

CHAPTER

12

Mathematical Methods for Economics



“The master economist must possess a rare combination of gifts. He must be mathematician, historian, statesman, philosopher to some degree”

- J.M.Keynes



LEARNING OBJECTIVES

- 1 To understand why mathematics is required for economics,
- 2 To learn the knowledge of mathematical methods, as a facility for self-expression not only in descriptive economics, but also in quantitative economics.



12.1

Introduction

Economic analysis is a systematic approach to (a) determine the optimum use of scarce resources and (b) choose available alternatives and select the best alternative to achieve a particular objective. Mathematical methods are helpful for achieving the objectives of the economic analysis.

12.1.1 Why Study Mathematics?

The subject Economics deals with many quantitative variables and functions, in consumption, production, distribution and

policy making. Hence, the mathematical methods would help economists to use the quantitative variables in a better way and to obtain accurate results.

The lengthy and descriptive economic contents can be clearly set in simple notation in mathematical models for clear and easy understanding. For example, **the number of pens demanded in a given time period in a Higher Secondary School is 200 when price is zero. This decreases by 10 for every ₹1 rise in the price of pen.** It is expressed mathematically as

$Q = 200 - 10P$, here Q is the quantity demanded and P is the price. Thus large information can be expressed and communicated with simple functions and equations.

12.1.2 Mathematics in Economics

Sir William Petty declared that he wanted to reduce political and economic matters in terms of number, weight and measure. He was the first one to use mathematics in economics. The first known writer to apply mathematical method to economic problems was Giovanni Ceva (1711), an Italian.



Sir William Petty
1623-1687

12.1.3 Uses of Mathematical Methods in Economics

1. Mathematical Methods help to present the economic problems in a more precise form.
2. Mathematical Methods help to explain economic concepts.
3. Mathematical Methods help to use a large number of variables in economic analyses.
4. Mathematical Methods help to quantify the impact or effect of any economic activity implemented by Government or anybody. There are of course many other uses.



Think and Do

- Who is the father of Economics? Did he use any of the mathematical tools in his contributions? If yes, list out.
- Find out the mathematical tools, which are used by you in your daily routine life.

12.2

Functions

12.2.1 Definition

A function is a mathematical relationship in which the values of a dependent variable are determined by the values of one or more independent variables.

Functions with a single independent variable are called Simple Univariate functions. There is a one to one correspondence. Functions, with more than one independent variable, are called Multivariate functions. The independent variable is often designated by X . The dependent variable is often designated by Y . For example, Y is function of X which means Y depends on X or the value of Y is determined by the value of X . Mathematically one can write $Y = f(X)$.

12.2.2 Linear Equation

A statement of relationship between two quantities is called an equation. In an equation, if the largest power of the independent variable is one, then it is called as Linear Equation. Such equations when graphed give straight lines. For example $Y = 100 - 10X$.

For a straight line, there are two variables namely X and Y . X is called independent variable and Y is called dependent variable.

When ' X ' value increases by one unit, then the corresponding change in the ' Y ' value is called as the slope of the line. Slope of the line is obtained by the formula,

$$m = \text{slope (marginal change)}$$

$$m = \frac{Y_2 - Y_1}{X_2 - X_1}, \frac{\text{Change in } Y}{\text{Change in } X}$$

Where (X_1, Y_1) and (X_2, Y_2) are two arbitrary points

Slope or Gradient of the line represents the ratio of the changes in vertical and horizontal lines.

The formula for constructing a straight line is

$$(Y - Y_1) = m(X - X_1)$$

If the two points are $(0, 0)$ and (X, Y) then the formula is $Y = mX$

Example 12.1

Find the equation of a straight line which passes through two points $(2, 2)$ and $(4, -8)$ which are (X_1, Y_1) and (X_2, Y_2) respectively.

Note: For drawing a straight line, at least two points are required. Many straight lines can pass through a single point.

Solution

Here $X_1 = 2, Y_1 = 2$
 $X_2 = 4, Y_2 = -8$

Formula for construction of straight line

$$\frac{Y - Y_1}{Y_2 - Y_1} = \frac{X - X_1}{X_2 - X_1}$$

Applying the values

$$\frac{Y - 2}{-8 - 2} = \frac{X - 2}{4 - 2}$$

$$\frac{Y - 2}{-10} = \frac{X - 2}{2}$$

$$2(Y - 2) = -10(X - 2)$$

$$2Y - 4 = -10X + 20$$

$$2Y = -10X + 24$$

$$Y = -5X + 12$$

-5 is slope, denoted by **m**

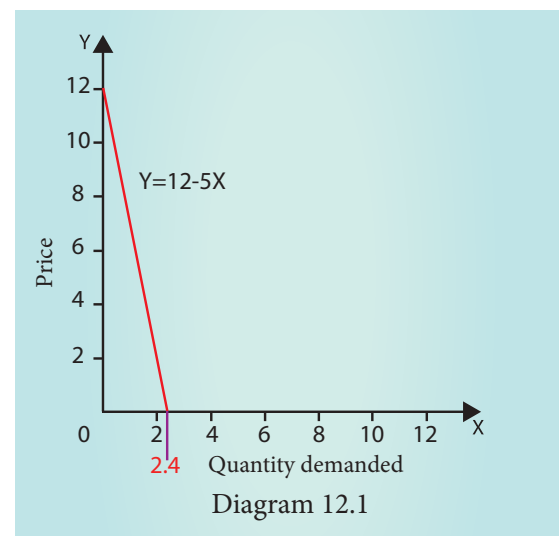
12 is **Y** intercept, or constant denoted by **c**

This is of the form $Y = mX + c$

$Y = 12 - 5X$ when $X = 0$; $Y = 12$

When $Y = 0$; $X = 12/5 = 2.4$

(This line looks like demand line in micro economics)



12.2.3 Application in Economics

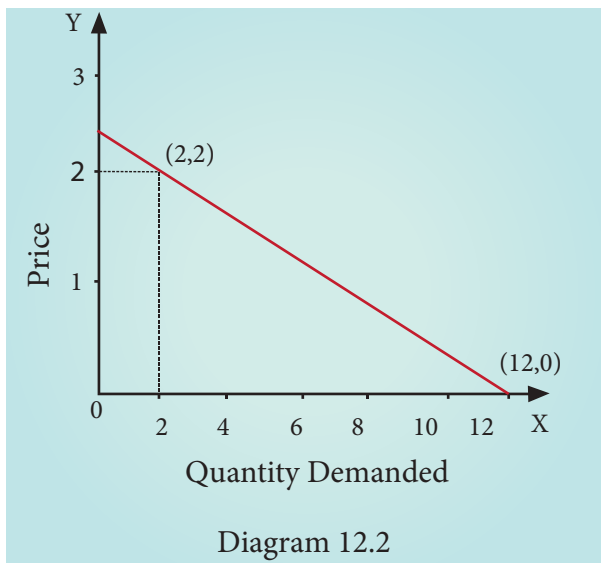
By applying the above method, the demand and supply functions are obtained.

Demand Function: $Q_d = f(P_x)$ where Q_d stands for Quantity demand of a commodity and P_x is the price of that commodity.

Supply Function: $Q_s = f(P_x)$ where ' Q_s ' stands for Quantity supplied of a commodity and P_x is the price of that commodity.

In the example 12.1 the equation $Y = -5X + 12$ has been obtained. It is a linear function. Since slope is negative here, this function could be a demand function.

Demand Line



Price-quantity relationship is negative in demand function. $Q_d = 12 - 5X$ or $Q_d = 12 - 5P$. If $P = 2$, $Q_d = 2$.

When P assumes 0, only 12 alone remains in the equation. This is called Intercept or Constant, if $P = 0$ and $Q_d = 12$.

In Marshallian analysis, money terms measured in Y-axis and physical units are measured in X-axis. Accordingly, price is measured in Y-axis and quantity demanded is measured in X-axis

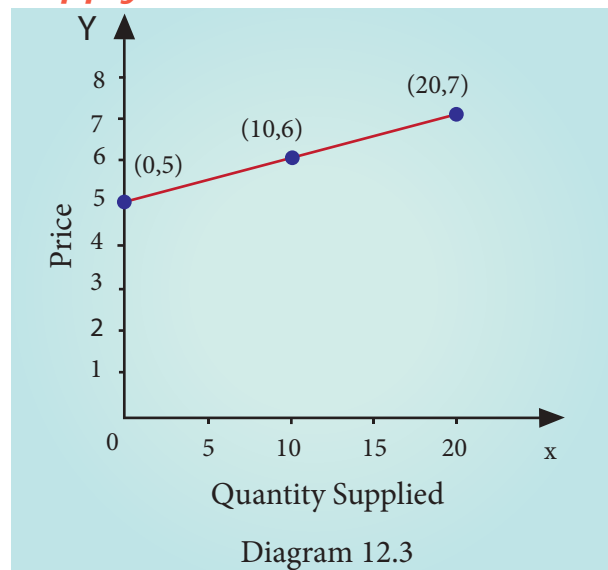
Example: 12.2

Find the supply function of a commodity such that the quantity supplied is zero, when the price is ₹5 (or below) and the supply (quantity) increases continuously at the constant rate of 10 units for each one rupee rise when the price is above ₹5.

Solution:

To construct the linear supply function at least two points are needed. First data point of supply function is obtained from the statement that the quantity supplied is zero, when the price is ₹5, that is (0, 5). The second and third data points of

Supply Line



supply function can be obtained from the statement that supply increases 10 units for each one rupee rise in price, that is (10, 6) & (20, 7).

When $p = 5$, supply is zero. When $p = 6$, supply is 10 and so on. When p is less than 5, say 4, supply is -10, which is possible in mathematics. But it is meaningless in Economics. Normally supply curve originates from zero, noting that when price is zero, supply is also zero.

The equation of the straight line joining two data points (10, 6) and (20, 7) is given as

The equation of the straight line is

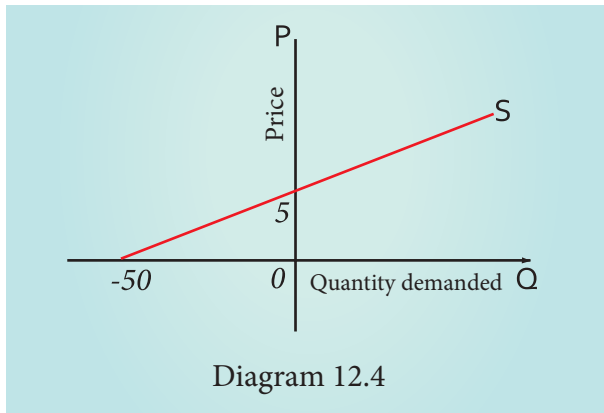
$$\frac{Y - Y_1}{Y_2 - Y_1} = \frac{X - X_1}{X_2 - X_1}$$

substituting the values of (x_1, y_1) (x_2, y_2)

by (10, 6), (20, 7) respectively,

$$\frac{Y - 6}{7 - 6} = \frac{X - 10}{20 - 10}$$

$$\frac{Y - 6}{1} = \frac{X - 10}{10}$$



Then
$$Y - 6 = \frac{X - 10}{10}$$

$$10(Y - 6) = X - 10$$

$$10Y - 60 = X - 10$$

$$10Y - 60 + 10 = X$$

$$10Y - 50 = X$$

$$-X = -10Y + 50$$

Multiplying both sides by minus (-), we get

$$X = -50 + 10Y$$

Considering X as quantity supplied and Y as price (P)

Then $X = 10P - 50$ (or)

$$X = -50 + 10P$$

If Price = 0; Q = -50

If Q = 0; P = 5

Note: The coefficient of 'P' is - in demand function.

The coefficient of 'P' is + in supply function.

12.2.4 Equilibrium

The point of intersection of demand line and supply line is known as equilibrium. The point of equilibrium is obtained by using the method of solving a set of equations. One can obtain the values of two unknowns with two equations. At equilibrium point,

Demand = Supply

(These are hypothetical examples)

$$100 - 10P = 50 + 10P$$

$$100 - 50 = 20P$$

$$50 = 20P$$

$$\frac{50}{20} = P$$

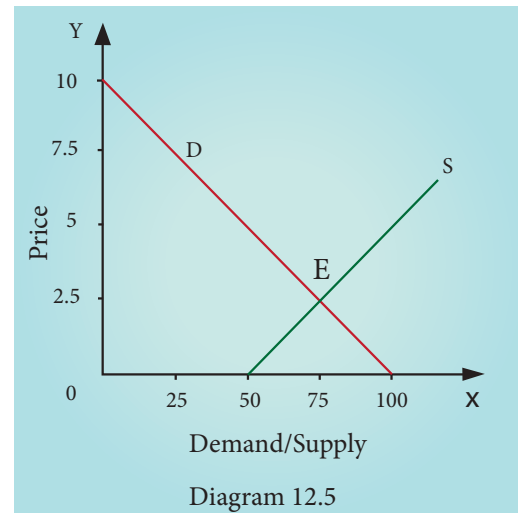
$$P = 2.5$$

When $P = 2.5$, Demand = $100 - 10(2.5)$
= 75

When $P = 2.5$, Supply = $50 + 10(2.5)$
= 75

Example: 12.3

Find the equilibrium price and quantity by using the following demand and supply functions $Q_d = 100 - 5P$ and $Q_s = 5P$ respectively.



Solution:

Equilibrium is attained when,

$$Q_s = Q_d$$

$$5P = 100 - 5P$$

$$10P = 100$$

$$P = 10$$

When $P = 10$

In supply function

$$Q_s = 5P = 5 \times 10 = 50$$

In demand function,

$$Q_d = 100 - 5P = 100 - 5(10) = 50$$

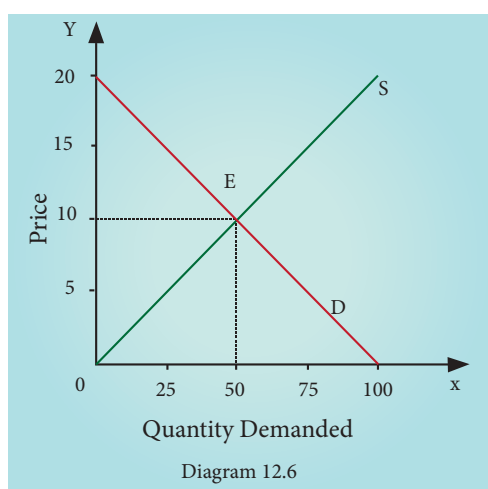
Hence at

$$P = 10, Q_d = 50, Q_s = 50.$$

Quantity demanded is equal to supply at 50 units when price is ₹10

Example: 12.4

The market demand curve is given by $D = 50 - 5P$. Find the maximum price beyond which nobody will buy the commodity.



Solution:

Given

$$Q_d = 50 - 5P$$

$$5P = 50 - Q_d$$

$$5P = 50 \text{ when } Q_d \text{ is zero.}$$

$$P = \frac{50}{5}$$

$$P = 10 \text{ When } P = 10, \text{ Demand is } 0$$

Hence $P = 10$, which is the maximum price beyond which nobody will demand the commodity.

Example: 12.5

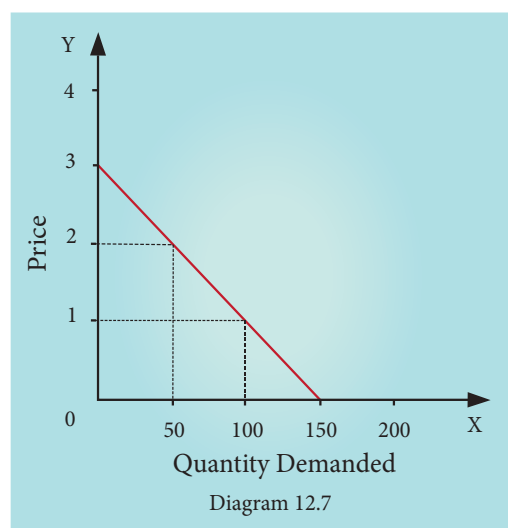
The demand for milk is given by

Price (Y)	1	2	3
Demand (X)	100	50	0

Find the linear demand function and its slope.

Solution:

Equation of demand function joining two data points $(100, 1)$ and $(50, 2)$ are (x_1, y_1) and (x_2, y_2) respectively.



$$\frac{Y - Y_1}{Y_2 - Y_1} = \frac{X - X_1}{X_2 - X_1}$$

$$\frac{Y - 1}{2 - 1} = \frac{X - 100}{50 - 100}$$

$$\frac{Y - 1}{1} = \frac{X - 100}{-50}$$

$$-50(Y - 1) = 1(X - 100)$$

$$-50Y + 50 = X - 100$$

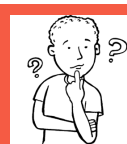
$$-50Y + 50 + 100 = X$$

$$-50Y + 150 = X$$

$$X = 150 - 50Y$$

Hence the demand function is

$$Q_d = 150 - 50P \text{ and Slope } m = -50$$



Think and Do for Water Management in your area

Try to find the demand function for water in your street and the daily total demand for water in litre for all purposes.

12.3

Matrices

12.3.1 Matrices

'Matrix' is a singular while 'matrices' is a plural form. Matrix is a rectangular array of numbers systematically arranged in rows and columns within brackets. In a matrix, if the number of rows and columns are equal, it is called a square matrix.

12.3.2 Determinants

For every square matrix, there exists a determinant. This determinant is an arrangement of same elements of the corresponding matrix into rows and columns by enclosing vertical lines.

For example,

$\begin{pmatrix} 1 & 3 & 5 \\ 6 & 2 & 4 \\ 7 & 8 & 9 \end{pmatrix}$ is a square matrix of order 3 x 3, then

$\begin{vmatrix} 1 & 3 & 5 \\ 6 & 2 & 4 \\ 7 & 8 & 9 \end{vmatrix}$ is a determinant.

$\begin{pmatrix} 2 & 3 \\ 5 & 7 \end{pmatrix}$ is a square matrix of order 2 x 2, then

$\begin{vmatrix} 2 & 3 \\ 5 & 7 \end{vmatrix}$ is a determinant.

In general, if $A = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix}$ is a matrix then,

$\begin{vmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{vmatrix}$ is a determinant of the

matrix A denoted by $|A|$.

The value of the determinant is expressed as a single number.

Calculation of the value of determinant for a 2 x 2 matrix is shown below

If $|A| = \begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix}$ then $|A| = a_1b_2 - a_2b_1$

Calculation of determinant value for a 3 x 3 matrix is shown below

$\begin{vmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix} = a_1 \begin{vmatrix} b_2 & c_2 \\ b_3 & c_3 \end{vmatrix} - b_1 \begin{vmatrix} a_2 & c_2 \\ a_3 & c_3 \end{vmatrix} + c_1 \begin{vmatrix} a_2 & b_2 \\ a_3 & b_3 \end{vmatrix}$
 $= a_1(b_2c_3 - b_3c_2) - b_1(a_2c_3 - a_3c_2) + c_1(a_2b_3 - a_3b_2)$

Example: 12.6

Find the value of the determinant for the matrix $A = \begin{pmatrix} 3 & 4 \\ 10 & -2 \end{pmatrix}$

Solution:

Given matrix $A = \begin{pmatrix} 3 & 4 \\ 10 & -2 \end{pmatrix}$ then, the Determinant

$$|A| = \begin{vmatrix} 3 & 4 \\ 10 & -2 \end{vmatrix} = 3(-2) - 10(4)$$

$= -6 - 40 = -46$ is the value of the determinant.

Example: 12.7

Find the value of the determinant of the matrix

$$A = \begin{pmatrix} 3 & 4 & 7 \\ 2 & 1 & 3 \\ 7 & 2 & 1 \end{pmatrix}$$

Solution:

Determinant of the given matrix is,

$$\begin{aligned} |A| &= \begin{vmatrix} 3 & 4 & 7 \\ 2 & 1 & 3 \\ 7 & 2 & 1 \end{vmatrix} = 3 \begin{vmatrix} 1 & 3 \\ 2 & 1 \end{vmatrix} - 4 \begin{vmatrix} 2 & 3 \\ 7 & 1 \end{vmatrix} + 7 \begin{vmatrix} 2 & 1 \\ 7 & 2 \end{vmatrix} \\ &= 3(1 - 6) - 4(2 - 21) \\ &\quad + 7(4 - 7) \\ &= 3(-5) - 4(-19) + 7(-3) \\ &= -15 + 76 - 21 \end{aligned}$$

$$|A| = 40$$

The value of determinant is 40.

12.3.3 Cramer's Rule



G. CRAMER
(1704-1752)

Cramer's rule provides the solution of a system of linear equations with 'n' variables and 'n' equations. It helps to arrive at a unique solution of a system of linear equations

with as many equations as unknowns.

If the given equations are

$$a_{11}x + a_{12}y + a_{13}z = b_1$$

$$a_{21}x + a_{22}y + a_{23}z = b_2$$

$$a_{31}x + a_{32}y + a_{33}z = b_3$$

then

$$x = \frac{\Delta_x}{\Delta}, \quad y = \frac{\Delta_y}{\Delta}, \quad z = \frac{\Delta_z}{\Delta}$$

$$\text{where, } \Delta = \begin{vmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{vmatrix}$$

$$\Delta_x = \begin{vmatrix} b_1 & a_{12} & a_{13} \\ b_2 & a_{22} & a_{23} \\ b_3 & a_{32} & a_{33} \end{vmatrix}, \Delta_y = \begin{vmatrix} a_{11} & b_1 & a_{13} \\ a_{21} & b_2 & a_{23} \\ a_{31} & b_3 & a_{33} \end{vmatrix},$$

$$\Delta_z = \begin{vmatrix} a_{11} & a_{12} & b_1 \\ a_{21} & a_{22} & b_2 \\ a_{31} & a_{32} & b_3 \end{vmatrix}$$

Key Note

If the determinant $\Delta = 0$, then solution does not exist.

Example: 12.8

Find the value of x and y in the equations by using Cramer's rule. $x + 3y = 1$ and $3x - 2y = 14$

Solution:

Given equations are

$$x + 3y = 1$$

$$3x - 2y = 14$$

Then the equations in the matrix form :

$$\begin{pmatrix} 1 & 3 \\ 3 & -2 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 1 \\ 14 \end{pmatrix}$$

$$\begin{aligned} \text{Calculating } \Delta, \quad \Delta &= \begin{vmatrix} 1 & 3 \\ 3 & -2 \end{vmatrix} \\ &= -2 - 9 \\ &= -11 \end{aligned}$$

$\Delta \neq 0$, Hence solution exists.

$$\Delta_x = \begin{vmatrix} 1 & 3 \\ 14 & -2 \end{vmatrix} = -2 - 42 = -44$$

$$\Delta_y = \begin{vmatrix} 1 & 1 \\ 3 & 14 \end{vmatrix} = 14 - 3 = 11$$

Hence $x = \frac{\Delta x}{\Delta} = \frac{-44}{-11} = 4$, $y = \frac{\Delta y}{\Delta} = \frac{11}{-11} = -1$
 $\therefore x = 4$ and $y = -1$

Answer checking:

Substituting in equation the values of x and y ,

$$4 + 3(-1) = 1,$$

$$3(4) - 2(-1) = 14$$

Example: 12.9

Find the solution of the system of equations.

$$5x_1 + 3x_2 = 30$$

$$6x_1 - 2x_2 = 8$$

Solution:

The coefficient and the constant terms are given below for the equations

$$\Delta = \begin{vmatrix} 5 & 3 \\ 6 & -2 \end{vmatrix} = -10 - 18 = -28$$

$$\Delta x_1 = \begin{vmatrix} 30 & 3 \\ 8 & -2 \end{vmatrix} = -60 - 24 = -84$$

$$\Delta x_2 = \begin{vmatrix} 5 & 30 \\ 6 & 8 \end{vmatrix} = +40 - 180 = -140$$

$$\therefore x_1 = \frac{\Delta x_1}{\Delta} = \frac{-84}{-28} = 3$$

$$x_2 = \frac{\Delta x_2}{\Delta} = \frac{-140}{-28} = 5$$

$$\therefore x_1 = 3, \quad x_2 = 5$$

Example: 12.10

Find the solution of the system of equation

$$7x_1 - x_2 - x_3 = 0$$

$$10x_1 - 2x_2 + x_3 = 8$$

$$6x_1 + 3x_2 - 2x_3 = 7$$

Solution:

The matrix form of the given equation is written as

$$\begin{bmatrix} 7 & -1 & -1 \\ 10 & -2 & 1 \\ 6 & 3 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 8 \\ 7 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 7 & -1 & -1 \\ 10 & -2 & 1 \\ 6 & 3 & -2 \end{vmatrix}$$

$$= 7(4-3) - (-1)(-20-6) + (-1)(30+12)$$

$$= 7(1) + 1(-26) - 1(42)$$

$$= 7 - 26 - 42 = -61$$

$$\Delta x_1 = \begin{vmatrix} 0 & -1 & -1 \\ 8 & -2 & 1 \\ 7 & 3 & -2 \end{vmatrix}$$

$$= 0(4-3) - (-1)(-16-7) + (-1)(24+14)$$

$$= 0 + 1(-23) - 1(38)$$

$$= -23 - 38 = -61$$

$$\Delta x_2 = \begin{vmatrix} 7 & 0 & -1 \\ 10 & 8 & 1 \\ 6 & 7 & -2 \end{vmatrix}$$

$$= 7(-16-7) - 0(-20-6) + (-1)(70-48)$$

$$= 7(-23) + 0 - 1(22)$$

$$= -161 - 22 = -183$$

$$\Delta x_3 = \begin{vmatrix} 7 & -1 & 0 \\ 10 & -2 & 8 \\ 6 & 3 & 7 \end{vmatrix}$$

$$= 7(-14-24) - (-1)(70-48) + 0(30+12)$$

$$= 7(-38) + 1(22) + 0$$

$$= -266 + 22 = -244$$

$$x_1 = \frac{\Delta x_1}{\Delta} = \frac{-61}{-61} = 1$$



$$x_2 = \frac{\Delta x_2}{\Delta} = \frac{-183}{-61} = 3$$

$$x_3 = \frac{\Delta x_3}{\Delta} = \frac{-244}{-61} = 4$$

12.3.4 Application in Economics

Example 12.11

Mr. Anbu, purchased 2 pens, 3 pencils and 1 note book. Mr. Barakath, purchased 4 pens, 3 pencils and 2 notebooks. Mr. Charles purchased 2 pens, 5 pencils and 3 notebooks. They spent ₹32, ₹52 and ₹60 respectively. Find the price of a pen, a pencil and a note book.

Solution:

Let x be the price of a pen, y be the price of a pencil and z be the price of a notebook,

In equations:

$$2x + 3y + 1z = 32,$$

$$4x + 3y + 2z = 52,$$

$$2x + 5y + 3z = 60$$

In matrix form

$$\begin{bmatrix} 2 & 3 & 1 \\ 4 & 3 & 2 \\ 2 & 5 & 3 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 32 \\ 52 \\ 60 \end{bmatrix}$$

$$\begin{aligned} \Delta &= 2(9 - 10) - 3(12 - 4) + 1(20 - 6) \\ &= 2(-1) - 3(8) + 1(14) \\ &= -2 - 24 + 14 = -12 \end{aligned}$$

To find Δ_x

$$\Delta_x = \begin{vmatrix} 32 & 3 & 1 \\ 52 & 3 & 2 \\ 60 & 5 & 3 \end{vmatrix}$$

$$\begin{aligned} \Delta_x &= 32(9 - 10) - 3(156 - 120) + 1(260 - 180) \\ &= 32(-1) - 3(36) + 1(80) \\ &= -32 - 108 + 80 = -60 \end{aligned}$$

To find Δ_y

$$\Delta_y = \begin{vmatrix} 2 & 32 & 1 \\ 4 & 52 & 2 \\ 2 & 60 & 3 \end{vmatrix}$$

$$\begin{aligned} \Delta_y &= 2(156 - 120) - 32(12 - 4) + 1(240 - 104) \\ &= 2(36) - 32(8) + 1(136) \\ &= 72 - 256 + 136 = -48 \end{aligned}$$

To find Δ_z

$$\Delta_z = \begin{vmatrix} 2 & 3 & 32 \\ 4 & 3 & 52 \\ 2 & 5 & 60 \end{vmatrix}$$

$$\begin{aligned} \Delta_z &= 2(180 - 260) - 3(240 - 104) + 32(20 - 6) \\ &= 2(-80) - 3(136) + 32(14) \\ &= -160 - 408 + 448 = -120 \end{aligned}$$

$$x = \frac{-60}{-12} = 5 \quad (\text{Price of a pen})$$

$$y = \frac{-48}{-12} = 4 \quad (\text{Price of a pencil})$$

$$z = \frac{-120}{-12} = 10 \quad (\text{Price of a notebook})$$

Answer checking

$$2(5) + 3(4) + 1(10) = 32$$

$$4(5) + 3(4) + 2(10) = 52$$

$$2(5) + 5(4) + 3(10) = 60$$



Think and Do

Fathima, purchased 6 pens and 5 Pencils spending ₹49, Rani purchased 3 Pens and 4 pencils spending ₹32. What is the price of a pen and pencil?

$$\begin{bmatrix} 6 & 5 \\ 3 & 4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 49 \\ 32 \end{bmatrix}$$

Solution : Price of a pen = ₹4

Price of a pencil = ₹5

12.4

DIFFERENTIAL CALCULUS

12.4.1 Meaning

The fundamental operation of calculus is differentiation. Derivative is used to express the rate of change in any function. Derivative means a change in the dependent variable with respect to small change (closer to zero) in independent variable.

Let the function be,

$$y = f(x)$$

Differentiating y with respect to x is,

$$\frac{d(y)}{dx} = \frac{df(x)}{dx}$$

12.4.2 Some Standard Forms of Differentiation

(Constant, addition and subtraction only)

1. $\frac{d(c)}{dx} = 0$ where C is a constant.

(Read differentiation of 'C' with respect to 'x' is)

2. $\frac{d(x^n)}{dx} = nx^{n-1}$

3. $\frac{d(x)}{dx} = 1x^{1-1} = 1x^0 = 1$

4. $\frac{d(u+v)}{dx} = \frac{du}{dx} + \frac{dv}{dx}$

5. $\frac{d(u-v)}{dx} = \frac{du}{dx} - \frac{dv}{dx}$

Key Note

If the power of any non-zero real number is zero, its value is 1
 $x^0 = 1$ when $x \neq 0$

Example: 12.12

If $Y = 4$, then find $\frac{dy}{dx}$

Solution:

$Y = 4$, here 4 is a constant. Differentiation of constant function is zero.

$$\text{So, } \frac{dy}{dx} = \frac{d(4)}{dx} = 0$$

Example: 12.13

Find the slope of the function $y = 6x^3$ for any value of x .

Solution:

Given $y = 6x^3$

$$\text{Slope} = \frac{dy}{dx}$$

$$\frac{dy}{dx} = 6(3)x^{3-1} = 18x^2 \text{ for any value of } x.$$

Example: 12.14

What is the slope of the function $y = 5x^4$ when $x = 10$?

Solution:

Given function $y = 5x^4$

$$\text{Slope} = \frac{dy}{dx}$$

$$\begin{aligned} \frac{dy}{dx} &= 5(4)x^{4-1} \\ &= 20x^3 \end{aligned}$$

$$\begin{aligned} \text{When } x = 10, \text{ then slope} &= 20(10)^3 \\ &= 20,000, \end{aligned}$$

Therefore Slope is 20,000.

Example: 12.15

Differentiate the function $Y = 3x^2 + 16x^3$ with respect to x .

Solution:

$$Y = 3x^2 + 16x^3$$

Differentiating,

$$\begin{aligned}\frac{dy}{dx} &= 3(2)x^{2-1} + 16(3)x^{3-1} \\ &= 6x^1 + 48x^2 \\ \frac{dy}{dx} &= 6x + 48x^2\end{aligned}$$

Example: 12.16

If $Y = 2x^3 - 6x$, then find $\frac{dy}{dx}$

Solution:

$$Y = 2x^3 - 6x$$

Differentiate 'y' with respect to x ,

$$\begin{aligned}\frac{dy}{dx} &= 2(3)x^{3-1} - 6(1)x^{1-1} \\ &= 6x^2 - 6x^0 \\ \frac{dy}{dx} &= 6x^2 - 6\end{aligned}$$

12.4.3 Application of Differential Calculus

The relation between two or more variables can be expressed by means of a function. Continuous functions alone are differentiable. For instance, the differential calculus is applicable for finding the following:

- (1) The rate of change in demand with respect to price (in micro economics)
- (2) The rate of change in income with respect to the investment. (in macroeconomics).

12.4.4 Marginal concepts

Marginal concept is concerned with variations of Y (on the margin of X), that is, it is the variation corresponding in Y to a very small variation in X . (X is the independent variable and Y is the dependent variable)

12.4.5 Marginal Product

Marginal product of a factor of production refers to addition to total product due to the use of an additional unit of a factor.

$$MP = d(TP)/dQ = \Delta TP/\Delta Q$$

12.4.6 Marginal Cost

Marginal cost is an addition to the total cost caused by producing one more unit of output. In symbols:

$$MC = \frac{d(TC)}{dQ} \text{ or } MC = \frac{\Delta(TC)}{\Delta Q}$$

Where, ΔTC represents a change in total cost and ΔQ represents a small change in output or quantity. (in economics one worker, one output etc are assumed to be very small units)

Example: 12.17

Given the total cost function, $TC = 15 + 3Q^2 + 7Q^3$, drive the marginal cost function.

Solution:

$$TC = 15 + 3Q^2 + 7Q^3$$

$$\begin{aligned}MC &= \frac{d(15)}{dQ} + \frac{d(3Q^2)}{dQ} + \frac{d(7Q^3)}{dQ} \\ &= 0 + 3(2)Q^{2-1} + 7(3)Q^{3-1}\end{aligned}$$

$$MC = 6Q + 21Q^2$$

12.4.7 Marginal Revenue

Marginal Revenue is the revenue earned by selling an additional unit of the product. In other words, Marginal Revenue is an addition made to the total revenue by selling one more unit of the good.

$$MR = \frac{d(TR)}{dQ} \text{ or } = \frac{\Delta TR}{\Delta Q}$$

Where ΔTR stands for change in the total revenue, and ΔQ stands for change in output.

Example: 12.18

Given $TR = 50Q - 4Q^2$, find marginal revenue when $Q = 3$.

Solution:

$$TR = 50Q - 4Q^2$$

$$MR = d(TR)/dQ$$

$$MR = 50(1)Q^{1-1} - 4(2)Q^{2-1}$$

$$= 50(1)Q^0 - 8Q^1$$

$$= 50(1) - 8Q \quad (\because Q^0 = 1, Q^1 = Q)$$

$$MR = 50 - 8Q$$

When $Q = 3$

$$MR = 50 - 8(3) = 26$$

Example: 12.19

A producer has the total cost function $TC(Q) = Q^3 - 18Q^2 + 91Q + 10$ where costs are given in rupees. Find the marginal cost (MC) and the average variable cost (AVC), when $Q = 3$.

Solution:

Given $TC(Q) = Q^3 - 18Q^2 + 91Q + 10$, To find MC differentiate the function with respect to Q .

$$MC(Q) = \frac{d(TC)}{dQ} = 3Q^{3-1} - 18(2)Q^{2-1}$$

$$+ 91(1)Q^{1-1} + 0$$

$$= 3Q^2 - 36Q + 91Q^0 + 0$$

$$MC(Q) = 3Q^2 - 36Q + 91 \quad (\because Q^0 = 1)$$

When $Q = 3$

$$MC(Q) = 3(3^2) - 36(3) + 91$$

$$= 3(9) - 108 + 91$$

$$= 27 - 108 + 91$$

$$= 118 - 108$$

$$= 10$$

To find AVC

$$\text{Given } TC(Q) = Q^3 - 18Q^2 + 91Q + 10$$

We know $TVC(Q) = Q^3 - 18Q^2 + 91Q$ (\because constant value is fixed cost)

$$AVC(Q) = TVC(Q)/Q$$

$$AVC(Q) = Q^2 - 18Q + 91$$

When $Q = 3$

$$AVC(Q) = 3^2 - 18(3) + 91$$

$$= 9 - 54 + 91$$

$$= 100 - 54 = 46$$

$$\therefore AVC(Q) = \frac{Q^3 - 18Q^2 + 91Q}{Q}$$

$$= Q^2 - 18Q + 91$$

Note : Fixed cost = 10

$$\text{Average fixed cost} = \frac{10}{Q}$$

$$\text{Average cost} = \frac{Q^3 - 18Q^2 + 91Q + 10}{Q}$$

$$= Q^2 - 18Q + 91 + \frac{10}{Q}$$

So Average cost = AVC + AFC

$$AC = AVC + AFC$$

$$AC = \frac{TC}{Q}$$

Example: 12.20

A manufacturer estimates that, when units of a commodity are produced each month the total costs will be $TC(Q) = 128 + 60Q + 8Q^2$. Find the marginal cost, average cost, fixed cost, variable cost, average fixed cost and average variable cost.

Solution:

Given that $TC(Q) = 128 + 60Q + 8Q^2$

We know $TC = \text{Fixed cost} + \text{variable cost}$

$$\begin{aligned} MC(Q) &= \frac{d(TC)}{dQ} \\ &= 0 + 60(1)Q^{1-1} + 8(2)Q^{2-1} \\ &= 0 + 60Q^0 + 16Q^1 (\text{Since, } Q^0=1) \end{aligned}$$

$$MC = 60 + 16Q$$

$$\begin{aligned} \text{Average Cost} &= \frac{TC}{Q} \\ &= \frac{128 + 60Q + 8Q^2}{Q} \end{aligned}$$

$$AC = \frac{128}{Q} + 60 + 8Q$$

Constant value is known as fixed cost

$$\text{Fixed cost} = 128$$

$$FC = 128$$

$$\text{Average Fixed cost} = \frac{128}{Q}$$

$$AFC = \frac{128}{Q}$$

Average Variable cost = $60 + 8Q$ (total variable cost divided by Q)

$$\therefore AVC = 60 + 8Q$$

12.4.8 Elasticity of Demand

Elasticity of Demand is the ratio of the proportionate change in quantity demanded to the proportionate change in price. In mathematical terms,

$$e_d = \left(\frac{P}{x}\right) \left(\frac{dx}{dp}\right)$$

In demand function $Q = a - bP$

$$e_d = (dQ/dP)(P/Q)$$

Example 12.21

If the demand function is $x = \frac{100}{P}$, find e_d with respect to price at the point where $P = 2$

Note

By taking supply function, the elasticity of supply can be calculated

Solution:

Given

$$\begin{aligned} x &= \frac{100}{P} = 100P^{-1} \\ \therefore \frac{dx}{dp} &= 100(-1)P^{-1-1} \\ &= 100(-1)P^{-2} \\ &= -100(P^{-2}) \\ &= \frac{-100}{P^2} \end{aligned}$$

At $P=2$,

$$\frac{dx}{dp} = \frac{-100}{4} = -25 \quad \text{and} \quad x = \frac{100}{2} = 50$$

Substituting the values in formula

$$\begin{aligned} e_d &= \frac{Pdx}{x dp} = \left(\frac{2}{50}\right) \left(\frac{-100}{4}\right) = \frac{-200}{200} = -1 \\ e_d &= -1 \end{aligned}$$

12.5

Integral Calculus

12.5.1 Integration

Differential calculus measures the rate of change of functions. In Economics it is also necessary to reverse the process of differentiation and find the function $F(x)$ whose rate of change has been given. This is called integration. The function $F(x)$ is termed an integral or anti-derivative of the function $f(x)$.

The integral of a function $f(x)$ is expressed mathematically as

$$\int f(x) dx = F(x) + C$$

Here the left hand side of the equation is read “the integral of $f(x)$ with respect to x ” The symbol \int is an integral sign, $f(x)$ is integrand, C is the constant of integration, and $F(x)+c$ is an indefinite integral. It is so called because, as a function of x , which is here unspecified, it can assume many values.

12.5.2 Meaning

If the differential coefficient of $F(x)$ with respect to x is $f(x)$, then an integral of $f(x)$ with respect to x is $F(x)$. It is a reverse process of differentiation. In symbols:

$$\text{If } \frac{d[F(x)]}{dx} = f(x), \text{ then } \int f(x) dx = F(x) + C$$

Following points need to be remembered:

- a. \int is used to denote the process of integration. In fact, this symbol is an elongated ‘S’ denoting sum.

- b. The differential symbol ‘ dx ’ is written by the side of the function to be integrated.

- c. $\int f(x) dx = F(x) + C$, C is the integral constant
 $\int f(x) dx$ means, integration of $f(x)$ with respect to x .

12.5.3 Basic Rule of Integration

- (i) Power Rule $\int x^n dx = \frac{x^{(n+1)}}{n+1} + C$
(ii) $\int k \cdot dx = kx + c$, where k is a constant
(iii) $\int a \cdot x^n dx = a \int x^n dx$

Example 12.22

$$\begin{aligned} \int 4x^3 dx &= 4 \int x^3 dx \\ &= 4 \frac{x^{3+1}}{3+1} + c \\ &= 4 \frac{x^4}{4} + c \\ &= x^4 + c \end{aligned}$$

Example 12.23

$$\begin{aligned} \int (x^2 + x - 1) dx &= \int x^2 dx + \int x dx - \int dx \\ &= \frac{x^{2+1}}{2+1} + \frac{x^{1+1}}{1+1} - x + c \\ &= \frac{x^3}{3} + \frac{x^2}{2} - x + c \end{aligned}$$

Example 12.24

$$\int 5dx = 5x + c$$

Example 12.25

$$\begin{aligned} \int 4x dx &= 4 \frac{x^{1+1}}{1+1} + c \\ &= 4 \frac{x^2}{2} + c \\ &= 2x^2 + c \end{aligned}$$

12.5.4 Application of Integration

Example 12.26

Let the marginal cost function of a firm be $100 - 10x + 0.1x^2$ where x is the output. Obtain the total cost function of the firm under the assumption that its fixed cost is ₹500.

Solution

$$MC = 100 - 10x + 0.1x^2$$

$$TC = \int (100 - 10x + 0.1x^2) dx$$

$$= 100x - 10 \frac{x^2}{2} + 0.1 \frac{x^3}{3} + c$$

$$= 100x - 5x^2 + \frac{x^3}{30} + c$$

Fixed cost is given as ₹500

$$\therefore TC = 100x - 5x^2 + \frac{x^3}{30} + 500$$

$$= \frac{x^3}{30} - 5x^2 + 100x + 500$$

Example 12.27

The marginal cost function for producing x units is $y = 23 + 16x - 3x^2$ and the total cost for producing zero unit is ₹40. Obtain the total cost function and the average cost function.

Solution:

Given the marginal cost function $y = 23 + 16x - 3x^2$; $c = 40$

₹40 is the fixed cost.

We know that

Total Cost function = \int (Marginal cost function) $dx + c$

$$TC = \int y dx + c$$

$$= \int (23 + 16x - 3x^2) dx + c, \text{ where } c \text{ is a constant}$$

$$= \int 23 dx + \int 16x dx - \int 3x^2 dx + c$$

$$= 23x + 16 \left[\frac{x^2}{2} \right] - 3 \left[\frac{x^3}{3} \right] + c$$

$$TC = 23x + 8x^2 - x^3 + c$$

$$c = 40 \text{ given}$$

$$\therefore TC = 23x + 8x^2 - x^3 + 40$$

$$\text{Average cost function} = \frac{TC}{x}$$

$$= 23 + 8x - x^2 + \frac{40}{x}$$

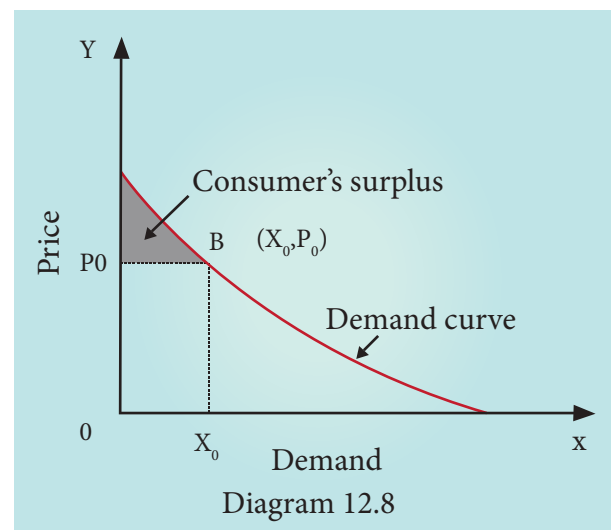
12.5.5 Consumer's Surplus

This theory was developed by the Alfred Marshall. The demand function $P(x)$ reveals the relationship between the quantities that the people would buy at given price. It can be expressed as

$$P = f(x)$$

Consumer surplus is the difference between the price one is willing to pay and the price that is actually paid.

It is represented in the following diagram.



Mathematically, the consumer's surplus (CS) can be defined as

CS = (Area under the demand curve from $x = 0$ to $x = x_0$) – (Area of the rectangle OX_0BP_0)

$$CS = \left[\int_0^{x_0} p(x) dx \right] - x_0 p_0$$

Example:12.28

If the demand function is $P = 35 - 2x - x^2$ and the demand x_0 is 3, what will be the consumer's surplus?

Solution

Given demand function,

$$P = 35 - 2x - x^2$$

for $x = 3$

$$P = 35 - 2(3) - 3^2$$

$$= 35 - 6 - 9$$

$$P = 20$$

Therefore,

CS = (Area of the curve below the demand curve from 0 to 3) – Area of the rectangle ($20 \times 3 = 60$)

$$\begin{aligned} CS &= \int_0^3 (35 - 2x - x^2) dx - (20 \times 3) \\ &= \left[35x - 2 \frac{x^2}{2} - \frac{x^3}{3} \right]_0^3 - 60 \\ &= 35(3) - 2 \left(\frac{3^2}{2} \right) - \frac{3^3}{3} - 60 \\ &= 105 - 9 - 9 - 60 \\ &= 27 \text{ Units.} \end{aligned}$$

12.5.6 Producer's surplus

$$PS = P_0 x_0 - \int_0^{x_0} g(x) dx$$

Example 12.29

Given the demand function $P_d = 25 - Q^2$ and the supply function $P_s = 2Q + 1$. Assuming pure competition, find (a) consumers surplus and (b) producers surplus. (P_d = Demand price; P_s = Supply price)

Solution:

For market equilibrium, $P_d = P_s$

$$25 - Q^2 = 2Q + 1$$

$$0 = -25 + Q^2 + 2Q + 1$$

$$0 = -24 + Q^2 + 2Q$$

$$Q^2 + 2Q - 24 = 0$$

$$Q^2 + 6Q - 4Q - 24 = 0$$

$$Q(Q + 6) - 4(Q + 6) = 0$$

$$(Q + 6)(Q - 4) = 0$$

So, $Q = 4$ or $Q = -6$. Since Q cannot be equal to -6 ,

$$Q = 4$$

When $Q=4$, $P_d = 25 - 4^2 = 9$;

$$P_s = 2(4) + 1 = 9$$

Consumers' surplus = $\int_0^4 (25 - Q^2) dQ - (9 \times 4)$

$$\begin{aligned} &= \left[25Q - \frac{Q^3}{3} \right]_0^4 - 36 \\ &= [(25)(4) - \frac{1}{3} (4)^3] - (0) - 36 \\ &= \left[100 - \frac{64}{3} \right] - (0) - 36 = 42.67 \end{aligned}$$

Producers' surplus PS

$$\begin{aligned} (PS) &= (9 \times 4) - \int_0^4 (2Q + 1) dQ \\ &= 36 - \left[(Q^2 + Q) \right]_0^4 \\ &= 36 - (16 + 4) = 16 \end{aligned}$$



Think and Do

- Find your change in mark by additional hour of study in any of your subject
- Find your consumption of petrol for an additional unit of kilometer travelled
- Ask your parents about their spending with respect to every additional unit of wage or salary or income

12.6

Information and Communication Technology (ICT)

Information and Communication Technology (ICT) is the infrastructure that enables computing faster and accurate. The following table gives an idea of range of technologies that fall under the category of ICT.

S.No	Information	Technologies
1	Creation	Personal Computers, Digital Camera, Scanner, Smart Phone
2	Processing	Calculator, PC, Smart Phone
3	Storage	CD, DVD, Pen Drive, Microchip, Cloud
4	Display	PC, TV, Projector, Smart Phone

S.No	Information	Technologies
5	Transmission	Internet, Teleconference, Video conferencing, Mobile Technology, Radio
6	Exchange	E mail, Cell phone

The evaluation of ICT has five phases. They are evolution in

- (a) Computer
- (b) PC
- (c) Microprocessor
- (d) Internet and
- (e) Wireless links

In Economics, the uses of mathematical and statistical tools need the support of ICT for data compiling, editing, manipulating and presenting the results. In general, SPSS and Excel packages are often used by researchers in economics. Such Software is designed to do certain user tasks. Word processor, spread sheet and web browser are some of the examples which are frequently used while undertaking analysis in the study of economics.

12.6.1 MS Word

MS word is a word processor, which helps to create, edit, print and save documents for future retrieval and reference.

The features of word processor are

- a) Document can be created, copied, edited and formatted.

- b) Words and sentences can be inserted, changed or deleted.
- c) Formatting can be applied.
- d) Margins and page size can be adjusted.
- f) Spell check can be availed.
- g) Multiple documents – files can be merged.

How to open a word Document?

One can open MSWord from various options.

Click start → All program → MS word or Double click the MS word icon from the desktop.

Uses of Menu

- Home menu → It is used to change the fonts, font size, change the text color and apply text style bold, italic, underline etc.
- Insert → It is used to insert page numbers, charts, tables, shapes, word art forms, equations, symbols and pictures.
- Page Layout → It is used to change the margin size, split the text into more columns, background colour of a page.
- Reference → Insert table of authors, endnote, footnote
- Review → Spell check, Grammar, Translate.
- View → Print layout, full screen reading, document view

12.6.2 Microsoft Office Excel

It is used in data analysis by using formula. A spread sheet is a large sheet of paper which contains rows and columns. The intersection of rows and columns is termed as 'cell'. MS Excel 2007 version supports up to 1 million rows and 16 thousand columns per work sheet.

Start

You can start excel from various options.

- Click Start → Program → Micro Soft Excel.
- Double Click the MS Excel Icon from the Desk top.

Work Sheet

A worksheet is a table like document containing rows and columns with data and formula. There are four kinds of calculation operators. They are arithmetic, comparison, text concatenation (link together) and reference. MS Excel helps to do data analysis and data presentation in the form of graphs, diagrams, area chart, line chart etc.

12.6.3 Microsoft Power Point

It is a software used to perform computer based presentation.

Steps involved in making presentation:

- (i) Click Start Menu
- (ii) Click Program

- (iii) Select Microsoft Power point – Click.
- (iv) New Power Point file will open, and then type the title and subtitle if wanted.
- (v) A new slide can be inserted by ‘click’ on icon ‘new slide’ or using short key ‘Ctrl + M’
- (vi) We can type the content, insert the table, pictures, movies, sounds, etc., with the content.
- (vii) Tab ‘Design’ helps to design the slides (can select common design for all slides or separate slide for each slide)
- (viii) Click icon slide show, one can run slide show either starting from the first slide or starting from the current slide.

The power point presentation (PPT) facilitates the key points to be kept in memory and understand the particular topic. Recently, the smart class room teaching uses the PPT to deliver the information in an effective way to enhance the quality of teaching.



Think and Do

- Make a Document with MS word on “Incredible India”.
- Prepare an Excel Sheet for your daily pocket expenses for each category/item in last month
- Prepare and present a “Power Point” for “Day out with your parents”

CONCLUSION

This chapter provide the knowledge of necessity of mathematics in economics by explaining the application of linear algebra, calculus and Information Communication and Technology. Specifically the knowledge of functions, matrices , differential calculus, Integral calculus ,MS word, MS Excel and Power Point Presentation are depicted with suitable applications. The activities are also added for students to learn it reality about the use of mathematical methods in economics.

FORMULAE

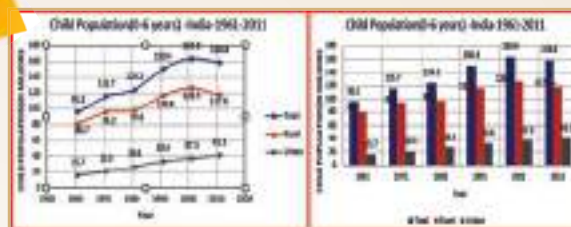
1. $m = \frac{y_2 - y_1}{x_2 - x_1}$ for Slope
2. $(y - y_1) = m (x - x_1)$ for straight Line
3. $|A| = a_1(b_2c_3 - b_3c_2) - a_2(b_1c_3 - b_3c_1) + a_3(b_1c_2 - b_2c_1)$ for 3x3 matrices
4. Differentiation of constant is zero
5. Differentiation of x^n is $nx^{(n-1)}$
6. $e_d = \text{Marginal function} / \text{Average function}$
7. $e_d = \frac{-P}{x} \frac{dx}{dp}$
8. Integration of x^n is $\frac{x^{n+1}}{n+1} + C$
9. $CS = \left[\int_0^{x_0} f(x) dx \right] - x_0 p_0$
10. $PS = x_0 p_0 - \int_0^{x_0} g(x) dx$ integration of supply function within limit



ICT CORNER

Drawing Graphs for the Data Collected

Graphs using EXCEL for the given data is given

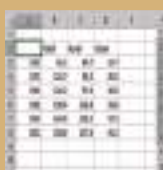


Steps:

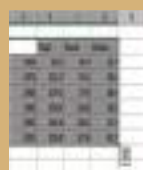
- Collection of data of Child population (0-6 years) from 1961 to 2011 in Rural and Urban areas in India. Let us draw the graph for the data.
- Open Microsoft Excel workbook, Type the X-axis data in the First column and then type respective data in consecutive columns.
- Now select all the typed data, After selecting the data Click “Insert” to get Charts. select scatter type to get scroll down menu.
- Select “Scatter with Smooth Lines and Markers” you will get the required graph as shown here.
- By selecting 3 icons on the right side to edit “chart elements” Particularly Check on the boxes Axis Titles and Chart Title.
- Type x-axis and y-Axis, followed by Chart Title. Click “Legend” to change the position
- Now right click on the graph (a) to copy the graph and Then paste in a word page (or) Select move chart to move In other excel page, Menu will appear to place it in new sheet.
- Now If you want to change the graph type as bar chart or any other type, click on the graph to select and then click on any type of graph given in the top menu



Step1



Step2



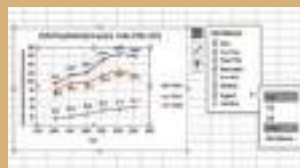
Step3



Step4



Step5



Step6



Step7



Step8

Pictures are indicatives only*

URL:

<https://youtu.be/Xn7Sd5Uu42A>

(or) scan the QR Code

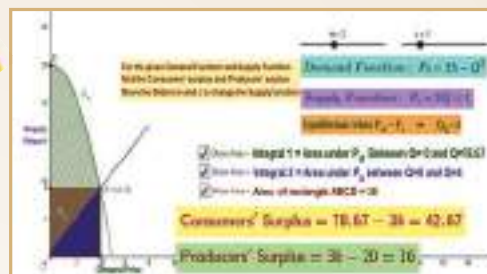




ICT CORNER

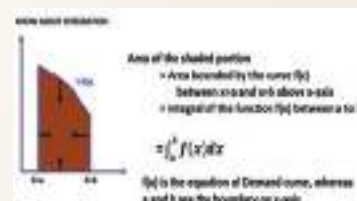
Consumer's and Producer's Surplus

Lets use Integration to find Consumer's and Producer's Surplus

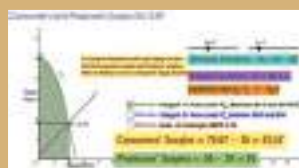


Steps:

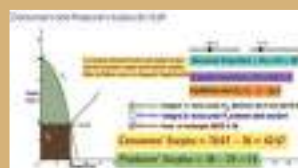
- Open the Browser type the URL given (or) Scan the QR Code.
- GeoGebra Work book called "XI STD ECONOMICS" will appear, Open the worksheet named "Consumer's and Producer's Surplus Ex:12.29"
- Without integration we cannot find the Area under the curve. For Higher studies atleast you should know what is Integration and why it is needed.
- In the worksheet Green colour is the Demand Curve and Blue colour is the Supply curve. They intersect at Point A (4,9). In which x axis value 4 is the demand price. If you integrate the Demand curve between 0 and 4 we get the area as shown. Click "Show Area Integral1" integrating the demand price between 0 and 4.
- If you click on "Show Area of Rectangle" you can see the area of the rectangle which is obtained by Multiplying the length 4 and Breadth 9 (Point A(4,9))
- If you subtract: the area under the curve PD -Area of the rectangle you get the Consumer's Surplus.
- Click on "Show Area Integral 2" you see Blue colour area which is obtained by Integrating Supply Price line between 0 and 4. Subtract: Area of the rectangle - Area under the line PS you get The Producer's Surplus. You can change PS line by moving the sliders 'm' and 'c'. you can see the changes in Consumer's Surplus and Producer's Surplus.



Step1



Step2



Step3



Step4

Pictures are indicatives only*

URL:

<https://ggbm.at/ddY3wkjp>

(or) scan the QR Code



B171_11_ECO_EM



MODEL QUESTIONS

Part-A Multiple Choice Questions

1. Mathematical Economics is the integration of
 - a. Mathematics and Economics
 - b. Economics and Statistics
 - c. Economics and Equations
 - d. Graphs and Economics
2. The construction of demand line or supply line is the result of using
 - a. Matrices
 - b. Calculus
 - c. Algebra
 - d. Analytical Geometry
3. The first person used the mathematics in Economics is
 - a. Sir William Petty
 - b. Giovanni Ceva
 - c. Adam Smith
 - d. Irving Fisher
4. Function with single independent variable is known as
 - a. Multivariate Function
 - b. Bivariate Function
 - c. Univariate Function
 - d. Polynomial Function
5. A statement of equality between two quantities is called
 - a. Inequality
 - b. Equality
 - c. Equations
 - d. Functions
6. An incremental change in dependent variable with respect to change in independent variable is known as
 - a. Slope
 - b. Intercept
 - c. Variant
 - d. Constant
7. $(y - y_1) = m(x - x_1)$ gives the
 - a. Slope
 - b. Straight line
 - c. Constant
 - d. Curve
8. Suppose $D = 50 - 5P$. When D is zero then
 - a. P is 10
 - b. P is 20
 - c. P is 5
 - d. P is -10
9. Suppose $D = 150 - 50P$. Then, the slope is
 - a. -5
 - b. 50
 - c. 5
 - d. -50
10. Suppose determinant of a matrix $\Delta = 0$, then the solution
 - a. Exists
 - b. Does not exist
 - c. is infinity
 - d. is zero





11. State of rest is a point termed as
- Equilibrium
 - Non-Equilibrium
 - Minimum Point
 - Maximum Point
12. Differentiation of constant term gives
- one
 - zero
 - infinity
 - non-infinity
13. Differentiation of x^n is
- $nx^{(n-1)}$
 - $n x^{(n+1)}$
 - zero
 - one
14. Fixed Cost is the -----term in cost function represented in mathematical form.
- Middle
 - Price
 - Quantity
 - Constant
15. The first differentiation of Total Revenue function gives
- Average Revenue
 - Profit
 - Marginal Revenue
 - Zero
16. The elasticity of demand is the ratio of
- Marginal demand function and Revenue function
 - Marginal demand function to Average demand function
 - Fixed and variable revenues
 - Marginal Demand function and Total demand function
17. If $x+y = 5$ and $x-y= 3$ then, Value of x
- 4
 - 3
 - 16
 - 8
18. Integration is the reverse process of
- Difference
 - Mixing
 - Amalgamation
 - Differentiation
19. Data processing is done by
- PC alone
 - Calculator alone
 - Both PC and Calculator
 - Pen drive
20. The command **Ctrl + M** is applied for
- Saving
 - Copying
 - getting new slide
 - deleting a slide



Part-A Answers

1	2	3	4	5	6	7	8	9	10
a	d	b	c	c	a	b	a	d	b
11	12	13	14	15	16	17	18	19	20
a	b	a	d	c	b	a	d	c	c

Part – B Answer the following questions in one or two sentences:

1. If $62 = 34 + 4x$ what is x ? (Answer : x is 7)
2. Given the demand function $q = 150 - 3p$, derive a function for MR.
3. Find the average cost function where $TC = 60 + 10x + 15x^2$
4. The demand function is given by $x = 20 - 2p - p^2$ where p and x are the price and the quantity respectively. Find the elasticity of demand for $p = 2.5$.
5. Suppose the price p and quantity q of a commodity are related by the equation $q = 30 - 4p - p^2$ find (i) e_d at $p = 2$ (ii) MR
6. What is the formula for elasticity of supply if you know the supply function?
7. What are the Main menus of MS Word?

Part – C Answer the following questions in one paragraph:

1. Illustrate the uses of Mathematical Methods in Economics.
2. Solve for x quantity demanded if $16x - 4 = 68 + 7x$. (Ans: x is 8)
3. A firm has the revenue function $R = 600q - 0.03q^2$ and the cost function is $C = 150q + 60,000$, where q is the number of units produced. Find AR, AC, MR and MC. (Answers: AR = $600 - 0.03q$; MR = $600 - 0.06q$; AC = $150 + (60000/q)$)
4. Solve the following linear equations by using Cramer's rule.

$$\begin{matrix} x_1 - x_2 + x_3 = 2: & x_1 + x_2 - x_3 = 0 : \\ -x_1 - x_2 - x_3 = -6 \end{matrix}$$
5. If a firm faces the total cost function $TC = 5 + x^2$ where x is output, what is TC when x is 10?
6. If $TC = 2.5q^3 - 13q^2 + 50q + 12$ derive the MC function and AC function.
7. What are the steps involved in executing a MS Excel Sheet?

Part – D Answer the following questions in about a page:

1. A Research scholar researching the market for fresh cow milk assumes that $Q_t = f(P_t, Y, A, N, P_c)$ where Q_t is the quantity of milk demanded, P_t is the price of fresh cow milk, Y is average household income, A is advertising expenditure on processed pocket milk, N is population and P_c is the price of processed pocket milk.
 - (a) What does $Q_t = f(P_t, Y, A, N, P_c)$ mean in words?
 - (b) Identify the independent variables.
 - (c) Make up a specific form for this function. (Use your knowledge of Economics to deduce whether the coefficients of the different independent variables should be positive or negative.)
2. Calculate the elasticity of demand for the demand schedule by using differential calculus method $P = 60 - 0.2Q$ where price is (i) zero, (ii) ₹20, (iii) ₹40.
3. The demand and supply functions are $p_d = 1600 - x^2$ and $p_s = 2x^2 + 400$ respectively. Find the consumer's surplus and producer's surplus at equilibrium point.
4. What are the ideas of information and communication technology used in economics?

ACTIVITY

1. The petrol consumption of your car is 16 Kilometers per litre. Let x be the distance you travel in Kilometers and p the price per litre of petrol in Rupees. Write expressions for demand for Petrol.
2. Make up your own demand function and then derive the corresponding MR function and find the output level which corresponds to zero marginal revenue.
3. Use an Excel spreadsheet to calculate values for Quantity of demand at various prices for the function $Q = 100 - 10P$ then plot these values on a graph.
4. Open MS-Word and put the title as **PRESENT AND ABSENT OF STUDENTS** and insert the table and collect the data for all classes of your school and find the class of highest absentees in a month. Justify with reason for the absentees in a paragraph by using MS Word.

References

1. Chiang A.C. and K. Wainwright, Fundamental Methods of Mathematical Economics, Tata McGraw-Hill Education; Fourth edition (2013).
2. Dowling E.T, Introduction to Mathematical Economics, 2nd Edition, Schaum's Outline Series, McGraw-Hill, New York, 2003 (ETD).
3. Henderson, J. M. and R.E. Quandt (1980), Microeconomic Theory: A Mathematical Approach, McGraw Hill, New Delhi.
4. James Bradfield, Jeffrey Baldani, An Introduction to Mathematical Economics, Cengage Learning India Pvt Ltd (2008)
5. Koutsoyiannis. A Modern Microeconomics, Palgrave Macmillan; 2nd Revised edition (2003)
6. Mike Rosser, Basic Mathematics for Economists, Second Edition, Routledge Taylor & Francis London 2003.
7. Mehta and Maddani, Mathematics for Economics, Sultan Chand and Sons 9th editions 2008
[https://pdfdrive.net/fundamental methods of mathematical economics](https://pdfdrive.net/fundamental-methods-of-mathematical-economics).
[https://researchgate.net/mathematical economics](https://researchgate.net/mathematical-economics)



GLOSSARY

Accelerator	முடுக்கி
Advertising elasticity of demand	விளம்பரத் தேவை நெகிழ்ச்சி
Alternative uses	மாற்று வழிகள்
Annual plan	ஓராண்டுத் திட்டம்
Art	கலை
Assumption	அனுமானம்
Average cost	சராசரி செலவு
Average product	சராசரி உற்பத்தி
Barter	பண்டமாற்று
Behavioural Economics	போக்கு சார் பொருளியல்
Business	வணிகம்
Capability	செயலாற்றல்
Capital	மூலதனம் (K)
Cardinal Utility Analysis	இயல்பெண் பயன்பாட்டு ஆய்வு
Cash Reserve Ratio (CRR)	ரொக்க இருப்பு வீதம்
Characteristics	குணாதிசயங்கள்
Child sex Ratio	6 வயதுக்கு கீழே உள்ள 1000 ஆண் குழந்தைகளுக்கு எத்தனை பெண்கள் இருக்கிறார்கள் என்பது குழந்தைகளின் பாலின விகிதம்
Classical	தொன்மை
Coefficient	கெழு
Colonial capitalism	காலனி ஆதிக்க முதலாளித்துவம்
Concealed unemployment, Disguised unemployment	மறைமுக வேலையின்மை
Concentration	செறிவு
Constant Returns to Scale	மாறா விகித அளவு
Consumer	நுகர்பவர்
Consumer's Surplus	நுகர்வோர் உபரி / நுகர்வோர் எச்சம்
Consumption	நுகர்வு (C)
Contraction of demand	விலை அதிகரிப்பால் நிகழ்வு தேவைச்சுருக்கம்
Criticism	திறனாய்வு
Crop insurance	பயிர் காப்பீடு
Cross elasticity of demand	குறுக்கு தேவை நெகிழ்ச்சி
Crude Birth rate	1000 நபர்களுக்கு பிறந்த குழந்தைகளின் எண்ணிக்கை
Crude Death Rate	1000 நபர்களுக்கு இறந்தவர்களின் எண்ணிக்கை
Data /Statistics /information	புள்ளி விவரங்கள்
Decentralization	பரவலாக்கப்படல்
Decrease in demand	தேவை குறைதல்
Deductive Method	பகுத்தாய்வு முறை
Definition	வரையறை / இலக்கணம்
Delicensing	உரிமம் விலக்கல்
Demand	தேவை
Democracy	குடியாட்சி





Demographic dividend	மக்கள் தொகையின் அனுகூலம்
Demonstration effect	பகட்டு விளைவு
Density of population	மொத்த மக்கள் தொகையை நிலத்தின் அளவால் வகுக்கக் கிடைப்பது
Determinants	நிர்ணயிப்பவைகள்
Determinant	அணிக்கோவை
Development Economics	மேம்பாட்டுப் பொருளியல்
Development	மேம்பாடு
Differential calculus	வகை நுண்கணிதம்
Diminishing Returns to Scale	குறைந்து செல் விகித அளவு
Diseconomies of Scale	சிக்கனமின்மைகள்
Disinvestment	பொதுத்துறைச் சொத்துக்களை விற்பது
Dismal Science	இருண்ட அறிவியல்
Distribution	பகிர்வு
Division of labour	வேலைப்பகுப்பு
Domain	சார்பகம்
Dualism	இரு வேறுபட்ட குணங்கள் காணப்படுவது. எ.கா. மாட்டு வண்டியும், SUV மகிழ் உந்து வண்டியும்
Duopoly	இருவர் முற்றுரிமை (இரண்டு விற்பனையாளர்கள் மட்டும்)
Dynamic	இயங்கு / இயக்கம்
Economics	பொருளியியல்
Economies of scale	பொருளாதாரச் சிக்கனங்கள்
Economy	பொருளாதாரம்
Elasticity of demand	தேவை நெகிழ்வு / தேவை நெகிழ்ச்சி
Elasticity of Supply	அளிப்பு நெகிழ்வு
Empowerment	வலிமை பெறுதல்
Enterprise	நிறுவனம்
Entrepreneurship	தொழில் முயலும்தன்மை
Entrepreneur	தொழில் முயல்வோர்
Environmental Economics	சுற்றுச்சூழல் பொருளியல்
Equal- Marginal utility	சம-இறுதி நிலைப் பயன்பாடு
Equation	சமன்பாடு
Equilibrium	சமநிலை
Ethical	அறநெறி சார்ந்த
Exchange	பரிமாற்றம்
Expansion of demand	விலை குறைவால் நிகழ்ந்த தேவை விரிவு
Explicit cost	வெளிப்படையான செலவு
Export promotion zone	ஏற்றுமதி ஊக்குவிப்பு மண்டலம்
Export	ஏற்றுமதி (X)
External Diseconomies	புறச்சிக்கனமின்மைகள்
External Economies of Scale	பொருளாதார புறச்சிக்கனங்கள்
Factors of Production	உற்பத்திக் காரணிகள்
Factors	காரணிகள்
Facts	உண்மைகள், எண்களிலாலான விவரங்கள்
Famine	பஞ்சம்
Features	சிறப்பம்சங்கள்
Finance Capital	நிதி மூலதனம்
Financial Economics	நிதிப் பொருளியல்
Fiscal reforms	அரசுநிதிச் சீர்திருத்தங்கள்



Fixed cost	மாறாச் செலவு
Floating cost	மிதக்கும் செலவு
Foreign Capital	வெளிநாட்டு மூலதனம்
Frictional unemployment	உடன்பாடில்லா வேலையின்மை (கிடைக்கின்ற வேலையில் திருப்தியடையாமல் வேறு ஒரு நல்ல வேலை கிட்டும் வரை வேலையின்றி இருப்பது.)
Gender equality	பாலினச் சமத்துவம்
General equilibrium	பொதுச்சமநிலை
Globalization	உலகமயமாக்குதல்
Goods / Products/ Commodities / things	பண்டங்கள் / சரக்குகள்/பொருட்கள்
Goods and Services Tax(GST)	பண்டங்கள் மற்றும் பணிகள் வரி (அல்லது) சரக்கு மற்றும் சேவை வரி
Gross sown Area	மொத்த விதைக்கப்பட்ட நிலப்பரப்பு, ஒரு ஏக்கர் நிலத்தில் இரண்டு போகம் பயிரிட்டால் அது இரண்டு ஏக்கராக்கக் கணக்கிடப்படும்
Government Spending	அரசுச் செலவு அரசுச் செலவு (G)
Green revolution	பசுமைப்புரட்சி
Gross National Happiness Index	மொத்த நாட்டு மகிழ்ச்சிக் குறியீடு
Gross state domestic Product	மொத்த மாநில உள்நாட்டு உற்பத்தி
Growth	வளர்ச்சி
Health Economics	உடல் நலப் பொருளியல்
Human Development Index	மனித வள மேம்பாட்டுக் குறியீடு
Human welfare	மனித நலம்
Hypothesis	கருதுகோள்
Imitation	போலி செய்தல்
Imperfect competition	நிறைகுறைப் போட்டி
Implicit cost	மறைமுகச் செலவு
Import	இறக்குமதி (M)
Income elasticity of demand	வருமானத் தேவை நெகிழ்ச்சி
Income	வருமானம்
Increase in demand	தேவை கூடுதல்
Increasing Returns to Scale	வளர்ந்து செல்விகித அளவு
Index	குறியீடு
Indicators	குறிகாட்டிகள்
Indifference curve	சம நோக்கு வளைகோடு
Indifference Map	சம நோக்கு வரைபடம்
Indifference schedule	சம நோக்கு அட்டவணை
Inductive Method	விதிவருமுறை, தொகுத்தாய்வு முறை
Industrialization	தொழில் மயமாதல்
Industrial Policy resolution	தொழிற்கொள்கை தீர்மானம்
Infant Mortality Rate (IMR)	சிசு இறப்பு விகிதம் (1000 குழந்தைகளில் ஒரு வயதை முடிக்கும் முன்புஇறக்கும் குழந்தைகளின் விகிதம்)
Innovation	புத்தாக்கம், புதியன புனைதல்
Integral calculus	தொகை நுண்கணிதம்
Interest rate	வட்டிவீதம் (i)
Internal Economies of Scale	அகப் பொருளாதாரச் சிக்கனங்கள்
Investment	முதலீடு
Invisible hand	புலனாகா உந்துசக்தி
Involuntary unemployment	வேலைக்குத் தயாராக இருந்தும் வேலை கிடைக்காத நிலை
Iso- quants	சம அளவு உற்பத்திக் கோடுகள்
Labour	உழைப்பு



Land Tenure	நில உடைமை முறை
Land use pattern	நிலத்தை பயன்படுத்தும் விதம்
Law of variable proportions	மாறும் விகித விளைவு விதி
Laws of Returns to Scale	விகித அளவு விளைவு விதி
Liberalization	தாராள மயமாக்குதல்
Life Expectancy at Birth	வாழ்நாள் எதிர்பார்ப்பு காலம்
Linear Equation	நேர்க்கோட்டுச் சமன்பாடு
Liquidity preference	நீர்மை விருப்பம்
Literacy Ratio	மொத்த மக்கள் தொகையில் எழுதப்படிக்க தெரிந்தவர்களின் விகிதம்
Long – run	நீண்ட காலம்
Macro – Economics	பேரினப் பொருளியல் / பேரியல் பொருளியில்
Mahalwari system	குழு உரிமை முறை (இதில் கிராமக் குழுக்கள் நிலத்தை நிர்வாகம் செய்து நிலத் தீர்வையை அரசுக்கு செலுத்தவேண்டும்)
Management	மேலாண்மை
Marginal cost	இறுதிநிலைச் செலவு
Marginal product	இறுதிநிலை உற்பத்தி
Marginal Rate of substitution	இறுதி நிலை பதிலீட்டு வீதம்
Marginal Rate of Technical Substitution	இறுதிநிலை தொழில்நுட்பப் பதிலீட்டு வீதம்
Marginal utility	இறுதி நிலைப் பயன்பாடு
Market	அங்காடி / சந்தை
Material wealth	பருப்பொருட் செல்வம்
Maternal Mortality Rate (MMR)	மகப்பேறு இறப்பு விகிதம் (ஒரு லட்சம் தாய்மார்களில் மகப்பேறுவின் போது இறக்கின்ற பெண்களின் எண்ணிக்கை)
Matrix / Matrices	அணி / அணிகள்
Merchant Capital	வணிக மூலதனம்
Micro, small and medium Enterprises	குறு, சிறு மற்றும் நடுத்தர நிறுவனங்கள்
Micro-Economics	நுண் பொருளியியல் / நுண்ணினப் பொருளியியல்/
Migration	குடி பெயர்தல் / புலம் பெயர்தல்
Modern age	நவீனயுகம்
Monetary Reforms	பணச் சீர்திருத்தங்கள்
Money Cost	பணச் செலவு
Monopolistic competition	முற்றுகிறமைப் போட்டி (ஒரு பொருளை சிறிது வேறுபாடு செய்து பலர் விற்பார்கள்)
Monopoly	முற்றுகிறமை (ஒரே ஒரு விற்பனையாளர்)
Morbidity Rate	உடல் நலமின்மை விகிதம்
MRTTP ACT	முற்றுகிறமை வணிகக் கட்டுப்பாட்டுச் சட்டம் (Monopoly and Restrictive Trade Practices ACT)
Multiplier	பெருக்கி
National Income	தேசிய வருமானம் (Y)
Nationalization	நாட்டுடைமையாக்குதல்
Need	உயிர் பிழைக்க அடிப்படைத் தேவைகள்
Neo – classical	புதிய மரபு வழி
Net sown Area	நிகர விதைக்கப்பட்ட நிலம் பரப்பு, இது மொத்தம் விதைக்கப்பட்ட நிலப்பரப்புக்குச் சம்மாகவோ குறைவாகவோ இருக்கும்
NITI Aayog	இந்தியாவை மாற்றுவதற்கான தேசிய அளவிலான நிலையத்திற்கான திட்டம்
Nominal income/Money income	பெயரளவு வருமானம்/பணவருமானம்
Non renewable Energy sources	புதுப்பிக்க இயலாத சக்தி வளங்கள்
Normative Science	நெறியுரை அறிவியல்



Oligopoly	சில்லோர் முற்றுரிமை
Opportunity cost	வாய்ப்புச் செலவு
Organisation	அமைப்பு
Particular / partial equilibrium	தனிச் சமநிலை / பகுதிச் சமநிலை
Per capita income	தலைவீத வருமானம் (மொத்த தேசிய வருமானத்தை மொத்த மக்கள் தொகையால் வகுக்க கிடைப்பது)
Perfect Competition	நிறைவுப் போட்டி
Physical quality of life index	வாழ்க்கைத் தரக் குறியீடு
Plan Holiday	திட்ட விடுமுறை (1966 முதல் மூன்று ஆண்டுகளுக்கு ஐந்தாண்டுத் திட்டங்கள் செயல்படுத்த இயலவில்லை)
Point of inflexion / point of inflection	மாறும் விகிதம் மாறுகின்ற புள்ளி
Political Economy	அரசியல் பொருளாதாரம்
Positive Science	இயல்புரை அறிவியல்
Poverty	வறுமை
Price determination	விலை நிர்ணயம் / விலை தீர்மானம்
Price discrimination	விலைப்பேதம்
Price Elasticity of demand	விலைத்தேவை நெகிழ்ச்சி
Price line	விலைக்கோடு
Prime cost	முதன்மைச் செலவு
Privatization	தனியார் மயமாக்குதல்
Producer's Equilibrium	உற்பத்தியாளர் சமநிலை
Producer's Surplus	உற்பத்தியாளர் உபரி / உற்பத்தியாளர் எச்சம்
Production Possibility curve	உற்பத்தி வாய்ப்பு வளைகோடு
Production Possibility Frontier	உற்பத்தி வாய்ப்பு எல்லைக்கோடு
Production Possibility Schedule	உற்பத்தி வாய்ப்பு பட்டியல்
Production	உற்பத்தி
Public Economics	பொதுப் பொருளியல்
Public Finance	பொது நிதி
Public sector enterprises	பொதுத்துறை நிறுவனங்கள்
Quasi – rent	போலி வாரம்
Quotation	மேற்கோள்
Rational	பகுத்துணர்வல்ல
Real Cost	உண்மைச் செலவு
Real income	உண்மை வருமானம் (பணவருமானத்தின்வாங்கும் சக்தி)
Rectangular Hyperbola	செவ்வக அதிபர வளைவு
Redeemable Energy	புதுப்பிக்கக் கூடிய சக்தி வளங்கள்
Regional development	வட்டார மேம்பாடு
Rent	வாரம்
Repo rate Repurchase Rate	மைய வங்கியிடமிருந்து பிற வங்கிகள் பெறும் குறுகிய கால கடனுக்கான வட்டி வீதம் ($RR > RRR$)
Reserve Requirements	ஒதுக்கீட்டு விகித அளவுகள் (வங்கிகள் வைத்திருக்க வேண்டிய வைப்புகள்)
Resources	வளங்கள்
Revenue	வருவாய்
Reverse Repo Rate (RRR)	வங்கிகள் மைய வங்கியிடம் வைத்திருக்கும் குறுகிய கால வைப்புகளுக்கு மைய வங்கி கொடுக்கின்ற வட்டி வீதம் ($RR > RRR$)
Risk bearing	இடர் தாங்குதல்
Risk	இடர்





Rolling Plan	சுழல் திட்டம் (1978 – 79 ஆம் ஆண்டு மட்டும் இத்திட்டம் நடைமுறையில் இருந்தது)
Ryotwari system	உழுபவர் உரிமை முறை (இதில் நிலத்தை உழுபவரே நிலச் சொந்தக்காரராக இருப்பார்)
Savings	சேமிப்பு (S)
Scale	அளவுகோல்
Scarcity	பற்றாக்குறை : அளிப்பு < தேவை
Scope	எல்லை
Secularism	மதச்சார்பின்மை
Self – Help Groups	சுய உதவிக் குழுக்கள் (பொதுவாக 10 முதல் 20 பெண்களைக் கொண்டவை)
Services	பணிகள் / சேவைகள்
Sex ratio	பாலின விகிதம் (1000 ஆண்களுக்கு எத்தனை பெண்கள் என்பது)
Shift in demand curve	தேவை வளைகோடு இடப்பெயர்வு
Short –run	குறுகிய காலம்
Skewed distribution	சமமற்ற பரவல்
Slope	சாய்வு
Social Cost	சமூகச் செலவு
Social Infrastructure	சமூகக் கட்டமைப்பு எ.கா. கல்வி மற்றும் மருத்துவ நிறுவனங்கள்
Social justice	சமூக நீதி
Special Economic Zone	சிறப்புப் பொருளாதார மண்டலம்
Static equilibrium	நிலையான சமநிலை
Statutory Liquidity Ratio(SLR)	சட்ட ரீதியான நீர்மை வீதம்
Structural unemployment	அமைப்பு சார் வேலையின்மை
Sunk cost	அமிழ்த்தப்பட்ட செலவு, மீண்டும் திரும்பப் பெற முடியாத செலவு
Super Multiplier	மிகைப் பெருக்கி
Supply	அளிப்பு
Tangible	தொட்டுச் செல்லும் / தொட்டுணரச் கூடிய
Tax	வரி (T)
Theories	கோட்பாடுகள்
Total cost	மொத்தச் செலவு
Total product	மொத்த உற்பத்தி
Trade /international trade	வணிபம்
Uncertainty	நிலையின்மை
Urbanisation	நகர் மயமாதல்
Utility	பயன்பாடு
Util	அலகு
Values	மதிப்பீடுகள் / விழுமியங்கள்
Value	மதிப்பு
Variable cost	மாறும் செலவு
Variable	மாறி
Voluntary unemployment	வேலை கிடைத்தும் வேலைக்கச் செல்லாமல் இருப்பது
Wants	விருப்பங்கள்
Y intercept	y அச்சை வெட்டும் இடம்
Zamindari system	நிலக்கிழார் முறை (இதில் நிலக்கிழார் நிலத் தீர்வையை வசூலித்து அரசுக்கு செலுத்தவேண்டும்)



Economics – XI

List of Authors and Reviewers

Reviewers

Dr. L. Venkatachalam

Professor, Madras Institute of Developmental Studies,
Chennai

Dr. George V. Kallarackal

Former HOD, Economics Department
CMS College, Kottayam, Kerala

Domain Experts

Dr. S. Iyyam Pillai

Former Professor, Dept. of Economics
Bharathidasan University, Trichy

Dr. A.G. Leonard SJ

Former Professor, Dept. of Economics
Loyola College, Chennai

Subject Coordinator

J. Sornalatha

Post Graduate Assistant, Government Muslim Hr. Sec School.
Chennai-600002

Authors

Dr. J. Socrates

Head, Department of Economics
Manonmaniam Sundaranar University
Tirunelveli

Dr. M. Chitra

Assistant Professor, School of Economics
Madurai Kamaraj University, Madurai

Dr. B.P. Chandramohan

Associate Professor, Dept. of Economics,
Presidency College, Chennai

Dr. S. Theenathayalan

Head, Department of Economics
The Madura College, Madurai

K. Karnan

Post Graduate Assistant
Government Girls Higher Secondary School
Thirumangalam, Madurai

K. Alamarselvan

Post Graduate Assistant
Government Boys Higher Secondary School, Bhuvanagiri, Cuddalore

S. Bhuvana

Post Graduate Assistant
SRBAKD Dharma Raja Girls Higher Secondary School, Rajapalayam

Dr. K. Sadasivam

Assistant Professor, School of Economics
Madurai Kamaraj University, Madurai-625 021

Dr. R. Bernadshaw

Former Professor, Dept. of Economics,
NMSSVN College, Nagamalai, Madurai

Dr. R. Albert Christopher Dhas

Associate Professor, Dept. of Economics
The American College, Madurai

Dr. R. Vaheedha Banu

Assistant Professor
MSS WAKF Board College, Madurai

Stephen Elangovan

Post Graduate Assistant
TVS Matric Higher Secondary School
Madurai

B. Shunmugam

Post Graduate Assistant
Natarajan Dhamayanthi Higher Secondary School,
Nagapattinam

Content Readers

Dr. A. Paramasivan

Professor of Economics, The MDT Hindu College, Tirunelveli

Dr. A. Mariyappan

Assistant Professor, Loyola College, Chennai

Art and Design Team

Illustration

R. Yuvaraj
Gokulakrishnan

Art Teachers,
Government of Tamil Nadu.

Students

Government College of Fine Arts, Chennai & Kumbakonam.

Layout

Udaya Info

In-House QC

Gopu Rasuvel
Jerald Wilson
Tamilkumaran

Wrapper Design

Kathir Arumugam

Co-ordination

Ramesh Munisamy

Typist

G. Anitha

ICT Coordinator

D. Vasuraj

BT Assistant, Pums, Kosapur, Puzhal Block,
Thiruvallur DT

S. Ganesh

BT Assistant, Pums School, Kilariyam,
Koradacherry Block, Thiruvallur DT

QR Code Management Team

R. Jaganathan

S.G.T. (SPOC), PUMS Ganesapuram - Polur, Thiruvannamalai Dist.

N. Jagan

B.T. Asst., GBHSS Uthiramerur, Kanchipuram Dist.

J.F. Paul Edwin Roy

B.T. Asst., PUMS Rakkipatti, Salem Dist.

This book has been printed on 80 GSM
Elegant Maplitho paper.

Printed by offset at:





NOTES