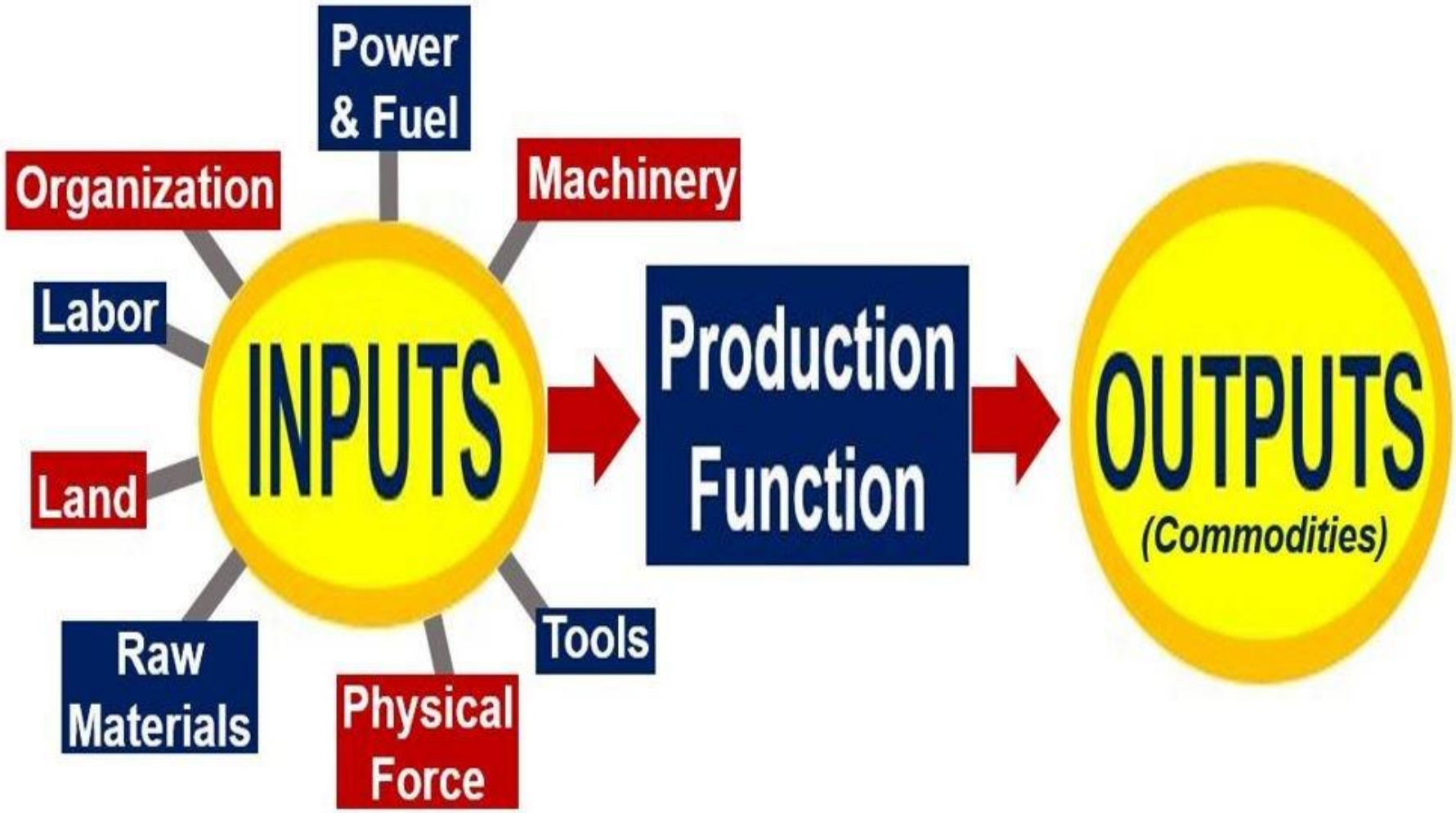
Unit-III
Production and Cost Analysis

UNIT-3

Production


Power & Fuel
Organization
Machinery
Labor
INPUTS
Land
Production Function
OUTPUTS
(Commodities)
Raw Materials
Tools
Physical Force

Production Functions

- ***Production function*** – a curve that describes the relationship between the inputs (factors of production) and output.

- The production function tells the maximum amount of output that can be derived from a given number of inputs.

Production function

- **Production function:** defines the relationship between inputs and the maximum amount that can be produced within a given period of time with a given level of technology

$$Q=f(X_1, X_2, \ldots, X_k)$$

Q = level of output

$X_1, X_2, \ldots, X_k$ = inputs used in production

Production function

- Alternative terms in reference to inputs
  - ‘inputs’
  - ‘factors’
  - ‘factors of production’
  - ‘resources’
- Alternative terms in reference to outputs
  - ‘output’
  - ‘quantity’ (Q)
  - ‘total product’ (TP)
  - ‘product’

Production function

- Key assumptions
  - given ‘state of the art’ production technology
  - whatever input or input combinations are included in a particular function, the output resulting from their utilization is at the maximum level

Production function

- For simplicity we will often consider a production function of two inputs:

$$Q=f(X, Y)$$

Q = output

X = labor

Y = capital

Production Function

Short Run

Short period of production – some of the inputs cannot be varied because there is not enough time.

For example: for an employer it is easier to add new labor than new equipment.

Labor is an input factor that can be varied – which impacts production.

Long Run

There is enough time in this period of production for managers to vary all the inputs used to make a product – not just labor.

For example: new equipment, as well as labor, can be added to the existing setup to boost production.

Production

- ***Marginal product*** is the additional output that will be forthcoming from an additional worker, other inputs remaining constant.

- ***Average product*** is calculated by dividing total output by the number of workers who produced it.

Short-run analysis of Total, Average, and Marginal product

- **Marginal product** (MP) = change in output (Total Product) resulting from a unit change in a variable input

$$MP_X = \frac{\Delta Q}{\Delta X}$$

- **Average product** (AP) = Total Product per unit of input used

$$AP_X = \frac{Q}{X}$$

Marginal Rate of Technical Substitution

- MRTS measures the reduction in one input due to unit increase in the other input that is just sufficient to maintain the same level of output.

$$MRTS_{LK} = -\frac{\Delta K}{\Delta L}$$

- MRTS of labour for capital is equal to the slope of the isoquant
- Also equal to the ratio of the marginal product of one input to the marginal product of other input

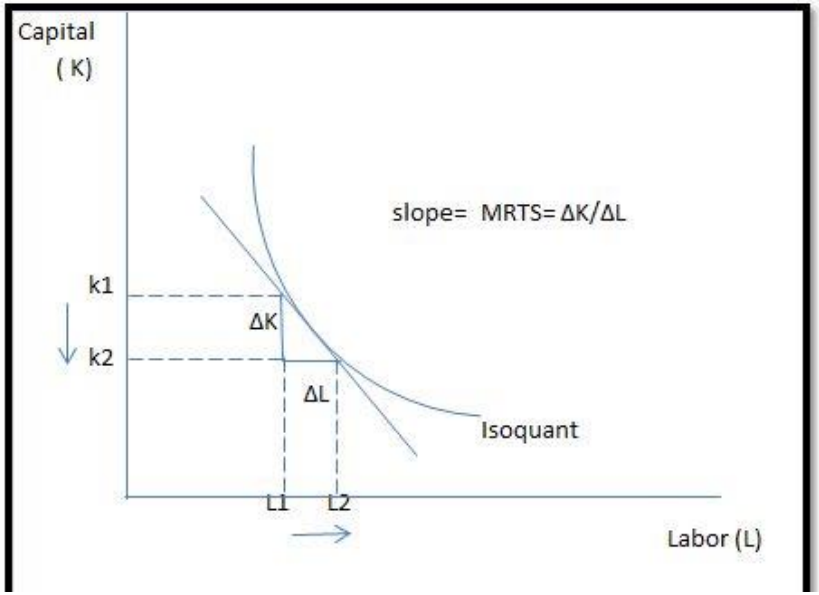
$$\Delta Q = MP_L \times \Delta L + MP_K \times \Delta K$$

$$0 = MP_L \times \Delta L + MP_K \times \Delta K$$

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

Concept of MRTS in graph

- In the following figure, the slope (ΔK/ΔL) of isoquant is Marginal Rate of Technical Substitution (MRTS) which shows the way the producer substitute capital (decreases the use of capital from k1 to k2) with labor (increases the use of labor from L1 to L2) so that he remains in the same isoquant (that means the level of output remains the same)



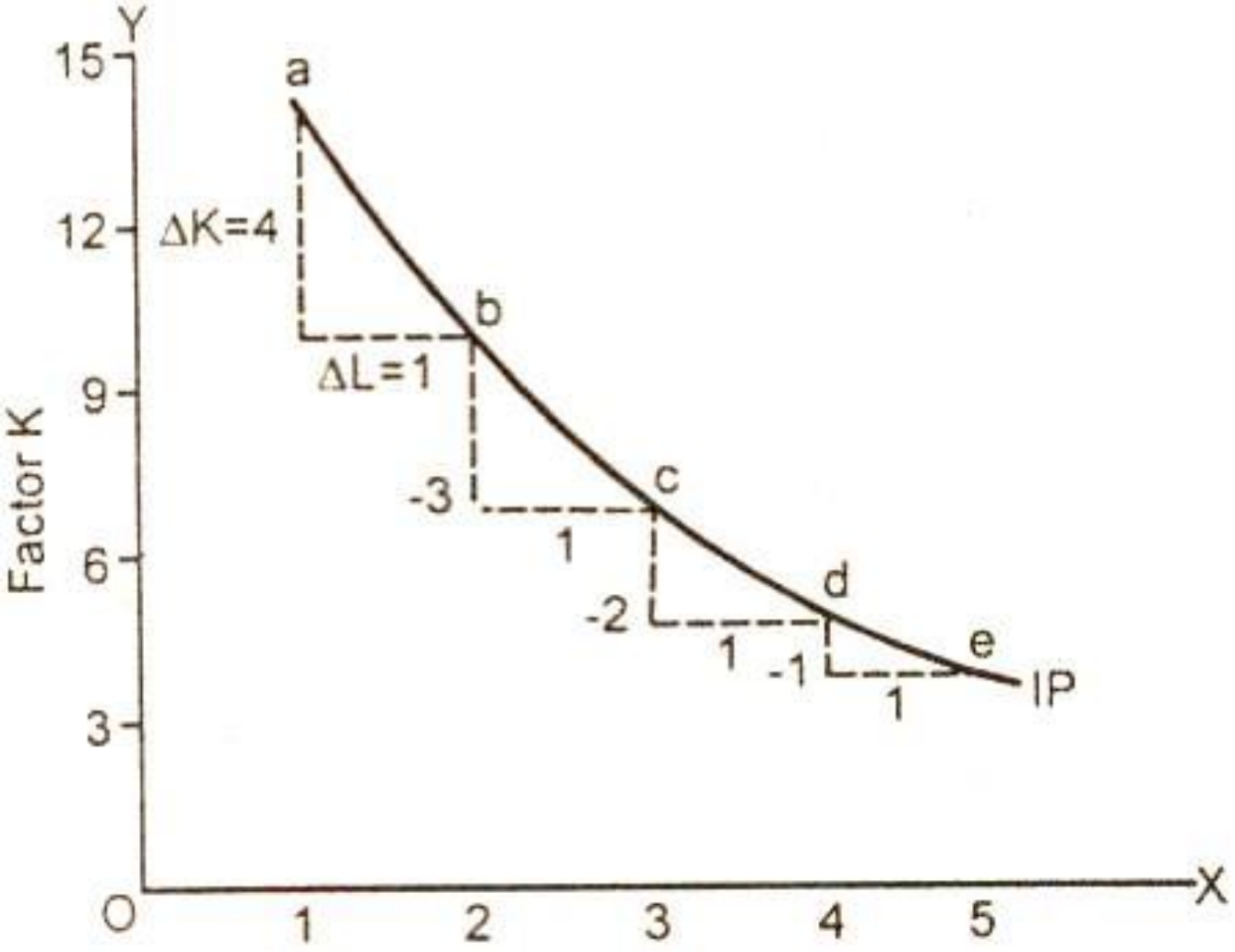
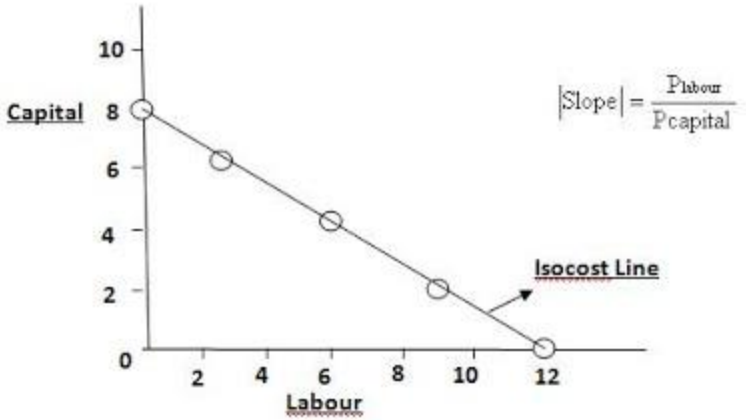


Fig. 12.8

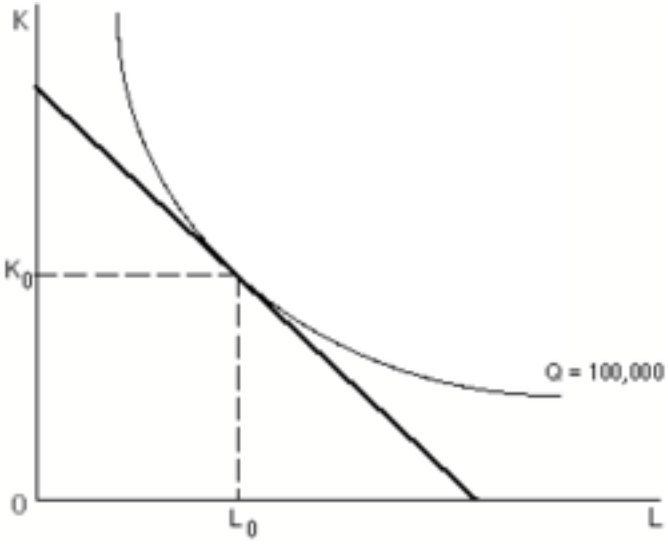
ISOCOST

- The isocost line is an important component when analysing producer's behaviour.
- The isocost line illustrates all the possible combinations of two factors that can be used at given costs and for a given producer's budget.
- In simple words, an isocost line represents a combination of inputs which all cost the same amount.

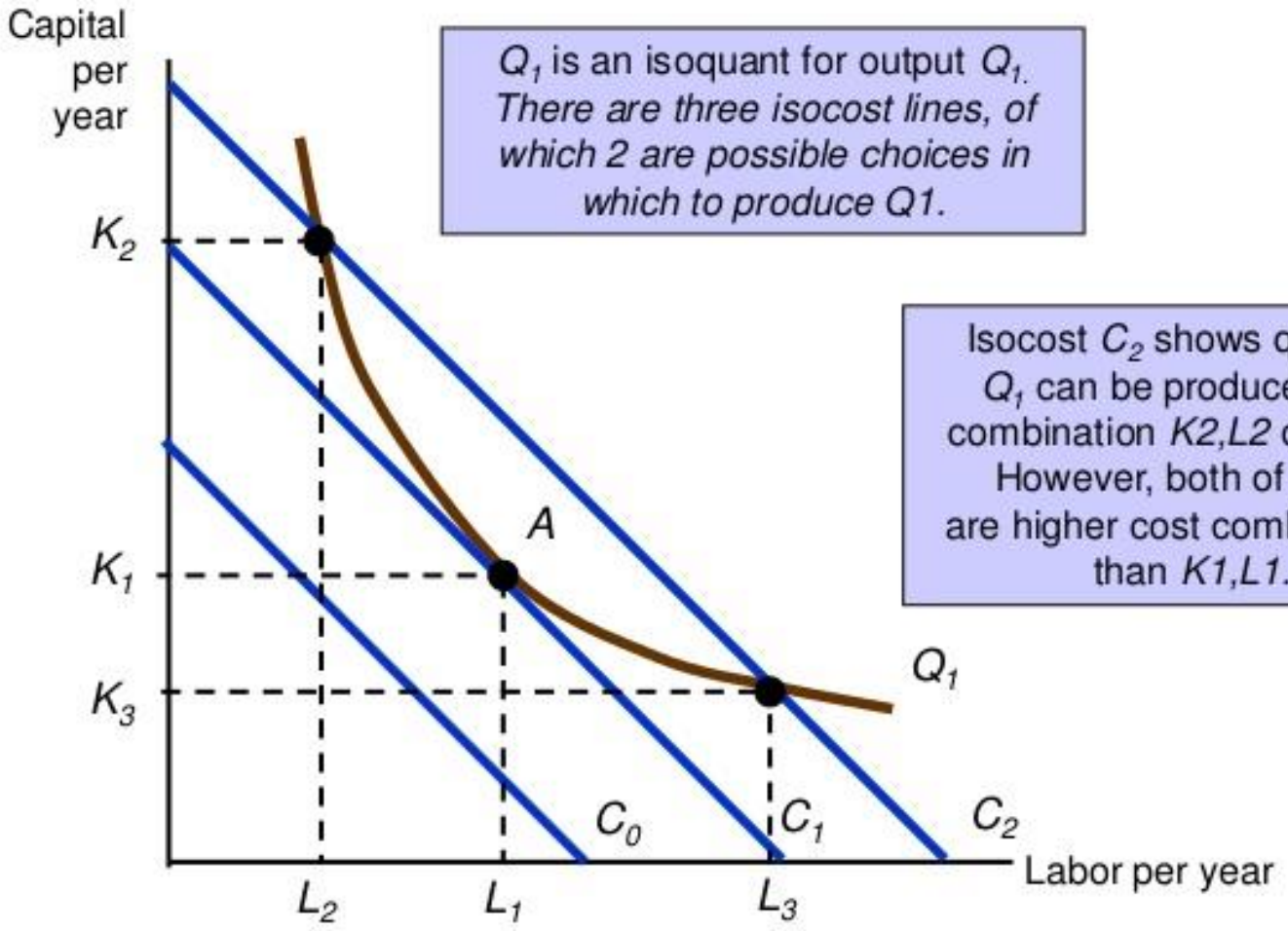


ISOQUANT

- 'Iso' means equal and 'quant' means quantity.
- Therefore, an **isoquant** represents a constant quantity of output.
- An **isoquant** is a firm's counterpart of the consumer's indifference curve.
- An **isoquant** is a curve that shows all the combinations of inputs that yield the same level of output.



Producing a Given Output at Minimum Cost



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Production function with one/two variables

- There are two Variable Proportions Production Function_

1- **Production Function With One Variable Input.**

2- Production With Two Variable Inputs

Production Function With One Variable Input

- When discussing production in the short run, three definitions are important:
  - Total product
  - Marginal product
  - Average product

Production Function With One Variable Input

Total Product $TP = Q = f(L)$

Marginal Product $MP_L = \frac{\Delta TP}{\Delta L}$

Average Product $AP_L = \frac{TP}{L}$

Production or Output Elasticity $E_L = \frac{MP_L}{AP_L}$

Total Product

- Total product (TP) is another name for output in the short run.

$$TP = Q = f(L)$$

Marginal Product

- The marginal product (MP) of a variable input is the change in output (or TP) resulting from a one unit change in the input.
- MP tells us how output changes as we change the level of the input by one unit.
- Consider the two input production function Q=*f* (L,K) in which input L is variable and input K is fixed at some level.
- The marginal product of input L is defined as holding input K constant.

$$MP_L = \frac{\Delta TP}{\Delta L}$$

Average Product

- The average product (AP) of an input is the total product divided by the level of the input.
- AP tells us, on average, how many units of output are produced per unit of input used.
- The average product of input L is defined as holding input K constant.

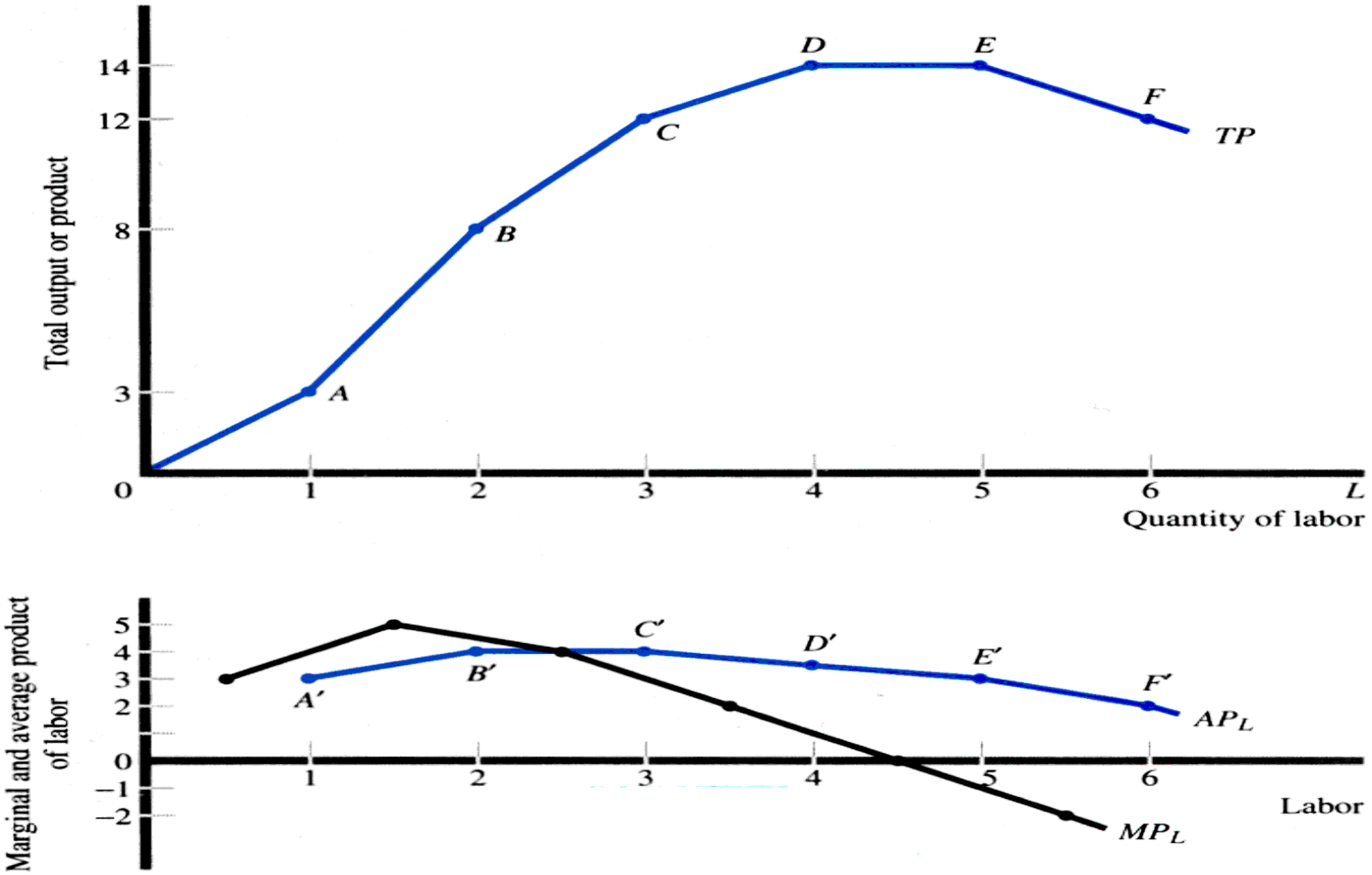
$$AP_L = \frac{TP}{L}$$

Production Function With One Variable Input-Example

Total, Marginal, and Average Product of Labor, and Output Elasticity

L	Q	MP_L	AP_L	E_L
0	0	-	-	-
1	3	3	3	1
2	8	5	4	1.25
3	12	4	4	1
4	14	2	3.5	0.57
5	14	0	2.8	0
6	12	-2	2	-1

Production Function With One Variable Input



Production With Two Variable Inputs

-In the long run, all inputs are variable.

Isoquants show combinations of two inputs that can produce the same level of output.

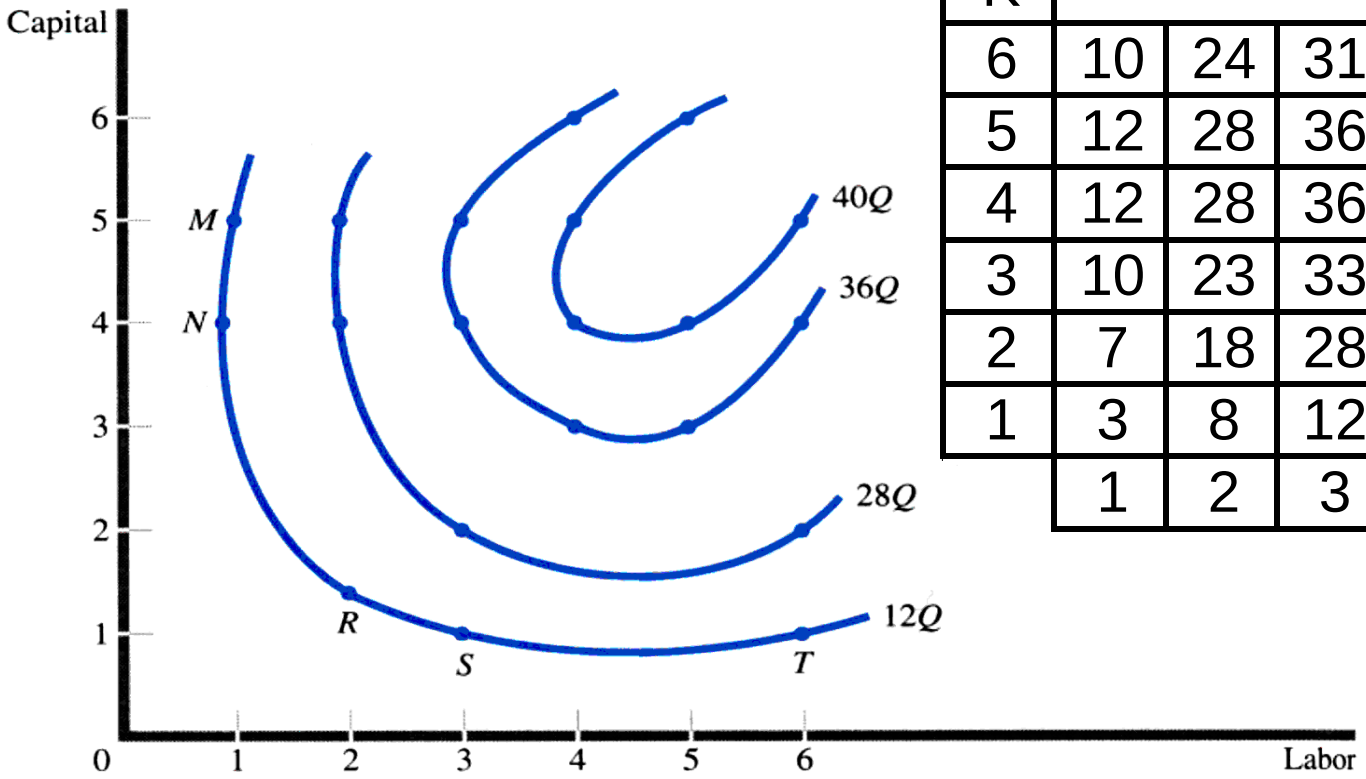
-In other words, Production isoquant shows the various combination of two inputs that the firm can use to produce a specific level of output.

-Firms will only use combinations of two inputs that are in the economic region of production, which is defined by the portion of each isoquant that is negatively sloped.

-A higher isoquant refers to a larger output, while a lower isoquant refers to a smaller output.

Production With Two Variable Inputs

Isoquants



K							Q
6	10	24	31	36	40	39	
5	12	28	36	40	42	40	
4	12	28	36	40	40	36	
3	10	23	33	36	36	33	
2	7	18	28	30	30	28	
1	3	8	12	14	14	12	
	1	2	3	4	5	6	L

ASSUMPTIONS

- THE PRODUCTION FUNCTIONS ARE BASED ON CERTAIN ASSUMPTIONS.

- 1 Perfect divisibility of both inputs and outputs

- 2 Limited substitution of one factor for another

- 3 Constant technology

Returns to Factors

- If I keep adding labor (or any particular factor of production) to the production setup while keeping all other factors constant (i.e. - ceteris paribus), then diminishing returns will set in.
- For example, one farmer on a plot with X input units may produce 1 unit of output. 2 farmers on the same parcel of land and X input units may produce 3 units of output. This is the stage of "Increasing Returns to Scale". This may continue for a while; however, eventually, when we add nth farmer, the production will rise at a continuously decreasing rate, finally taking a negative turn.

Returns to Scale

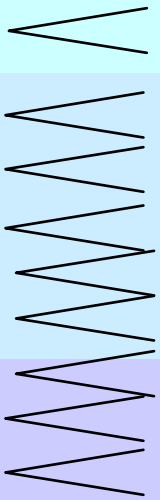
- Let's say all the factors of production are taken as X input to produce output Y. Now, ask how much will 2X produce? If the answer is 2Y, we have constant returns to scale. If the answer is >2Y, we have increasing returns to scale. If the answer is <2Y, we have decreasing returns to scale.

Critical Differences to note:

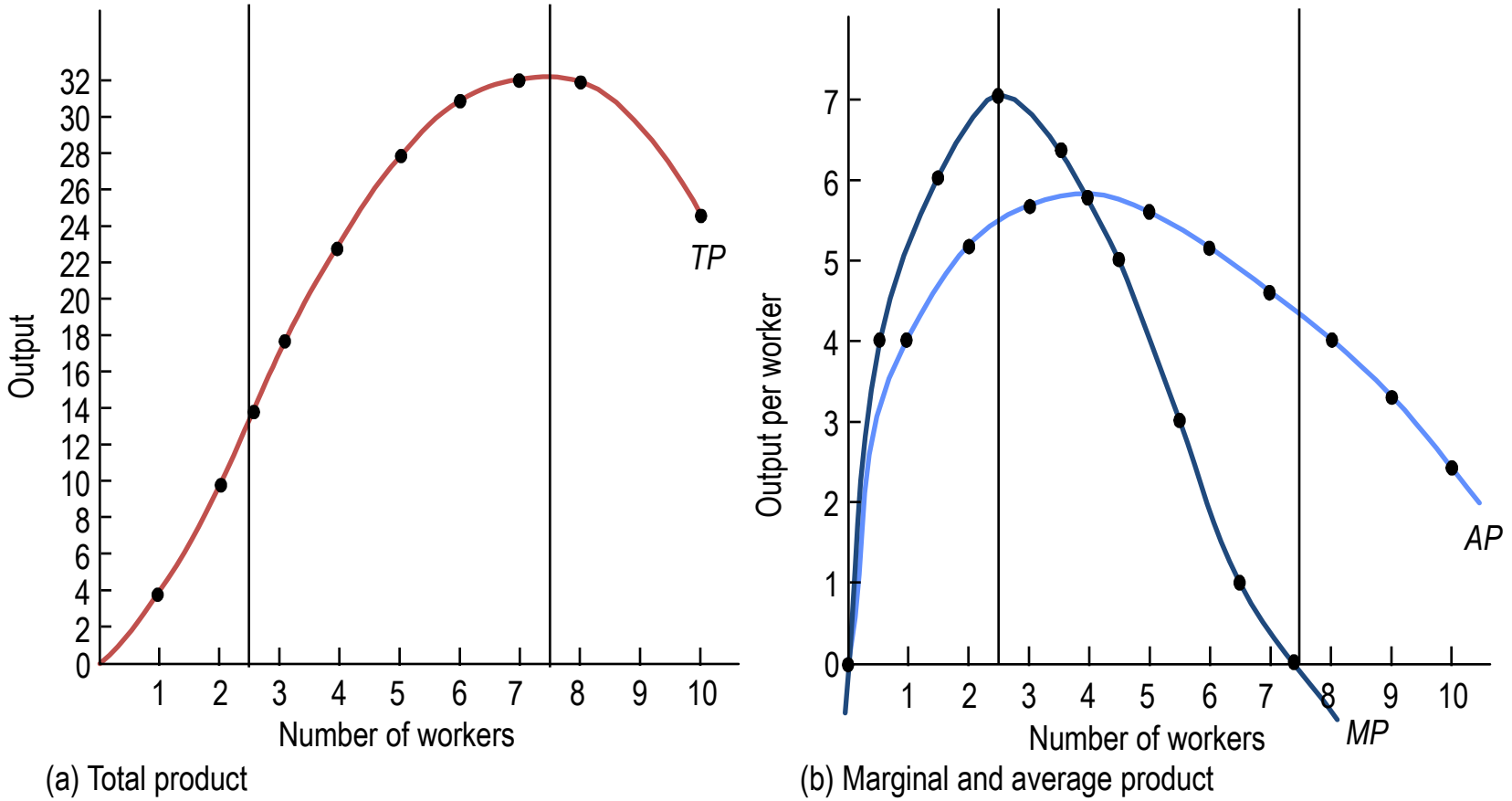
- 1. In LoR, only one factor changes. In RtS, the entire set of inputs is changed.
- 2. In LoR, diminishing returns is like a final truth. There may be increasing returns initially but eventually, diminishing returns will set in.
- In RtS, it depends on the industry and the process. Therefore, we may have constant RtS going on for forever (typically in low specialisation industries, like making chairs or Pizza) or otherwise as well.

Production Table

Number of workers	Total output	Marginal product	Average product
0	0		—
1	4	4	4
2	10	6	5
3	17	7	5.7
4	23	6	5.8
5	28	5	5.6
6	31	3	5.2
7	32	1	4.6
8	32	0	4.0
9	30	-2	3.3
10	25	-5	2.5



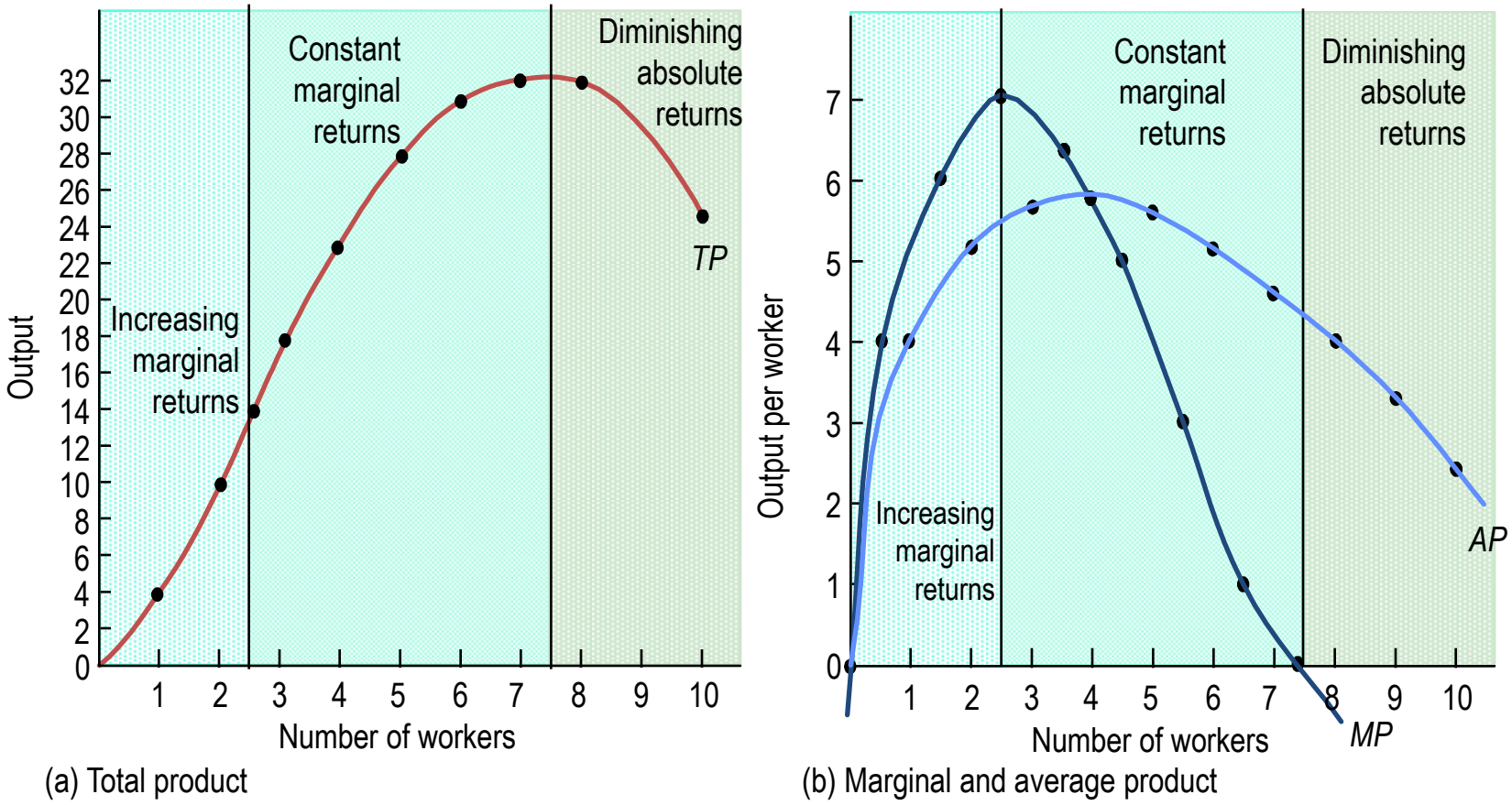
Returns to Scale and Returns to Factors



Diminishing Marginal Productivity

- ***Law of diminishing marginal productivity*** – as more and more of a variable input is added to an existing fixed input, after some point the additional output one gets from the additional input will fall.

Diminishing Marginal Productivity



THESE STAGES CAN BE EXPLAINED USING GRAPH:

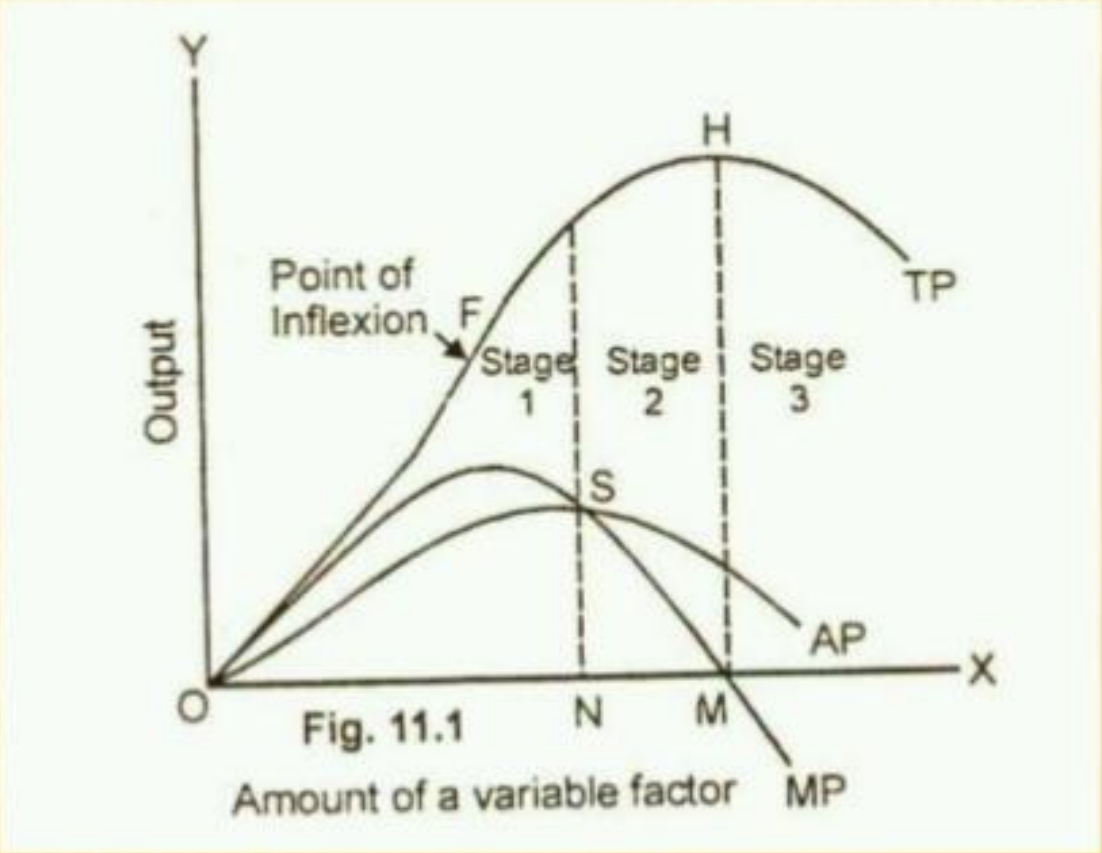


Fig. 11.1

Cost Concepts

Cost Concept

- A **cost** is a sacrifice of resources. Every day, we buy many different things: clothing, food, books, music, perhaps an automobile, and so on. When we buy one thing, we give up (sacrifice) the ability to use these resources (typically cash or a line of credit) to buy something else. The price of each item measures the sacrifice we must make to acquire it.
- Whether we pay cash or use another asset, whether we pay now or later (by using a credit card), the cost of the item acquired is represented by what we forgo as a result.

DETERMINANTS OF COSTS

- The determinants of cost are as follows.

1. Size of plant
2. Level of output
3. Prices of inputs
4. Productivities of factors of production
5. Technology
6. Managerial efficiency

Fixed Costs

- ***Fixed costs*** are those that cannot be changed in the period of time under consideration regardless of output.
  - In the long run there are no fixed costs since all costs are variable.
  - In the short run, a number of costs will be fixed.

Variable Costs

- ***Variable costs*** are costs that change as output changes, such as the costs of labour and materials.

Fixed Costs, Variable Costs, and Total Costs

- The sum of the fixed costs and variable costs are total costs.

$$TC = FC + VC$$

Average Costs

- ***Average total cost*** (often called average cost) equals total cost divided by the quantity produced.

$$ATC = TC/Q$$

Average Costs

- ***Average fixed cost*** equals fixed cost divided by quantity produced.

$$AFC = FC/Q$$

Average Costs

- ***Average variable cost*** equals variable cost divided by quantity produced.

$$AVC = VC/Q$$

Average Costs

- Average total cost can also be thought of as the sum of average fixed cost and average variable cost.

$$ATC = AFC + AVC$$

Marginal Cost

- ***Marginal cost*** is the increase in total cost of increasing the level of output by one unit,

$$MC = \Delta TC / \Delta Q$$

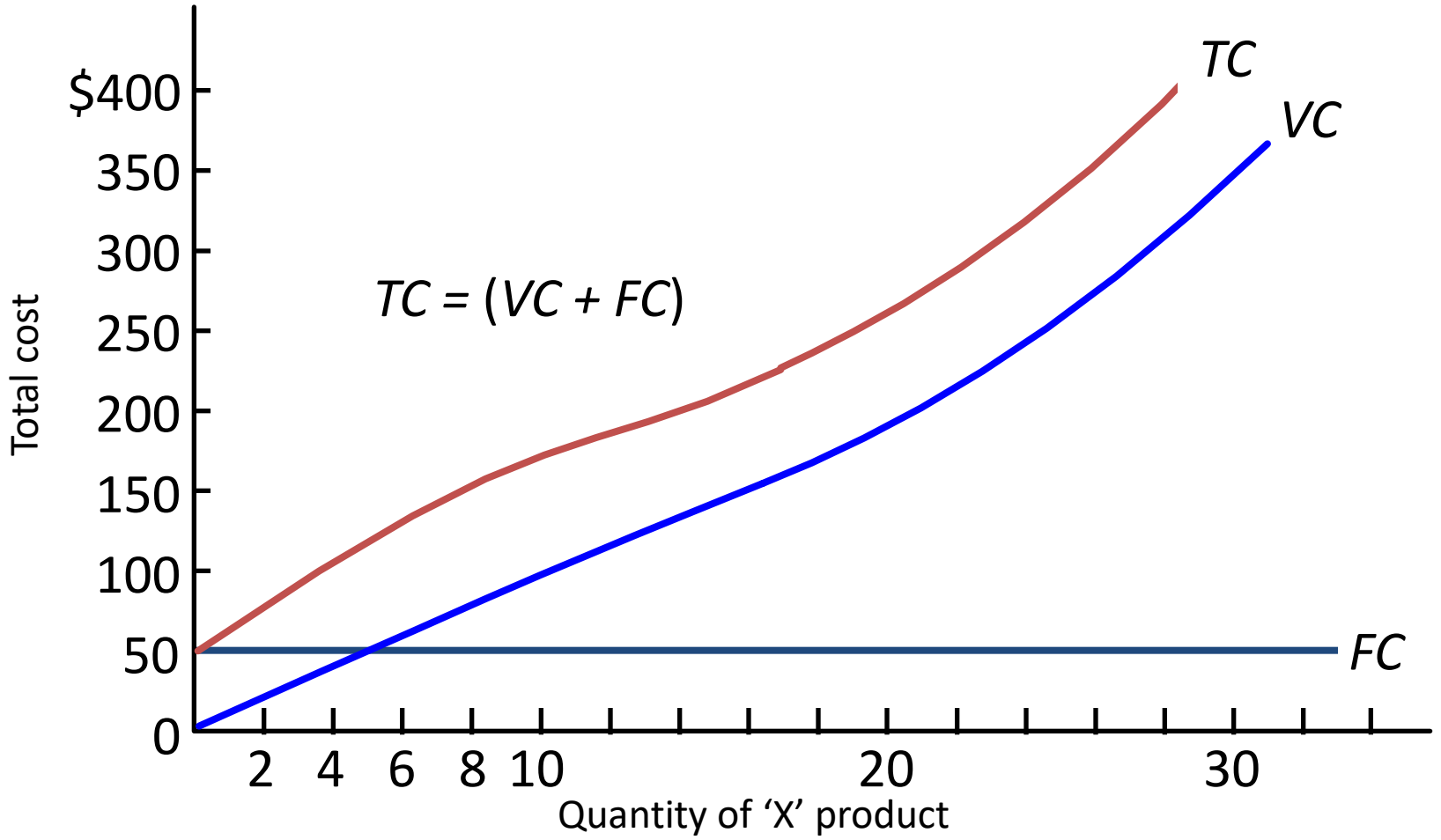
- In deciding how many units to produce, the most important variable is marginal cost.

Cost-output relationship in the short run

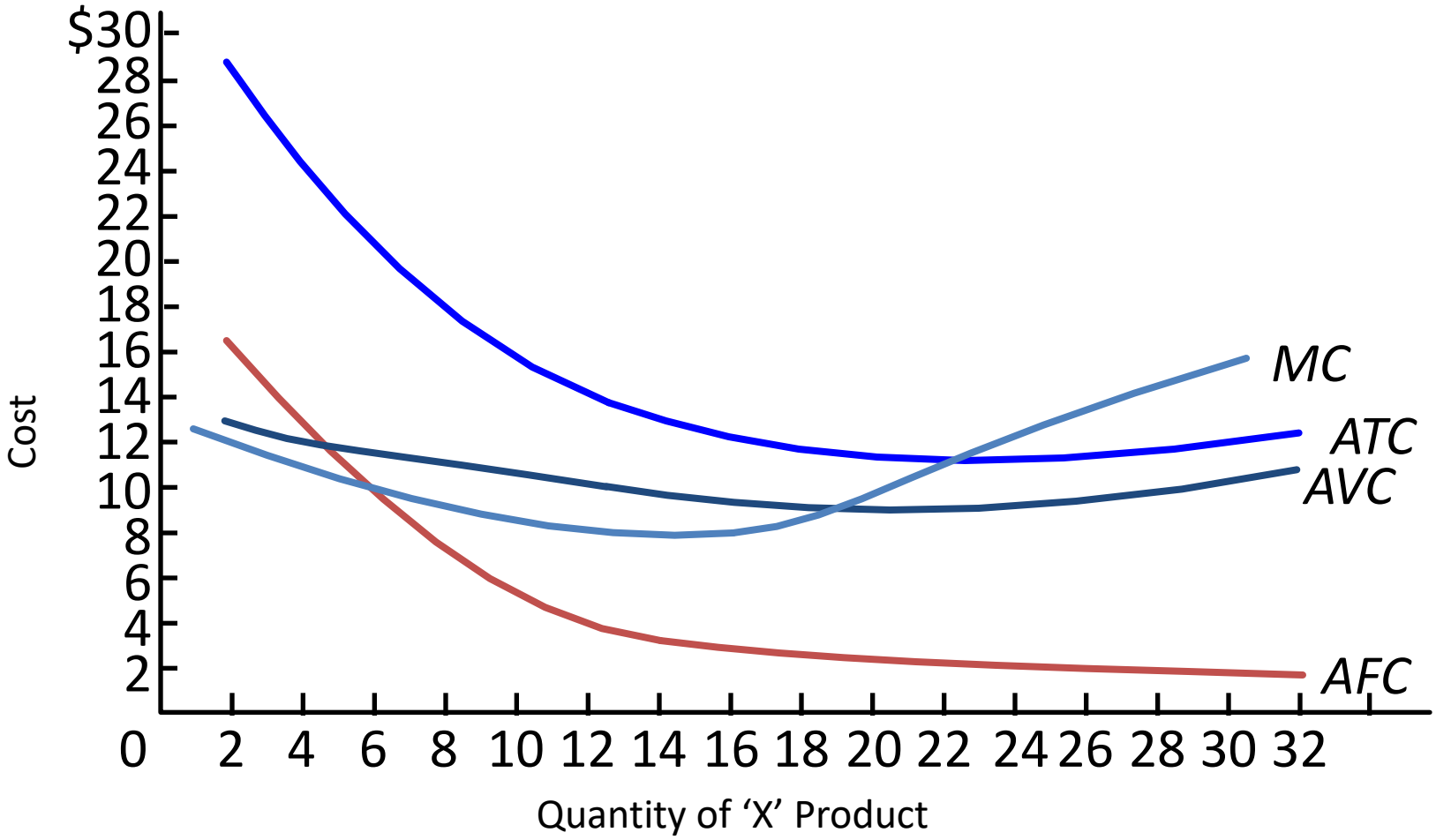
The Cost of Producing X Product							
Output	FC	VC	TC	MC	AFC	AVC	ATC
3	50	38	88	—			
4	50	50	100	12			
9	50	100	150	—			
10	50	108	158	8			
16	50	150	200	—			
17	50	157	207	7			
22	50	200	250	—			
23	50	210	260	10			
27	50	255	305	—			
28	50	270	320	15			

The Cost of Producing 'X' product							
Output	FC	VC	TC	MC	AFC	AVC	ATC
3	50	38	88	—	16.67	12.66	29.33
4	50	50	100	12	12.50	12.50	25.00
9	50	100	150	—	5.56	11.11	16.67
10	50	108	158	8	5.00	10.80	15.80
16	50	150	200	—	3.13	9.38	12.50
17	50	157	207	7	2.94	9.24	12.18
22	50	200	250	—	2.27	9.09	11.36
23	50	210	260	10	2.17	9.13	11.30
27	50	255	305	—	1.85	9.44	11.30
28	50	270	320	15	1.79	9.64	11.42

Total Cost Curves



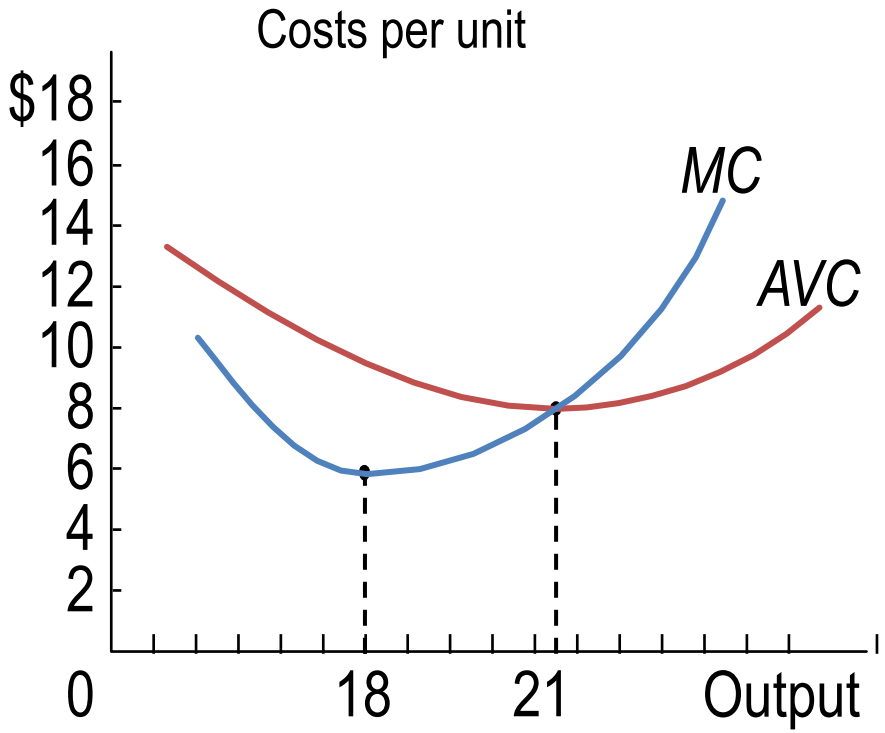
Average (Per Unit) Cost Curves

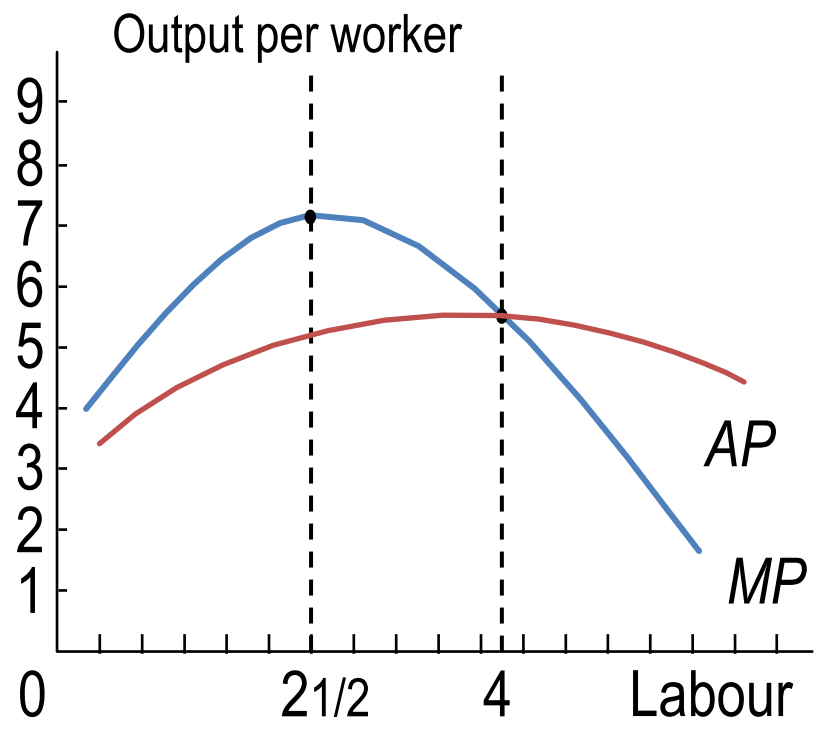


Relationship Between Productivity and Costs

- The shapes of the cost curves are mirror-image reflections of the shapes of the corresponding productivity curves.

Relationship Between Productivity and Costs





Relationship Between Marginal and Average Costs

- The marginal cost and average cost curves are related.
  - When marginal cost exceeds average cost, average cost must be rising.
  - When marginal cost is less than average cost, average cost must be falling.

Relationship Between Marginal and Average Costs

- This relationship explains why marginal cost curves always intersect average cost curves at the minimum of the average cost curve.

Relationship Between Marginal and Average Costs

- To summarize:

If MC > ATC, then ATC is rising.

If MC = ATC, then ATC is at its minimum.

If MC < ATC, then ATC is falling.

Relationship Between Marginal and Average Costs

- Marginal and average total cost reflect a general relationship that also holds for marginal cost and average variable cost.

If MC > AVC, then AVC is rising.

If MC = AVC, then AVC is at its minimum.

If MC < AVC, then AVC is falling.

Relationship Between Marginal and Average Costs

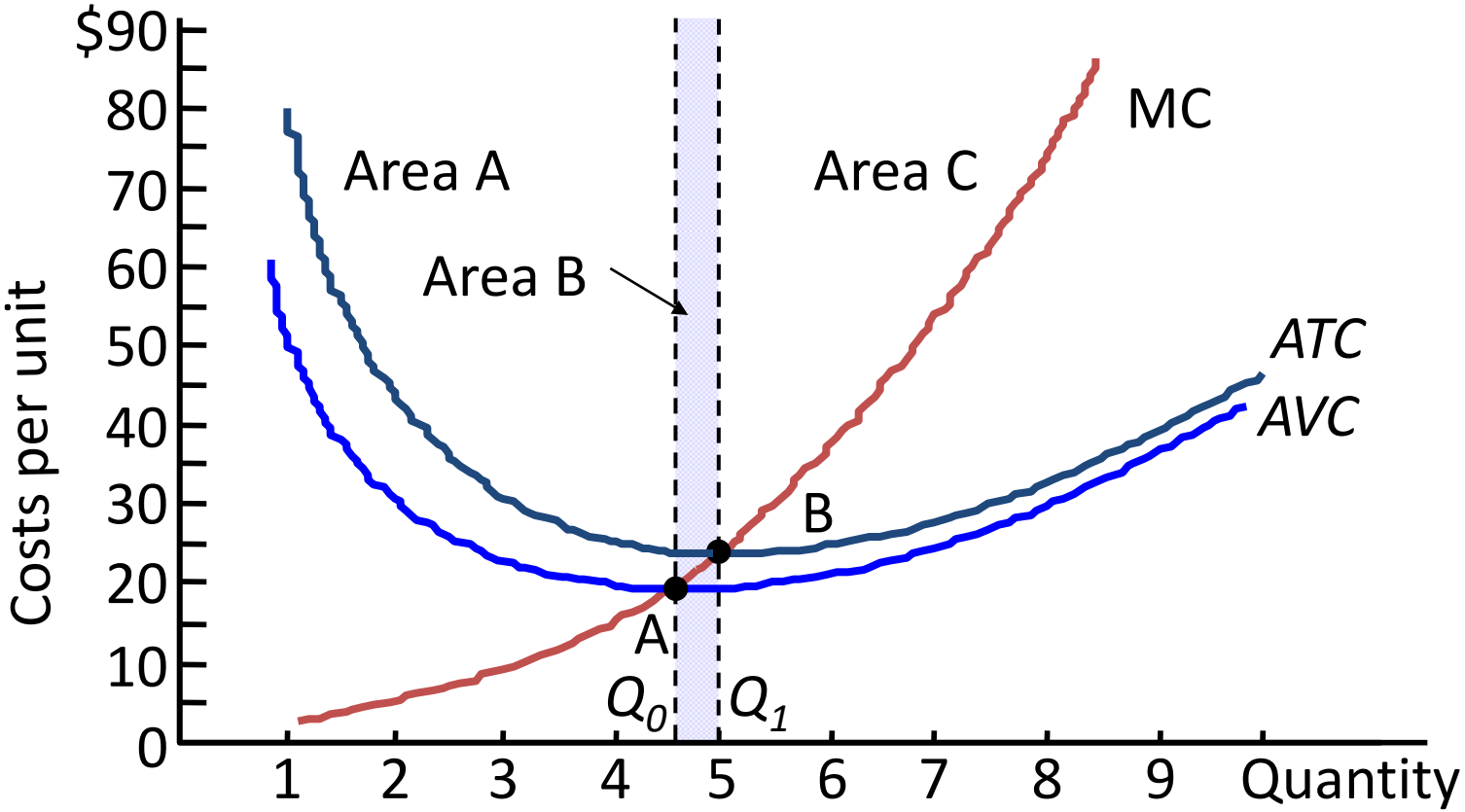


Table 7.1 : A Firm's Short-run Costs (£)							
Rate of Output	Fixed Cost (FC)	Variable Cost (VC)	Total Cost (TC)	Marginal Cost (MC)	Average Fixed Cost (AFC)	Average Variable Cost (AVC)	Average Total Cost (ATC)
0	50	0	50	—	—	—	—
1	"	50	100	50	50	50	100
2	"	78	128	28	25	39	64
3	"	98	148	20	16.7	32.7	49.3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

Cost-output relationship in the long run

- **Short-run** is defined as that period during which the physical capacity of the firm is fixed, and during which output can be increased only by using the existing capacity more intensively.
- **Long-run** is a period during which it is possible to increase the firm's capacity or to reduce it in size.

- **Total, average & marginal cost**

1. **Total cost (TC) = TFC + TVC, rise as output rises**

2. **Average cost (AC) = TC/output**

3. **Marginal cost (MC) = change in TC as a result of changing output by one unit**

- **Fixed cost & variable cost**

1. **Total fixed cost (TFC) = cost of using fixed factors = cost that does not change when output is changed, e.g.**

2. **Total variable cost (TVC) = cost of using variable factors = cost that changes when output is changed,**

Making Long-Run Production Decisions

- To make their long-run decisions, firms look at costs of various inputs and the technologies available for combining these inputs, and then decide which combination offers the lowest cost.
- The firm makes long-run decisions on the basis of the expected costs, and expected usefulness, of inputs.

Technical Efficiency and Economic Efficiency

- ***Technical efficiency*** is a situation in which as few inputs as possible are used to produce a given output.
- Technical efficiency is efficiency that does not consider cost of inputs.

Technical Efficiency and Economic Efficiency

- The ***economically efficient*** method of production is that method that produces a given level of output at the lowest possible cost.

  - It is the least-cost technically efficient process.

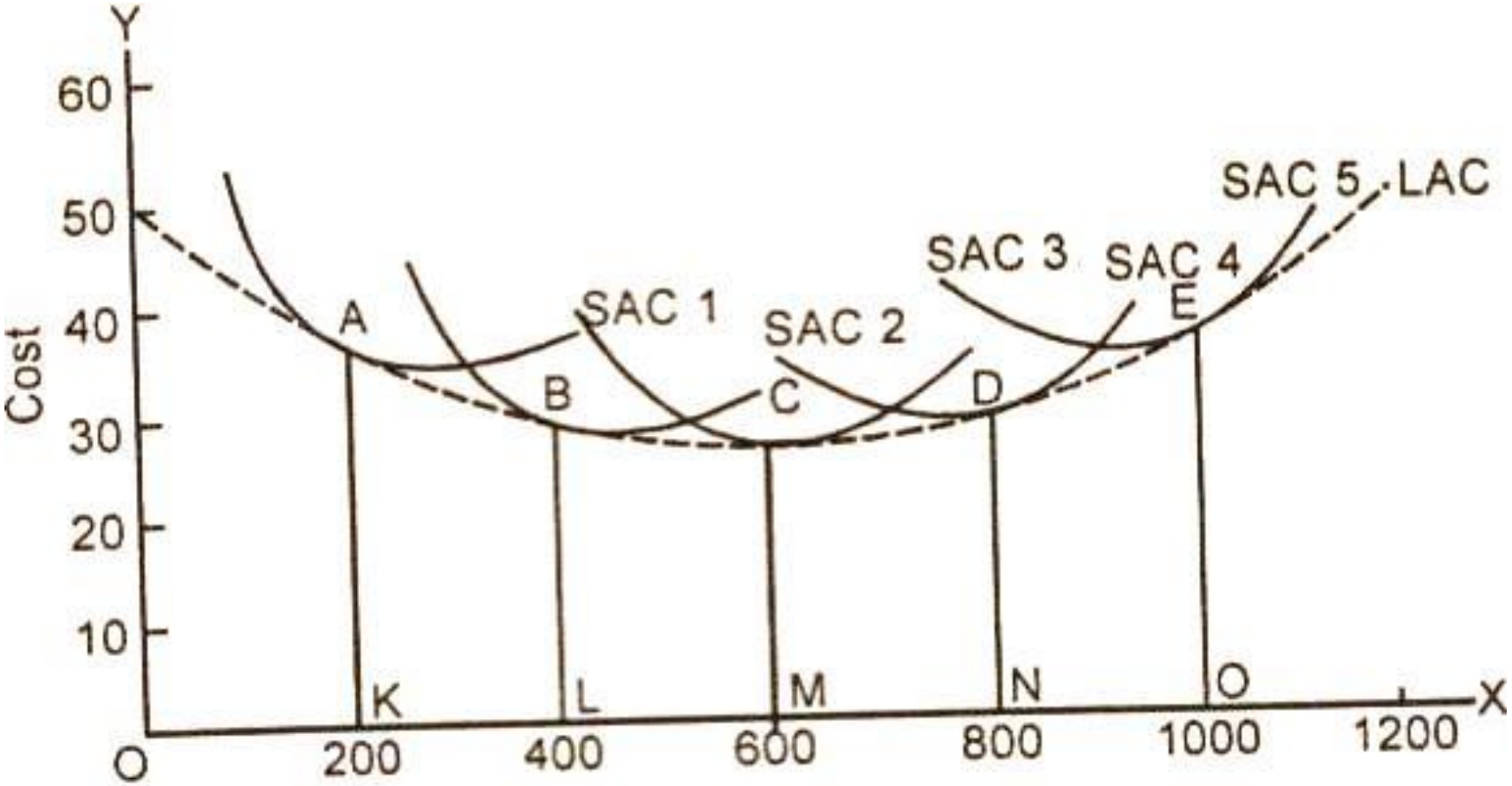

Y
60
50
40
30
20
10
Cost
O
200
400
600
800
1000
1200
X
Output
A
B
C
D
E
K
L
M
N
O
SAC 1
SAC 2
SAC 3
SAC 4
SAC 5
LAC

Fig. 13.7

The Envelope Relationship

- In the long run all inputs are flexible, while in the short run some inputs are not flexible.
- As a result, long-run cost will always be less than or equal to short-run cost.

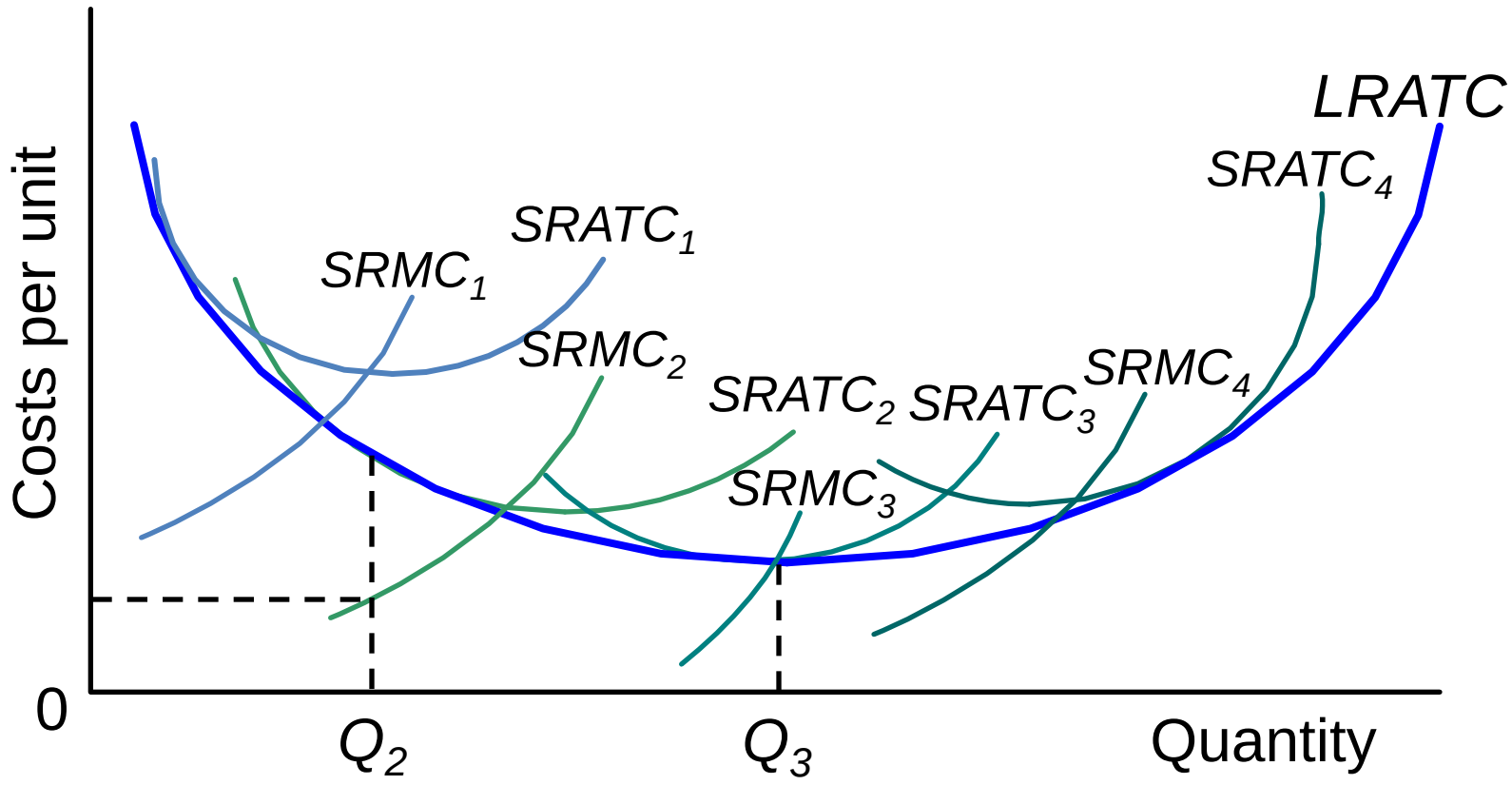
The Envelope Relationship

- In the short run the firm faces an additional constraint: all expansion must proceed using only the variable input.
    - These additional constraints increase cost.

The Envelope Relationship

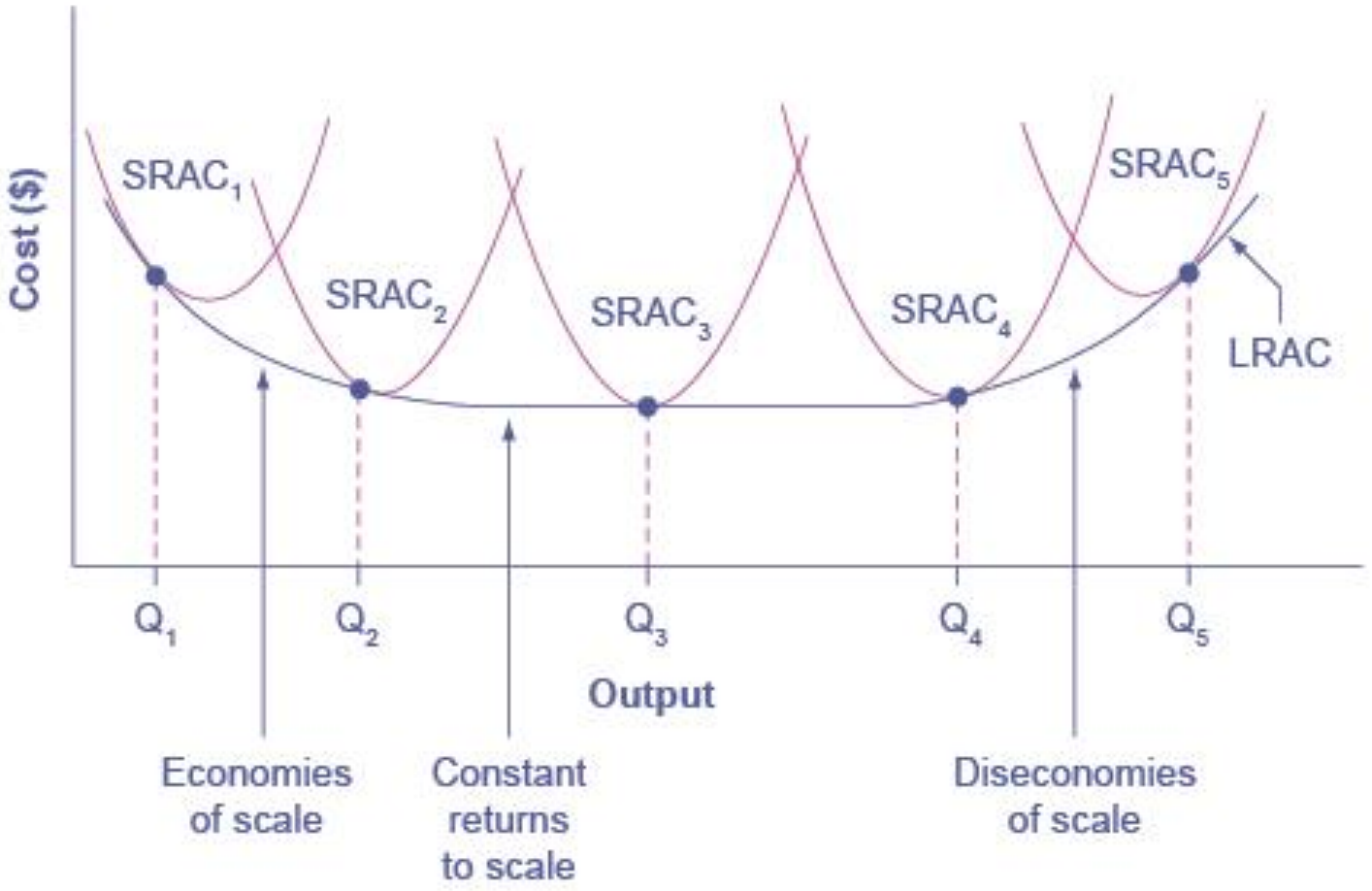
- The ***envelope relationship*** explains that:
  - At the planned output level, short-run average total cost equals long-run average total cost.
  - At all other levels of output, short-run average total cost is higher than long-run average total cost.

Envelope of Short-Run Average Total Cost Curves

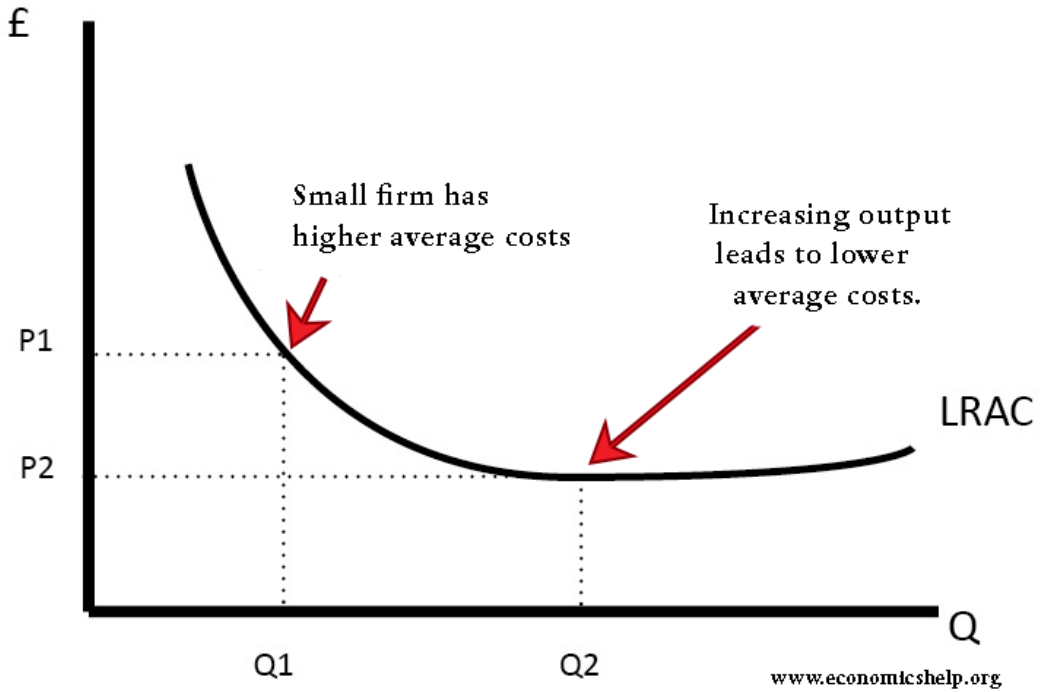


Economies of Scale

- There are ***economies of scale*** in production when the per-unit output cost decreases as output increases when all inputs are changeable.
- In real-world production processes, economies of scale are extremely important at low levels of production.


Cost ($)
SRAC1
SRAC2
SRAC3
SRAC4
SRAC5
LRAC
Q1
Q2
Q3
Q4
Q5
Output
Economies of scale
Constant returns to scale
Diseconomies of scale

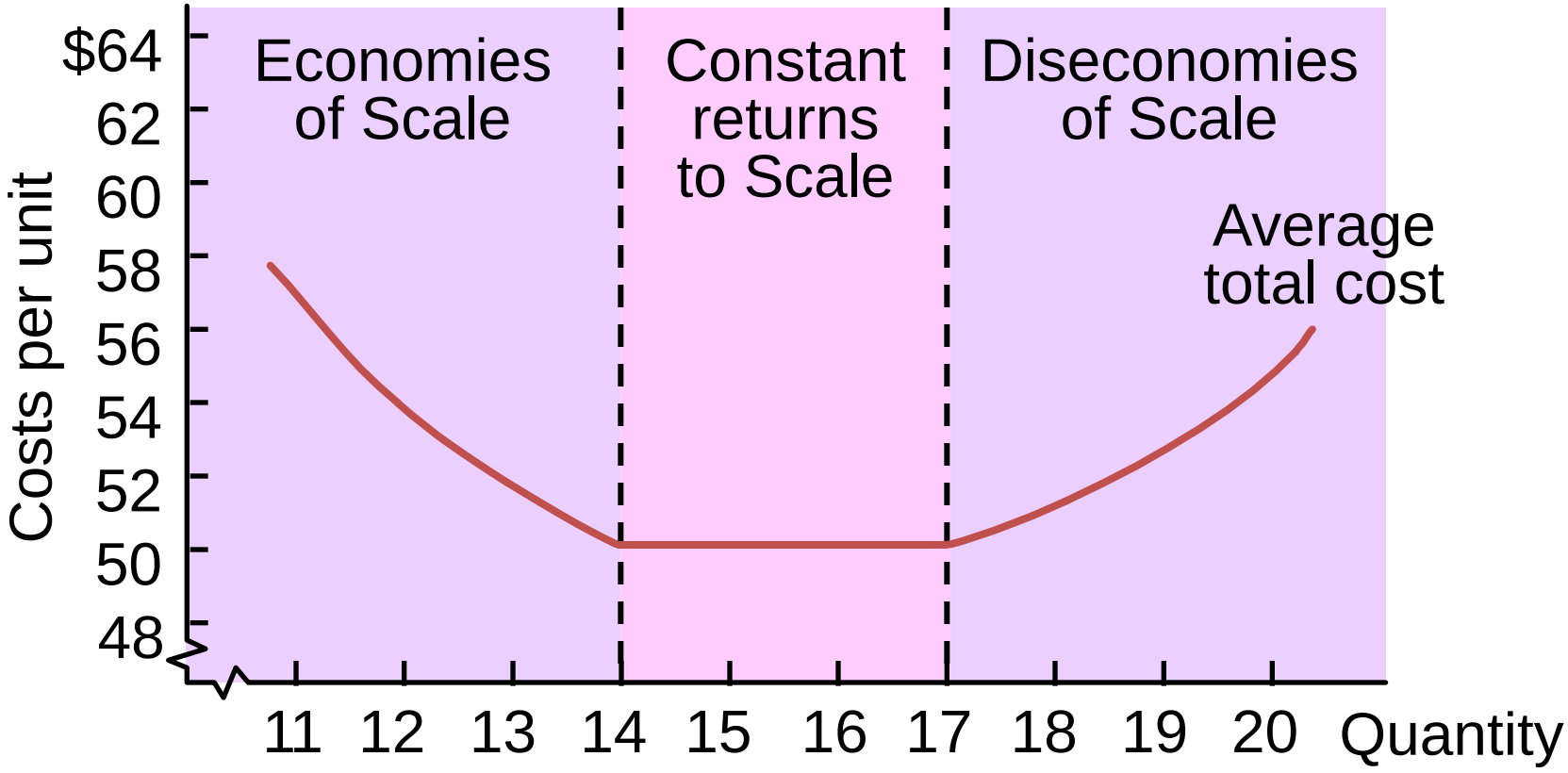
Economies of scale



Constant Returns to Scale

- Constant returns to scale is where long-run average total costs do not change as output increases.
- It is shown by the flat portion of the LRATC curve.

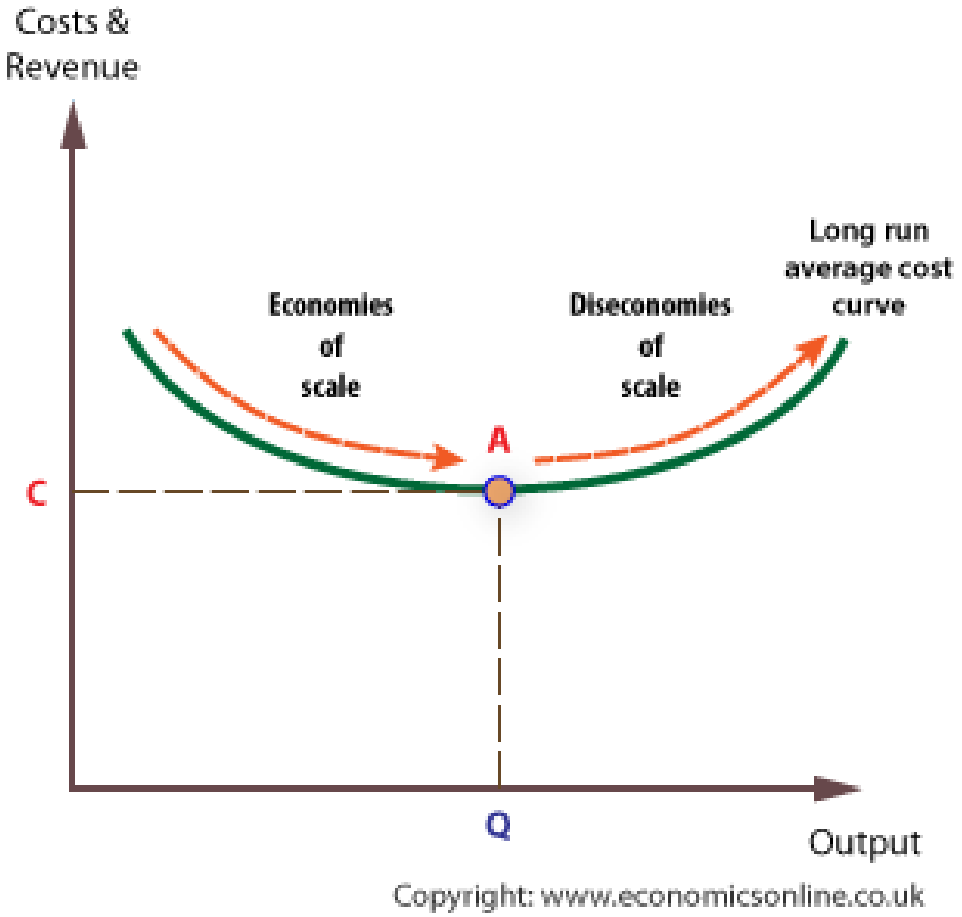
Economies and Diseconomies of Scale



Diseconomies of Scale

- ***Diseconomies of scale*** refer to decreases in productivity which occur when there are equal increases of all inputs (no input is fixed).
  - Diseconomies of scale occur on the right side of the graph of the long-run average cost curve where it is upward sloping, meaning that average cost is increasing.

Dis-economies of scale



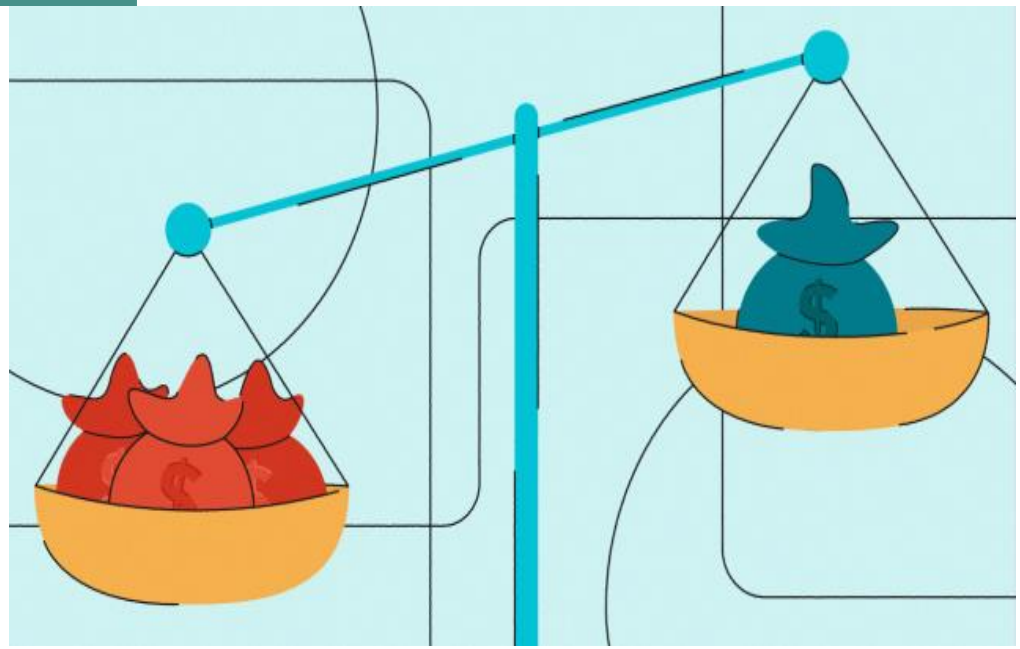
OPPORTUNITY COST

?

choice 1 **choice 2**

Opportunity Cost

Opportunity Cost is the cost of any decision measured in terms of the next-best alternative that has had to be sacrificed or forgone in the making of the decision.



Incremental Cost Example

- Our airline provides a $.50 bag of peanuts and a $.75 can of soda to each passenger
- Additional fuel cost per passenger is $8.75
- What is the Incremental cost of increasing from 125 to 126 passengers?
- Incremental cost =

Cost of 126 psgrs – Cost of 125 psgrs

($10 * 126 + $15,000) - ($10 * 125 + $15,000)

= $10

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Marginal Cost And Incremental Cost

Marginal Cost	Incremental Cost
Marginal cost refers to the cost incurred in producing an additional unit of the output.	Incremental costs are defined as the change in overall costs that result from particular decisions being made
	For e.g. introducing of new marketing and adverting strategic production of a components of the product instead of outstanding, etc. will affect the total cost

Utility schedule

Units consumed	Total Utility (TU)	Marginal Utility (MU)
0	0	–
1	8	8 – 0 = 8
2	14	14 – 8 = 6
3	18	18 – 14 = 4
4	20	20 – 18 = 2
5	20	20 – 20 = 0
6	18	18 – 20 = –2

Equi-Marginalism

- The law of equi-marginal utility states that the consumer will distribute his money income between the goods in such a way that the utility derived from the last rupee spend on each good is equal. In other words, consumer is in equilibrium position when marginal utility of money expenditure on each goods is the same.

Units	Marginal utility of icecream	Marginal utility of chocolate
1	10	8
2	8	6
3	6	4
4	4	2
5	2	0
6	0	−2
7	−2	−4
8	−4	−6

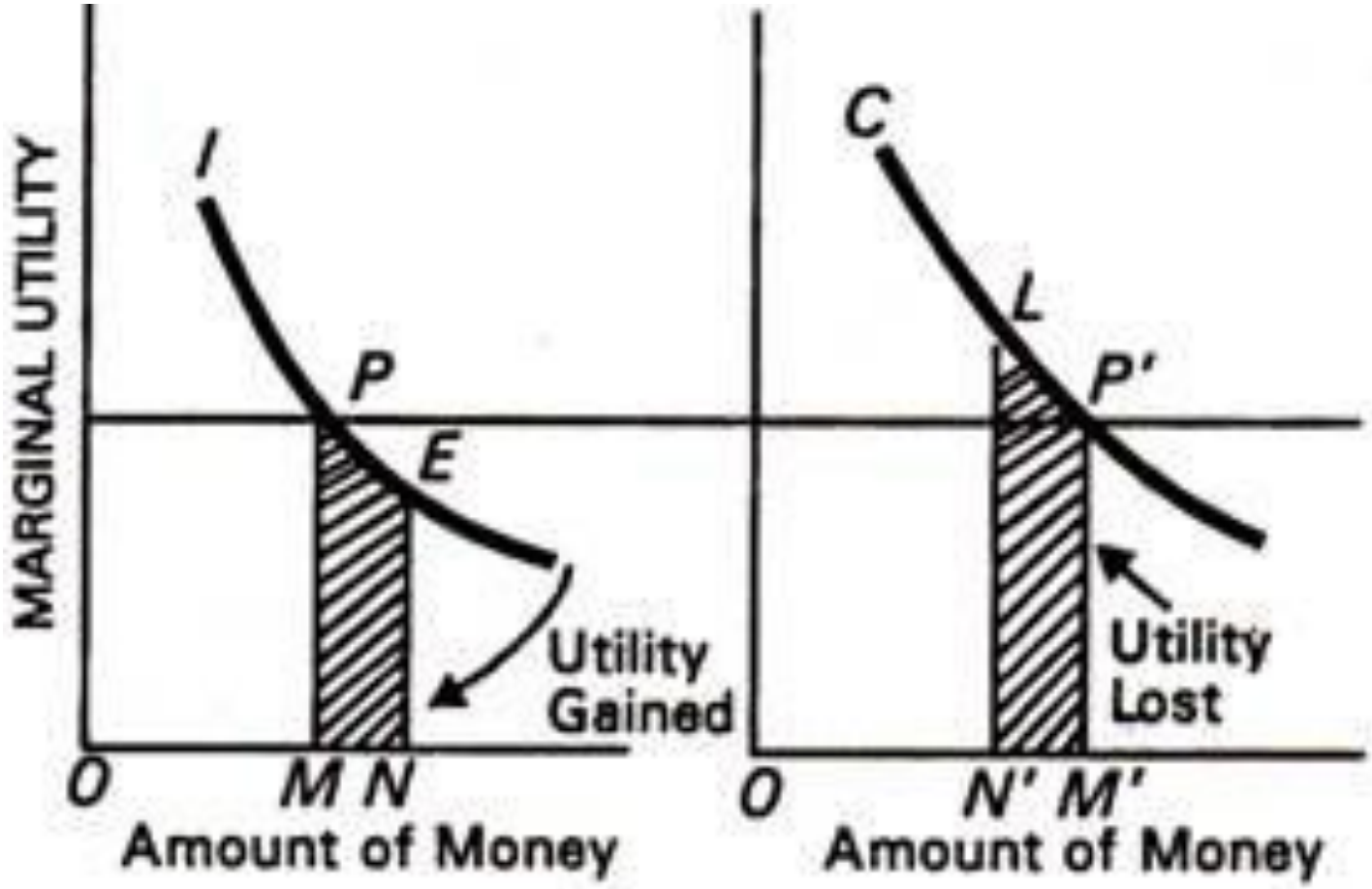
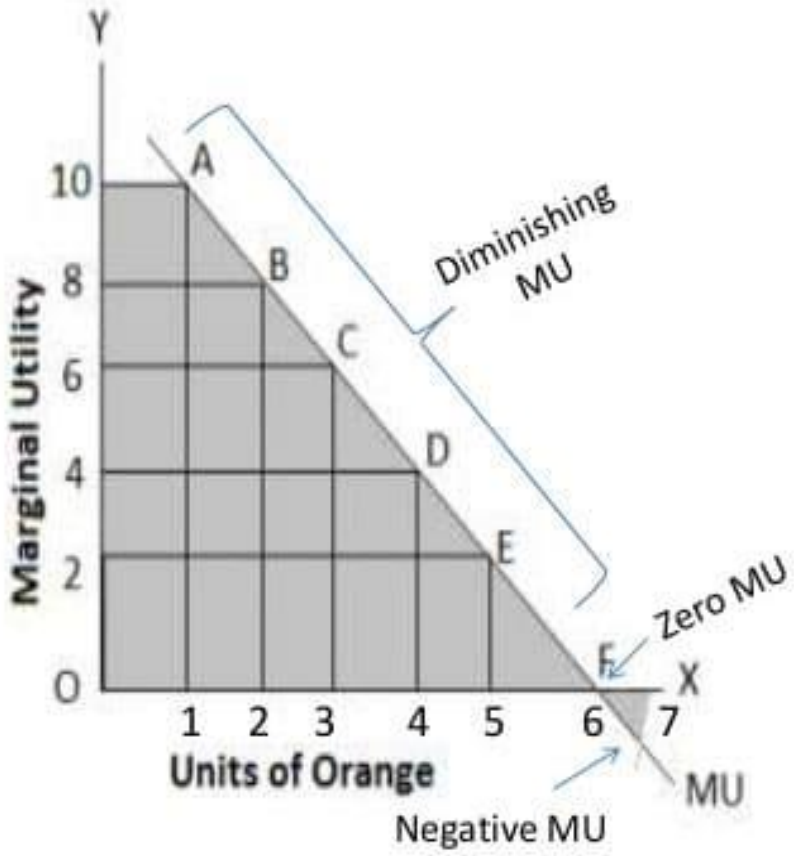


Fig. 4.6. Illustration of the Law of Equi-marginal Utility

Law of Diminishing Marginal Utility

Units	Total Utility	Marginal Utility
1	10	10
2	18	8
3	24	6
4	28	4
5	30	2
6	30	0
7	28	-2

MU curve is downward sloping because of the fact that consumption of successive units gives less satisfaction.



The Law of Equi-Marginal Utility……

- The wants of a consumer remain unchanged.
- He has a fixed income.
- The prices of all goods are given and known to a consumer.
- He is one of the many buyers in the sense that he is powerless to alter the market price.
- He can spend his income in small amounts

Thanks