UNIT II
THEORY OF PRODUCTION AND COSTS (9 Hours)

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Content

- Production with One Variable Input: Total, Average, and Marginal Product.

- The Shapes of the Average and Marginal Product Curves.

- Stages of Production.

- Production with Two Variable Inputs: Isoquants. Short-Run Total Cost Curves.

- The Long-Run Average Cost Curve.

- The Long-Run Marginal Cost Curve.

- The Long-Run Total Cost Curve.

- The Cobb-Douglas Production Function.

PRODUCTION: **Basic Concept**

- The process of transformation of resources (like land, labour, capital and entrepreneurship) into goods and services of utility to consumers and/or producers.

- Goods includes all tangible items such as furniture, house, machine, food, car, television etc.

- Services include all intangible items, like banking, education, management, consultancy, transportation.

Theory of Production

- Production is a process that create/adds value or utility

- It is the process in which the inputs are converted in to outputs.

Inputs	• The factors of production such as Land, Labour, Capital, Technology ,etc
Outputs	• The goods and service produced such as Soap, Air Bus, etc

Factors of Production

Land	• Natural resources such as surface, mineral, air, rivers, sea, etc • Free gift of nature, fixed
Labour	• Mental or physical effort done by a man with the view of
Capital	• Man made goods used in the production process • Most mobile factor
Organization	• Entrepreneur or coordinator of all other factors of production

FACTORS OF PRODUCTION

- **Land**
  - Anything which is gift of nature and not the result of human effort, e.g. soil, water, forests, minerals
  - Reward is called as *rent*
- **Labour**
  - Physical or mental effort of human beings that undertakes the production process. Skilled as well as unskilled.
  - Reward is called as *wages/ salary*
- **Capital**
  - Wealth which is used for further production as machine/ equipment/intermediary good
  - It is outcome of human efforts
  - Reward is called as *interest*
- **Enterprise**
  - The ability and action to take risk of collecting, coordinating, and utilizing all the factors of production for the purpose of uncertain economic gains
  - Reward is called as *profit*

Production Function

- Production function means the functional relationship between inputs and outputs in the process of production.

- It is a technical relation which connects factors inputs used in the production function and the level of outputs

Q = f (Land, Labour, Capital, Organization, Technology, etc)

PRODUCTION FUNCTION

- A technological relationship between physical inputs and physical outputs over a given period of time.

- shows the *maximum* quantity of the commodity that can be produced per unit of time for each set of alternative inputs, and with a given level of production technology.

- Normally a production function is written as:

$$Q = f(L, K, l, R, E)$$

- where Q is the maximum quantity of output of a good being produced, and L=labour; K=capital; l=land; R=raw material; E= efficiency parameter.

TYPES OF INPUTS

Technology

- determines the type, quantity and proportion of inputs.

- also determines the maximum limit of total output from a given combination of inputs.

- at any *point* of time, technology will be given; impact of technology can be seen only over a *period* of time.

Fixed and Variable Inputs

- *Variable input* : that can be made to vary in the short run, e.g. raw material, unskilled/semi skilled labour, etc.

- *Fixed input:* that cannot be varied in the short run, e.g. land, machine, technology, skill set, etc.

Inputs : Fixed inputs and Variable inputs

- The factors of production that is carry out the production is called inputs.
- Land, Labour, Capital, Organizer, Technology, are the example of inputs

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            ┌─────────────────┐
            │  Inputs Factors │
            └─────────────────┘
         ┌──────────┴──────────┐
┌─────────────────┐   ┌─────────────────┐
│ Variable Inputs │   │  Fixed Inputs   │
└─────────────────┘   └─────────────────┘
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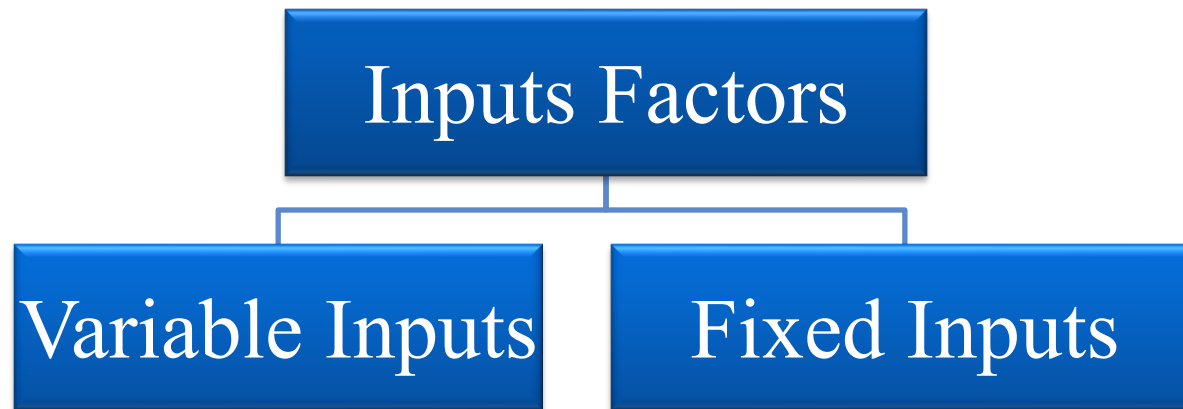
Inputs : Fixed inputs and Variable inputs

Fixed inputs

- ❑ Remain the same in the short period .
- ❑ At any level of output, the amount is remain the same.
- ❑ The cost of these inputs are called Fixed Cost
- ❑ Examples:- Building, Land etc.
- ❑ (In the long run fixed inputs are become varies)

Variable inputs

- ❑ In the long run all factors of production are varies according to the volume of outputs.
- ❑ The cost of variable inputs is called Variable Cost
- ❑ Example:- Raw materials, labour, etc

Various concept of production

- **Total Product-** Total product is a function of labour:

$$TP_L = f(\overline{K}, L)$$

- **Average Product- Ratio of Total Product and one variable inputs:**

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

- **Marginal Product – The rate of change of output as a result changes in one variable input:**

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

Total, Average and Marginal Product

Cobb-Douglas Production Function: $Y = A\sqrt{K}\ \sqrt{L}$

Suppose, A=12, K=36, L=4 then Y=144 Rs. 4 per unit

Illustrate TP, AP & MP

7 working hours and wage Rs.8 per hour

Labor UNIT	TP	MP	AP
1	72		72
2	101.82	29.82	50.91
3	124.71	22.89	41.57
4	144	19.29	36.00
5	160.997	16.997	32.199
6	176.36	15.363	29.39
7	190.49	14.13	27.213
8	203.65	13.16	25.456
9	216.00	12.35	24.00
10	227.68	11.68	22.768

Labour (L)	Capital (K)	Total Output (TP)	Average Product (AP)	Marginal Product (MP)
0	10	0		
1	10	10		
2	10	30		
3	10	60		
4	10	80		
5	10	95		
6	10	108		
7	10	112		
8	10	112		
9	10	108		
10	10	100		

Short run Production Function with Labour as Variable factor

Short run Production Function with Labour as Variable factor

Labour (L)	Capital (K)	Total Output (TP)	Average Product (AP)	Marginal Product (MP)
0	10	0	-	
1	10	10	10	10
2	10	30	15	20
3	10	60	20	30
4	10	80	20	20
5	10	95	19	15
6	10	108	18	13
7	10	112	16	4
8	10	112	14	0
9	10	108	12	-4
10	10	100	10	-8

Output per month

112

60

A

B

C

D

Total Product

3 4   8   Labor per month

30

20   E

10

Average product

3 4   8   Labor per month

Marginal product
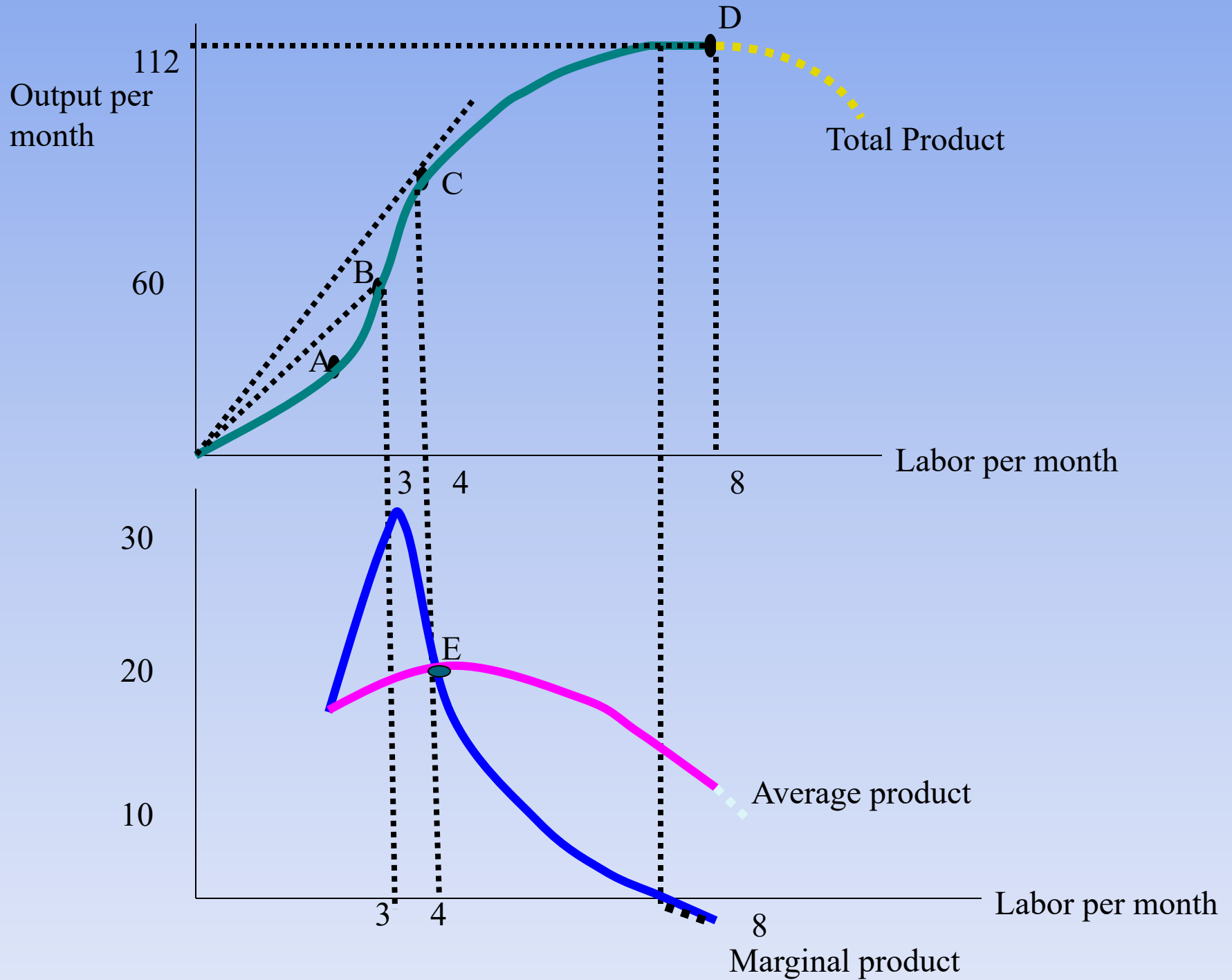
Law of Production Function
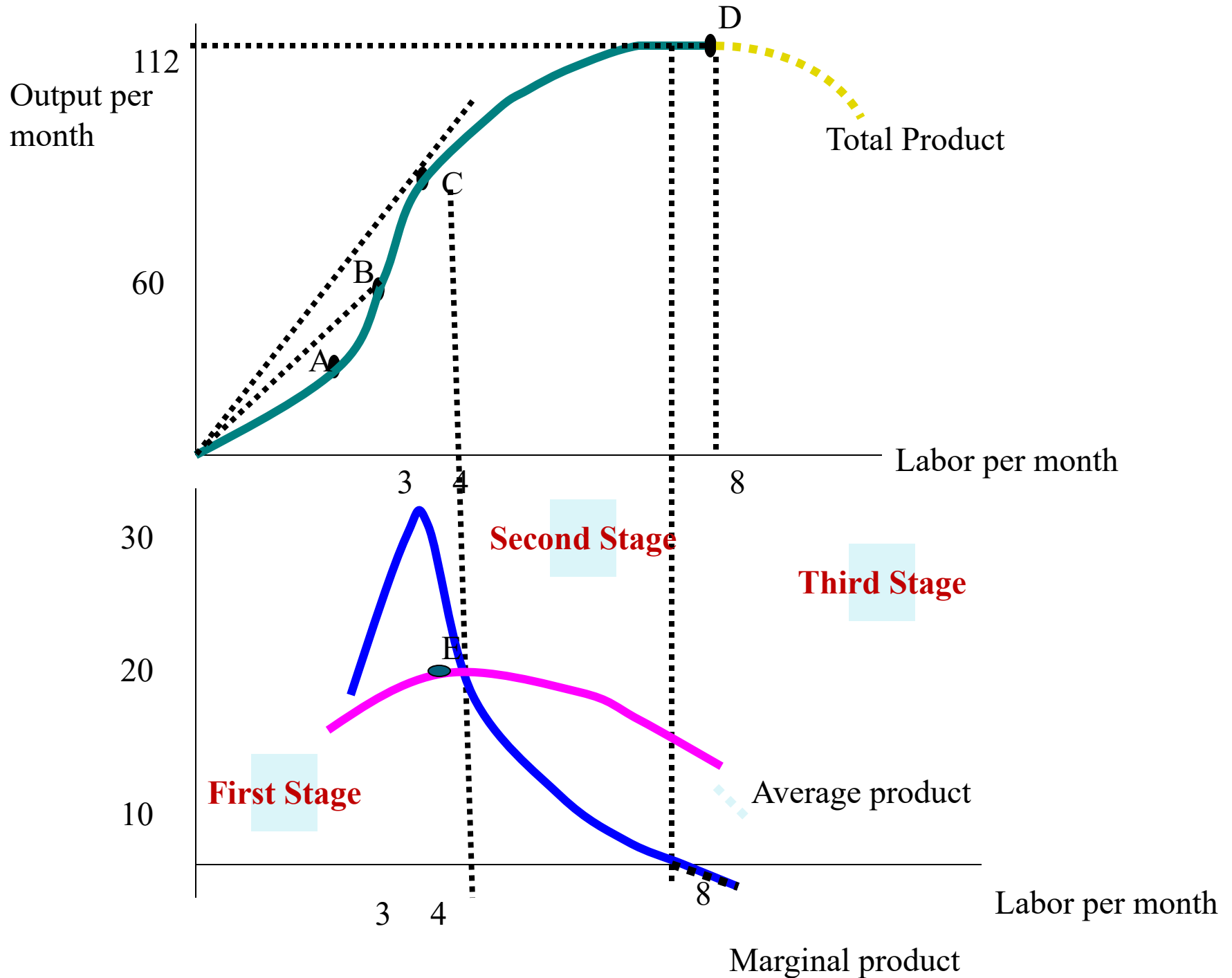
1) **Laws of Variable proportion**- Law of Diminishing Return (Short run production function with at least one input is variable)

2) **Laws of Return scales** – Long run production function with all inputs factors are variable.

1. Law of variable proportion: Short run Production Function

- Production function with at least one variable factor keeping the quantities of others inputs as a Fixed.

- If one of the variable factor of production used more and more unit, keeping other inputs fixed, the total product(TP) will increase at an increase rate in the first stage, and in the second stage TP continuously increase but at diminishing rate and eventually TP decrease.

Short run Production Function with Labour as Variable factor

Labour	Land	Capital (K)	Total Output (TP)	Average Product (AP)	Marginal Product (MP)	
0	10	10	0	-		
1	10	10	10	10	10	**First Stage**
2	10	10	30	15	20	
3	10	10	60	20	30	
4	10	10	80	20	20	
5	10	10	95	19	15	**Second Stage**
6	10	10	108	18	13	
7	10	10	112	16	4	
8	10	10	112	14	0	
9	10	10	108	12	-4	**Third Stage**
10	10	10	100	10	-8	

Output per month

112

60

A

B

C

D

Total Product

3   4   8

Labor per month

30

Second Stage

Third Stage

20

F

10

First Stage

Average product

3   4   8

Labor per month

Marginal product

Stages in Law of variable proportion

First Stage: Increasing return

- TP increase at increasing rate till the end of the stage.
- AP also increase and reaches at highest point at the end of the stage.
- MP also increase at it become equal to AP at the end of the stage.
- MP>AP

Second Stage: Diminishing return

- TP increase but at diminishing rate and it reach at highest at the end of the stage.
- AP and MP are decreasing but both are positive.
- MP become zero when TP is at Maximum, at the end of the stage
- MP<AP.

Third Stage: Negative return

- TP decrease and TP Curve slopes downward
- As TP is decrease MP is negative. AP is decreasing but positive.

Where should rational firm produce?

- **Stage I:** MP is above AP implies an increase in input increases output in greater proportion.

- The firm is not making the best possible use of the fixed factor.

- So, the firm has an incentive to increase input until it crosses over to stage II.

- **Stage III:** MP is negative implies contribution of additional labor is negative so the total output decreases .

- In this case it will be unwise to employ an additional labor.

- **Stage II:** MP is below AP implies increase in input increases output in lesser proportion.

- *A rational producer/firm should produce in stage II.*

- But where exactly the firm will operate within stage II cannot be determined only on the basis of the product curves.

- We need information about input costs and price of output.

2. Law of return to scales: Long run Production Function

- Production function with all factors of productions are variable..

- Return to scale refers to the relationship between changes of outputs and proportionate changes in the in all factors of production

Law of return to scales: Long run Production Function

Labour	Capital	TP	MP
2	1	8	8
4	2	18	10
6	3	30	12
8	4	40	10
10	5	50	10
12	6	60	10
14	7	68	8
16	8	74	6
18	9	78	4

Increasing returns to scale

Constant returns to scale

Decreasing returns to scale

Law of return to scales: Long run Production Function

Inputs 10% increase – Outputs 15% increase   **Increasing returns to scale**

Inputs 10% increase – Outputs 10% increase   **Constant returns to scale**

Inputs 10% increase – Outputs 5% increase   **Decreasing returns to scale**
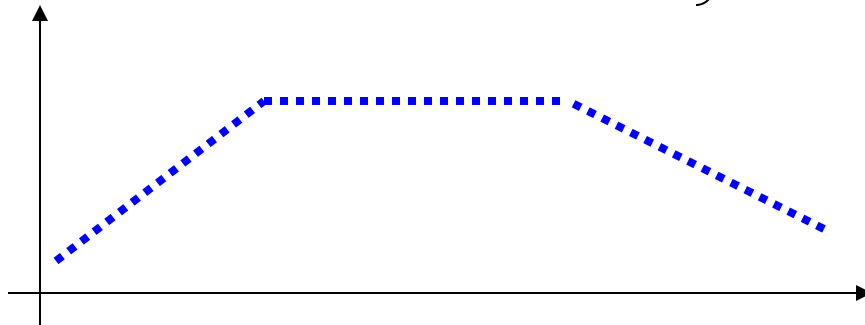
Homogeneous production function

In the long run all inputs are variable. The production function is homogeneous if all inputs factors are increased in the same proportions in order to change the outputs.

A Production function Q = f (L, K)
An increase in Q>   Q^ = f (L+L.10%, K+K.10%)-

Inputs increased same proportion

Increasing returns to scale **Inputs increased 10% => output increased 15%**

Constant returns to scale **Inputs increased 10% => output increased 10%**

Decreasing returns to scale **Inputs increased 10% => output increased 8%**

Economic Costs

- The payment that must be made to obtain and retain the services of a resource

- Explicit Costs
  - Monetary payments

- Implicit Costs
  - Value of next best use
  - Self-owned resources
  - Includes normal profit

Accounting Profit and Normal Profit

- Accounting profit

  = Revenue – Explicit Costs

- Economic profit

  = Accounting Profit – Implicit Costs

- Economic profit (to summarize)

  =Total Revenue – Economic Costs

  =Total Revenue – Explicit Costs – Implicit Costs

Economic Profit
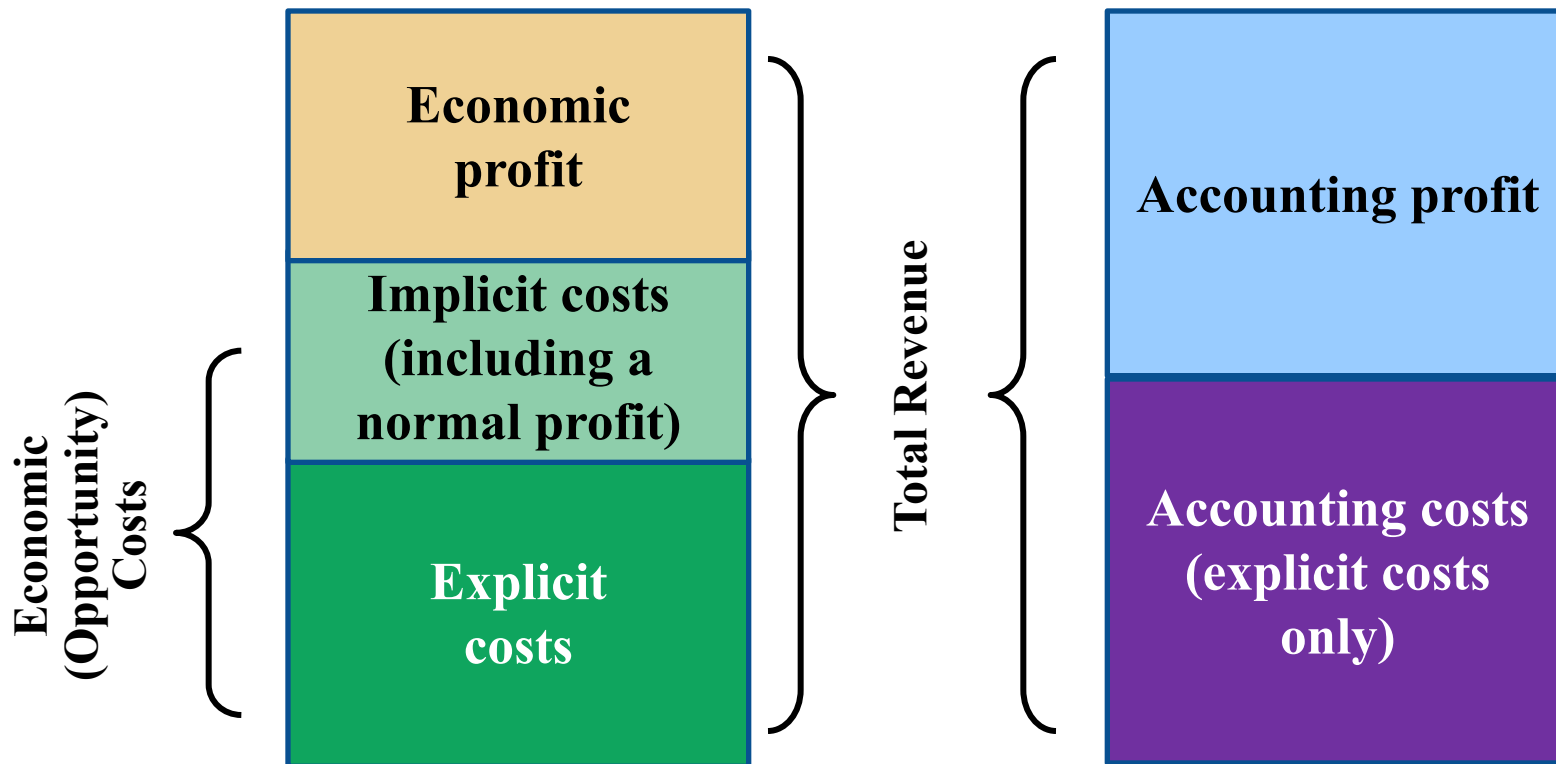
Short Run and Long Run

- Short Run
  - Some variable inputs
  - Fixed plant
- Long Run
  - All inputs are variable
  - Variable plant
  - Firms enter and exit
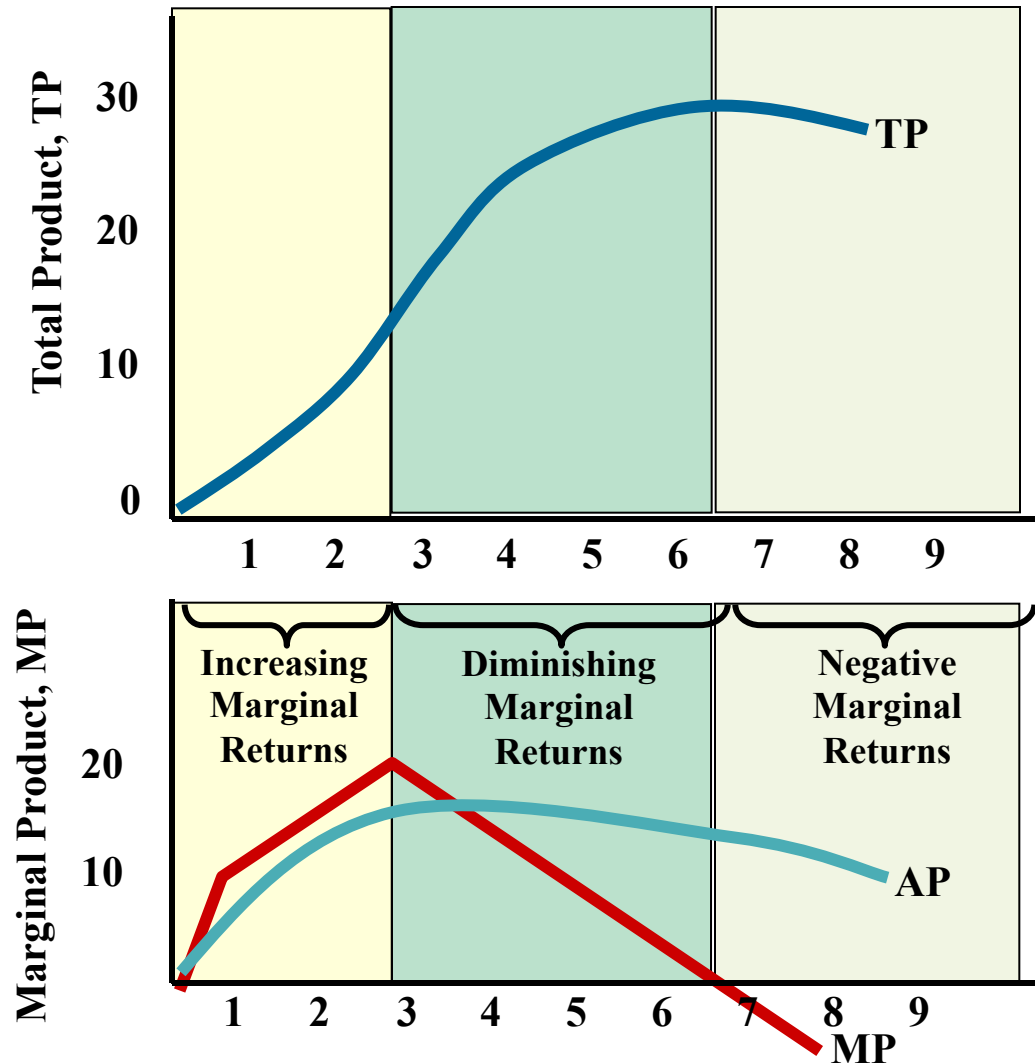
Short-Run Production Relationships

- Total Product (TP)
- Marginal Product (MP)

$$\text{Marginal Product} = \frac{\text{Change in Total Product}}{\text{Change in Labor Input}}$$

- Average Product (AP)

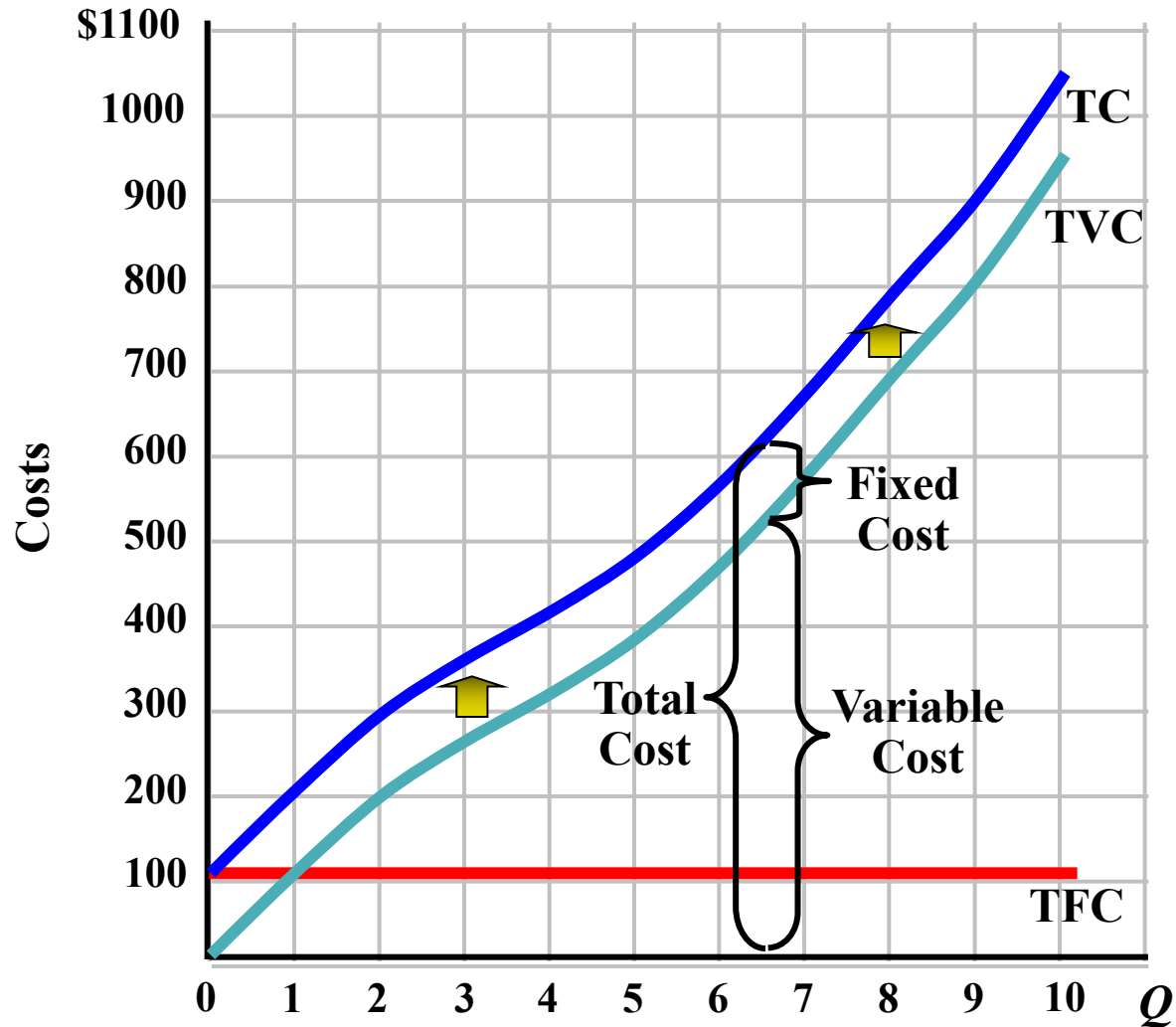$$\text{Average Product} = \frac{\text{Total Product}}{\text{Units of Labor}}$$

The Law of Diminishing Returns

Short-Run Production Costs

- Fixed Costs (TFC)
  - Costs do not vary with output
- Variable Costs (TVC)
  - Costs vary with output
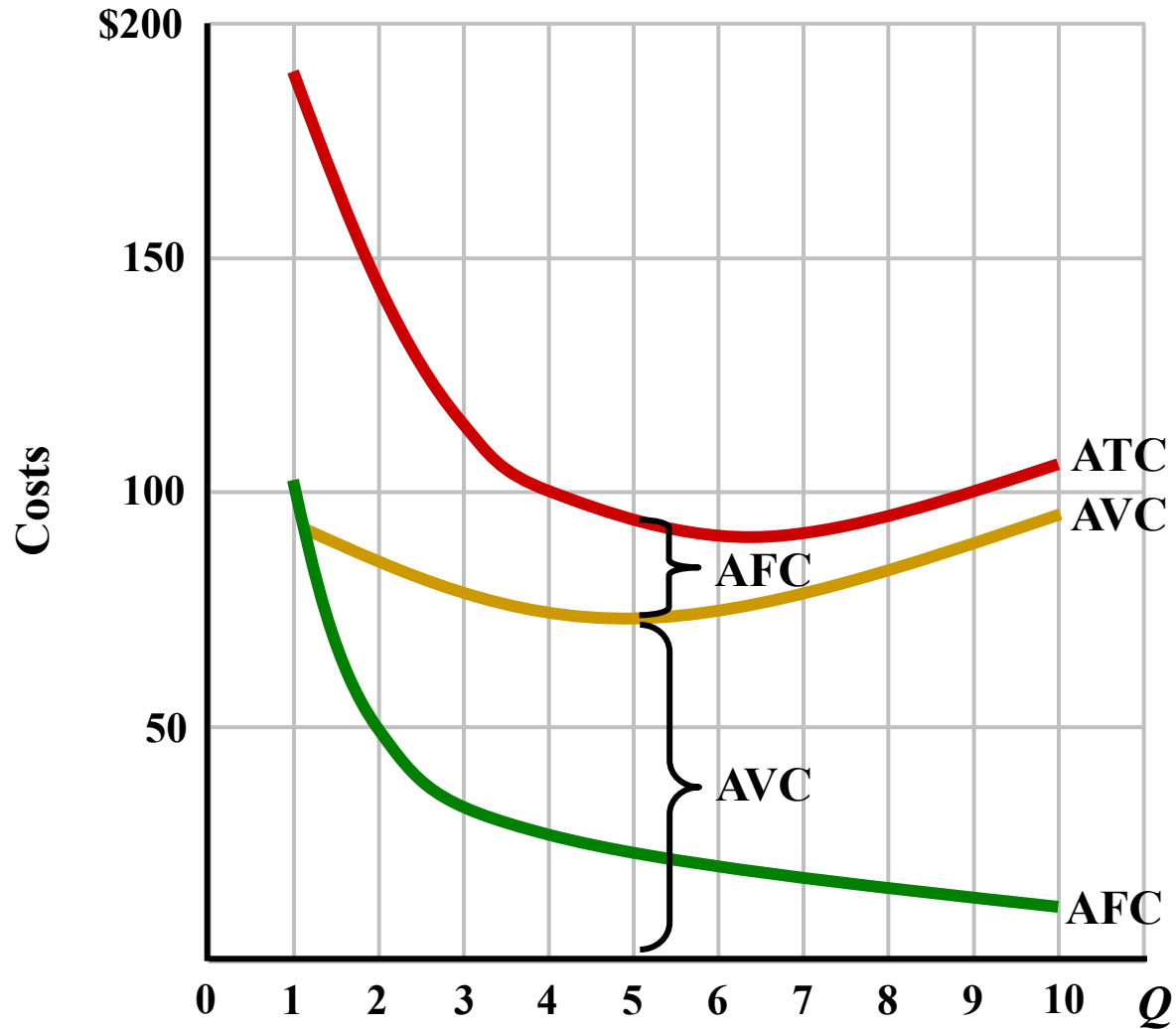- Total Costs (TC)
  - Sum of TFC and TVC
  - TC = TFC + TVC
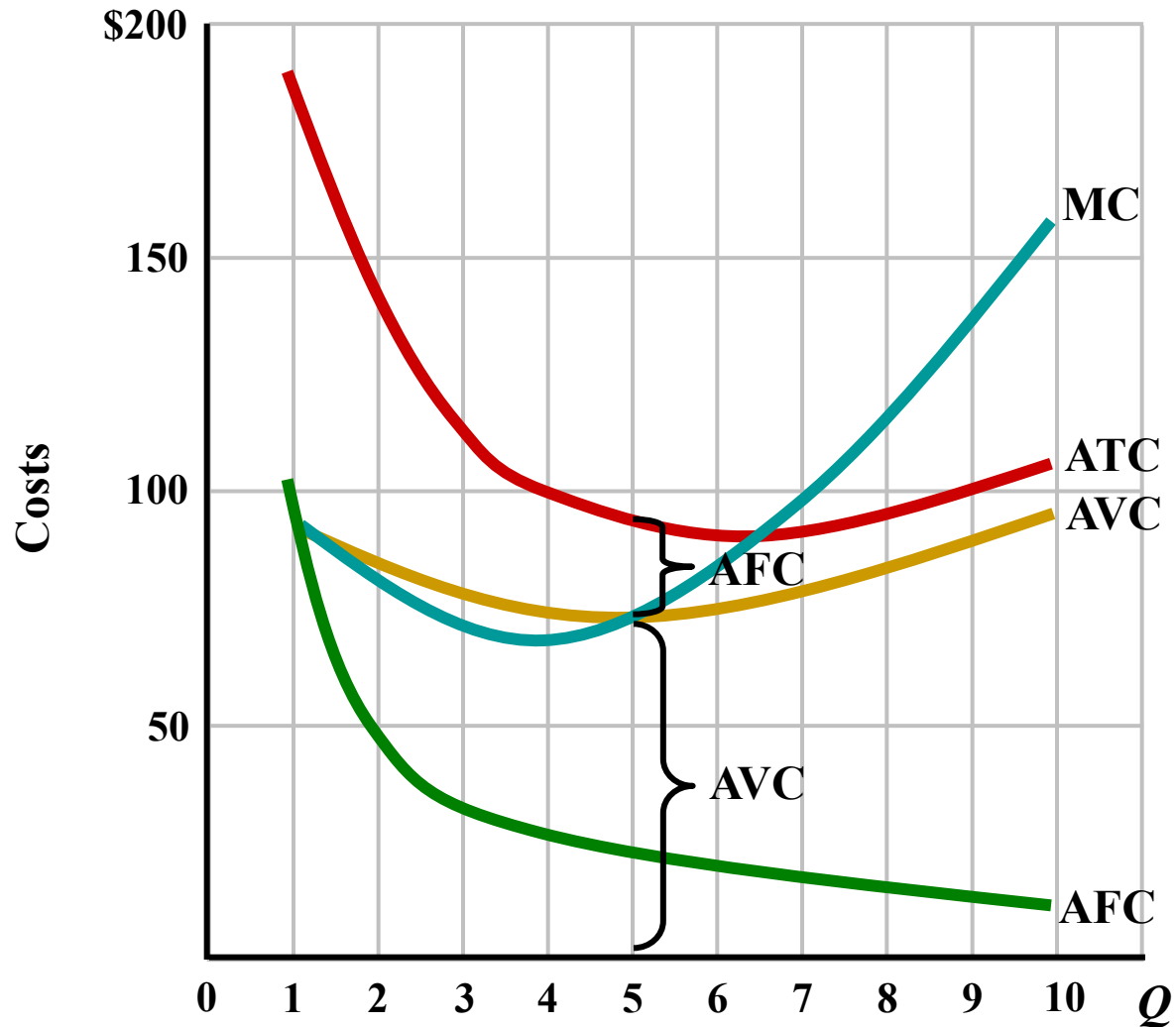
Short-Run Production Costs

Per-Unit, or Average, Costs

- Average Fixed Costs   AFC = TFC/Q

- Average Variable Costs   AVC = TVC/Q

- Average Total Costs   ATC = TC/Q

- Marginal Costs   MC = ΔTC/ΔQ
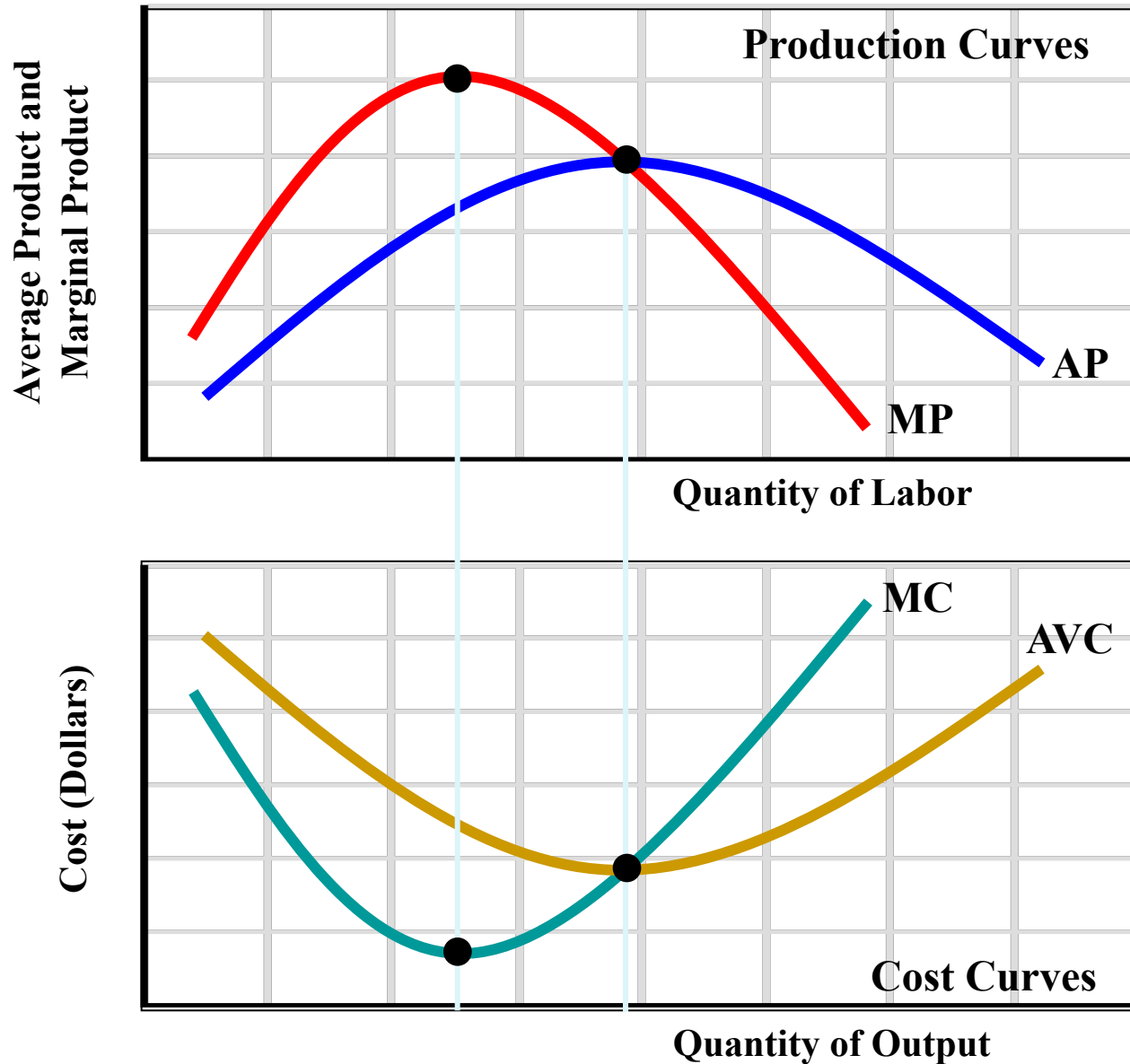
Per-Unit, or Average, Costs

Marginal Cost

MC and Marginal Product

Production Curves

Average Product and Marginal Product

AP

MP

Quantity of Labor

MC

AVC

Cost (Dollars)

Cost Curves

Quantity of Output
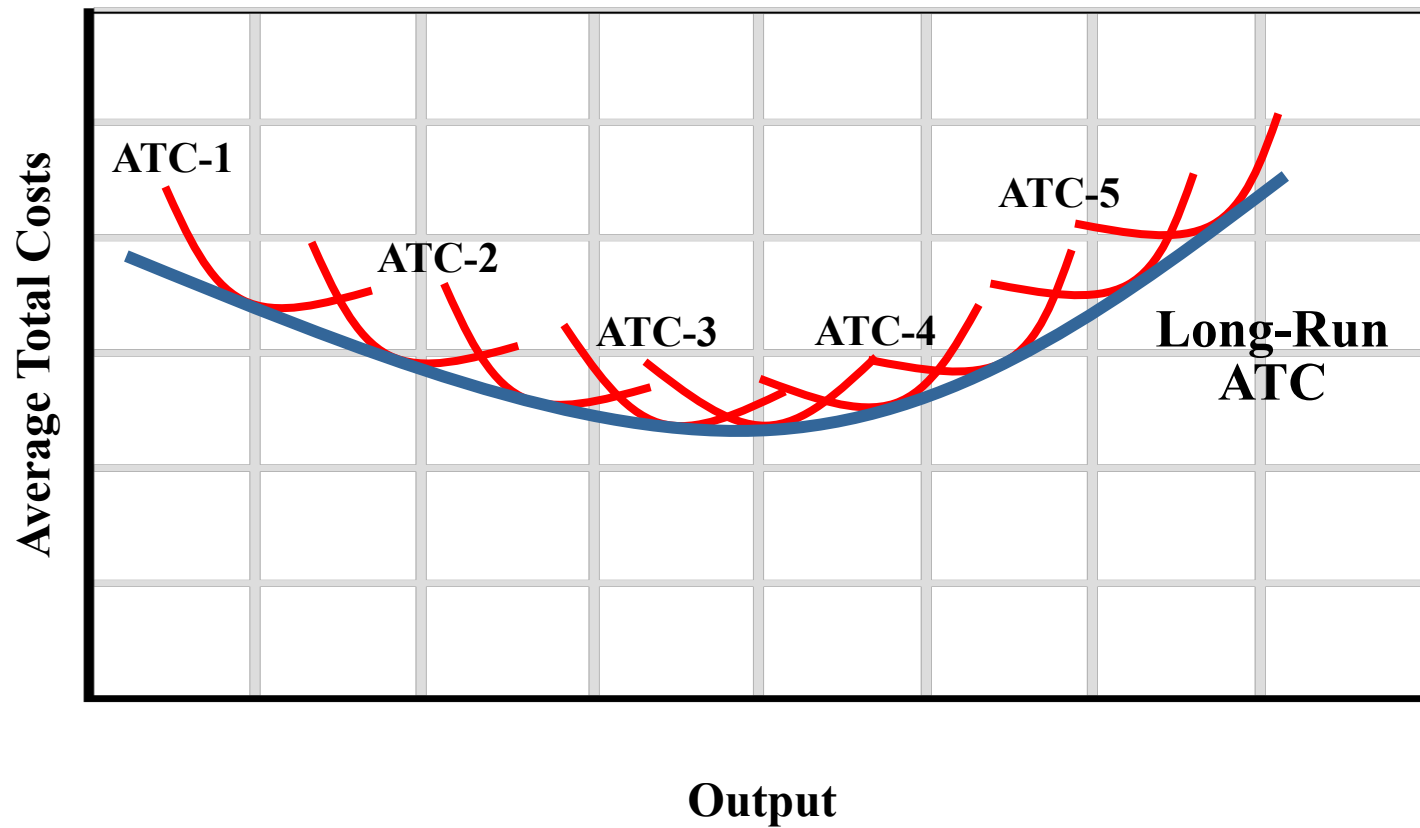
Long-Run Production Costs

- The firm can change all input amounts, including plant size.

- All costs are variable in the long run.

- Long run ATC
  - Different short run ATCs

The Long-Run Cost Curve

Economies and Diseconomies of Scale

- Economies of scale
    - Labor specialization
    - Managerial specialization
    - Efficient capital
    - Other factors
- Constant returns to scale

Economies and Diseconomies of Scale

- Diseconomies of scale
  - Control and coordination problems
  - Communication problems
  - Worker disaffection
  - Shirking

MES and Industry Structure

- Minimum Efficient Scale (MES):
  - Lowest level of output where long- run average costs are minimized
  - Can determine the structure of the industry

MES and Industry Structure
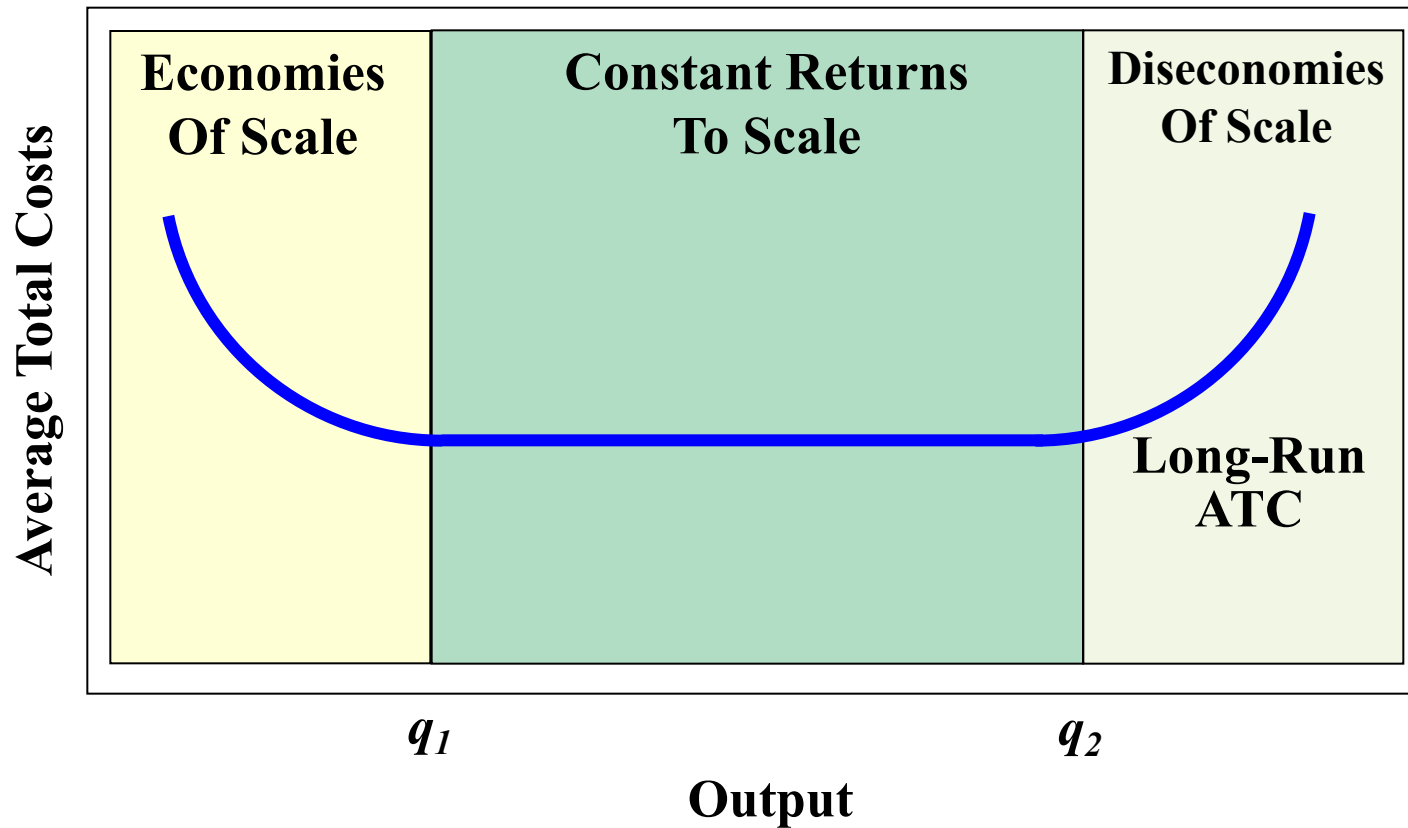
The Revenue of a Firm

- Total revenue for a firm is the *selling price* times the *quantity sold*.

$$TR = (P \times Q)$$

Total revenue is proportional to the amount of output.

The Revenue

- *Average revenue* tells us how much revenue a firm receives for the typical unit sold.

- Average revenue is total revenue divided by the quantity sold.

Revenue

- In perfect competition, average revenue equals the price of the good.

$$\text{Average Revenue} = \frac{\text{Total revenue}}{\text{Quantity}}$$

$$= \frac{\text{Price} \times \text{Quantity}}{\text{Quantity}}$$

$$= \text{Price}$$

MR
When There are Many Competitors

P

P*

S

D

Market for Memory

P

P*=Marginal Revenue

Our Firm
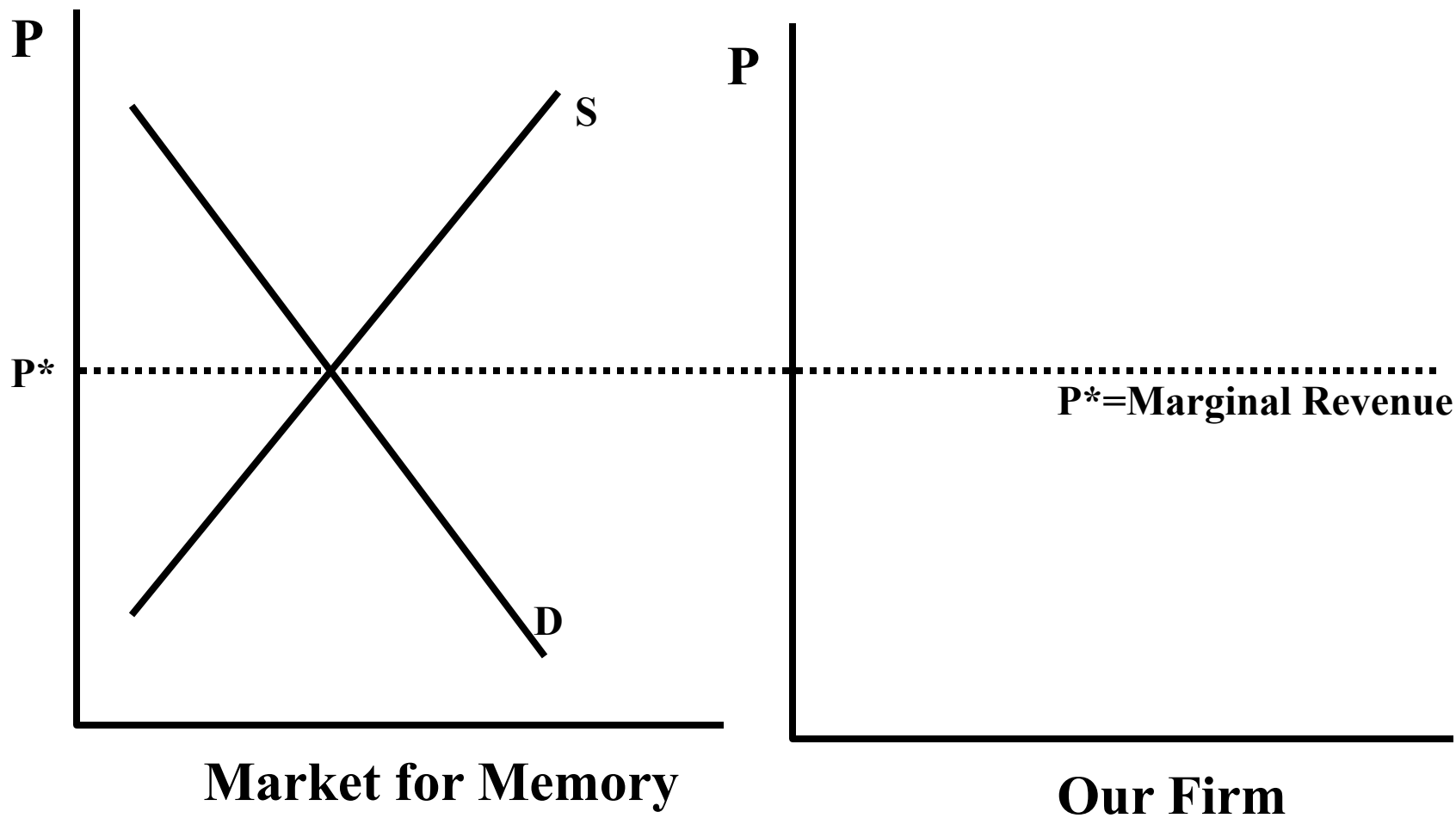
Marginal Revenue
When there are No Competitors

P

MR   AR=D

Market for Memory
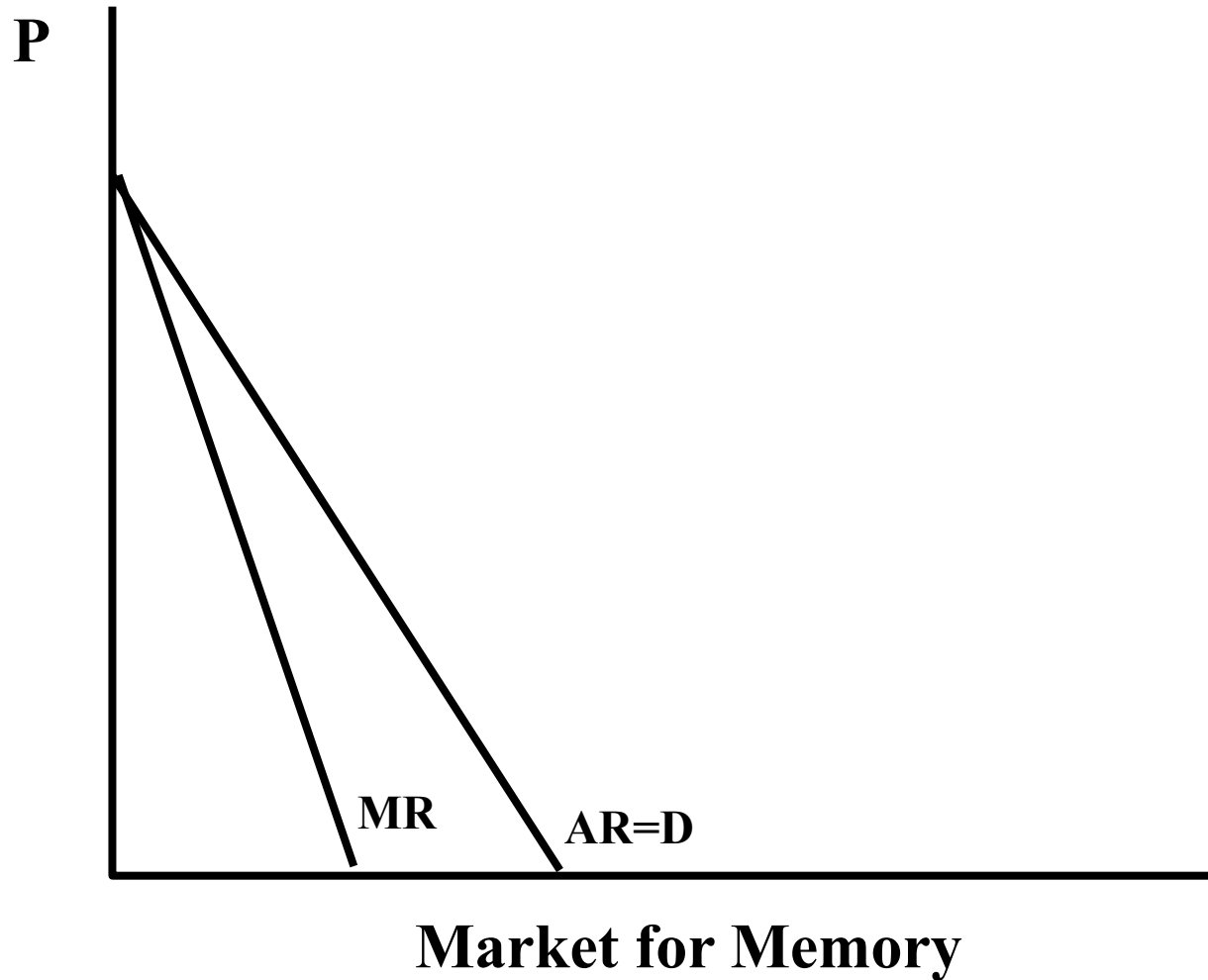
The Revenue

- *Marginal revenue* is the change in total revenue from an additional unit sold.

$$MR = \Delta TR / \Delta Q$$

PROFIT MAXIMIZATION AND THE COMPETITIVE FIRM'S SUPPLY CURVE

- The goal of a competitive firm is to maximize profit.

- This means that the firm will want to produce the quantity that maximizes the *difference between total revenue and total cost*.

PROFIT MAXIMIZATION AND THE COMPETITIVE FIRM'S SUPPLY CURVE

- Profit maximization occurs at the quantity where *marginal revenue equals marginal cost.*

PROFIT MAXIMIZATION AND THE COMPETITIVE FIRM'S SUPPLY CURVE

- **When *MR* > *MC* increase *Q***
- **When *MR* < *MC* decrease *Q***
- **When *MR* = *MC* Profit is maximized.**

The Firm's Short-Run Decision to Shut Down

- A *shutdown* refers to a short-run decision not to produce anything during a specific period of time because of current market conditions.
- *Exit* refers to a long-run decision to leave the market.

The Firm's Short-Run Decision to Shut Down

- The firm considers its *sunk costs* when deciding to exit, but ignores them when deciding whether to shut down.

  - *Sunk costs* are costs that have already been committed and cannot be recovered.

The Firm's Short-Run Decision to Shut Down

- The firm shuts down if the revenue it gets from producing is less than the variable cost of production.
  - Shut down if $TR < VC$
  - Shut down if $TR/Q < VC/Q$
  - Shut down if $P < AVC$

The Firm's Short-Run Decision to Shut Down

- The portion of the marginal-cost curve that lies above average variable cost is the competitive firm's *short-run supply curve.*

The Firm's Long-Run Decision to Exit or Enter a Market

- In the long run, the firm exits if the revenue it would get from producing is less than its total cost.
  - Exit if $TR < TC$
  - Exit if $TR/Q < TC/Q$
  - Exit if $P < ATC$

The Firm's Long-Run Decision to Exit or Enter a Market

- A firm will enter the industry if such an action would be profitable.
  - Enter if $TR > TC$
  - Enter if $TR/Q > TC/Q$
  - Enter if $P > ATC$

Example
For the Many Competitors Case

Q	P	TR	MR*
0	45		
100	45		
200	45		
300	45		
400	45		
500	45		
600	45		
700	45		
800	45		
900	45		
1000	45		

* MR is per 100

Example
For the Many Competitors Case

Q	P	TR	MR*
0	45	0	
100	45	4,500	45
200	45	9,000	45
300	45	13,500	45
400	45	18,000	45
500	45	22,500	45
600	45	27,000	45
700	45	31,500	45
800	45	36,000	45
900	45	40,500	45
1000	45	45,000	45

* MR is per 100

Example: No Competitors Case

Q	P	TR	MR*
0	75		
100	70		
200	65		
300	60		
400	55		
500	50		
600	45		
700	40		
800	35		
900	30		
1000	25		

Example: No Competitors Case

Q	P	TR	MR*
0	75	0	
100	70	7,000	70
200	65	13,000	60
300	60	18,000	50
400	55	22,000	40
500	50	25,000	30
600	45	27,000	20
700	40	28,000	10
800	35	28,000	0
900	30	27,000	-10
1000	25	25,000	-20

Maximizing Profit

- Assume that firms wish to maximize profits

Market Forms

- **Perfect Competition:** a situation in a market where there are many firms producing the same good

- **Monopoly**: a situation in a market where there is only one firm producing the good

Rules of Production

- A firm should

  a) produce an amount such that Marginal Revenue equals Marginal Cost (MR=MC),

  unless

  b) the price is less than the average variable cost (P<AVC).

Example of Profit Maximization With Many Competitors

Q	P	TR	TC	MR	MC	Profit
0	45	0	8,500			
100	45	4,500	11,000	45	25	
200	45	9,000	12,300	45	13	
300	45	13,500	13,300	45	10	
400	45	18,000	14,500	45	12	
500	45	22,500	16,000	45	15	
600	45	27,000	18,000	45	20	
700	45	31,500	21,000	45	30	
800	45	36,000	25,500	45	45	
900	45	40,500	31,000	45	55	
1000	45	45,000	41,000	45	75	

Example of Profit Maximization With Many Competitors

Q	P	TR	TC	MR	MC	Profit
0	45	0	8,500			
100	45	4,500	11,000	45	25	
200	45	9,000	12,300	45	13	
300	45	13,500	13,300	45	10	
400	45	18,000	14,500	45	12	
500	45	22,500	16,000	45	15	
600	45	27,000	18,000	45	20	
700	45	31,500	21,000	45	30	
800	45	36,000	25,500	45	45	
900	45	40,500	31,000	45	55	
1000	45	45,000	41,000	45	75	

Example of Profit Maximization With No Competitors

Q	P	TR	TC	MR	MC	Profit
0	75	0	8,500			-8,500
100	70	7,000	11,000	70	25	-6,500
200	65	13,000	12,300	60	13	-3,300
300	60	18,000	13,300	50	10	200
400	55	22,000	14,500	40	12	3,500
500	50	25,000	16,000	30	15	6,500
600	**45**	**27,000**	**18,000**	**20**	**20**	**9,000**
700	40	28,000	21,000	10	30	7,000
800	35	28,000	25,500	0	45	2,500
900	30	27,000	31,000	-10	55	-4,000
1000	25	25,000	41,000	-20	75	-16,000