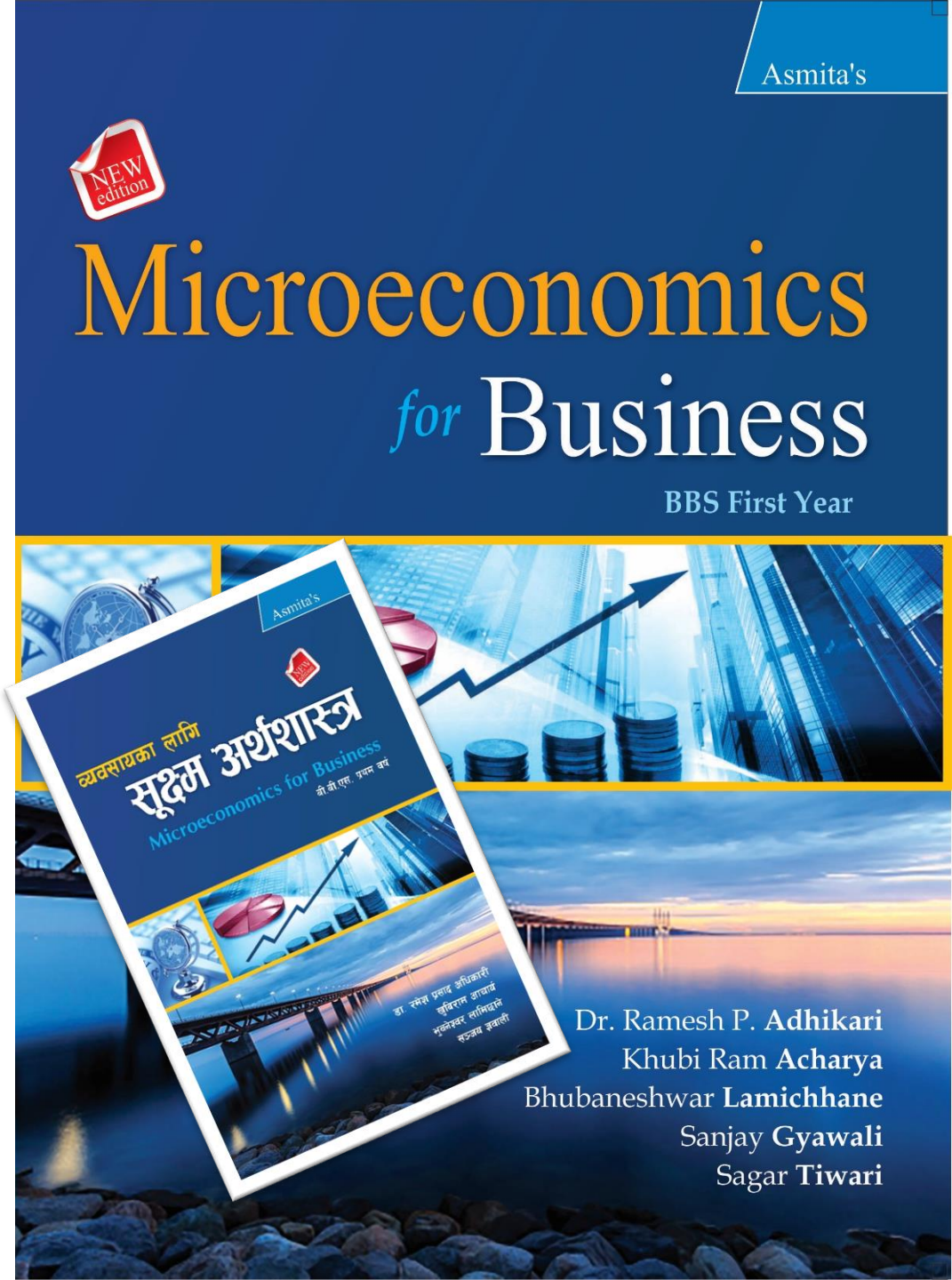
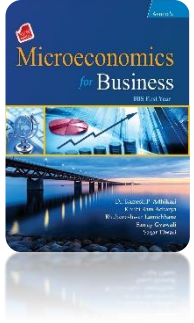
Cost and Revenue Curves

Unit 6



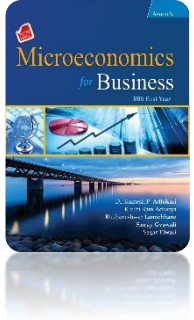


Learning Objectives

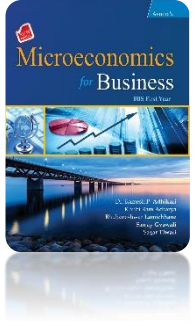
On completion of this unit, students will be able to:

- describe the cost function
- define cost and its various concepts
- derive short run and long run cost curves
- explain the relationship between AC and MC
- describe economies and diseconomies of scale
- describe the economies of scope
- explain the various concepts of revenue
- derive revenue curves under the different market conditions
- explain the relationship between price elasticity of demand, marginal, average and total revenue.

Introduction



- A firm has to play dual role of a producer and a seller.
- As a producer, it attempts to minimise cost of production and as a seller, it attempts to maximize the revenue.
- The ultimate goal of the producer is to maximise the profit.
- It is possible only through maximization of revenue or minimization of cost or both.
- In the modern competitive world, the producer maximizes the profit by the minimization of cost.
- The maximization of profit by the revenue maximization is the traditional approach. In this unit, we study cost and revenue.



Theory of Cost

Cost Function

- Cost function shows the relationship between cost of production and the level of production.
- Cost of production is influenced by various variables like level of output, price of inputs, technology, etc.
- The cost function is expressed as

$$C = f(Q, P_f, T)$$

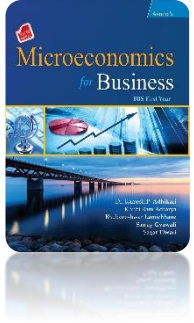
where

C = Cost of production T = Technology

P_f = Price of inputs or factors of production Q = Quantity of output

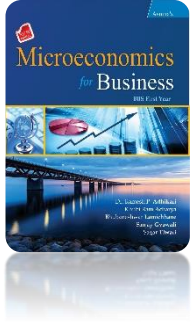
- Although, cost of production is influenced by various factors, for simplicity we assume that cost of production is the function of level of output. It is expressed as

$$C = f(Q)$$



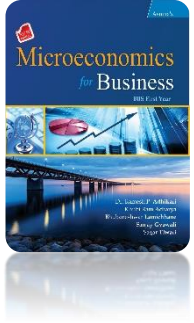
Concept of Cost

- Cost is defined as the money expenditure incurred on factors of production while producing a commodity.
- In order to produce goods and services, a firm uses raw materials and various factors of production, which are called inputs.
- The expenditure incurred on these inputs is called cost.
- In other words, cost refers to all sorts of monetary expenditures incurred in the production of a commodity.



Different Concepts of Cost

1. Implicit and Explicit Cost
   a. **Implicit cost**: Implicit cost is defined as the value of factor inputs owned and used by the firm or the entrepreneur in its own production process.
   b. **Explicit cost**: Explicit cost is defined as the payment made by a firm for the use of inputs purchased or hired from outside or others.
2. Accounting and Economic Cost
   a. **Accounting cost**: Accounting cost is defined as the cost that involves direct payment of money by entrepreneur to the various factors of production.
   b. **Economic cost**: The accountants consider those costs, which involve cash payment by the entrepreneur or the firm to others.



Different Concepts of Cost Contd.

3. Historical and Replacement Cost

a. **Historical cost**: Historical cost is defined as the actual monetary value of inputs like raw materials, machineries, etc. at the time they were purchased or produced rather than their current value.

b. **Replacement Cost**: Replacement cost is defined as the expenditure that would have incurred if that asset was purchased now.

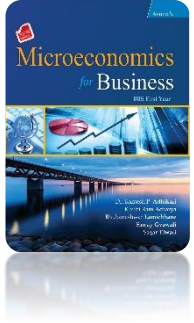
4. Separable and Common Cost

a. **Separable cost**: Separable cost is defined as the cost that can be easily known to a product, a division or a process.

b. **Common cost**: Common cost is defined as the cost that cannot be known to any one unit of operation.

5. Opportunity Cost

Opportunity cost is defined as the loss of income due to opportunity foregone

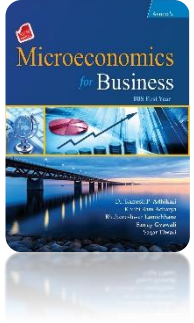


Short Run Costs

- Short run is a period of time in which the firm can vary its output by varying only the amount of variable factors, such as labour and raw materials.
- In the short-run, fixed factors, such as capital, equipment, top management, etc. cannot be changed to change the level of output.
- The Short-run costs are those costs, which are incurred by the firm during a period in which some factors, especially capital equipment, land and management are held constant.
- The short-run costs are incurred on the purchases of labour, raw materials, fuel, etc. which vary with the change in the level of output.

Cost-Output Relationship

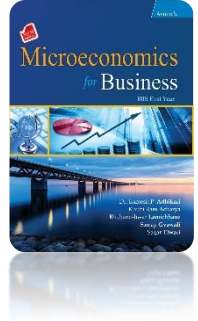
- The cost theory explains with how cost of production changes with



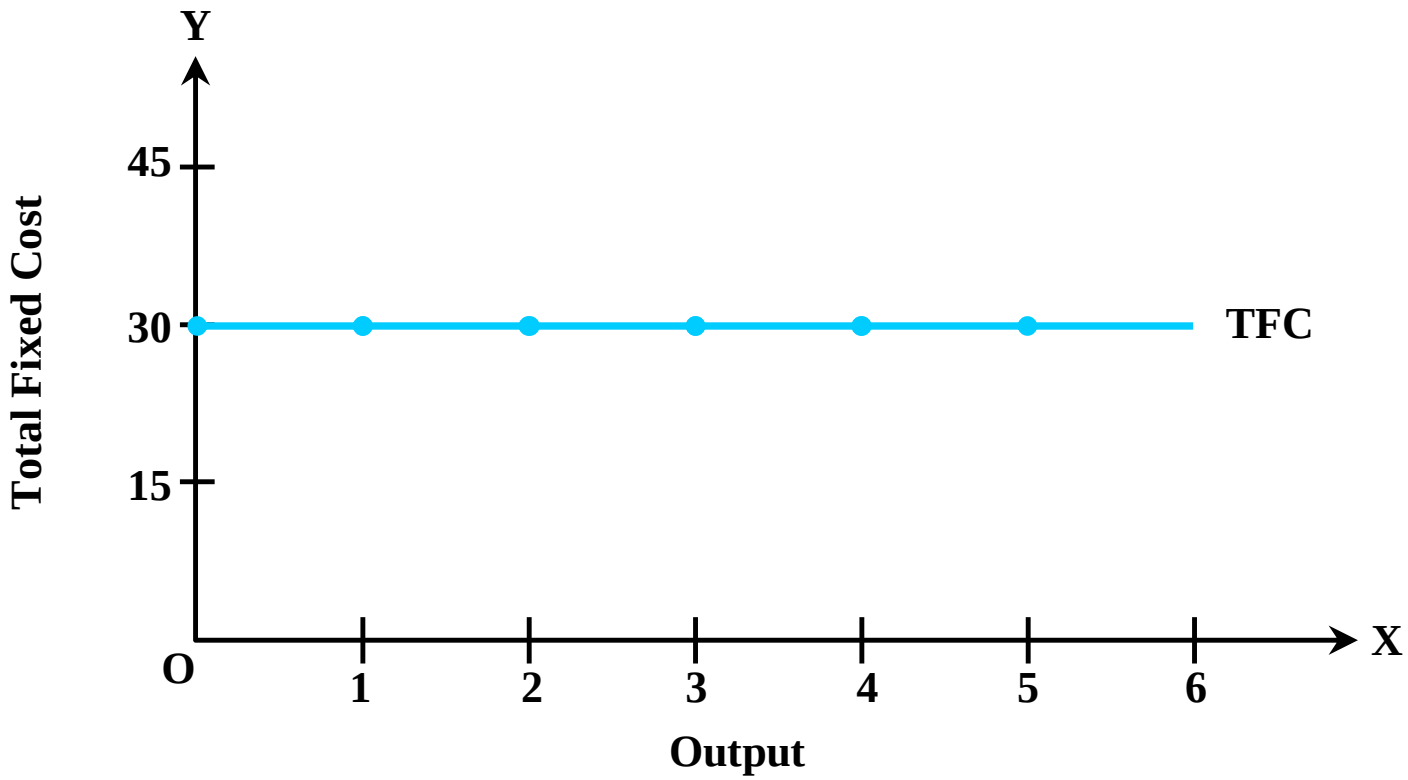
Derivation of Short-Run Total Cost Curves

1. Total Fixed Cost (TFC)

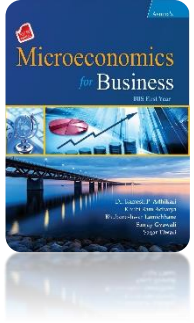
- Total fixed cost is defined as the total expenses incurred by fixed factors of production.
- Fixed factors are those factors, which cannot be changed in short run.
- The fixed cost remains unchanged, whatever be the level of output.
- Even if there is no output at a time, this cost will have to be incurred.
- Fixed cost includes rent of factory, salaries payment of permanent employees, interest on capital, insurance premium, license fee, etc.



Output (in units)	TFC (in Rs.)
0	30
1	30
2	30
3	30
4	30
5	30

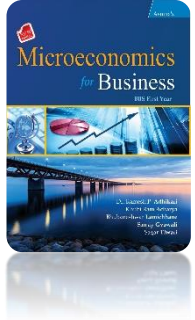

Y
45
30
15
Total Fixed Cost
TFC
O
1
2
3
4
5
6
X
Output

Derivation of Short-Run Total Cost Curves Contd.

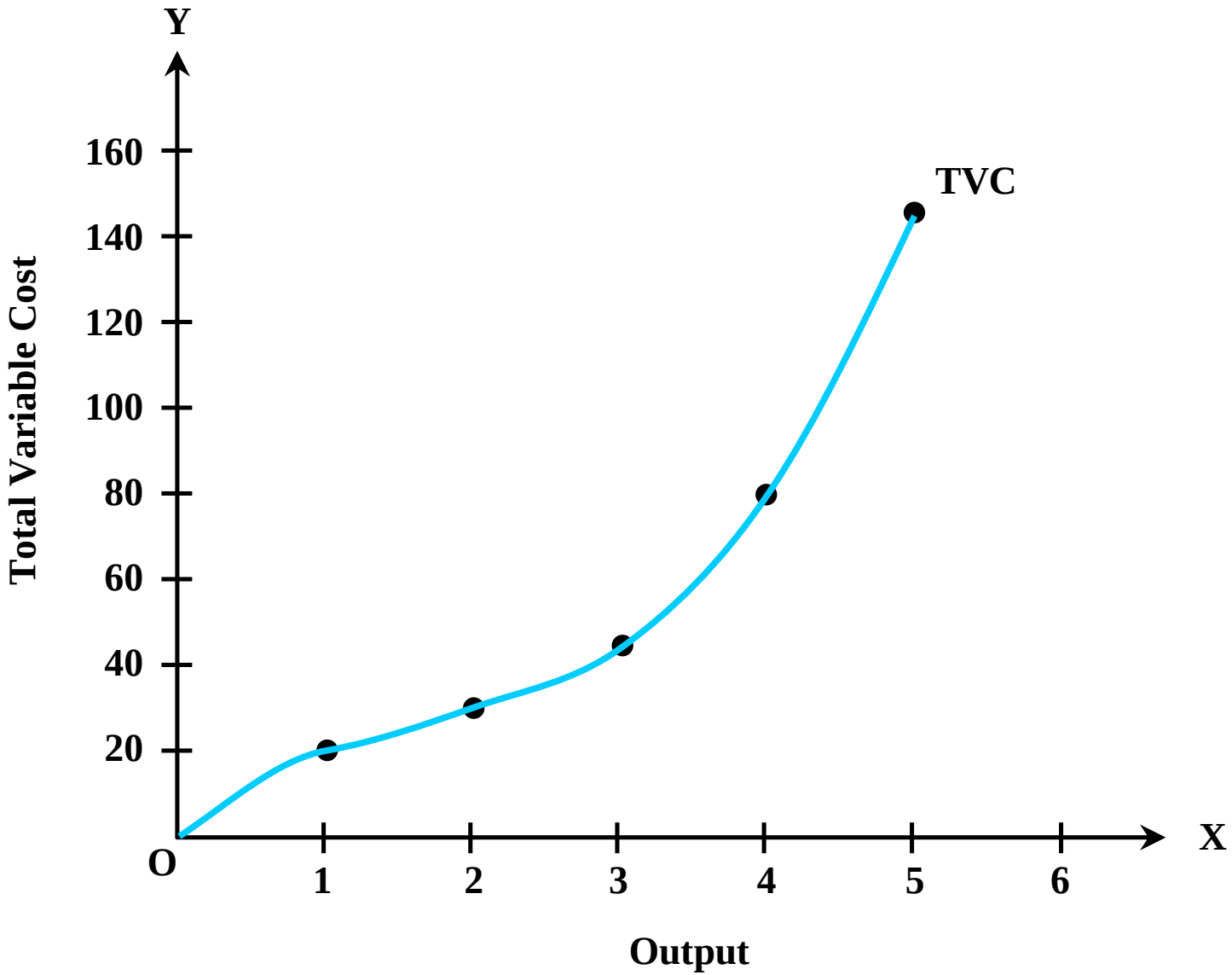


2. Total Variable Cost (TVC)

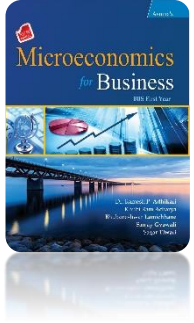
- Total variable cost is defined as the total expenses incurred on variable factors of production.
- Variable factors are the factors, which change with the change in output.
- Thus, variable cost is that cost which changes with the change in output.
- Variable cost includes the cost of raw materials, wages of labour, cost of fuel, etc.
- If the output increases, the total variable cost will increase.
- If the output decreases, the total variable cost will decrease.
- If the output is zero, the total variable cost will also be zero.



Output (in units)	TVC (in Rs.)
0	0
1	20
2	30
3	45
4	80
5	145


Y
160
140
120
100
80
60
40
20
Total Variable Cost
TVC
O
1
2
3
4
5
6
X
Output

Derivation of Short-Run Total Cost Curves Contd.

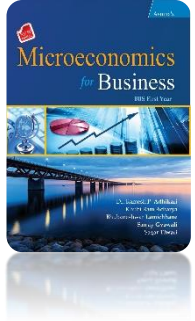


3. Total Cost (TC)

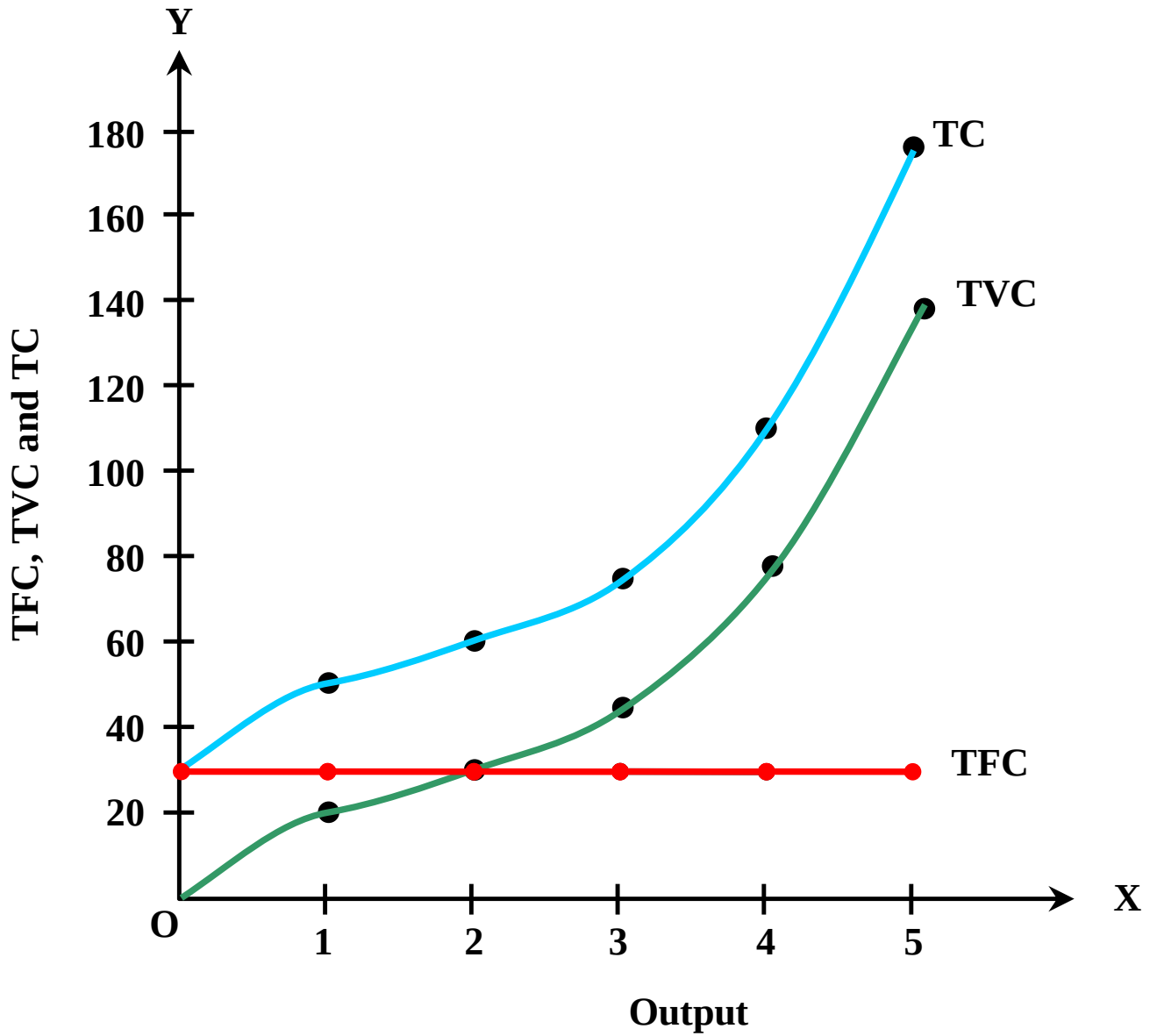
- Total cost is defined as the total monetary expenditures incurred in the production of a commodity.
- In other word, it is the sum of total fixed cost and total variable cost.
- When quantity of output is zero, total cost will be equal to total fixed cost because total variable cost will be zero.

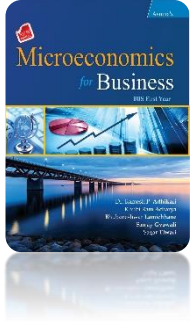
$$TC = TFC + TVC$$

- Initially, total cost increases at a decreasing rate and then increase at an increasing rate.
- Like variable cost total cost also changes with the change in output.



Output (in units)	TFC (in Rs.)	TVC (in Rs.)	TC
0	30	0	30
1	30	20	50
2	30	30	60
3	30	45	75
4	30	80	110
5	30	145	175


Y
180
160
140
120
100
80
60
40
20
TFC, TVC and TC
TC
TVC
TFC
O
1
2
3
4
5
X
Output



Derivation of Short-Run Average Cost Curves

1. Average Fixed Cost (AFC)

The average fixed cost is defined as the total fixed cost divided by the total quantity of output produced.

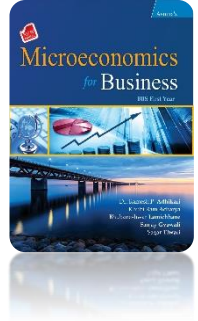
$$AFC = \frac{TFC}{Q}$$

where

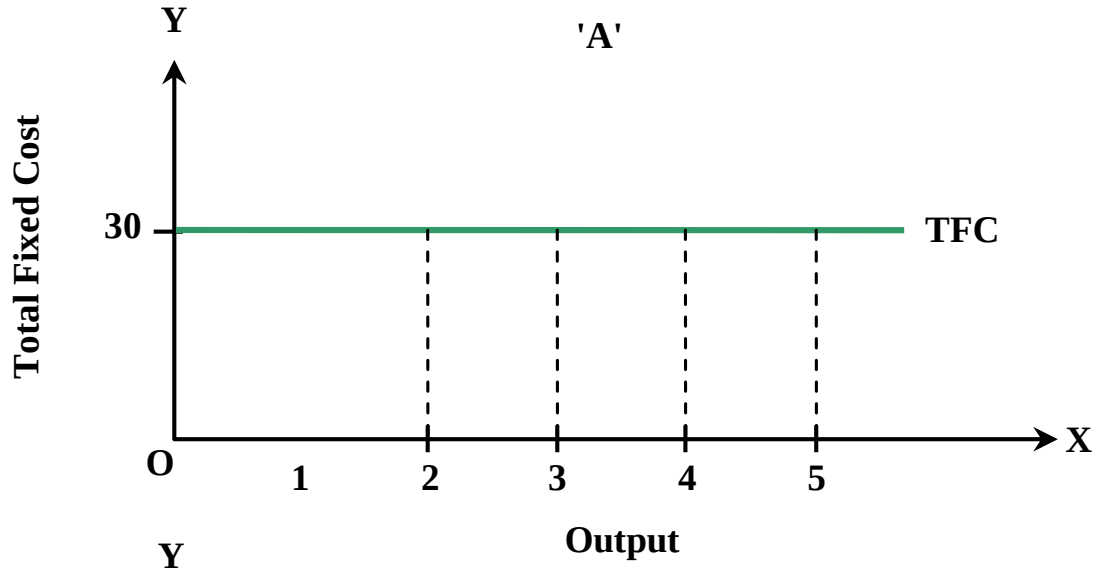
AFC = Average fixed cost

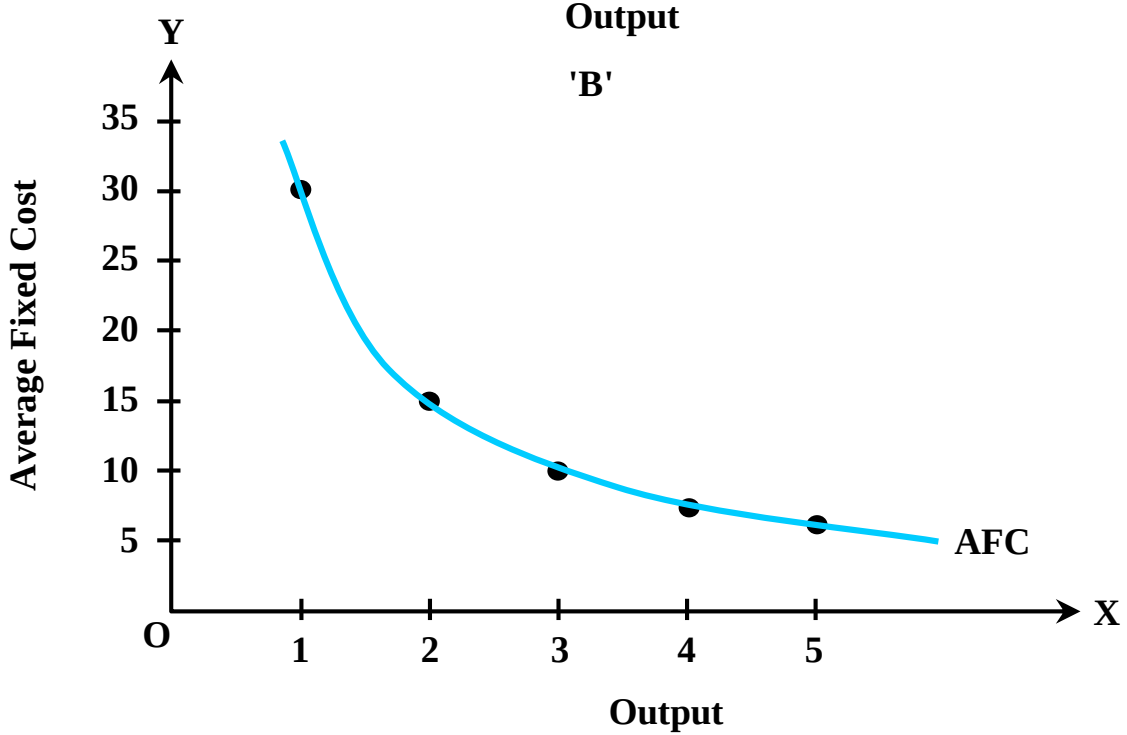
TFC = Total fixed cost

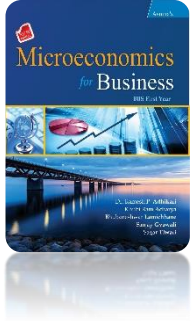
Q = Total quantity of output produced



Output	Total Fixed Cost	Average Fixed Cost
0	30	-
1	30	30
2	30	15
3	30	10
4	30	7.5
5	30	6


Y
'A'
Total Fixed Cost
30
TFC
O
1
2
3
4
5
X
Output


Y
'B'
Average Fixed Cost
35
30
25
20
15
10
5
O
1
2
3
4
5
X
AFC
Output



Derivation of Short-Run Average Cost Curves Contd.

2. Average Variable Cost (AVC)

Average variable cost is defined as the total variable cost divided by total quantity of output produced.

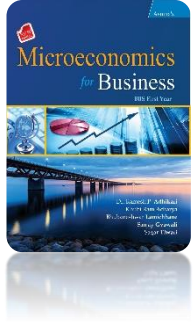
$$AVC = \frac{TVC}{Q}$$

where

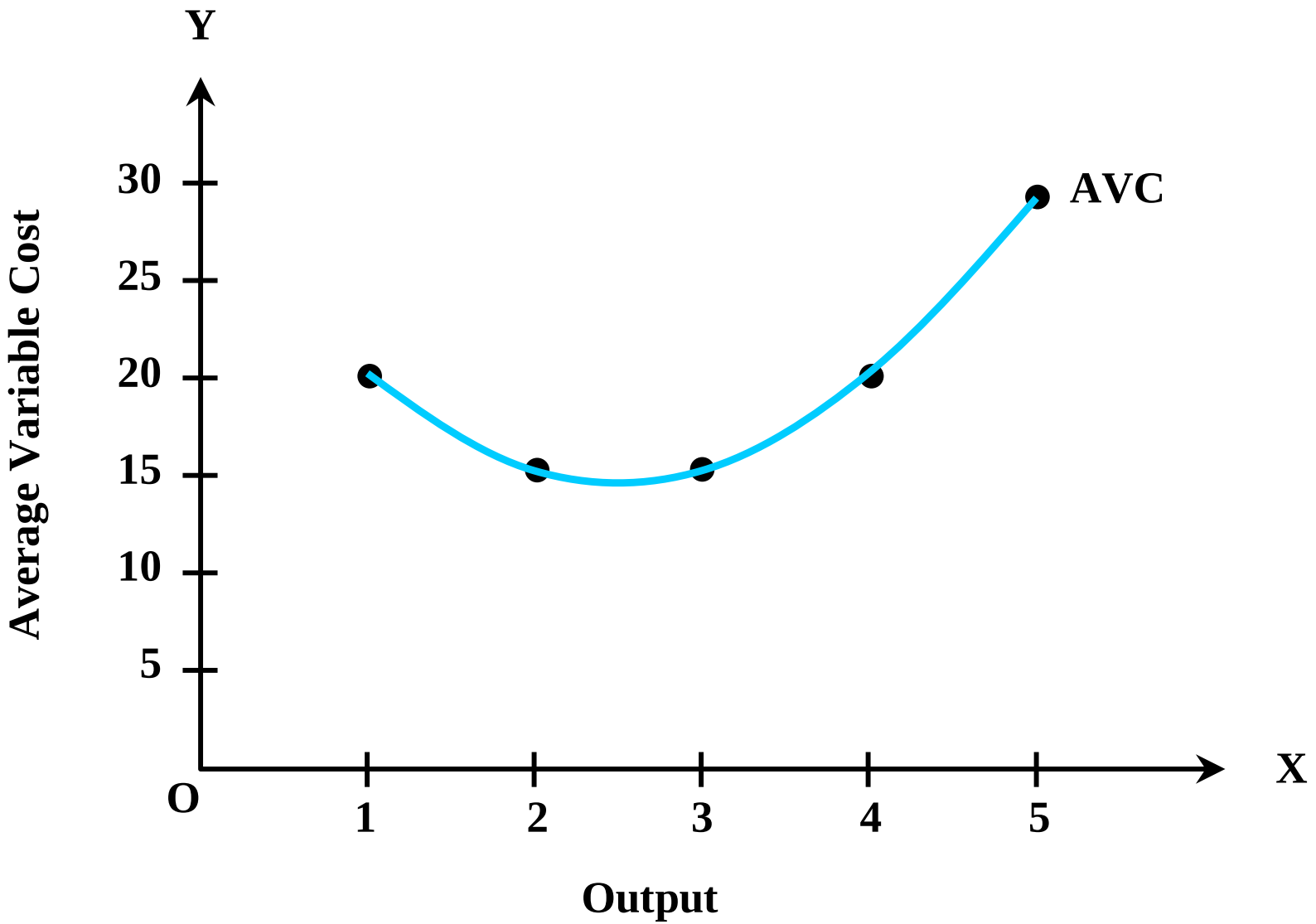
AVC = Average variable cost

TVC = Total variable cost

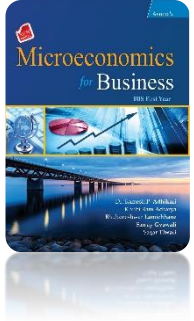
Q = Total quantity of output produced



Output	Total Variable Cost	Average Variable Cost
0	0	0
1	20	20
2	30	15
3	45	15
4	80	20
5	145	29


Y
Average Variable Cost
30
25
20
15
10
5
O
1
2
3
4
5
X
AVC
Output

Derivation of Short-Run Average Cost Curves Contd.



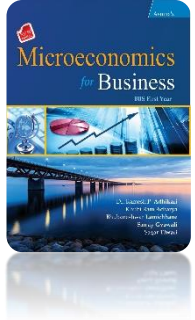
3. Average Total Cost/ Average Cost (ATC/ AC)

- Average total cost is defined as the total cost divided by total quantity of output.
- In other words, it is the sum of AFC and AVC.

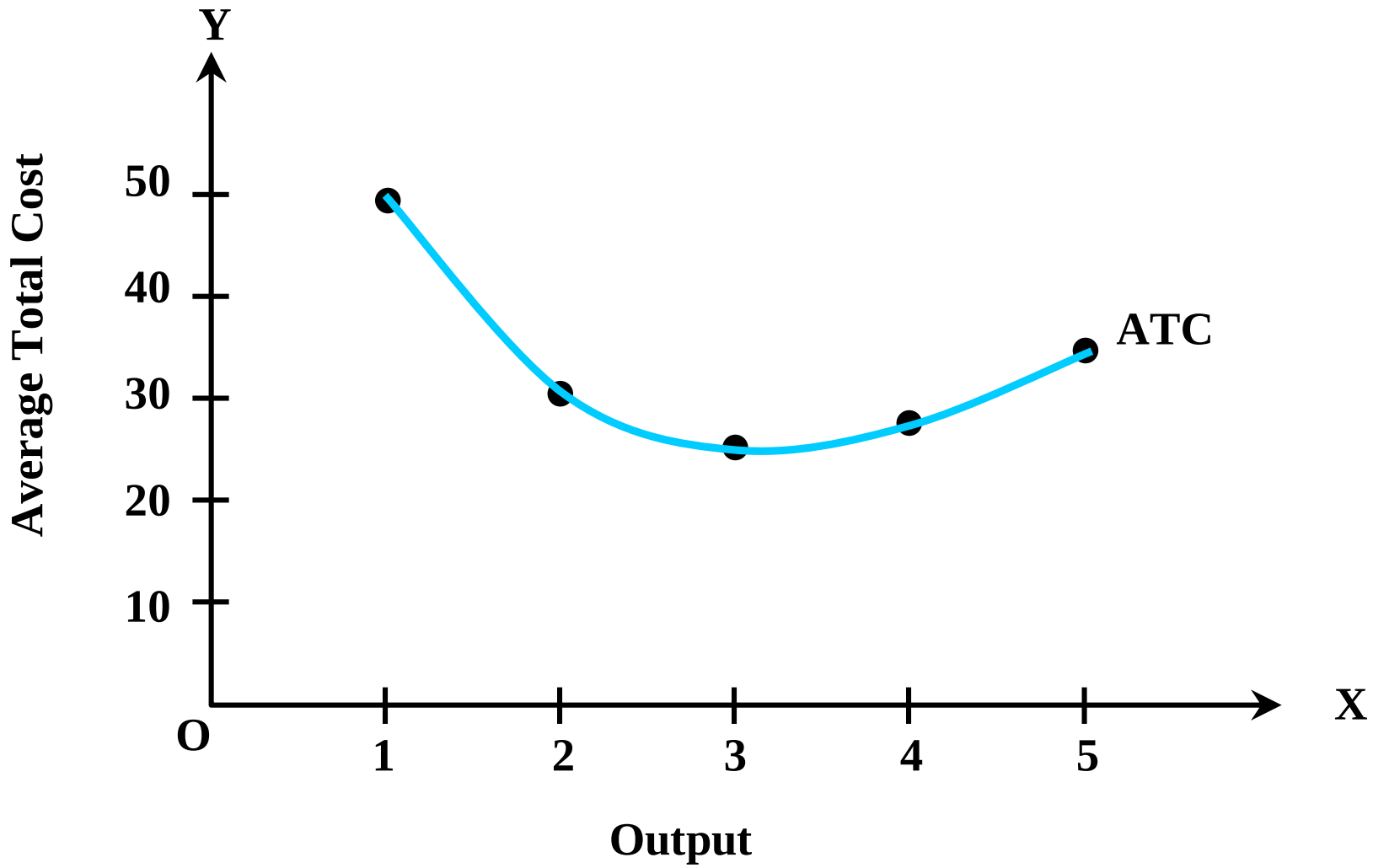
$$ATC = \frac{TC}{Q} = \frac{TFC + TVC}{Q} = \frac{TFC}{Q} + \frac{TVC}{Q} = AFC + AVC$$

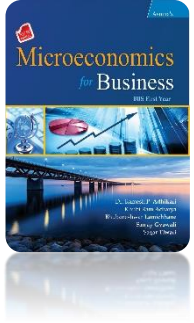
where

ATC = Average total cost
TFC = Total fixed cost
AFC = Average fixed cost
Q = Output
TVC = Total variable cost
AVC = Average variable cost



Output	Total Cost	Average Cost
0	30	-
1	50	50
2	60	30
3	75	25
4	110	27.5
5	175	35


Y
Average Total Cost
50
40
30
20
10
O
1
2
3
4
5
X
ATC
Output



Derivation of Short-Run Marginal Cost (MC)

- Marginal cost is defined as the change in total cost due to one unit change in output.
- In other words, marginal cost is the ratio of change in total cost to the change in total output.
- Symbolically, it can be expressed as follows:

$$MC = \frac{\Delta TC}{\Delta Q}$$

or, $MC = TC_n - TC_{n-1}$

where

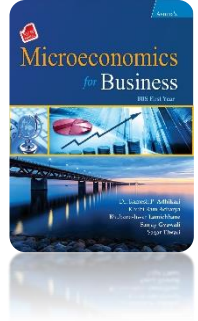
MC = Short run marginal cost

ΔTC = Change in total cost

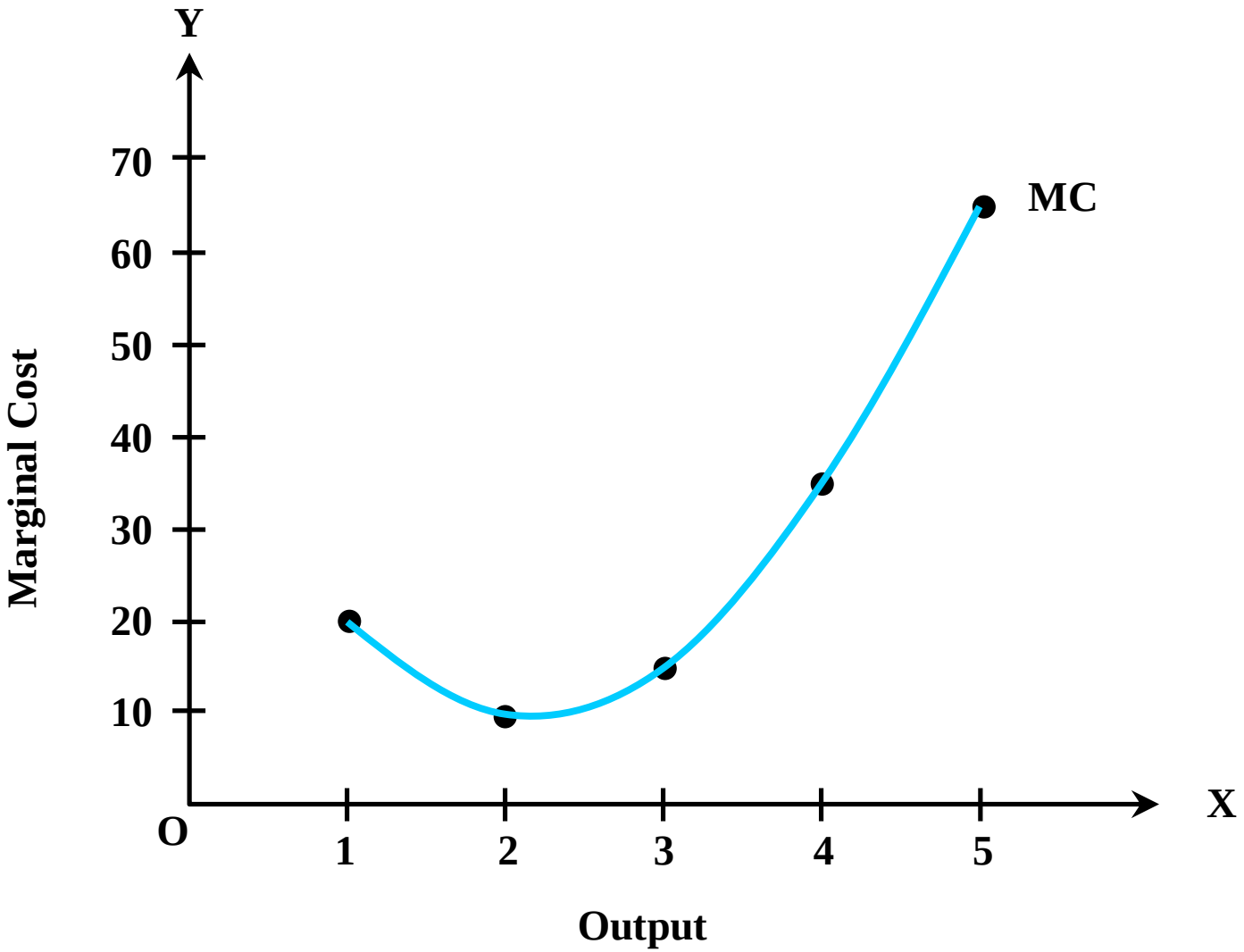
TC_n = Total cost of n^{th} unit

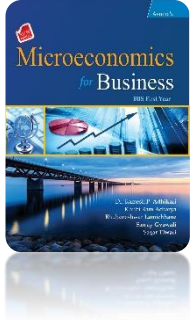
ΔQ = Change in quantity of output produced

TC_{n-1} = Total cost of $(n - 1)^{th}$ unit



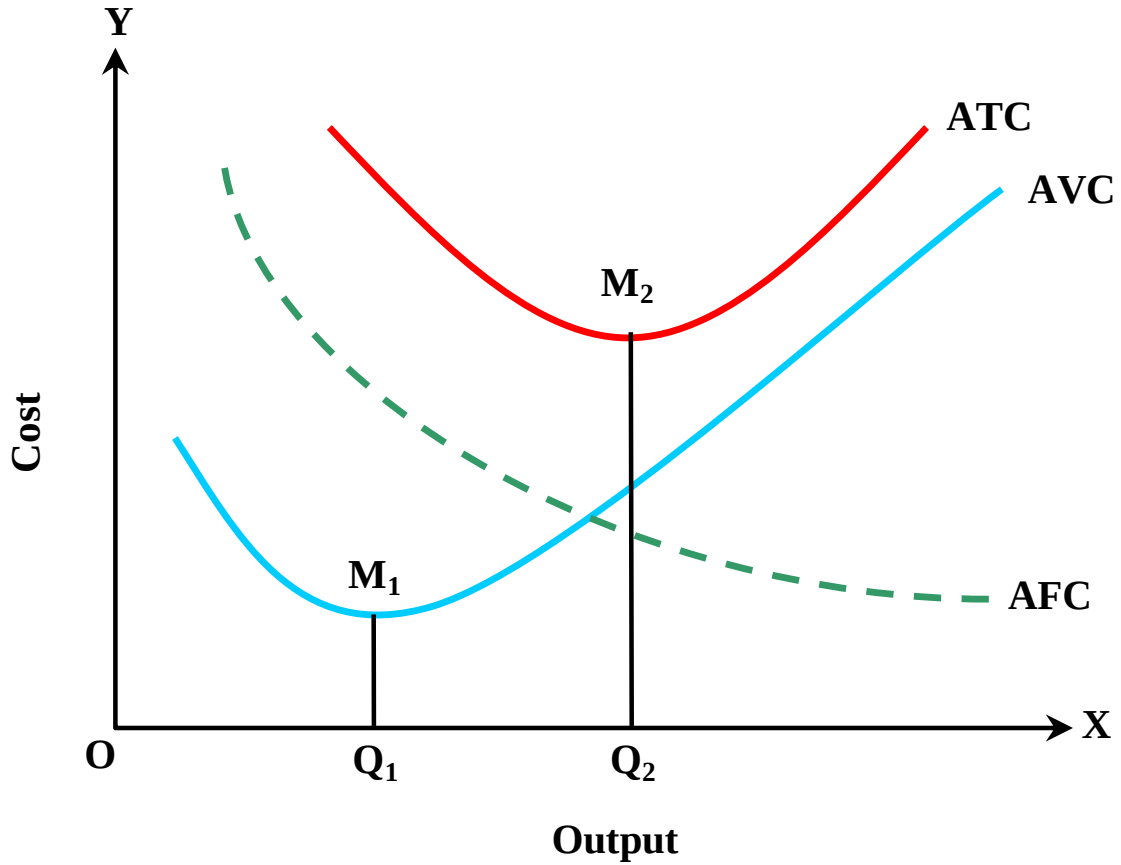
Output	Total Cost	Marginal Cost
0	30	-
1	50	20
2	60	10
3	75	15
4	110	35
5	175	65


Y
70
60
50
40
30
20
10
O
1
2
3
4
5
X
MC
Marginal Cost
Output

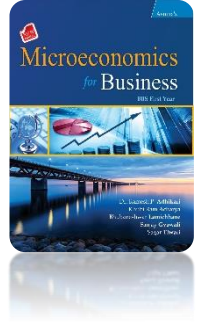


Why ATC Curve is 'U' shaped?

- Average total cost curve (ATC) is ‘U’ shaped.
- It means that in the beginning, it falls and after reaching the minimum point, it starts to rise upward.
- It gets U shaped due to the following reasons:
  - 1. Basis of AFC and AVC
  - 2. Basics of the law of variable proportions
  - 3. Indivisibility of the factors



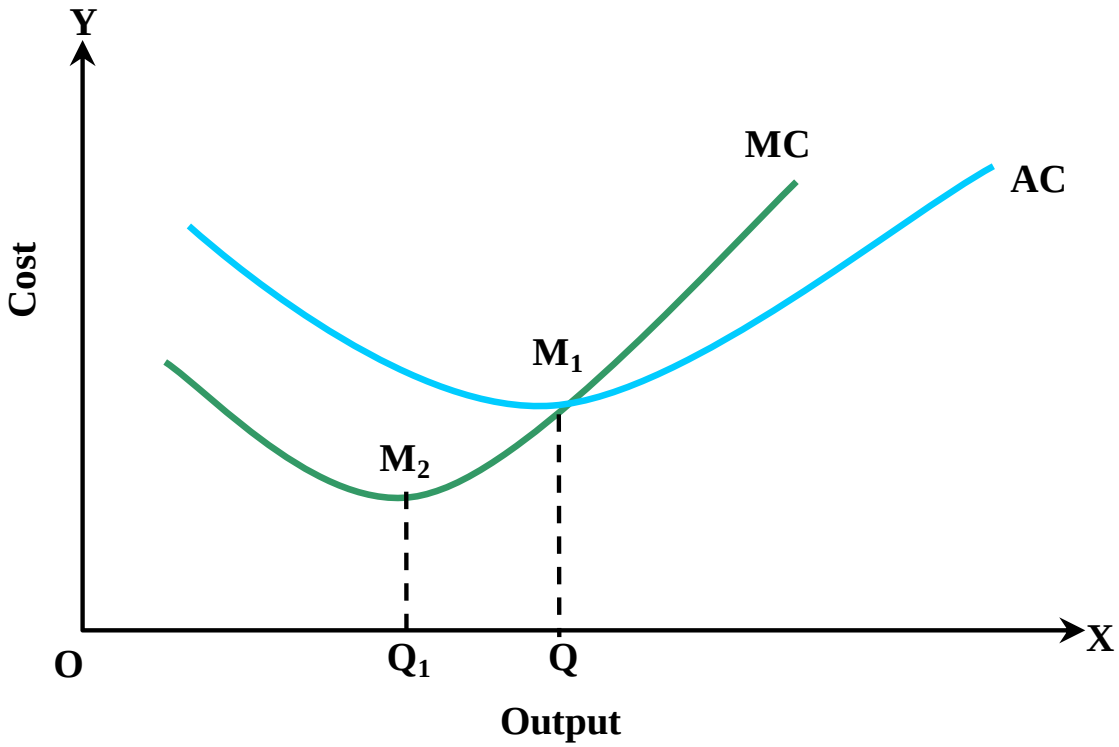
Relationship between AC and MC in the Short-Run



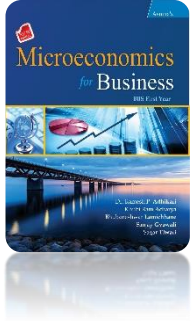
- There is close relationship between AC and MC.
- MC is the change in TC resulted from the change in production of one unit of output where as AC is total cost divided by the output.
- It means that both AC and MC are derived from TC. Thus,

$$MC = \frac{\Delta TC}{\Delta Q}, \qquad AC = \frac{TC}{Q}$$

- In general, both AC and MC are U-shaped and MC = AC when AC is minimum.



Relationship between AC and MC in the Short-Run Contd.



The relationship between AC and MC can be summarized as below:

i. Both AC and MC are calculated from total cost.

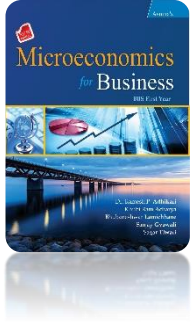
ii. Both AC and MC are U shaped.

iii. When AC is falling, the MC curve is always below the AC curve and the MC falls faster than AC.

iv. When the AC is rising, the MC curve lies above the AC curve and the MC rises faster than the AC.

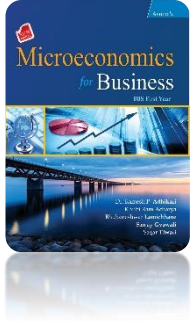
v. When the AC is minimum, the MC equals to AC.

vi. MC intersects at the minimum point of AC.



Long Run Cost

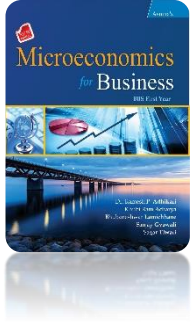
- Long-run is a period of time during which the quantities of all factors of production are variable.
- Thus, in the long-run, output can be increased by increasing capital equipment or by increasing the size of existing plant or by building a new plant.
- The long-run costs are the costs incurred during a period, which is sufficiently large to allow the variation in all factors of production including capital equipment, land and managerial staff to produce a level of output.



Derivation of Long-Run Cost Curves

Long-Run Cost of the Traditional Theory

- In the long- run, all factors of production are assumed to be variable.
- There are no any fixed factors in the long-run.
- Long-run cost curve is a planning curve in the sense that it is a guide to the entrepreneur in his decision to plan the future expansion of his output.



Long-Run Average Cost Curve (LAC)

- Long-run average cost is obtained by dividing the long-run total cost by the level of output.
- A long-run cost curve depicts the functional relationship between output and the long-run cost of production.

$$LAC = \frac{LTC}{Q}$$

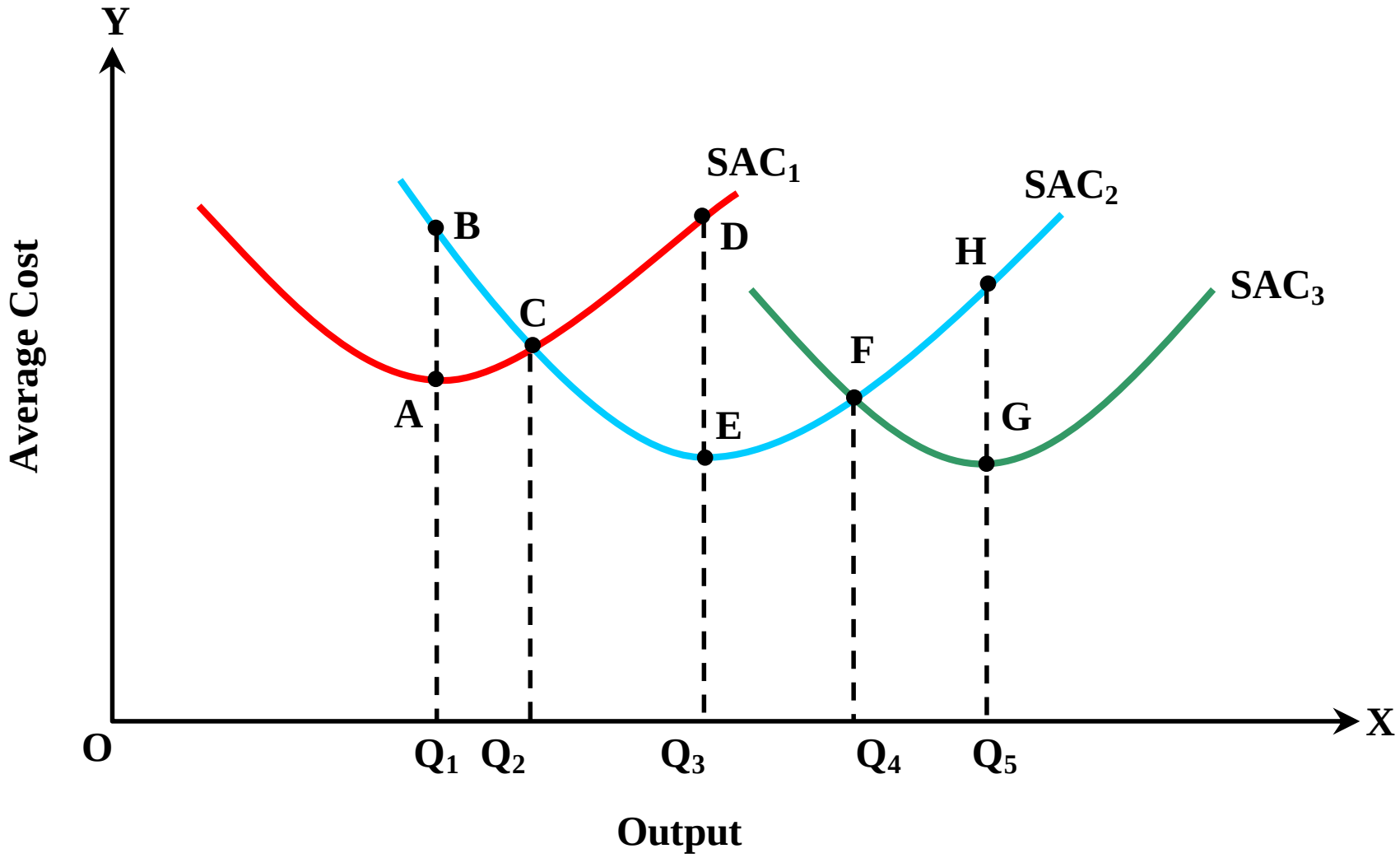
where

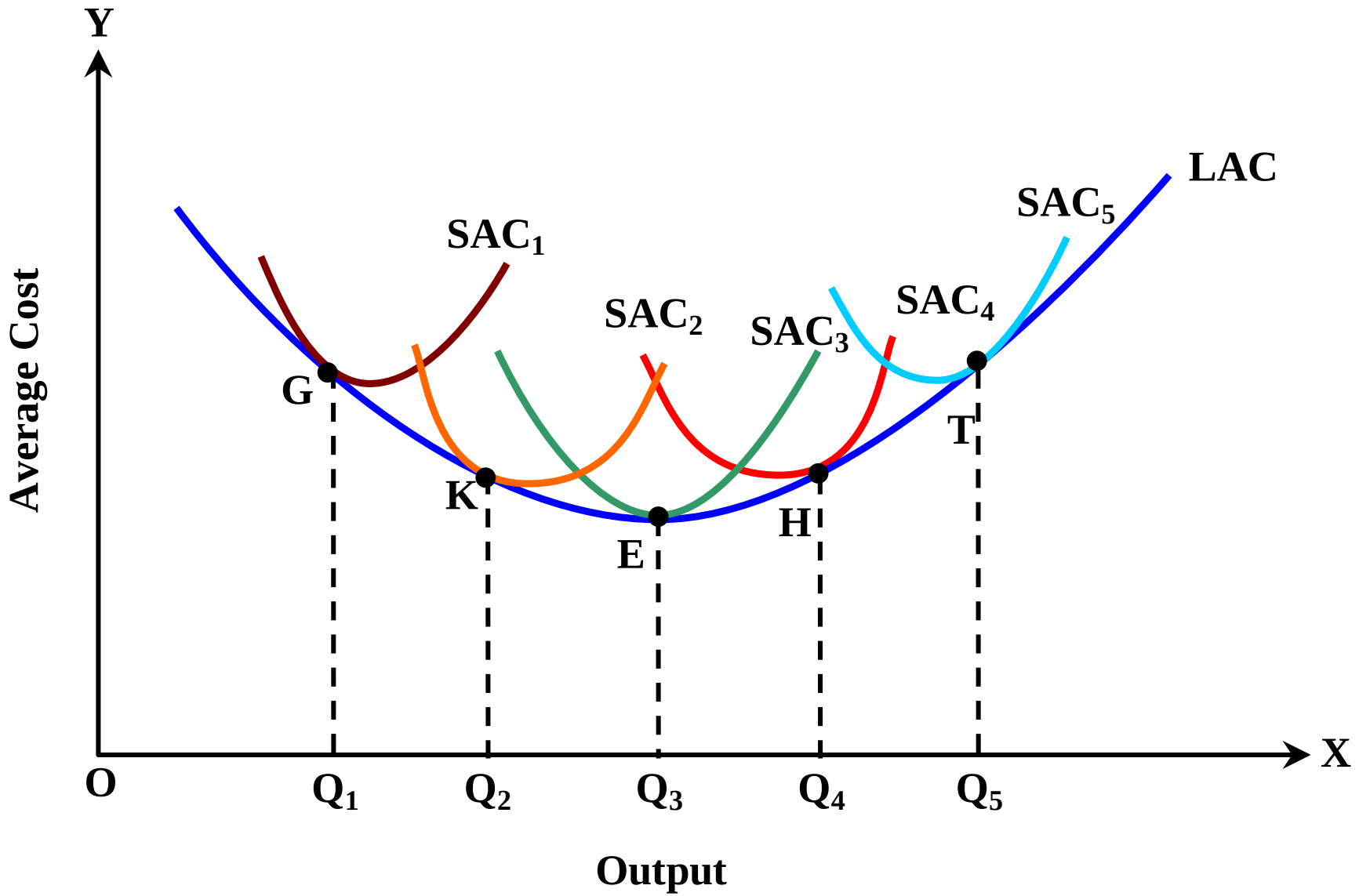
Q = Output

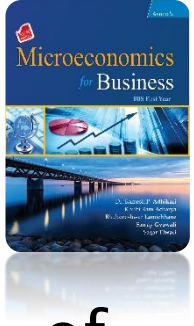
LAC = Long-run average cost

LTC = Long-run total cost

- Long-run average cost curve is obtained from the short-run average cost curves (SACs).


Y
Average Cost
SAC1
SAC2
SAC3
B
D
H
C
F
A
E
G
O
Q1
Q2
Q3
Q4
Q5
X
Output

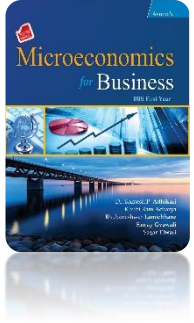

Y
Average Cost
LAC
SAC1
SAC2
SAC3
SAC4
SAC5
G
K
E
H
T
O
Q1
Q2
Q3
Q4
Q5
X
Output



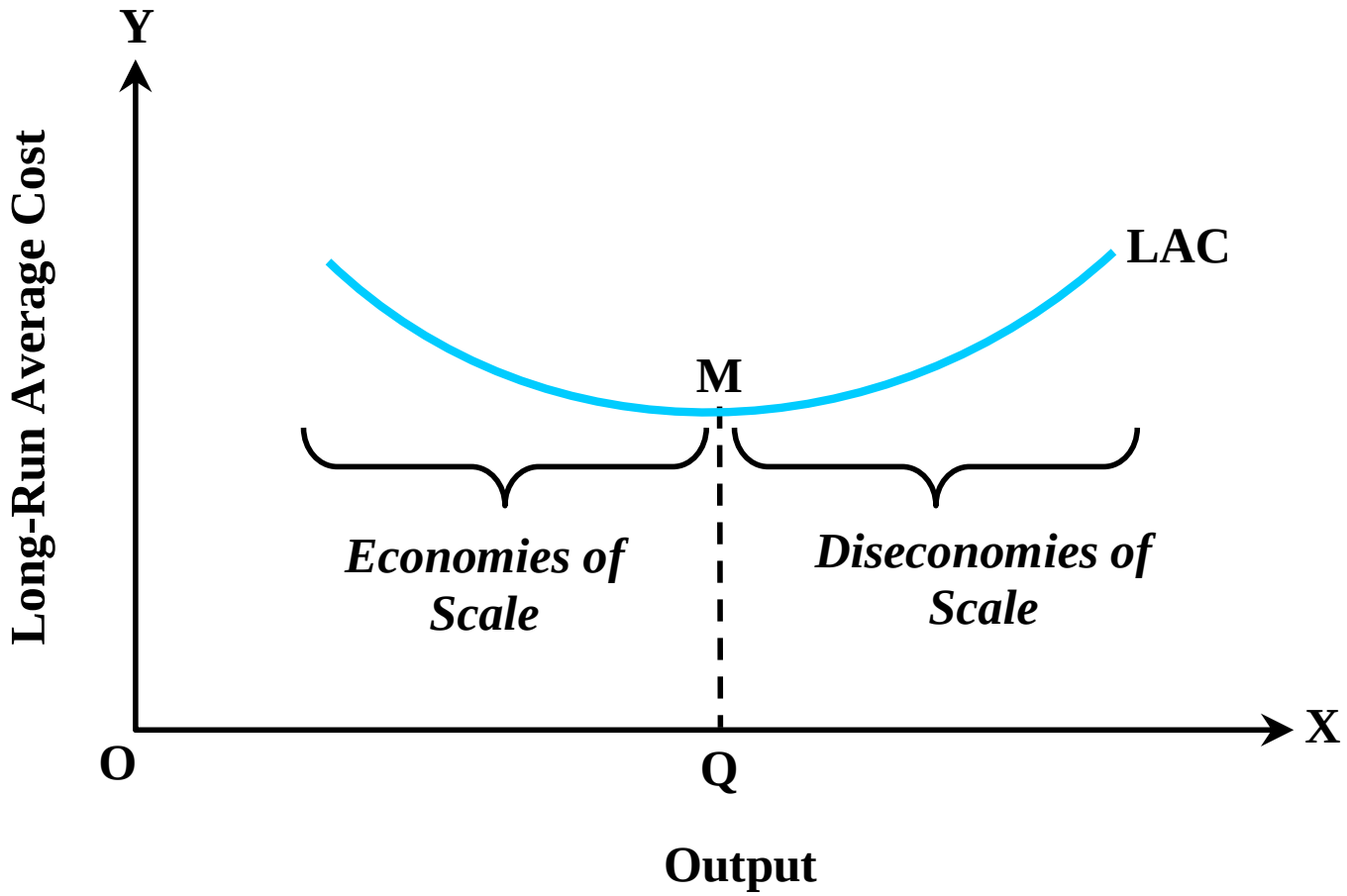
Why is SAC_3 Optimum Size Plant?

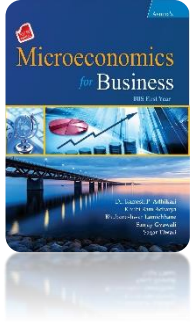
- The plant SAC_3 is optimum plant because its minimum cost of production is the lowest.
- If the size of plants is increased beyond SAC_3, it results in higher average cost of production.
- Similarly, if the size of the plant is smaller than SAC_3, average cost of production is higher.
- Thus, the optimum output (least cost output) of the plant SAC_3 is OQ_3.
- Now if the firm produces output OQ_3 with the optimum plant SAC_3, it is said to have achieved the optimum size.
- Thus, an optimum firm is that firm which is producing optimum output with the optimum plant.
- The firm is of optimum size if it employs plant SAC_3 and uses it to produce OQ_3 output.
- The output OQ_3 is also regarded as the socially optimum output.

Why is LAC Less Pronounced (Flatter) than SAC?



- Though the LAC curve is 'U' shaped, it is less pronounced (flatter) than SAC curves.
- It means that the LAC curve first falls slowly and then rises gradually after a minimum point is reached.

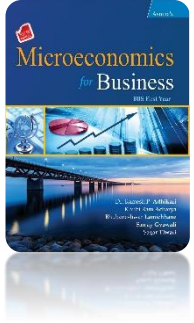




Why is LAC Curve called Planning Curve?

- Long-run average cost curve is often called the planning curve of the firm by some economists because firm plans to produce any output in the long-run by choosing a plant on the long-run average cost curve corresponding to the given output.
- The long-run average cost curve reveals to the firm that how large should be the plant for producing a certain output at the least possible cost.

Derivation of Long-run Marginal Cost Curve (LMC)



- Long-run marginal cost (LMC) is the change in long-run total cost as a result of one unit change in output.

$$\text{LMC} = \frac{\Delta \text{LTC}}{\Delta \text{Q}}$$

where

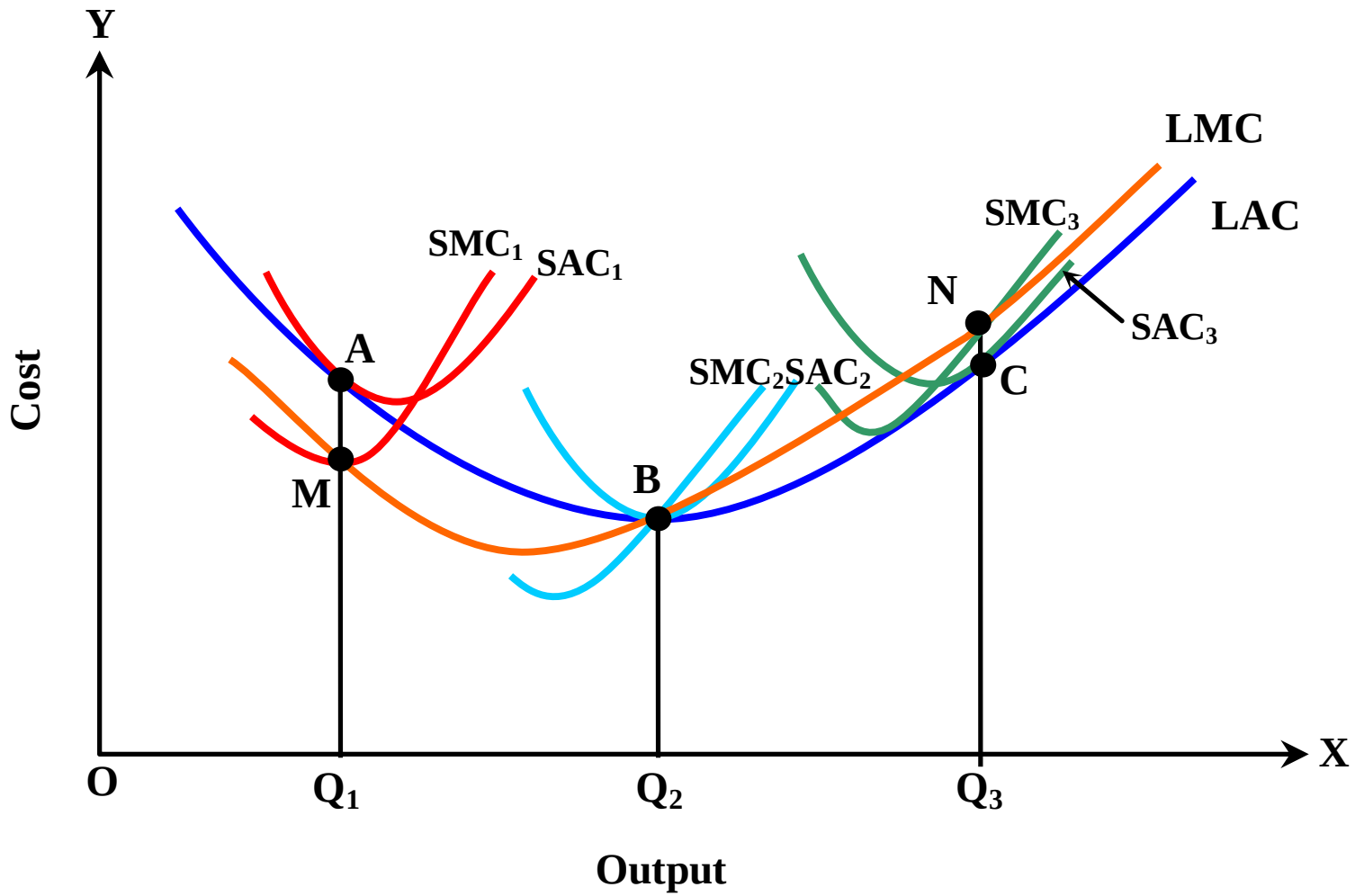
LMC = Long-run marginal cost

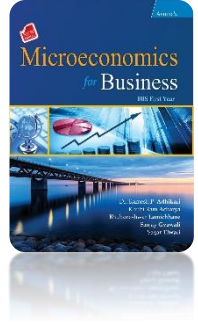
Δ Q = Change in total output

Δ LTC = Change in long-run total cost

- Long-run marginal cost curve is derived from short-run marginal cost curves.

Derivation of Long-run Marginal Cost Curve (LMC)

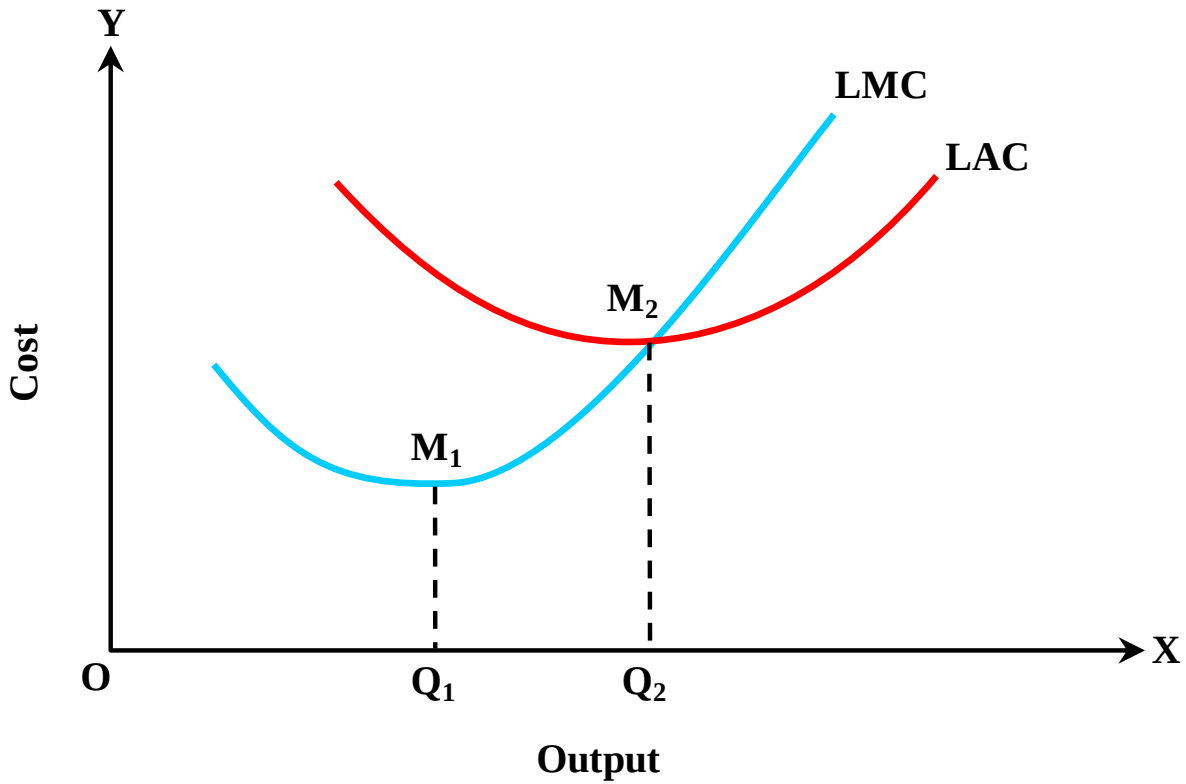


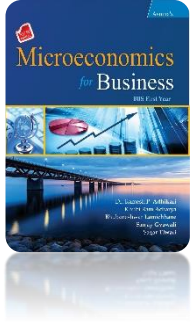


Relationship between LAC and LMC

Both LAC and LMC are derived from long-run total cost (LTC)

$$LAC = \frac{LTC}{Q}\ ;\ LMC = \frac{\Delta LTC}{\Delta Q}$$



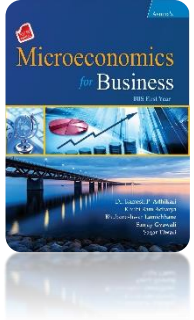


Relationship between LAC and LMC Contd.

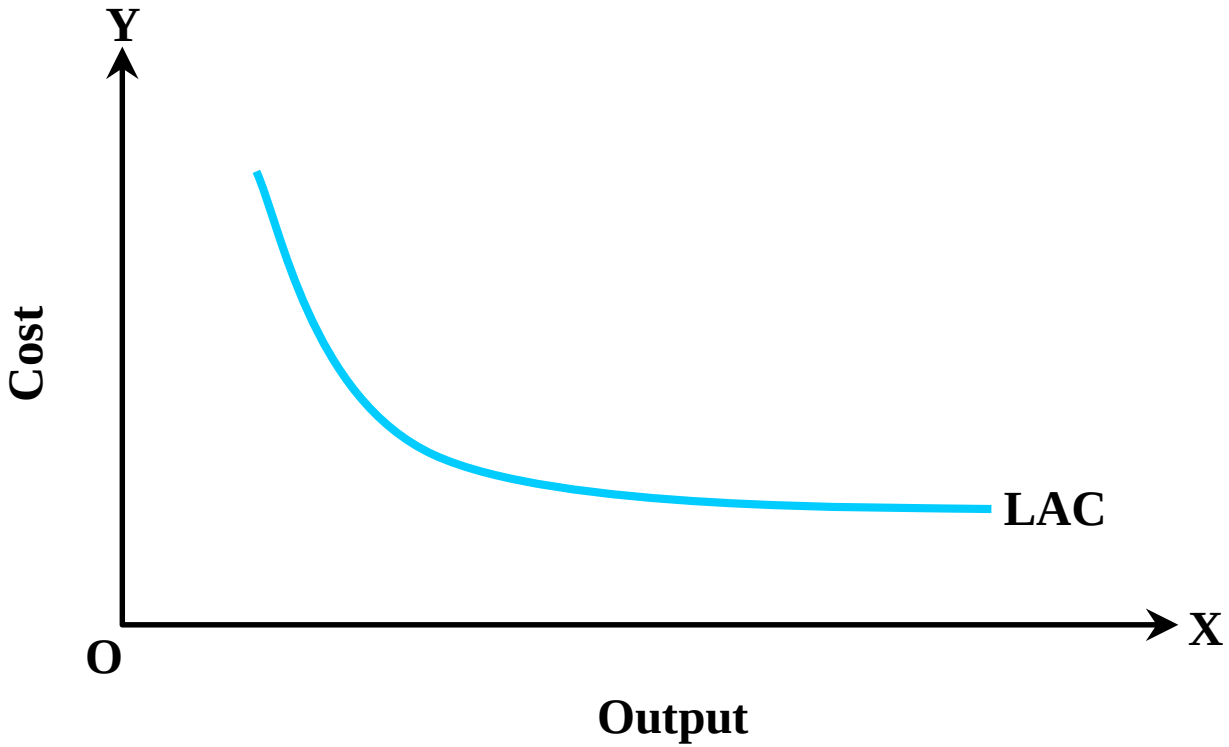
The relationship between LAC and LMC can be pointed out as follows:

- When LAC is minimum at point M_1, LAC = LMC.
- When LAC is decreasing, LAC > LMC.
- When LAC is increasing, LMC > LAC.
- LMC becomes minimum earlier than LAC. It means that minimum point of LMC is left of minimum of LAC, and
- When LMC is decreasing, it decreases faster than LAC and when LMC is increasing, it increases faster than LAC.

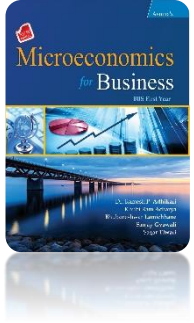
L-Shaped and Continuously Falling Long-run Average Cost Curve (L-Shaped LAC: Modern Theory of Cost)



- The U-shaped cost curves of the traditional theory have been questioned by various economists both on theoretical and empirical grounds. The empirical studies on cost have proved U-shaped cost curves to be wrong.
- In 1939 A.D. **George Stigler** said that firms also look into flexibility while producing. According to him, long run average cost curve is 'L' shaped rather than 'U' shaped.
- This is also known as the



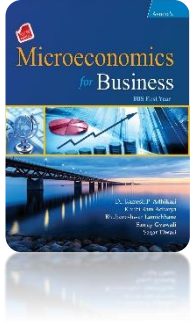
L-Shaped and Continuously Falling Long-run Average Cost Curve (L-Shaped LAC: Modern Theory of Cost) Contd.



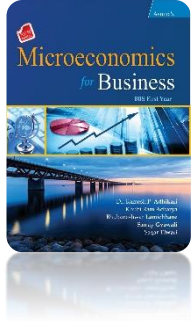
- In respect of LAC behavior, the modern theory of cost distinguishes between production costs and managerial costs. Both these costs are variable in the long-run. The behaviour of these costs determines the slope of long-run average cost curve (LAC).

1. **Production cost behaviour**: Production cost decreases steeply in the beginning with the increase in scale of production but the rate of decreases in cost slows down as the scale increase beyond a certain level of production.
2. **Managerial cost behaviour**: According to modern theory of cost, managerial cost first decreases but begins to increase as the scale of production is expanded beyond a certain level.

What makes LAC L-Shaped?

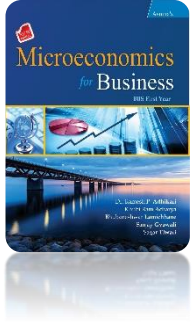


- The net effect of decreasing production cost and increasing managerial cost determines the shape of long-run average cost.
- In the initial stage of production, LAC decreases very steeply because of continuous decrease in cost of production.
- Beyond a certain scale, managerial cost begins to rise.
- According to modern theory of cost, rise in managerial cost is more than offset by the decrease in production costs.
- Therefore, LAC is continuous to fall but very slowly.
- In case the decrease in production cost is just sufficient to offset rise in managerial cost, the LAC becomes constant.
- This makes LAC an L-shaped curve.



Derivation of LAC Curve

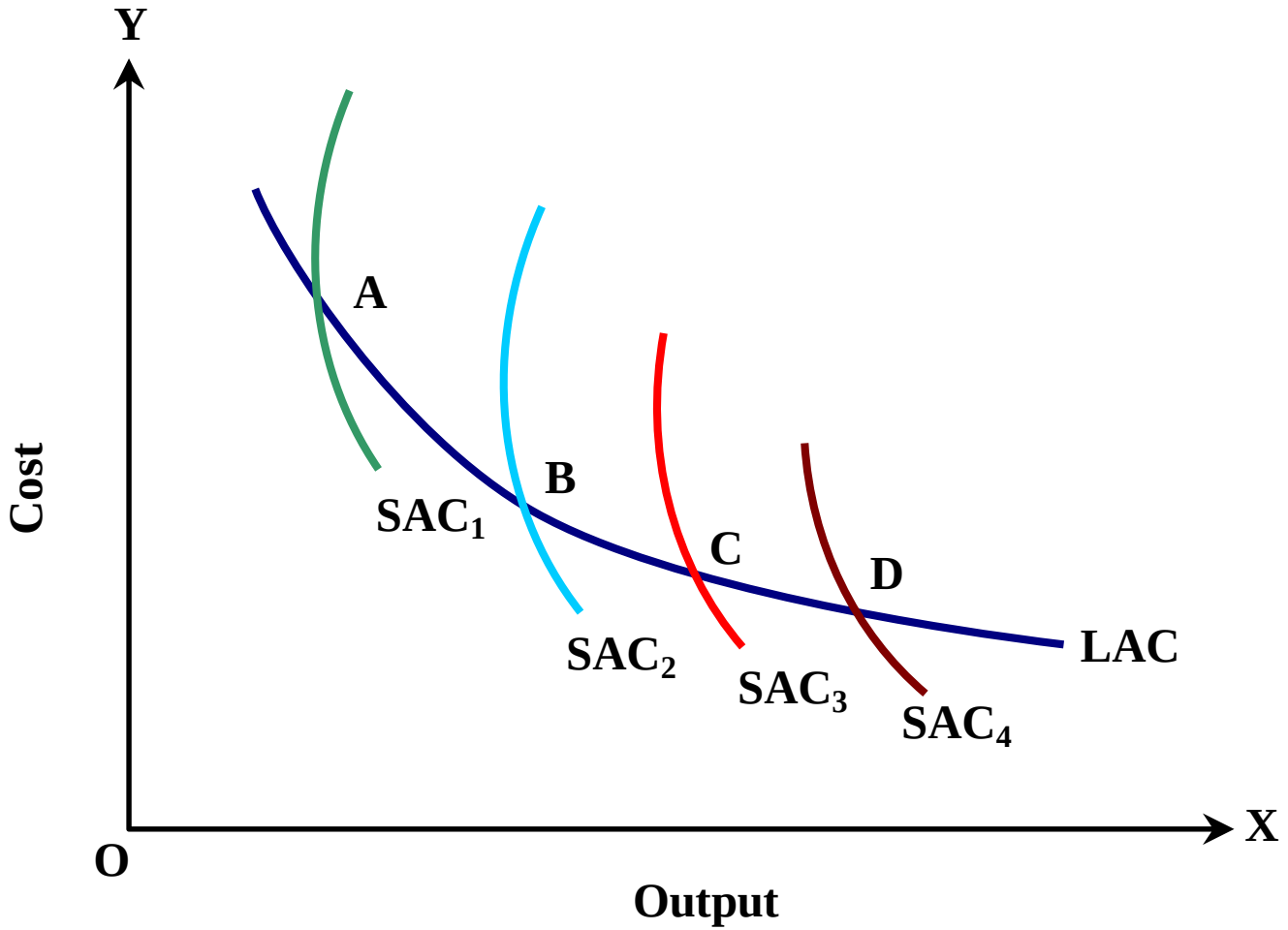
- Long-run average cost is obtained by dividing the long-run total cost by the level of output.
- The figure shows the decreasing or downward sloping LAC curve.
- In the modern theory of cost, LAC curve is also derived from the SAC curves.
- In the figure, there are four plants with short-run average cost curves SAC_1, SAC_2, SAC_3 and SAC_4.
- The empirical studies have found that firms use normally 2/3 to 3/4 of the plant size.
- This is called reserve capacity.



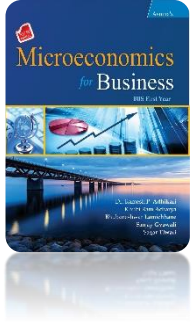
Derivation of LAC Curve Contd…

According to the modern theory of cost and theoretical as well as empirical evidence of the cost curve, we can draw following conclusions:

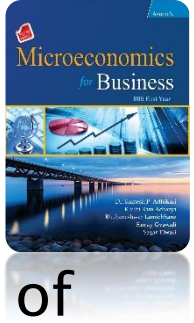
- LAC is roughly L-shaped.
- LAC does not envelop short-run cost curves.
- It interests certain points of SAC.
- It never turns up with the increase in output.



Economies and Diseconomies of Scale



- A firm experiences economies and diseconomies of scale when it increases its level of production.
- The LAC curve is ‘U’ shaped due to economies and diseconomies of scale.

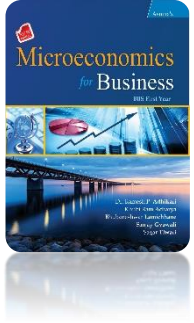


Economies of Scale

- Economies of scale are defined as the decrease in long run average cost of production due to increase in size of the firm.
- In other words, it refers to the property whereby long-run average total cost falls as the quantity of output increases.
- In the initial stage of production, when output increases by increasing variable factors of production, the different types of economies of scale accrue in production.
- The economies of scale are classified as under:

Types of Economics of Scale

1. Internal Economies
    i. Economies in production
    ii. Marketing Economies
    iii. Managerial Economies
    iv. Economies in Transportation and storage cost
2. External Economies

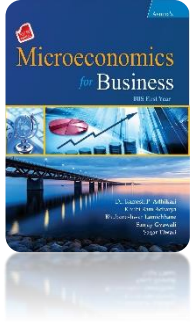


Diseconomies of Scale

- Diseconomies of scale refer to the property whereby long-run average total cost rises as the quantity of output increases.
- With the expansion of output, the different types of difficulties appear which increases average cost of production.
- As a result, LAC starts to increase.
- Diseconomies of scale are classified as under.

Types of Diseconomies of Scale

1. Internal Diseconomies
    i. Managerial inefficiency
    ii. Labour inefficiency
2. External Economies



Economies of Scope

- Economies of scope is the situation in which it is cheaper to produce various products jointly by a firm than by the separate firms independently.
- In other words, production is said to exhibit economies of scope if the cost of a single firm producing two or more different products is less than the costs of the outputs produced separately by two or more firms independently.

Symbolically,

$$TC(Q_A, Q_B) < TC(Q_A) + TC(Q_B)$$

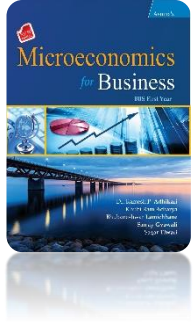
where

$TC(Q_A, Q_B)$ = Total cost of producing good- A and B by a single firm

$TC(Q_A) + TC(Q_B)$ = Total cost of producing good- A and B by two firms

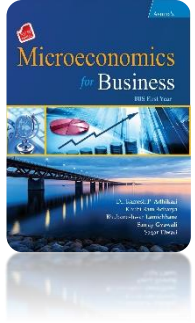
- Economies of scope exist if the total cost of jointly producing two commodities A and B by a firm is smaller than by two firms

Economies of Scope Contd.



Causes of Economies of Scope

1. Common production facilities
2. Use of by-products
3. Common marketing and administration



Economies of Scope Contd.

Measurement of Economies of Scope

- The degree of economies of scope measures the extent to which the cost of production decreases by producing products together by a firm rather than by different firms separately.
- The economies of scope as calculated using following formula:

$$S = \frac{TC(Q_A) + TC(Q_B) - TC(Q_A, Q_B)}{TC(Q_A, Q_B)} \times 100$$

where

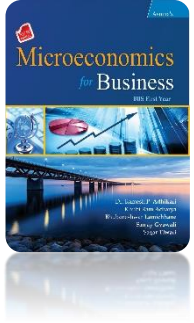
S = Degree of economies of scope

$TC(Q_A)$ = Total cost of producing only product A

$TC(Q_B)$ = Total cost of producing only product B

$TC(Q_A, Q_B)$ = Total cost of producing both products A and B

If $S > 0$, there is economies of scope and $S < 0$, there is diseconomies of scope.



Theory of Revenue

Revenue Function

- Revenue function shows the relationship between revenue and its determinants like price per unit, quantity sold, etc. Symbolically, it can be expressed as

$$R = f(P, Q)$$

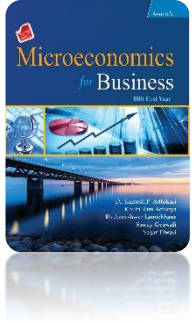
where

R = Revenue

P = Price per unit

Q = Quantity of output

- It implies that revenue is influenced by per unit price and quantity sold in the market. Therefore, revenue changes with the change in price per unit and quantity sold.



Concept of Revenue

Money receipt of a firm from the sale of its product is called revenue.

Types of Revenue

1. Total Revenue (TR)

Total revenue is the total amount of money received by a firm from the sales of its own product at the given period of time. In other words, total revenue is the sum of marginal revenue. Total revenue is also the product of price and quantity sold.

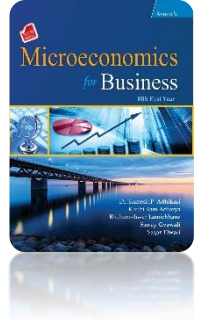
$$TR = P \times Q$$

where

P = Price

Q = Quantity sold

TR = Total revenue

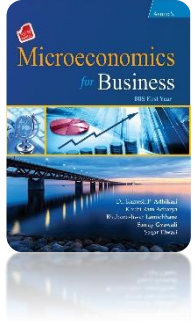


Concept of Revenue

2. Average Revenue (AR)

- Average revenue is the price per unit.
- It is obtained dividing total revenue by the number of units sold. Symbolically,

$$AR = \frac{TR}{Q} = \frac{P \times Q}{Q} = P$$



Concept of Revenue

3. Marginal Revenue

- Marginal revenue is the addition to total revenue from the sales of an additional unit of the commodity.
- Marginal revenue is obtained by dividing the change in total revenue by the change in quantity sold.

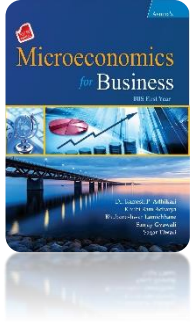
$$MR = TR_n - TR_{n-1}$$

$$\text{or,} \quad MR = \frac{\text{Change in total revenue}}{\text{Change in quantity sold}} = \frac{\Delta TR}{\Delta Q}$$

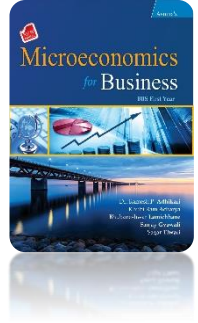
where

MR = Marginal revenue
TR_n = Total revenue of 'n^{th}' product
Q = Quantity sold
TR_{n-1} = Total revenue of $(n-1)^{th}$ product
ΔQ = Change in quantity sold
ΔTR = Change in total revenue

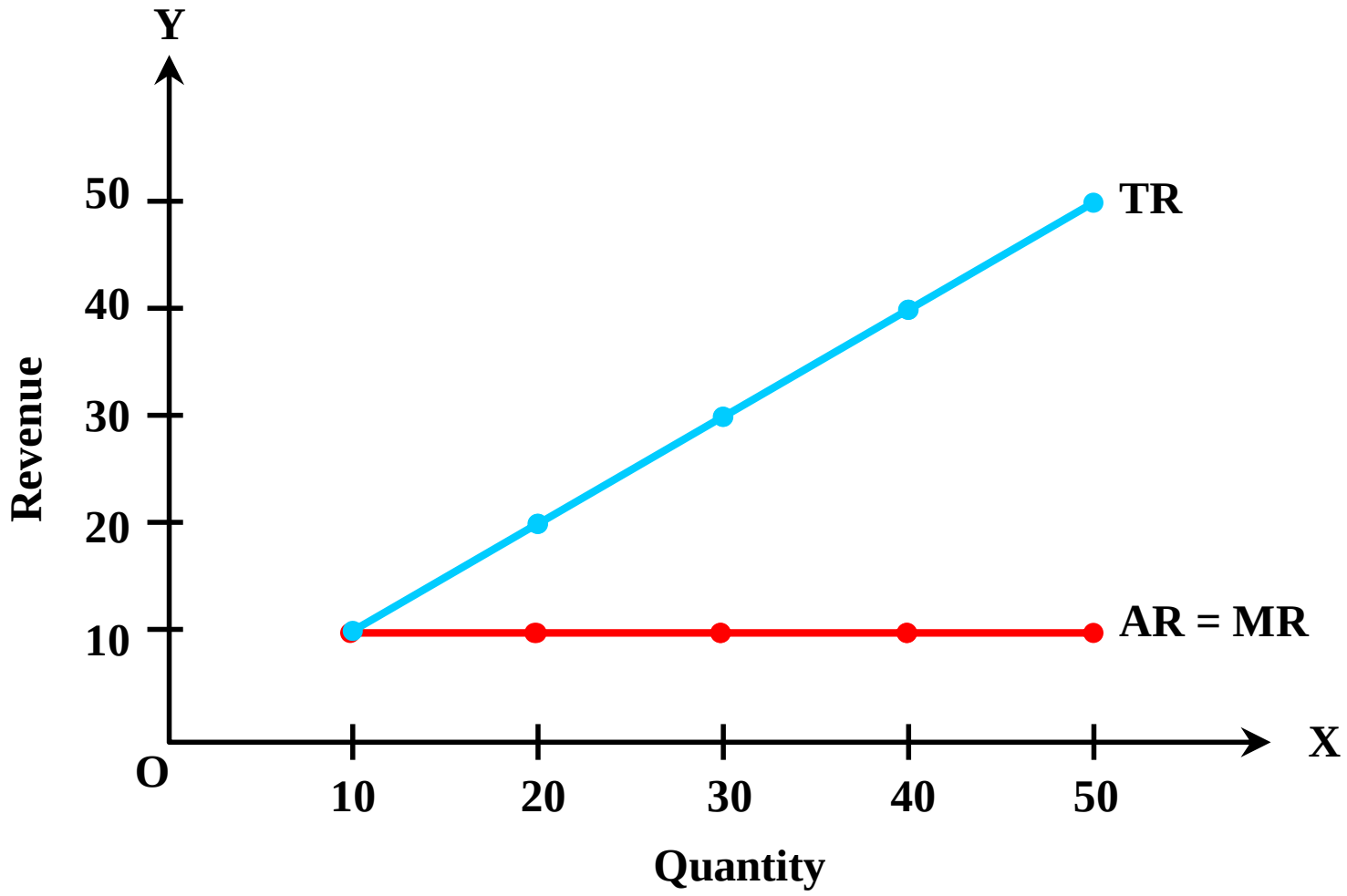
Derivation of Revenue Curves under Perfect Competition

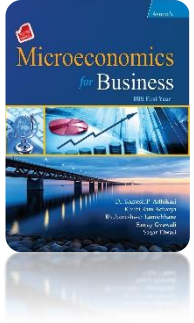


- Perfect competition is the market structure where there are a large number of buyers and sellers producing a homogeneous product with uniform price.
- In the perfect competition, firm is a 'price-taker'.
- A firm can sell whatever output it produces at the given price.
- Therefore, price remains constant at any level of output.
- The price is determined by the intersection of market demand and supply curves.
- From price and quantity values, TR, AR and MR can be obtained.



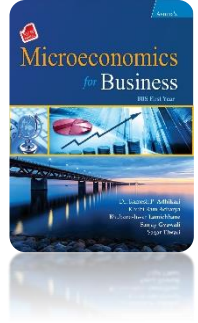
No. of Units Sold (Q)	Price (P)	TR = (P × Q)	AR	MR
1	10	10	10	10
2	10	20	10	10
3	10	30	10	10
4	10	40	10	10
5	10	50	10	10


Y
50
40
30
20
10
Revenue
TR
AR = MR
O
10
20
30
40
50
X
Quantity

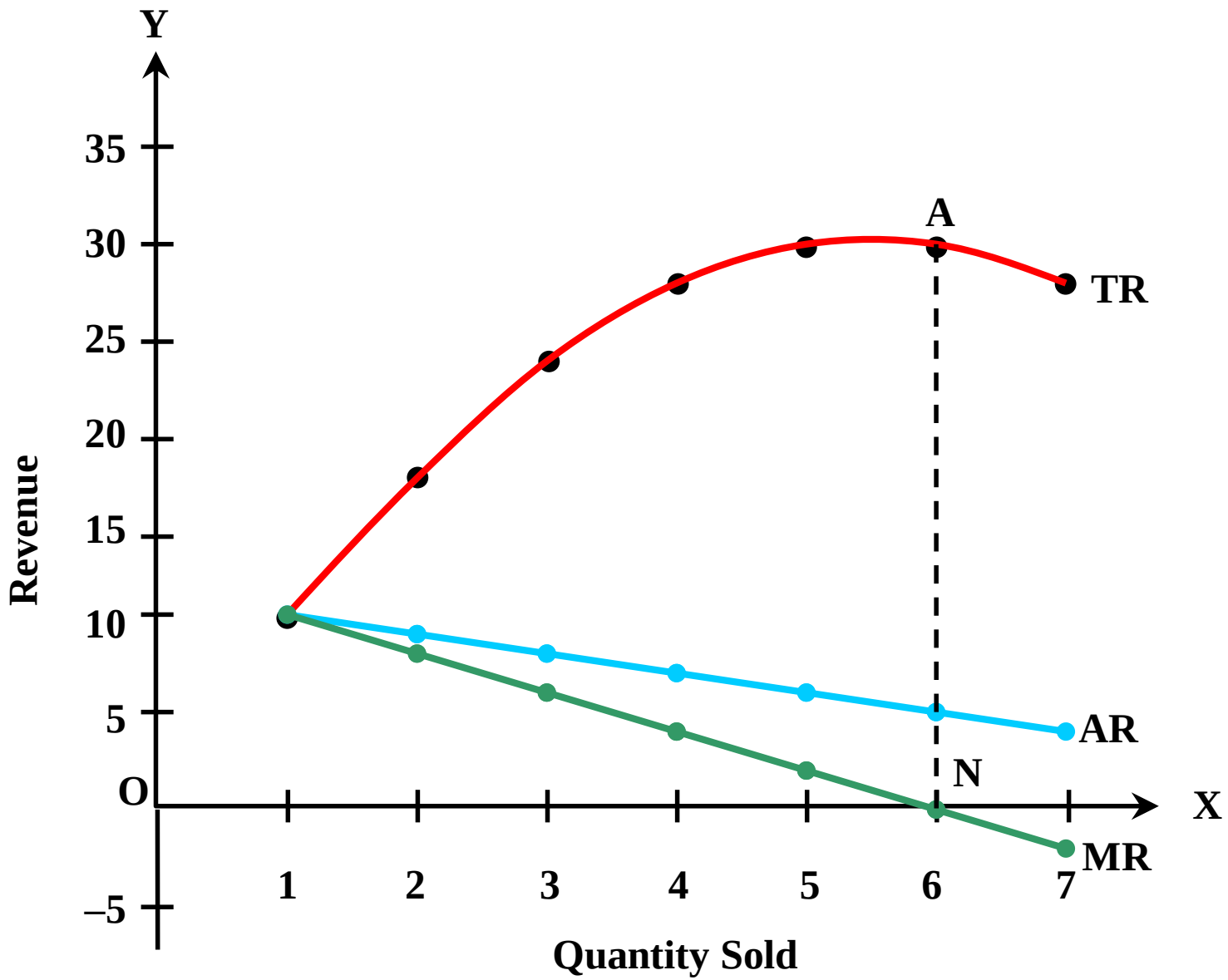


Derivation of Revenue Curves under Imperfect Competition or Monopoly

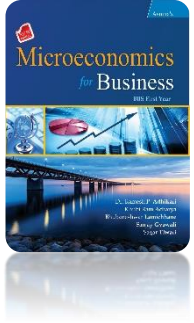
- Monopoly is a market structure in which there is a single seller or producer of a commodity, there are no close substitutes for the commodity it produces and there are barriers to entry of new firm in the market.
- In imperfect competition or monopoly, the firm is itself a 'price maker'.
- Therefore, it reduces prices in order to increase the sales.
- Consequently, both the average and marginal revenue curves slope downward from left to right.
- It means that if a monopolist desires to sell more units of the output, he will have to reduce the price.
- On the other hand, if the monopolist desires to charge high price, he will have to sell less units of output.



Quantity Sold (Q)	Price (P)	TR = (P × Q)	AR	MR
1	10	10	10	10
2	9	18	9	8
3	8	24	8	6
4	7	28	7	4
5	6	30	6	2
6	5	30	5	0
7	4	28	4	– 2

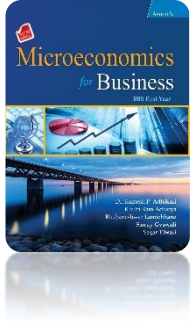

Y
35
30
25
20
15
10
5
O
–5
Revenue
A
TR
AR
N
MR
X
1
2
3
4
5
6
7
Quantity Sold

Relationship between Average Revenue and Marginal Revenue Curves

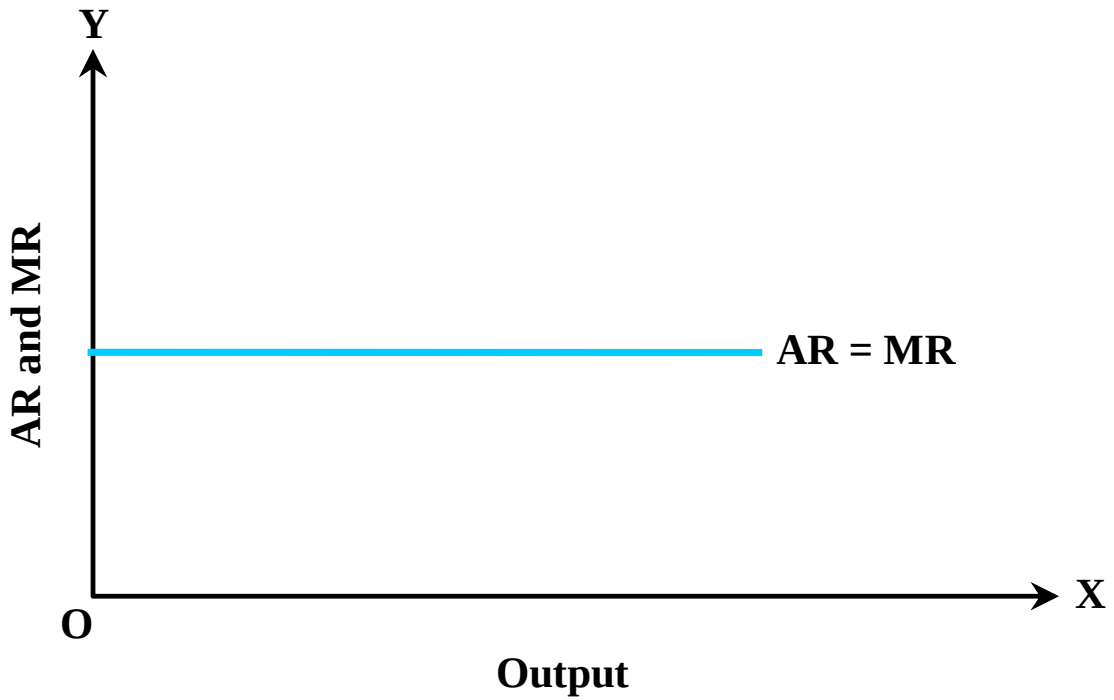


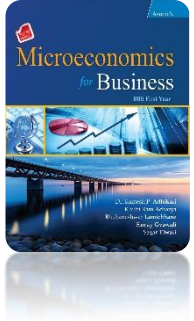
- The relationship between AR and MR depends upon the nature of market.
- Therefore, the relationship between AR and MR is explained under perfect competition and imperfect competition respectively.

Relationship between AR and MR Curves under Perfect Competition



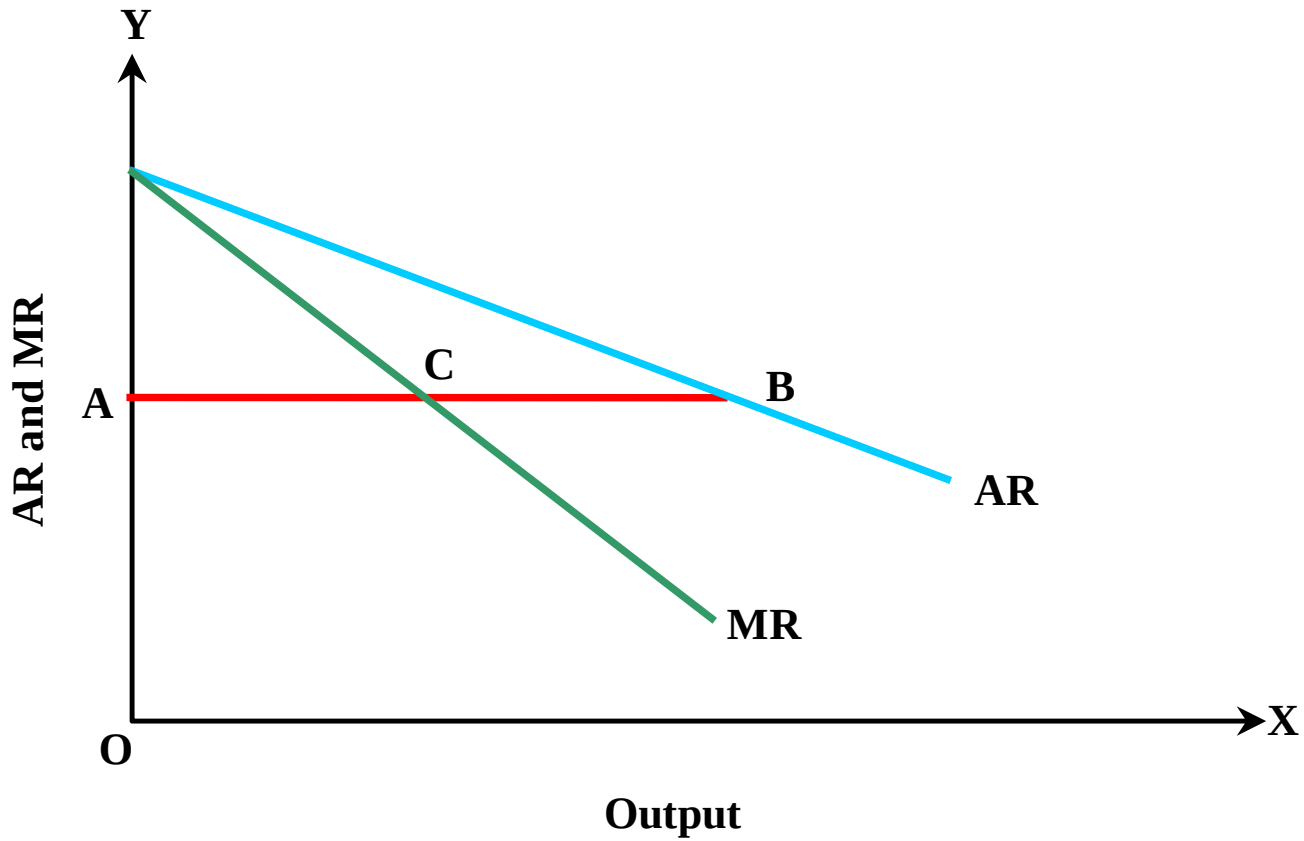
- Under perfect competition, seller cannot influence price of the product.
- He has to sell at the ruling price prevailing in the market.
- Thus, average revenue or price is same throughout.
- Marginal revenue curve coincides with the average revenue curve because additional units are sold at the same price as before.

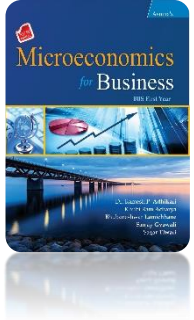




Relationship between AR and MR Curves under the Monopoly/ Imperfect Competition

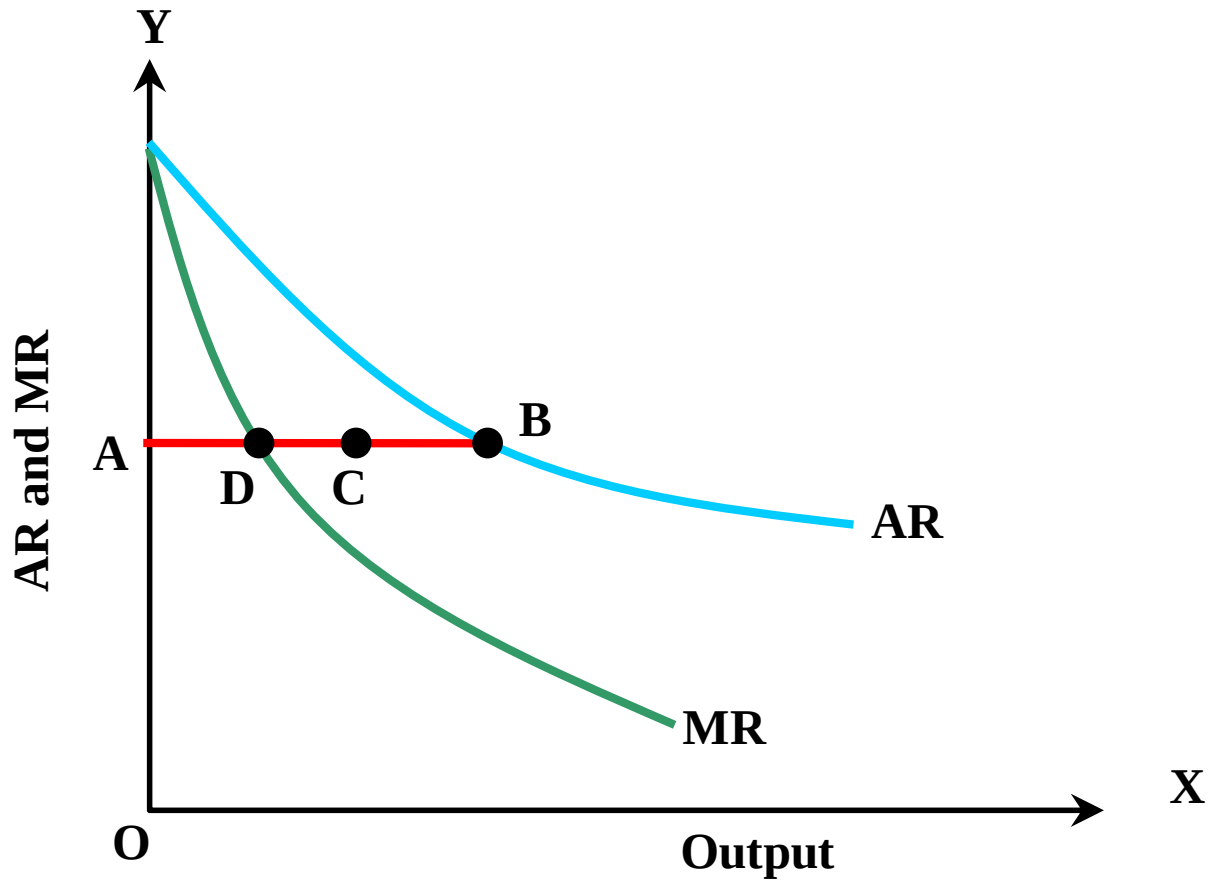
1. When both AR and MR Curves are Straight Line

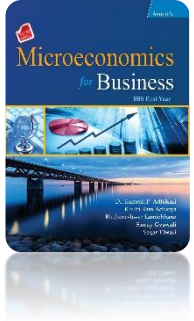




Relationship between AR and MR Curves under the Monopoly/ Imperfect Competition Contd.

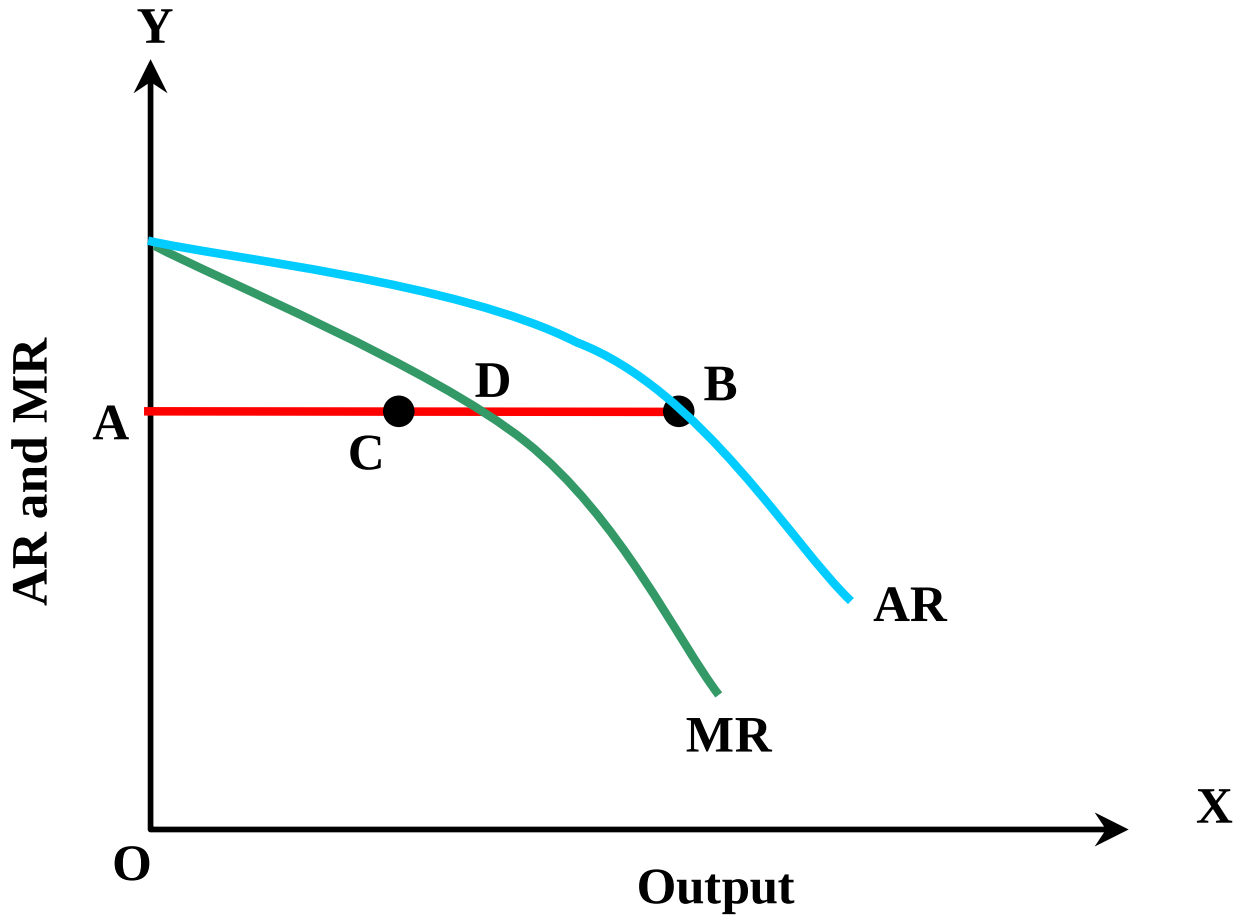
2. When both AR and MR Curves are Convex to the Origin



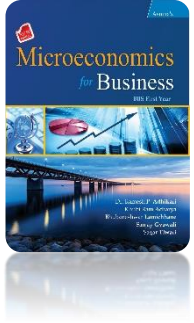


Relationship between AR and MR Curves under the Monopoly/ Imperfect Competition Contd.

3. When both AR and MR Curves are Concave to the Origin

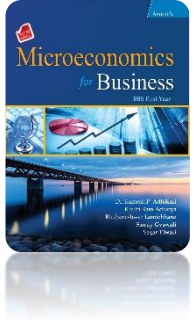


Relationship between Price Elasticity of Demand and Revenue



There is very useful relationship between price elasticity of demand and concept of revenue. This relationship can be studied as follows:

- Relationship between Price Elasticity of Demand and Marginal Revenue
- Relation between Price Elasticity of Demand and Average Revenue
- Relationship between Price Elasticity of Demand and Total Revenue



Relationship between Price Elasticity of Demand and Marginal Revenue

Marginal revenue is the addition in total revenue as a results of increase in sales by one additional unit. Then,

$$\mathbf{MR = \frac{d(TR)}{dQ}}$$

or, $MR = \frac{d(P \times Q)}{dQ}$ $(\because TR = P \times Q)$

or, $MR = P.\frac{dQ}{dQ} + Q.\frac{dP}{dQ}$

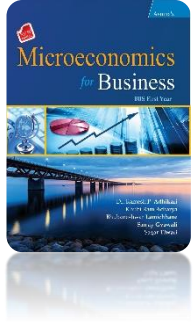
or, $MR = P.1 + Q.\frac{dP}{dQ}$

$\therefore$ $\mathbf{MR = P + Q.\frac{dP}{dQ}}$

Taking P common, we get,

$$\mathbf{MR = P\left(1 + \frac{Q}{P} \cdot \frac{dP}{dQ}\right)} \qquad \text{... (i)}$$

Relationship between Price Elasticity of Demand and Marginal Revenue Contd.



In the above equation $\frac{dP}{dQ} \cdot \frac{Q}{P}$ is the reciprocal of coefficient of price elasticity of demand. It means that,

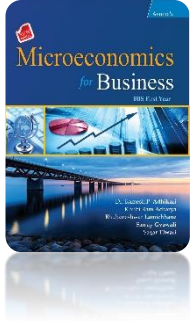
$$\frac{dP}{dQ} \cdot \frac{Q}{P} = \frac{-1}{E_P}$$

By substituting $\left(\frac{-1}{E_P}\right)$ in the above equation (I), we get,

$$MR = P\left(1 - \frac{1}{E_P}\right)$$

or, $$MR = P\left(\frac{E_P - 1}{E_P}\right) \quad \text{... (ii)}$$

Relationship between Price Elasticity of Demand and Marginal Revenue Contd.



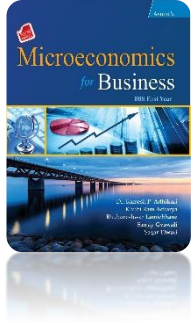
- The above equation (ii), gives the relationship between price elasticity of demand and marginal revenue.
- Given the relationship between marginal revenue (MR) and price elasticity of demand E_P, we can draw following conclusions:

i. When $E_P = 1$, $MR = 0$. It means that total revenue remains constant for both rise and fall in price.

ii. If $E_P > 1$, $MR > 0$. It means that increase in price results decrease in total revenue and vice-versa.

iii. If $E_P < 1$, $MR < 0$. It means that increase in price results increase in total revenue and vice-versa.

Relation between Price Elasticity of Demand and Average Revenue

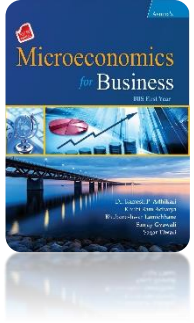


- We know that price is same as average revenue in all market conditions.
- Therefore, substituting $P = AR$ in the above equation, (ii) we get,

$$MR = AR\left(\frac{E_P - 1}{E_P}\right)$$

or, $$AR = MR\left(\frac{E_P}{E_P - 1}\right)$$

Relation between Price Elasticity of Demand and Average Revenue Contd.



$$AR.E_P - AR = MR.E_P$$

$$\text{or,} \quad MR.E_P = AR.E_P - AR$$

$$\text{or,} \quad MR.E_P - E_P.AR = -AR$$

$$\text{or,} \quad E_P(MR - AR) = (-AR)$$

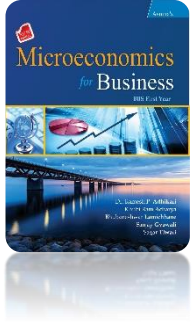
$$\text{or,} \quad E_P = \frac{(-AR)}{MR - AR}$$

$$\text{or,} \quad E_P = \frac{-AR}{-(AR - MR)}$$

$$\therefore \quad \mathbf{E_P = \left(\frac{AR}{AR - MR}\right)} \qquad \textbf{...(iii)}$$

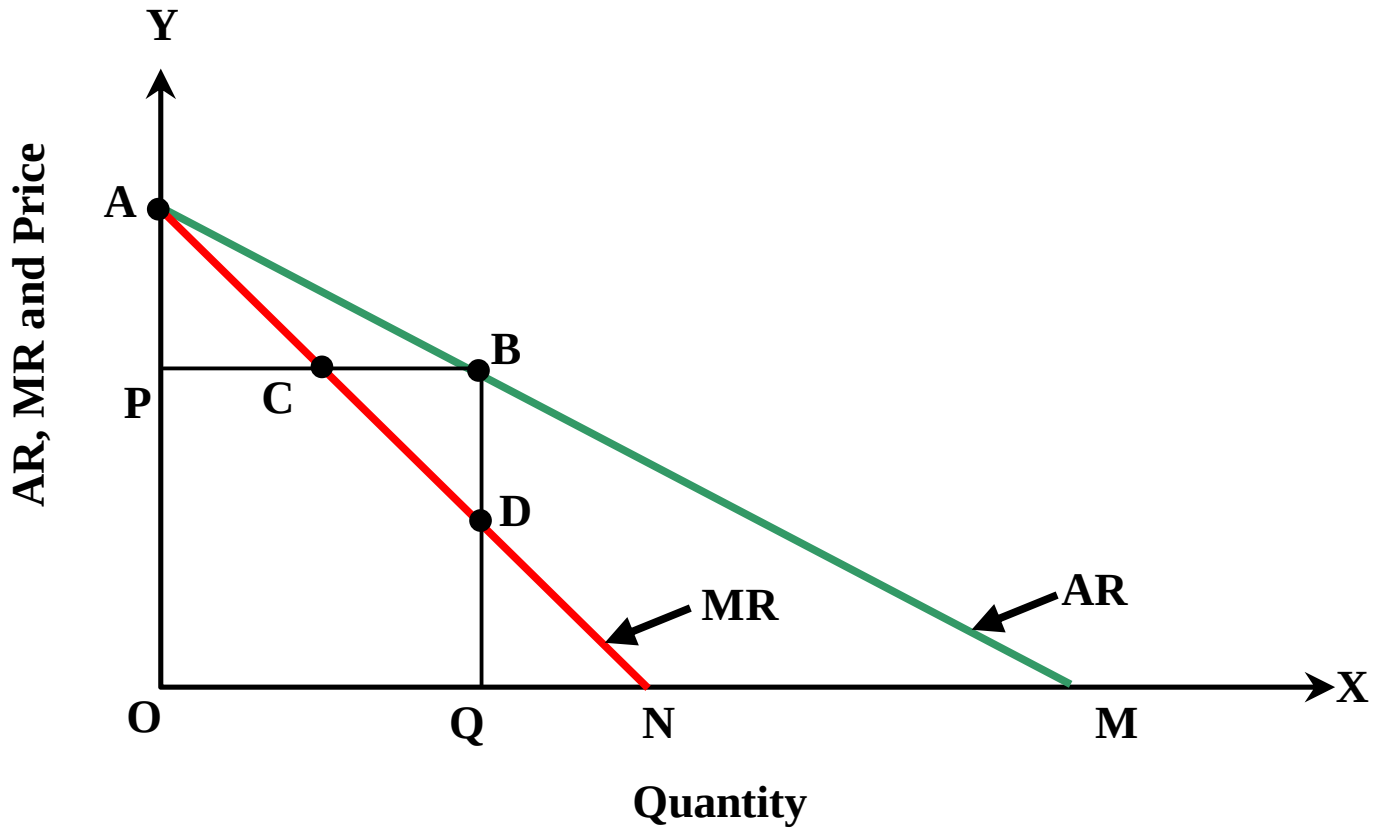
Above equation (iii), gives the relationship between average revenue (AR) and price elasticity of demand (E_P).

Relation between Price Elasticity of Demand and Average Revenue Contd.

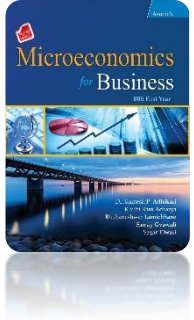


Alternatives Method (Graphical/ Geometrical Proof)

- The above equation (iii) gives the relationship between AP and MR and between AR and E_P.



Relation between Price Elasticity of Demand and Average Revenue Contd.



- X-axis represents quantity and Y-axis represents average revenue, marginal revenue and price.
- The downward sloping curve AM represents average revenue curve (AR) and AN represents marginal revenue curve (MR).
- Lets us suppose that price is given at OP (= QB).
- According to point elasticity of demand, price elasticity of demand at point B is the lower segment of the demand curve (AR curve) divided by upper segment of the demand curve (AR curve).

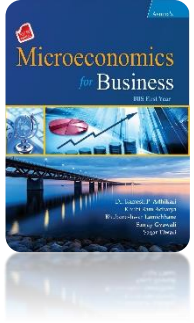
$$E_P \text{ at } B = \frac{\text{Lower segment}}{\text{Upper segment}}$$

$$= \frac{BM}{AB} \quad \text{... (i)}$$

Since, ΔAPB and ΔQBM are equiangular,

$$E_P \text{ at } B = \frac{BM}{AB} = \frac{BQ}{AP} \quad \text{... (ii)}$$

Relation between Price Elasticity of Demand and Average Revenue Contd.



Again, in congruent triangles, APC and DBC,

$$AP = BD \qquad \text{... (iii)}$$

From equation (i), (ii) and (iii), we get,

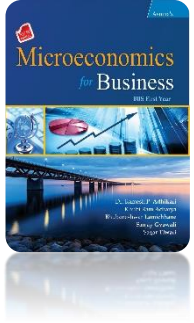
$$E_P \text{ at } B = \frac{BM}{AB} = \frac{BQ}{AP} = \frac{BQ}{BD} \qquad [\because AP = BD]$$

$$= \frac{BQ}{(BQ - DQ)} \qquad [\because BD = BQ - BD]$$

$$E_P \text{ at } B = \left(\frac{AR}{AR - MR}\right) \qquad [\because BQ = AR \text{ and } DQ = MR]$$

Hence, by graphical or geometrical method also we can establish the relationship between. E_P, AR and MR

Relationship between Price Elasticity of Demand and Total Revenue

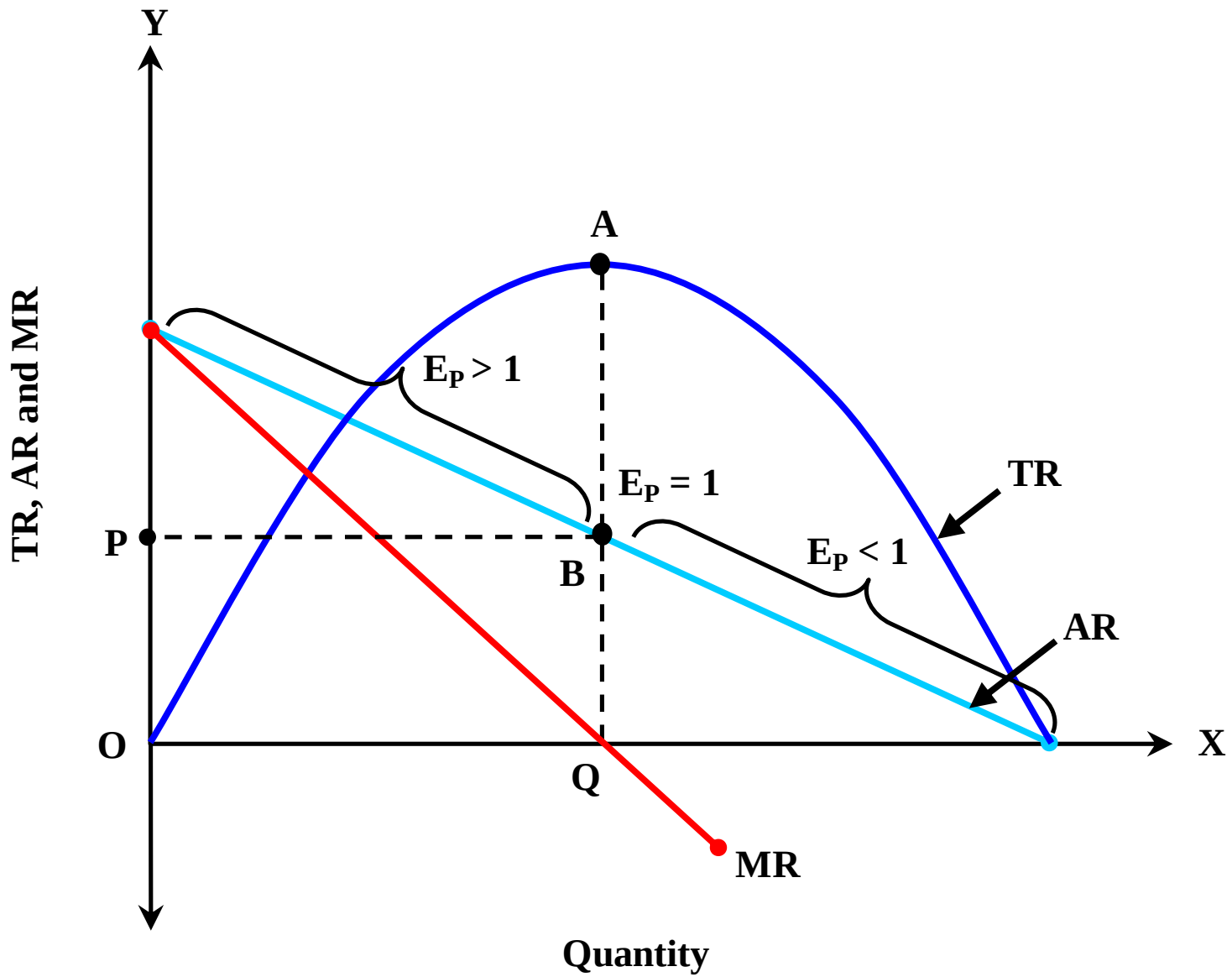


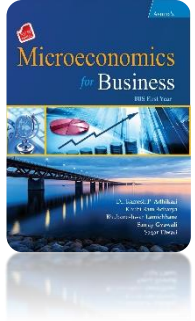
- Since, the total revenue (TR), marginal revenue (MR) and price elasticity of demand (E_P) are interrelated, the relationship between TR and E_P can be traced through the relationship between MR and E_P.
- Given the relationship between MR and E_P in the equation, $MR = P\left(1 - \frac{1}{E_P}\right)$, the relationship between TR and E_P can be summed up as follows:

i. If $E_P = 1$, $MR = 0$; TR does not change with change in price.

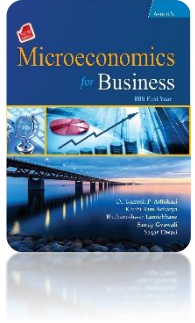
ii. If $E_P < 1$, $MR < 0$; TR decreases with decrease in price and increase with increase in price.

iii. If $E_P > 1$, $MR > 0$; TR decreases with increase in price and increases with decrease in price.


Y
A
TR, AR and MR
$E_P > 1$
$E_P = 1$
TR
P
B
$E_P < 1$
AR
O
X
Q
MR
Quantity



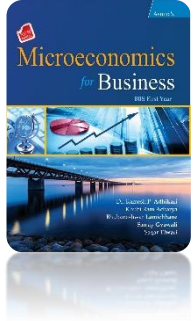
S.No.	Coefficient of Price Elasticity of Demand	Change in Price	Change in Total Revenue
1.	$E_P = 1$ (Unity Elastic Demand)	Increase Decrease	No Change No Change
2.	$E_P < 1$ (Inelastic Demand)	Increase Decrease	Increase Decrease
3.	$E_P > 1$ (Elastic Demand)	Increase Decrease	Decrease Increase
4.	$E_P = 0$ (Perfectly Inelastic)	Increase Decrease	Increase Decrease
5.	$E_P = \infty$ (Perfectly Elastic)	Increase Decrease	Decrease Increase



Numerical Examples 1

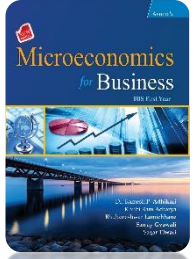
Complete the following table, draw TC, TVC and TFC and briefly explain the relationship between TC, TVC and TFC.

Quantity	TFC	TVC	TC
0	60	0	–
1	-	30	–
2	-	40	–
3	-	45	–
4	-	55	–
5	-	75	–
6	-	120	–

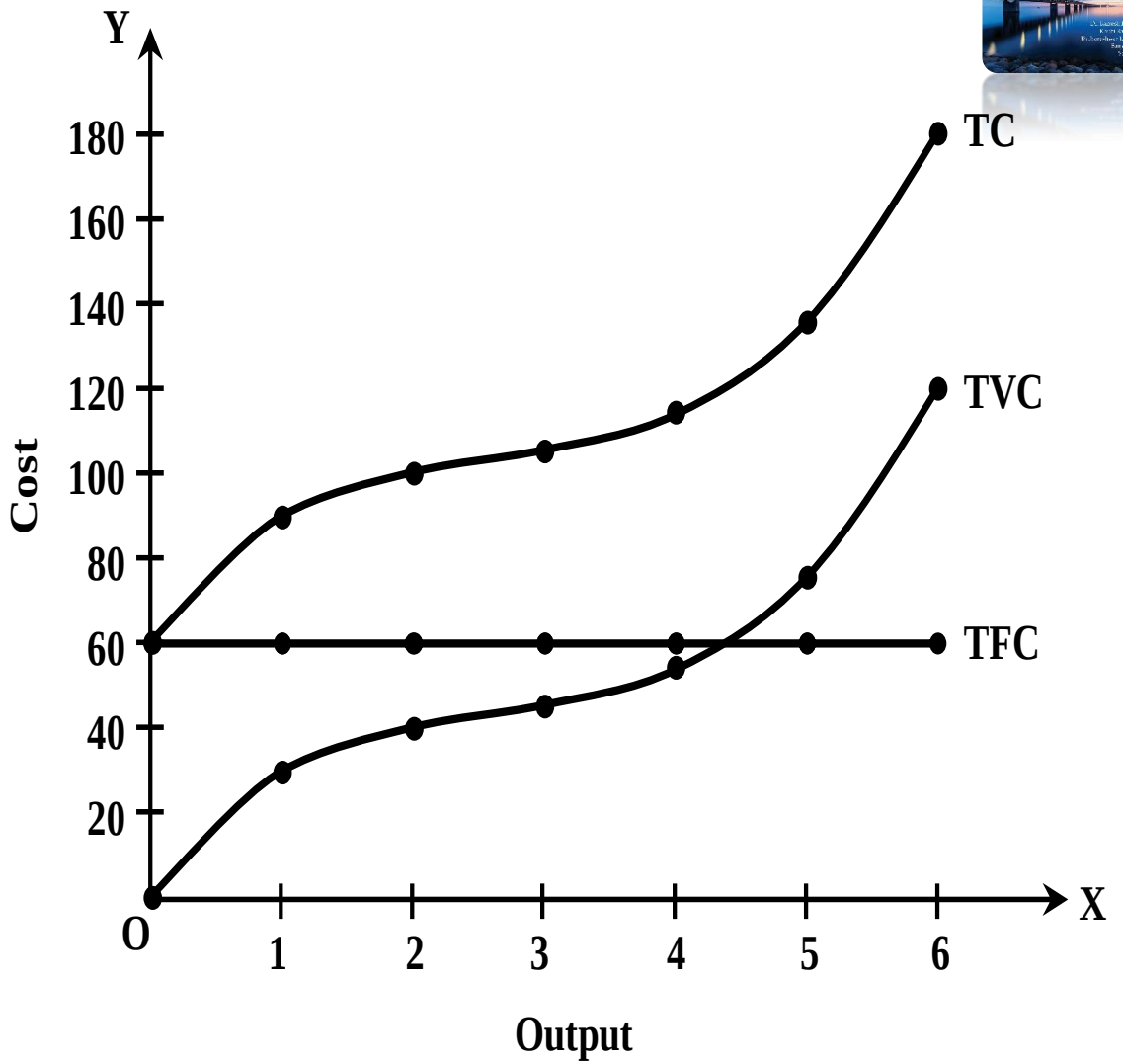


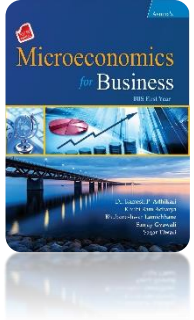
SOLUTION

Quantity	TFC	TVC	TC
0	60	0	60
1	60	30	90
2	60	40	100
3	60	45	105
4	60	55	115
5	60	75	135
6	60	120	180



- In the above diagram, TFC curve is horizontal because it is Rs. 60 regardless of level of output.
- TVC is zero when output is zero.
- It increases with increase in output.
- It is roughly U-shaped because of operation of law of variable proportion.
- TC begins from Rs. 60 because it is the sum of TVC and TFC.
- It is also roughly U-shaped because of operations of law of variable proportion.
- At every level of output the difference between TC and TVC is Rs. 60.
- Therefore, distance between

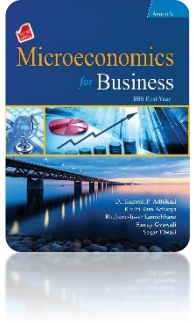




Numerical Examples 2

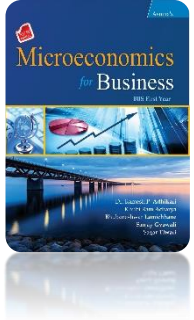
Complete the following table and explain the relationship between AC and MC with diagram.

Output	TFC	TVC	TC	AFC	AVC	AC	MC
0	200	0					
1	-	50					
2	-	90					
3	-	120					
4	-	140					
5	-	175					
6	-	230					
7	-	310					
8	-	400					



SOLUTION

Output (Q)	TFC	TVC	TC = TFC + TVC	AFC = TFC / Q	AVC = TVC / Q	AC = TC / Q	MC = ΔTC / ΔQ
0	200	0	200	-	-	0	-
1	200	50	250	200	50	250	50
2	200	90	290	100	45	145	40
3	200	120	320	66.6	40	106.6	30
4	200	140	340	50	35	85	20
5	200	175	375	40	35	80	35
6	200	230	430	33.3	38.3	71.6	55
7	200	310	510	28.5	44.2	72.7	80
8	200	400	600	25	50	75	90



The relationship between AC and MC can be pointed as follows:

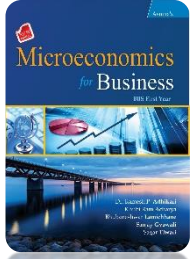
i. At the beginning both AC and MC are declining.

ii. When MC is decreasing, it declines faster than AC.

iii. MC is minimum at fifth unit of output and AC is minimum at sixth unit of output.

iv. AC = MC at sixth unit of output and at this output AC is minimum.

v. Beyond minimum point of AC, MC > AC.



Numerical Examples 3

Total cost function of a producer is given by $TC = 1000 + 10Q - 0.9Q^2 + 0.004Q^3$. Find TFC, TVC, TC, AFC, AVC and MC to produce 5 units of output.

SOLUTION

Given, $TC = 100 + 10Q - 0.9Q^2 + 0.004Q^3$

Total fixed cost (TFC) is the total cost at zero level of output and it remains the same whatever be the level of output. It remains the same regard less of change in output.

When $Q = 0$, $TC = 1000$. Hence, at $Q = 5$, $TFC = 1000$

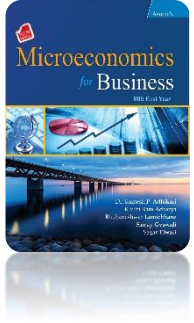
When $Q = 5$, $AFC = \frac{TFC}{Q} = \frac{1000}{5} = 200$

We know that $TC = TFC + TVC$

$TVC = TC - TFC$

$TVC = 1000 + 10Q - 0.9Q^2 + 0.004Q^3 - 1000$

$TVC = 10Q - 0.9Q^2 + 0.004Q^3$



At, $Q = 5$

$TVC = 10 \times 5 - 0.9\,(5)^2 + 0.004(5)^3 = 50 - 22.5 + 0.5 = 28$

Now, $TC = TFC + TVC = 1000 + 28 = 1028$

Now,

$$AVC = \frac{TVC}{Q} = \frac{28}{5} = 5.6$$

$$MC = \frac{d(TC)}{dQ} = \frac{d}{dQ}(1{,}000 + 10Q - 0.9Q^2 + 0.004Q^3)$$

$$= \frac{d(1000)}{dQ} + 10\frac{dQ}{dQ} - 0.9\left(\frac{dQ^2}{dQ}\right) + 0.004\left(\frac{dQ^3}{dQ}\right)$$

$$= 0 + 10 \times 1 - 2 \times 0.9 \times Q + 3 \times 0.004 \times Q^2$$

$$= 10 - 1.8\,Q + 0.012Q^2$$

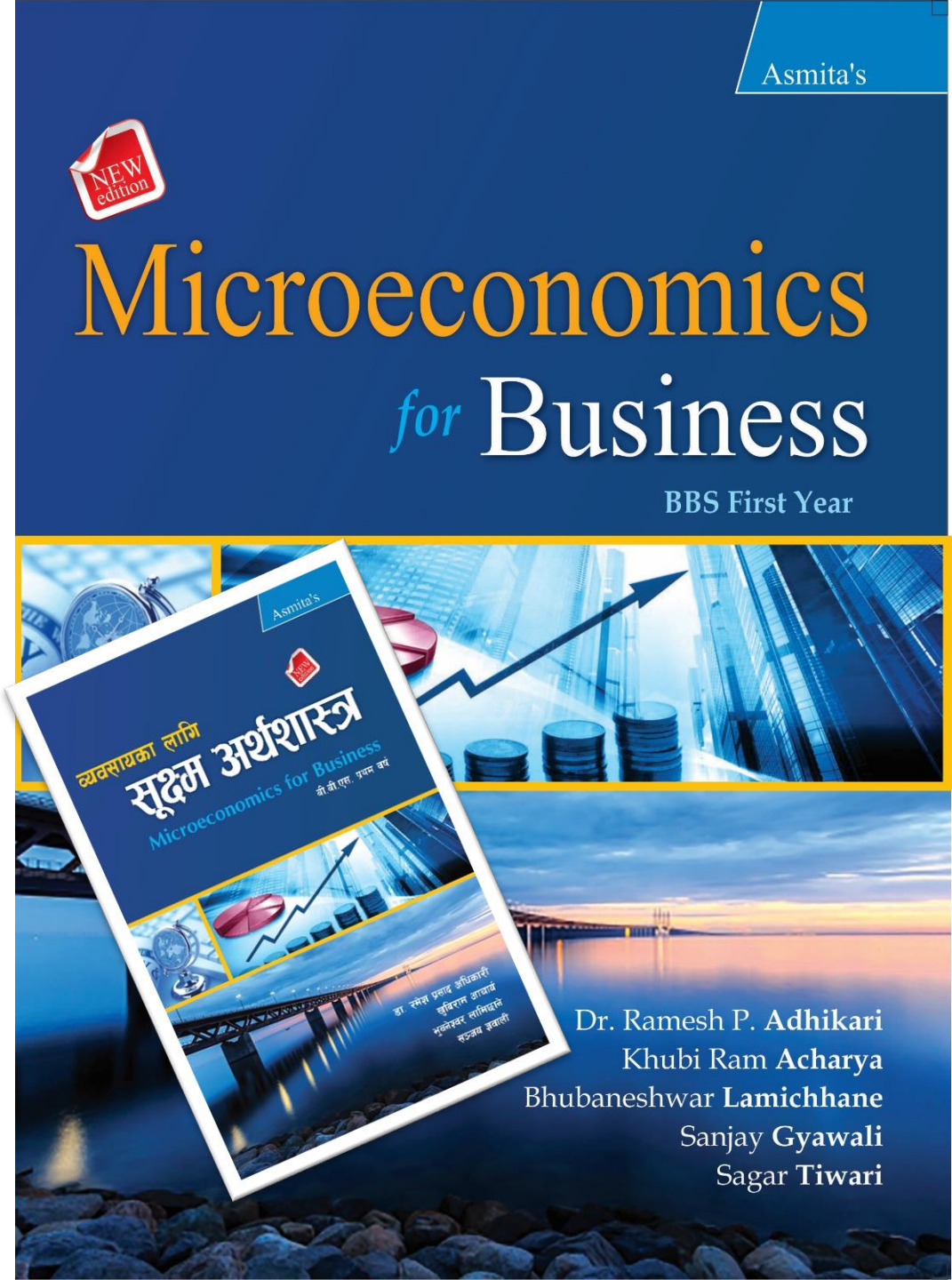
Putting $Q = 5$, we get

$$MC = 10 - 1.8(5) + 0.012 \times 5^2$$

$$= 10 - 9 + 0.3$$

$$= Rs.\ 1.3$$

Thank You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