

# Engineering Economics

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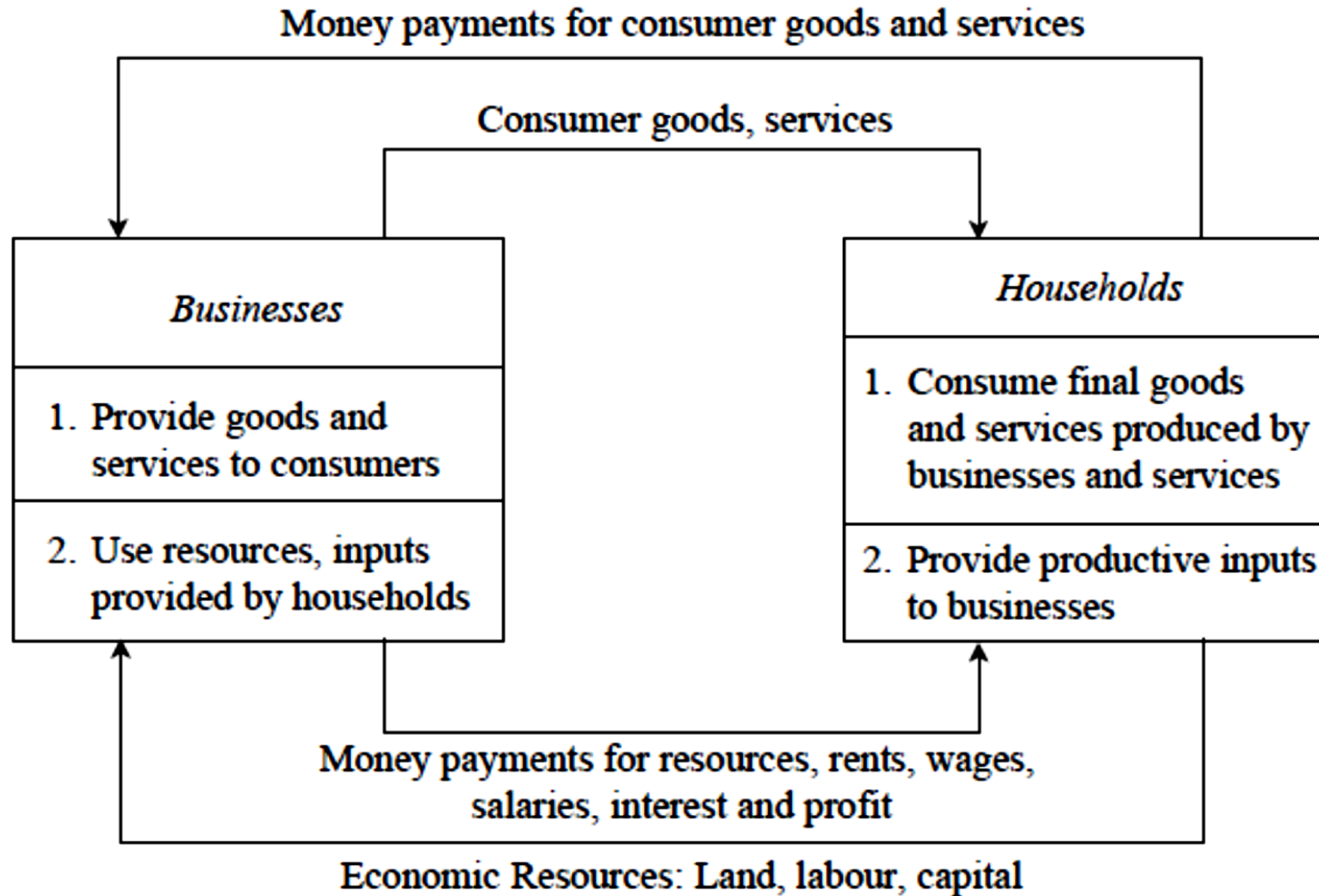
# ECONOMICS

- **Economics** is the science that deals with the production and consumption of goods and services and the distribution and rendering of these for human welfare.
- The following are the economic goals.
  - A high level of employment
  - Price stability
  - Efficiency
  - An equitable distribution of income
  - Growth
- Some of the above goals are interdependent. The economic goals are not always complementary; in many cases they are in conflict. For example, any move to have a significant reduction in unemployment will lead to an increase in inflation.

# Flow in an Economy

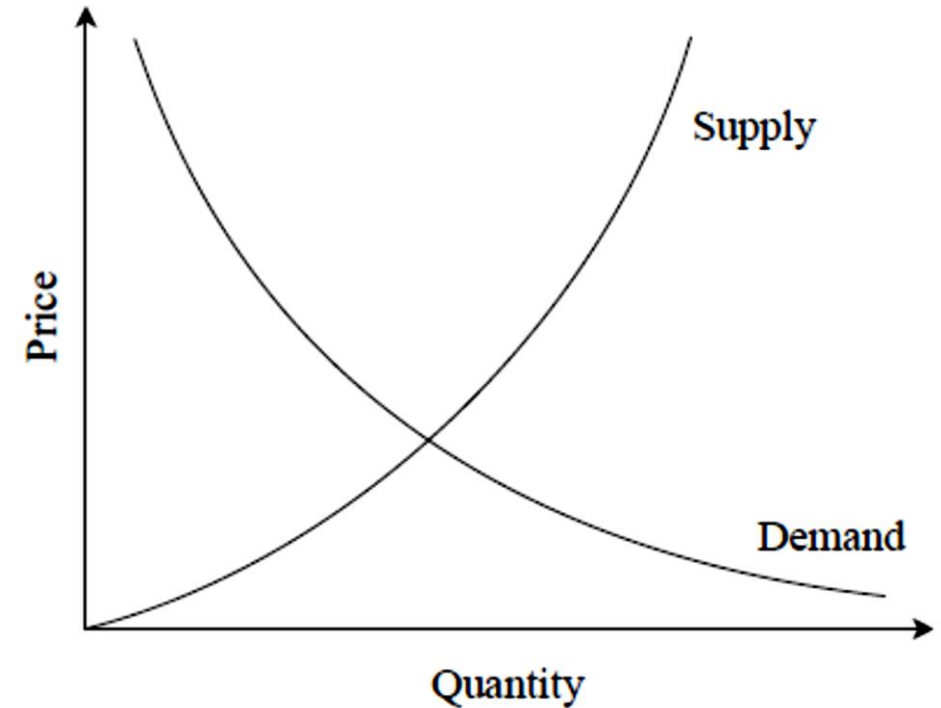
- The flow of goods, services, resources and money payments in a simple economy are shown in Fig. 1.1. Households and businesses are the two major entities in a simple economy. Business organizations use various economic resources like land, labour and capital which are provided by households to produce consumer goods and services which will be used by them.
- Business organizations make payment of money to the households for receiving various resources. The households in turn make payment of money to business organizations for receiving consumer goods and services.
- This cycle shows the interdependence between the two major entities in a simple economy.

# Flow in an Economy (Fig. 1.1)



# Law of Supply and Demand

- An interesting aspect of the economy is that the demand and supply of a product are interdependent and they are sensitive with respect to the price of that product.
- The interrelationships between them are shown in Fig. 1.2.



**Fig. 1.2** Demand and supply curve.

# Law of Supply and Demand

- From Fig. 1.2 it is clear that when there is a decrease in the price of a product, the demand for the product increases and its supply decreases.
- Also, the product is more in demand and hence the demand of the product increases.
- At the same time, lowering of the price of the product makes the producers restrain from releasing more quantities of the product in the market. Hence, the supply of the product is decreased.
- The point of intersection of the supply curve and the demand curve is known as the *equilibrium point*.
- At the price corresponding to this point, the quantity of supply is equal to the quantity of demand. Hence, this point is called the *equilibrium point*.

# Factors influencing demand

- The shape of the demand curve is influenced by the following factors:
  - Income of the people
  - Prices of related goods
  - Tastes of consumers

# Factors influencing supply

- The shape of the supply curve is affected by the following factors:
  - Cost of the inputs
  - Technology
  - Weather/Season
  - Prices of related goods



# CONCEPT OF ENGINEERING ECONOMICS

- Science is a field of study where the basic principles of different physical systems are formulated and tested. Engineering is the application of science.
- It establishes varied application systems based on different scientific principles.
- From the discussions in the previous section, it is clear that price has a major role in deciding the demand and supply of a product.
- Hence, from the organization's point of view, efficient and effective functioning of the organization would certainly help it to provide goods/services at a lower cost which in turn will enable it to fix a lower price for its goods or services.

# Types of Efficiency

- Efficiency of a system is generally defined as the ratio of its output to input.
- The efficiency can be classified into *technical efficiency* and *economic efficiency*.

# Technical efficiency

It is the ratio of the output to input of a physical system. The physical system may be a diesel engine, a machine working in a shop floor, a furnace, etc.

$$\text{Technical efficiency (\%)} = \frac{\text{Output}}{\text{Input}} \times 100$$

The technical efficiency of a diesel engine is as follows:

$$\text{Technical efficiency (\%)} = \frac{\text{Heat equivalent of mechanical energy produced}}{\text{Heat equivalent of fuel used}} \times 100$$

In practice, technical efficiency can never be more than 100%. This is mainly due to frictional loss and incomplete combustion of fuel, which are considered to be unavoidable phenomena in the working of a diesel engine.

# Economic efficiency

- Economic efficiency is the ratio of output to input of a business system.

$$\text{Economic efficiency (\%)} = \frac{\text{Output}}{\text{Input}} \times 100 = \frac{\text{Worth}}{\text{Cost}} \times 100$$

- ‘Worth’ is the annual revenue generated by way of operating the business and ‘cost’ is the total annual expenses incurred in carrying out the business.
- For the survival and growth of any business, the economic efficiency should be more than 100%.

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# Economic efficiency

- Economic efficiency is also called ‘productivity’. There are several ways of improving productivity.
  - Increased output for the same input
  - Decreased input for the same output
  - By a proportionate increase in the output which is more than the proportionate increase in the input
  - By a proportionate decrease in the input which is more than the proportionate decrease in the output
  - Through simultaneous increase in the output with decrease in the input.

# Definition and Scope of Engineering Economics

- As stated earlier, efficient functioning of any business organization would enable it to provide goods/services at a lower price.
- In the process of managing organizations, the managers at different levels should take appropriate economic decisions which will help in minimizing investment, operating and maintenance expenditures besides increasing the revenue, savings and other related gains of the organization.

# Definition and Scope of Engineering Economics

## Definition

- Engineering economics deals with the methods that enable one to take economic decisions towards minimizing costs and/or maximizing benefits to business organizations.

## Scope

- The issues that are covered in this course are elementary economic analysis, interest formulae, bases for comparing alternatives, present worth method, future worth method, annual equivalent method, rate of return method, replacement analysis, depreciation, and linear programming.



# ELEMENTS OF COSTS

- Cost can be broadly classified into *variable cost* and *overhead cost*. Variable cost varies with the volume of production while overhead cost is fixed, irrespective of the production volume.
- Variable cost can be further classified into direct material cost, direct labour cost, and direct expenses.
- The overhead cost can be classified into factory overhead, administration overhead, selling overhead, and distribution overhead.

# ELEMENTS OF COSTS

The selling price of a product is derived as shown below:

- (a)  $\text{Direct material costs} + \text{Direct labour costs} + \text{Direct expenses} = \text{Prime cost}$
- (b)  $\text{Prime cost} + \text{Factory overhead} = \text{Factory cost}$
- (c)  $\text{Factory cost} + \text{Office and administrative overhead} = \text{Costs of production}$
- (d)  $\text{Cost of production} + \text{Opening finished stock} - \text{Closing finished stock} = \text{Cost of goods sold}$
- (e)  $\text{Cost of goods sold} + \text{Selling and distribution overhead} = \text{Cost of sales}$
- (f)  $\text{Cost of sales} + \text{Profit} = \text{Sales}$
- (g)  $\text{Sales} / \text{Quantity sold} = \text{Selling price per unit}$

- In the above calculations, if the opening finished stock is equal to the closing finished stock, then the cost of production is equal to the cost of goods sold.

# OTHER COSTS/REVENUES

- The following are the costs/revenues other than the costs which are presented in the previous section:
  - Marginal cost
  - Marginal revenue
  - Sunk cost
  - Opportunity cost

# OTHER COSTS/REVENUES

## Marginal Cost

- Marginal cost of a product is the cost of producing an additional unit of that product.
- Let the cost of producing 20 units of a product be Rs. 10,000, and the cost of producing 21 units of the same product be Rs. 10,045. Then the marginal cost of producing the 21st unit is Rs. 45.

# OTHER COSTS/REVENUES

## Marginal Revenue

- Marginal revenue of a product is the incremental revenue of selling an additional unit of that product.
- Let, the revenue of selling 20 units of a product be Rs. 15,000 and the revenue of selling 21 units of the same product be Rs. 15,085. Then, the marginal revenue of selling the 21st unit is Rs. 85.

# OTHER COSTS/REVENUES

## Sunk Cost

- This is known as the past cost of an equipment/asset.
- Let us assume that an equipment has been purchased for Rs. 1,00,000 about three years back. If it is considered for replacement, then its present value is not Rs. 1,00,000. Instead, its present market value should be taken as the present value of the equipment for further analysis. So, the purchase value of the equipment in the past is known as its sunk cost. The sunk cost should not be considered for any analysis done from now onwards.

# OTHER COSTS/REVENUES

## Opportunity Cost

- In practice, if an alternative ( $X$ ) is selected from a set of competing alternatives ( $X, Y$ ), then the corresponding investment in the selected alternative is not available for any other purpose. If the same money is invested in some other alternative ( $Y$ ), it may fetch some return. Since the money is invested in the selected alternative ( $X$ ), one has to forego the return from the other alternative ( $Y$ ). The amount that is foregone by not investing in the other alternative ( $Y$ ) is known as the opportunity cost of the selected alternative ( $X$ ).
- So the opportunity cost of an alternative is the return that will be foregone by not investing the same money in another alternative.

# OTHER COSTS/REVENUES

## Opportunity Cost

- Consider that a person has invested a sum of Rs. 50,000 in shares. Let the expected annual return by this alternative be Rs. 7,500. If the same amount is invested in a fixed deposit, a bank will pay a return of 18%. Then, the corresponding total return per year for the investment in the bank is Rs. 9,000.
- This return is greater than the return from shares. The foregone excess return of Rs. 1,500 by way of not investing in the bank is the opportunity cost of investing in shares.



# BREAK-EVEN ANALYSIS

- The main objective of break-even analysis is to find the cut-off production volume from where a firm will make profit. Let

$s$  = selling price per unit

$v$  = variable cost per unit

$FC$  = fixed cost per period

$Q$  = volume of production

- The total sales revenue ( $S$ ) of the firm is given by the following formula:

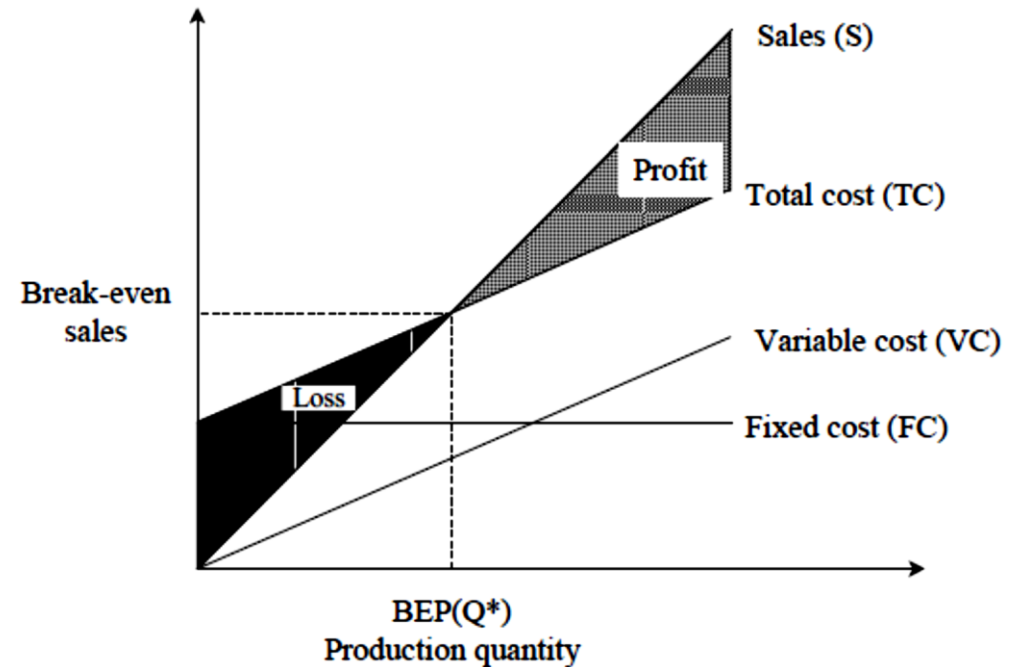
$$S = s \times Q$$

- The total cost of the firm for a given production volume is given as 7

$$\begin{aligned} TC &= \text{Total variable cost} + \text{Fixed cost} \\ &= v \times Q + FC \end{aligned}$$

# BREAK-EVEN ANALYSIS

- The linear plots of the above two equations are shown in Fig. 1.3. The intersection point of the total sales revenue line and the total cost line is called the break-even point.
- The corresponding volume of production on the X-axis is known as the break-even sales quantity. At the intersection point, the total cost is equal to the total revenue.



# BREAK-EVEN ANALYSIS

- For any production quantity which is more than the break-even quantity, the total revenue will be more than the total cost. Hence, the firm will be making profit.

$$\begin{aligned}\text{Profit} &= \text{Sales} - (\text{Fixed cost} + \text{Variable costs}) \\ &= s \ Q - (FC + v \ Q)\end{aligned}$$

- The formulae to find the break-even quantity and break-even sales quantity

$$\begin{aligned}\text{Break-even quantity} &= \frac{\text{Fixed cost}}{\text{Selling price/unit} - \text{Variable cost/unit}} \\ &= \frac{FC}{s - v} \text{ (in units)}\end{aligned}$$

$$\begin{aligned}\text{Break-even sales} &= \frac{\text{Fixed cost}}{\text{Selling price/unit} - \text{Variable cost/unit}} \times \text{Selling price/unit} \\ &= \frac{FC}{s - v} \times s \text{ (Rs.)}\end{aligned}$$

# BREAK-EVEN ANALYSIS

- The contribution is the difference between the sales and the variable costs. The margin of safety (M.S.) is the sales over and above the break-even sales. The formulae to compute these values are

$$\text{Contribution} = \text{Sales} - \text{Variable costs}$$

$$\text{Contribution/unit} = \text{Selling price/unit} - \text{Variable cost/unit}$$

$$\text{M.S.} = \text{Actual sales} - \text{Break-even sales}$$

$$= \frac{\text{Profit}}{\text{Contribution}} \times \text{sales}$$

$$\text{M.S. as a per cent of sales} = (\text{M.S./Sales}) \times 100$$

# Problem 1.1

- Alpha Associates has the following details:  
Fixed cost = Rs. 20,00,000  
Variable cost per unit = Rs. 100  
Selling price per unit = Rs. 200
- Find
  - a) The break-even sales quantity,
  - b) The break-even sales
  - c) If the actual production quantity is 60,000, find (i) contribution; and (ii) margin of safety by all methods.

# Problem 1.1

- *Solution*

$$\begin{aligned}\text{(a) Break-even quantity} &= \frac{FC}{s - v} = \frac{20,00,000}{200 - 100} \\ &= 20,00,000/100 = 20,000 \text{ units}\end{aligned}$$

$$\begin{aligned}\text{(b) Break-even sales} &= \frac{FC}{s - v} \times s \text{ (Rs.)} \\ &= \frac{20,00,000}{200 - 100} \times 200 \\ &= \frac{20,00,000}{100} \times 200 = \text{Rs. } 40,00,000\end{aligned}$$

$$\begin{aligned}\text{(c) (i) Contribution} &= \text{Sales} - \text{Variable cost} \\ &= s \times Q - v \times Q \\ &= 200 \times 60,000 - 100 \times 60,000 \\ &= 1,20,00,000 - 60,00,000 \\ &= \text{Rs. } 60,00,000\end{aligned}$$

# Problem 1.1

(ii) Margin of safety

METHOD I

$$\begin{aligned}\text{M.S.} &= \text{Sales} - \text{Break-even sales} \\ &= 60,000 \times 200 - 40,00,000 \\ &= 1,20,00,000 - 40,00,000 = \text{Rs. } 80,00,000\end{aligned}$$

METHOD II

$$\text{M.S.} = \frac{\text{Profit}}{\text{Contribution}} \times \text{Sales}$$

$$\begin{aligned}\text{Profit} &= \text{Sales} - (FC + v \times Q) \\ &= 60,000 \times 200 - (20,00,000 + 100 \times 60,000) \\ &= 1,20,00,000 - 80,00,000 \\ &= \text{Rs. } 40,00,000\end{aligned}$$

$$\text{M.S.} = \frac{40,00,000}{60,00,000} \times 1,20,00,000 = \text{Rs. } 80,00,000$$

$$\text{M.S. as a per cent of sales} = \frac{80,00,000}{1,20,00,000} \times 100 = 67\%$$



# PROFIT/VOLUME RATIO (*P/V* RATIO)

*P/V* ratio is a valid ratio which is useful for further analysis. The different formulae for the *P/V* ratio are as follows:

$$P/V \text{ ratio} = \frac{\text{Contribution}}{\text{Sales}} = \frac{\text{Sales} - \text{Variable costs}}{\text{Sales}}$$

The relationship between BEP and *P/V* ratio is as follows:

$$\text{BEP} = \frac{\text{Fixed cost}}{P/V \text{ ratio}}$$

The following formula helps us find the M.S. using the *P/V* ratio:

$$\text{M.S.} = \frac{\text{Profit}}{P/V \text{ ratio}}$$



# Problem 1.2

- Consider the following data of a company for the year 1997:

Sales = Rs. 1,20,000

Fixed cost = Rs. 25,000

Variable cost = Rs. 45,000

Find the following:

- (a) Contribution
- (b) Profit
- (c) BEP
- (d) M.S.

# Problem 1.2 - *Solution*

$$\begin{aligned}\text{(a) Contribution} &= \text{Sales} - \text{Variable costs} \\ &= \text{Rs. } 1,20,000 - \text{Rs. } 45,000 \\ &= \text{Rs. } 75,000\end{aligned}$$

$$\begin{aligned}\text{(b) Profit} &= \text{Contribution} - \text{Fixed cost} \\ &= \text{Rs. } 75,000 - \text{Rs. } 25,000 \\ &= \text{Rs. } 50,000\end{aligned}$$

(c) BEP

$$\begin{aligned}P/V \text{ ratio} &= \frac{\text{Contribution}}{\text{Sales}} \\ &= \frac{75,000}{1,20,000} \times 100 = 62.50\%\end{aligned}$$

$$\text{BEP} = \frac{\text{Fixed cost}}{P/V \text{ ratio}} = \frac{25,000}{62.50} \times 100 = \text{Rs. } 40,000$$

$$\text{M.S.} = \frac{\text{Profit}}{P/V \text{ ratio}} = \frac{50,000}{62.50} \times 100 = \text{Rs. } 80,000$$