Production and Costs

Althaf S PhD.

SOMS

Adapted from Pindyck and Rubinfield– ‘Microeconomics’ and ‘Nordhaus and Samuelson, ‘Economics’

Production

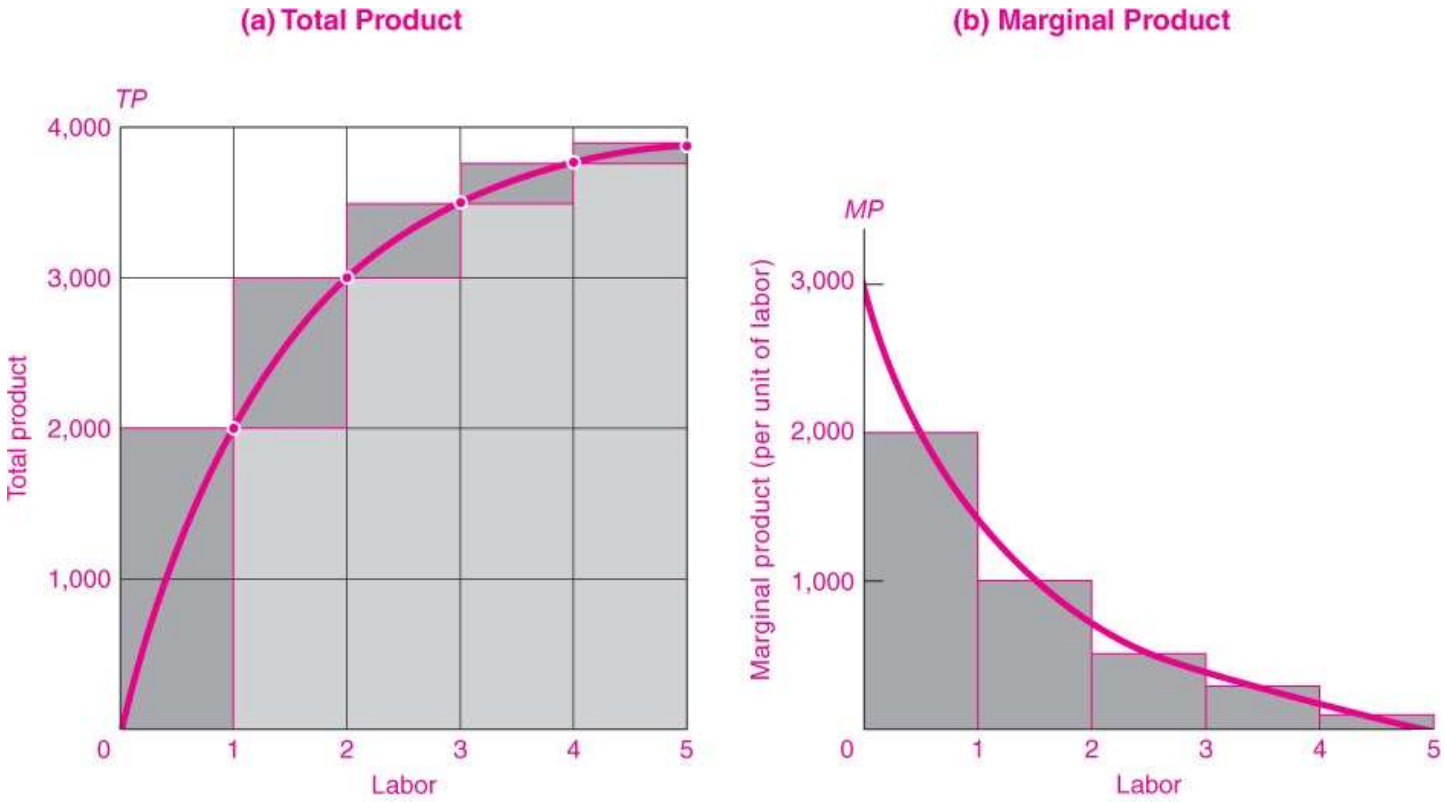


FIGURE 6-1. Marginal Product Is Derived from Total Product

(1) Units of labor input	(2) Total product	(3) Marginal product	(4) Average product
0	0		
		2,000	
1	2,000		2,000
		1,000	
2	3,000		1,500
		500	
3	3,500		1,167
		300	
4	3,800		950
		100	
5	3,900		780

TABLE 6-1. Total, Marginal, and Average Product

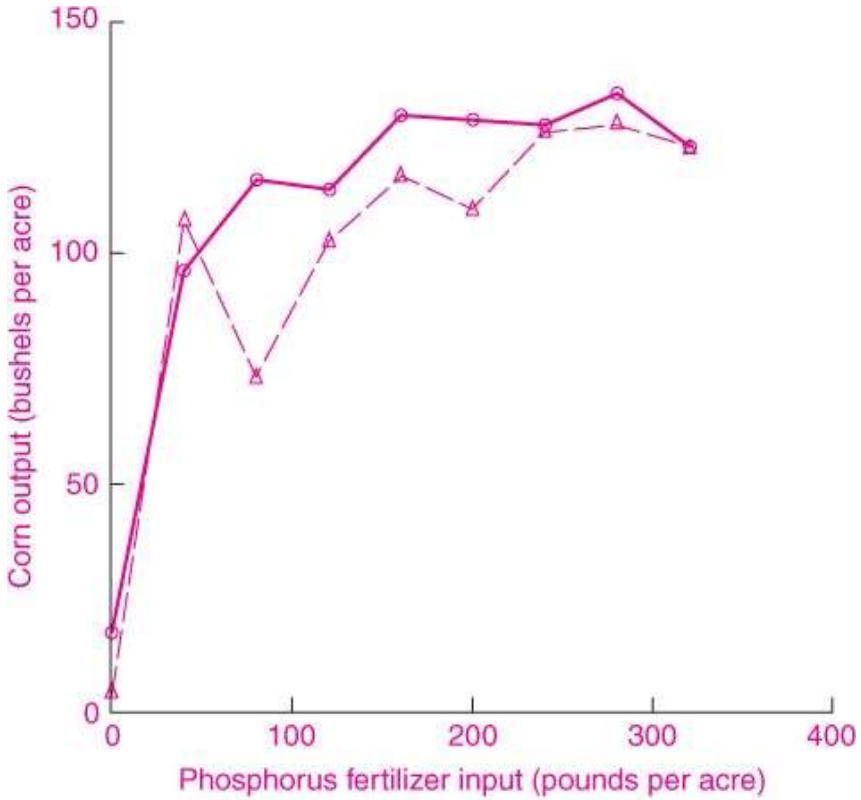


FIGURE 6-2. Diminishing Returns in Corn Production

Production concept	Definition
Diminishing returns	Declining marginal product of an input, holding all other inputs constant
Returns to scale	Increase in output for balanced increase in all inputs is
Decreasing	. . . less than proportional
Constant	. . . proportional
Increasing	. . . more than proportional

TABLE 6-2. Important Production Concepts

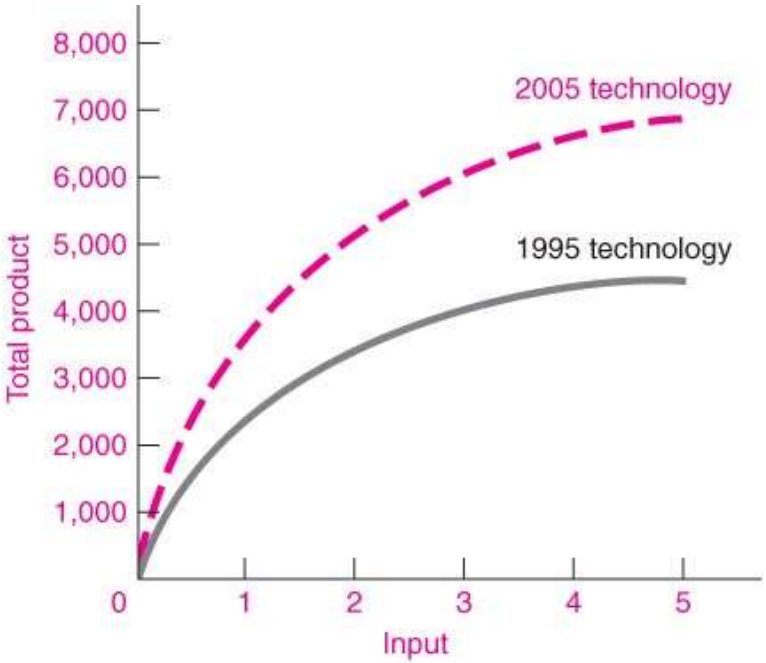


FIGURE 6-3. Technological Change Shifts Production Function Upward

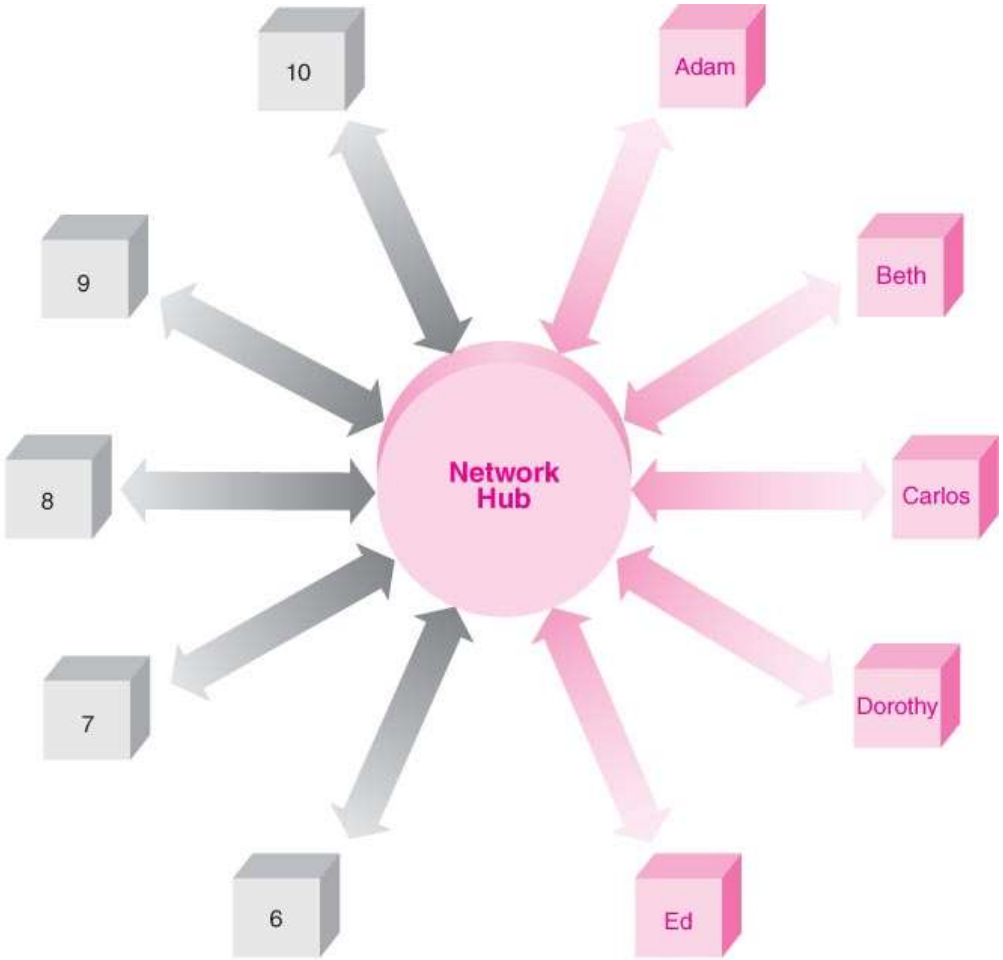


FIGURE 6-4. Value of Networking Increases as Membership Rises

FIGURE 6-5. Growth in Labor Productivity

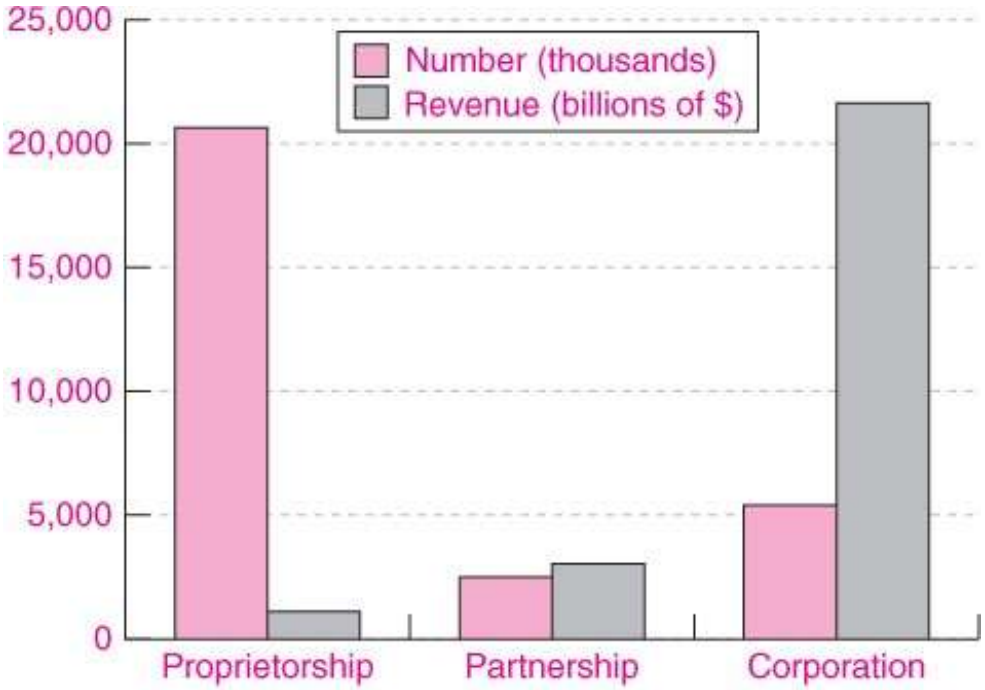


FIGURE 6-6. Number and Size of Different Business Forms, 2004

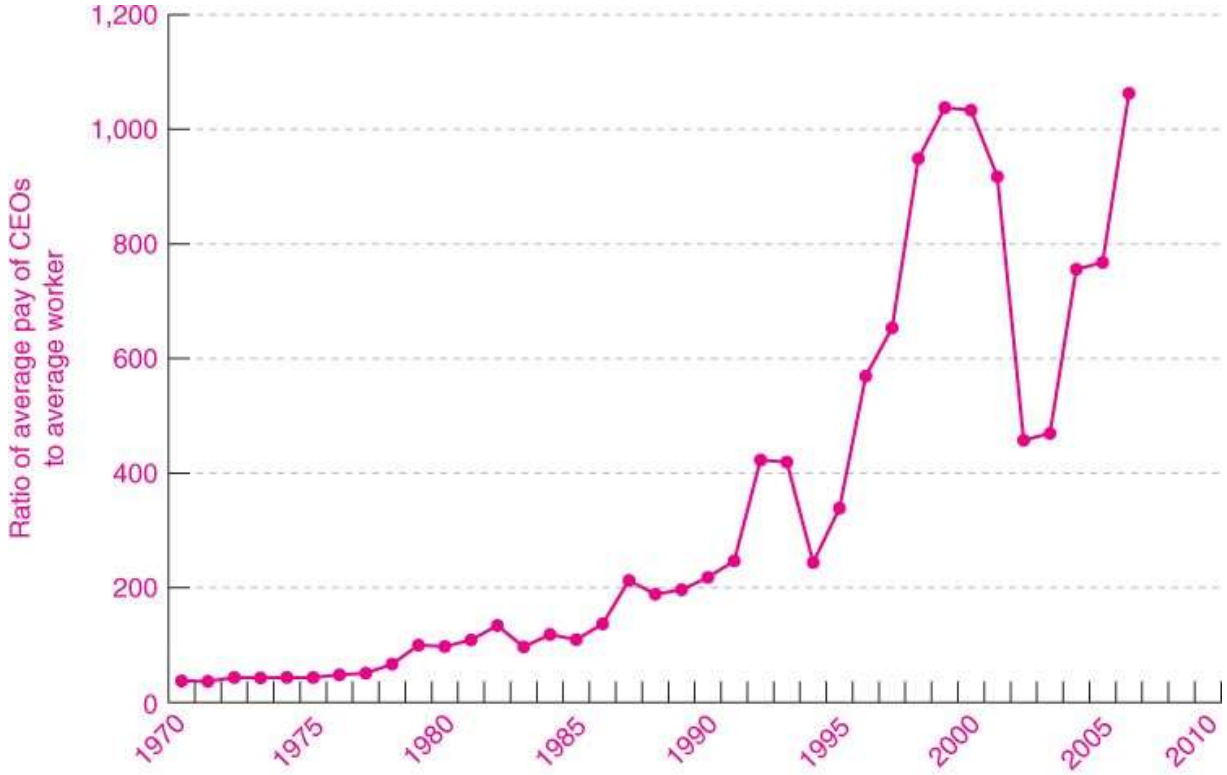


FIGURE 6-7. The Explosion in Executive Compensation

- The Technology of Production
- Production with One Variable Input (Labor)
- Production with Two Variable Inputs
- Returns to Scale

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 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

THE TECHNOLOGY OF PRODUCTION

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

- **The Production Function**

$$q = F(K, L)$$

  - **production function** Function showing the highest output that a firm can produce for every specified combination of inputs.

  Remember the following:

  Inputs and outputs are *flows*.

  Equation above applies to a *given technology.*

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

PRODUCTION WITH ONE VARIABLE INPUT (LABOR)

Production with One Variable Input				
Labour(L)	**Capital (K)**	**Total Output (*q*)**	**Marginal Output (*q*)**	**Average Output (*q*)**
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

PRODUCTION WITH ONE VARIABLE INPUT (LABOR)

- 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 = $\Delta q/\Delta L$

PRODUCTION WI

- The Slopes of the Product Curve

Production with One Variable Input

The total product curve shows the output produced for different amounts of labor input.

The average and marginal products below can be obtained (using the data from the total product curve.

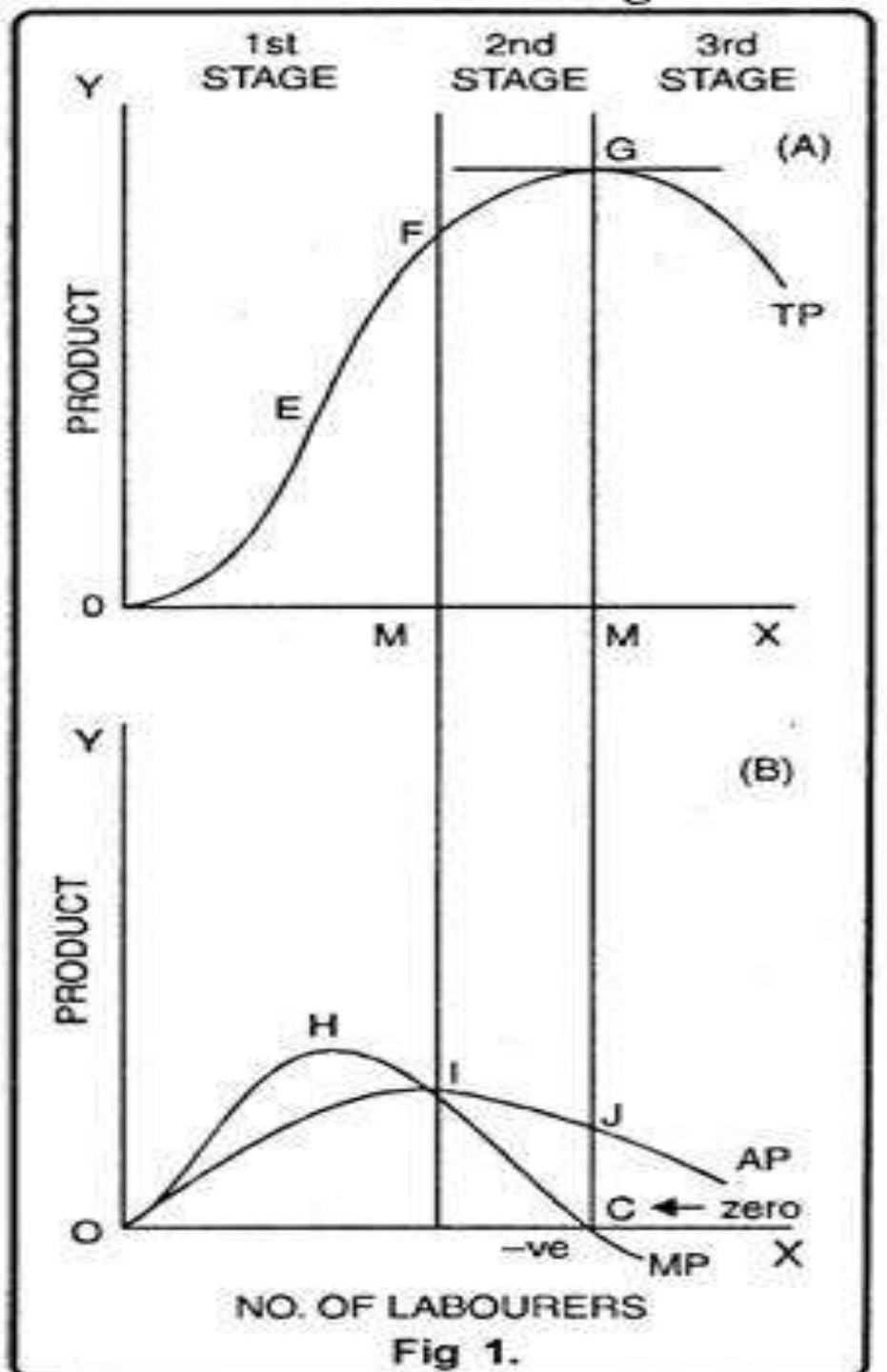


Fig 1.

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.

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.

Malthus and 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).

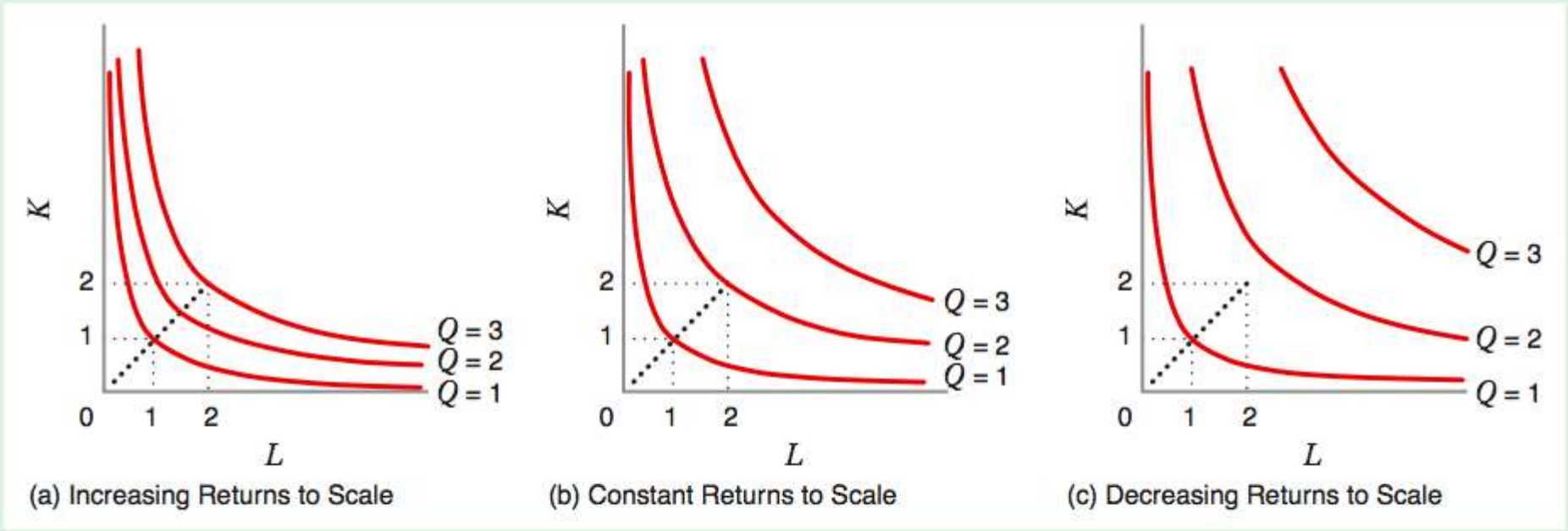
Index of World Food Production per Capita	
Year	**Index**
1948-1952	100
1960	115
1970	123
1980	128
1990	138
2000	150
2005	156

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.

Returns to Scale

Returns to Scale



Increasing, Constant, and Decreasing Returns to Scale
In panel (a), doubling the quantities of capital and labor more than doubles output. In panel (b), doubling the quantities of capital and labor exactly doubles output. In panel (c), doubling the quantities of capital and labor less than doubles output.

https://economics.stackexchange.com/questions/21847/question-on-returns-of-scale-in-isoquants

Returns to Scale

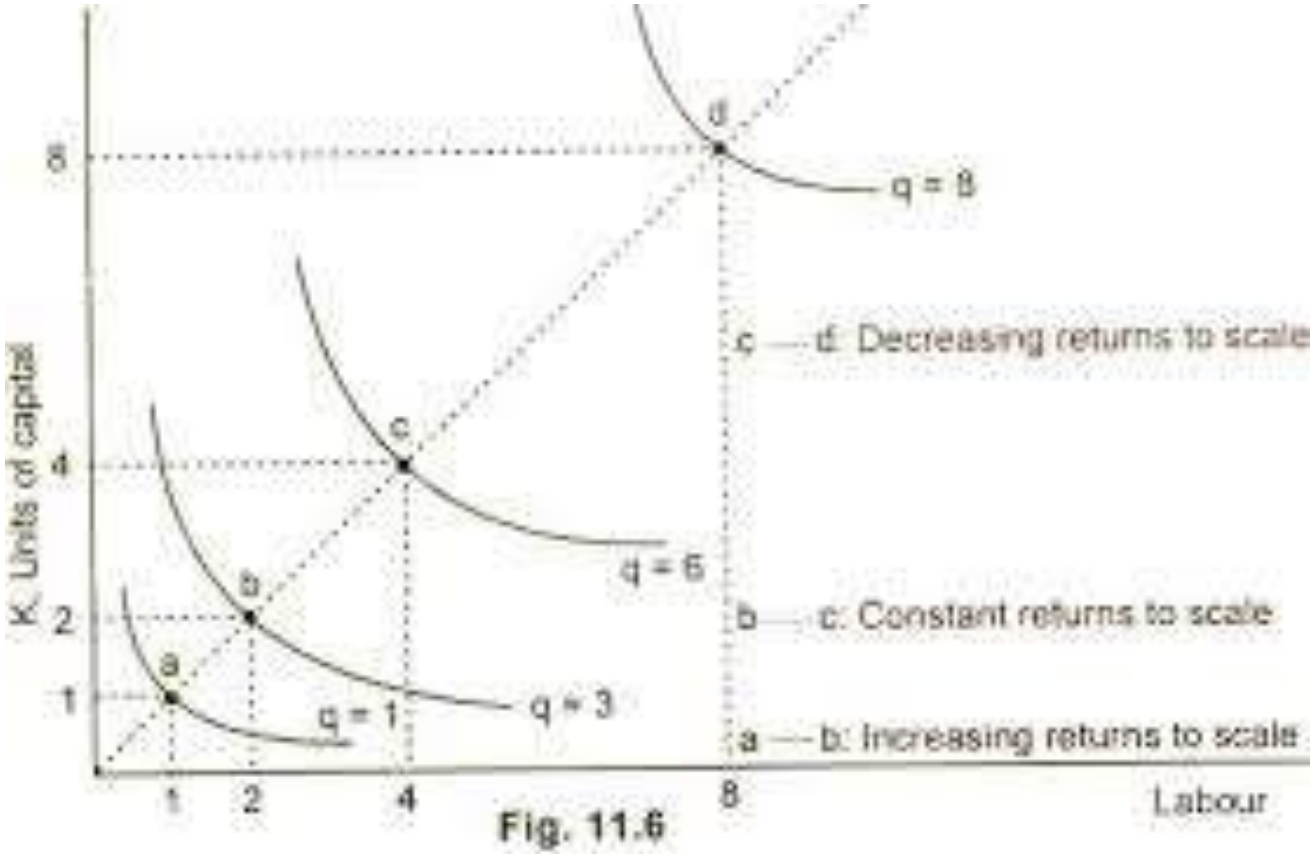


Fig. 11.6

COSTS OF PRODUCTION

Economic Cost versus Accounting Cost

- **accounting cost** Actual expenses plus depreciation charges for capital equipment.
- **economic cost** Cost to a firm of utilizing economic resources in production, including opportunity cost.

Opportunity Cost

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

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.

Sunk Cost

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

Because a sunk cost cannot be recovered, it should not influence the firm's decisions.

For example, consider the purchase of specialized equipment for a plant. Suppose the equipment can be used to do only what it was originally designed for and cannot be converted for alternative use.

The expenditure on this equipment is a sunk cost.

Because it has no alternative use, its opportunity cost is zero.
Thus it should not be included as part of the firm's economic costs.

Fixed Costs and Variable Costs

- **total cost (TC** or **C)** Total economic cost of production, consisting of fixed and variable costs.
- **fixed cost (FC)** Cost that does not vary with the level of output and that can be eliminated only by shutting down.
- **variable cost (VC)** Cost that varies as output varies.

The only way that a firm can eliminate its fixed costs is by shutting down.

Fixed Costs and Variable Costs

Shutting Down

Shutting down doesn't necessarily mean going out of business.

By reducing the output of a factory to zero, the company could eliminate the costs of raw materials and much of the labor. The only way to eliminate fixed costs would be to close the doors, turn off the electricity, and perhaps even sell off or scrap the machinery.

Fixed or Variable?

How do we know which costs are fixed and which are variable?

Over a very short time horizon—say, a few months—most costs are fixed. Over such a short period, a firm is usually obligated to pay for contracted shipments of materials.

Over a very long time horizon—say, ten years—nearly all costs are variable. Workers and managers can be laid off (or employment can be reduced by attrition), and much of the machinery can be sold off or not replaced as it becomes obsolete and is scrapped.

Sunk costs are costs that have been incurred and *cannot be recovered*.

An example is the cost of R&D to a pharmaceutical company to develop and test a new drug and then, if the drug has been proven to be safe and effective, the cost of marketing it.

Whether the drug is a success or a failure, these costs cannot be recovered and thus are sunk.

Amortizing Sunk Costs

- **amortization** Policy of treating a one-time expenditure as an annual cost spread out over some number of years.

Marginal and Average Cost

Marginal Cost (MC)

- **marginal cost (MC)** Increase in cost resulting from the production of one extra unit of output.

Because fixed cost does not change as the firm's level of output changes, marginal cost is equal to the increase in variable cost or the increase in total cost that results from an extra unit of output.

We can therefore write marginal cost as

$$MC = \Delta VC/\Delta q = \Delta TC/\Delta q$$

Marginal and Average Cost

Marginal Cost (MC)

Rate of Output (Units per Year)	Fixed Cost per Year) (FC) (1)	Variable Cost per Year) (VC) (2)	Total Cost per Unit) (TC) (3)	Marginal Cost per Unit) (MC) (4)	Average Fixed Cost per Unit) (AFC) (5)	Average Variable Cost (per Unit) (AVC) (6)	Average Total Cost per Year) (ATC) (7)
0	50	0	50	--	--	--	--
1	50	50	100	50	50	50	100
2	50	78	128	28	25	39	64
3	50	98	148	20	16.7	32.7	49.3
4	50	112	162	14	12.5	28	40.5
5	50	130	180	18	10	26	36
6	50	150	200	20	8.3	25	33.3
7	50	175	225	25	7.1	25	32.1
8	50	204	254	29	6.3	25.5	31.8
9	50	242	292	38	5.6	26.9	32.4
10	50	300	350	58	5	30	35
11	50	385	435	85	4.5	35	39.5

Marginal and Average Cost

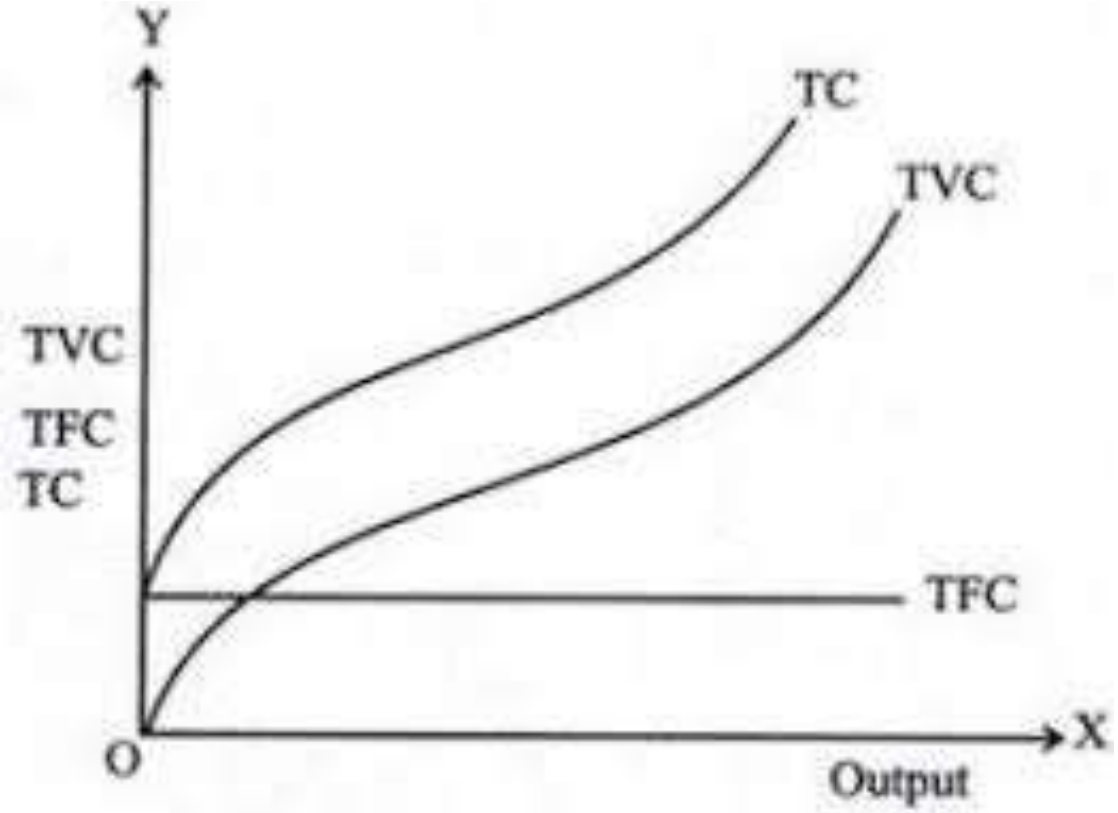
Average Total Cost (ATC)

- **average total cost (ATC)**
  Firm's total cost divided by its level of output.

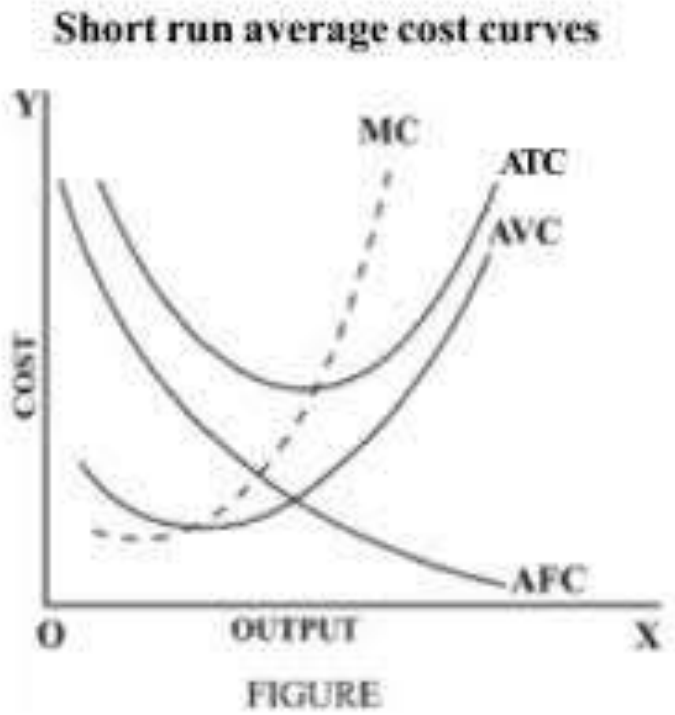
- **average fixed cost (AFC)**
  Fixed cost divided by the level of output.

- **average variable cost (AVC)**
  Variable cost divided by the level of output.

Shape of the Cost Curves



Shape of the Cost Curves



The User Cost of Capital

- **user cost of capital** Annual cost of owning and using a capital asset, equal to economic depreciation plus forgone interest.

The user cost of capital is given by the *sum of the economic depreciation and the interest (i.e., the financial return) that could have been earned had the money been invested elsewhere.* Formally,

$$\text{User Cost of Capital} = \text{Economic Depreciation} + (\text{Interest Rate})(\text{Value of Capital})$$

We can also express the user cost of capital as a *rate* per dollar of capital:

$$r = \text{Depreciation rate} + \text{Interest rate}$$

COST IN THE LONG RUN

The Cost-Minimizing Input Choice

We now turn to a fundamental problem that all firms face: *how to select inputs to produce a given output at minimum cost.*

For simplicity, we will work with two variable inputs: labor (measured in hours of work per year) and capital (measured in hours of use of machinery per year).

The Price of Capital

The price of capital is its *user cost*, given by r = Depreciation rate + Interest rate.

The Rental Rate of Capital

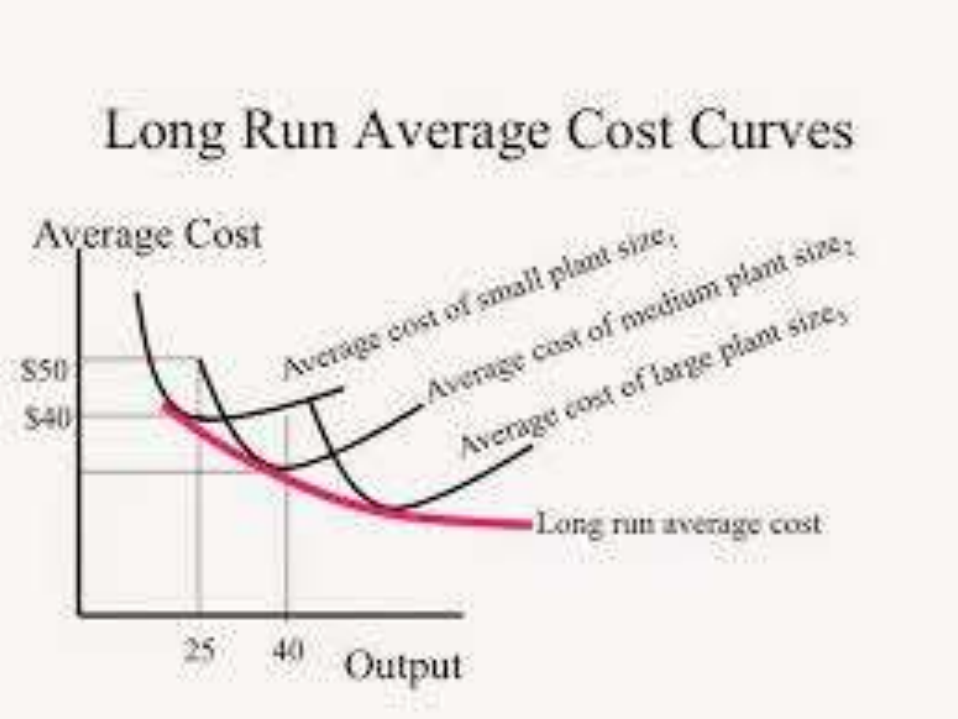
- **rental rate** Cost per year of renting one unit of capital.

If the capital market is competitive, *the rental rate should be equal to the user cost, r.* Why? Firms that own capital expect to earn a competitive return when they rent it. *This competitive return is the user cost of capital.*

Capital that is purchased can be treated as though it were rented at a rental rate equal to the user cost of capital.

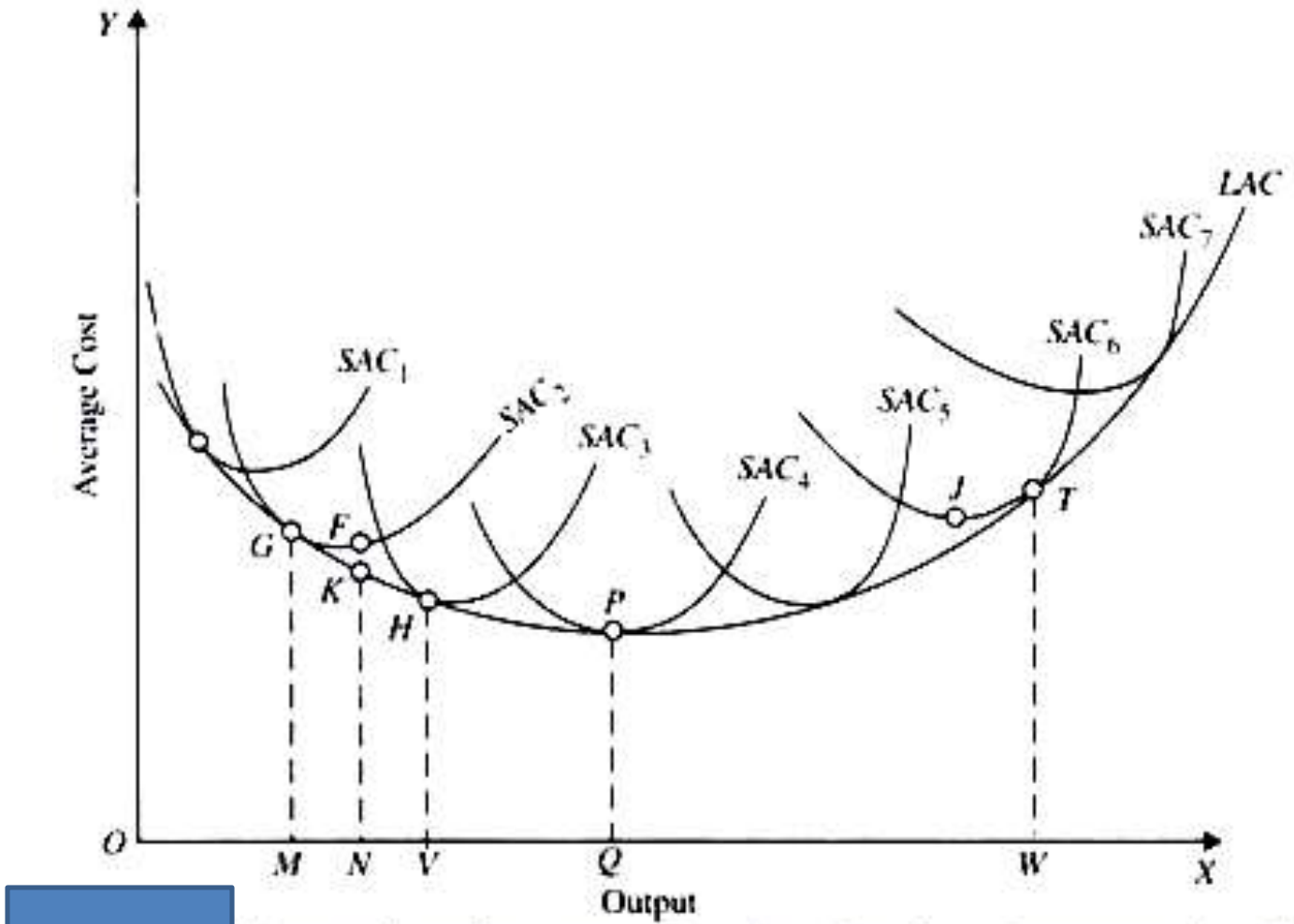
LONG-RUN VERSUS SHORT-RUN COST CURVES

Long-Run Average Cost

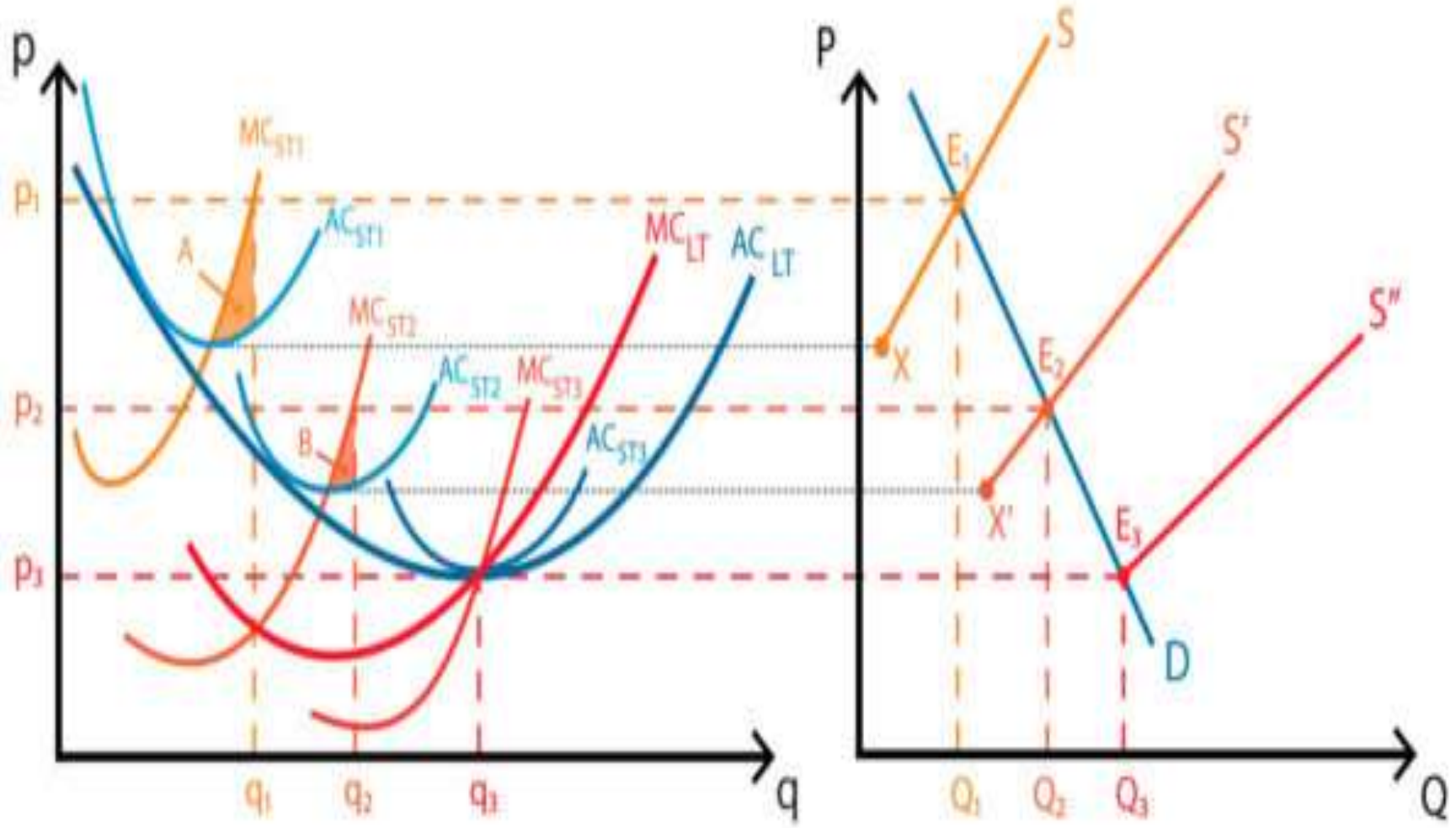


LONG-RUN VERSUS SHORT-RUN COST CURVES

Long-Run Average Cost



Deriving Long-Run Average Cost Curve from Short-Run Average Cost Curves


p
P
S
S'
S''
MC_{ST1}
AC_{ST1}
MC_{LT}
AC_{LT}
MC_{ST2}
AC_{ST2}
MC_{ST3}
AC_{ST3}
A
B
p_1
p_2
p_3
E_1
E_2
E_3
X
X'
D
q_1
q_2
q_3
q
Q_1
Q_2
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Q

Long-Run Average Cost

- **long-run average cost curve (LAC)** Curve relating average cost of production to output when all inputs, including capital, are variable.

- **short-run average cost curve (SAC)** Curve relating average cost of production to output when level of capital is fixed.

- **long-run marginal cost curve (LMC)** Curve showing the change in long-run total cost as output is increased incrementally by 1 unit.

Economies and Diseconomies of Scale

As output increases, the firm's average cost of producing that output is likely to decline, at least to a point.

This can happen for the following reasons:

1. If the firm operates on a larger scale, workers can specialize in the activities at which they are most productive.
2. Scale can provide flexibility. By varying the combination of inputs utilized to produce the firm's output, managers can organize the production process more effectively.
3. The firm may be able to acquire some production inputs at lower cost because it is buying them in large quantities and can therefore negotiate better prices. The mix of inputs might change with the scale of the firm's operation if managers take advantage of lower-cost inputs.

Economies and Diseconomies of Scale

At some point, however, it is likely that the average cost of production will begin to increase with output.

There are three reasons for this shift:

1. At least in the short run, factory space and machinery may make it more difficult for workers to do their jobs effectively.
2. Managing a larger firm may become more complex and inefficient as the number of tasks increases.
3. The advantages of buying in bulk may have disappeared once certain quantities are reached. At some point, available supplies of key inputs may be limited, pushing their costs up.

Economies and Diseconomies of Scale

- **economies of scale** Situation in which output can be doubled for less than a doubling of cost.
- **diseconomies of scale** Situation in which a doubling of output requires more than a doubling of cost.

Increasing Returns to Scale:	Output more than doubles when the quantities of all inputs are doubled.
Economies of Scale:	A doubling of output requires less than a doubling of cost.

Economies and Diseconomies of Scope

- **economies of scope** Situation in which joint output of a single firm is greater than output that could be achieved by two different firms when each produces a single product.

- **diseconomies of scope** Situation in which joint output of a single firm is less than could be achieved by separate firms when each produces a single product.