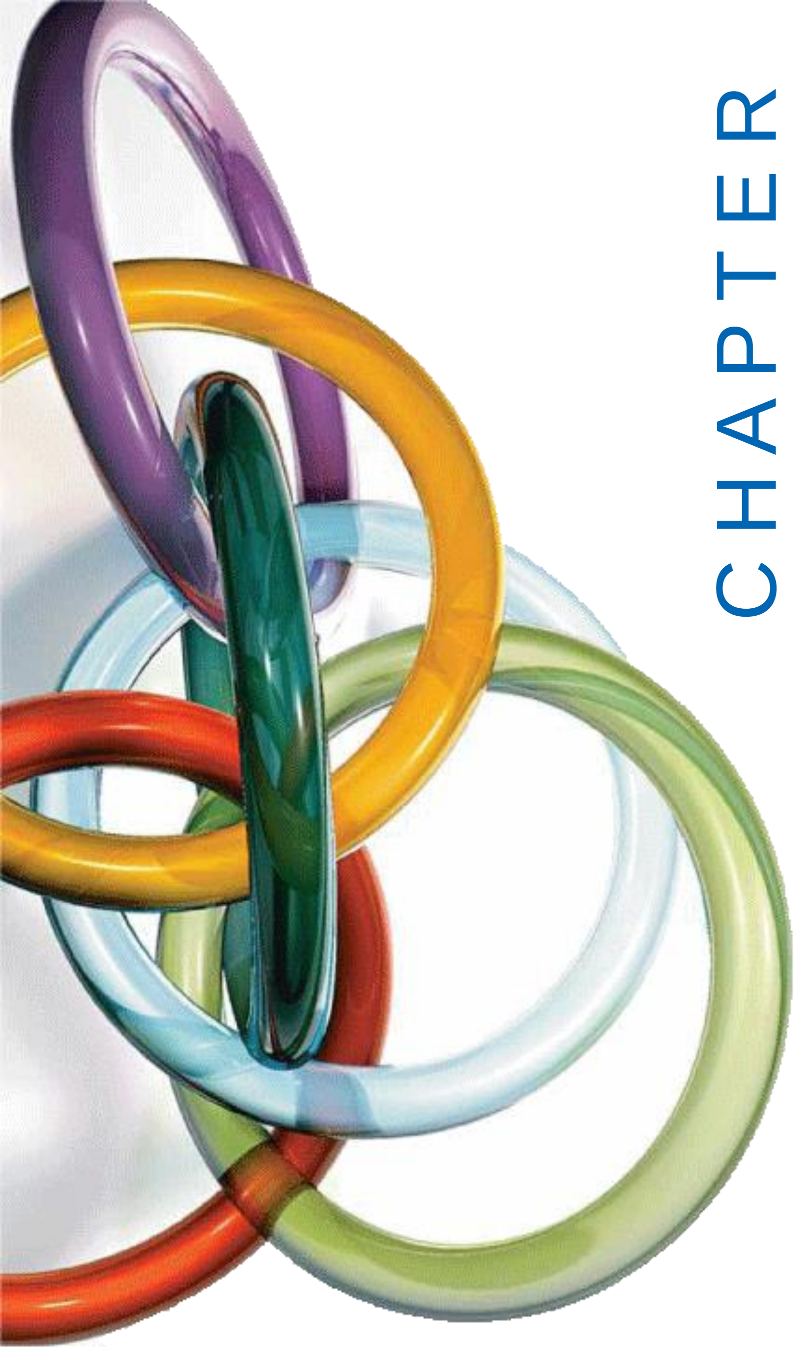
CHAPTER 6

Production



Prepared by:

Fernando & Yvonn Quijano

CHAPTER 3 OUTLINE

Production

The **theory of the firm** describes how a firm makes cost-minimizing production decisions and how the firm's resulting cost varies with its output.

The Production Decisions of a Firm

The production decisions of firms are analogous to the purchasing decisions of consumers, and can likewise be understood in three steps:

1. Production Technology
2. Cost Constraints
3. Input Choices

6.1 THE TECHNOLOGY OF PRODUCTION

- **factors of production** Inputs into the production process (e.g., labor, capital, and materials).

The Production Function

$$q = F(K, L) \tag{6.1}$$

Remember the following:

Inputs and outputs are *flows*.

Equation (6.1) applies to a *given technology*

Production functions describe what is *technically feasible* when the firm operates *efficiently*.

6.1 THE TECHNOLOGY OF PRODUCTION

The Short Run versus the Long Run

- **short run** Period of time in which quantities of one or more production factors cannot be changed.
- **fixed input** Production factor that cannot be varied.
- **long run** Amount of time needed to make all production inputs variable.

6.2 PRODUCTION WITH ONE VARIABLE INPUT (LABOR)

TABLE 6.1 Market Baskets and the Budget Line

Amount of Labor (L)	Amount of Capital (K)	Total Output (q)	Average Product (q/L)	Marginal Product (Δq/ΔL)
0	10	0	—	—
1	10	10	10	10
2	10	30	15	20
3	10	60	20	30
4	10	80	20	20
5	10	95	19	15
6	10	108	18	13
7	10	112	16	4
8	10	112	14	0
9	10	108	12	–4
10	10	100	10	–8

Average and Marginal Products

- **average product** Output per unit of a particular input.

- **marginal product** Additional output produced as an input is increased by one unit.

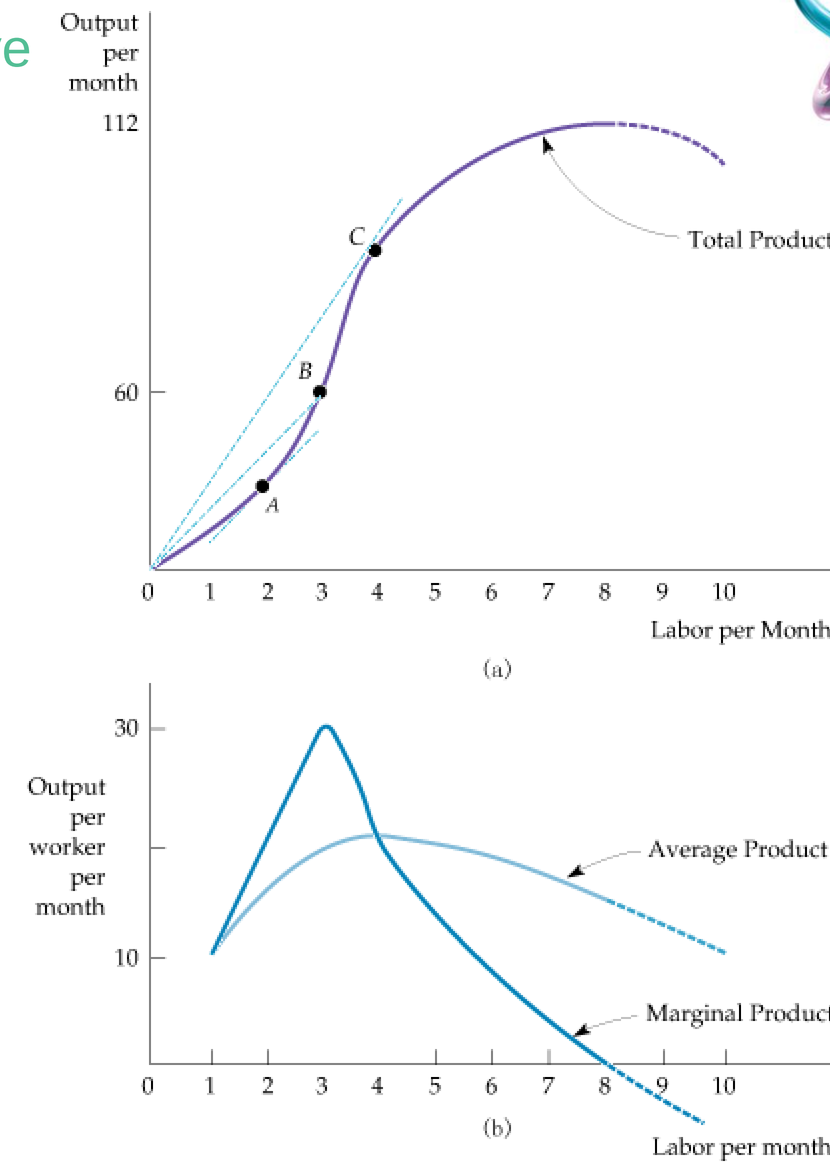
Average product of labor = Output/labor input = q/L

Marginal product of labor = Change in output/change in labor input = $\Delta q/\Delta L$

The Slopes of the Product Curve

Figure 6.1

Production with One Variable Input



The total product curve in (a) shows the output produced for different amounts of labor input.

The average and marginal products in (b) can be obtained (using the data in Table 6.1) from the total product curve.

At point *A* in (a), the marginal product is 20 because the tangent to the total product curve has a slope of 20.

At point *B* in (a) the average product of labor is 20, which is the slope of the line from the origin to *B*.

The average product of labor at point *C* in (a) is given by the slope of the line 0*C*.

The Slopes of the Product Curve

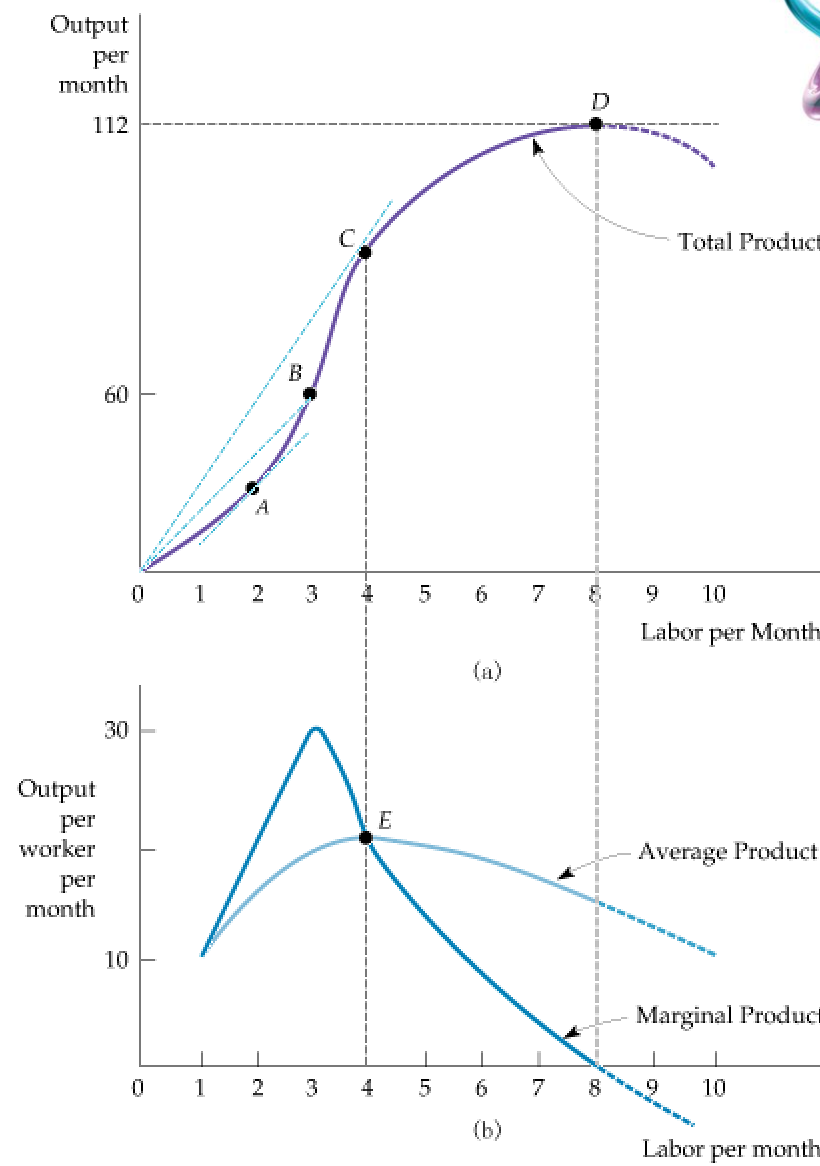
Figure 6.1

Production with One Variable Input (continued)

To the left of point *E* in (b), the marginal product is above the average product and the average is increasing; to the right of *E*, the marginal product is below the average product and the average is decreasing.

As a result, *E* represents the point at which the average and marginal products are equal, when the average product reaches its maximum.

At *D*, when total output is maximized, the slope of the tangent to the total product curve is 0, as is the marginal product.



The Law of Diminishing Marginal Returns

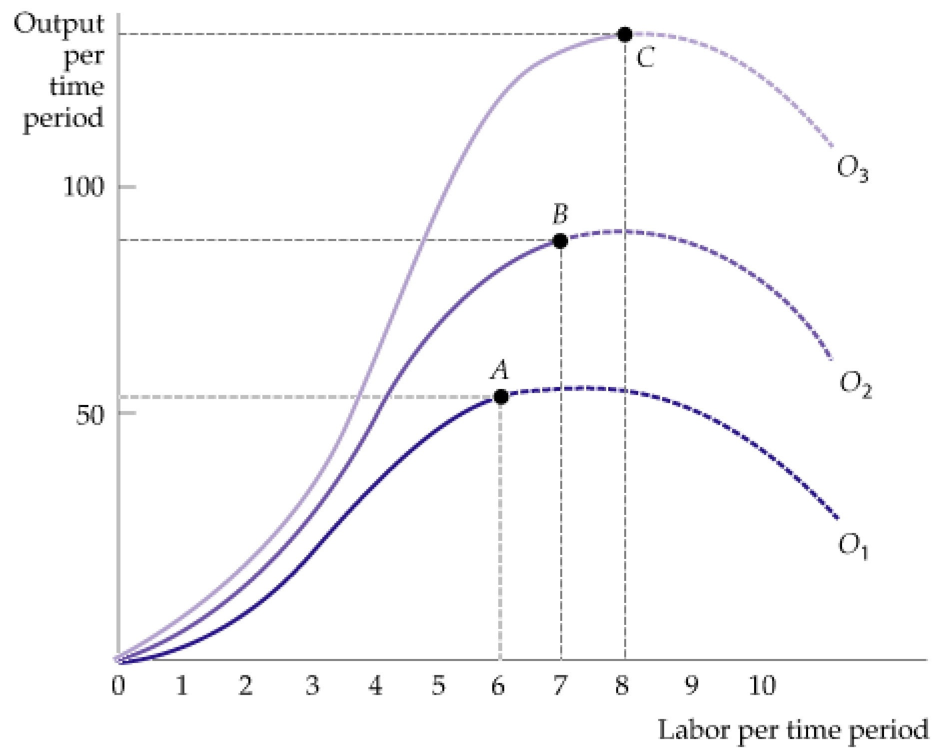
- **law of diminishing marginal returns** Principle that as the use of an input increases with other inputs fixed, the resulting additions to output will eventually decrease.

Figure 6.2

The Effect of Technological Improvement

Labor productivity (output per unit of labor) can increase if there are improvements in technology, even though any given production process exhibits diminishing returns to labor.

As we move from point *A* on curve O_1 to *B* on curve O_2 to *C* on curve O_3 over time, labor productivity increases.



EXAMPLE 6.1 Malthus and the Food Crisis

The law of diminishing marginal returns was central to the thinking of political economist Thomas Malthus (1766–1834).

Malthus believed that the world's limited amount of land would not be able to supply enough food as the population grew. He predicted that as both the marginal and average productivity of labor fell and there were more mouths to feed, mass hunger and starvation would result.

Fortunately, Malthus was wrong (although he was right about the diminishing marginal returns to labor).

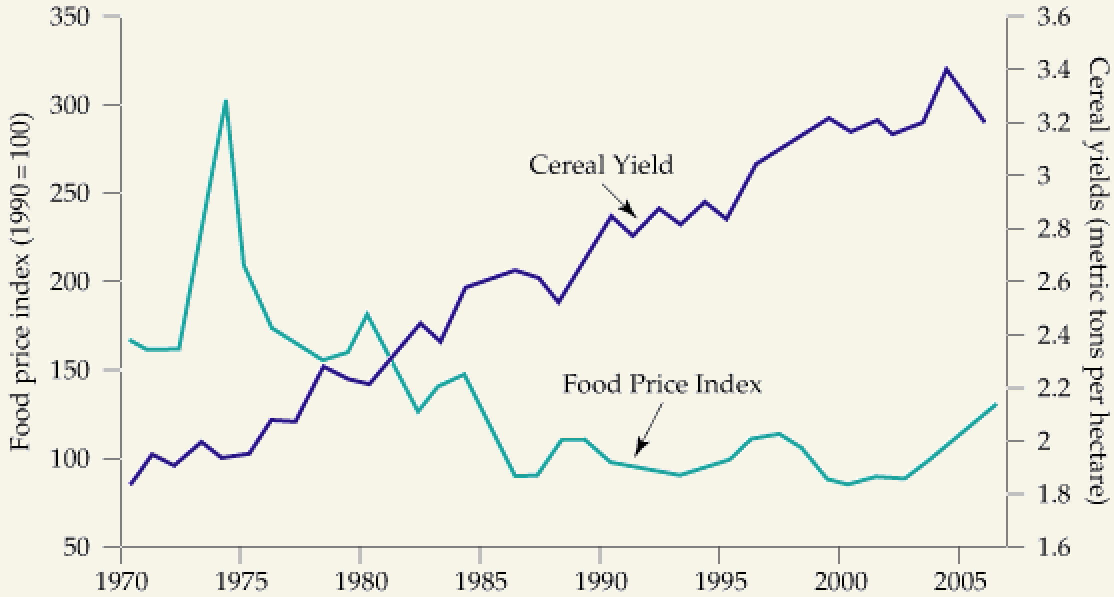
TABLE 6.2 Index of World Food Production Per Capita

Year	Index
1948-1952	100
1960	115
1970	123
1980	128
1990	138
2000	150
2005	156

EXAMPLE 6.1 Malthus and the Food Crisis (continued)

Figure 6.3

Cereal Yields and the World Price of Food



Cereal yields have increased. The average world price of food increased temporarily in the early 1970s but has declined since.

Labor Productivity

- **labor productivity** Average product of labor for an entire industry or for the economy as a whole.

Productivity and the Standard of Living

- **stock of capital** Total amount of capital available for use in production.
- **technological change** Development of new technologies allowing factors of production to be used more effectively.

EXAMPLE 6.2 Labor Productivity and the Standard of Living

TABLE 6.3 Labor Productivity in Developed Countries

	UNITED STATES	JAPAN	FRANCE	GERMANY	UNITED KINGDOM
	Real Output per Employed Person (2006)				
	$82,158	**$57,721**	**$72,949**	**$60,692**	**$65,224**
Years	*Annual Rate of Growth of Labor Productivity (%)*				
1960-1973	2.29	7.86	4.70	3.98	2.84
1974-1982	0.22	2.29	1.73	2.28	1.53
1983-1991	1.54	2.64	1.50	2.07	1.57
1992-2000	1.94	1.08	1.40	1.64	2.22
2001-2006	1.78	1.73	1.02	1.10	1.47

The level of output per employed person in the United States in 2006 was higher than in other industrial countries. But, until the 1990s, productivity in the United States grew on average less rapidly than productivity in most other developed nations. Also, productivity growth during 1974–2006 was much lower in all developed countries than it had been in the past.

Isoquants

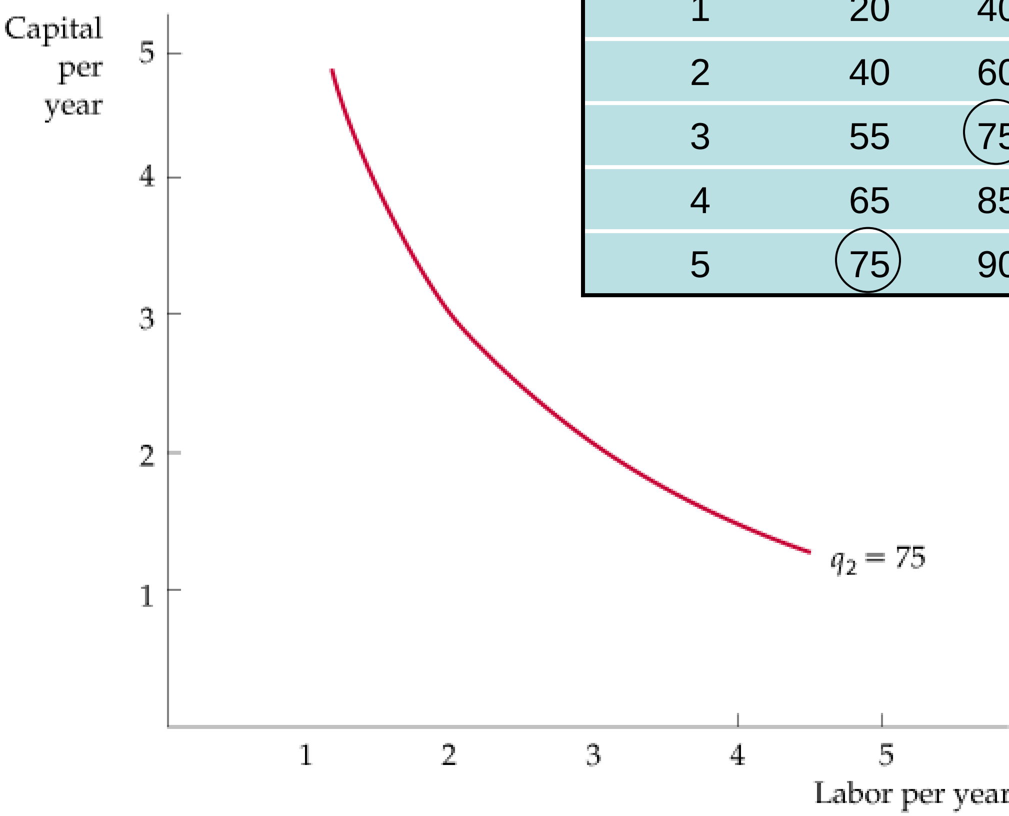


TABLE 6.4 Production with Two Variable Inputs

	LABOR INPUT				
Capital Input	1	2	3	4	5
1	20	40	55	65	75
2	40	60	75	85	90
3	55	75	90	100	105
4	65	85	100	110	115
5	75	90	105	115	120

- **isoquant** Curve showing all possible combinations of inputs that yield the same output.

Isoquants

- **isoquant map** Graph combining a number of isoquants, used to describe a production function.

Figure 6.4

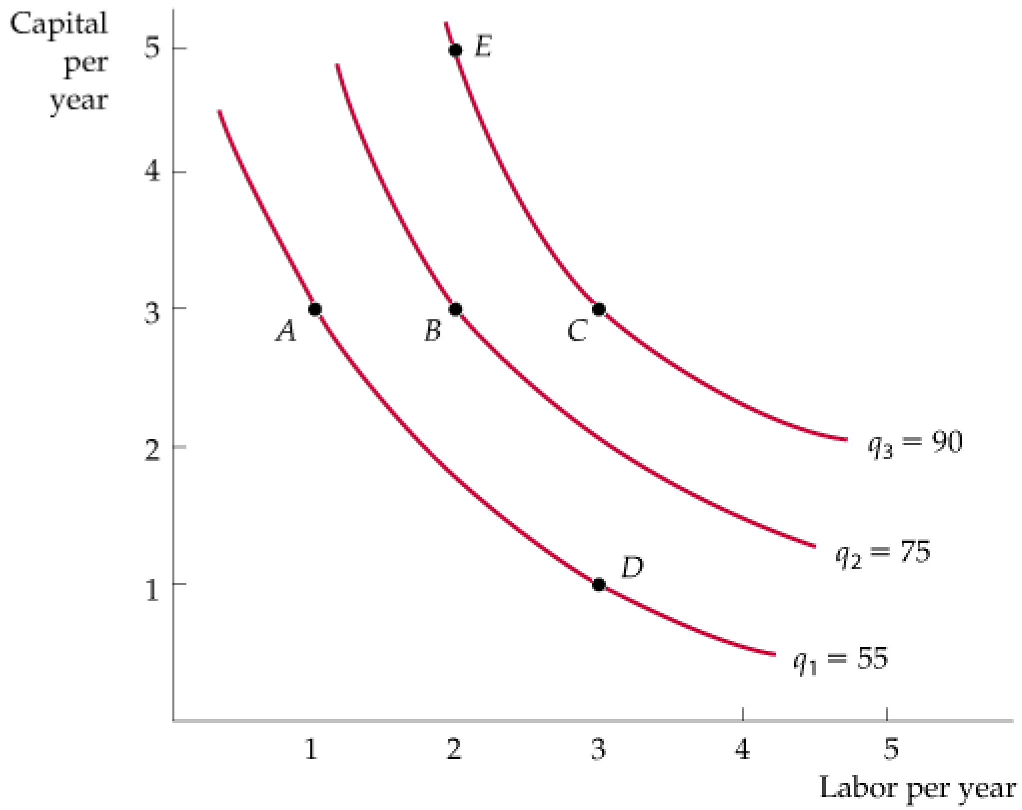
Production with Two Variable Inputs (continued)

A set of isoquants, or isoquant map, describes the firm's production function.

Output increases as we move from isoquant q_1 (at which 55 units per year are produced at points such as *A* and *D*),

to isoquant q_2 (75 units per year at points such as *B*) and

to isoquant q_3 (90 units per year at points such as *C* and *E*).

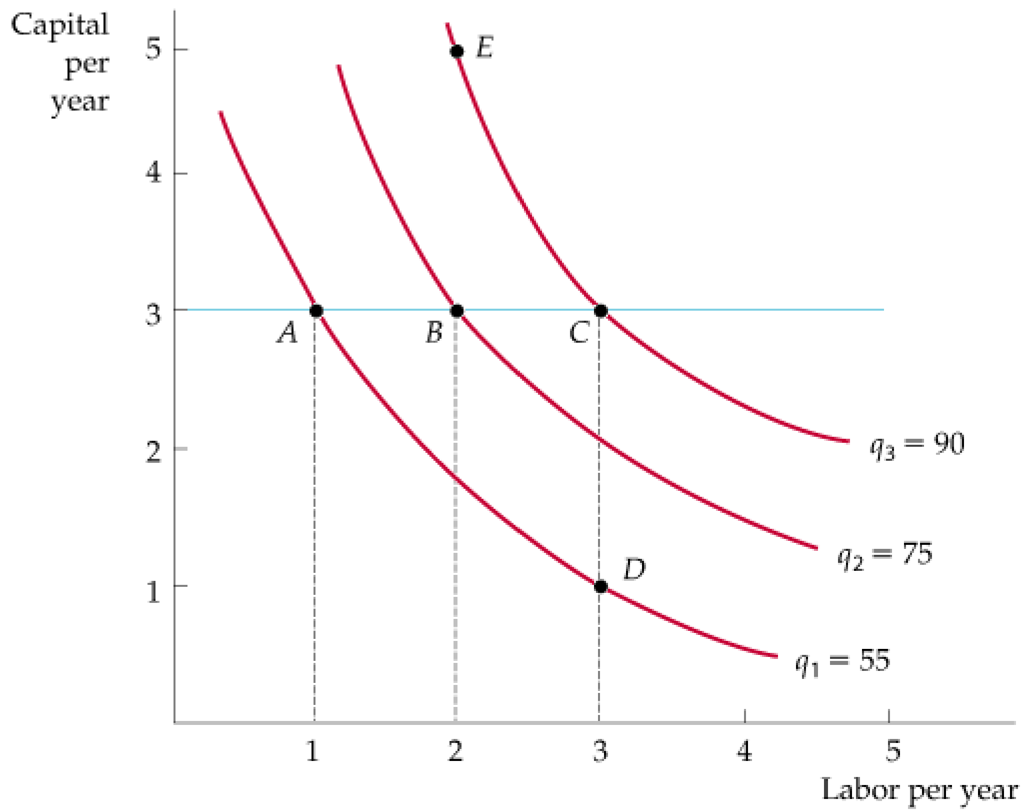


Diminishing Marginal Returns

Figure 6.4

Production with Two Variable Inputs (continued)

Diminishing Marginal Returns
Holding the amount of capital fixed at a particular level—say 3, we can see that each additional unit of labor generates less and less additional output.



Substitution Among Inputs

- **marginal rate of technical substitution (MRTS)** Amount by which the quantity of one input can be reduced when one extra unit of another input is used, so that output remains constant.

Figure 6.4

Marginal rate of technical substitution

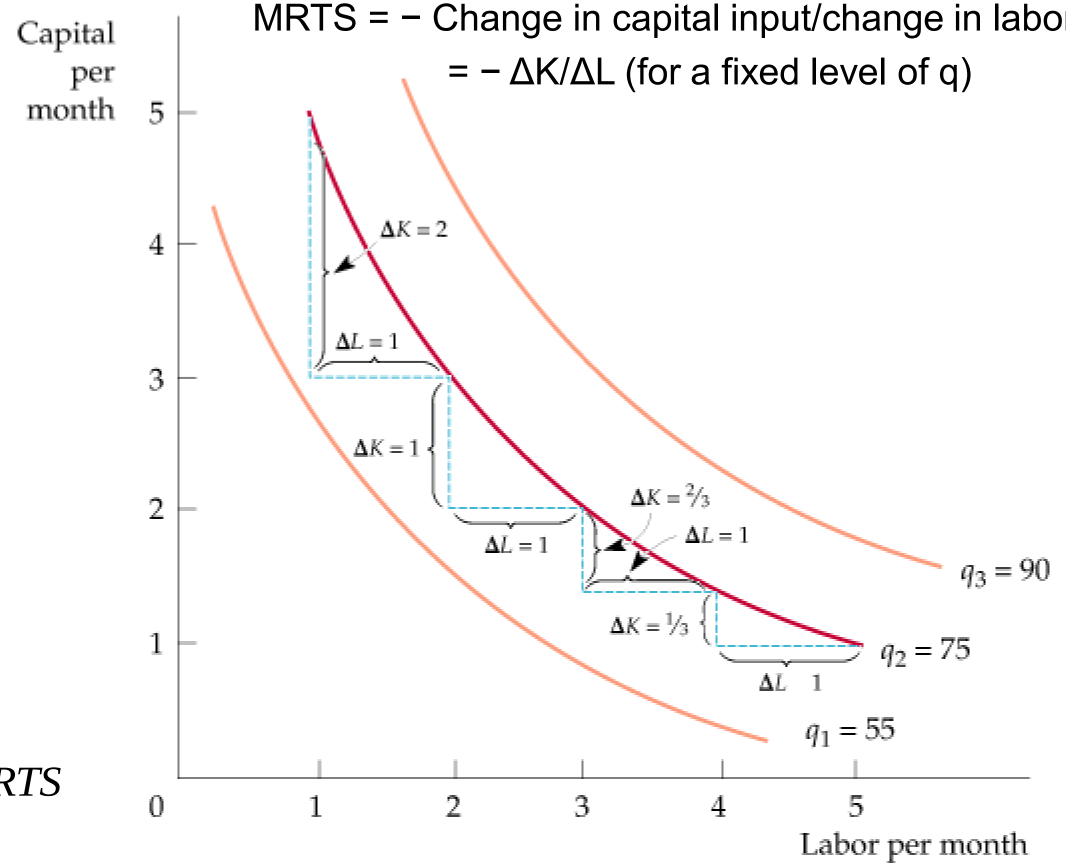
Like indifference curves, isoquants are downward sloping and convex. The slope of the isoquant at any point measures the marginal rate of technical substitution—the ability of the firm to replace capital with labor while maintaining the same level of output.

On isoquant q_2, the MRTS falls from 2 to 1 to 2/3 to 1/3.

$$(MP_L)/(MP_K) = -(\Delta K/\Delta L) = MRTS$$

MRTS = − Change in capital input/change in labor input

= − ΔK/ΔL (for a fixed level of q)



Production Functions—Two Special Cases

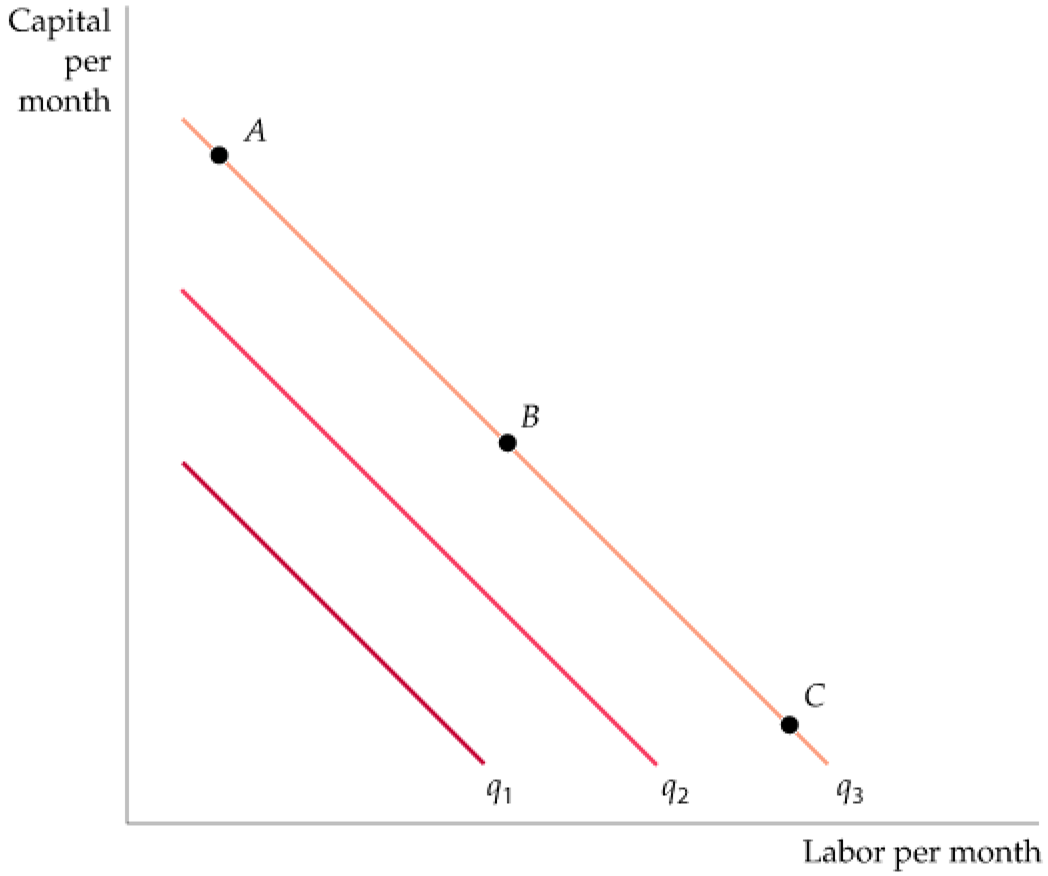


Figure 6.6

Isoquants When Inputs Are Perfect Substitutes

When the isoquants are straight lines, the MRTS is constant. Thus the rate at which capital and labor can be substituted for each other is the same no matter what level of inputs is being used.

Points A, B, and C represent three different capital-labor combinations that generate the same output q3.

Production Functions—Two Special Cases

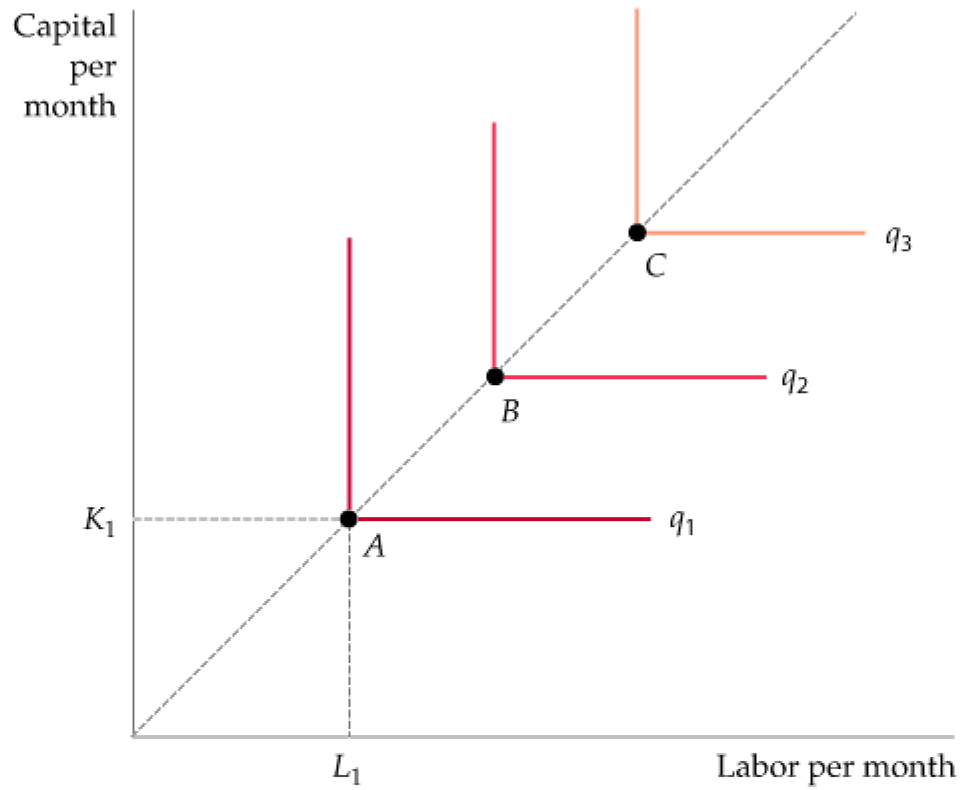
- **fixed-proportions production function** Production function with L-shaped isoquants, so that only one combination of labor and capital can be used to produce each level of output.

Figure 6.7

Fixed-Proportions Production Function

When the isoquants are L-shaped, only one combination of labor and capital can be used to produce a given output (as at point A on isoquant q1, point B on isoquant q2, and point C on isoquant q3). Adding more labor alone does not increase output, nor does adding more capital alone.

The fixed-proportions production function describes situations in which methods of production are limited.



6.2 PRODUCTION WITH TWO VARIABLE INPUTS

EXAMPLE 6.3 A Production Function for Wheat

Figure 6.8

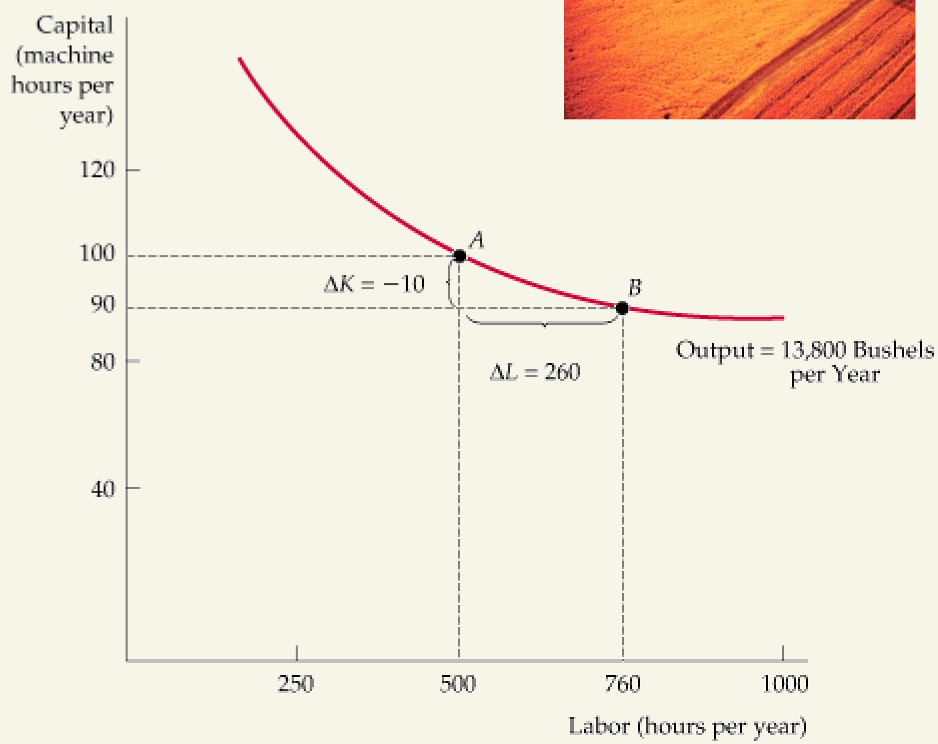
Isoquant Describing the Production of Wheat

A wheat output of 13,800 bushels per year can be produced with different combinations of labor and capital.

The more capital-intensive production process is shown as point A,

the more labor- intensive process as point B.

The marginal rate of technical substitution between A and B is 10/260 = 0.04.



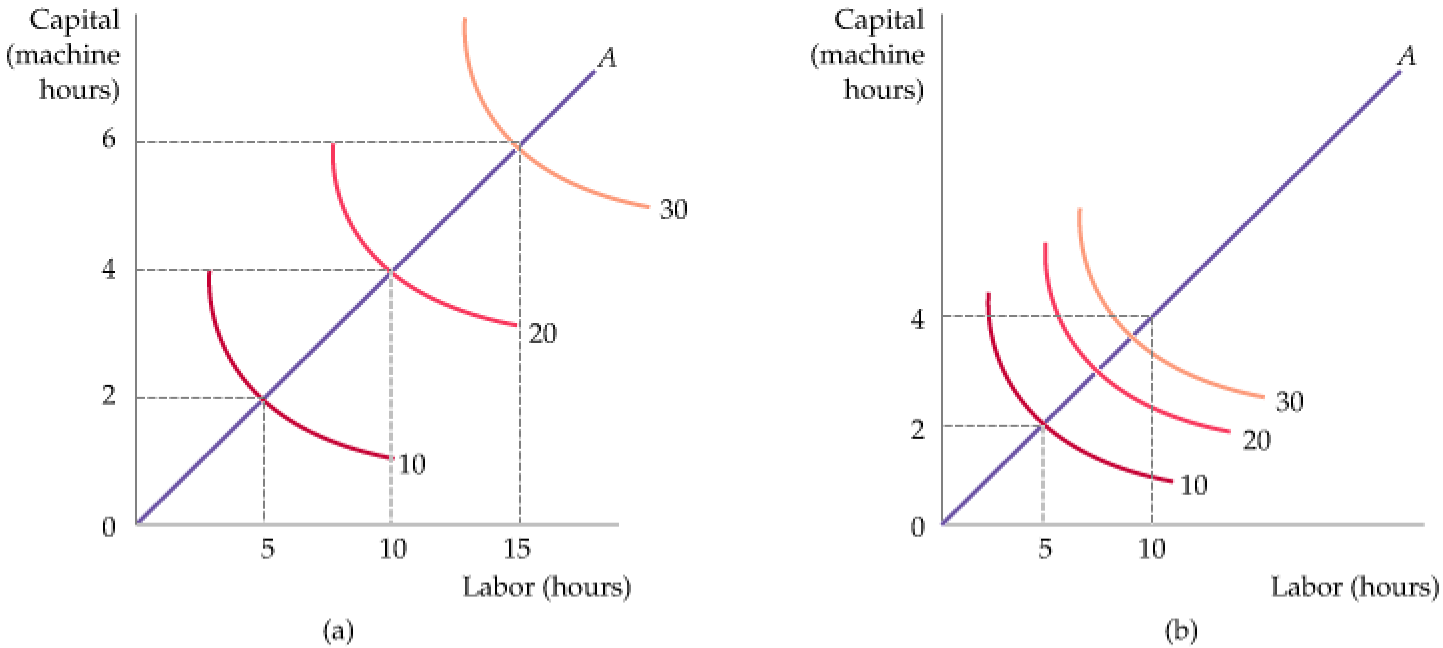
6.4 RETURNS TO SCALE

- **returns to scale** Rate at which output increases as inputs are increased proportionately.
- **increasing returns to scale** Situation in which output more than doubles when all inputs are doubled.
- **constant returns to scale** Situation in which output doubles when all inputs are doubled.
- **decreasing returns to scale** Situation in which output less than doubles when all inputs are doubled.

Describing Returns to Scale

Figure 6.9

Returns to Scale



When a firm's production process exhibits constant returns to scale as shown by a movement along line 0*A* in part (a), the isoquants are equally spaced as output increases proportionally.

However, when there are increasing returns to scale as shown in (b), the isoquants move closer together as inputs are increased along the line.

EXAMPLE 6.4 Returns to Scale in the Carpet Industry

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.

TABLE 6.5 The U.S. Carpet Industry

	Carpet Sales, 2005 (Millions of Dollars per Year)	
1.	Shaw	4346
2.	Mohawk	3779
3.	Beaulieu	1115
4.	Interface	421
5.	Royalty	298

