

CHAPTER III

INTRODUCTION TO QUANTITATIVE TECHNIQUES

3.1 IMPORTANCE OF QUANTITATIVE TECHNIQUES.

3.2 PROCEDURE OF OPERATIONS RESEARCH TECHNIQUES.

3.3 REGRESSION (TIME SERIES) ANALYSIS.

3.4 STATISTICAL QUALITY CONTROL.

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THEORETICAL BACKGROUND OF THE STUDY :-

Decision making is a Fundamental part of Management process & it provides the activities of every business manager. In fact it is the manager's competence as a decision - maker that enables us to distinguish between good manager & a bad one. Modern Management is adopting & applying quantitative techniques to aid the process of decision making in an everincreasing measure. This is due to the fact that an intelligent application of the appropriate tools can reduce an otherwise unwieldy & complex problem to one of manageable dimensions. The decision maker can use analytical tools in a wise manner only if he comprehends fully the underlying assumptions : what the analysis achieves, what compromises the model used makes with reality & above all how the conclusions derived are to be adopted to the dynamic environmental conditions. Doubtless, however a knowledge of quantitative analysis is a boon to the managers.

Thus decision making is an essential & dominating part of the management process. It is the power to determine what plans will be made & how activities will be organized & controlled. The right to make decisions is an integral part of right of authority upon which entire concept of management rests. Further since to carry out the key managerial functions of planning organising directing & controlling , the management is engaged in a continuous process of them, management may be regarded as equivalent to decision-making.

Traditionally decision-making has been considered purely as an art, a talent which is acquired over a period of time through Experience. However, the environment in which management has to operate nowadays is complex & fast changing. There is a greater need for supplementing the art of decision-making by systematic & scientific methods. most of the business decisions can not be made simply on the basis of rule of thumb, using common sense & / or snap judgment. For large business a single wrong decision may not only be ruinous but may also have ramifications in national economy. As such present day managers can not rely solely on a trial-& - error approach & the managers have to be more sophisticated. They should employ scientific methods to help them make proper choices. Thus the decision-makers in the business world of today must understand Scientific methodology for making decisions. This calls for

1. Defining the problem in a clear manner.
2. Collecting pertinent facts.
3. Analysing the facts thoroughly. &
4. Deriving & Implementing the solution.

DECISION MAKING & QUANTITATIVE TECHNIQUES :

Managerial decision making is a process by which management, when faced with a problem, chooses a specific course of action from a set of possible options. In making a decision, a business manager attempts to choose that course of action which is most effective in the given circumstances in attaining the goals of organisation. The various types of decision making situations that a manager might encounter can be listed as, -

1. a) Decisions under certainty where all facts are known fully & for sure.

b) Decisions under uncertainty where the event that would actually occur is not known but probabilities can be assigned, to various possible occurrences.

2. a) Decisions for one time period called static decisions.

b) A sequence of interrelated decisions made either simultaneously or over several time periods called dynamic decisions.

3. a) Decisions where the opponent is nature (digging an oil well cultivating Agricultural produce).

b) The opponent is a rational one (e.g. setting advertising strategy, when the actions of opponent have to be considered).

THE ELEMENTS OF ANY DECISION ARE -

a). A decision maker who could be an individual, group, organisation or society.

b). A set of possible actions that may be taken to solve the decision problem.

c). A set of possible states that might occur.

d). A set of consequences associated with various combinations of courses of action & the states that may occur.

e). The relationship between the consequences & the values of decision - makers.

In real life some decision - making situations are simple while others are not. Complexities in decision situation arise due to several factors. these include the complicated manner of Interaction of the Economic Political Technological Environmental & Competitive forces in society ; the limited resources of Organisation ; the values ; risk attitude & the Knowledge of decision - maker. The essential idea of the Quantitative approach to decision - making is that if the factors that influence the decisions can be Identified & Quantified then it becomes easier to resolve the complexity of the decision - making situations. A large number business problems have been given a Quantitative Representation with varying degrees of success & it has led to a general approach which is variedly designed as operations research management science system analysis, decision analysis, decision science etc. Quantitative analysis is now extended to several areas of business operations & represents probably the most effective approach to handling of some types of decision problems.

A significant benefit of attaining some degree of Proficiency with Quantitative methods is exhibited in the way the problems are perceived & formulated. A problem has to be well defined before it can be formulated in to a well - structured framework for solution. This requires an orderly & organised way of thinking.

In general terms Operations research attempts to provide a Systematic & Rational approach to the fundamental problems involved in the control of systems by making decisions which, in a sense achieve the best results considering all the information that can be profitably used.

A classical definition of OR is given by Churchman,
 " Operations Research is the application of Scientific Methods, Techniques & tools to problems involving the operations of systems so as to provide those in control of operations with optimum solutions to the problems."

Thus it may be regarded as the Scientific method employed for problem solving & decision - making by the management.

The Significant features of Operations Research are given below. -

1. DECISION MAKING :- A major premise of OR is that decision - making Irrespective of the situation involved can be considered as a general systematic process that consists of following steps :-

a) Define the problem & establish the criterion which will be used. The criterion may be maximisation of profits , utility & minimisation of costs etc.

b) Select the alternative courses of action of Consideration.

c) Determine the model to be used and the values of the parameters of the process.

d) Evaluate the alternatives & select the one which is optimum.

2. SCIENTIFIC APPROACH : - O.R. employs scientific methods for the purpose of solving problems. It is a formalised process of reasoning & consists of the following steps -

a) The problem to be analysed is defined clearly & the conditions for observations are determined.

b) Observations are made under varying conditions to determine the behavior of the systems.

c) On the basis of the observations a hypothesis describing how the various factors involved are believed to interact & the best solution to the problem is formulated.

d) To test the hypothesis an experiment is designed & executed. Observations are made & measurements are recorded.

e) Finally the results of the experiment are analysed & the hypothesis is either accepted or rejected. If the hypothesis is accepted the best solution to the problem is obtained.

3. THE NATURE OF OR IS OBJECTIVE :-

O.R. attempts to locate the best or optimal solution to the problem, under consideration. for this purpose it is necessary that a measure of effectiveness is defined which is based on the goals of the Organisation.

4. INTER - DISCIPLINARY TEAM APPROACH :

Managerial problem have economic physical Psychological, Biological, Sociological & Engineering aspects. This requires a blend of people with expertise in the areas of Mathematics , Statistics , Engineering , Economics management & computer science & so on.

5. DIGITAL COMPUTER ;:-

Use of a digital computer has become an integral part of the operations research approach to decision making . The computer may be required due to the complexity of the model volume of data required or the computation to be made. Many OR techniques are available in the form of 'canned' programs.

METHODOLOGY OF OPERATION RESEARCH

The basic & dominant characteristic feature of operations research is that it employs mathematical representation or models to analyse problems. This distinctive approach represent an adoption of the scientific methodology used by other physical sciences. The scientific method translates a real given problem in to a mathematical representation which is solved & transformed in to the original context. The OR approach to problem solving consists of following steps. :

1. Formulate the Problem.
2. Determine the model building & formulate the problem in a mathematical framework.
3. Solve the model formulated & interprets results.
4. Validate the model.
5. Implement the solution obtained.

PROBLEM FORMULATION :-

The first & most important requirement is that the root problem should be identified & understood . Once the problem has been identified it is categorised as being standard or special. The standard problems are also known as programmed problems. They are well - structured problems characterised by routine , repetitive decisions which utilize specific decision making techniques in their solution strategy. Standard solution procedures have been developed to handle such prototype problem . Examples of these workers to jobs fixing the product mix & determination of the quantity of materials to be bought .

2. MODEL BUILDING :-

Once the problem is defined the next is to build a suitable model. The concepts of models & model building lie at the very heart of the operations research approach to problem solving. A model is theoretical abstraction of a real-life problem . In fact many real-life situations tend to be very complex because there are literally innumerable inherent factors in any given situation. Thus the decision - maker has to abstract from the empirical situation those factors which are most relevant to the problem. Having selected the critical factors he combines them in some logical manner so that they form a counterpart or a model of the actual problem.

Thus a model is a simplified representation of a real-world situation that ideally strips a natural phenomenon of its complexity. Models may be regrantred in a variety of ways.

USE OF MATHEMATICAL MODELS :-

Various types of mathematical models are used in modern operation research. Two broad categories of these are deterministic & probabilistic models. A Deterministic model is the one in which all parameters in the mathematical formulation are fixed at Predetermined values so that no uncertainty exists. In probabilistic model on the other had some or all the basic characteristics may be random variables. In such models uncertainty & errors are required to be given explicit consideration. I Probabilistic models are also termed as stochastic or chance models.

The mathematical models comprise the three basic components : decision variables, result variables & uncontrollable variable . The decision variable represent those factors where a choice could be made. These variables can be manipulated & therefore, controllable by the decision - maker. The result variable indicate the level of effectiveness of a system & are also termed as dependent variables. Finally the uncontrollable variable are those which influence the result variables but are beyond the control of decision - maker.

The different components of a mathematical model are tied together with the relationships in the form of equations, inequalities et. Such a model consists of an objective function system function. The objective function describes how a dependent (result) variable is related to independent (decision) variable.

SOLUTION OF MODEL :-

Once an appropriate model has been formulated , the next stage in the analysis calls for its solution & the interpretation of the solution in the context of the given problem. A solution to a model implies determination of a specific set o decision variables that would yield a desired level of output. The desired level of output in turn is determined by the principle of choice adopted & represents the level which 'optimises'. Optimisation might mean maximising the level of goal attainment from given set of resources or minimisation of cost as will satisfy the required level of goal attainment .

It may be noted that the solutions can be classified as being feasible or unfeasible , optimal or non-optimal & unique or multiple.

a) FEASIBLE & UNFEASIBLE SOLUTIONS :-

A solution (a set of values of the decision variables) which satisfies all the constraints of the problem is called a feasible solution where as an infeasible solution is the one which does not satisfy all the constraints. Only feasible solutions are of interest to decision maker.

b) OPTIMAL & NON - OPTIMAL SOLUTIONS :-

An optimal solution is one of the feasible solutions to a problem that optimises & is therefore the best of all of them. The feasible solutions other than the optimal solution are called non - optimal solutions.

UNIQUE & MULTIPLE SOLUTIONS :-

If only one optimal solution to a given problem exists it is called unique solution. On the other hand, if two or more optimal solutions to a problem exist which are equally efficient then multiple optimal solutions are said to exist. Of course these are preferable from the management point of view as they provide a greater flexibility in implementation.

Once the principle of choice has been specified the model is solved for optimal solution. For this the feasible solutions are considered & of them the one (or more) that optimises is selected. For this a complete enumeration may be made so that all the possible solutions are checked & evaluated. However, this approach is limited to those situations where the number of alternatives is small. Alternatively & more commonly , methods involving algorithms may be used to get optimal solutions. It is significant to note that in contrast to complete enumeration where all solutions are checked, an algorithm represents a trial -& - error process where only a part of the feasible solutions are considered & the solutions are gradually improved until an optimal solution is obtained.

MODEL VALIDATION :-

The validation of a model requires determining if the model can adequately & reliably predict the behavior of the real system it seeks to represent. Also it involves testing the structural assumptions of the model to ascertain their validity. Usually the validity of a model is tested by comparing its performance with the past data available in respect of the actual system.

IMPLEMENTATION :-

A model which secures a moderate theoretical benefit & is implemented is better than a model which ranks very high on obtaining theoretical advantage but cannot be implemented, because the techniques & models used in operation research may sound high & may be detailed in mathematical terms but they generally do not consider the human aspects which are significant in implementation of a solution.

Another aspect emphasised in this study is the time series analysis. One of the major responsibilities is the Design & Implementation of policies for the achievement of the short term & long-term goals of the Business. Previous performances must be studied so as to Generate or Forecast future Business activity. Given a Projection of the pattern & the level of future Business activity the Desirability of alternative actions can then be investigated. The Suitability & Timing of Capital Intensive Projects must be carefully evaluated & lastly once a strategy has been selected control Procedures must be incorporated to enable the firm to reassess the validity of the original projected values & the extent to which the actual results vary on a continuous basis. The Quality of the forecasts or projections the Management can make is strongly related to the information that can be extracted & use from past data. Time series analysis is one of the Statistical methods used to determine the patterns of the data collected over a period of time. Thus a time series consists of a set of chronological observations of a Statistical series recorded at successive points of time.

Analysis of time series is of great significance as it helps in understanding the past behavior. By closely observing the past data one can easily understand the changes that have taken place in the past. Such analysis helps in perfecting the future behavior & thus helps in planning for future Operations.

Time series analysis also helps in evaluation the current Performance. The actual Performance can be compared with the Predicted Performance & the cause of Variations can be analysed. It should, however be noted that time series analysis will not help 100 Percent Perfect Predictions as it would be Difficult to Identify all factors Affecting or Influencing the time series data. Moreover Predictions in time series analysis is on

the basis of past data & future may not be a Perfect Replication of the past. However when such analysis is combined with a careful Examination of the Present Business Environment one can Definitely Improve upon the Estimates based upon guesswork in Forecasting the Future Business Operations.

There are four kinds of changes or Variations involved in time series analysis they are ----

1. Secular Trend.
2. Cyclical Fluctuation.
3. Seasonal Variation.
4. Irregular Variation.

With the secular trend the value of the variable tends to Increase or decrease over a long period of time. Cyclical Fluctuations are mainly due to Business Cycle. These Cyclical Movements Representing Intervals of Property Recession Depression & Recovery of the Business. Seasonal Variations involve the pattern of change from year to year. The Irregular Variations may be due to (i) Random Fluctuations which refer a large number of minute Environmental Influences Operating on is Significantly Important. (ii) Non-Recurring Irregular Variations that exert a Significant impact on the time series.

There are four Methods for Fitting the Trend in time series.

1. Free Hand Method.
2. Method of Semi Averages.
3. Method of Moving Averages.
4. Method of Least Squares.

Fitting a Trend Involves Assuming that a given time Series Exhibits a certain Trend Movement (linear, Parabolas or Exponential & an attempt is made to measure this trend. Measuring a trend Actually means Computing the Constants of the Equation that we have Selected to be Representative of the Trend in the Data.

The Device for getting an Objective fit of a Straight line to a series of data is the least square method. In the least square method the sum of the Vertical Deviations of the Observed values from the fitted straight line as Zero. Secondly the sum of the Squares of all these Deviations is less than the sum of Squared Vertical Deviations from any other Straight line. The Method of least Square can be used for fitting Linear & Non-Linear trends as well.

To Determine the values of a & b in a linear Equation.

$$Y = a + b x$$

by the least Square Method, it is required to solve the following two Normal Equations Simultaneously.

$$\sum y = n * a + b \sum x$$

$$\sum xy = a \sum x + b \sum x^2$$

In the case of time series analysis, the Solution of a & b from these two Equations is Simplified by using the middle of the series as the Origin. Since the time units in a series are usually of uniform Duration & are Consecutive numbers, when the middle point is taken as Origins the sum of time units i.e. $\sum x$ will be zero. As a result the above two normal Equations reduce to

$$\sum y = n.a.$$

$$\& \sum xy = b \sum x^2$$

Therefore,

$$a = \frac{\sum y}{n}$$

&

$$b = \frac{\sum xy}{\sum x^2}$$

From the above Expressions a is the Arithmetic mean of the Y Variable, the value of b is the Average amount of change in the trend values per unit of time.

It should be noted that in Computing the trend it is Convenient to use the Middle of the series as the Origin. If the series contains an odd number of Periods. The origin the middle of the given period. If an even number of period is involved the origin is set between the two middle Periods.

Another Important to Statistical is applied in the Present study which is Process Control.

Process Control is the Application of Statistical tools to Industry to Maintain Quality of Process & Hence the quality of Product. The Object of keeping the Process under Control is Achieved with the help of Control Charts, a Graphic Method of Presenting a Sequence of suitable sample Characteristics (mean, standard deviation) thereby Revealing the Frequency & Extent of Variation from Established Standards or goals. The chart sets the control limits & whenever a goes outside the control limits the trouble its Indicated. As the Process Control Involves the use of control charts, therefore, this method is sometimes calls the control chart Technique.

There are two control limits upper & lower. They are called Tolerance limits. At regular Periodical Intervals the Observations are then & the data plotted on the graph. If these Observations are within the control limits. Then it does not call for any Corrective action because the Variations are Attributed to chance. But any Observation Deviates Considerably from either of these limits, the Manager comes to the Conclusion that there are some Defects in the Process of Production. He may then inspect Examine & Correct the Process.

Construction of Control Charts. They are simple to Construct as they Involve only three Horizontal lines.

1. A Central line to Indicate the Desired Standard or level of the Process.
2. Upper Control Limit.
3. Lower Control Limit.

The Observations are Recorded on Graph Paper and Decisions are made with the help of Control Limits.

Application of χ^2 test

The χ^2 test is derived from the properties of Chi-square distribution, which has many applications in the Statistics. The test provides a technique whereby it is possible to (i) Test the goodness of fit (ii) Comparison of the frequency distribution (iii) Find out an association and relationship between attributes. It is a test of independence, homogeneity and goodness of fit. With the help of this test, it is possible to assess the significant difference between the observed frequencies and the expected frequency. It is therefore possible to test the goodness of fit to see how well the distribution of observed data fits the assumed theoretical or expected values. If the distribution of observed data does in fact approximate to an assumed hypothesis, then there is no significant difference between the expected frequencies and the actual frequencies. For each actual frequency (O_i) there will be an expected frequency (E_i) and χ^2 is calculated as

$$\chi^2 = \sum \left\{ \frac{(O_i - E_i)^2}{E_i} \right\}$$

Whether or not a calculated value of chi-square is considered significant is ascertained by reference to tabulated values at a certain level of confidence. If the value of chi-square exceeds the tabulated chi-square value the difference between observed and expected frequencies is significant.

On the otherhand, if it's value less than the table value, the difference is attributed to chance and may be ignored.