the quantity produced in a given time period.

While Figure 6.4 illustrates *total* costs of production, other measures of cost are often desired. One of the most common measures of cost is average, or per-unit, cost. **Average total cost (ATC)** is simply total cost divided by the rate of output:

$$\text{Average total cost (ATC)} = \frac{\text{total cost}}{\text{total output}}$$

At an output of 15 pairs of jeans per day, total costs are $245. The average cost of production is thus $16.33 per pair (= 245 ÷ 15) at this rate of output.

Figure 6.5 shows how average costs change as the rate of output varies. Row *J* of the cost schedule, for example, again indicates the fixed, variable, and total costs of producing 15 pairs of jeans per day. Fixed costs are still $120; variable costs are $125. Thus the total cost of producing 15 pairs per day is $245, as we saw earlier.

The rest of row *J* shows the average costs of jeans production. These figures are obtained by dividing each dollar total (columns 2, 3, and 4) by the rate of physical output (column 1). At an output rate of 15 pairs per day, **average fixed cost (AFC)** is $8 per pair, **average variable cost (AVC)** is $8.33, and *average total cost (ATC)* is $16.33. ATC, then, is simply the sum of AFC and AVC:

average fixed cost (AFC): Total fixed cost divided by the quantity produced in a given time period.

average variable cost (AVC): Total variable cost divided by the quantity produced in a given time period.

$$\text{ATC} = \text{AFC} + \text{AVC}$$

Falling AFC. At this relatively low rate of output, fixed costs are a large portion of total costs. The rent paid for the factory and sewing machines works out to $8 per pair ($120 ÷ 15). This high average fixed cost accounts for nearly one-half of total average costs. This suggests that it's quite expensive to lease a factory and sewing machine to produce only 15 pairs of jeans per day. To reduce average costs, we must make fuller use of our leased plant and equipment.

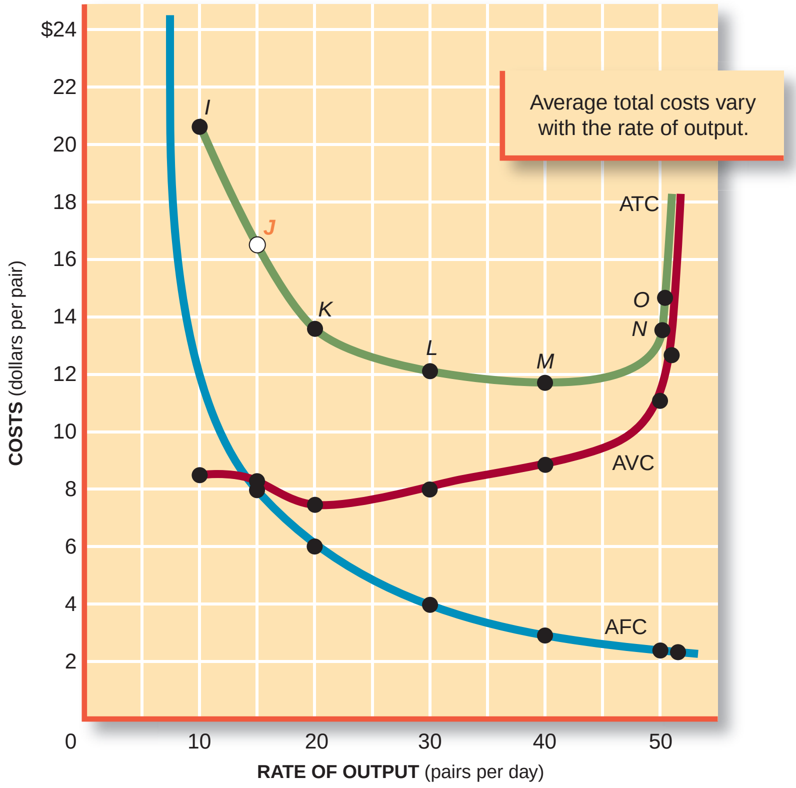


FIGURE 6.5
Average Costs

Average total cost (ATC) in column 7 equals total cost (column 4) divided by the rate of output (column 1). Since total cost includes both fixed (column 2) and variable (column 3) costs, ATC also equals AFC (column 5) plus AVC (column 6). This relationship is illustrated in the graph. The ATC of producing 15 pairs per day (point *J*) equals $16.33—the sum of AFC ($8) and AVC ($8.33).

	(1) Rate of Output	(2) Fixed Costs	+	(3) Variable Costs	=	(4) Total Cost	(5) Average Fixed Cost	+	(6) Average Variable Cost	=	(7) Average Total Cost
H	0	$120		$ 0		$120	—		—		—
I	10	120		85		205	$12.00		$ 8.50		$20.50
J	15	120		125		245	8.00		8.33		16.33
K	20	120		150		270	6.00		7.50		13.50
L	30	120		240		360	4.00		8.00		12.00
M	40	120		350		470	3.00		8.75		11.75
N	50	120		550		670	2.40		11.00		13.40
O	51	120		633		753	2.35		12.41		14.76

Notice what happens to average costs when the rate of output is increased to 20 pairs per day (row *K* in Figure 6.5). Average fixed costs go down, to only $6 per pair. This sharp decline in AFC results from the fact that total fixed costs ($120) are now spread over more output. Even though our rent hasn't dropped, the *average* fixed cost of producing jeans has.

If we produce more than 20 pairs of jeans per day, AFC will continue to fall. Recall that

$$\text{AFC} = \frac{\text{total fixed cost}}{\text{total output}}$$

The numerator is fixed (at $120 in this case). But the denominator increases as output expands. Hence, ***any increase in output will lower average fixed cost.*** This is reflected in Figure 6.5 by the constantly declining AFC curve.

As jeans output increases from 15 to 20 pairs per day, AVC falls as well. AVC includes the price of denim purchased and labor costs. The price of denim is unchanged, at $3 per pair ($30 per bolt). But per-unit *labor* costs have fallen, from $5.33 to $4.50 per pair. Thus, the reduction in AVC is completely due to the greater productivity of a second worker. To get 20 pairs of jeans, we had to employ a second worker part-time. In the process, the marginal physical product of labor rose and AVC fell.

With both AFC and AVC falling, ATC must decline as well. In this case, *average* total cost falls from $16.33 per pair to $13.50. This is reflected in row *K* in the table as well as in point *K* on the ATC curve in Figure 6.5.

Rising AVC. Although AFC continues to decline as output expands, AVC doesn't keep dropping. On the contrary, AVC tends to start rising quite early in the expansion process. Look at column 6 of the table in Figure 6.5. After an initial decline, AVC starts to increase. At an output of 20 pairs, AVC is $7.50. At 30 pairs, AVC is $8.00. By the time the rate of output reaches 51 pairs per day, AVC is $12.41.

Average variable cost rises because of diminishing returns in the production process. We discussed this concept before. As output expands, each unit of labor has less land and capital to work with. Marginal physical product falls. As it does, labor costs *per pair of jeans* rise, pushing up AVC.

U-Shaped ATC. The steady decline of AFC, when combined with the typical increase in AVC, results in a U-shaped pattern for average total costs. In the early stages of output expansion, the large declines in AFC outweigh any increases in AVC. As a result, ATC tends to fall. Notice that ATC declines from $20.50 to $11.75 as output increases from 10 to 40 pairs per day. This is also illustrated in Figure 6.5 with the downward move from point *I* to point *M*.

The battle between falling AFC and rising AVC takes an irreversible turn soon thereafter. When output is increased from 40 to 50 pairs of jeans per day, AFC continues to fall (row *N* in the table). But the decline in AFC (−60 cents) is overshadowed by the increase in AVC (+$2.25). Once rising AVC dominates, ATC starts to increase as well. ATC increases from $11.75 to $13.40 when jeans production expands from 40 to 50 pairs per day.

This and further increases in average total costs cause the ATC curve in Figure 6.5 to start rising. ***The initial dominance of falling AFC, combined with the later resurgence of rising AVC, is what gives the ATC curve its characteristic U shape.***

Minimum Average Cost. It's easy to get lost in this thicket of intertwined graphs and jumble of equations. A couple of landmarks will help guide us out, however. One of those is located at the very bottom of the U-shaped average total cost curve. Point *M* in Figure 6.5 represents *minimum* average total costs. By producing exactly 40 pairs per day, we minimize the amount of land, labor, and capital used per pair of jeans. For Low-Rider Jeans Corporation, point *M* represents least-cost production—the lowest-cost jeans. For society as a whole, point *M* also represents the lowest possible opportunity cost: At point *M*, we're minimizing the amount of resources used to produce a pair of jeans and therefore maximizing the amount of resources left over for the production of other goods and services.

As attractive as point *M* is, you shouldn't conclude that it's everyone's dream. The primary objective of producers is to maximize *profits*. This is not necessarily the same thing as minimizing average *costs*.

Marginal Cost

One final cost concept is important. Indeed, this last concept is probably the most important one for production. It's *marginal cost*. We encountered this concept in our discussion of resource costs, where we noted that marginal cost refers to the value of the resources needed to produce one more unit of a good. To produce *one* more pair of jeans, we need the denim itself and a very small amount of additional labor. These are the extra or added costs of increasing output by one pair of jeans per day. To compute the *dollar* value of these

Resources Used to Produce 16th Pair of Jeans	×	Market Value	=	Marginal Cost
0.053 unit of labor		0.053 × $80 per unit of labor		$4.24
0.1 bolt of denim		0.1 × $30 per bolt		3.00
				$7.24

TABLE 6.3
Resource Computation of Marginal Cost

Marginal cost refers to the value of the additional inputs needed to produce one more unit of output. To increase daily jeans output from 15 to 16 pairs, we need 0.053 unit of labor and one-tenth of a bolt of denim. These extra inputs cost $7.24.

marginal costs, we could determine the market price of denim and labor and then add them up. Table 6.3 provides an example. In this case, we calculate that the additional or *marginal* cost of producing a sixteenth pair of jeans is $7.24. This is how much *total* costs will increase if we decide to expand jeans output by only one pair per day (from 15 to 16).

Table 6.3 emphasizes the link between resource costs and dollar costs. However, there's a much easier way to compute marginal cost. ***Marginal cost refers to the change in total costs associated with one more unit of output.*** Accordingly, we can simply observe *total* dollar costs before and after the rate of output is increased. The difference between the two totals equals the *marginal cost* of increasing the rate of output. This technique is much easier for jeans manufacturers who don't know much about marginal resource utilization but have a sharp eye for dollar costs. It's also a lot easier for economics students, of course. But they have an obligation to understand the resource origins of marginal costs and what causes marginal costs to rise or fall. As we noted before, ***diminishing returns in production cause marginal costs to increase as the rate of output is expanded.***

Figure 6.6 shows what the marginal costs of producing jeans look like. At each output rate, marginal cost is computed as the *change* in total cost divided by the *change* in output. When output increases from 20 jeans to 30 jeans, total cost rises by $90. Dividing this change in costs by 10 (the change in output) gives us a marginal cost of $9, as illustrated by point *s*.

Notice in Figure 6.6 how the marginal cost curve slopes steeply up after 20 units of output have been produced. This rise in marginal costs reflects the law of diminishing returns. As increases in output become more difficult to achieve, they also become more expensive. Each additional pair of jeans beyond 20 requires a bit more labor than the preceding pair and thus entails rising marginal cost.

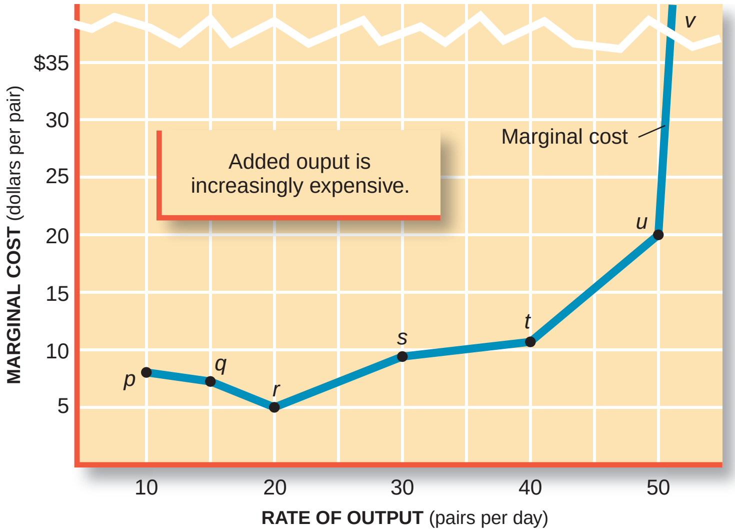
A Cost Summary

All these cost calculations can give you a real headache. They can also give you second thoughts about jumping into Low-Rider Jeans or any other business. There are tough choices to be made. A given firm can produce many different rates of output, each of which entails a distinct level of costs. ***The output decision has to be based not only on the* capacity *to produce (the production function) but also on the* costs *of production (the cost functions).*** Only those who make the right decisions will succeed in business.

The decision-making process is made a bit easier with the glossary in Table 6.4 and the generalized cost curves in Figure 6.7. As before, we're concentrating on a short-run production process, with fixed quantities of land and capital. In this case, however, we've abandoned the Low-Rider Jeans Corporation and provided hypothetical costs for an idealized production process. The purpose of these figures is to provide a more general view of how the various cost concepts relate to each other. Note that MC, ATC, AFC, and AVC can all be computed from total costs. All we need, then, are the first two columns of the table in Figure 6.7, and we can compute and graph all the rest of the cost figures.

FIGURE 6.6
Marginal Costs

Marginal cost is the change in total cost that occurs when more output is produced. MC equals $\Delta TC/\Delta q$. When diminishing returns set in, MC begins rising, as it does here after the output rate of 20 pairs per day is exceeded.



	Rate of Output	Total Cost	$\frac{\Delta TC}{\Delta q}$ = MC
	0	$120	
p	10	205	$85/10 = $8.5
q	15	245	$40/5 = $8.0
r	20	270	$25/5 = $5.0
s	30	360	$90/10 = $9.0
t	40	470	$110/10 = $11.0
u	50	670	$200/10 = $20.0
v	51	753	$83/1 = $83.0

MC-ATC Intersection. The centerpiece of Figure 6.7 is the U-shaped ATC curve. Of special significance is its relationship to marginal costs. Notice that ***the MC curve intersects the ATC curve at its lowest point*** (point *m*). This will always be the case. So long as the marginal cost of producing one more unit is less than the previous average cost, average

TABLE 6.4
A Guide to Costs

A quick reference to key measures of cost.

Total costs of production are comprised of **fixed costs** and **variable costs:**

$$TC = FC + VC$$

Dividing total costs by the quantity of output yields the **average total cost:**

$$ATC = \frac{TC}{q}$$

which also equals the sum of **average fixed cost** and **average variable cost:**

$$ATC = AFC + AVC$$

The most important measure of changes in cost is **marginal cost,** which equals the increase in total costs when an additional unit of output is produced:

$$MC = \frac{\text{change in total cost}}{\text{change in output}}$$

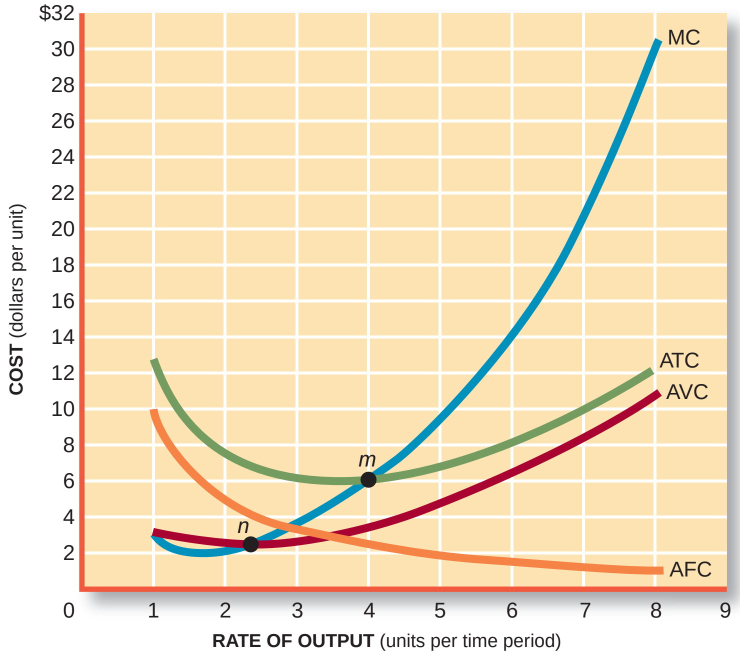


FIGURE 6.7
Basic Cost Curves

With total cost and the rate of output, all other cost concepts can be computed. The resulting cost curves have several distinct features. The AFC curve always slopes downward. The MC curve typically rises, sometimes after a brief decline. The ATC curve has a U shape. And the MC curve will always intersect both the ATC and AVC curves at their lowest points (*m* and *n*, respectively).

Rate of Output	TC	MC	ATC	AFC	AVC
0	$10.00	—	—	—	—
1	13.00	$ 3.00	$13.00	$10.00	$ 3.00
2	15.00	2.00	7.50	5.00	2.50
3	19.00	4.00	6.33	3.33	3.00
4	25.00	6.00	6.25	2.50	3.75
5	34.00	9.00	6.80	2.00	4.80
6	48.00	14.00	8.00	1.67	6.33
7	68.00	20.00	9.71	1.43	8.28
8	98.00	30.00	12.25	1.25	11.00

costs must fall. ***Thus, average total costs decline as long as the marginal cost curve lies below the average cost curve,*** as to the left of point *m* in Figure 6.7.

We already observed, however, that marginal costs rise as output expands, largely because additional workers reduce the amount of land and capital available to each worker (in the short run, the size of plant and equipment is fixed). Consequently, at some point (*m* in Figure 6.7) marginal costs will rise to the level of average costs.

As marginal costs continue to rise beyond point *m*, they begin to pull average costs up, giving the average cost curve its U shape. ***Average total costs increase whenever marginal costs exceed average costs.*** This is the case to the right of point *m*, since the marginal cost curve always lies above the average cost curve in that part of Figure 6.7.

To visualize the relationship between marginal cost and average cost, imagine computing the average height of people entering a room. If the first person who comes through the door is six feet tall, then the average height of people entering the room is six feet at that point. But what happens to average height if the second person entering the room is only three feet tall? *Average* height declines because the last (marginal) person entering the room is shorter than the previous average. Whenever the last entrant is shorter than the average, the average must fall.

The relationship between marginal costs and average costs is also similar to that between your grade in this course and your grade-point average. If your grade in economics is better (higher) than your other grades, then your overall grade-point average will rise. In other words, a high *marginal* grade will pull your *average* grade up. If you don't understand this, your grade-point average is likely to fall.

ECONOMIC VS. ACCOUNTING COSTS

The cost curves we observed here are based on *real* production relationships. The dollar costs we compute are a direct reflection of underlying resource costs: the land, labor, and capital used in the production process. Not everyone counts this way. On the contrary, accountants and businesspeople typically count dollar costs only and ignore any resource use that doesn't result in an explicit dollar cost.

Return to Low-Rider Jeans for a moment to see the difference. When we computed the dollar cost of producing 15 pairs of jeans per day, we noted the following resource inputs:

INPUTS	COST PER DAY
1 factory rent	$100
1 machine rent	20
1 machine operator	80
1.5 bolts of denim	45
Total cost	$245

The total value of the resources used in the production of 15 pairs of jeans was thus $245 per day. But this figure needn't conform to *actual* dollar costs. Suppose the owners of Low-Rider Jeans decided to sew jeans. Then they wouldn't have to hire a worker or pay $80 per day in wages. **Explicit costs**—the *dollar* payments—would drop to $165 per day. The producers and their accountant would consider this a remarkable achievement. They might assert that the cost of producing jeans had fallen.

explicit cost: A payment made for the use of a resource.

Economic Cost

An economist would draw no such conclusions. ***The essential economic question is how many resources are used in production.*** This hasn't changed. One unit of labor is still being employed at the factory; now it's simply the owner, not a hired worker. In either case, one unit of labor is not available for the production of other goods and services. Hence, society is still paying $245 for jeans, whether the owners of Low-Rider Jeans write checks in that amount or not. The only difference is that we now have an **implicit cost** rather than an explicit one. We really don't care who sews jeans—the essential point is that someone (i.e., a unit of labor) does.

implicit cost: The value of resources used, even when no direct payment is made.

The same would be true if Low-Rider Jeans owned its own factory rather than rented it. If the factory were owned rather than rented, the owners probably wouldn't write any rent checks. Hence, accounting costs would drop by $100 per day. But the factory would still be in use for jeans production and therefore unavailable for the production of other goods and services. The economic (resource) cost of producing 15 pairs of jeans would still be $245.

The distinction between an economic cost and an accounting cost is essentially one between resource and dollar costs. *Dollar cost* refers to the explicit dollar outlays made by a producer; it's the lifeblood of accountants. **Economic cost,** in contrast, refers to the *value* of *all* resources used in the production process; it's the lifeblood of economists. In other words, economists count costs as

economic cost: The value of all resources used to produce a good or service; opportunity cost.

$$\text{Economic cost} = \text{explicit costs} + \text{implicit costs}$$

As this formula suggests, ***economic and accounting costs will diverge whenever any factor of production is not paid an explicit wage (or rent, etc.).***

The Cost of Homework. These distinctions between economic and accounting costs apply also to the "production" of homework. You can pay people to write term papers for you or buy them off the Internet. At large schools you can often buy lecture notes as well. But most students do their own homework so they'll learn something and not just turn in required assignments.

Doing homework is expensive, however, even if you don't pay someone to do it. The time you spend reading this chapter is valuable. You could be doing something else if you weren't reading right now. What would you be doing? The forgone activity—the best alternative use of your time—represents the economic cost of doing homework. Even if you don't pay yourself for reading this chapter, you'll still incur that *economic* cost.

LONG-RUN COSTS

We've confined our discussion thus far to short-run production costs. ***The short run is characterized by fixed costs***—a commitment to specific plant and equipment. A factory, an office building, or some other plant and equipment have been leased or purchased: We're stuck with *fixed costs.* In the short run, our objective is to make the best use of those fixed costs by choosing the appropriate rate of production.

The long run opens up a whole new range of options. In the **long run,** we have no lease or purchase commitments. We're free to start all over again, with whatever scale of plant and equipment we desire and whatever technology is available. Quite simply, ***there are no fixed costs in the long run.*** Nor are there any commitments to existing technology. In 2004, General Motors could have built an engine plant in China of any size. But they decided to build one with a capacity of 300,000 engines (see World View). In building the plant, the company incurred a fixed cost. Once the plant was completed, GM focused on the short-run production decision of how many engines to manufacture.

long run: A period of time long enough for all inputs to be varied (no fixed costs).

Long-Run Average Costs

The opportunities available in the long run include building a plant of any desired size. Suppose we still wanted to go into the jeans business. In the long run, we could build or lease any size factory we wanted and could lease as many sewing machines as we desired. Figure 6.8 illustrates three choices: a small factory (ATC_1), a medium-sized factory (ATC_2), and a large factory (ATC_3). As we observed earlier, it's very expensive to produce lots of jeans with a small factory. The ATC curve for a small factory (ATC_1) starts to head straight up at relatively low rates of output. In the long run, we'd lease or build such a factory only if we anticipated a continuing low rate of output.

The ATC_2 curve illustrates how costs might fall if we leased or built a medium-sized factory. With a small-sized factory, ATC becomes prohibitive at an output of 50 to 60 pairs of

WORLD VIEW

GM Plans to Invest $3 Billion in China to Boost Its Presence

BEIJING—General Motors Corp. said it plans to invest more than $3 billion in China in the next three years, underscoring its bid to become a leader in the world's fastest growing auto market. . . .

The new investments are mainly for expanding its production capacity for vehicles and engines, improving its research and development center, and a new auto-financing venture it is launching this year with its main partner in China, Shanghai Automotive Industry Corp. . . .

All in all, GM expects its vehicle-assembly capacity in China to reach 1.3 million units a year by 2007 from its current 530,000 units a year.

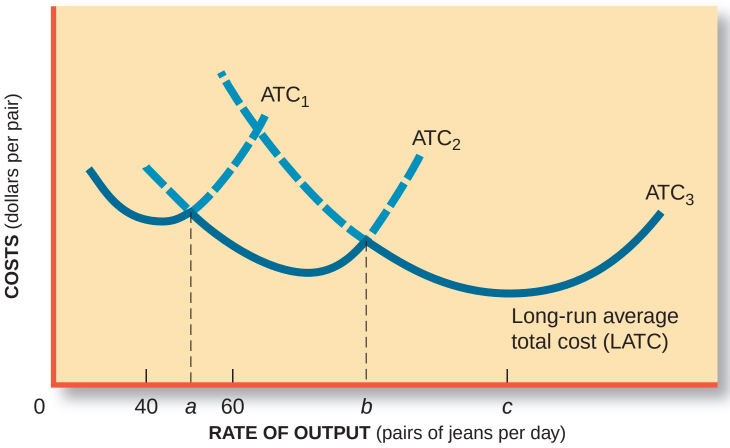
To support its expansion, GM also plans to build a new engine plant with a production capacity of 300,000 engines a year, and a new transmission plant.

—Jane Lanhee Lee

Analysis: In the long run, a firm has no fixed costs and can select any desired plant size. Once a plant is built, leased, or purchased, a firm has fixed costs and focuses on short-run output decisions.

FIGURE 6.8
Long-Run Costs with Three Plant Size Options

Long-run cost possibilities are determined by all possible short-run options. In this case, there are three options of varying size (ATC_1, ATC_2, and ATC_3). In the long run, we'd choose the plant that yielded the lowest average cost for any desired rate of output. The solid portion of the curves (LATC) represents these choices. The smallest factory (ATC_1) is best for output levels below *a;* the largest (ATC_3), output rates in excess of *b.*



jeans per day. A medium-sized factory can produce these quantities at lower cost. Moreover, ATC continues to drop as jeans production increases in the medium-sized factory—at least for a while. Even a medium-sized factory must contend with resource constraints and therefore rising average costs: Its ATC curve is U-shaped also.

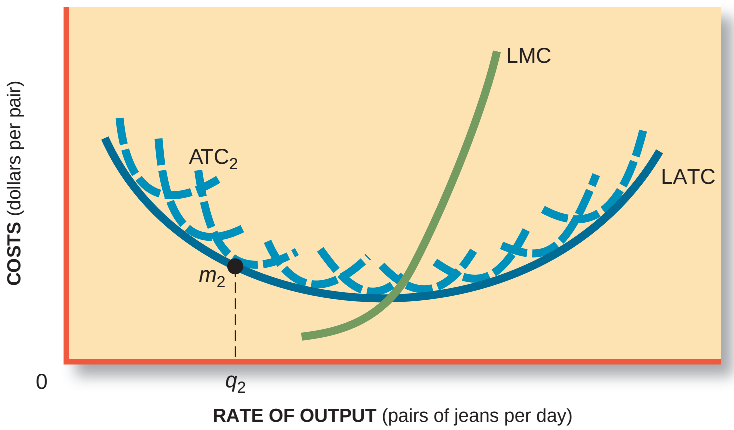
If we expected to sell really large quantities of jeans, we'd want to build or lease a large factory. Beyond the rate of output *b*, the largest factory offers the lowest average total cost. There's a risk in leasing such a large factory, of course. If our sales don't live up to our high expectations, we'll end up with very high fixed costs and thus very expensive jeans. Look at the high average cost of producing only 60 pairs of jeans per day with the large factory (ATC_3).

In choosing an appropriate factory, then, we must decide how many jeans we expect to sell. Once we know our expected output, we can select the right-sized factory. It will be the one that offers the lowest ATC for that rate of output. If we expect to sell fewer jeans than *a*, we'll choose the small factory in Figure 6.8. If we expect to sell jeans at a rate between *a* and *b*, we'll select a medium-sized factory. Beyond rate *b*, we'll want the largest factory. These choices are reflected in the solid part of the three ATC curves. The composite "curve" created by these three segments constitutes our long-run cost possibilities. ***The long-run cost curve is just a summary of our best short-run cost possibilities, using existing technology and facilities.***

We might confront more than three choices, of course. There's really no reason we couldn't build a factory to *any* desired size. In the long run, we face an infinite number of scale choices, not just three. The effect of all these choices is to smooth out the long-run cost curve. Figure 6.9 depicts the long-run curve that results. Each rate of output is most efficiently produced by some size (scale) of plant. That sized plant indicates the minimum

FIGURE 6.9
Long-Run Costs with Unlimited Options

If plants of all sizes can be built, short-run options are infinite. In this case, the LATC curve becomes a smooth U-shaped curve. Each point on the curve represents lowest-cost production for a plant size best suited to one rate of output. The long-run ATC curve has its own MC curve.



cost of producing a particular rate of output. Its corresponding short-run ATC curve provides one point on the long-run ATC curve.

Long-Run Marginal Costs

Like all average cost curves, the long-run (LATC) curve has its own marginal cost curve. The long-run marginal cost (LMC) curve isn't a composite of short-run marginal cost curves. Rather, it's computed on the basis of the costs reflected in the long-run ATC curve itself. We won't bother to compute those costs here. Note, however, that the long-run MC curve—like all MC curves—intersects its associated average cost curve at its lowest point.

ECONOMIES OF SCALE

Figure 6.8 seems to imply that a producer must choose either a small plant or a larger one. That isn't completely true. The choice is often between one large plant or *several* small ones. Suppose the desired level of output was relatively large, as at point *c* in Figure 6.8. A single small plant (ATC_1) is clearly not up to the task. But what about using several small plants rather than one large one (ATC_3)? How would costs be affected?

Notice what happens to *minimum ATC* in Figure 6.8 when the size (scale) of the factory changes. When a medium-sized factory (ATC_2) replaces a small factory (ATC_1), minimum average cost drops (the bottom of ATC_2 is below the bottom of ATC_1). This implies that a jeans producer who wants to minimize costs should build one medium-sized factory rather than try to produce the same quantity with two small ones. **Economies of scale** exist in this situation: Larger facilities reduce *minimum* average costs. Such economies of scale help explain why a single firm has come to dominate the funeral business (see News).

economies of scale: Reductions in minimum average costs that come about through increases in the size (scale) of plant and equipment.

Larger production facilities don't always result in cost reductions. Suppose a firm has the choice of producing the quantity Q_m from several small factories or from one large, centralized facility. Centralization may have three different impacts on costs; these are illustrated in Figure 6.10. In each illustration, we see the average total cost (ATC) curve for a typical small firm or plant and the ATC curve for a much larger plant producing the same product.

webnote

To learn more about the business of dying, go to www.sci-corp.com

Constant Returns. Figure 6.10*a* depicts a situation in which there's no economic advantage to centralization of manufacturing operations, because a large plant is no more efficient

IN THE NEWS

Funeral Giant Moves In on Small Rivals

Life's two certainties are death and taxes. Some day, it could be just as certain that Service Corp. International will handle your funeral.

The Houston-based company will handle one in 10 funeral services in the USA this year, or about 230,000. In just 32 years, the company has grown from a single funeral home into the world's biggest death-services provider with 2,631 funeral homes, 250 cemeteries and 137 crematoria in North America, Europe and Australia. . . .

SCI's sheer size provides big advantages over competitors. SCI is able to get cheaper prices on caskets and other products from suppliers.

Its funeral homes clustered in the same markets cut costs by sharing vehicles, personnel, services and supplies. That helps give SCI a profit of 31 cents on every dollar it takes in for a typical funeral, vs. 12 cents for the industry as a whole, SCI says.

Funeral directors "don't want to think of (death) as big business," says Betty Murray of the National Foundation of Funeral Directors. "But we're in the era of acquisitions and consolidations."

—Ron Trujillo

Source: *USA Today*, October 31, 1995. www.usatoday.com

Analysis: As the size of a firm increases, it may be able to reduce the costs of doing business. Economies of scale can give a large firm a competitive advantage over smaller firms.

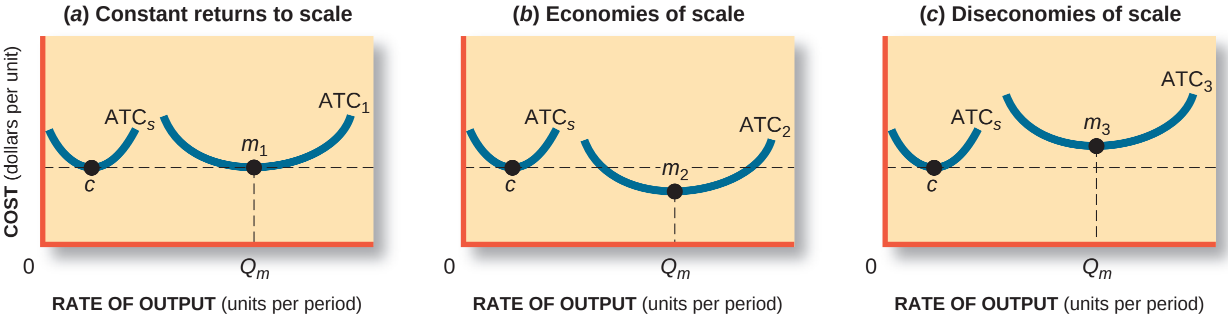


FIGURE 6.10
Economies of Scale

A lot of output (Q_m) can be produced from one large plant or many small ones. Here we contrast the average total costs associated with one small plant (ATC_s) and three large plants (ATC_1, ATC_2, and ATC_3). If a large plant attains the same *minimum* average costs (point m_1 in part *a*) as a smaller plant (point *c*), there's no advantage to large size (scale). Many small plants can produce the same output just as cheaply. However, either economies (part *b*) or diseconomies (part *c*) of scale may exist.

than a lot of small plants. The critical focus here is on the *minimum* average costs attainable for a given rate of output. Note that the lowest point on the smaller plant's ATC curve (point *c*) is no higher or lower than the lowest point on the larger firm's ATC curve (point m_1). Hence, it would be just as cheap to produce the quantity Q_m from a multitude of small plants as it would be to produce Q_m from one large plant. Thus increasing the size (or *scale*) of individual plants won't reduce minimum average costs: This is a situation of **constant returns to scale.**

constant returns to scale: Increases in plant size do not affect minimum average cost: minimum per-unit costs are identical for small plants and large plants.

Economies of Scale. Figure 6.10*b* illustrates the situation in which a larger plant can attain a lower minimum average cost than a smaller plant. That is, economies of scale (or *increasing returns to scale*) exist. This is evident from the fact that the larger firm's ATC curve falls *below* the dashed line in the graph (m_2 is less than *c*). The greater efficiency of the large factory might come from any of several sources. This is the situation of the funeral home depicted in the News feature. By centralizing core funeral services, Services Corp. International was able to reduce average costs per funeral. Larger organizations may also gain a cost advantage through specialization, by having each worker become expert in a particular skill. By contrast, a smaller establishment might have to use the same individual(s) to perform several functions, thereby reducing productivity at each task. Also, some kinds of machinery may be economical only if they're used to produce massive volumes, an opportunity only very large factories have. Finally, a large plant might acquire a persistent cost advantage through the process of learning by doing. That is, its longer experience and greater volume of output may translate into improved organization and efficiency.

Diseconomies of Scale. Even though large plants may be able to achieve greater efficiencies than smaller plants, there's no assurance that they actually will. In fact, increasing the size (scale) of a plant may actually *reduce* operating efficiency, as depicted in Figure 6.10*c*. Workers may feel alienated in a plant of massive proportions and feel little commitment to productivity. Creativity may be stifled by rigid corporate structures and off-site management. A large plant may also foster a sense of anonymity that induces workers to underperform. When these things happen, *diseconomies of scale* result. Microsoft tries to avoid such diseconomies of scale by creating autonomous cells of no more than 35 employees ("small plants") within its larger corporate structure.

In evaluating long-run options, then, we must be careful to recognize that ***efficiency and size don't necessarily go hand in hand.*** Some firms and industries may be subject to economies of scale, but others may not. Bigger isn't always better.

THE ECONOMY TOMORROW

GLOBAL COMPETITIVENESS

From 1900 to 1970, the United States regularly exported more goods and services than it imported. Since then, America has had a trade deficit nearly every year. In 2006, U.S. imports exceeded exports by more than $700 billion. To many people, such trade deficits are a symptom that the United States can no longer compete effectively in world markets.

Global competitiveness ultimately depends on the costs of production. If international competitors can produce goods more cheaply, they'll be able to undersell U.S. goods in global markets.

Cheap Foreign Labor? Cheap labor keeps costs down in many countries. The average wage in Mexico, for example, ranges from $2 to $3 an hour, compared to over $16 an hour in the United States. China's manufacturing workers make only $1 to $2 an hour. Low wages are *not*, however, a reliable measure of global competitiveness. To compete in global markets, one must produce more *output* for a given quantity of *inputs*. In other words, labor is "cheap" only if it produces a lot of output in return for the wages paid.

A worker's contribution to output is measured by *marginal physical product (MPP)*. What we saw in this chapter was that ***a worker's productivity (MPP) depends on the quantity and quality of other resources in the production process.*** In this regard, U.S. workers have a tremendous advantage: They work with vast quantities of capital and state-of-the-art technology. They also come to the workplace with more education. Their high wages reflect this greater productivity.

Unit Labor Costs. A true measure of global competitiveness must take into account both factor costs (e.g., wages) and productivity. One such measure is **unit labor costs,** which indicates the labor cost of producing one unit of output. It's computed as

unit labor cost: Hourly wage rate divided by output per labor-hour.

$$\text{Unit labor cost} = \frac{\text{wage rate}}{\text{MPP}}$$

Suppose the MPP of a U.S. worker is 7 units per hour and the wage is $14 an hour. The unit labor cost would be

$$\begin{array}{c}\text{Unit labor cost}\\ \text{(United States)}\end{array} = \frac{\$14/\text{hour}}{7\text{ units/hour}} = \begin{array}{c}\$2/\text{unit}\\ \text{of output}\end{array}$$

By contrast, assume the average worker in Mexico has an MPP of 1 unit per hour and a wage of $3 an hour. In this case, the unit labor cost would be

$$\begin{array}{c}\text{Unit labor cost}\\ \text{(Mexico)}\end{array} = \frac{\$3}{1} = \begin{array}{c}\$3/\text{unit}\\ \text{of output}\end{array}$$

According to these hypothetical examples, "cheap" Mexican labor is no bargain. Mexican labor is actually *more* costly in production, despite the lower wage rate.

Productivity Advance. What these calculations illustrate is how important productivity is for global competitiveness. If we want the United States to stay competitive in global markets, U.S. productivity must increase as fast as that in other nations.

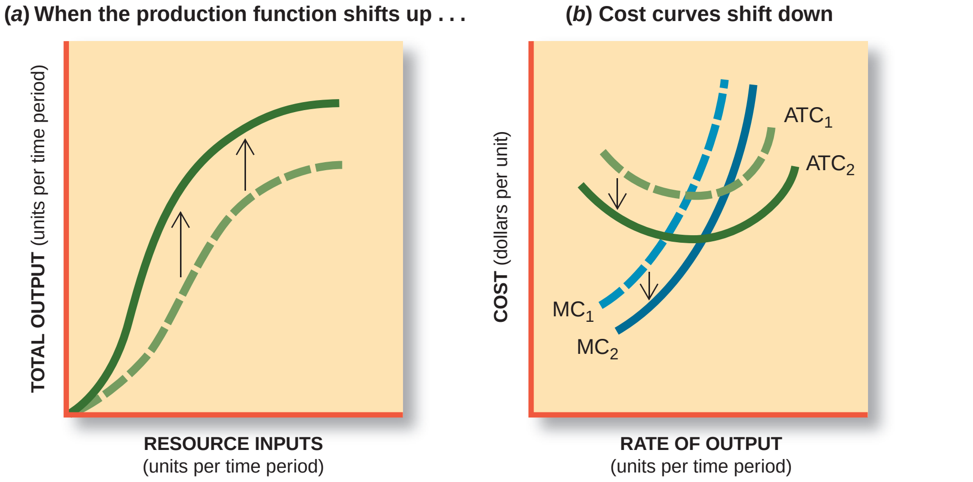
The production function introduced in this chapter helps illustrate the essence of global competitiveness in the economy tomorrow. Until now, we've regarded a firm's production function as a technological fact of life—the *best* we could do, given our state of technological and managerial knowledge. In the real world, however, the best is always getting better. Science and technology are continuously advancing. So is our knowledge of how to organize and manage our resources. These advances keep *shifting* production functions upward: More can be produced with any given quantity of inputs. In the process, the costs of production shift downward, as illustrated in Figure 6.11 by the downward shifts of the

webnote

For current data on unit labor costs and underlying wage and productivity trends, visit the U.S. Bureau of Labor Statistics at www.bls.gov

FIGURE 6.11
Improvements in Productivity Reduce Costs

Advances in technological or managerial knowledge increase our productive capability. This is reflected in upward shifts of the production function (part *a*) and downward shifts of production cost curves (part *b*).



MC and ATC curves. These downward shifts imply that we can get more of the goods and services we desire with available resources. We can also compete more effectively in global markets.

Internet-Driven Gains. The Internet has been an important source of productivity gains in the last 10 years. Although the Internet originated over 30 years ago, its commercial potential emerged with the creation of the World Wide Web around 1990. As recently as 1995 there were only 10,000 Web sites. Now there are over 100 *million* sites. This vastly expanded spectrum of information has helped businesses cut costs in many ways. The cost of gathering information about markets and inputs has been reduced. With the reach of the Internet, firms can engage in greater specialization. Firms can also manage their inventories and supply chains much more efficiently. Transaction and communications costs are reduced as well. All of these productivity improvements are cutting U.S. production costs by \$100–250 billion a

WORLD VIEW

United States Gains Cost Advantage

Productivity is increasing faster than wages in U.S. manufacturing, giving the U.S. an edge in the race for global competitiveness. In the last 10 years, the cost of producing a widget has fallen by nearly 10 percent in the U.S., but risen by nearly 17 percent in Japan. Other contenders:

Country	Change in Unit Labor Costs, 1995–2005
Italy	31.9
Denmark	24.2
Japan	16.8
United Kingdom	16.5
Canada	1.6
Korea	−9.1
United States	**−9.8**
France	−11.8
Taiwan	−26.7

Source: U.S. Bureau of Labor Statistics. www.bls.gov

Analysis: Global competitiveness depends on unit labor costs. U.S. unit labor costs have declined in the last decade or so, increasing America's competitiveness in world markets.

year. These cost savings helped U.S. businesses *reduce* unit labor costs by 0.4 percent a year in the 1990s. As the accompanying World View confirms, those gains widened the United States' lead in the ongoing race for global competitiveness. To maintain that leading position in the economy tomorrow, U.S. productivity must continue to advance at a brisk pace.

SUMMARY

- A production function indicates the maximum amount of output that can be produced with different combinations of inputs. It's a technological relationship and changes (shifts) when new technology or management techniques are discovered. LO1
- In the short run, some inputs (e.g., land and capital) are fixed in quantity. Increases in (short-run) output result from more use of variable inputs (e.g., labor). LO1
- The contribution of a variable input to total output is measured by its marginal physical product (MPP). This is the amount by which *total* output increases when one more unit of the input is employed. LO1
- The MPP of a factor tends to decline as more of it is used in a given production facility. Diminishing marginal returns result from crowding more of a variable input (e.g., labor) into a production process, reducing the amount of fixed inputs *per unit* of variable input. LO2
- Marginal cost is the increase in total cost that results when output is increased by one unit. Marginal cost increases whenever marginal physical product diminishes. LO2
- Not all costs go up when the rate of output is increased. Fixed costs such as space and equipment leases don't vary with the rate of output. Only variable costs such as labor and material go up when output is increased. LO3
- Average total cost (ATC) equals total cost divided by the quantity of output produced. ATC declines whenever marginal cost (MC) is less than average cost and rises when MC exceeds it. The MC and ATC curves intersect at minimum ATC (the bottom of the U). That intersection represents least-cost production. LO3
- The economic costs of production include the value of *all* resources used. Accounting costs typically include only those dollar costs actually paid (explicit costs). LO3
- In the long run there are no fixed costs; the size (scale) of production can be varied. The long-run ATC curve indicates the lowest cost of producing output with facilities of appropriate size. LO3
- Economies of scale refer to reductions in *minimum* average cost attained with larger plant size (scale). If minimum ATC rises with plant size, diseconomies of scale exist. LO3
- Global competitiveness and domestic living standards depend on productivity advances. Improvements in productivity shift production functions up and push cost curves down. LO1

Key Terms

factors of production
production function
productivity
efficiency
opportunity cost
short run
marginal physical product (MPP)
law of diminishing returns
profit
marginal cost (MC)
total cost
fixed costs
variable costs
average total cost (ATC)
average fixed cost (AFC)
average variable cost (AVC)
explicit cost
implicit cost
economic cost
long run
economies of scale
constant returns to scale
unit labor cost

Questions for Discussion

1. What are the production costs of your economics class? What are the fixed costs? The variable costs? What's the marginal cost of enrolling more students? LO1
2. Suppose all your friends offered to help wash your car. Would marginal physical product decline as more friends helped? Why or why not? LO2
3. How many cars *can* GM produce in China? (See World View, page 133.) How many cars will GM *want* to produce? LO1
4. Owner/operators of small gas stations rarely pay themselves an hourly wage. How does this practice affect the economic cost of dispensing gasoline? LO3
5. Corporate funeral giants have replaced small family-run funeral homes in many areas, in large part because of the lower costs they achieve. (See News, page 135.) What kind of economies of scale exist in the funeral business? Why doesn't someone build one colossal funeral home and drive costs down further? LO3

6. Are colleges subject to economies of scale or diseconomies? LO3
7. Why don't more U.S. firms move to Mexico to take advantage of low wages there? Would an *identical* plant in Mexico be as productive as its U.S. counterpart? LO1
8. How would your productivity in completing course work be measured? Has your productivity changed since you began college? What caused the productivity changes? How could you increase productivity further? LO1
9. What is the economic cost of doing this homework? LO1

problems The Student Problem Set at the back of this book contains numerical and graphing problems for this chapter.

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! web activities to accompany this chapter can be found on the Online Learning Center: **http://www.mhhe.com/economics/schiller11e**