MODULE 3: 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.

3.1 CONCEPT OF PRODUCTIVITY

In general sense, productivity is some relationship between inputs and output of an enterprise. It is the quantitative relationship between what we produce and the resources used. The only way of raising the living standard of the society is to increase productivity. Productivity can be increased by increasing output from each unit of input.

Some of the definitions, given below explain the fundamental concept of productivity:

(i) Productivity is measure of how much input is required to produce a given output i.e. it is ratio of output to input.

(ii) Productivity is the ratio between the amount produced and the amount of resources used in the course of production. The resources may be any combination of materials, machines, men and space.

(iii) European productivity council defines "Productivity is an attitude of mind. It is a mentality of progress, of the constant improvement of that which exists; it is the certainty of being able to do better than yesterday and continuously. It is constant adaptation of economic and social life to changing conditions. It is continual effort to apply new techniques and methods. It is the faith in human progress."

(iv) According to Peter Drucker, "Productivity means balance between all factors of production that will give the maximum output with the smallest effort."

(v) I.L.O. generally takes productivity to mean, "The ratio between the volume of output as measured by production indices and the corresponding volume of labour input as measured by employment indices."

(vi) Organization of European Economic Community (OEEC) defines productivity as the ratio between the production of a given commodity measured by volume and one or more of the corresponding input factors also measured by volume. Thus there can be a number of measures indicating the level of performance corresponding to each input. In general sense, productivity is measure how much input is required to produce a given output i.e.,

$$Productivity = \frac{Measure\ of\ Output}{Measure\ of\ Input}$$

Inputs in a business organization can be labour, capital etc. The measures can be expressed in terms of money value or in terms of quantity. In most cases output will be goods and services produced, for which input will be men, money, equipment, power, plant facilities and other items used in the process of production.

High productivity suggests minimum use of resources for achieving a set of targets. Without a set result there is no productivity. Improvement in productivity will result in accomplishment of set targets with relatively lower sacrifice of input resources.

Higher the productivity ratio, better it is. High productivity increases production and reduces cost of production per unit and, therefore, reduces selling price and increases profitability of the concern.

Productivity should not be confused with production because the latter refers directly to the output while the former relates

to the ratio of output in terms of input of materials, labour hours, machine hours, capital employed or any other factor of production. Thus in a broad sense, productivity means goods and services produced in relation to resources utilized in producing the same.

3.1.1 Measures to Improve Productivity

(i) Better planning and training of employees, improved jobs and communication and effective management through CPM/PERT methods.

(ii) Use of time and motion studies to study and improve work performance. It enables to assess the quantum of work, which can be used for planning and control.

(iii) Better transportation and material handling system.

(iv) By providing work incentives and other benefits to workers.

(v) Workers involvement in decision making and working of organizations.

(vi) Improvement in technology of production process and nature of raw-material and its quality

(vii) Simplification, standardization and specialization technique.

(viii) Better and efficient utilization of resources at the disposal of the enterprises.

(ix) Use of linear programming and other quantitative techniques for better decision making.

(x) ABC analysis to identify more important items and then apply inventory control to reduce capital investment

(xi) Value engineering to reduce material content by good design.

Question 1:

Calculate productivity per machine hour from the following information:

Month	Production (Units)	Machine hours used
January	50,000	5,000
February	57,000	6,000
March	63,000	7,000

Solution:

$$Productivity = \frac{Measure\ of\ Output}{Measure\ of\ Input} \text{ ie } \frac{Output}{Machine\ Hours\ used}$$

Productivity per machine hour:

January = $\frac{50000}{5000} = \mathbf{10\ units}$

February = $\frac{57000}{6000} = \mathbf{9.5\ units}$

January = $\frac{63000}{7000} = \mathbf{9\ units}$

3.1.2 Factors Affecting Productivity in an Organization

1. Product or System Design:

If through better product design, a product can be simplified by eliminating some of its parts, it is obvious that the material these pieces are made of will no longer be needed. Nor will the equipment, tooling, and labour to make them be required. Value Analysis can bring out many product design changes that improve productivity. R&D is a vital contributor to improved product design. Standardization of the product and the use of group technology arc other design factors that make possible greater productivity in the factory.

2. Machinery and Equipment:

Once the product is designed, then how it is made offers the next opportunity for productivity improvement. The equipment used-machines, tools, conveyors, robots, the way the factory is laid out—all are important. Computer has helped design the products (CAD), it helps oper... mplicated

machine tools (CNC machines) and it controls the inventory of material and parts. It has become an essential ingredient in productivity improvement.

3. The Skill and Effectiveness of the Worker:

The trained and experienced worker can do the same job in a much shorter time and with far greater effectiveness than a new one. However, even the well-trained employees must be motivated to be productive.

4. Production Volume:

Assume that the volume of output is to be doubled. The number of direct workers would have to be doubled and a few indirect workers might also be needed. But there would probably not be a need for more engineers, research scientists, headquarters staff people or other support personnel. So if the output is doubled, the productivity of these support people is in effect doubled.

3.1.3 Benefits from Increased Productivity

Higher productivity results in higher volume of production and hence sales at lower cost and higher profit.

It is beneficial to all as stated below:

(A) Benefit to Organisation:

1. More profit.
2. Higher productivity ensures stability of the concern.
3. Higher productivity and higher volume of sales provide opportunity for expansion of the concern and wide spread market.
4. It provides overall prosperity and reputation of the concern.

(B) Benefit to Workers:

(i) Higher productivity permits more wages.

(ii) More wages permit better standard of living of workers.

(iii) Thus more productivity means better working conditions for workers which also help in maintaining better health for workers.

(iv) Higher productivity yields improved moral and greater satisfaction for workers.

(C) Benefit to Consumers:

(i) More productivity ensures better quality of product.

(ii) It also enables reduction in prices.

(iii) It provides more satisfaction to consumers.

(D) Benefit to Nation:

(i) It provides greater national wealth.

(ii) It increases per capital income.

(iii) It helps expansion of international market with the help of standardised and good quality goods.

(iv) It improves standard of living.

(v) It helps in better utilisation of resources of the nation.

3.2 MEASUREMENT OF PRODUCTIVITY

Productivity is difficult to measure on account of the following:

Interdependence of Factorial Productivities:

Productivity of one factor may be affected by the productivity of another. For example, labour productivity may be affected by bad quality of materials, defective tools and machinery and poor quality of management.

General Disagreement as to Measuring Output and Input:

When a concern is engaged in the production of a variety of goods, it is difficult to measure productivity of the whole concern because of the differences in the volume of individual

products. Moreover, when the value of money does not remain stable due to fluctuations in price level, the productivity measured in terms of monetary value may not reveal the correct position.

In such a case, relevant figures should be deflated with the help of index numbers for calculating productivity. The difficulty of measurement of productivity, where variety of goods is produced, can be overcome by expressing the output in terms of standard hours.

Measurement of productivity includes overall productivity and factorial productivity:

Measurement of Overall Productivity means calculating productivity taking all input factors together or the productivity of the business as a whole. As material, labour and overhead affect productivity of the business as a whole, it is difficult to express these factors by a common denominator for measuring overall productivity.

To overcome this difficulty, cost of different units of input is adopted as convenient measure of productivity. Overall productivity can be measured by the following formula:

$$\frac{Value\ of\ Output}{Cost\ of\ Input} = \frac{Total\ Cost + net\ Added\ Value}{Total\ Cost} = 1 + \frac{Ned\ Added\ Vale}{Total\ Cost}$$

Overall Productivity is also measured by:

$$Return\ on\ Capital\ Employed = \frac{Profit}{Capital\ Employed} \times 100$$

$$= \frac{Profit}{Sales} \times \frac{Sales}{Capital\ Employed} \times 100$$

Here, Profit = Profit before providing interest on long-term borrowings and income tax.

Capital Employed = Fixed Assets + Current Assets − Current liabilities.

Factorial Productivity means the prod... of individu... factors which contribute to the overall productivity and it ma... be of the following types:

Labour Productivity:

Where most of the work is done by hand labour, measuremen... of labour productivity is essential to know the efficiency o... labour. While calculating labour productivity all factory labour... both direct and indirect, should be included. Some of the way... of measuring labour productivity are as follows:

a) In terms of hours:

i. Output per man-hour = $\frac{Total\ Output}{Total\ Man-hours}$

ii. Man-hours per unit of production = $\frac{Total\ Man-hours}{Total\ outputs\ in\ units}$

iii. Labour Productivity or Efficiency = $\frac{Production\ in\ standard\ hour...}{Actual\ Man-hours}$

iv. Lost Time Percentage = $\frac{Man-hours\ Lost}{Possible\ Man-hours} \times 100$

b) In terms of Money:

i. Labour Productivity = $\frac{Sales\ Value\ (or\ Cost)of\ Output}{Number\ of\ Workers}$

ii. Added Value per unit of Labour Cost = $\frac{Added\ Value}{Wages}$

Here, Added Value = Sales Value – Material Cost i.e., Total o... Wages, Overheads and Profit.

Material Productivity:

Some of the ways of measuring material productivity are given as follows:

i. Material Productivity = $\frac{Material\ Cost}{No\ of\ Units\ Produced}$

ii. Ratio of Wastage of Material = $\frac{Wastage\ of\ Material}{Total\ Material\ Consumed}$

Machine Productivity:

Where most of the work is done by machinery, measure of machine productivity is essential to know the capacity utilisation and efficiency of machinery.

Machine productivity is measured by the following ways:

i. Output per Machine Hour = $\frac{Output}{Actual\ Machine\ Hours}$

ii. Machine Hours per unit of Production = $\frac{Actual\ Machine\ Hours}{Output\ in\ Units}$

iii. Machine Unitization = $\frac{Output\ in\ Standard\ Hours}{Planned\ Machine\ Hours}$

iv. Capacity Percentage = $\frac{Actual\ Machine\ Hours}{Planned\ Machine\ Hours} \times 100$

v. Lost Time Percentage = $\frac{Machine\ Hours\ Lost}{Planned\ Machine\ Hours} \times 100$

Total productivity (Craig and Harris model):

$$P_T = \frac{Q_T}{L+C+R+M}$$

where P_T: Total productivity

L = Labour input

C = Capital input

R = Raw material and purchased parts input

M = Other miscellaneous goods and services input factors

Q_T = Total output

All the input and output factors are measured in some common unit.

Partial Productivity Measures(PPM)

Partial Productivity = $\frac{Total\ Output}{Individual\ Input}$

Labour Productivity = $\frac{Total\ Output}{Labour\ Input}$

$$\text{Capital Productivity} = \frac{\textit{Total Output}}{\textit{Capital Input}}$$

$$\text{Material Productivity} = \frac{\textit{Total Output}}{\textit{Material Input}}$$

$$\text{Energy Productivity} = \frac{\textit{Total Output}}{\textit{Energy Input}}$$

Total Productivity Measure (TPM)

$$\text{Total Productivity} = \frac{\textit{Total Tangible Output}}{\textit{Total Tangible Input}}$$

Total Tangible Output = Value of finished gods produced + Value of partial units produced + dividents from securities + interest + other income

Total Tangible Input = Value of (human + Material + Capital + Energy + Other inputs) used

Total Factor Productivity Measure (TFP)

$$\text{Total Factor Productivity (TFP)} = \frac{\textit{Net Output}}{(\textit{Labour}+\textit{Capital})\ \textit{Input}}$$

Question 2:

The following information regarding the output produced and inputs consumed for a particular time period for a particular company is given below. Compute various productivity indices.

Output	= ₹ 10000
Human Input	= ₹ 3000
Material Input	= ₹ 200
Capital Input	= ₹ 300
Energy Input	= ₹ 100
Other misc. input	= ₹ 50

Solution:

$$\text{Labour Productivity} = \frac{\textit{Total Output}}{\textit{Labour Input}} = \frac{10000}{3000} = 3.33$$

$$\text{Capital Productivity} = \frac{\textit{Total Output}}{\textit{Capital Input}} = \frac{10000}{3000} = 3.33$$

$$\text{Material Productivity} = \frac{\textit{Total Output}}{\textit{Material Input}} = \frac{10000}{2000} = 5.00$$

$$\text{Energy Productivity} = \frac{\textit{Total Output}}{\textit{Energy Input}} = \frac{10000}{500} = 20.00$$

$$\text{Total Productivity} = \frac{\textit{Total Output}}{\textit{Total Input}} = \frac{10000}{3000+2000+3000+1000+500}$$

$$= \frac{10000}{9500} = 1.053$$

$$\text{Total Factor Productivity} = \frac{\textit{Net Output}}{\textit{Labour}+\textit{Capital Input}}$$

$$= \frac{\textit{Total Output}-\textit{Material and services purchased}}{(\textit{Labour}+\textit{Capital})\ \textit{Input}}$$

Assume that the company purchases all its material and services including energy, m/c and equipment (leasing)

$$= \frac{10000-(2000+3000+1000+500)}{3000+3000} = \frac{3500}{6000} = 0.583$$

3.3 COMPETITIVENESS

Competitive advantage refers to factors that allow a company to produce goods or services better or more cheaply than its rivals. These factors allow the productive entity to generate more sales or superior margins compared to its market rivals. Competitive advantages are attributed to a variety of factors including cost structure, branding, the quality of product offerings, the distribution network, intellectual property, and customer service.

- Competitive advantage is what makes ...ty's produc... or services more desirable to customer... than that of an... other rival.
- Competitive advantages can be broken down int... comparative advantages and differential advantages.
- Comparative advantage is a company's ability to produc... something more efficiently than a rival, which leads t... greater profit margins.
- A differential advantage is when a company's product... are seen as both unique and of higher quality, relative t... those of a competitor.

Achieve Competitive Advantage

Firms can gain a competitive advantage through differentiatio... of their product offerings which provides superior custome... value, or by managing for lowest delivery cost.

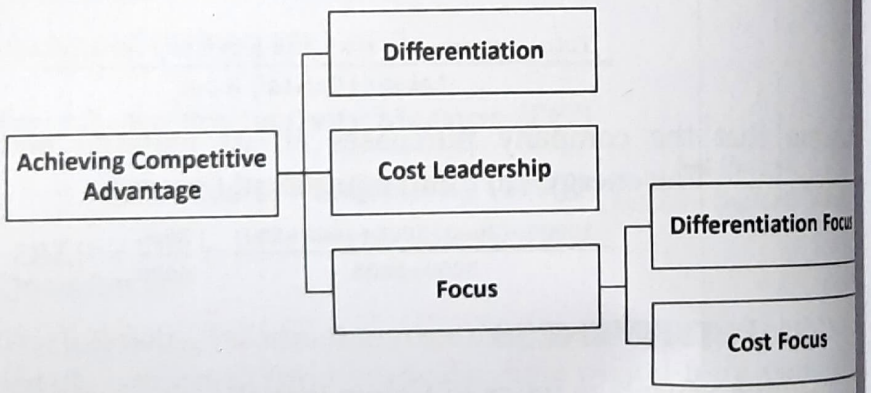


Fig 3.1 Achieving Competitive Advantage

i. Differentiation:

A company that pursues differentiation strategy selects on... one or just a few of the total choice criteria that are used b... customers of the industry. It then uniquely positions itself t... meet these choice criteria by designing a product that gives... very high level of performance on the chosen choice criteri...

and only a mediocre level of performance on other choice criteria.

For example, a manufacturer of air conditioners may target customers whose choice criteria is 'rapid cooling.' Therefore, it designs an air conditioner which 'cools rapidly,' but is not very 'energy efficient.' Differentiation strategies raise the average cost of the industry, because players of the industry are providing higher level of performance based on one choice criteria or the other.

But the players can charge premium prices because customers are getting their desired values. Such an industry will be segmented on choice criteria, and players will target only one or just a few of the total segments. Therefore, another manufacturer of air conditioners may target customers whose choice criteria is 'energy efficiency.' Companies that pursue differentiation strategy differentiate in ways that lead to price premiums in excess of cost of differentiating. Differentiation gives customers a reason to prefer one product over another and is thus central to segmentation and positioning.

ii. Cost leadership:

Cost leadership involves the achievement of lowest cost position in an industry. Firms market standard products that are believed to be acceptable to customers, at reasonable prices which give them above average profits. Some cost leaders discount prices in order to achieve higher sales levels.

iii. Differentiation focus:

The company targets a small segment or niche, which has special needs. The special needs of the segment offer an opportunity to the company to differentiate its product from those of competitors, who may be targeting a broader group of customers. It designs a product to meet the unique needs of the customers of this small segment.

Therefore, when a company pursues differentiation focus strategy, its underlying premise is that the needs of its target

segment differ from the broader market, and that existing competitors are underperforming in its target segment.

iv. Cost focus:

A firm seeks a cost advantage with one or a small number of target market segments. Services/features may be provided to all segments but in some segments those services/features may not be needed. For these segments, the company is over performing. By providing a basic product, a company is able to reduce costs more than the price discount it has to give to sell it.

3.3 DECISION MAKING PROCESS

A decision is an act of selection or choice of one action from several alternatives.

Decision-making can be defined as the process of selecting the right and effective course of action from two or more alternatives for the purpose of achieving a desired result. Decision-making is the essence of management.

According to P. F. Drucker – "What-ever a manager does he does through making decisions." All matters relating to planning, organising, direction, co-ordination and control are settled by the managers through decisions which are executed into practice by the operators of the enterprise.

The entire managerial process is based on decisions. Decisions are needed both for tackling the problems as well as for taking maximum advantages of the opportunities available. Correct decisions reduce complexities, uncertainties and diversities of the organisational environments.

Characteristics of Decision Making

1. Decision making is based on rational thinking. The manager tries to force various possible effects of a decision on before deciding a particular one.

2. It involves the evaluation of various alternatives available. The selection of best alternative will be made only when pros and cons of all of them are discussed and evaluated.

3. It is a process of selecting the best from among alternatives available.

4. It involves certain commitment. Management is committed to every decision it takes.

5. Decision making is the end product because it is preceded by discussions and deliberations.

6. Decision making is aimed to achieve organisational goals.

3.3.1 Process of Decision Making

1. Define the Problem:

A problem is a question put forward for solution. A problem may arise due to the unfilled goals or due to deviations from the desired state of affairs. Therefore, clear understanding of the problem is necessary for providing the right alternatives for solving a problem.

As the saying goes, "a problem well defined is a problem half-solved". Wrong definition of the problem leads to wrong solutions. The problem has to be examined from different angles so as to identify the exact causes. Unless exact causes are identified, right decisions cannot be taken.

2. Analyze the Problem:

Problem is to be thoroughly analyzed to determine the causes and scope. This can be done through classification of the problem and collection of relevant information. The past events that contributed to the problem, the present situation and the impact of the problem on the future have to be examined.

Personal prejudices have to be avoided. An objective assessment of the situation is to be done. If the problem is of minor nature, subordinates can be authorized to solve it. If it is a major problem, manager can initiate the necessary steps.

Sometimes, the problem may not warrant any decision. Leaving the problem as it is could be better solution.

3. Develop Alternatives:

There are number of ways in which a problem may be solved, but all of them may not be equally good. Effective decision-making depends on the development of, as many alternative solutions, as possible. The ability to identify and develop alternative courses of action depends on the manager's creativity and imagination.

4. Evaluate Alternatives:

Development of alternatives does not give any guarantee of finding the best possible solution but it helps in weighing one alternative against others and thereby eliminated unwanted alternatives. Alternatives have to be evaluated in the light of the objectives to be achieved, and the resources required. Evaluation involves a thorough scrutiny of the relative merits and demerits of each of the alternatives in relation to the objectives sought to be achieved by solving the problem.

5. Select and Implement the Decision:

Scientific evaluation of the alternatives reveals the acceptability of various alternatives. It gives a clear picture as to how each alternative contributes towards solving the problem. The best alternative has to be selected and implemented. It may not always be possible to select the best alternative for want of complete information, time and resources. In such a case, the manager has to satisfy with limited information and optimize the yield under given circumstances.

Once an alternative is selected, that becomes the decision and it has to be implemented in a systematic way. The required resources for the implementation and the necessary cooperation from the people concerned have to be ensured. Otherwise, even the best decision may encounter resistance in the implementation stage.

6. Follow-Up and Feedback:

Once the- decision is implemented, it brings certain results and these results are to be compared with the expected results. It has to be closely monitored to find our whether decision taken is correct or not. Follow-up enables to identify the shortcomings of the decision. It provides valuable feed-back on which the decision may be reviewed or reconsidered. The decision may not yield the desired results. Constant follow-up helps to take corrective action as and when necessary.

3.3.2 Types of Decisions

(i) Personal and Organisational Decisions:

Personal decisions are those which are taken by managers concerning their personal life matters. On the other hand, organisational decisions are those which are taken by managers, in the context of organisation and for furthering the objectives of the organisation.

The highlight of the above distinction between personal and organisational decisions is that sometimes, personal decisions of managers have got organisational implications; and then such personal decisions must be taken by managers, in the best interests of the organisation.

For example, the decision of a manager to proceed on a long leave is a personal decision of the manager. But then, in the interest of the organisation, he must appoint some deputy to act on his behalf, till he returns.

(ii) Casual and Routine Decisions:

Casual decisions (whether more significant or less significant) are those which are taken only on some special issues concerning organisational life e.g. a decision to install a new piece of machinery. Casual decisions of a significant nature are taken at upper levels of management. Insignificant casual decisions may, however, be permitted even at lower levels of management.

On the other hand, routine decisions are those which are taken in large numbers during the normal course of organisational life, with repeated frequency. A major number of routine decisions are taken at operational levels of management.

(iii) Strategic and Tactical Decisions:

Decisions relating to designing of strategies are strategic decisions i.e. decisions of utmost significance for the organisation. Such decisions are taken at uppermost levels of management. For implementation purposes, strategies are translated into operational plans or tactical decisions. Such tactical decisions are taken at middle and lower levels of management.

(iv) Policy and Operative Decisions:

A policy decision is a decision in the nature of guidance and instruction; which defines and confines the area of discretion of subordinates, in matters of decision-making. Naturally policies are decided by superiors for the guidance of subordinates. Decisions of subordinates taken within the prescribed limits and guidance of policies are, in management terminology, called operative decisions.

(v) Programmed and Non-Programmed Decisions:

Programmed decisions are those which are taken within the framework of the existing plans of the organisation; and for taking which prescribed policies, rules, procedures and methods are available with the organisation. Such decisions do not pose much problem for managers.

On the other hand, non-programmed decisions are those for taking which there is no provision in the existing planning framework of the organisation. Such decisions are warranted by extra¬ordinary exceptional or emergency situations.

For example, if workers are on strike on a particular day; such a situation will call for an un-programmed decision as to how to deal with the work- situation on that day. Non-programmed

decisions are taken by managers confronting emergency situations, in consultation with higher levels of management.

(vi) Individual and Collective Decisions:

This classification of decisions rests on the manner of decision-making. An individual (not personal) decision is one which is taken by a manager in his individual capacity, without being in consultation with any other person, whatsoever. Such decisions are dictatorial or authoritarian in nature, and are taken by 'big bosses' of the organisation.

On the other hand, collective decisions are those which are jointly taken by a group of managers and other persons - through a process of mutual consultations - in meetings or committees or other joint forum. Such decisions are democratic in nature.

(vii) Financial and Non-financial Decisions:

Financial decisions are those which involve financial implications or commitment of organisational finances. In fact, most of the management decisions are financial in nature. On the other hand, non-financial decisions are those which do not involve financial implications; e.g. a decision-asking people to be punctual for the organisation or a decision-asking people not to accept gifts from suppliers or others.

In a way, non-financial decisions may also be very significant for the organisation.

3.3.3 Programmed and Non Programmed Decisions

Programmed Decisions:

- These are made for solving routine and repetitive problems.
- Decisions are made by using pre-determined procedures and rules.
- These involve less use of judgement.
- There is often consistency for longer period of time over many situations.

- Such decisions are made for solving both simple and complex problems.
- Techniques used for programmed decisions include standard procedures and rules, organisational structure, etc.

Non-Programmed Decisions:

- These are made for solving unique and non- repetitive problems.
- Decisions are made by using experience, creativity and innovativeness.
- These involve more use of experience and judgement.
- There is consistency in the long-run.
- Such decisions are made generally for solving complex problems.
- Techniques used for non-programmed decisions include linear programming, queuing, theory, break even analysis, simulation, replacement theory, etc.

3.3.4 Quantitative techniques for evaluating the alternatives

In order to evaluate the alternatives, certain quantitative techniques have been developed which facilitate making objective decisions.

Some of these techniques are discussed below:

1. Marginal Cost Analysis:

The technique is also known as marginal costing as under it the additional revenues from additional costs are compared. The profits are maximum at the level where marginal revenues and marginal costs are equal. Marginal analysis can also be used in comparing factors other than costs and revenues.

For instance, in order to find the optimum output of a machine, one can vary inputs against output until the additional inputs equal the additional output. This would be the point of the maximum efficiency of the machine. Break-even analysis is the

modification of this technique which tells the management the point of production where there is not profit and no loss.

2. Cost-Benefit Analysis:

It is a technique of weighing alternatives where the optimum solution cannot be conveniently reduced to monetary terms as in the case of marginal cost analysis. It is used for choosing among alternatives to identify a preferred choice when objectives are far less specific than those expressed by such clear quantities as sales, costs or profits. For instance, social objectives may be to reduce pollution of air and water which lacks precision.

Cost models may be developed to show cost estimates for each alternative and benefit models to show the relationship between each alternative and its effectiveness. Then, synthesizing models, combining these results, may be made to show the relationships of costs and effectiveness for each alternative.

3. Operations Research:

Operations Research has been defined as the scientific method of analysis of organisational problems to provide the executive the needed quantitative information in making suitable decisions. The object of operations research is to provide the managers with a scientific basis for solving organisational problems involving the interaction of components of the organisation.

In days gone by, executive decisions used to be taken on the basis intuition, subjectively or past experience even in big organisations. Operations research seeks to replace this process by an analytic, objective and quantitative basis based on information supplied by the system in operation and possibly without disturbing the operation.

Operations research is widely used in modern business organisations. For instance, inventory models are used to control the level of inventory. Linear programming is useful for

allocation of work among individuals in the organisation. Sequencing theory helps the management to determine the sequence of particular operations.

In addition to these, there are other techniques like queuing theory, games theory, reliability theory and marketing theory which are important tools of operations research which can be used by the management to analyse the problems and take decisions.

4. Linear Programming:

Linear programming is a technique devised for determining the optimum combination of limiting resources to achieve a given objective. It is based on the assumption that there exists a linear relationship between variables and that the limits of variations could be ascertained. It is particularly helpful where input data can be quantified and objectives are subject to definite measurement.

It is applicable in such problem areas as production planning, transportation, warehouse location and utilisation of production and warehousing facilities at an overall minimum cost. Linear programming involves maximisation or minimisation of a linear function subject to a set of some real or assumed restrictions known as constraints.

5. Network Analysis:

Network analysis is used for planning and controlling the project activities. Under this, a project is broken down to small operations which are engaged in a logical cycle. The next step is to decide the sequence of operations to be performed. A network diagram may be drawn to present the relationship between all the operations involved.

The diagram will reveal gaps in the flow plans. It will also show the interdependence of various activities of project and point out the activities which should be completed before the others are initiated. A number of network techniques have been developed of which PERT (Programme Evaluation and Review

Technique) and CPM (Critical Path Method) have become very popular.

3.4 MODELS OF DECISION MAKING

The decision-making process though a logical one is a difficult task. All decisions can be categorized into the following three basic models.

(1) The Rational/Classical Model.

(2) The Administrative or Bounded Rationality Model.

(3) The Retrospective Decision-Making Model.

All models are beneficial for understanding the nature of decision-making processes in enterprises or organisations. All models are based on certain assumptions on which the decisions are taken.

1. The Rational/Classical Model:

The rational model is the first attempt to know the decision-making-process. It is considered by some as the classical approach to understand the decision-making process. The classical model gave various steps in decision-making process which have been discussed earlier.

Features of Classical Model:

1. Problems are clear.
2. Objectives are clear.
3. People agree on criteria and weights.
4. All alternatives are known.
5. All consequences can be anticipated.
6. Decision makes are rational.

i. They are not biased in recognizing problems.

ii. They are capable of processing ail relevant information

iii. They anticipate present and f consequences o decisions.

iv. They search for all alternatives that maximizes the desire results.

2. Bounded Rationality Model or Administrative Man Model

Decision-making involve the achievement of a goal. Rationality demands that the decision-maker should properly understand the alternative courses of action for reaching the goals.

He should also have full information and the ability to analyse properly various alternative courses of action in the light of goals sought. There should also be a desire to select the best solutions by selecting the alternative which will satisfy the goal achievement.

Herbert A. Simon defines rationality in terms of objective and intelligent action. It is characterised by behavioural nexus between ends and means. If appropriate means are chosen to reach desired ends the decision is rational.

Bounded Rationality model is based on the concept developed by Herbert Simon. This model does not assume individual rationality in the decision process.

Instead, it assumes that people, while they may seek the best solution, normally settle for much less, because the decisions they confront typically demand greater information, time, processing capabilities than they possess. They settle for "bounded rationality or limited rationality in decisions. This model is based on certain basic concepts.

a. Sequential Attention to alternative solution:

Normally it is the tendency for people to examine possible solution one at a time instead of identifying all possible solutions and stop searching once an acceptable (though not necessarily the best) solution is found.

b. Heuristic:

These are the assumptions that guide the search for alternatives into areas that have a high probability for yielding success.

c. Satisficing:

Herbert Simon called this "satisficing" that is picking a course of action that is satisfactory or "good enough" under the circumstances. It is the tendency for decision makers to accept the first alternative that meets their minimally acceptable requirements rather than pushing them further for an alternative that produces the best results.

Satisficing is preferred for decisions of small significance when time is the major constraint or where most of the alternatives are essentially similar.

Thus, while the rational or classic model indicates how decisions should be made (i.e. it works as a prescriptive model), it falls somewhat short concerning how decisions are actually made (i.e. as a descriptive model).

3. Retrospective decision model (implicit favourite model):

This decision-making model focuses on how decision-makers attempt to rationalise their choices after they have been made and try to justify their decisions. This model has been developed by Per Soelberg. He made an observation regarding the job choice processes of graduating business students and noted that, in many cases, the students identified implicit favorites (i.e. the alternative they wanted) very early in the recruiting and choice process. However, students continued their search for additional alternatives and quickly selected the best alternative.

The total process is designed to justify, through the guise of scientific rigor, a decision that has already been made intuitively. By this means, the individual becomes convinced that he or she is acting rationally and taking a logical, reasoned decision on an important topic.

3.5 TYPES OF DECISION MAKING SITUATIONS

3.5.1 Components of a decision problem

A decision problem consists of i) decision maker ii) numbe alternatives iii) different states of nature iv) outcome of th decision.

(i) Decision maker: The decision maker is charged wit responsibility of making the decision. That is, he has to selec one from a set of possible courses of action.

(ii) Acts (courses of action): Acts are the alternative courses o action or strategies that are available to the decision maker. The decision involves a selection among two or more alternative courses of action. The problem is to choose the best of these alternatives to achieve an objective. If the decision maker has the alternative choices A_1, A_2, A_3, A_4, then (A_1, A_2, A_3, A_4) forms the action space.

(iii) Event (state of nature): Events are the occurrences which affect the achievement of the objectives. They are also called states of nature. The events constitute a mutually exclusive and exhaustive set of outcomes, which describe the possible behaviors of the environment in which the decision is made. The decision maker has no control over the event which will take place and can only attach a subjective probability of occurrence of each.

(iv) Outcomes: To every act in combination with every state of nature, there is an outcome (or consequence). The outcome is also known as conditional value. That is, when the decision maker selects a particular act under a particular state of nature the result obtained is called the outcome. Outcomes may be evaluated in terms of profit or cost or opportunity loss or utility

(a) Pay off: The payoff can be interpreted as the outcome in quantitative form when the decision maker adopts a particular strategy under a particular state of nature. It is the monetary gain or loss of each such outcome. Pay offs can also be based on cost or time.

(b) Opportunity loss (regret): An opportunity loss is the incurred because of failure to take the best possible decision. Opportunity losses are calculated separately for each state of nature that might occur. Given the occurrence of a specific state of nature, we can determine the best possible act. For a given state of nature, the opportunity loss of an act is the difference between the pay off of that act and the pay off for the best act that could have been selected.

3.5.2 Pay off and Regret tables

Pay off table is in matrix form. It lists the acts and events. It considers the economics of the problem by calculating a conditional pay off value for each act and event combination. Similarly regret table is a matrix showing opportunity loss for each act under a state of nature.

Example:

Pay off table

	A_1	A_2	A_3
S_1	2	3	10
S_2	0	5	15
S_3	-2	8	20

Regret table

	A_1	A_2	A_3
S_2	8	7	0
S_2	15	10	0
S_3	22	12	0

In the pay off table every figure represents outcome (pay offs) to the decision maker when he selects a particular act under a particular state of nature. For example, when A selects A_2 under the state of nature, S_2, his gain is 5. Similarly, when A selects A_2 under the state of nature S_2, opportunity loss to A is 10.

Preparing Regret table from pay off table

Method: Let every row of pay off table represent a state of nature and every column represent a course of action. Then from each row select the highest pay off and subtract all pay offs of that row from it. They are the opportunity losses.

Question 3:

Given below is a pay off table. From it form a regret (opportunity loss) table.

	Acts		
States of nature	**A_1**	**A_2**	**A_3**
E_1	156	153	150
E_2	156	158	155
E_3	156	158	160

Solution:

Opportunity Losses

	A_1	A_2	A_3
E_1	156 - 156 = 0	156 – 153 = 3	156 – 150 = 6
E_2	158 – 156 = 2	158 – 158 = 0	158 – 155 = 0
E_3	160 – 156 = 4	160 – 158 = 2	160 – 160 = 0

=

	A_1	A_2	A_3
E_1	0	3	6
E_2	2	0	3
E_3	4	2	0

3.5.3 Types of Decision Making Situations

In any decision problem, the decision maker is concerned with choosing from among the available alternative courses of action, the one that yields the best result. If the consequences of each choice are known with certainty, the decision maker has to deal with situations where uncertainty of the outcomes prevail.

The decision making problems can be discussed under the following heads on the basis of their environments.

1. Decision making under Uncertainty
2. Decision making under Risk
3. Decision making under Certainty

Decision-making under Risk:

When a manager lacks perfect information or whenever an information asymmetry exists, risk arises. Under a state of risk, the decision maker has incomplete information about available alternatives but has a good idea of the probability of outcomes for each alternative.

While making decisions under a state of risk, managers must determine the probability associated with each alternative on the basis of the available information and his experience.

Decision-making under Certainty:

A condition of certainty exists when the decision-maker knows with reasonable certainty what the alternatives are, what conditions are associated with each alternative, and the outcome of each alternative. Under conditions of certainty, accurate, measurable, and reliable information on which to base decisions is available.

The cause and effect relationships are known and the future is highly predictable under conditions of certainty. Such conditions exist in case of routine and repetitive decisions concerning the day-to-day operations of the business.

3.6 DECISION-MAKING UNDER UNCERTAINTY

Most significant decisions made in today's complex environment are formulated under a state of uncertainty. Conditions of uncertainty exist when the future environment is unpredictable and everything is in a state of flux. The decision-maker is not aware of all available alternatives, the risks associated with each, and the consequences of each alternative or their probabilities.

The manager does not possess complete information about the alternatives and whatever information is available, may not be completely reliable. In the face of such uncertainty, managers need to make certain assumptions about the situation in order to provide a reasonable framework for decision-making. They have to depend upon their judgment and experience for making decisions.

The following choices are available before the decision maker in situations of uncertainty.

(a) Maximum Criterion
(b) Minimax Criterion

(c) Maximin Criterion
(d) Laplace Criterion (Criterion of equally likelihood)
(e) Hurwiczalpha Criterion (Criterion of Realism) (criterion of rationality)

3.6.1 The maximax decision criterion (Criterion of optimism)

The term 'maximax' is an abbreviation of the phrase maximum of the maxima. An adventurous and aggressive decision maker may choose the act that would result in the maximum payoff possible. Suppose for each act there are three possible payoffs corresponding to three states of nature as given in the following decision matrix.

Pay off table

States of nature	Decisions		
	A_1	A_2	A_3
S_1	220	180	100
S_2	160	190	180
S_3	140	170	200

Maximum payoffs under each decision A_1, A_2, A_3 are respectively

$$\frac{A_1}{220}, \frac{A_2}{190}, \frac{A_3}{200}$$

The maximum of these three maximums is 220 which relates to A_1. Consequently, according to the maximax criteria, the decision is to choose A_1.

3.6.2 The minimax decision criterion

Minimax is just opposite to maxima. Application of the minimax criterion requires a table of losses instead of gains. The losses are the costs to be incurred or the damage to be suffered for each of the alternative act and states of nature. The minimax rule minimizes the maximum possible loss for each course of action. The term 'minimax' is an abbreviation of the phrase minimum of the maxima. Under each of the various acts there is a maximum loss and the act that is associated with the

minimum of the various maximum losses is the act to be undertaken according to the minimax criterion. Suppose the loss table

States of nature	Decisions		
	A_1	A_2	A_3
S_1	0	4	10
S_2	3	0	6
S_3	18	14	0

Maximum losses incurred by the various decisions:

$$\frac{A_1}{18}\ \frac{A_2}{14}\ \frac{A_3}{10}$$

and the minimum among these three maximums is 10 which is for act A_3. Thus, according to minimax criterion, the decision maker should take a decision for A_3.

3.6.3 The maximin decision criterion (Criterion of pessimism)

This is called Waldian criterion

The maximin criterion of decision making stands for choice between alternative courses of action assuming pessimistic view of nature. Taking each act in turn, we note the worst possible results in terms of payoff and select the act which maximises the minimum pay off. Suppose the payoff table is

States of nature	Decisions		
	A_1	A_2	A_3
S_1	-80	-60	-20
S_2	-30	-10	-2
S_3	30	15	7
S_4	75	80	25

Minimum under each decision A_1, A_2, A_3 are respectively

-80, -60, -20

The Act A_3 is to be undertaken according to this criterion because it is the maximum among minimum.

3.6.4 Laplace criterion:

As the decision maker has no information about the probability of occurrence of various events, the decision maker makes a simple assumption that each probability is equally likely. The expected pay off is worked out on the basis of these probabilities. The act having maximum expected pay off is selected.

Events	Act		
	A_1	A_2	A_3
E_1	20	12	25
E_2	25	15	30
E_3	30	20	22

Ans: We associate equal probability for each event say $\frac{1}{3}$. So the expected pay off are the averages of pay offs under each act.

$$A_1 \rightarrow \frac{1}{3}(20 + 25 + 30) = \frac{75}{3} = 25$$

$$A_2 \rightarrow \frac{1}{3}(12 + 15 + 20) = \frac{47}{3} = 15.67$$

$$A_3 \rightarrow \frac{1}{3}(25 + 30 + 22) = \frac{77}{3} = 25.67$$

Since A_3 has maximum expected payoff, A_3 is the optimal act.

3.6.5 Harwicz alpha criterion

This method is a combination of maximin criterion and maximin criterion. In this method, the decision maker's degree of optimism is represented by α, the coefficient of optimism, α varies between 0 and 1. When $\alpha = 0$, there is total pessimism and when $\alpha = 1$, there is total optimism.

We find D_1, D_2, D_3 etc. connected with all strategies where $D_i = \alpha M_i + (1 - \alpha) m_i$ and M_i is the maximum payoff of 'i' th strategy and m_i is the minimum payoff of 'i' th strategy. The strategy with highest of $D_1, D_2, \ldots$ is chosen. The decision maker will specify the value of α depending upon his level of optimism.

Example:

Events	Act		
	A_1	A_2	A_3
E_1	20	12	25
E_2	25	15	30
E_3	30	20	22

Ans: Let $\alpha = 6$

For A_1, maximum pay off = 30 and Minimum pay off = 20

$\therefore \quad D_1 = (0.6 \times 30) + (1 - 0.6)20 = 26$

Similarly, for A_2, maximum pay off = 20 and minimum pay off = 12

$\therefore \quad D_2 = (0.6 \times 20) + (1 - 0.6)12 = 16.8$

For A_3, maximum pay off = 30 and minimum pay off = 22

$\therefore \quad D_3 = (0.6 \times 30) + (1 - 0.6022 = 26.8$

Since D_3 is max, select the act A_3.

Question 4:

A food products company is planning the introduction of a revolutionary new product with new packing to replace the existing product at much higher price (S_1) or a moderate change in the composition of the existing product with a new packaging at a small increase in price(S_2) or a small change in the composition of the existing except the word, 'New' with a negligible increase in the price (S_3). The three possible states of nature of events are (i) high increase in sales (N_1) (ii) no change in sales (N_2) (iii) decrease in sales (N_3). The marketing department of the company worked out the pay offs in terms of yearly new profits for each of the strategies on these events. This is represented in the following table (in next page).

Which strategy should the executive concerned choose on the basis of (a) Maximin criterion (b) Maximax criterion (c) Minimax regret criterion (d) Laplace Criterion

Pay offs

States of nature

Strategies	N_1	N_2	N_3
S_1	700	300	150
S_2	500	450	0
S_3	300	300	300

Solution:

Rewriting the pay off table (with strategies in columns)

	Strategies		
States of nature	S_1	S_2	S_3
N_1	700	500	300
N_2	300	450	300
N_3	150	0	300

(a) Maximin criterion

Minimum pay offs for S_1, S_2, S_3 are

S_1	S_2	S_3
150	0	300

Max of these minima = 300 which relates to S_3

The executive should choose strategy S_3

(b) Maximax criterion

Maximum pay offs

S_1	S_2	S_3
700	500	300

Maximum of these maxima = 700

∴ The executive can choose Act S_1

(c) Minimax Regret Criterion

Opportunity Loss table

	S_1	S_2	S_3
N_1	$700 - 700 = 0$	$700 - 500 = 200$	$700 - 300 = 400$
N_2	$450 - 300 = 150$	$450 - 450 = 0$	$450 - 300 = 150$
N_3	$300 - 150 = 150$	$300 - 0 = 300$	$300 - 300 = 0$

Maximum opportunity loss for S_1, S_2, S_3

S_1	S_2	S_3
150	300	400

Minimum of these maxima = 150 which relates to S_i.

∴ The executive should choose strategy S_1 since it minimizes the maximum

(d) Laplace criterion

	Pay off table		
	S_1	S_2	S_3
	700	500	300
	300	450	300
	150	0	300
Total	1150	950	900
Average (divided by 3)	383.3	316.67	300

Since the average is highest for strategy 1, the executive may select strategy S_1

Question 5:

The research department of consumer products division has recommended to the marketing department to launch a soap with three different perfumes. The marketing manager has to decide the type of perfume to launch under the following estimated pay off for the various levels of scales (In next page).

Estimate which type can be chosen under maximax, minimax, maximin, laplace and Hurwicz Alpha criteria. (given $\alpha = 0.6$)

Estimated levels of sales (units)			
Types of perfumes	**20,000**	**10,000**	**2000**
I	250	15	10
II	40	20	5
III	60	25	3

Solution:

(i) Maximax criterion

Pay off table

Levels of Sales	Types of perfume I	II	III
20000	250	40	60
10000	15	20	25
2000	10	5	3

Maximum for each type

Type I	Type II	Type III
250	40	60

Maximum of maximum = 250 which relates to type I

∴ Select type I perfume

(ii) Minimax criterion prepare Regret table

Regret table

Sales	Type I	II	III
24,000	0	210	190
10,000	10	5	0
2,000	0	5	7

Maximum losses

Type I	TypeII	Type III
10	210	190

Minimum of these is 10 which relates to type I

∴ Type I is preferred

(iii) Maximin Criterion

From the pay off table (Table I), Minimum pay off under each act is

Type I	TypeII	Type III
10	5	3

Maximum of these minima is 10 which relates to type I

∴ Type I is preferred.

(iv) Laplace Criterion

	Pay off table		
	Type I	Type II	Type III
	250	40	60
	15	20	25
	10	5	3
Total	275	65	88
Average	91.67	21.67	29.33

Average pay off is more for type I. So choose Type I perfume

(v) Hurwicz Alpha Criterion

Given $\alpha = 0.6, 1 - \alpha = 1 - 0.6 = 4$

Max. pay off for type I = 250, minimum pay off for type I = 10

$D_1 = (0.6 \times 250) + (0.4 \times 10) = 150 + 4 = 154$

Max. pay off for type II = 40, Minimum pay off for type II = 5

$D_2 = (0.6 \times 40) + (0.4 \times 5) = 24 + 2 = 26$

Max. pay off for type III = 60, Minimum pay off for type III = 3

$D_3 = (0.6 \times 60) + (0.4 \times 3) = 36 + 1.2 = 37.2$

D_1 is highest. So, select type I.

3.6.6 Modern Approaches to Decision-making under Uncertainty

There are several modern techniques to improve the quality of decision-making under conditions of uncertainty.

The most important among these are:

(1) Risk analysis,
(2) Decision trees and
(3) Preference theory.

Risk Analysis:

Managers who follow this approach analyze the size and nature of the risk involved in choosing a particular course of action.

For instance, while launching a new product, a manager has to carefully analyze each of the following variables the cost of launching the product, its production cost, the capital investment required, the price that can be set for the product, the potential market size and what percent of the total market it will represent.

Risk analysis involves quantitative and qualitative risk assessment, risk management and risk communication and provides managers with a better understanding of the risk and the benefits associated with a proposed course of action. The decision represents a trade-off between the risks and the benefits associated with a particular course of action under conditions of uncertainty.

Decision Trees:

These are considered to be one of the best ways to analyze a decision. A decision-tree approach involves a graphic representation of alternative courses of action and the possible outcomes and risks associated with each action.

By means of a "tree" diagram depicting the decision points, chance events and probabilities involved in various courses of

action, this technique of decision-making allows the decision-maker to trace the optimum path or course of action.

Preference or Utility Theory:

This is another approach to decision-making under conditions of uncertainty. This approach is based on the notion that individual attitudes towards risk vary. Some individuals are willing to take only smaller risks ("risk averters"), while others are willing to take greater risks ("gamblers"). Statistical probabilities associated with the various courses of action are based on the assumption that decision-makers will follow them.

For instance, if there were a 60 percent chance of a decision being right, it might seem reasonable that a person would take the risk. This may not be necessarily true as the individual might not wish to take the risk, since the chances of the decision being wrong are 40 percent. The attitudes towards risk vary with events, with people and positions.

Top-level managers usually take the largest amount of risk. However, the same managers who make a decision that risks millions of rupees of the company in a given program with a 75 percent chance of success are not likely to do the same with their own money.

Moreover, a manager willing to take a 75 percent risk in one situation may not be willing to do so in another. Similarly, a top executive might launch an advertising campaign having a 70 percent chance of success but might decide against investing in plant and machinery unless it involves a higher probability of success.

Though personal attitudes towards risk vary, two things are certain.

Firstly, attitudes towards risk vary with situations, i.e. some people are risk averters in some situations and gamblers in others.

Secondly, some people have a high aversion to risk, while others have a low aversion.

Most managers prefer to be risk averters to a certain extent, and may thus also forego opportunities. When the stakes are high, most managers tend to be risk averters; when the stakes are small, they tend to be gamblers.

3.7 DECISION MAKING UNDER RISK

In this situation the decision maker has to face several states of nature. But he has some knowledge or experience which will enable him to assign probability to the occurrence of each state of nature. The objective is to optimize the expected profit, or to minimize the opportunity loss.

For decision problem under risk, the most popular methods used are EMV (Expected Monetary Value) criterion and EOL (Expected Opportunity Loss) criterion.

3.7.1 Expected Monetary Value (EMV):

When the probabilities can be assigned to various states of nature, it is possible to calculate the expected pay off for each course of action. These expected pay offs are known as EMV.

The conditional value of each event in the pay off table is multiplied by its probability and the product is summed up. The resulting number is the EMV for the act. The decision maker then selects from the available alternatives, the act that leads to the optimum expected outcome (that is the act with optimal EMV). 'Optimal' means maximization in the case of profit or income and minimization in the case of cost, expenditure etc.

i.e., EMV $= (x_1 \times p_1) + (x_2 \times p_2) + \ldots\ldots$ where $x_1, x_2, \ldots$ are pay offs and $p_1, p_2 \ldots$ are probabilities of states of nature.

Consider the following example. Let the states of nature be S_1 and S_2 and the alternative strategies be A_1 and A_2. Let the pay off table be as shown below.

	A_1	A_2
S_1	30	20
S_2	35	30

Let the probabilities for the states of nature S_1 and S_2 be the respectively 0.6 and 0.4. Then,

EMV for $A_1 = (30 \times 0.6) + (35 \times 0.4) = 18 + 14 = 32$
EMV for $A_2 = (20 \times 0.6) + (30 \times 0.4) = 12 + 12 = 24$

EMV for A_1 is greater. ∴ The decision maker will choose the strategy A_1.

The criterion of selecting the maximum expected pay off act, is some times referred to as Baye's decision rule.

3.7.2 Expected Opportunity Loss (EOL):

When the probabilities for various states of nature are known, it is possible to calculate the expected losses for each course of action.

$$EOL = (x_1 \times p_1) + (x_2 \times p_2) + \ldots\ldots$$

where $x_1, x_2, \ldots$ are losses and $p_1, p_2, \ldots$ are the probabilities of states of nature. These expected losses are known as Expected Opportunity Losses (EOL). Under this criterion the strategy which has minimum Expected Opportunity Loss (EOL) is chosen.

Consider the following Example: Given below is an opportunity loss table. A_1 and A_2 are the strategies and S_1 and S_2 are the states of nature.

	A_1	A_2
S_1	0	10
S_2	2	-5

Let the probabilities for two states be 0.6 and 0.4

EOL for $A_1 = (0 \times 0.6) + (2 \times 0.4) = 0.8$
EOL for $A_2 = (10 \times 0.6) + (-5 \times 0.4) = 6 - 2 = 4$

EOL for A_1 is least. Therefore, the strategy A_1 may be chosen.

Question 6:

You are given the following pay – off matrix

States of nature	A_1	A_2	A_3
S_1	25	-10	-125
S_2	400	440	400
S_3	650	740	750

The probabilities of the states of nature are respectively 0 .1, 0.7 and 0.2. Calculate and tabulate the EMV and conclude which of the acts can be chosen as the best.

Solution:

Act A_1	Act A_2	Act A_3
Prob × Pay off	Prob × Pay off	Prob × Pay off
$25 \times 0.1 = 25$	$-10 \times 0.1 = -1$	$-125 \times 0.1 = -12.5$
$400 \times 0.7 = 280$	$440 \times 0.7 = 308$	$440 \times 0.7 = 280$
$650 \times 0.2 = 130$	$740 \times 0.2 = 148$	$750 \times 0.2 = 150$
EMV = 412.5	EMV = 455	EMV = 417.5

Since EMV is maximum for A_2, choose the Act A_2

Question 7:

Find EMV for all the A_1, A_2, A_3 acts from the table given below which is the optimal act.

	Events			
Strategies (Acts)	S_1	S_2	S_3	
A_1	2	8	15	$P(S_1) = 0.4, P(S_2) = 0.3$
A_2	-3	10	20	*and* $P(S_3) = 0.3$
A_3	-10	20	35	

Solution:

Rewriting the pay off matrix to have strategies (acts) in columns

	A_1	A_2	A_3	Probability
S_1	2	-3	-10	0.4
S_2	8	10	20	0.3
S_3	15	20	35	0.3

Act A_1	Act A_2	Act A_3
Prob × Pay off	Prob × Pay off	Prob × Pay off
$2 \times 0.4 = 0.8$	$-3 \times 0.4 = -1.2$	$-10 \times 0.4 = -4$
$8 \times 0.3 = 2.4$	$10 \times 0.3 = 3$	$20 \times 0.3 = 6$
$15 \times 0.3 = 4.5$	$20 \times 0.3 = 6$	$35 \times 0.3 = 10.5$
EMV = 7.7	EMV = 7.8	EMV = 12.5

Highest EMV is A_3. So A_3 is the optimal act.

Question 8:

Find which act is optimal, A or B.

A		B	
Pay off	**Probability**	**Pay off**	**Probability**
12	0.5	10	0.4
15	0.2	20	0.3
20	0.3	20	0.3

Solution:

EMV for A= $(12 \times 0.5) + (15 \times 0.2) + (20 \times 0.3) = 6 + 3 + 36 = 15$

EMV for B= $(10 \times 0.4) + (20 \times 0.3) + (20 \times 0.3) = 4 + 6 + 6 = 16$

EMV is more for B. So B is the optimal act.

Question 9:

A management is faced with the problem of choosing one of the products for manufacturing. The probability matrix after market research for the two products was as follows.

	State of nature		
Act	**Good**	**Fair**	**Poor**
Product 'A'	0.75	0.15	0.10
Product 'B'	0.60	0.30	0.10

The profit that the management can make for different levels of market acceptability of the products are as follows.

Act	State of nature Profit (in ₹) if market is Good	Fair	Poor
Product 'A'	35,000	15,000	5,000
Product 'B'	50,000	20,000	Loss of 3,000

Calculate expected value of the choice of alternatives and advise the management.

Solution:

	Product A Pay off × profit	Product B Pay off × profit
Good	$35000 \times 0.75 = 26250$	$5000 \times 0.60 = 30000$
Fair	$15000 \times 0.15 = 2250$	$20000 \times 0.30 = 6000$
	$5000 \times 0.10 = 500$	$-3000 \times 0.10 = -300$
	EMV = 29000	EMV = 35700

Since the expected pay off (EMV) for product B is greater, product B should be preferred by the management.

Preparing of Pay off table

Question 10:

A small ink manufacturer produces a certain type of ink at a total average cost of ₹ 3 per bottle and sells at a price of ₹ 5 per bottle. The ink is produced over the week - end and is sold during the following week. According to the past experience the weekly demand has never been less than 78 or greater than 80 bottles in this place. You are required to formulate pay off table.

Solution:

The different states of nature are the demands for 78 units, 79 units or 80 units. Call them S_1, S_2, S_3.

The alternative courses of action are selling 78 units, 79 units or 80 units. Call them A_1, A_2, A_3.

Selling price of ink = ₹ 5/- per bottle
Cost price = ₹ 3/- per bottle

Calculation of pay - offs

$A_1S_1 = 78 \times 5 - 78 \times 3 = 390 - 234 = 156$

$A_2S_1 = 75 \times 5 - 79 \times 3 = 390 - 237 = 153$

$A_3S_1 = 78 \times 5 - 80 \times 3 = 390 - 240 = 150$

$A_1S_2 = 78 \times 5 - 78 \times 3 = 390 - 234 = 156$

$A_2S_2 = 79 \times 5 - 79 \times 3 = 395 - 237 = 158$

$A_3S_2 = 79 \times 5 - 80 \times 3 = 395 - 240 = 155$

$A_1S_3 = 78 \times 5 - 78 \times 3 = 390 - 234 = 156$

$A_2S_3 = 79 \times 5 - 79 \times 3 = 395 - 237 = 158$

$A_3S_3 = 80 \times 5 - 80 \times 3 = 400 - 240 = 160$

Pay - off Table

States of nature	Act (Strategy) A_1	A_2	A_3
S_1	156	153	150
S_2	156	158	155
S_3	156	158	160

Note: We shall show the states of nature in rows and Acts in columns.

Question 11:

A factory produces 3 varieties of fountain pens. The fixed and variable costs are given below.

	Fixed cost	Variable cost
Type 1	₹ 2,00,000	₹ 10
Type 2	₹ 3,20,000	₹ 8
Type 3	₹ 6,00,000	₹ 6

The likely demands under three situations are given below:
Poor: 25,000, Moderate: 1,00,000, High: 1,50,000

If the price of each type is ₹ 20, prepare the pay off table after showing necessary calculations.

Solution:

Let T_1, T_2, T_3 stand for Type 1, Type 2, and Type 3. Let D_1, D_2 and D_3 stand for poor demand, moderate demand and high demand respectively.

The pay off (in thousands) = Sales revenue – Total variable cost – Fixed cost.

$T_1D_1 = (20 \times 25) - (10 \times 25) - 200 = 500 - 250 - 200 = +50$

$T_2D_1 = (20 \times 25) - (8 \times 25) - 320 = 500 - 200 - 320 = -20$

$T_3D_1 = (20 \times 25) - (6 \times 25) - 600 = 500 - 150 - 600 = -250$

$T_1D_2 = (20 \times 100) - (10 \times 100) - 200 = 2000 - 1000 - 200 = +800$

$T_2D_2 = (20 \times 100) - (8 \times 100) - 320 = 2000 - 800 - 320 = +880$

$T_3D_2 = (20 \times 100) - (6 \times 100) - 600 = 2000 - 600 - 600 = +800$

$T_1D_3 = (20 \times 150) - (10 \times 150) - 200 = 3000 - 1500 - 200 = +1300$

$T_2D_3 = (20 \times 150) - (8 \times 150) - 320 = 3000 - 1200 - 320 = +1480$

$T_3D_3 = (20 \times 150) - (6 \times 150) - 600 = 3000 - 900 - 600 = +1500$

The pay off table (in '000s)

	T_1	T_2	T_3
D_1	50	-20	-250
D_2	800	8800	800
D_3	1300	1480	1500

Question 12:

A newspaper boy has the following probability of selling a magazine.

No. of copies sold	Probability
10	0.1
11	0.3
12	0.4
13	0.2

Cost of a copy is ₹3 And sale price is ₹5. He can not return magazine but each for one Rupee only. Prepare pay off table.

How many copies should he order? Also find expected number of sales.

Solution:

We can apply either EMV criterion or EOL criterion. Let us apply EMV criterion for which we have to calculate pay off. Number of copies to be ordered are different courses of action. The copies ordered are 10, 11, 12, 13. Denote them by A_1, A_2, A_3, A_4.

Similarly, number of copies demanded are 10, 11, 12 or 13. These demands may be denoted by D_1, D_2, D_3, D_4. These are events, the pay off values are calculated below:

$A_1D_1 = (10 \times 5) - (10 \times 3) = 20$

$A_2D_1 = (10 \times 5) - (11 \times 3) + (1 \times 1) = 18$

$A_3D_1 = (10 \times 5) - (12 \times 3) + (2 \times 1) = 16$

$A_4D_1 = (10 \times 5) - (13 \times 3) + (3 \times 1) = 14$

$A_1D_2 = (10 \times 5) - (10 \times 3) = 20$

$A_2D_2 = (11 \times 5) - (11 \times 3) = 22$

$A_3D_2 = (11 \times 5) - (12 \times 3) + (1 \times 1) = 20$

$A_4D_2 = (11 \times 5) - (13 \times 3) + (2 \times 1) = 18$

$A_1D_3 = (10 \times 5) - (10 \times 3) = 20$

$A_2D_3 = (11 \times 5) - (11 \times 3) = 22$

$A_3D_3 = (12 \times 5) - (12 \times 3) = 24$

$A_4D_3 = (12 \times 5) - (13 \times 3) + (1 \times 1) = 22$

$A_1D_4 = (10 \times 5) - (10 \times 3) = 20$

$A_2D_4 = (11 \times 5) - (11 \times 3) = 22$

$A_3D_4 = (12 \times 5) - (12 \times 3) = 24$

$A_4D_4 = (13 \times 5) - (13 \times 3) = 26$

Pay of table

	A_1	A_2	A_3	A_4
D_1	20	18	16	14
D_2	20	22	20	18
D_3	20	22	24	22
D_4	20	22	24	26

Given probabilities are 0.1, 0.3, 0.4, 0.2

Calculation of EMV for all the Acts

A_1	A_2	A_3	A_4
$20 \times 0.1 = 20$	$18 \times 0.1 = 1.8$	$16 \times 0.1 = 1.6$	$14 \times 0.1 = 1.4$
$20 \times 0.3 = 60$	$22 \times 0.3 = 6.6$	$20 \times 0.3 = 6.0$	$18 \times 0.3 = 5.4$
$20 \times 0.4 = 80$	$22 \times 0.4 = 8.8$	$24 \times 0.4 = 9.6$	$22 \times 0.4 = 8.8$
$20 \times 0.2 = 40$	$22 \times 0.2 = 4.4$	$24 \times 0.2 = 4.8$	$26 \times 0.2 = 5.2$
EMV = 20	EMV = 21.6	EMV = 22	EMV = 20.8

EMV for A_3 is greater and therefore A_3 is the optimal act.

$\therefore$ No. of copies to be ordered = 12

To find the expected number of sale, we multiply number of copies sold and probability.

$\therefore$ Expected number of sales

$$= (10 \times 0.1) + (11 \times 0.3) + (12 \times 0.4) + (13 \times 0.2)$$

$$= 11.7 = \mathbf{12}$$

Choosing optimal Act by EOL criterion

Question 13:

Given below is a regret table

	Events (state of nature)		
Act	E_1	E_2	E_3
A_1	350	0	250
A_2	0	300	0
A_3	450	100	100

Suppose that the probabilities of the events in this table are

$$P(E_1) = 0.30; P(E_2) = 0.45; P(E_3) = 0.25$$

Calculate the expected loss of each action. Interpret.

Solution:

Rewrite the problem by taking Acts in columns and events in rows.

Opportunity loss table
(Regret table)

	A_1	A_2	A_3
E_1	350	0	450
E_2	0	300	100
E_3	250	0	100

Calculation of Expected Loss (EOL)

A_1	A_2	A_3
Loss × Prob	Loss × Prob	Loss × Prob
$350 \times 0.30 = 105$	$0 \times 0.30 = 0$	$450 \times 0.3 = 135$
$0 \times 0.45 = 0$	$3000.45 = 135$	$100 \times 0.45 = 45$
$250 \times 0.25 = 62.5$	$0 \times 0.25 = 0$	$100 \times 0.25 = 25$
EOL = 167.5	EOL = 135	EOL = 205

Least EOL is for A_2. So A_2 is the optimal act.

Preparing Regret Table

Question 14:

A small ink manufacturer produces a certain type of ink at total average cost of ₹ 3 per bottle and sells at a price of ₹ 5 per bottle. The ink is produced over the week-end and is sold during the following week. According to the past experience the weekly demand has never been less than 78 or greater than 80 bottles.

You are required to formulate the loss table.

Solution:

Calculation of opportunity loss

$A_1S_1 = 0$ (since production and sales are of equal quantity say 78)

$A_2S_1 = 1 \times 3 = 3$ (since one unit of production is in excess whose cost = ₹ 3)

$A_3S_1 = 2 \times 3 = 6$ (since 2 units of production are in excess whose units cost is at ₹ 3)

$A_1S_2 = 1 \times 2 = 2$ (since the demand of one unit is more than produced. The profit for one unit is ₹ 2)

Similarly $A_2S_2 = 0$ [since units of production = units of demand]

$A_3S_2 = 1 \times 3 = 3$,

$A_1S_3 = 2 \times 2 = 4$, $A_2S_3 = 2 \times 1 = 2$ and $A_2S_3 = 0$

Opportunity Loss table (Regret Table)

States of nature	A_1	A_2	A_3
S_1	0	3	6
S_2	2	0	3
S_3	4	2	0

Preparing Regret Table from pay off table

Note: When each element in the pay off table stands for the gain (income or profit) to get Regret table from it, subtract all the elements of each row from the highest pay off that row. (Every row in a pay off table representing a state of nature)

Question 15:

Given below is a pay off table. Prepare Regret table from it.

	Acts		
Events	A_1	A_2	A_3
B_1	4	-2	-10
B_2	7	8	3
B_3	12	25	48

Solution:

Regret Table

	A_1	A_2	A_3
B_1	$4-4s$	$4--2$	$4--10$
B_2	$8-7$	$8-8$	$8-3$
B_3	$48-12$	$48-25$	$48-48$

=

A_1	A_2	A_3
0	6	14
1	0	5
36	23	0

Expected Value of Perfect Information (EVPI):

(1) To get perfect value with perfect information, select the highest pay off from every row and with these pay offs, find the expected value, i.e., Expected value with perfect information = $m_1p_1 + m_2p_2 + \ldots$ where $m_1, m_2, \ldots$ are respectively the maximum pay offs of each row.

$P_1, P_2, \ldots$ are the probabilities of corresponding states of nature.

(2) EMV of the optimal act is the Maximum along the EMV's of all acts.

(3) Expected value of perfect information (EVPI) is the difference between the two.

i.e., EVPI = Expected value with perfect information - Optimum EMV.

EVPI gives an upper bound of the amount which the decision maker can spend for obtaining perfect information.

Question 16:

Compute EVPI from the Pay off table given below known that $P(S_1) = 0.5, P(S_2) = 4$ and $P(S_3) = 0.1$

	Pay off table		
State of nature	A_1	A_2	A_3
S_1	30	25	22
S_2	20	35	20
S_3	40	30	35

Solution:

A_1 Pay off × prob	A_2 Pay off × prob	A_3 Pay off × prob
$30 \times 0.5 = 15$	$25 \times 0.5 = 12.5$	$22 \times 0.5 = 11$
$20 \times 0.4 = 8$	$35 \times 0.4 = 14$	$20 \times 0.4 = 8$
$40 \times 0.1 = 4$	$30 \times 0.1 = 3$	$35 \times 0.1 = 3.5$
EMV = 27	EMV = 29.5	EMV = 22.5

The highest EMV is for the strategy A_2 and it is 29.5

Calculating expected value with perfect information, considering highest profit in every now

Events	Max. Pay off of each row	Probability	Expected value (Profit × prob.)
S_1	30	0.5	15
S_2	35	0.4	14
S_3	40	0.1	4

∴ Expected pay off with perfect information = 15 +14 + 4 = 33

Thus the expected value of perfect information = (EVPI) = Expected Value with perfect information – minimum EMV

= 33 – 29.5 = 3.5

Question 17:

A grocery store with a bakery department is faced with the problem of how many cakes to buy in order to meet the day's demand. The grocer prefers not to sell day – old goods in competition with fresh products. Leftover cakes are, therefore, a complete loss. On the other hand, if a customer desires a cake and all of them have been sold, the disappointed customer will but elsewhere and the sales will be lost. The grocer has, therefore collected information on the past sales or a selected 100-day period as shown in the table below:

Sales per day	No. of days	Probability
25	10	0.1
26	30	0.3
27	50	0.5
28	10	0.1
	100	1.0

Construct the payoff table. What is the optimal number of cakes that should be bought each day? Find and interpret EVPI. A cake costs Rs. 0.80 and sells for Rs. 1.

Solution:

Let A_1, A_2, A_3, A_4 stand for strategies and S_1, S_2, S_3, S_4 stand for states of nature.

Then A_1, A_2, A_3, A_4 respectively stand for stocking 25, 26, 27, 28 cakes and S_1, S_2, S_3, S_4 respectively stand for demands for 25, 26, 27, 28 cakes.

Conditional payoff values can be obtained as explained in Example 8. The payoff values thus obtained are given below.

Pay off table

Alternative Strategies

State of nature	$A_1(25)$	$A_2(26)$	$A_3(27)$	$A_4(28)$	Prob.
$S_1(25)$	5.00	4.20	3.40	2.60	0.1
$S_2(26)$	5.00	5.20	4.40	3.60	0.3
$S_3(27)$	5.00	5.20	5.40	4.60	0.5
$S_4(28)$	5.00	5.20	5.40	5.60	0.1
EMV	5	5.1	4.9	4.2	

Students may obtain EMV values for all acts in Ex. No. 4.

Max EMV is for Act A_2, which is equal to 5.10

Thus according to the EMV decision criterion, the store would stock 26 cakes.

For calculating Expected value with perfect information, select Highest pay off for each state of nature (i.e., each row) and find expected value.

Pay off	Prob.	Pay off × Prob.
5.00	0.10	0.50
5.20	0.30	1.56
5.40	0.50	2.70
5.60	0.10	0.56
		5.32

∴ Expected values with perfect information = 5.32

Expected value of perfect information (EVPI) = Expected Value with Perfect Information – Highest EMV = 5.32 – 5.10 = 0.22

Note: In the case of Cost matrix, optimal st[illegible]y is that having least EMV.

EVPI = Minimum EMV – Expected value with perfect information. In the case of cost matrix, expected value with perfect information is calculated by selecting the least pay off of each row.

Question 18:

Given below is a pay off table

Events	Act		
	A_1	A_2	A_3
E_1	5	-1	-17
E_2	18	28	30
E_3	25	50	80

What will be the optimal decision if the criterion followed is (i) maximax (ii) minimax (iii) maximin (iv) Laplace (v) EMV (vi) EOL. Given probabilities for various events are 0.3, 0.4, 0.3 respectively.

Solution:

Pay off table

	A_1	A_2	A_3
E_1	5	-1	-17
E_2	18	28	26
E_3	25	50	80

Regret table

	A_1	A_2	A_3
E_1	0	6	22
E_2	10	0	2
E_3	55	30	0

Probability

$P(E_1) = 0.3$

$P(E_2) = 0.4$

$P(E_3) = 0.3$

(i) Maximax creation

Maximum pay off for the acts (from pay off table)

$\frac{A_1}{25} = \frac{A_2}{50} = \frac{A_3}{80}$

Maximum of these maxima = 80, (which relates to A_3).

∴ Optimal Act is A_3

(ii) Minimax criterion

Maximum loss for the Acts (From regret table)

$\frac{A_1}{55} = \frac{A_2}{30} = \frac{A_3}{22}$

Minimum of these maxima = 22 which relate to A_3.

∴ Optimal Act is A_3

(iii) Maximin criterion

$\frac{A_1}{5} = \frac{A_2}{-1} = \frac{A_3}{-17}$

Maximum of these minima = 5, which relates to A_1

∴ Optimal Act is A_1

(iv) Laplace criterion

Average of pay offs of the Acts

$A_1 \rightarrow \frac{1}{3}(5 + 18 + 25) = \frac{48}{3} = 16$

$A_2 \rightarrow \frac{1}{3}(-1 + 28 + 50) = \frac{77}{3} = 25.67$

$A_3 \rightarrow \frac{1}{3}(-17 + 26 + 80) = \frac{89}{3} = 29.67$

Highest average is 29.67, which relates to A_3.

∴ The optimal Act is A_3

(v) EMV creation

EMV for various acts (pay off×prob.)

$A_1 \rightarrow (5 \times 0.3) + (18 \times 0.4) + (25 \times 0.3) = 1.5 + 7.2 + 7.5$
$= 16.2$

$A_2 \rightarrow (-1 \times 0.3) + (28 \times 0.4) + (50 \times 0.3)$
$= -0.3 + 11.2 + 15 = 25.9$

$A_3 \rightarrow (-17 \times 0.3) + (26 \times 0.4) + (80 \times 0.3)$
$= -5.1 + 10.4 + 24 = 29.3$

Highest EMV is 29.3, which relates to A_3

∴A_3 is the optimal act

(vi) EOL criterion

EOL for various acts are (Regret×prob.)

$A_1 \rightarrow (0 \times 0.3) + (10 \times 0.4) + (55 \times 0.3) = 0 + 4 + 16.5$
$= 20.5$

$A_2 \rightarrow (6 \times 0.3) + (0 \times 0.4) + (30 \times 0.3) = 1.8 + 0 + 9$
$= 10.8$

$A_3 \rightarrow (22 \times 0.3) + (2 \times 0.4) + (0 \times 0.3) = 6.6 + 0.8 + 0$
$= 7.4$

Minimum EOL is 7.4, which relates to A_3

$\therefore A_3$ is the optimal act

Bayesian Rule (Posterior analysis)

Bayesian rule of decision theory is an approach in which the decision maker selects a course of action on rational basis by using subjective evaluation of probability based on experience, past performance, judgement etc.

For making use of the Baye's Principle in the statistical decision problem, the decision maker has to assign probabilities to each state of nature. These probabilities represent the strength of the decision maker's belief. ie., a subjective evaluation regarding the likelihood of the occurrence of the various states of nature.

After determining the probabilities, the Baye's principle must be used phasewise. The three phases are (i) prior analysis (ii) preposterior analysis (iii) posterior analysis.

A decision maker assigns probabilities to various events which is his subjective evaluation of likelihood of the occrrence of the various states on the basis of experience of past performance. When these prior probbabilities are used, the procedure is known *as* perior analysis.

If prior analysis reveals a high EVPI, additional information is to be obtained. Prior probabilities may then, be revised on the basis of these additional information. By applying Baye's theorem of probability, the revised probabilities are computed. These-probabilities are known as posterior probabilities. A further analysis of the problem using these posterior probabilities give new expected pay offs.

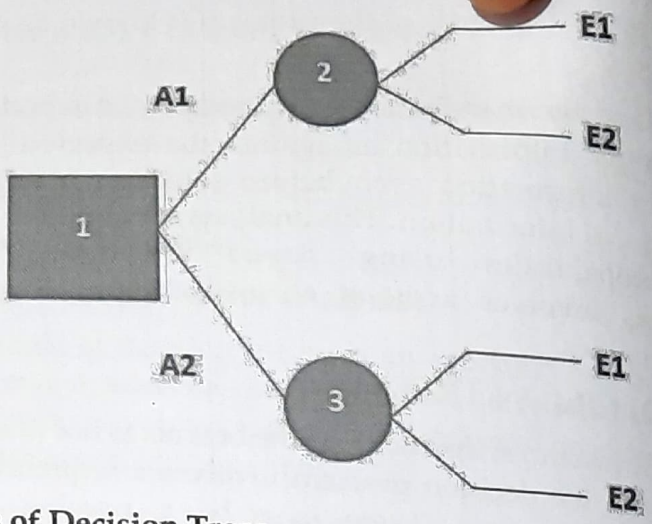
This revised analysis of the problem is known as posterior analysis.

Preposterior analysis is done to assess the expected value of sample information as against the expected value of perfect information even before selecting a sample for additional information. This analysis involves the revision of probabilities using Baye's theorem. Posterior analysis involves arriving at a decision after revising probabilities.

3.8 DECISION TREES

In many instances, the choice of the best act is not made in one stage, and the decision problem involves a sequence of acts, events, acts, events. There may be a number of basic alternatives, each leading to one of a number of situations depending on the outcome of a certain random process. At each such situation, a number of other alternatives may be available which also lead to a new set of situations depending on another set of events and so on, with acts followed by events, followed by acts, events. Discrete decision theory problems can be represented pictorially using decision tress. It chronically portrays the sequence of actions and events as they unfolds. In below figure, square symbol precedes the set of actions that can be taken by decision maker. The round node precedes the set of events or states of nature that could be encountered after decisions is made. The nodes are connected by branches.

A decision tree is the graphical depiction of all the possibilities or outcomes to solve a specific issue or avail a potential opportunity. It is a useful financial tool which visually facilitates the classification of all the probable results in a given situation.



Analysis of Decision Trees

After the tree has been drawn, it is scrutinized from right to left. The aim of analysis is to determine the best strategy of the decision maker that means an optimal sequence of the decisions. To analyze a decision tree, managers must know a decision criterion, probabilities that are assigned to each event, and revenues and costs for the decision alternatives and the chance events that occur.

There are two possibilities to how to include revenues and costs in a decision tree. One possibility is to assign them only to terminating nodes where they are included in the conditional value of the decision criterion associated with the decisions and events along the path from the first part of the tree to the end. However, it can be appropriate to assign revenues and costs to branches. This reduces the required arithmetic for calculating the values of the decision criterion for terminating nodes and focuses attention on the parameters for sensitivity analysis.

When analyzing a decision tree, managers must start at the end of the tree and work backwards. They perform two kinds of calculations.

For chance event nodes managers calculate certainty equivalents related to the events emanating from these nodes. Under the assumption that the decision maker has a neutral attitude toward risk, certainty equivalent of uncertain outcomes can be replaced by their expected value. At decision nodes, the alternative with the best expected value of the decision criterion is selected.

Steps in Decision Tree Analysis

1. The first step is understanding and specifying the problem area for which decision making is required.
2. The second step is interpreting and chalking out all possible solutions to the particular issue as well as their consequences.
3. The third step is presenting the variables on a decision tree along with its respective probability values.
4. The fourth step is finding out the outcomes of all the variables and specifying it in the decision tree.
5. The last step is highly crucial and backs the overall analysis of this process. It involves calculating the EMV values for all the chance nodes or options, to figure out the solution which provides the highest expected value.

Benefits of Decision Trees

Depicts Most Suitable Project/Solution: It is an effective means of picking out the most appropriate project or solution after examining all the possibilities.

Easy Data Interpretation and Classification: Not being rocket science, decision tree eases out the process of segregation of the acquired data into different classes.

Assist Multiple Decision-Making Tools: It also benefits the decision-maker by providing input for other analytical methods like nature's tree.

Considers Both, Categorial and Numerical Data: This technique takes into consideration the quantitative as well as the qualitative variables for better results.

Initiates Variable Analysis: Its structured phenomena also facilitates the investigation and filtration of the relevant data.

Terminologies Used

Let us understand some of the relevant concepts and terms used in the decision tree:

Root Node: A root node compiles the whole sample, it is then divided into multiple sets which comprise of homogeneous variables.

Decision Node: That sub-node which diverges into further possibilities, can be denoted as a decision node.

Terminal Node: The final node showing the outcome which cannot be categorized any further, is termed as a value or terminal node.

Branch: A branch denotes the various alternatives available with the decision tree maker.

Splitting: The division of the available option (depicted by a node or sub-node) into multiple sub-nodes is termed as splitting.

Pruning: It is just the reverse of splitting, where the decision tree maker can eliminate one or more sub-nodes from a particular decision node.

Limitations of decision trees

- Only one decision criterion can be considered.
- The decision tree is an abstraction and simplification of the real problem. Only the important decisions and events are included.
- Managers cannot use decision trees if the chance event outcomes are continuous. Instead, they must redefine the outcomes so that there is a finite set of possibilities.

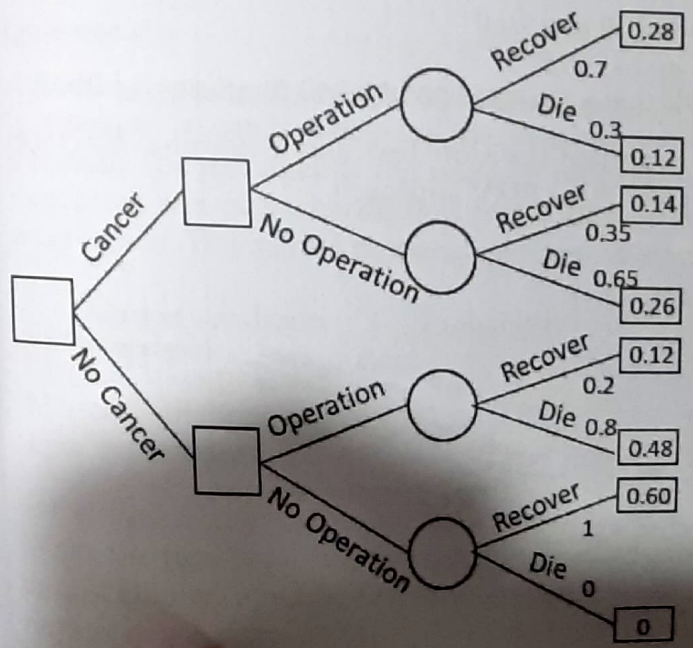
The significant result of the analysis of a decision tree is to choose the best alternative in the first stage of the decision process. After this stage, some changes in the decision

situations can come, an additional information can be obtained, and usually, it is essential to actualize the decision tree and to determine a new optimal strategy. This procedure is required before every further stage.

Question 19:

There is 40% chance that a patient admitted to the hospital, is suffering from cancer. A doctor has to decide whether a serious operation should be performed or not. If the patient is suffering from cancer, and the serious operation is performed, the chance that he will recover is 70%, otherwise it is 35%. On the other hand, if the patient is not suffering from cancer and the serious operation is performed, the chance that he will recover is 20%, otherwise it is 100%. Assume that recovering and death are the only possible results. Construct an appropriate decision tree. What decision should the doctor take?

Solution:



P_1 = Probability that the patient shall recover after operation = 0.28 + 0.12 =0.4

P_2= Probability that the patient will recover without any operation = 0.14 + 0.60 = 0.74

Since $P_2 > P_1$, doctor should not take a decision for operation to the patient.

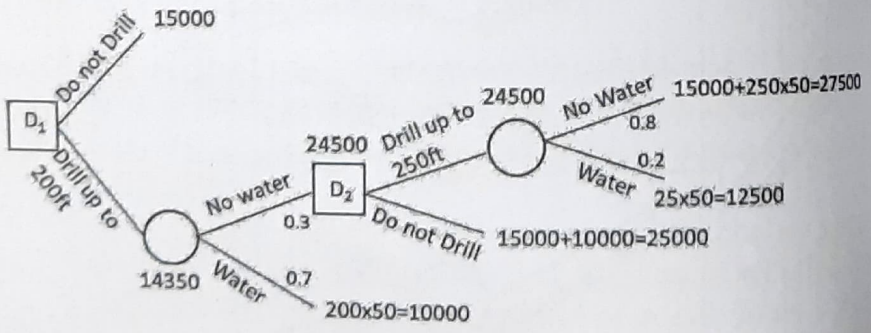
Question 20:

A firm owner is seriously considering of drilling a farm well. In this past, only 70% of the wells drilled were successful at 200 feet of depth in the area. Moreover on finding no water at 200 ft, some persons drilled it further up to 250 feet but only 20% struck water at 250 ft. The prevailing cost of drilling is ₹ 50 per foot. The farm owner has estimated that in case he does not get his own wells he will have to pay ₹ 15000 over the next 10 years, in PV term, to buy water from the neighbor. The following decisions can be optimal.

i) Do not drill any well
ii) Drill up to 200 ft
iii) If no water is found at 200 ft, drill further up to 250 ft.

Draw an appropriate decision tree and determine the farm owner's strategy under EMV approach.

Solution:



At D_2 Point

Decision: a) drill upto 250 feet b) Do not drill
Event: a) No water b) Water

Probabilities are 0.2, 0.8
EMV for drilling upto 250 feet
= (12500 x 0.2) + (27000 x 0.8) = 24500
EMV for do not drill = 25000 (from the tree)

EMV is smaller for the act drill upto 250 feet. So it is optimal act.

At D_1 Point

The decision are drill upto 200 feet and do not drill. Events are same as those of D_2 point.

Probabilities are 0.7 and 0.3
EMV for drill upto 200 feet = (10000x0.7) + (24500x0.3)= 14350
EMV for do not drill = 1500 (from the tree)

The optimal decision is drill upto 200 feet (as the EMV is smaller).

Therefore combining D_1 and D_2 the optimal strategy is to drill the well upto 200 feet and if no water is struck, then further drill it upto 250 feet.

Question 21:

A firm is planning to develop and market a new drug. The cost of extensive research to develop the drug has been estimated at ₹ 100000. The manager of the research programme has found that there is a 60% chance that the drug will be developed successfully. The market potential has been assessed as follows.

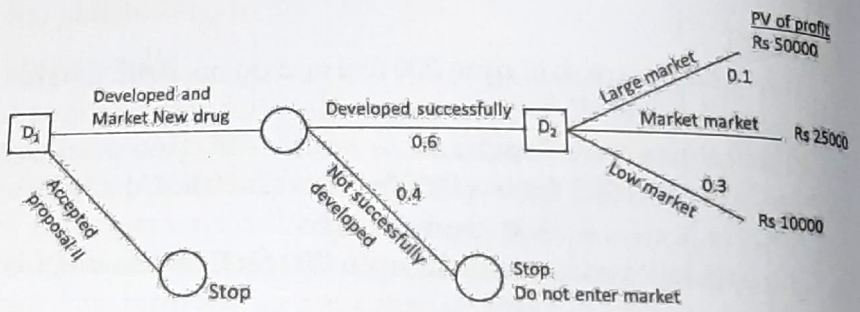
Market condition	Probability	Present value of profit (₹)
Large Market potential	0.1	50000
Moderate market potential	0.6	25000
Low market potential	0.3	10000

The present value figures do not increase the cost of research. While the firm is considering this proposal, a second proposal almost similar comes up for consideration. The second one also requires an investment of ₹ 100000, but the present value of all profits is ₹ 12000. The return on investment in the second proposal is certain

i) Draw a decision tree indicating all events and choices of the firm

ii) What decision the firm should take regarding the investment of ₹ 100000?

Solution:



At point D_2

Decisions are (1) Enter market (2) Do not enter market

Events: (1) Large market (2) Moderate market (3) Low market

Probabilities 0.1, 0.6, 0.3

a) Enter market

EMV = Expected PV = (50000x1) + (25000x0.6) + (10000x0.3) = 5000 + 150000 + 3000 = 23000

b) Do not enter market

EMV = Expected PV = 0x1 = 0

Decision: Enter market since EMV is more.

At point D_1

Decisions are (1) Develop new drug (2) Accept proposal II

Events are (1) successful (2) not successful

Probabilities 0.6, 0.6

a) Develop new drug

EMV = Expected PV = (23000x0.6) + (0x0.4) = (13000+0) = 13800

b) Accept proposal II

EMV = Expected PV = 12000x1 = 12000

Using EMV criterion, the optimal decision at D_1 is to develop and market the new drug.

3.9 DECISION MAKING MODELS: RATIONAL AND BEHAVIOUR MODEL

A manager has to make decisions under different conditions and situations. While taking a decision how does a manager perceive the things, how does he react and how does he try to resolve, all this is human behaviour. Two models or approaches explain the behaviour of the decision maker.

1. Rational or 'Economic Man Model':

The classical approach to decision making in economics has used the 'economic man' model under conditions of certainty. The economic man is completely 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.

This economic man model has the following features:

(i) The approach is logical and full of reasoning,

(ii) Economic man always identifies clearly the ends to which he wants to reach and the means which are available for the purpose,

(iii) The manager knows of various alternatives available and will be in a position to evaluate them rationally,

(iv) The manager is supposed to be objective, not allow any bias, preference, liking or disliking in decision making process,

(v) Manager should try to reach goals with positive attitude.

(vi) A manager must have a clear understanding of the existing environment. The economic man model is applicable to routine and repetitive decisions which are programmed. The pre-determined rules and procedures are applied for taking routine decisions. Economic man is always in search of an optional solution or best way of doing things for maximising

his benefits. He is governed by economic considerations and uses mathematical and statistical tools for solving problems.

2. Behaviour Model:

Bounded Rationality, 'Adminis-trative Man'. Rationality approach may not always be applicable in practical situations. Management experts have developed 'behavioural approach' which is realistic as per the demand of the situation. This approach is pragmatic and holds the view that a manager is a human being and cannot be fully rational because he is confronted with many constraints, problems, limitations and inadequacies.

Taking into consideration various factors of real-life decision-making. Herbert Simon has proposed a theory of' Bounded Rationality". This theory states that the real-life decision maker must cope with inadequate information about the nature of problem and its solution. The norm of rationality is bounded by many limitations and, therefore, the concept is known as 'bounded rationality'.

The manager's rationality is bounded by the following major limitations:

(i) A manager may not have access to all type of required information or information may not be available,

(ii) A rational decision-making requires the search and analysis of various alternatives before reaching a decision. In real situation time available to a decision maker may not be sufficient to go through the rational process. A decision may have to be taken immediately without going through various formalities,

(iii) There may be a situation where multiple and conflicting objectives may be involved, a process of compromise and adjustment becomes necessary for taking decisions rather than rationality,

(iv) Decisions are made to be implemented in future. The future environment is full of complexities and uncertainties and cannot be predicted with a high degree of accuracy. A manager may have to accommodate the changing situations in decision making process,

(v) The problem requiring a solution may be complex and unstructured, it may not be defined with rationality. In such situations a manager may rely on intuition than on rationality,

(vi) The organizational variables such as philosophy, multiplicity of goals, existence of informal goals, power structure may be taken into account while taking decisions. A manager may have to make certain adjustments while taking decisions, even defying the norms of rationality.

In real life situation decision-making is sub-rational, fragmented and pragmatic activity. According to Herberton Simol, the norm of' satisfying' represents and describes actual decision-making behaviour of the manager and involves choosing a course of action that is satisfactory or good enough under the circumstances.