The Production Process: The Behavior of Profit-Maximizing Firms

7

CHAPTER OUTLINE

production The process by which inputs are combined, transformed, and turned into outputs.

firm An organization that comes into being when a person or a group of people decides to produce a good or service to meet a perceived demand.

In which of the following industries is perfect competition more likely to prevail?

a. Airlines.
b. Energy.
c. Agriculture.
d. Satellite communications.

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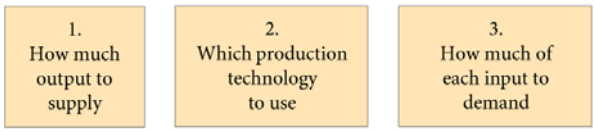
The Behavior of Profit-Maximizing Firms

All firms must make several basic decisions to achieve what we assume to be their primary objective—maximum profits.



▲ FIGURE 7.1 **The Three Decisions That All Firms Must Make**

Profits and Economic Costs

profit The difference between total revenue and total cost.

profit = total revenue – total cost

total revenue The amount received from the sale of the product (q x P).

total cost The total of (1) out-of-pocket costs and (2) opportunity cost of all factors of production.

The term *profit* will from here on refer to *economic profit*.

So whenever we say profit = total revenue – total cost, what we really mean is

economic profit = total revenue – total economic cost

economic profit Profit that accounts for both explicit and opportunity costs.

Normal Rate of Return

The way we treat the opportunity cost of capital is to add a *normal rate of return* to capital as part of economic cost.

normal rate of return A rate of return on capital that is just sufficient to keep owners and investors satisfied. For relatively risk-free firms, it should be nearly the same as the interest rate on risk-free government bonds.

TABLE 7.1 Calculating Total Revenue, Total Cost, and Profit

Initial Investment:	**$20,000**
Market Interest Rate Available:	**0.10, or 10%**
Total revenue (3,000 belts x $10 each)	**$30,000**
Costs	
Belts from Supplier	$15,000
Labor cost	14,000
Normal return/opportunity cost of capital ($20,000 x 0.10)	2,000
Total Cost	**$31,000**
Profit = total revenue – total cost	**–$1,000**[a]

[a]There is a loss of $1,000.

Among the components of total cost is:

a. Total revenue.
b. A normal rate of return.
c. Economic profit.
d. Productivity.
e. None of the above.

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Short-Run versus Long-Run Decisions

short run The period of time for which two conditions hold: The firm is operating under a fixed scale (fixed factor) of production, and firms can neither enter nor exit an industry.

long run That period of time for which there are no fixed factors of production: Firms can increase or decrease the scale of operation, and new firms can enter and existing firms can exit the industry.

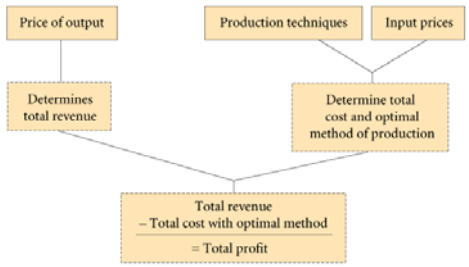
The Bases of Decisions: Market Price of Outputs, Available Technology, and Input Prices

In the language of economics, a firm needs to know three things:

1. The market price of output.
2. The techniques of production that are available.
3. The prices of inputs.

Output price determines potential revenues. The techniques available tell me how much of each input I need, and input prices tell me how much they will cost. Together the available production techniques and the prices of inputs determine costs.

optimal method of production The production method that minimizes cost for a given level of output.



▲ **FIGURE 7.2 Determining the Optimal Method of Production**

The Production Process

production technology The quantitative relationship between inputs and outputs.

labor-intensive technology Technology that relies heavily on human labor instead of capital.

capital-intensive technology Technology that relies heavily on capital instead of human labor.

Firms in an economy with high labor costs have an incentive to use:

a. Labor-intensive technologies.
b. Capital-intensive technologies.
c. Less than optimal production technologies.
d. The production method than maximizes cost.

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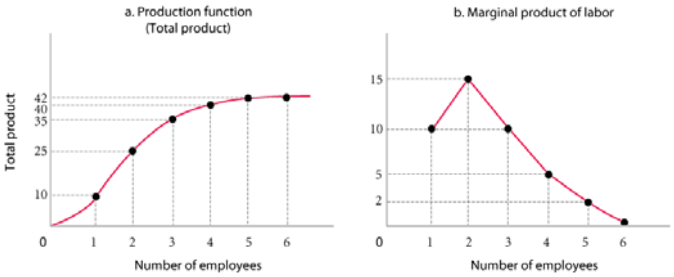
Production Functions: Total Product, Marginal Product, and Average Product

production function *or* **total product function** A numerical or mathematical expression of a relationship between inputs and outputs. It shows units of total product as a function of units of inputs.

TABLE 7.2 Production Function

(1) Labor Units (Employees)	(2) Total Product (Sandwiches per Hour)	(3) Marginal Product of Labor	(4) Average Product of Labor (Total Product ÷ Labor Units)
0	0	–	–
1	10	10	10.0
2	25	15	12.5
3	35	10	11.7
4	40	5	10.0
5	42	2	8.4
6	42	0	7.0



▲ **FIGURE 7.3 Production Function for Sandwiches**

A *production function* is a numerical representation of the relationship between inputs and outputs.
In Figure 7.3(a), total product (sandwiches) is graphed as a function of labor inputs.
The *marginal product* of labor is the additional output that one additional unit of labor produces.
Figure 7.3(b) shows that the marginal product of the second unit of labor at the sandwich shop is 15 units of output; the marginal product of the fourth unit of labor is 5 units of output.

The shape of the short-run production function is fundamentally attributed to:

a. A labor constraint.
b. A capital constraint.
c. The assumption that not all workers are equally capable.
d. All of the above.

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Marginal Product and the Law of Diminishing Returns

marginal product The additional output that can be produced by adding one more unit of a specific input, *ceteris paribus*.

law of diminishing returns When additional units of a variable input are added to fixed inputs, after a certain point, the marginal product of the variable input declines.

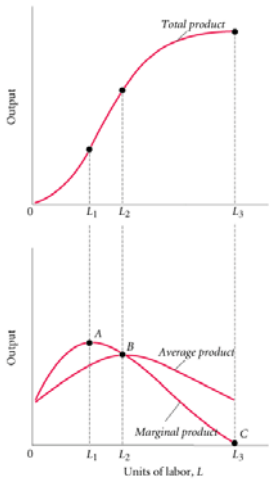
Every firm will face diminishing returns, which always apply in the short run. This means that every firm finds it progressively more difficult to increase its output as it approaches capacity production.

Marginal Product versus Average Product

average product The average amount produced by each unit of a variable factor of production.

$$\text{average product of labor} = \frac{\text{total product}}{\text{total units of labor}}$$

If marginal product is above average product, the average rises; if marginal product is below average product, the average falls.



◀ **FIGURE 7.4 Total Average and Marginal Product**

Marginal and average product curves can be derived from total product curves. Average product is at its maximum at the point of intersection with marginal product.

The relationship between the average product of labor (AP_L) and the marginal product of labor (MP_L) is as follows:

a. When MP_L is below AP_L, AP_L rises.
b. When MP_L is above AP_L, AP_L rises.
c. AP_L increases as long as MP_L increases.
d. $MP_L > AP_L$ when AP_L is declining.
e. When MP_L is equal to AP_L, AP_L is minimum.

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Production Functions with Two Variable Factors of Production

Inputs work together in production. Capital and labor are *complementary inputs*.

Additional capital increases the *productivity* of labor—that is, the amount of output produced per worker per hour.

This simple relationship lies at the heart of worries about productivity at the national and international levels. Building new, modern plants and equipment enhances a nation's productivity.

In the last decade, China has accumulated capital (that is, built plants and equipment) at a very high rate. The result is growth in the average quantity of output per worker in China.

ECONOMICS IN PRACTICE

Learning about Growing Pineapples in Ghana

In farming, as in manufacturing, we need a given combination of labor and capital to produce output, here a crop.

In the 1990s, an area of Ghana changed from an exclusive reliance on maize as the agricultural crop to the development of pineapple farms.

The choice of how much fertilizer to use was highly dependent on how much fertilizer their more successful neighbor farmers used.

Social learning obviously plays a role in the diffusion of manufacturing technology as well.

THINKING PRACTICALLY

1. In many high-tech firms, executives must sign non-compete agreements, preventing them from working for a competitor after they stop working for their current firm. These agreements are much less common in mature manufacturing firms. Why?

Choice of Technology

TABLE 7.3 Inputs Required to Produce 100 Diapers Using Alternative Technologies

Technology	Units of Capital (K)	Units of Labor (L)
A	2	10
B	3	6
C	4	4
D	6	3
E	10	2

TABLE 7.4 Cost-Minimizing Choice among Alternative Technologies (100 Diapers)

			Cost = (L X P_L) + (K X P_K)	
			(4)	(5)
(1) Technology	(2) Units of Capital (K)	(3) Units of Labor (L)	P_L = \$1 P_K = \$1	P_L = \$5 P_K = \$1
A	2	10	\$12	\$52
B	3	6	9	33
C	4	4	8	24
D	6	3	9	21
E	10	2	12	20

Two things determine the cost of production: (1) technologies that are available and (2) input prices. Profit-maximizing firms will choose the technology that minimizes the cost of production given current market input prices.

ECONOMICS IN PRACTICE

How Fast Should a Truck Driver Go?

The trucking business gives us an opportunity to think about choice among technologies in a concrete way.

Modern technology, in the form of on-board computers, allows a modern trucking firm to monitor driving speed and instruct drivers.

Fuel Price	$3.50	$4.00	$4.50
Drive Fast	$124.98	$133.33	$141.63
Drive Slowly	$126.67	$133.33	$139.99

THINKING PRACTICALLY

1. When gasoline prices rise, accident rates fall. Provide two reasons this might be true.

Looking Ahead: Cost and Supply

So far, we have looked only at a single level of output.

One of our main objectives in the next chapter is to determine the amount that a competitive firm will choose to *supply* during a given time period.

REVIEW TERMS AND CONCEPTS

average product	production
capital-intensive technology	production function *or* total product function
firm	production technology
labor-intensive technology	profit (economic profit)
law of diminishing returns	short run
long run	total cost (total economic cost)
marginal product	total revenue
normal rate of return	*Profit = total revenue – total cost*
optimal method of production	$\text{Average product of labor} = \frac{\text{total product}}{\text{total units of labor}}$

CHAPTER 7 APPENDIX

Isoquants and Isocosts

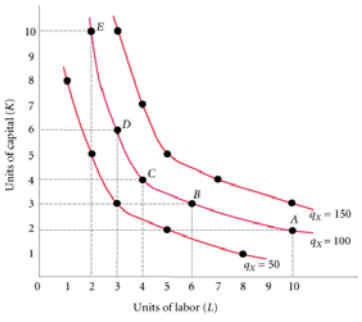
New Look at Technology: Isoquants

This chapter has shown that the cost structure facing a firm depends on two key pieces of information: (1) input (factor) prices and (2) technology. This Appendix presents a more formal analysis of technology and factor prices and their relationship to cost.

TABLE 7A.1 Alternative Combinations of Capital (*K*) and Labor (*L*) Required to Produce 50, 100, and 150 Units of Output

	$Q_X = 50$		$Q_X = 100$		$Q_X = 150$	
	K	*L*	*K*	*L*	*K*	*L*
A	1	8	2	10	3	10
B	2	5	3	6	4	7
C	3	3	4	4	5	5
D	5	2	6	3	7	4
E	8	1	10	2	10	3

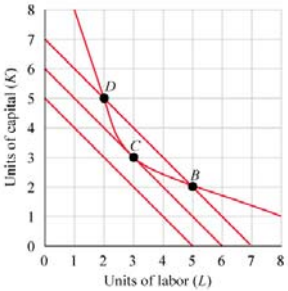
▶ **FIGURE 7A.1 Isoquants Showing All Combinations of Capital and Labor That Can Be Used to Produce 50, 100, and 150 Units of Output**



isoquant A graph that shows all the combinations of capital and labor that can be used to produce a given amount of output.

Refer to the figure. Which of the following statements is correct?

a. At points *D*, *C*, and *B*, the total cost of production is minimized.
b. Points *D*, *C*, and *B* show different combinations of inputs that yield the same cost of production.
c. At points *D*, *C*, and *B*, the amount of output produced is the same.
d. All of the above.



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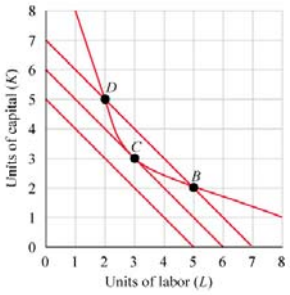
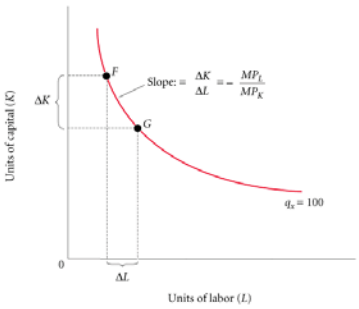




▲ **FIGURE 7A.2 The Slope of an Isoquant Is Equal to the Ratio of MP_L to MP_K**

For output to remain constant, the loss of output from using less capital must be matched by the added output produced by using more labor.

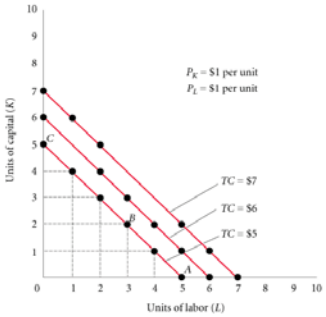
$$\Delta K \cdot MP_K = -\Delta L \cdot MP_L$$

Slope of isoquant:

$$\frac{\Delta K}{\Delta L} = -\frac{MP_L}{MP_K}$$

marginal rate of technical substitution The rate at which a firm can substitute capital for labor and hold output constant.

Factor Prices and Input Combinations: Isocosts



◄ **FIGURE 7A.3 Isocost Lines Showing the Combinations of Capital and Labor Available for $5, $6, and $7**

An isocost line shows all the combinations of capital and labor that are available for a given total cost.

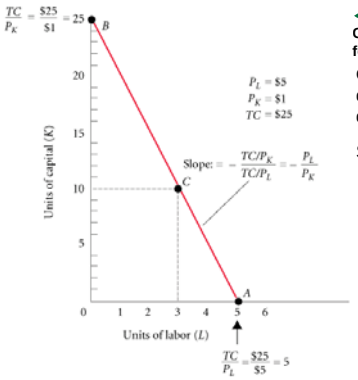
$$(P_K \cdot K) + (P_L \cdot L) = TC$$

Substituting our data for the lowest isocost line into this general equation, we get

$$(\$1 \cdot K) + (\$1 \cdot L) = \$5, or\ (K + L) = 5$$

isocost line A graph that shows all the combinations of capital and labor available for a given total cost.

Factor Prices and Input Combinations: Isocosts



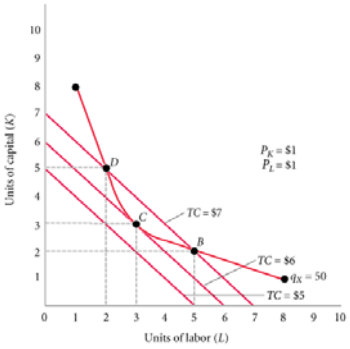
◄ **FIGURE 7A.4 Isocost Line Showing All Combinations of Capital and Labor Available for $25**

One way to draw an isocost line is to determine the endpoints of that line and draw a line connecting them.

Slope of isocost line:

$$\frac{\Delta K}{\Delta L} = -\frac{TC/P_L}{TC/P_K} = -\frac{P_L}{P_K}$$

Finding the Least-Cost Technology with Isoquants and Isocosts

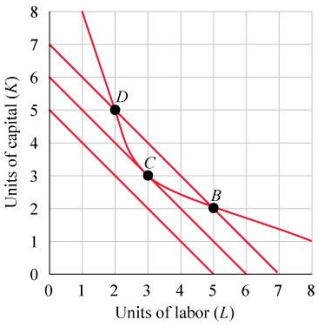


◄ **FIGURE 7A.5 Finding the Least-Cost Combination of Capital and Labor to Produce 50 Units of Output**

Profit-maximizing firms will minimize costs by producing their chosen level of output with the technology represented by the point at which the isoquant is tangent to an isocost line.
Here the cost-minimizing technology—3 units of capital and 3 units of labor—is represented by point *C*.

Refer to the figure below. Which point shows the cost-minimizing equilibrium condition?

a. Points *D* and *B*.
b. Points *D*, *C*, and *B*.
c. Point *D* only.
d. Point *C* only.



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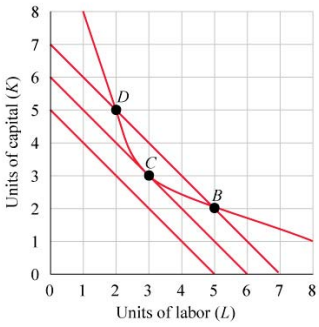
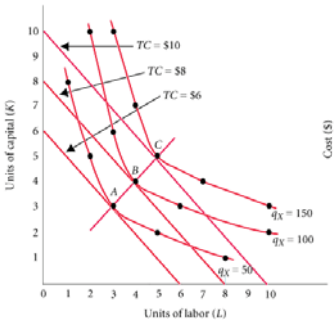
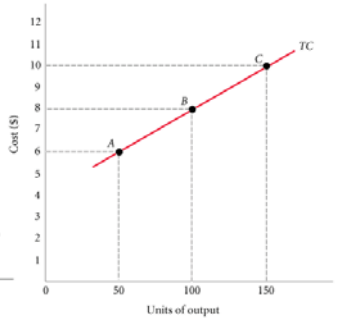




▲ **FIGURE 7A.6 Minimizing Cost of Production for $q_X = 50$, $q_X = 100$, and $q_X = 150$**



▲ **FIGURE 7A.7 A Cost Curve Shows the *Minimum* Cost of Producing Each Level of Output**

Plotting a series of cost-minimizing combinations of inputs—shown in this graph as points *A*, *B*, and *C*— on a separate graph results in a *cost curve* like the one shown in Figure 7A.7.

The Cost-Minimizing Equilibrium Condition

At the point where a line is just tangent to a curve, the two have the same slope. At each point of tangency, the following must be true:

$$\text{slope of isoquant} = -\frac{MP_L}{MP_K} = \text{slope of isocost} = -\frac{P_L}{P_K}$$

Thus,

$$\frac{MP_L}{MP_K} = \frac{P_L}{P_K}$$

Dividing both sides by P_L and multiplying both sides by MP_K, we get

$$\frac{MP_L}{P_L} = \frac{MP_K}{P_K}$$

APPENDIX REVIEW TERMS AND CONCEPTS

isocost line

isoquant

marginal rate of technical substitution

1. Slope of isoquant:

$$\frac{\Delta K}{\Delta L} = -\frac{MP_L}{MP_K}$$

2. Slope of isocost line:

$$\frac{\Delta K}{\Delta L} = -\frac{TC/P_L}{TC/P_K} = -\frac{P_L}{P_K}$$