HUT 310 MANAGEMENT FOR ENGINEERS

Module 3: Productivity and Decision making

COURSE OUTCOMES(COS)

Course Outcome Designation	Course Outcome (CO) Description
HUT 310	**Management For Engineers**
	At the end of the course, the students will be able to:
CO1	Explain the characteristics of management in the contemporary context (Cognitive Knowledge level: Understand)
CO2	Describe the functions of management (Cognitive Knowledge level: Understand)
CO3	**Demonstrate ability in decision making process and productivity analysis (Cognitive Knowledge level: Understand???)**
CO4	Illustrate project management technique and develop a project schedule (Cognitive Knowledge level: Apply)
CO5	Summarize the functional areas of management (Cognitive Knowledge level: Understand)
CO6	Comprehend the concept of entrepreneurship and create business plans (Cognitive Knowledge level: Understand)

SYLLABUS - MODULE 3 (7 HRS.)

Productivity and Decision making

- Concept of productivity and its measurement; Competitiveness; Decision making process; decision making under certainty, risk and uncertainty; Decision trees; Models of decision making

PRODUCTIVITY PROBLEMS AND MEASUREMENT

- Productivity is one of the major concerns of managers in the 21st century
- Productivity may be defined as the output–input ratio within a time period with due consideration for quality
- This definition may be applied to productivity of organizations, managers, staff personnel and other workers
- Productivity refers to the physical relationship between the quantity produced (output) and the quantity of resources used in the course of production (input)
- It is a measure of how well resources are used
- The productivity of the knowledge worker is more difficult to measure than that of the skill worker

PRODUCTIVITY

- In its broadest sense, productivity is defined as

Productivity = Outputs/Inputs

where Output implies production(quantity of goods & services produced) while Inputs may be land, labor, capital, management etc.

- Productivity measures the efficiency of the production system
- To increase productivity, we want to make this ratio of outputs to inputs as large as practical
- Productivity is called a relative measure because, to be meaningful, it needs to be compared with something else
- Productivity may be expressed as partial measures, multifactor measures, or total measures

SYSTEM CONCEPT OF PRODUCTIVITY

$$\text{Productivity} = \frac{\text{Output in a Period of Time}}{\text{Input in the Same Period of Time}}$$

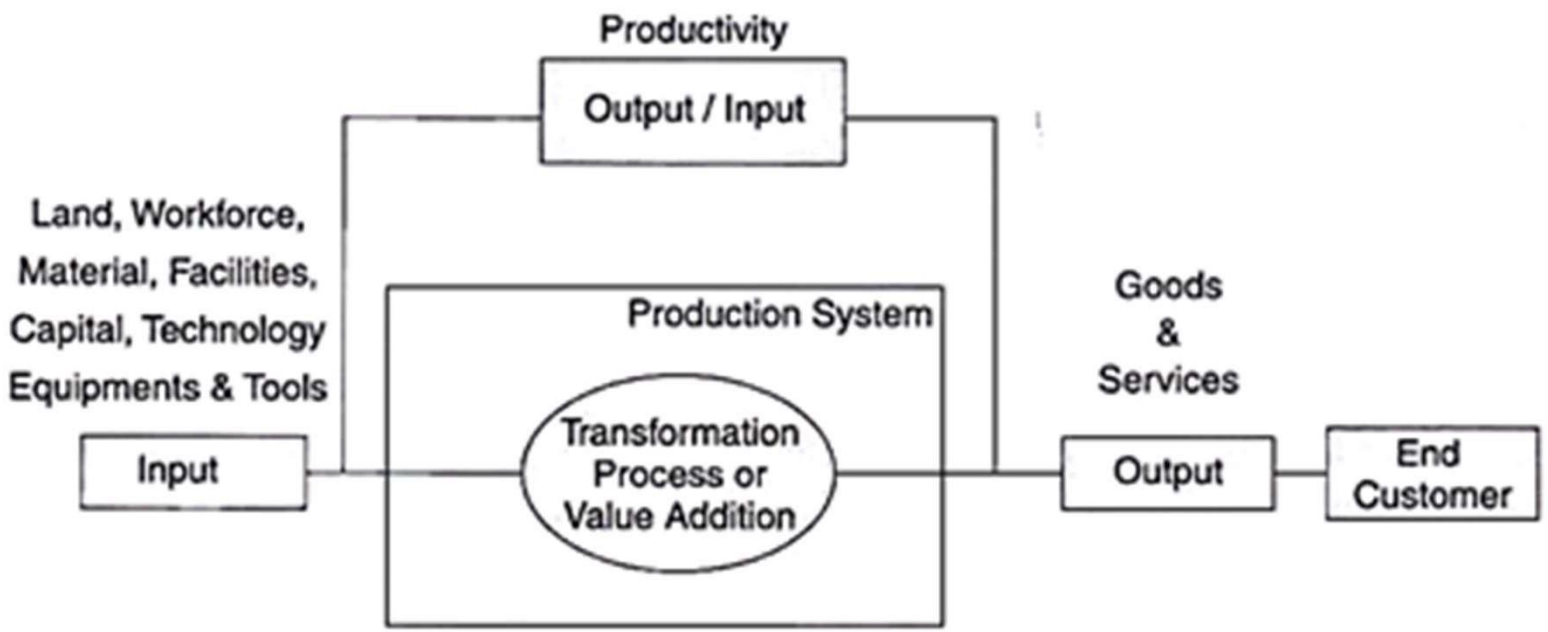


Fig. 2.1 System Concept of Productivity

PRODUCTIVITY

- For the long term growth of the firm and the economy as a whole, it is important that a high level of productivity is maintained
- A high productivity means that the resources are utilized to the optimum, while minimizing wastage
- This leads to reduction in cost of production, and subsequently availability of quality products to customers at lower price
- Profitability of the firm is also related to its productivity

MAIN TYPES OF PRODUCTIVITY MEASURES

- Broadly, productivity measures can be classified as single factor productivity measures (relating a measure of output to a single measure of input), multifactor productivity measures (relating a measure of output to a bundle of inputs) and total factor productivity measures
- Another distinction, of particular relevance at the industry or firm level is between productivity measures that relate some measure of gross output to one or several inputs and those which use a value-added concept to capture movements of output

MAIN TYPES OF PRODUCTIVITY MEASURES

- Value-added vs Gross Output Measures:
- Two basic measures of output are by value added and gross output
- The Value added measure excludes intermediate inputs (materials, energy and services used up in the process of production) while the Gross-output measure includes those inputs
- Either output measure can be used to estimate labor productivity growth and multifactor productivity (MFP) growth

MAIN TYPES OF PRODUCTIVITY MEASURES

- Value-Added Productivity per Employee
- The value-added approach has considerable advantages as it is a simple measure that ignores the difficulties of dealing with inter-industry and intra-industry flows of goods and services
- Intermediate inputs are simply excluded by the value-added measure
- Value added in an industry represents the contribution of that industry to sectoral or aggregate gross product
- Value added per worker is a measure of labor productivity—value added per unit of input
  - Value-Added Productivity per Employee is an outstanding measure of the extent to which the organization is utilizing the employee's strengths
- Value added denotes the net output of a sector after adding up all outputs and subtracting intermediate inputs

MAIN TYPES OF PRODUCTIVITY MEASURES

- The value-added approach provides a simple conceptual link of industry-level MFP and sectoral or aggregate MFP growth
- Value added in an industry represents the contribution of that industry to sectoral or aggregate gross product
- Current price values of value added can simply be summed across different industries without regard to any inter-industry flows of inputs
- Quantity indices of value added can be aggregated by forming weighted averages, with weights adding to unity
- The weights are simply each industry's current price share in total value added

MAIN TYPES OF PRODUCTIVITY MEASURES

- Thus, value added based productivity measures are weighted averages of their components and can be compared across sectors or industries
  - For example, the productivity growth of a sector can be compared with the average for all sectors
  - If in a two-sector economy, both sectors grew at one per cent a year then aggregate productivity would also grow at one percent a year

MAIN TYPES OF PRODUCTIVITY MEASURES

- Calculation Of Value Added Productivity (At Firm Level)
- Value Added Productivity(VA per employee)

$$= \frac{\text{Firm's Value Added}(\$)}{\text{Total No. of employees on firm's payroll}}$$

- Where,
  - Firm's Value Added = Total Remuneration + Operating Profit Before Tax + Depreciation + Indirect Taxes And Levies

PARTIAL(SINGLE-FACTOR) PRODUCTIVITY

- Partial(Single-Factor) Productivity is a measure of output against a single specific input
- *i.e.*, partial productivity measures use one class of inputs or factors, but not multiple factors
- Partial productivity is concerned with efficiency of one class of input
- Its significance lies in its focus on utilization of a single resource
- Does not reflect the overall performance of the business

TYPES OF PARTIAL PRODUCTIVITY MEASURES

- Labor productivity: It is the ratio of output* to labor input (unit - output per labor hour)
- Material productivity: It is the ratio of output to materials input
- Machine productivity: It is the ratio of machine units of output per machine hour, output per unit machine
- Capital productivity: It is the ratio of output to capital input and it is measured in Rupees
- Energy Productivity: Ratio of output per Unit Energy (E.g.: Rupee value of output per kilowatt-hour)

* Here "Output" can be gross output or value added

SINGLE FACTOR PRODUCTIVITY

- Advantages of Single-Factor Productivity:

  1. Ease in obtaining relevant data and easy to comprehend
  2. Acts as a good diagnostic measure to identify areas of improvement by evaluating inputs separately across the output
  3. Ease in comparing with other businesses in the industry

- Disadvantages of Single-Factor Productivity:

  1. Does not reflect the overall performance of the business
  2. Misinterpreted as technical change or efficiency/effectiveness of labor
  3. Management may identify wrong areas of improvements if the focus areas of a business are not examined accurately

MULTIFACTOR PRODUCTIVITY

- If we want to look at the ratio of some output to a group of inputs (but not all inputs), we use a multifactor productivity measure
- Multi-factor productivity is an index of output obtained from more than one of the resources (inputs) used in production
- The concept of multi-factor productivity was developed by Scott D. Sink
- Multifactor productivity (MFP) is a measure of economic performance that compares the amount of output to the amount of combined inputs used to produce that output

MULTIFACTOR PRODUCTIVITY

- Combinations of inputs can include labor, capital, energy, materials, and purchased services
- It is the ratio of net output to the sum of associated labor and other factor inputs:
- $MFP = \frac{\text{Output}}{\text{Labor+Machine+Energy}}$ OR

$$\frac{\text{Output}}{\text{Labor+Machine+Material}}$$

MULTIFACTOR PRODUCTIVITY

- Multifactor productivity (MFP) reflects the overall efficiency with which labor and capital inputs are used together in the production process
- Changes in MFP reflect the effects of changes in management practices, brand names, organizational change, general knowledge, network effects, spillovers from production factors, adjustment costs, economies of scale, the effects of imperfect competition and measurement errors

MULTIFACTOR PRODUCTIVITY

- Advantages of Multifactor Productivity:
  1. Considers intermediate inputs of a business
  2. Measures technical change in an industry
- Disadvantages of Multifactor Productivity
  1. Difficulty in obtaining all the inputs
  2. Difficulty in communicating inter-industry linkages and aggregation

TOTAL FACTOR PRODUCTIVITY

- If we want to express the ratio of all outputs to all inputs, we can use a total factor measure of productivity to describe the productivity of an entire organization
- The Total Factor Productivity model developed by John W. Kendrick in 1951
- He has taken only labor and capital as only two input factors as he believed them to be the most significant in contribution in the process of production.

$$\text{TFP} = \frac{\text{Net Output}}{\text{Labor+Capital Input}}$$

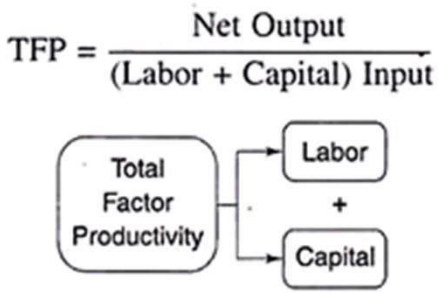


Fig. 2.3 Total Factor Productivity Measurement

TOTAL FACTOR PRODUCTIVITY

- Craig and Harris defined Total Productivity measure as:

$$P_t = \frac{Q_t}{(L+C+R+Q)}$$

- Where
- P_t = Total Productivity
- Q_t = Total Output
- L = Labor Input Factor
- C = Capital Input Factor
- R = Raw Material Input Factor
- Q = Other miscellaneous goods and services input factor

TOTAL FACTOR PRODUCTIVITY

- Sumanth's Total Productivity Model:
- Total Productivity Model was developed by David J. Sumanth in 1979 considering five items as inputs
- These are human, material, capital, energy and other expenses
- This model can be applied in any manufacturing or service organization

$$\text{Total productivity (TPM)} = \frac{\text{Total Tangible Output}}{\text{Total Tangible Input}}$$

- Where:
- Total Tangible Output = Value of finished units produced + value of partial units produced +dividends from securities + interest from bonds + other income
- Total Tangible Input = Value of (human + material + capital +energy+ other expenses) inputs used

TOTAL FACTOR PRODUCTIVITY

- Sumanth provided a structure for finding Productivity at product level and summing product level productivities to total firm level Productivity
- The model also has the structure for finding partial productivities at the product level and aggregating them to product level productivities

TOTAL FACTOR PRODUCTIVITY

- Advantages of Total Productivity Measure:
  1. All quantifiable inputs are considered
  2. Sensitivity analysis can be done
  3. Provides both firm level and operational unit level productivity
- Disadvantages of Total Productivity:
  1. Data is difficult to compute
  2. Does not consider intangible factors of input and output

Comparison of Various Productivity Measures

Partial measure	$\frac{\text{Output}}{\text{Labor}}$ or $\frac{\text{Output}}{\text{Capital}}$ or $\frac{\text{Output}}{\text{Materials}}$ or $\frac{\text{Output}}{\text{Energy}}$
Multifactor measure	$\frac{\text{Output}}{\text{Labor + Capital + Energy}}$ or $\frac{\text{Output}}{\text{Labor + Capital + Materials}}$
Total measure	$\frac{\text{Output}}{\text{Inputs}}$ or $\frac{\text{Goods and services produced}}{\text{All resources used}}$

Input and Output Production Data ($1,000)		Productivity Measure Examples
Output		Total measure
1. Finished units	$10,000	$\frac{\text{Total output}}{\text{Total input}} = \frac{13,500}{15,193} = 0.89$
2. Work in process	2,500	
3. Dividends	1,000	Multifactor measures:
Total output	$13,500	$\frac{\text{Total output}}{\text{Labor + Material}} = \frac{13,500}{3,153} = 4.28$
		$\frac{\text{Finished units}}{\text{Labor + Material}} = \frac{10,000}{3,153} = 3.17$
Input		
1. Labor	$ 3,000	Partial measures:
2. Material	153	
3. Capital	10,000	$\frac{\text{Total output}}{\text{Energy}} = \frac{13,500}{540} = 25$
4. Energy	540	
5. Other expenses	1,500	$\frac{\text{Finished units}}{\text{Energy}} = \frac{10,000}{540} = 18.52$
Total input	$ 15,193	

EXAMPLE

A furniture manufacturing company has provided the following data (units are $1,000). Compare the labor, raw materials and supplies, and total productivity for the past two years. (*LO2–5*)

		Last Year	This Year
Output:	Sales value of production	$22,000	$35,000
Input:	Labor	10,000	15,000
	Raw materials and supplies	8,000	12,500
	Capital equipment depreciation	700	1,200
	Other	2,200	4,800

Solution

	Last Year	This Year
Partial productivities		
Labor	2.20	2.33
Raw materials and supplies	2.75	2.80
Total productivity	1.05	1.04

PRODUCTIVITY INDEX

- A productivity index is the ratio of productivity measured in some time period (Current Period) to the productivity measured in a base period

- $$\text{Productivity Index} = \frac{\text{Productivity of following (current)period}}{\text{Productivity of Base Period}}$$

- It is used to compare the productivity during the current year with the productivity during the base year

- Base year: Any year which is used for comparative study

- By tracking productivity indexes over time, managers can evaluate the success, or lack thereof, of projects and decisions

VARIOUS PRODUCTIVITY INDEXES

$$\text{Total Productivity Index} = \frac{\text{Total Productivity of Current Period}}{\text{Total Productivity of Base Period}}$$

- Partial Productivity Indices:

$$\text{Labour Productivity Index} = \frac{\text{Labour Productivity of Current Period}}{\text{Labour Productivity of Base Period}}$$

$$\text{Management Productivity Index} = \frac{\text{Management Productivity of Current Period}}{\text{Management Productivity of Base Period}}$$

$$\text{Land Productivity Index} = \frac{\text{Land Productivity of Current Current Period}}{\text{Land Productivity of Base Period}}$$

$$\text{Material Productivity Index} = \frac{\text{Material Productivity of Current Period}}{\text{Material Productivity of Base Period}}$$

$$\text{Energy Productivity Index} = \frac{\text{Energy Productivity of Current Period}}{\text{Energy Productivity of Base Period}}$$

Example:

- Compute the multifactor productivity measure for an eight-hour day in which the usable output was 300 units, produced by three workers who used 600 pounds of materials. Workers have an hourly wage of $20, and material cost is $1 per pound. Overhead is 1.5 times labor cost.

$$productivity = \frac{Output}{Input} = \frac{Output}{Labor + Material + Overhead}$$

$$= \frac{300}{3*8*20 + 600*1 + (3*8*20)*1.5}$$

$$= \frac{300}{480 + 600 + 720} = 0.17 \text{ units per dollar input}$$

Problems on Productivity Concept

Problem 1 : The following information regarding the output produced and inputs consumed for a particular company is given below:

Output = Rs 10,000 , Human input = Rs 3000

Material input = Rs 2000 , Capital input = Rs 3000

Energy input = Rs 1000 , Other misc. input = Rs 500

Compute the partial productivities.

Solution : Partial productivity

1. Labour productivity $= \frac{\text{Output}}{\text{Labour input}} = \frac{10{,}000}{3000} = \mathbf{3.33}$

2. Capital productivity $= \frac{\text{Output}}{\text{Capital input}} = \frac{10{,}000}{3000} = \mathbf{3.33}$

3. Material productivity $= \frac{\text{Output}}{\text{Material input}} = \frac{10{,}000}{2000} = \mathbf{5.00}$

4. Energy productivity $= \frac{\text{Output}}{\text{Energy input}} = \frac{10{,}000}{1000} = \mathbf{10.00}$

5. Other Misc. expenses $= \frac{\text{Output}}{\text{Other misc.input}} = \frac{10{,}000}{500} = \mathbf{20.00}$

Problem 2:

a) Find the productivity if **four workers** installed **720** square yards of carpet in **eight hours**.

b) Compute the productivity of a machine which produced **68 usable** pieces in **two hours**.

Solution :

a) Productivity of labour = $\frac{\text{Yards of carpet installed}}{\text{Labors hours}}$

= 720 square yard / (4 workers x 8 hours / worker)

= 720 yards / 32 Hours

= 22.5 yards/ hours

b) Productivity of a machine = Usable Pieces / Production Time

= 68 usable pieces / 2hrs

= 34 pieces/ hours

Problem 3:

A wrapping paper company produced 2,000 rolls of paper in a day. Standard price is $1/roll. Labor cost was $ 160, material cost was $ 50, and overhead cost was $ 320.

Determine the multi factor productivity.

Solution :

$$\text{Multifactor productivity} = \frac{\text{Quantity produced at standard price}}{(\text{Labor cost} + \text{Material cost} + \text{Overhead})}$$

$$= \frac{2{,}000 \text{ rolls} \times \$\ 1}{(\$160 + \$\ 50 + \$320)}$$

$$= \mathbf{3.77}$$

Problem 4:

Long beach bank employs **three** loan officers, each working **eight hours** per day. Each officer processes an average of **five loans** per day. The bank's payroll cost for the officers is **$820** per day, and there is a daily overhead expenses of **$500**.

a. Compute the labor productivity.

b. Compute the multifactor productivity, using loans per dollar cost as the measure.

Problem continue….

The bank is considering the purchase of new computer software for the loan operation. The software will enable each loan officer to process **eight loans** per day, although the overhead expense will increase to **$550.**

c. Compute the new labor productivity.

d. Compute the new multifactor productivity.

e. Should the bank proceed with the purchase of the new software? Explain.

Solution :

a. Labor productivity is simply the ratio of loans to labor-hours:

$$= \frac{\text{Output}}{\text{Input}} = \frac{3 \text{ officers} \times 5 \text{ loans/day}}{3 \text{ officers} \times 8 \text{ hrs./day}} = 0.625 \text{ loans/labor-hr.}$$

b. Multifactor productivity accounts for both labor cost and overhead:

$$= \frac{\text{Output (loans)}}{\text{Input(labor cost + overhead)}} = \frac{3 \text{ officers} \times 5 \text{ loans/day}}{\$820 + \$500}$$

$$= 0.0113 \text{ loans/\$}.$$

The new software increases the number of loans processed per day, but it also increases the overhead.

c. New labor productivity:

$$= \frac{\text{Output}}{\text{Input}} = \frac{3 \text{ officers} \times 8 \text{ loans/day}}{3 \text{ officers} \times 8 \text{ hrs./day}} = 1.0 \text{ loans/labor-hr.}$$

d. New multifactor productivity:

$$= \frac{\text{Output (loans)}}{\text{Input(labor cost + overhead)}} = \frac{3 \text{ officers} \times 8 \text{ loans/day}}{\$820 + \$550}$$

$$= 0.0175 \text{ loans/\$.}$$

e. Purchasing the new software would **increase the labor productivity** by 60%

Increase in labor productivity = [1.0−0.625]/0.625 = 0.6

and **would increase the multifactor productivity** by 55 %

Increase in multifactor productivity =

[0.0175 − 0.0113]/0.0113 = 0.55

See Model Question Paper

EXAMPLE 1– PRODUCTIVITY CALCULATION

- At Modern Lumber, Inc., Art Binley, president and producer of apple crates sold to growers, has been able, with his current equipment, to produce 240 crates per 100 logs
- He currently purchases 100 logs per day, and each log requires 3 labor-hours to process
- He believes that he can hire a professional buyer who can buy a better-quality log at the same cost
- If this is the case, he can increase his production to 260 crates per 100 logs. His labor-hours will increase by 8 hours per day
- What will be the impact on productivity (measured in crates per labor-hour) if the buyer is hired?

EXAMPLE 1– PRODUCTIVITY CALCULATION

- Soln:

- (a) Current labor productivity $= \frac{240 \text{ crates}}{100 \text{ logs} \times 3 \text{ hours/log}} = \frac{240}{300} =$

  0.8 crates per labor-hour

- (b) Labor productivity with buyer $=$

$$\frac{260 \text{ crates}}{(100 \text{ logs} \times 3 \text{ hours/log}) + 8 \text{ Hours}} = 0.844 \text{ crates per labor-hour}$$

- Using current productivity (.80 from (a)) as a base, the increase will be 5.5% (0.844/0.8 = 1.055, or a 5.5% increase)

EXAMPLE 2– PRODUCTIVITY CALCULATION

- In the previous example, Art Binley has decided to look at his productivity from a multifactor (total factor productivity) perspective
- To do so, he has determined his labor, capital, energy, and material usage and decided to use dollars as the common denominator
- His total labor-hours are now 300 per day and will increase to 308 per day
- His capital and energy costs will remain constant at $350 and $150 per day, respectively. Material costs for the 100 logs per day are $1,000 and will remain the same. He pays an average of $10 per hour
- Compute his productivity increase

EXAMPLE 2– PRODUCTIVITY CALCULATION

- Soln:
- Current System :
  - Labor: $300\ hrs \times \$10 = \$3{,}000$
  - Material Cost: for 100 logs/day = $1,000
  - Capital= $350
  - Energy cost= $150
  - Total Cost= $4,500
  - Multifactor productivity of current system: = 240 crates/ $4,500 = 0.0533 crates/dollar

EXAMPLE 2– PRODUCTIVITY CALCULATION

- System with Professional Buyer
  - Labor: 308 hrs × $10 = $3,080
  - Material Cost: for 100 logs/day = $1,000
  - Capital= $350
  - Energy cost= $150
  - Total Cost = $4,580
  - Multifactor productivity of proposed system: = 260 crates/4,580 = 0.0568 crates/dollar
- Using current productivity (.0533) as a base, the increase will be 0.066. That is, .0568/.0533 = 1.066, or a 6.6% increase

See Model Question Paper

EXAMPLE 3– PRODUCTIVITY CALCULATION

- Student tuition at Boehring University is $150 per semester credit hour
- The state supplements school revenue by $100 per semester credit hour
- Average class size for a typical 3-credit course is 50 students.
- Labor costs are $4,000 per class, material costs are $20 per student per class, and overhead costs are $25,000 per class.
- (a) Determine the multi factor productivity
- (b) If instructors deliver lecture 14 hours per week and the semester lasts for 16 weeks, what is the labor productivity?

EXAMPLE 3– PRODUCTIVITY CALCULATION

- Soln:
- a) Multifactor productivity is the ratio of the value of output to the value of input resources
- Value of output $= \left(\frac{50\ Student}{Class}\right)\left(\frac{3\ Credit\ Hours}{Student}\right)\left(\frac{\$150\ tuition + \$100\ state\ support}{Credit\ Hour}\right)$

  $= \$37{,}500/class$
- Value of inputs = Labor + Materials + Overhead

  $= \$4{,}000 + (\$20/student \times 50\ students/class) + \$25{,}000$

  $= \$30{,}000/class$
- Multifactor productivity $= \frac{\text{Value of output}}{\text{Value of inputs}} = 1.25$

EXAMPLE 3– PRODUCTIVITY CALCULATION

- b) Labor productivity is the ratio of the value of output to labor hours
- The value of output is the same as in part (a), or $37,500/class
- Labor hours of input $= \left(\frac{14\ Hours}{week}\right)\left(\frac{16\ weeks}{class}\right) = 224\ hours/class$
- Labor Productivity $= \frac{Output}{Labor\ Hours} = \frac{\$37500/class}{224\ Hours/class} = \$167.41/hour$

FACTORS AFFECTING PRODUCTIVITY

- The factors influencing productivity can be classified broadly into two categories:

1. Controllable Factors
   - Controllable Factors are considered as internal factors
   - These are the factors which are in control of the organization
2. Uncontrollable Factors
   - Uncontrollable factors are known as external factors
   - These are beyond the control of the organization

FACTORS AFFECTING PRODUCTIVITY

1. Controllable Factors

- Following are the controllable factors
  - A. Material and Power
  - B. Machinery and Plant Layout
  - C. Human Factors
  - D. Organization and Managerial Factors
  - E. Technological Factors

FACTORS AFFECTING PRODUCTIVITY

A. Material and Power

- Improved quality of raw materials has a favorable effect on productivity
- An effort to reduce materials and energy consumption brings about considerable improvement in productivity

B. Machinery and Plant Layout

- The size of the plant and the capacity utilization has direct bearing on productivity
- Production below or above the optimum level will be uneconomical and will tend towards lower level of productivity
- The position & arrangement of machines in the plant and the setup of the work-bench of an individual worker will determine how economically and efficiently production will be carried out

FACTORS AFFECTING PRODUCTIVITY

C. Human Factors

- Human Nature and Human Behavior are the most significant determinants of Productivity
- Human factors include:
  - The Ability to work
  - The Willingness to work

FACTORS AFFECTING PRODUCTIVITY

D. Organization and Managerial Factors

- Organization factors include various steps taken by the organization towards maintaining better industrial relations such as delegation and decentralization of authority
- These factors also influence motivation
- The competence and attitudes of managers also have an important bearing on productivity
- Competent and dedicated managers can obtain extraordinary results from ordinary people

FACTORS AFFECTING PRODUCTIVITY

E. Technological Factors

- Technological factors exert significant influence on the level of Productivity
- These include the following:
  - Size and Capacity of Plant
  - Product Design and Standardization
  - Timely supply of Materials and Fuels
  - Repairs and Maintenance
  - Production Planning and Control
  - Plant Layout and Location
  - Material Handling System
  - Inspection and Quality Control
  - Inventory Control

FACTORS AFFECTING PRODUCTIVITY

2. Uncontrollable Factors

- Following are examples of uncontrollable factors
  - A. Economic Political and Social Changes
  - B. Natural Resources
  - C. Government Factor

A. Economic Political and Social Changes

- Economic Factors like Size of the market, banking and credit facilities, transport and communication systems, etc. Influences productivity
- Political Factors like Law and order, stability of government, harmony between states etc. are essential for high productivity in industries
- Social Factors like Social customs, traditions etc. also influence productivity

FACTORS AFFECTING PRODUCTIVITY

B. Natural Resources

- Natural factors such as physical, geographical and climate conditions exert considerable influence on productivity
- Extreme climates (too cold or too hot) tends to make productivity comparatively low
- Natural resources like water, fuel and minerals also influence productivity

FACTORS AFFECTING PRODUCTIVITY

C. Government Factor

- Government policies and programs are significant to productivity
- Policies regarding transport, communication, power distribution and fiscal policies (interest rates, taxes) influence productivity to the greater extent

COMPETITIVENESS

- It is the ability and performance of a firm to sell and supply goods and services in a given market, in relation to the ability and performance of other firms.
- Competitive advantage is the leverage a business has over its competitors.

- It measures how well a company can make goods or provide services more quickly, creatively, and cheaply than its rivals, giving it an edge.
- Many different things go into making a business competitive, such as quality, productivity, innovation, adaptability, market share, and overall performance.

Following are the fundamental success drivers:-

- Cost competitiveness
- Differentiation advantage
- Quality
- Speed
- Innovation

Cost competitiveness:

Cost competitiveness is about keeping the price low and realizing profits.

Differentiation advantage

A firm differentiates itself from its competitors “when it provides something unique that is valuable to buyers beyond simply offering a low price.

Quality:

Quality refers to the excellent features of the product including attractiveness, lack of defects, reliability and long term dependability.

Speed :

Fast and timely manufacturing and delivery of the products is the key requirement in business.

Innovation:

Creation of new devices, objects, ideas or procedures is very important in business.

DECISION MAKING

DECISION MAKING

- It can be defined as "the selection from among alternatives of a course of action"
- It is at the core of planning
- The decision making process can be carried out either by individuals acting alone or by groups
- Decision making is a process of selection from a set of alternative courses of action which is thought to fulfill the objectives of the decision problem more satisfactorily than others
- "Whatever a manager does, he does through decision making." - Peter F. Drucker
- Decision making is often called the "essence" of managing

SIGNIFICANCE OF DECISION MAKING

- Decision making is important for organizational effectiveness because of its central role in the overall process of directing and controlling the behavior of organizational members
- Besides its organizational effect, however, decision making also has an individual effect - The quality of a decision has a bearing on his or her professional success and sense of satisfaction
- Another major reason for studying decision making is to enable us to make better quality decisions than we do presently
- In order to increase our effectiveness in decision making, we must first understand the decision making process. Decision making and planning are deeply interlinked

DECISION MAKING PROCESS

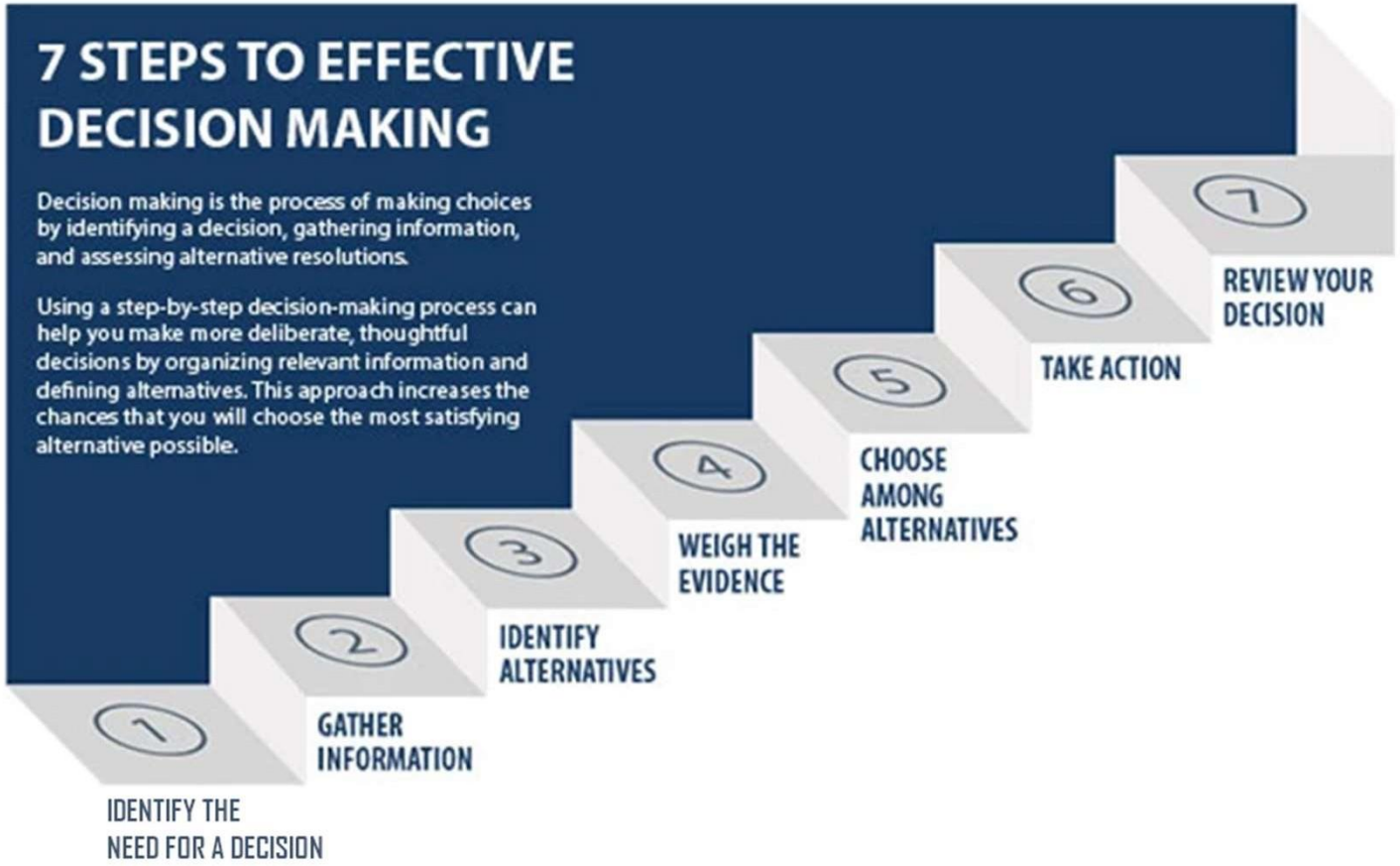
- The basic characteristics of decision making are:
- It is the process of choosing a course of action from among the alternative courses of action
- It is a human process involving to a great extent the application of intellectual abilities
- It is the end process preceded by deliberation and reasoning
- It is always related to the environment
- It always has a purpose. Keeping this in view, there may just be a decision to not to decide
- It involves all actions like defining the problem and probing and analyzing the various alternatives which take place before a final choice is made

DECISION MAKING PROCESS

- The components of decision making are as follows:
  - The decision maker
  - The decision problem
  - The environment in which the decision is to be made
  - The objectives of the decision maker
  - The alternative courses of action
  - The outcome expected from various alternatives
  - The final choice of the alternative

STEPS IN DECISION MAKING PROCESS

- Using a step-by-step decision-making process can help you make more deliberate, thoughtful decisions by organizing relevant information and defining alternatives



STEPS IN DECISION MAKING PROCESS

- Step 1: Identify the need for a decision
- At this step the manager realizes that a decision needs to be made. He must try to clearly define the nature of the decision that is to be made.
- Step 2: Gather relevant information
- The manager must collect relevant information before making a decision
- He needs to decide what information is needed, the best sources of information, and how to get it
- This step involves both internal and external information: Internal information can be collected through a process of self-assessment. External information can be collected online, from books, from other people, and from other sources

STEPS IN DECISION MAKING PROCESS

- Step 3: Identify the alternatives
- As the manager collects information, he will probably identify several possible paths of action, or alternatives. He can also use your imagination and additional information to construct new alternatives. In this step, the manager will list all possible and desirable alternatives
- Step 4: Weigh the evidence
- Considering the information gathered, the manager needs to be able to predict what it would be like if he carried out each of the alternatives to the end. He needs to evaluate whether the need identified in Step 1 would be met or resolved through the use of each alternative. As he goes through this difficult internal process, he'll begin to favor certain alternatives: those that seem to have a higher potential for reaching the goal. Finally, the alternatives are placed in a priority order, based upon the evaluation of pros and cons of each

STEPS IN DECISION MAKING PROCESS

- Step 5: Choose among alternatives
- Once all evidence are weighed, the manager is ready to select the alternative that seems to be best. He may even choose a combination of alternatives
- Step 6: Take action
- This is done by beginning the implementation of the alternative chosen in Step 5.
- Step 7: Review the decision & its consequences
- In this final step, the manager considers the results of his decision and evaluate whether or not it has resolved the need identified in Step 1. If the decision has not met the identified need, he may want to repeat certain steps of the process to make a new decision. For example, he might want to gather more detailed or somewhat different information or explore additional alternatives

TYPES OF DECISIONS

- Decisions may be classified into five major types

1. Organizational and personal decisions
2. Routine and strategic decisions
3. Policy and operating decisions
4. Programmed and non-programmed decisions
5. Individual and group decisions

TYPES OF DECISIONS

- Organizational and personal decisions
- Organizational decisions are those decisions that are taken to achieve organizational goals
- When an individual takes decision as an executive in the official capacity, it is known as organizational decision
- If decision is taken by the executive in the personal capacity (thereby affecting his personal life), it is known as personal decision
- Personal decisions are meant only to achieve personal goals
- Sometimes these decisions may affect functioning of the organization also. For example, if an executive leaves the organization, it may affect the organization
- The authority of taking organizational decisions may be delegated, whereas personal decisions cannot be delegated

TYPES OF DECISIONS

- Routine and strategic decisions
- Routine decisions are related to the general functioning of the organization
- They do not require much evaluation and analysis and can be taken quickly
- Ample powers are delegated to lower ranks to take these decisions within the broad policy structure of the organization
- Routine decisions are repetitive in nature
- Certain established rules, procedures and policies are to be followed while making these decisions

TYPES OF DECISIONS

- Strategic decisions are those decisions which have to be deliberated upon in depth
- They are important decisions which affect objectives, organizational goals and other important policy matters
- These decisions usually involve huge investments or funds
- These are non-repetitive in nature and are taken after careful analysis and evaluation of many alternatives
- These decisions are taken at the higher level of management

TYPES OF DECISIONS

- Policy(tactical) and operating decisions
- Decisions pertaining to various policy matters of the organization are policy decisions
- These are taken by the top management and have long term impact on the functioning of the concern
- For example, decisions regarding location of plant, volume of production and channels of distribution (Tactical) policies, etc. are policy decisions

TYPES OF DECISIONS

- Operating decisions relate to day-to-day functioning or operations of business
- Middle and lower level managers take these decisions
- An example may be taken to distinguish these decisions
  - Decisions concerning payment of bonus to employees are a policy decision
  - On the other hand if bonus is to be given to the employees, calculation of bonus in respect of each employee is an operating decision

PROGRAMMED & NON-PROGRAMMED DECISIONS

- Programmed & Non-programmed Decisions
- Programmed Decisions
- A programmed decision is applied to structured or routine problems
- Examples
  - Lathe operators have specifications and rules that tell them whether the part they made is acceptable, has to be discarded, or should be reworked
  - Reordering of standard inventory items
- Programmed decision is used for routine and repetitive work
- It relies primarily on previously established criteria
- It is, in effect, decision-making by precedent
- Problems at lower levels of the organization are often routine and well structured, requiring less decision discretion by managers and non-managers . Hence Programmed Decisions are mostly made at the lower level of managers

PROGRAMMED & NON-PROGRAMMED DECISIONS

- Non- Programmed Decisions
- Non-programmed decisions are used for unstructured, novel, and ill-defined situations of a non-recurring nature
- Examples
  - The introduction of the Macintosh computer by Apple
  - The development of the four-wheel-drive passenger car by Audi
- Strategic decisions, in general, are non-programmed decisions since they require subjective judgments
- Most non-programmed decisions are made by upper-level managers; as they have to deal with unstructured problems
- Note: Most decisions are neither completely programmed nor completely non-programmed; they are a combination of both

TYPES OF DECISIONS

- Individual and group decisions:
- When the decision is taken by a single individual, it is known as individual decision
- Usually routine type decisions are taken by individuals within the broad policy framework of the organization
- Group decisions are taken by group of individuals constituted in the form of a standing committee
- Generally very important and pertinent matters for the organization are referred to this committee
- The main aim in taking group decisions is the involvement of maximum number of individuals in the process of decision-making

MODELS OF DECISION MAKING

1. Contingency model
2. Economic man model
3. Administrative man model (Bounded Rationality model)
4. Social man model

MODELS OF DECISION MAKING

- Contingency model
- Beach and Mitchell (1978) felt that the decision maker uses one of three general types of decision strategies:
  1. Aided analytic,
  2. Unaided analytic, and
  3. No-analytic
- The aided analytic strategy employs some sort of formal model or formula, or an aid such as a checklist
- An unaided analytic strategy is one in which the decision maker is very systematic in his or her approach to the problem and perhaps follows some sort of model, but does it all in his or her head. Thinking of all the pros and cons for each alternative or trying to imagine the consequences of each action would fall in this category

MODELS OF DECISION MAKING

- In the category of no analytic strategy, the decision maker chooses by habit or uses some simple rule of thumb ("nothing ventured, nothing gained" or "better safe than sorry") to make the choice
- Which strategy is to be selected depends on the personal characteristic of the decision maker and the demands of the task
- The underlying assumption of the contingency model is that a person will choose a strategy that requires the least amount of time and effort to reach a satisfactory decision
- The more analytic a strategy, the more time and effort are required to use it

MODELS OF DECISION MAKING

- The model suggests that as the decision problem becomes less familiar and more ambiguous, complex, and unstable, the decision maker will use more time and analysis (more analytic strategies) to reduce the uncertainty caused by these factors
- However, this process continues only up to a point
- When the uncertainty due to these factors becomes too great, the decision maker is likely to return to a simpler rule
- The reason is that when there is an extremely high degree of uncertainty in the decision problem, the potential gains of a more accurate analytic decision are small and are often far outweighed by the cost (e.g., time and effort) required to arrive at that decision
- The model suggests that more analytic strategies will be selected when decisions are not reversible and very important, and when the decision maker is personally accountable
- Also, analytic procedures are more likely to be used where there are no time or money constraints

MODELS OF DECISION MAKING

- Economic man model (Econologic model)
- The economic model represents the earliest attempt to model decision process, under conditions of certainty
- The economic man is completely economically rational
- It states how a manager should behave in the process of decision making
- This approach, besides rational, is also idealistic because it cannot be fully applied to a practical situation
- This approach is supported by scientific and logical methods

MODELS OF DECISION MAKING

- This model makes two assumptions:

1. It assumes people are economically rational
   - Economic rationality exists when people attempt to maximize objectively measured advantage, such as money or units of goods produced
   - i.e., people will select the decision or course of action that has the greatest advantage or payoff from among the many alternatives
2. It also assumes that people attempt to maximize outcomes in an orderly, logical, planned and sequential process

MODELS OF DECISION MAKING

- Figure below shows a basic econologic decision model

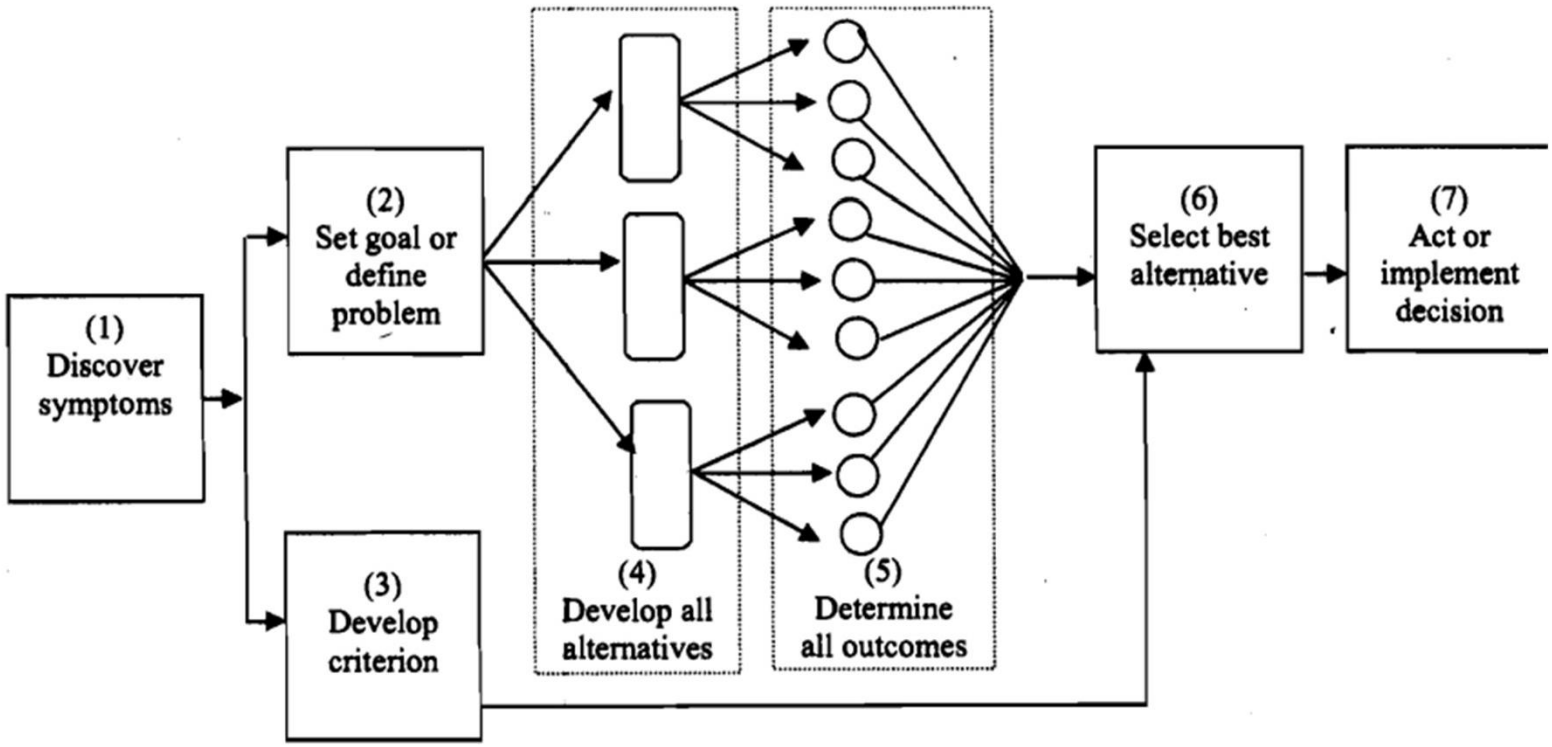


Fig.8.2: An Econologic Model of Decision making
Source: Behling and Schriesheim, 1976

MODELS OF DECISION MAKING

- The figure suggests the following orderly steps in the decision process:

1. Discover the symptoms of the problem or difficulty
2. Determine the goal to be achieved or define the problem to be solved
3. Develop a criterion against which alternative solutions can be evaluated
4. Identify all alternative courses of action
5. Consider the consequences of each alternatives as well as the likelihood of occurrence of each
6. Choose the best alternative by, comparing the consequences of each. Alternative (step 5) with the decision criterion (step 3); and
7. Act or implement the decision

MODELS OF DECISION MAKING

- The economic man model represents a useful prescription of how decisions should be made, but it does not adequately portray how decisions are actually made
- Some of the assumptions it makes about the capabilities of human beings are incorrect
- The human mind is simply incapable of executing such transactions at the level and magnitude required for complex decisions
- To that extent, this model is unrealistic
- However, due to the advent of sophisticated data storage, retrieval and processing machines, it is now possible to achieve economic rationality to some extent

MODELS OF DECISION MAKING

- Bounded Rationality Model (Administrative Man Model)
- An alternative model, one not bound by the above assumptions, has been presented by Herbet Simon
- This is the bounded rationality model, also known as the administrative man model
- Bounded rationality is the idea that rationality is limited when individuals make decisions
- In other words, humans' "preferences are determined by changes in outcomes relative to a certain reference level"
- This model does not assume individual rationality in the decision making process
- Instead, it assumes that people, while they may seek the best solution, usually settle for much less because the decisions they confront typically demand greater information processing capabilities than they possess
- They seek a kind of bounded (for limited) rationality in decisions

MODELS OF DECISION MAKING

- The concept of bounded rationality attempts to describe decision processes in terms of three mechanisms:
- Sequential attention to alternative solutions:
- People examine possible solutions to a problem sequentially
- Instead of identifying all possible solutions and selecting the best (as suggested in the econologic model), the various alternatives are identified and evaluated one at a time
- If the first solution fails to work it is discarded and the next solution is considered
- When an acceptable (that is, 'Good enough' and 'not necessarily the best') solution is found, the search is discontinued

MODELS OF DECISION MAKING

- Use of heuristics:
- A heuristic is a rule which guides the search for alternatives into areas that have a high probability for yielding satisfactory solutions
- For instance, some companies continually select Management graduates from certain institutions because in the past such graduates have performed well for the company
- According to the bounded rationality model, decision makers use heuristics to reduce large problems to manageable proportions so that decisions can be made rapidly
- They look for obvious solutions or previous solutions that worked in similar situations

MODELS OF DECISION MAKING

- Satisfying:
- Whereas the econologic model focuses on the decision maker as an optimizer, this model sees him or her as a satisficer
- An alternative is optimal if:
  1. There exists a set of criteria that permits all alternatives to be compared; and
  2. The alternative in question is preferred, by these criteria, to all other alternatives
- An alternative is satisfactory if:
  1. There exists a set of criteria that describes minimally satisfactory alternatives; and
  2. The alternative in question meets or exceeds all these criteria

MODELS OF DECISION MAKING

- The decision process as seen from the standpoint of the bounded rationality model is depicted below:

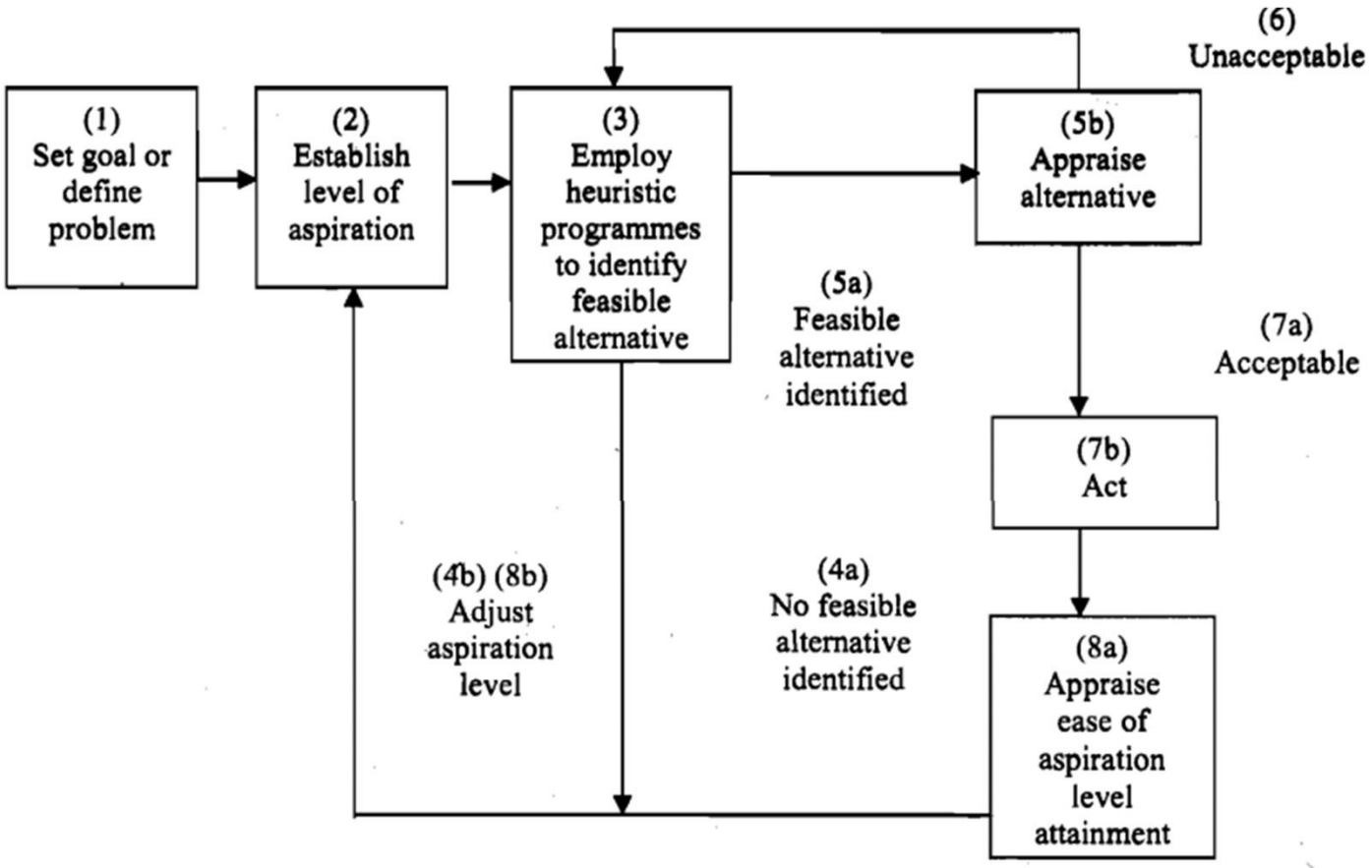


Fig.8.3: A Bounded Rationality Model of Decision Making
Source: Behling and Schriesheim, 1976

MODELS OF DECISION MAKING

1. Set the goal to be pursued or define the problem to be solved
2. Establish an appropriate level of aspiration or criterion level (that is, when do you know that a solution is sufficiently positive to be acceptable even if it is not perfect'?)
3. Employ heuristics to narrow problem space to a single promising alternative
4. If no feasible alternative is identified (a) lower the aspiration level, and (b) begin the search for a new alternative solution (repeat steps 2 and 3)
5. After identifying a feasible alternative (a), evaluate it to determine its acceptability (b)
6. If the identified alternative is unacceptable, initiate search for a new alternative solution (repeat steps 3-5)
7. If the identified alternative is acceptable (a) implement the solution (b)
8. Following implementation, evaluate the ease with which goal was (or was not) attained (a), and raise or lower level of aspiration accordingly on future decisions of this type.

MODELS OF DECISION MAKING

- Social man model
- This model was developed by the classical psychologists. This model feels that man being a social animal is subjected to social pressures and influences
- Freud, in particular says that men being a bundle of feelings, emotions and instincts is guided by his unconscious desires. He is also subject to social pressures and influences.
- Obviously, such a human being is not capable of making rational management decisions
- Here the decisions are taken under the following conditions:
  - Certainty: Because of certainty, accurate decisions can be taken
  - Uncertainty and risk: Several decisions are taken under conditions of risk

MODELS OF DECISION MAKING

- In order to generate alternatives three main processes are generally used. These are brainstorming, synectics and nominal grouping
- Brain storming:
- This is developed by Alex F. Osborn
- It is the best technique in stimulating creative thinking
- The objective of this method is to produce as many ideas as possible
- In this method 'criticism' is prohibited. 'Freewheeling' is welcome
- Combination and improvement are sought
- This method does have limitations. They are time consuming and costly
- Care should be taken to select group members who are familiar with the problem to be considered

MODELS OF DECISION MAKING

- Synectics:
- Here members are selected from different backgrounds and training
- The leader poses the problem in such a way that the members deviate from traditional ways of thinking
- Various methods employed include role playing, use of analogies, paradoxes, metaphors and other thought provoking exercises
- This is a widely used method and though it has limitations like brain storming, it is very useful for complex and technical problems

MODELS OF DECISION MAKING

- Nominal grouping:
- It means group in name only
- This model is useful when it requires a high degree of innovation and idea generation
- Here the search process is proactive rather than reactive
- It is also time consuming and costly
- Nominal group technique (NGT) is defined as a structured method for group brainstorming that encourages contributions from everyone and facilitates quick agreement on the relative importance of issues, problems, or solutions
- Team members begin by writing down their ideas, then selecting which idea they feel is best

MODELS OF DECISION MAKING

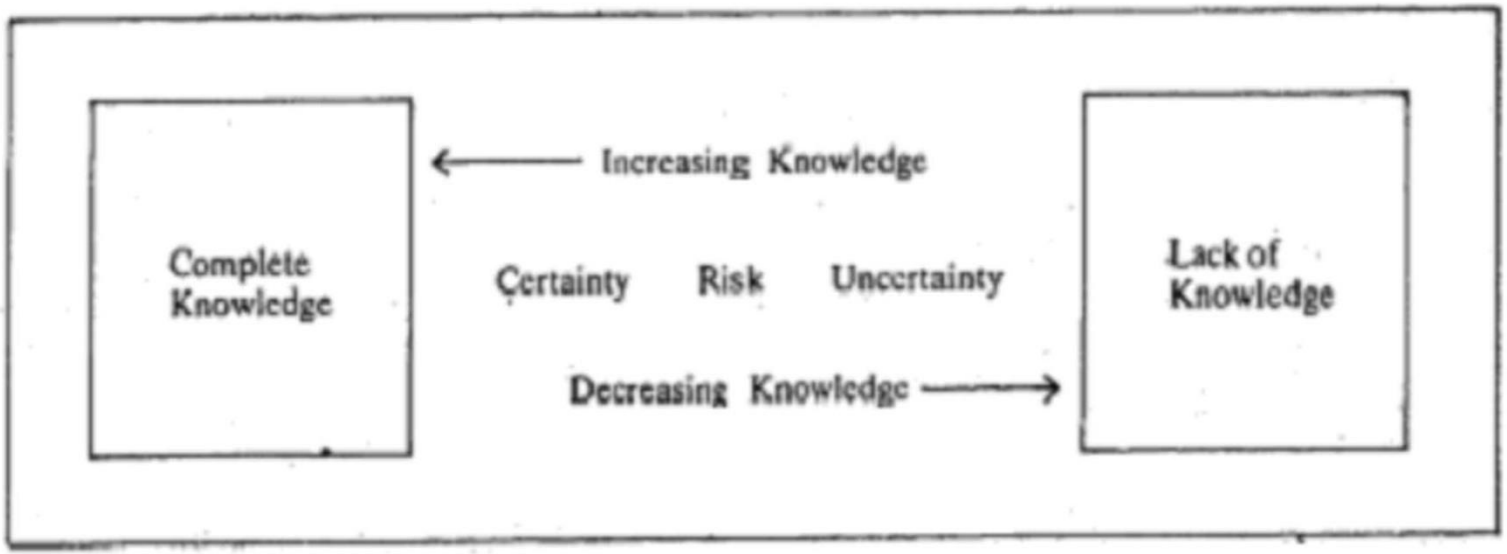
- The nominal group technique (NGT) is a group process involving problem identification, solution generation and decision making
- It can be used in groups of many sizes, who want to make their decision quickly, as by a vote, but want everyone's opinions taken into account (as opposed to traditional voting, where only the largest group is considered)
- The method of tallying is the difference
  - First, every member of the group gives their view of the solution, with a short explanation
  - Then, duplicate solutions are eliminated from the list of all solutions, and the members proceed to rank the solutions, 1st, 2nd, 3rd, 4th, and so on
  - In the basic method, the numbers each solution receives are totaled, and the solution with the highest (i.e. most favored) total ranking is selected as the final decision

DECISION MAKING UNDER DIFFERENT STATES OF NATURE

- A decision-maker may not always have complete knowledge about decision alternatives (i.e., High Problem Complexity) or about the outcome of a chosen alternative (i.e., High Outcome Uncertainty)
- These conditions of knowledge are often referred to as states of nature and have been labelled:
  1. Decisions under Certainty
  2. Decisions under Risk
  3. Decisions under Uncertainty

DECISION MAKING UNDER DIFFERENT STATES OF NATURE

Figure IV Decision Making Conditions Continuum



DECISION MAKING UNDER DIFFERENT STATES OF NATURE

- Decision making under certainty:
- A decision is made under conditions of certainty when a manager knows the precise outcome associated with each possible alternative or course of action
- In such situations, there is perfect knowledge about alternatives and their consequences
- Exact results are known in advance with absolute (100%) certainty
- A manager is simply faced with the task of identifying the consequences of available alternatives and selecting the outcome with the highest benefit or payoff

DECISION MAKING UNDER DIFFERENT STATES OF NATURE

- Managers rarely operate under conditions of certainty. The future is only barely known
- Indeed, it is difficult to think of examples of all but the most trivial business decisions that are made under such conditions
- One frequent illustration that is often cited as a decision under at least near certainty is the purchase of government bonds or certificates of deposit
  - For example, as per the assurance provided by Government of India, Rs. 1,000 invested in a 6-year National Savings Certificate will bring a fixed sum of Rs. 2,015 after six complete years of investment
  - It should still be realized, however, that the Government defaulting on its obligations is an unlikely probability, but the possibility still exists

DECISION MAKING UNDER DIFFERENT STATES OF NATURE

- Decision making under risk:
- A decision is made under conditions of risk when a single action may result in more than one potential outcome, but the relative probability of each outcome is known
- Decisions under conditions of risk are perhaps the most common
- In such situations, alternatives are recognized, but their resulting consequences are probabilistic and doubtful
- As an illustration, if you bet on number 6 for a single roll of a dice, you have a 1/6 probability of winning in that there is only one chance in six of rolling a 6

DECISION MAKING UNDER DIFFERENT STATES OF NATURE

- While the alternatives are clear, the consequence is probabilistic and doubtful
- Thus, a condition of risk may be said to exist
- In practice, managers assess the likelihood of various outcomes occurring based on past experience, research, and other information
- Example Situations:
  - A quality control inspector, for example, might determine the probability of number of `rejects' per production run
  - A safety engineer might determine the probability of number of accidents occurring
  - A personnel manager might determine the probability of a certain turnover or absenteeism rate

DECISION MAKING UNDER DIFFERENT STATES OF NATURE

- Decision making under uncertainty:
- A decision is made under conditions of uncertainty when a single action may result in more than one potential outcome, but the relative probability of each outcome is unknown
- Decisions under conditions of uncertainty are unquestionably the most difficult
- In such situations a manager has no knowledge whatsoever on which to estimate the likely occurrence of various alternatives
- Decisions under uncertainty generally occur in cases where no historical data are available from which to infer probabilities or in instances which are so novel and complex that it is impossible to make comparative judgements

DECISION MAKING UNDER DIFFERENT STATES OF NATURE

- Examples of decisions under complete uncertainty are as difficult to cite as are example of decisions under absolute certainty
- Given even limited experience and limited ability to generalize from past situations, most managers should be able to make at least some estimate of the probability of occurrence of various outcome
- Nevertheless, there are undoubtedly times when managers feel they are dealing with complete uncertainty
- Selection of a new advertising programmed from among several alternatives might be one such example
  - The number of factors to be considered and the large number of uncontrollable variables vital to the success of such a venture can be mind-boggling

DECISION MAKING UNDER RISK

DECISION MAKING UNDER RISK

- In this environment, we have additional information about the occurrence of the states of nature:
- We have the past data containing information about the occurrence of different states of nature
- We know either:
  1. The directly available probabilities of occurrence of different states of nature or
  2. The frequency data for different states of nature which can be converted into probabilities using the relative frequency approach of probability or
  3. Subjective probabilities on the basis of experience of individuals
- In all cases, we have with us the probabilities of occurrence of different states of nature in the environment of decision making under risk

DECISION MAKING UNDER RISK

- The following criteria are used to select an optimum course of action in this environment:
  1. Expected Monetary Value (EMV) Criterion
  2. Expected Opportunity Loss (EOL) Criterion

DECISION MAKING UNDER RISK

- Expected Monetary Value (EMV) Criterion :
- In this criterion, we first form the payoff table or payoff matrix if it is not already given
- Then for each course of action we find the expected value by multiplying the payoff value for each course of action one at a time with the probabilities of the corresponding state of nature
- The resulting values are called the expected monetary values (EMVs)
- Next we select the maximum of the EMVs in the case of profit or gain, and the minimum of the EMVs in the case of loss or cost
- In the case of profit or gain, the course of action corresponding to the maximum expected monetary value is the optimum course of action according to this criterion
- And in the case of loss or cost, the course of action corresponding to the minimum expected monetary value is the optimum course of action according to this criterion

DECISION MAKING UNDER RISK

- (Detailed) Steps in Expected Monetary Value (EMV) Criterion :
- Step 1: If the payoff table or payoff matrix is already given, Step 1 is not needed. Otherwise, we first define the courses of action and states of nature and then obtain the payoff table or payoff matrix for the given situation. We also add one more column to the table indicating the probabilities of different states of nature
- Step 2: To obtain the expected monetary value (EMV) for each course of action, we multiply the payoff value of each course of action with the probability of the corresponding state of nature and then add the results
- For example, let $x_{1j}, x_{2j}, \dots, x_{mj}$ be the payoff values for the j −th course of action corresponding to m states of nature $N_1, N_2 \dots, N_m$ and let $p_1, p_2, \dots, p_m$ be the corresponding probabilities of these m states of nature, respectively

DECISION MAKING UNDER RISK

- Then the Expected monetary value (EMV) for the jth course of action is given as:

$$EMV \text{ for the } j\text{th course of action} = p_1 x_{1j} + p_2 x_{2j} + \cdots + p_m x_{mj} = \sum_{i=1}^{m} p_i x_{ij}$$

- Where x_{ij} is the payoff value corresponding to the ith state of nature and the jth course of action and,
- p_i is the probability of ith state of nature
- Step 3: We select the maximum expected monetary value from among the expected monetary values obtained in Step 2 if payoff values represent profit or gain. We select the minimum EMV if the values represent loss or cost
- Step 4: Under this criterion, the course of action corresponding to the maximum (or minimum) EMV selected in Step 3 will be the optimum course of action

EXAMPLE: EMV CRITERION

- A vendor buys newspapers at the rate of Rs. 3 per newspaper and sells at the rate of Rs. 4 per newspaper. Assume that a newspaper which is not sold on the same day goes to scrap and pays him Rs 0.50 as regret value. The information for the past 200 days about the sale of the newspapers is shown below

No. of Newspapers Demanded	200	204	206	208	Total
No. of Days	40	100	40	20	200

- On the basis of this information, how many newspapers should be bought by the vendor so that his profit is maximum?

EXAMPLE: EMV CRITERION

- Soln:
- It is clear that the vendor should buy either 200, 204, 206 or 208 newspapers per day. Since the number of newspapers he will buy is under his control, purchases of newspapers form the courses of action
- If we denote these courses of action by A_1, A_2, A_3, A_4, respectively, then we have $A_1 = 200, A_2 = 204, A_3 = 206, A_4 = 208$
- But the future demand of newspapers on any day is not under his control. So the demands of newspapers form the states of nature
- If we denote these states of nature by N_1, N_2, N_3, N_4 respectively, then we have $N_1 = 200, N_2 = 204, N_3 = 206, N_4 = 208$

EXAMPLE: EMV CRITERION

- Now, the frequencies corresponding to these demands can be used to calculate probabilities (using the relative frequency approach of probability) and for the states of nature N_1, N_2, N_3, N_4 these are given as:

  $\frac{40}{200} = 0.2$, $\frac{100}{200} = 0.5$, $\frac{40}{200} = 0.2$ and $\frac{20}{200} = 0.1$ respectively

- Step 1: Let us now calculate the payoff values:

- The cost of a newspaper = Rs. 3

- The selling price of a newspaper = Rs. 4

- Profit gained by the vendor on selling one newspaper = Rs. (4 – 3) = Rs. 1

EXAMPLE: EMV CRITERION

- Loss to the vendor on an unsold newspaper = Rs (3 – 0.5) = Rs. 2.5
- Conditional Profit =(profit on a sold newspaper) ×(Number of newspapers sold)−(Loss on an unsold newspaper) × (Number of newspapers unsold)

  = Rs.1 ×(No. of newspapers sold)−$(Rs.\ 2.5)$ ×(No. of newspapers unsold)
- For example, for $A_1 = 200, N_1 = 200,$
- Conditional profit for A_1, N_1 is $= 1 \times 200 - 2.5 \times 0 = Rs.\ 200$
- For $A_1 = 200, N_2 = 204,$ Conditional profit $= 1 \times 200 - 2.5 \times 0 = Rs.\ 200$
- Similarly, other calculations can be done as shown in Table in next slide:

EXAMPLE: EMV CRITERION

Payoff Table for the Vendor

States of Nature	Courses of Action				
	Prob.	200 (A_1)	204 (A_2)	206 (A_3)	208 (A_4)
200 (N_1)	0.2	200	$1\times200-2.5\times4=190$	$1\times200-2.5\times6=185$	$1\times200-2.5\times8=180$
204 (N_2)	0.5	200	$1\times204-2.5\times0=204$	$1\times204-2.5\times2=199$	$1\times204-2.5\times4=194$
206 (N_3)	0.2	200	204	206	$1\times206-2.5\times2=201$
208 (N_4)	0.1	200	204	206	208

- Step 2: In this step, we have to calculate the expected monetary value for each course of action

EXAMPLE: EMV CRITERION

- Expected monetary values (EMVs) for different courses of action are given by:
- EMV for $A_1 = 0.2 \times 200 + 0.5 \times 200 + 0.2 \times 200 + 0.1 \times 200 = 200$
- EMV for $A_2 = 0.2 \times 190 + 0.5 \times 204 + 0.2 \times 204 + 0.1 \times 204 = 201.2$
- EMV for $A_3 = 0.2 \times 185 + 0.5 \times 199 + 0.2 \times 206 + 0.1 \times 206 = 198.3$
- EMV for $A_4 = 0.2 \times 180 + 0.5 \times 194 + 0.2 \times 201 + 0.1 \times 208 = 194$
- Step 3: $\max\{200, 201.2, 198.3, 194) = 201.2$
- Step 4: Max EMV corresponds to the course of action A_2. Hence, under this criterion, A_2 is the optimum course of action
- Hence the vendor should buy 204 Newspapers

DECISION MAKING UNDER RISK

- Expected Opportunity Loss (EOL) Criterion
- This criterion suggests the course of action which minimizes our Expected Opportunity Loss
- The steps involved in the procedure of this criterion are the same as in the expected monetary value (EMV) criterion except that instead of dealing with payoff values, here we deal with opportunity loss values

DECISION MAKING UNDER RISK

- Steps in EOL Criterion:
- Step 1: If the payoff table or payoff matrix is already given, then Step 1 is not needed. Otherwise, we first define the courses of action, states of nature and then obtain the payoff table. We also add one more column indicating the probabilities of different states of nature
- Step 2: We obtain the opportunity loss values or regret values or conditional opportunity loss values for each state of nature by subtracting
  - All payoff values corresponding to each state of nature from their respective maximum payoff values in case of profit or gain, or
  - The minimum payoff value corresponding to each state of nature from all other payoff values of the states of nature in case of cost or loss

DECISION MAKING UNDER RISK

- Step 3: Next, we obtain the expected opportunity loss values for each course of action by finding the sum of the products of the opportunity loss values of the course of action with the probabilities of the corresponding states of nature
- Step 4: Finally, we select the minimum from among the expected opportunity loss values calculated in Step 3. The course of action corresponding to the minimum expected opportunity loss value will be the optimum course of action

EXAMPLE: EOL CRITERION

- A company has decided to buy an equipment for its powerhouse station located in a remote area. But this equipment contains an expensive part, which is subject to random failure. The failure data of the same part on the basis of the experience of other users is given below

Table 10.3: Probability Distribution of the Random Variable, Number of Failures

Number of Failures	0	1	2	3 and more
Probability of Failure	0.70	0.20	0.10	0.00

- If the company purchases spares of this part at the time of purchasing the equipment, it costs Rs. 6000 per unit. If it is ordered after the failure of the part during its operation, the total cost including the cost of down time of the equipment is Rs. 30000. Assume that there is no scrap value of the part. On the basis of this information, what should the suggestion of a decision maker to the company be in each of the following cases?

I. What is the optimal number of spares the company should buy at the time of purchasing the equipment using the EMV criterion?

II. What is the optimal course of action using the EOL criterion?

EXAMPLE: EOL CRITERION

- I) We first define the states of nature and courses of action. Then we shall obtain the payoff matrix
- The purchases of spare parts of the equipment, (when the equipment is purchased or after the failure of the parts) are under the control of the company and so form the courses of action
- If we denote these courses of action by A_1, A_2, A_3 then we can write:
- A_1: No spare part was purchased at the time of purchasing the equipment
- A_2 : One spare part was purchased at the time of purchasing the equipment
- A_3 : Two spare parts were purchased at the time of purchasing the equipment

EXAMPLE: EOL CRITERION

- But the number of spares required by the company depends on the number of failures, which is a random event and not under the control of the company
- So these numbers correspond to the states of nature
- Since the probability of 3 or more failures is zero, there are only three states of nature $N_1, N_2\ and\ N_3$ as given below:
- N_1 : No failure occurs
- N_2 : One failure occurs
- N_3 : Two failures occur

EXAMPLE: EOL CRITERION

- Let x_{ij} be the payoff value corresponding to the ith state of nature N_i and the jth course of action A_j
- We first carry out the calculations shown in Table

Calculation(s) of Total Cost for Different Combinations of Courses of Action and States of Nature

States of Nature	Courses of Action	Cost when Spare(s) is/are Purchased at the Time when Equipment is Purchased	Cost when Company Orders after Occurrence of Failure	Total Cost
0	0	0	0	0
0	1	6000	0	6000
0	2	12000	0	12000
1	0	0	30000	30000
1	1	6000	0	6000
1	2	12000	0	12000
2	0	0	60000	60000
2	1	6000	30000	36000
2	2	12000	0	12000

EXAMPLE: EOL CRITERION

- Then we obtain the payoff table using the 9 payoff values given in the last column of the above table:

Payoff Table

States of Nature	Probability	Courses of Action		
		A_1	A_2	A_3
N_1	0.70	0	6000	12000
N_2	0.20	30000	6000	12000
N_3	0.10	60000	36000	12000

- We now find the optimal number of spares that should be purchased by the company using the EMV criterion
- Step 1: We have already obtained the payoff table, which also includes a column indicating probabilities of different states of nature
- Step 2: Next, we calculate the expected monetary value (EMV) for each course of action

EXAMPLE: EOL CRITERION

- EMV for $A_1 = 0.7 \times 0 + 0.2 \times 30000 + 0.1 \times 60000 = Rs.12000$
- EMV for $A_2 = 0.7 \times 6000 + 0.2 \times 6000 + 0.1 \times 36000 = Rs.9000$
- EMV for $A_3 = 0.7 \times 12000 + 0.2 \times 12000 + 0.1 \times 12000 = Rs.12000$
- Step 3: Here payoff values represent a cost to the company. So, in this step, instead of the maximum EMV we select the minimum EMV from among the values obtained in Step 2.

$$\min\{12000,9000,12000\} = Rs.9000$$

- Step 4: Minimum EMV as obtained in Step 3 corresponds to the course of action A_2. Hence, the suggestion of the decision maker to the company under EMV criterion is that the company should buy one spare part of the equipment to minimize the cost

EXAMPLE: EOL CRITERION

- II) Now, we use an EOL criterion to find the optimum course of action
- Step 1: We have already obtained the payoff table, which includes a column indicating the probabilities of different states of nature
- Step 2: In this step, we obtain the opportunity loss values (or regret values or conditional opportunity loss values) for each state of nature
- In this case, the payoff values represent costs
- So, the opportunity loss values are obtained by subtracting the minimum payoff value corresponding to each state of nature from all other payoff values of the states of nature as shown in below table

EXAMPLE: EOL CRITERION

Opportunity Loss Table for the Company

States of Nature	Prob.	Courses of Action		
		A_1	A_2	A_3
N_1	0.70	0 – 0 = 0	6000 – 0 = 6000	12000 – 0 = 12000
N_2	0.20	30000 – 6000 = 24000	6000 – 6000 = 0	12000 – 6000 = 6000
N_3	0.10	60000 – 12000 = 48000	36000 – 12000 = 24000	12000 – 12000 = 0

- Step 3: We now obtain the expected opportunity loss (EOL) value for each course of action as follows:
- EOL for $A_1 = 0.7 \times 0 + 0.2 \times 24000 + 0.1 \times 48000 = 9600$
- EOL for $A_2 = 0.7 \times 6000 + 0.2 \times 0 + 0.1 \times 24000 = 6600$
- EOL for $A_3 = 0.7 \times 12000 + 0.2 \times 6000 + 0.1 \times 0 = 9600$

EXAMPLE: EOL CRITERION

- Step 4: We select the minimum value from among the EOL values obtained in Step 3:
- $\min\{9600, 6600, 9600\} = 6600$
- This corresponds to the course of action A_2
- Hence, the suggestion of the decision maker to the company under EOL criterion is that the company should buy one spare part of the equipment to minimize the cost

DECISION TREE ANALYSIS

- So far we have studied decision criteria under different types of environment to solve decision making problems
- But in all those criteria, we were identifying an optimum course of action among the available courses of action at a given point in time
- That is, we were dealing with the types of situations in which the decision maker has to take the decision at a single stage
- But there may exist situations wherein the decision maker has to make a sequence of decisions
- That is, he/she has to select an optimum course of action more than once, because generally one decision taken by the decision maker leads to the next
- Decision tree analysis is the most useful technique for solving such complex problems

DECISION TREE ANALYSIS

- As we know, the basic shape of a tree looks like a sequence of branches and sub branches

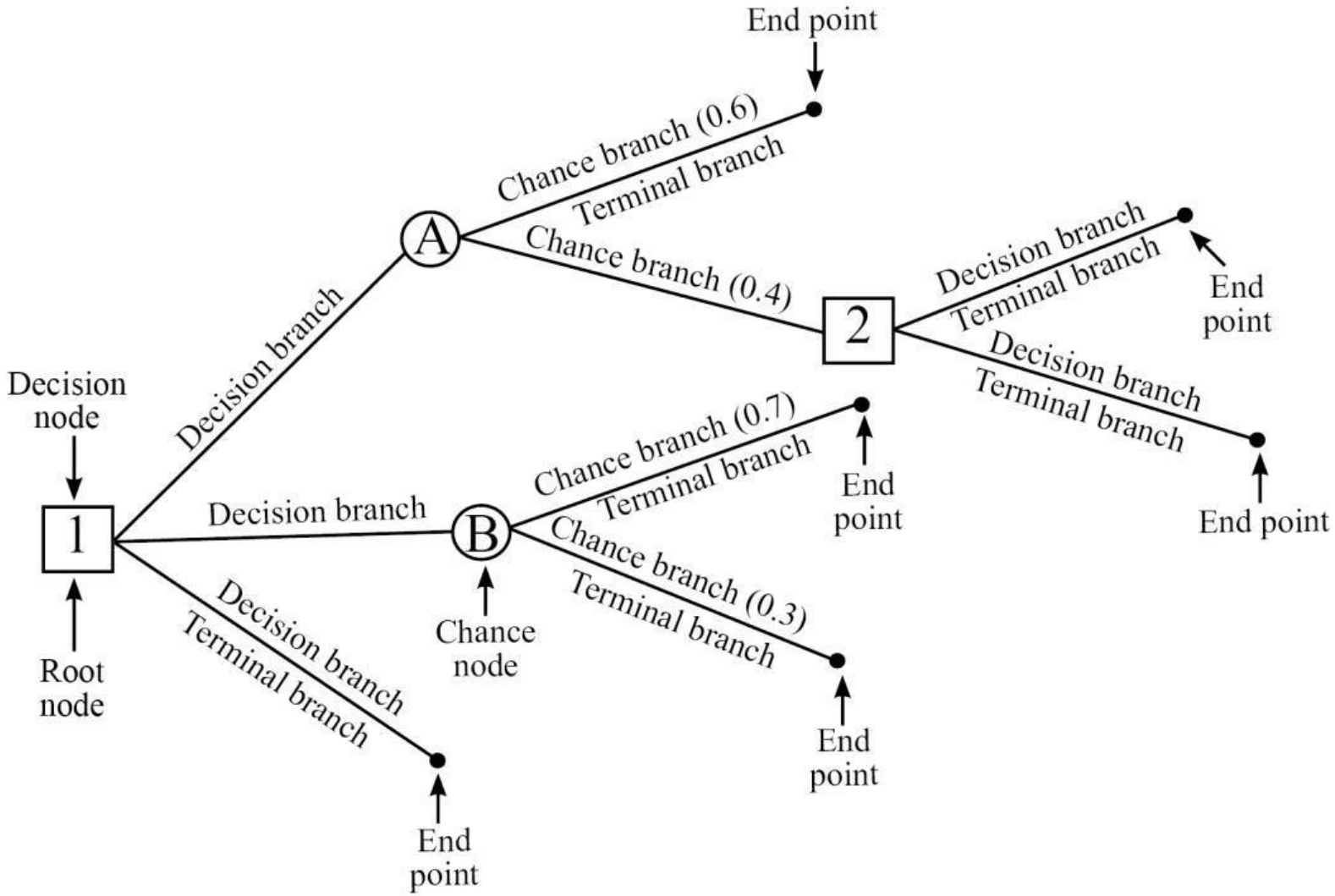
- If different branches and sub branches of a tree are associated with courses of action, the states of nature, probabilities of the states of nature and payoff values of a given decision making problem, then the tree so obtained is known as a decision tree

DECISION TREE ANALYSIS

- Generally we keep the direction of moving the decision trees from left to right, unlike the natural tree which moves in the vertical direction
- A typical representation of the decision tree is shown in next slide
- Terminology:
- Decision Point: A point in the pictorial representation of a decision tree having courses of action as immediate sub branches is known as a decision point
- *i.e.*, a point from which the branches representing the courses of action come out is known as a decision point
- The symbol □ (square) is used to represent a decision point

DECISION TREE ANALYSIS

Pictorial representation of a typical decision tree



DECISION TREE ANALYSIS

- Chance Point(chance node, event point):
- A point in the pictorial presentation of decision tree having states of nature as immediate sub branches is known as a chance point
- The symbol ◯ (circle) is used to represent an event point
- *i.e.*, a point from which the branches representing the states of nature come out is known as the chance point
- Root Node:
- Generally, we keep the direction of moving the decision tree from left to right and the leftmost node is known as the root node
- Root node is represented by the same symbol □ (square) as the one used for the decision point

DECISION TREE ANALYSIS

- Decision and Chance Branches:
- We know that any branch of a decision tree either represents a course of action or a state of nature
- So the branches which represent the courses of action are known as decision branches and the branches which represent the states of nature are known as chance branches
- Also, probabilities corresponding to different states of nature are written along the corresponding chance branches
- End Points:
- The points in the pictorial representation of a decision tree which are neither followed by any decision branch nor by any chance branch are known as its end points
- Terminal Branches:
- Any branch which ends at an end point is known as the terminal branch.

DECISION TREE ANALYSIS

- To solve multistage decision making problems using decision tree analysis, we apply the roll-back technique, which is explained below:
- In the situations where the decision maker has to make a sequence of decisions in multiple stages, the ultimate consequence of the decision taken at the first stage depends on the output of all subsequent decisions that will be taken in future as a result of this decision
- Also, the output of the last result is of primary concern for the decision maker
- That is why, in decision tree analysis, we start evaluating the output of the decisions from the last decision and move in the backward direction until we reach the root node
- Since we work in the backward direction, this technique is known as the roll-back technique

EXAMPLE: DECISION TREE ANALYSIS

- Mr. Singh had to decide whether or not to drill a tube-well at his farm
- In his village, only 40% of the tube-wells were successful at 60 feet of depth
- Some farmers who did not get water at 60 feet drilled up to 150 feet, but only 30% struck water at 150 feet
- The cost of drilling is Rs. 300 per foot
- Mr. Singh estimated that he would have to pay Rs. 20000 for the next 5 years, if he continued to buy water from his neighbor instead of drilling the tube-well, which would have a life of 5 years
- Also, if he struck water, the total cost of drawing water for 5 years from his own tube-well would be Rs. 3000
- If this problem is given to a decision maker, what should his/her suggestion be to Mr. Singh? Assume that all amounts are calculated in terms of the present value.

EXAMPLE: DECISION TREE ANALYSIS

- Soln:
- Deciding whether to drill the tube-well or not is under the control of the decision maker and so forms the courses of action
- Courses of Action
  - A_1: Not to drill any tube-well and continue buying water from the neighbor
  - A_2: To drill the tube-well up to a depth of 60 feet
  - A_3: To drill the tube-well up to a depth of 150 feet, if water is not struck water at 60 feet
  - A_4: Not to drill the tube-well up to 150 feet, if water is not struck at 60 feet
- States of Nature
  - N_1: Water is struck at 60 feet
  - N_2: Water is not struck at 60 feet
  - N_3: Water is struck at 150 feet
  - N_4: Water is not struck at 150 feet

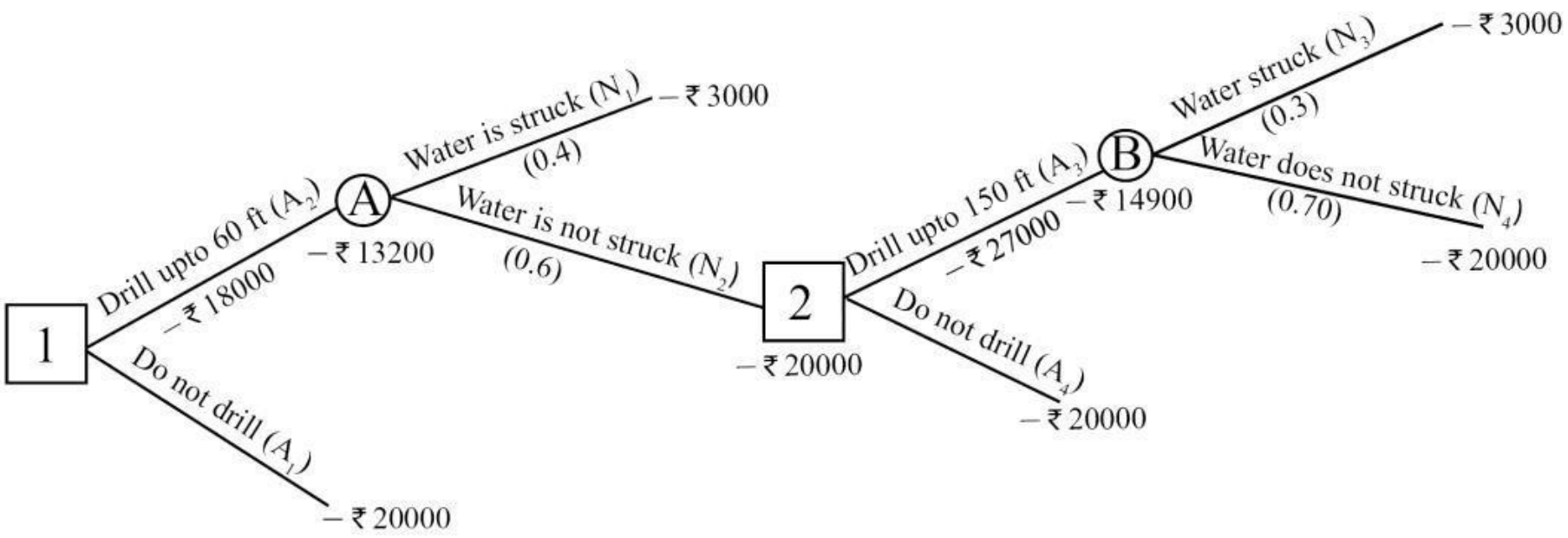
EXAMPLE: DECISION TREE ANALYSIS

- Further, it is given that the cost of drilling = Rs. 300 per foot
- Therefore, the cost of drilling up to 60 feet =Rs. 60x300=Rs. 18000,and
- The cost of drilling further 90 feet (150-60)=Rs. 90x300=Rs. 27000
- If Mr. Singh does not drill the tube well, he will have to pay Rs. 20000 to his neighbor, as water charges for the next 5 years
- But if water is struck, then the cost of watering from his own tube-well for the next five years is Rs. 3000
- Now, all these amounts represent costs
- So to convert them into profit we have to put a negative sign before each amount

EXAMPLE: DECISION TREE ANALYSIS

- Since this is a multistage decision making problem, we have to solve it using the roll-back technique:
- To solve the problem using roll-back technique, we have to draw the decision tree for the problem at hand
- The decision tree is a pictorial representation of the sequence of the decisions
- Here, Mr. Singh has to first decide whether he should drill the tube well or not. This is represented by two branches coming out from the root node 1
- Similarly, other decisions that lead from these branches are also shown in the decision tree shown in next slide

EXAMPLE: DECISION TREE ANALYSIS



EXAMPLE: DECISION TREE ANALYSIS

- Let us now carry out the calculations. We know that in the roll-back technique, we start the calculations from right and move towards the left as explained below:
- Expected monetary value(EMV) at chance node B= $0.3 \times (-3000) + 0.7 \times (-20000) = -$Rs.14900
- But if Mr. Singh decides to drill up to 150 ft, then he has to pay Rs. 27000 as drill charges for 90 ft (=150-60)
- Therefore,
- Total EMV at node B = $-14900 - 27000 = -Rs.41900$

EXAMPLE: DECISION TREE ANALYSIS

- Since node 2 is a decision node,

the EMV at node 2= $\max\{-41900, -20000\} = -Rs.\,20000$

- Since node A is a chance node,

the EMV at node $A = 0.4 \times -3000 + 0.6 \times -20000 = -Rs.\,13200$

- But if Mr. Singh decides to drill up to 60 ft, then he has to pay Rs. 18000 as drill charges
- Therefore, total EMV at node A $= -13200 - 18000 = -Rs.\,31200$
- Finally, node 1 is a decision node,

therefore EMV at node 1= $\max\{-31200, -20000\} = -Rs\ 20000$

EXAMPLE: DECISION TREE ANALYSIS

- Add these information to the decision tree
- Now, study node 1 in the decision tree. The EMV at node 1 corresponds to the course of action A_1
- Hence, the suggestion of the decision maker to Mr. Singh should be:
- Mr. Singh should not go for drilling a tube well at all. He should continue to buy water from his neighbor.

See Model Question Paper

EXAMPLE 2 – DECISION TREE ANALYSIS

- Modern forest management uses controlled fires to reduce fire hazards and to stimulate new forest growth. Management has the option to postpone or plan a burning
- In a specific forest tract, if burning is postponed, a general administrative cost of Rs. 300 is incurred.
- If a controlled burning is planned, there is a 50% chance that good weather will prevail and burning will cost Rs. 3200
- The results of the burning may be either successful with probability 0.6 or marginal with probability 0.4

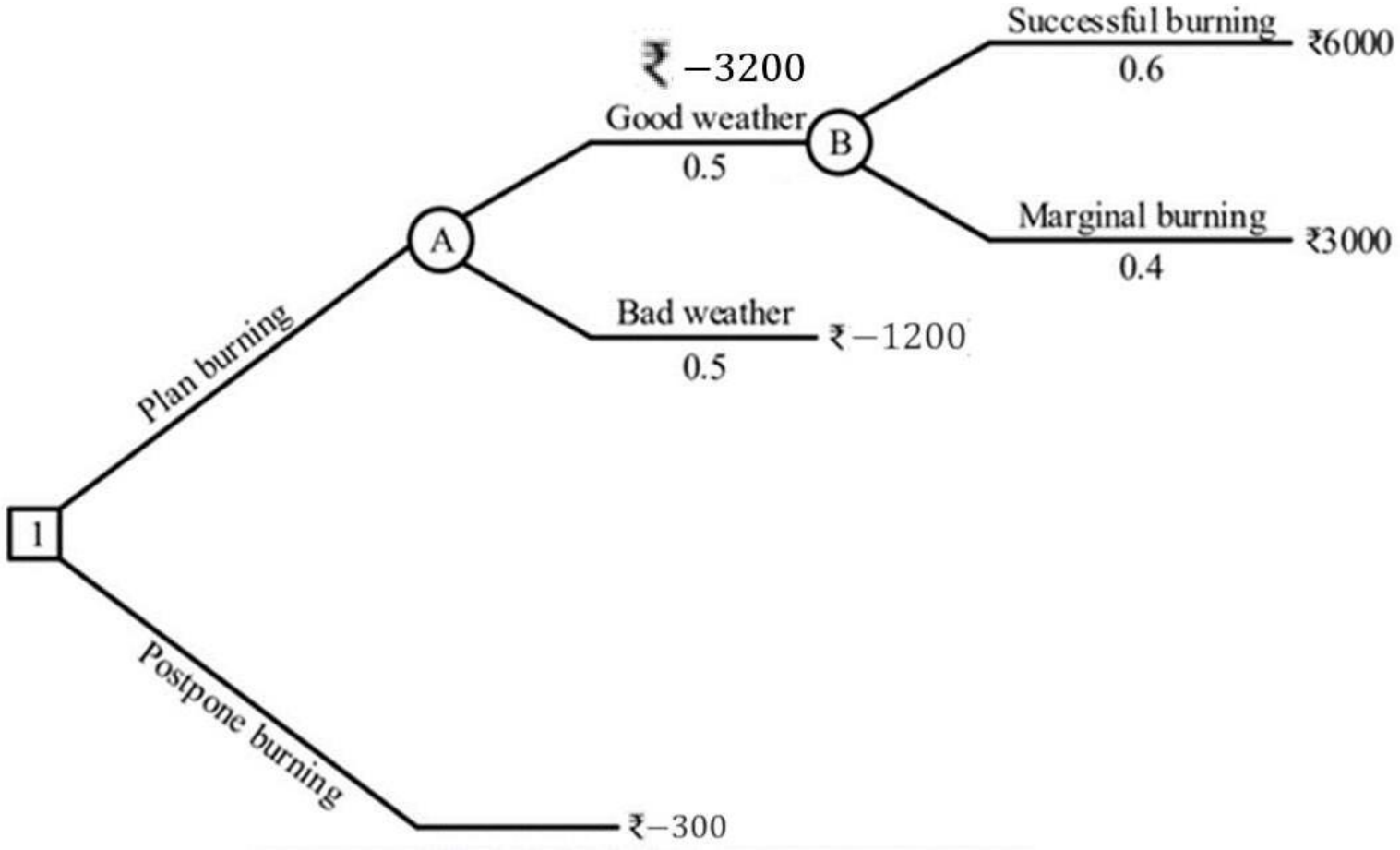
EXAMPLE 2 – DECISION TREE ANALYSIS

- Successful execution will result in an estimated benefit of Rs. 6000, and marginal execution will provide only Rs. 3000 in benefits
- If the weather is poor, burning will be cancelled incurring a cost of Rs. 1200 and no benefit
  a) Develop a decision tree for the problem
  b) Analyze the decision tree and determine the optimal course of action

EXAMPLE 2 – DECISION TREE ANALYSIS

- Soln:

- Based on the given data, the decision tree is given below:



EXAMPLE 2 – DECISION TREE ANALYSIS

- Total EMV of node B=$0.6 \times (Rs.\ 6000) + Rs. -3200 + (Rs. 3000) \times 0.4 = Rs. 1600$
- Total EMV of node A=$0.5 \times (Rs. 1600) + 0.5 \times (Rs. -1200) = Rs. 200$
- EMV of Decision node 1=$\max\{\text{Rs. } 200, Rs. -300\} = Rs. 200$ (As burning results in a profit of $Rs. 200$ and postponing burning results in an expense of Rs. 300)
- The EMV at node 1 corresponds to the course of action – "plan burning"
- Hence the management should plan on burning on the basis of expected values