GLOBAL EDITION

Microeconomics

NINTH EDITION

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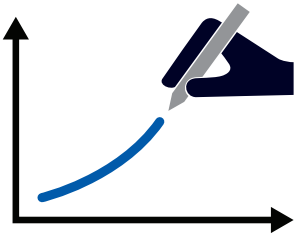

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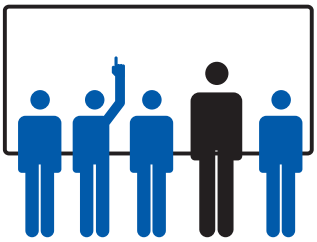

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Overall, physical capital (including plant and equipment) accounts for about 77 percent of a typical carpet manufacturer's costs, while labor accounts for the remaining 23 percent. Over time, the major carpet manufacturers have increased the scale of their operations by putting larger and more efficient tufting machines into larger plants. At the same time, the use of labor in these plants has also increased significantly. The result? Proportional increases in inputs have resulted in a more than proportional increase in output for these larger plants. For example, a doubling of capital and labor inputs might lead to a 110-percent increase in output. This pattern has not, however, been uniform across the industry. Most smaller carpet manufacturers have found that small changes in scale have little or no effect on output; i.e., small proportional increases in inputs have only increased output proportionally.

We can therefore characterize the carpet industry as one in which there are constant returns to scale for relatively small plants but increasing returns to scale for larger plants. These increasing returns, however, are limited, and we can expect that if plant size were increased further, there would eventually be decreasing returns to scale.

SUMMARY

1. A *production function* describes the maximum output that a firm can produce for each specified combination of inputs.
2. In the short run, one or more inputs to the production process are fixed. In the long run, all inputs are potentially variable.
3. Production with one variable input, labor, can be usefully described in terms of the *average product of labor* (which measures output per unit of labor input) and the *marginal product of labor* (which measures the additional output as labor is increased by 1 unit).
4. According to the *law of diminishing marginal returns*, when one or more inputs are fixed, a variable input (usually labor) is likely to have a marginal product that eventually diminishes as the level of input increases.
5. An *isoquant* is a curve that shows all combinations of inputs that yield a given level of output. A firm's production function can be represented by a series of isoquants associated with different levels of output.
6. Isoquants always slope downward because the marginal product of all inputs is positive. The shape of each isoquant can be described by the marginal rate of technical substitution at each point on the isoquant. The *marginal rate of technical substitution of labor for capital* (MRTS) is the amount by which the input of capital can be reduced when one extra unit of labor is used so that output remains constant.
7. The standard of living that a country can attain for its citizens is closely related to its level of labor productivity. Decreases in the rate of productivity growth in developed countries are due in part to the lack of growth of capital investment.
8. The possibilities for substitution among inputs in the production process range from a production function in which inputs are *perfect substitutes* to one in which the proportions of inputs to be used are fixed (a *fixed-proportions production function*).
9. In long-run analysis, we tend to focus on the firm's choice of its scale or size of operation. *Constant returns to scale* means that doubling all inputs leads to doubling output. *Increasing returns to scale* occurs when output more than doubles when inputs are doubled; *decreasing returns to scale* applies when output less than doubles.

QUESTIONS FOR REVIEW

1. What is a production function? How does a long-run production function differ from a short-run production function?
2. Why is the marginal product of labor likely to increase initially in the short run as more of the variable input is hired?
3. Why does production eventually experience diminishing marginal returns to labor in the short run?
4. You are an employer seeking to fill a vacant position on an assembly line. Are you more concerned with the average product of labor or the marginal product of labor for the last person hired? If you observe that your average product is just beginning to decline, should you hire any more workers? What does this situation imply about the marginal product of your last worker hired?

5. What is the difference between a production function and an isoquant?
6. Faced with constantly changing conditions, why would a firm ever keep *any* factors fixed? What criteria determine whether a factor is fixed or variable?
7. Isoquants can be convex, linear, or L-shaped. What does each of these shapes tell you about the nature of the production function? What does each of these shapes tell you about the MRTS?
8. Can an isoquant ever slope upward? Explain.
9. Explain the term "marginal rate of technical substitution." What does a MRTS = 4 mean?
10. Explain why the marginal rate of technical substitution is likely to diminish as more and more labor is substituted for capital.
11. Is it possible to have diminishing returns to a single factor of production and constant returns to scale at the same time? Discuss.
12. Can a firm have a production function that exhibits increasing returns to scale, constant returns to scale, and decreasing returns to scale as output increases? Discuss.
13. Suppose that output q is a function of a single input, labor (L). Describe the returns to scale associated with each of the following production functions: (a) $q = L/2$ (b) $q = L^2 + L$ (c) $q = \log(L)$.

EXERCISES

1. The menu at Joe's coffee shop consists of a variety of coffee drinks, pastries, and sandwiches. The marginal product of an additional worker can be defined as the number of customers that can be served by that worker in a given time period. Joe has been employing one worker, but is considering hiring a second and a third. Explain why the marginal product of the second and third workers might be higher than the first. Why might you expect the marginal product of additional workers to diminish eventually?
2. Suppose a chair manufacturer is producing in the short run (with its existing plant and equipment). The manufacturer has observed the following levels of production corresponding to different numbers of workers:

NUMBER OF WORKERS	NUMBER OF CHAIRS
1	10
2	18
3	24
4	28
5	30
6	28
7	25

   a. Calculate the marginal and average product of labor for this production function.
   b. Does this production function exhibit diminishing returns to labor? Explain.
   c. Explain intuitively what might cause the marginal product of labor to become negative.

3. Fill in the gaps in the table below.

QUANTITY OF VARIABLE INPUT	TOTAL OUTPUT	MARGINAL PRODUCT OF VARIABLE INPUT	AVERAGE PRODUCT OF VARIABLE INPUT
0	0	—	—
1	225		
2			300
3		300	
4	1140		
5		225	
6			225

4. A political campaign manager must decide whether to emphasize television advertisements or letters to potential voters in a reelection campaign. Describe the production function for campaign votes. How might information about this function (such as the shape of the isoquants) help the campaign manager to plan strategy?
5. For each of the following examples, draw a representative isoquant. What can you say about the marginal rate of technical substitution in each case?
   a. A firm can hire only full-time employees to produce its output, or it can hire some combination of full-time and part-time employees. For each full-time worker let go, the firm must hire an increasing number of temporary employees to maintain the same level of output.

b. A firm finds that it can always trade two units of labor for one unit of capital and still keep output constant.

c. A firm requires exactly two full-time workers to operate each piece of machinery in the factory.

6. A firm has a production process in which the inputs to production are perfectly substitutable in the long run. Can you tell whether the marginal rate of technical substitution is high or low, or is further information necessary? Discuss.

7. The marginal product of labor in the production of computer chips is 50 chips per hour. The marginal rate of technical substitution of hours of labor for hours of machine capital is 1/4. What is the marginal product of capital?

8. Do the following functions exhibit increasing, constant, or decreasing returns to scale? What happens to the marginal product of each individual factor as that factor is increased and the other factor held constant?

a. $q = 3L + 2K$

b. $q = (2L + 2K)^{1/2}$

c. $q = 3LK^2$

d. $q = L^{1/2}K^{1/2}$

e. $q = 4L^{1/2} + 4K$

9. The production function for the personal computers of DISK, Inc., is given by

$$q = 10K^{0.5}L^{0.5}$$

where q is the number of computers produced per day, K is hours of machine time, and L is hours of labor input. DISK's competitor, FLOPPY, Inc., is using the production function

$$q = 10K^{0.6}L^{0.4}$$

a. If both companies use the same amounts of capital and labor, which will generate more output?

b. Assume that capital is limited to 9 machine hours, but labor is unlimited in supply. In which company is the marginal product of labor greater? Explain.

10. In Example 6.4, wheat is produced according to the production function

$$q = 100(K^{0.8}L^{0.2})$$

a. Beginning with a capital input of 4 and a labor input of 49, show that the marginal product of labor and the marginal product of capital are both decreasing.

b. Does this production function exhibit increasing, decreasing, or constant returns to scale?

11. Suppose life expectancy in years (L) is a function of two inputs, health expenditures (H) and nutrition expenditures (N) in hundreds of dollars per year. The production function is $L = \mathrm{c}\,H^{0.8}N^{0.2}$.

a. Beginning with a health input of \$400 per year ($H = 4$) and a nutrition input of \$4900 per year ($N = 49$), show that the marginal product of health expenditures and the marginal product of nutrition expenditures are both decreasing.

b. Does this production function exhibit increasing, decreasing, or constant returns to scale?

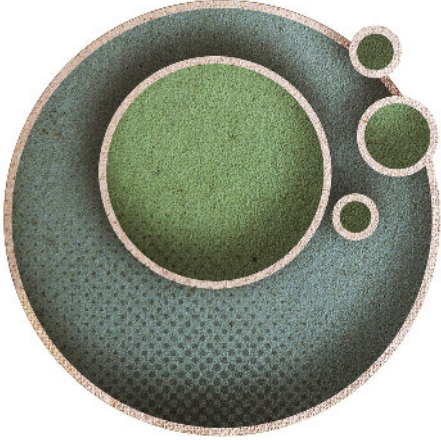
c. Suppose that in a country suffering from famine, N is fixed at 2 and that $\mathrm{c} = 20$. Plot the production function for life expectancy as a function of health expenditures, with L on the vertical axis and H on the horizontal axis.

d. Now suppose another nation provides food aid to the country suffering from famine so that N increases to 4. Plot the new production function.

e. Now suppose that $N = 4$ and $H = 2$. You run a charity that can provide either food aid or health aid to this country. Which would provide a greater benefit: increasing H by 1 or N by 1?

CHAPTER 7

The Cost of Production



In the last chapter, we examined the firm's production technology—the relationship that shows how factor inputs can be transformed into outputs. Now we will see how the production technology, together with the prices of factor inputs, determines the firm's cost of production.

Given a firm's production technology, managers must decide *how* to produce. As we saw, inputs can be combined in different ways to yield the same amount of output. For example, one can produce a certain output with a lot of labor and very little capital, with very little labor and a lot of capital, or with some other combination of the two. In this chapter we see how the *optimal*—i.e., cost-minimizing—combination of inputs is chosen. We will also see how a firm's costs depend on its rate of output and show how these costs are likely to change over time.

We begin by explaining how *cost* is defined and measured, distinguishing between the concept of cost used by economists, who are concerned about the firm's future performance, and by accountants, who focus on the firm's financial statements. We then examine how the characteristics of the firm's production technology affect costs, both in the short run, when the firm can do little to change its capital stock, and in the long run, when the firm can change all its factor inputs.

We then show how the concept of returns to scale can be generalized to allow for both changes in the mix of inputs and the production of many different outputs. We also show how cost sometimes falls over time as managers and workers learn from experience and make production processes more efficient. Finally, we show how empirical information can be used to estimate cost functions and predict future costs.

7.1 Measuring Cost: Which Costs Matter?

Before we can analyze how firms minimize costs, we must clarify what we mean by *cost* in the first place and how we should measure it. What items, for example, should be included as part of a firm's cost? Cost obviously includes the wages that a firm pays its workers and the rent that it pays for office space. But what if the firm already owns an

CHAPTER OUTLINE

LIST OF EXAMPLES

office building and doesn't have to pay rent? How should we treat money that the firm spent two or three years ago (and can't recover) for equipment or for research and development? We'll answer questions such as these in the context of the economic decisions that managers make.

Economic Cost versus Accounting Cost

Economists think of cost differently from financial accountants, who are usually concerned with keeping track of assets and liabilities and reporting past performance for external use, as in annual reports. Financial accountants tend to take a retrospective view of the firm's finances and operations. As a result **accounting cost**—the cost that financial accountants measure—can include items that an economist would not include and may not include items that economists usually do include. For example, accounting cost includes actual expenses plus depreciation expenses for capital equipment, which are determined on the basis of the allowable tax treatment by the Internal Revenue Service.

accounting cost Actual expenses plus depreciation charges for capital equipment.

Economists—and we hope managers—take a forward-looking view. They are concerned with the allocation of scarce resources. Therefore, they care about what cost is likely to be in the future and about ways in which the firm might be able to rearrange its resources to lower its costs and improve its profitability. As we will see, economists are therefore concerned with **economic cost**, which is the cost of utilizing resources in production. What kinds of resources are part of economic cost? The word *economic* tells us to distinguish between the costs the firm can control and those it cannot. It also tells us to consider *all* costs relevant to production. Clearly capital, labor, and raw materials are resources whose costs should be included. But the firm might use other resources with costs that are less obvious, but equally important. Here the concept of opportunity cost plays an important role.

economic cost Cost to a firm of utilizing economic resources in production.

Opportunity Cost

Opportunity cost is the cost associated with opportunities that are forgone by not putting the firm's resources to their best alternative use. This is easiest to understand through an example. Consider a firm that owns a building and therefore pays no rent for office space. Does this mean the cost of office space is zero? The firm's managers and accountant might say yes, but an economist would disagree. The economist would note that the firm could have earned rent on the office space by leasing it to another company. Leasing the office space would mean putting this resource to an alternative use, a use that would have provided the firm with rental income. This forgone rent is the opportunity cost of utilizing the office space. And because the office space is a resource that the firm is utilizing, this opportunity cost is also an economic cost of doing business.

opportunity cost Cost associated with opportunities forgone when a firm's resources are not put to their best alternative use.

What about the wages and salaries paid to the firm's workers? This is clearly an economic cost of doing business, but if you think about it, you will see that it is also an opportunity cost. The reason is that the money paid to the workers could have been put to some alternative use instead. Perhaps the firm could have used some or all of that money to buy more labor-saving machines, or even to produce a different product altogether. Thus we see that economic cost and opportunity cost actually boil down to the same thing. As long as we account for and measure all of the firm's resources properly, we will find that:

$$\textbf{Economic cost} = \textbf{Opportunity cost}$$

While economic cost and opportunity cost both describe the same thing, the concept of opportunity cost is particularly useful in situations where alternatives that are forgone do not reflect monetary outlays. Let's take a more detailed look at opportunity cost to see how it can make economic cost differ from accounting cost in the treatment of wages, and then in the cost of production inputs. Consider an owner that manages her own retail toy store and does not pay herself a salary. (We'll put aside the rent that she pays for the office space just to simplify the discussion.) Had our toy store owner chosen to work elsewhere she would have been able to find a job that paid $60,000 per year for essentially the same effort. In this case the opportunity cost of the time she spends working in her toy store business is $60,000.

Now suppose that last year she acquired an inventory of toys for which she paid $1 million. She hopes to be able to sell those toys during the holiday season for a substantial markup over her acquisition cost. However, early in the fall she receives an offer from another toy retailer to acquire her inventory for $1.5 million. Should she sell her inventory or not? The answer depends in part on her business prospects, but it also depends on the opportunity cost of acquiring a toy inventory. Assuming that it would cost $1.5 million to acquire the new inventory all over again, the opportunity cost of keeping it is $1.5 million, not the $1.0 million she originally paid.

You might ask why the opportunity cost isn't just $500,000, since that is the difference between the market value of the inventory and the cost of its acquisition. The key is that when the owner is deciding what to do with the inventory, she is deciding what is best for her business in the future. To do so, she needs to account for the fact that if she keeps the inventory for her own use, she would be sacrificing the $1.5 million that she could have received by selling the inventory to another firm.[1]

Note that an accountant may not see things this way. The accountant might tell the toy store owner that the cost of utilizing the inventory is just the $1 million that she paid for it. But we hope that you understand why this would be misleading. The actual economic cost of keeping and utilizing that inventory is the $1.5 million that the owner could have obtained by instead selling it to another retailer.

Accountants and economists will also sometimes differ in their treatment of depreciation. When estimating the future profitability of a business, economists and managers are concerned with the capital cost of plant and machinery. This cost involves not only the monetary outlay for buying and then running the machinery, but also the cost associated with wear and tear. When evaluating past performance, cost accountants use tax rules that apply to broadly defined types of assets to determine allowable depreciation in their cost and profit calculations. But these depreciation allowances need not reflect the actual wear and tear on the equipment, which is likely to vary asset by asset.

Sunk Costs

Although an opportunity cost is often hidden, it should be taken into account when making economic decisions. Just the opposite is true of a **sunk cost**: an expenditure that has been made and cannot be recovered. A sunk cost is usually visible, but after it has been incurred it should always be ignored when making future economic decisions.

sunk cost Expenditure that has been made and cannot be recovered.

[1]Of course, opportunity cost will change from circumstance to circumstance and from one time period to the next. If the value of our retailer's inventory suddenly increased to $1.7 million because that inventory included some holiday products that were in great demand, the opportunity cost of keeping and using the inventory would increase to $1.7 million.