स्वाध्याय स्वमन्थन स्वावलम्बन

UTTAR PRADESH RAJARSHI TANDON OPEN UNIVERSITY

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MBA-4.2

MBA-4.4
Research Methodology for Management Decisions

FIRST BLOCK
Introduction to Research Methodology

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MBA-4.2 4.2

Research Methodology For Management Decisions

Block

1

INTRODUCTION TO RESEARCH METHODOLOGY

BLOCK 1 INTRODUCTION TO RESEARCH METHODOLOGY

Block 1 on Introduction to Research Methodology consists of three units.

Unit 1 discusses the meaning of research and the need for research in decision making. It also discusses the actual process of research and distinguishes between various types of research.

Unit 2 explains the distinguishing features of research problems and also throws light on the significance and importance of elements that make up the complete research problem. It also explains the formulation of research problem in terms of a hypothesis to be tested.

Unit 3 on Experimental Designs discusses various types of designs, their assumptions and their relevance for a specific research problem. The usefulness of these designs to study cause and effect relationship is also discussed.

UNIT 1 IMPORTANCE OF RESEARCH IN DECISION MAKING

Objectives

After going through this unit, you should be able to:

- Explain the meaning of research in the context of making intelligent decisions.
- Discuss the need for research in decision making.
- Explain the actual process of research and its role in managerial decisions.
- Distinguish between the various types of research.

Structure

1.1 INTRODUCTION

When managers use research, they are applying the methods of science to the art of management. All business undertakings operate in the world of uncertainty. There is no unique method which can entirely eliminate uncertainty. But research methodology, more than any other procedure, can minimise the degree of uncertainty. Thus it reduces the probability of making a wrong choice amongst alternative courses of action. This is particularly significant in the light of increasing competition and growing size which make the task of choosing the best course of action difficult for any business enterprise.

It is imperative that any type of organisation in the present environment needs systematic supply of information coupled with tools of analysis for making sound decisions which involve minimum risk. It is in this context that the research methodology plays a very important role. In this unit, we will discuss at length the importance of research in decision making by delineating all its relevant elements.

1.2 MEANING OF RESEARCH

Research is not an existing bag of techniques. Research is not a fishing expedition or an encyclopaedic gathering of assorted facts. Research is purposeful investigation. It provides a structure for decision making. There are three parts involved in any investigation: (1) the implicit question posed. (2) the explicit answer proposed. (3) collection, analysis, and interpretation of the information leading from the question to the answer. This third part is the defense that justifies the recommendation and is viewed as research. For example consider the statement "We recommend that model A TV be priced at Rs.14000/!". This was the recommendation forwarded to the marketing vice president by the marketing research manager. The implicit question posed in this quote is what should be the selling price of model A? The explicit answer is Rs.14000/. The third part deals with the collection, analysis, and interpretation of the information leading from the question to the answer of Rs.14000/.

The word research identifies a process by which the organisation attempts to supply the information required for making sound management decisions. Research is not synonymous with common sense. The difference revolves around words such as "systematic," "objective," and "reproducible."Both research and common sense depend on information; the distinction between them lies in the procedures and methods adopted by which the information is obtained and used in arriving at conclusions. Research cannot address itself to the complete information on a particular subject. Hence two secondary characteristics of research specify "relevance", and "control."

A systematic approach is essential in good research. Each step must be so planned that it leads to the next step. It is usually very difficult to go back and correct the mistakes of the previous step; sometimes it is impossible. Even when it is possible, it will involve loss in time and money. Authors have divided research in to a number of steps. Both the number of steps and the names are somewhat arbitrary, however the recognition of a sequence is crucial. Planning and organisation are part of this systematic approach with a lot of emphasis given to the interdependence of the various steps.

While planning, one of the very common mistakes that is committed is the separation of data collection and data analysis. First we collect the data; then, we decide what anlysis is appropriate. This approach invites a disaster. In one of the research projects, depth interviews of the fresh college students were carried out at a very high cost and the necessary data were all collected. The data were still unanalysed because no one knew how to proceed. Our point is that considerable thought should have been given at the planning stage itself as to what kind of analysis will be required for the project which will satisfy the needs of the decision maker.

Objectivity warrants an approach which is independent of the researcher's personal views and opinions with regard to the answer to the problem under investigation. It is possible to have honest differences with respect to the proper definition or collection procedure, but the one selected must not be chosen in order to verify a prior position.

Look at a scene in the morning and then in the evening. Use the naked eye and then the tinted glasses. It is the same with research. A high proportion of shoppers in store A have a positive opinion of store A. Shoppers in store B may have a totally different opinion of store A. Purchase behaviour varies with price specials. It is always possible to prove a point if one desires, by carefully selecting the respondents, time, and place. True research attempts to find out an unbiased answer to the decision making problem.

A reproducible research procedure is one which an equally competent researcher could duplicate and from it obtain approximately the same results. In order to achieve reproducibility, all procedures must be stated unambiguously. Precise wording of questions, method of sampling, collection method, interviewer instructions, and all other details must be clearly stated. Even if the environment changes, the research is atleast "conceptually" reproducible in the sense that the steps could be mentally duplicated.

The interviewer should avoid the temptation of rephrasing the question for the respondent in order to preserve reproducibility aspect. Poor and vague sampling procedure can also lead to nonreproducibility. If procedures are vague and not stated clearly, you cannot expect consistency even from the same interviewers.

Relevancy accomplishes two important tasks. First it avoids the collection of unnecessary information along with the accompanying cost. In the second place it forces the comparison of the data collected with the decision maker's criteria for action. Before the start of the research project, you should ask the question "what action would you take if the research answer were-----?" This approach enables both the investigator and the decision maker to know whether the project is on the right direction.

Control aspect is particularly elusive in research. We must be aware that the results of our study are due to the presence of some factor other than those we are

investigating. It is impossible to have control on all other factors; the best we can do is to have control for those we think are most likely to cause us difficulty. Suppose we study the relationship between shopping behaviour and income without controlling for education and age, it will be the height of folly since our findings may reflect the effect of education or age rather than income.

Control raises extremely difficult issues when research is conducted in a live environment. Many factors other than the ones of principal interest may influence the research results. The danger is that the researcher may attribute changes to one variable when the uncontrolled variables are the causes.

Control must consider two aspects. (1) Those variables that are truly with in your control must be varied according to the nature of your investigation. (2) Those variables beyond your control should be recorded.

Activity 1

The three parts concerning any research investigation are:

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Activity 2

The five distinguishing features of any good research are:

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Activity 3

Mention a few research studies where it is impossible to have control on all other factors:

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1.3 ROLE OF RESEARCH IN IMPORTANT AREAS

Through research, an executive can quickly get a synopsis of the current scenario which improves his information base for making sound decisions affecting future operations of the enterprise. The following are the major areas in which research plays a key role in making effective decisions.

Marketing
Marketing research has become very crucial in taking sound marketing decisions. Marketing research involves the process of systematic collection, compilation, analysis, and interpretation of relevant data for marketing decisions. Research tools are applied effectively for studies involving demand forecasting, consumer buying behaviour, measuring advertising effectiveness, media selection, test marketing, product positioning, and new product potential.

Production
Research enables an organisation to decide on what to produce, how much to produce, when to produce, and for whom to produce in the field of production. Research tools are also of immense help in quality control, and setting up optimum inventory level.

Banking
Banking institutions have found it useful to setup research departments for the

purpose of gathering and analysing information both for their internal operations and for making indepth studies on economic conditions of business. Reserve Bank of India has setup an excellent research department for planning and management reporting.

Materials
The materials department uses research to frame suitable policies regarding where to buy, how much to buy, when to buy, and at what price to buy.

Human resource development
The human resource development department uses research to study wage rates, incentive schemes, cost of living, employee turnover rates, employment trends, and performance appraisal. It also uses research effectively for its most important activity namely manpower planning.

Government
Research lays the foundation for all government policies in our economic system. For example, research is applied for evolving the union finance budget and railway budget every year. Research is used for economic planning and optimum utilisation of resources for the development of the nation. Research is also needed for systematic collection of information on the economic and social structure of the nation. Such information indicates what is happening to the economy and what changes are taking place.

Activity 4

List out the uses of research in the field of :

a) Hospital Management

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b) Railways

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c) Temple Management

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d) Traffic Control (by Police)

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1.4 PROCESS OF RESEARCH

The process of research involves the following steps :

1) Problem definition

First of all we should be clear about the problem we are facing. Suppose in a particular case we want to know which mail piece be employed. Your decision may be to use either direct mail piece A or direct mail piece B. The researcher should atleast verify that these are the only two options open to you. Should other mail pieces be considered? Should methods other than direct mail be employed? Should a combination of A and B be used? Let us assume that the alternatives have been correctly specified: either A or B will be employed.

We have identified the alternatives available to you, but we have not specified a complete problem definition. The complete problem is also concerned with the criterion that will determine which mailing is superior. The criterion may be the rupee value of the sales generated, number of persons placing orders, or perhaps some definition of profitability from sales generated. The definition of problem is composed of three aspects: (a) the specification of the unit of analysis for the study,

(b) the identification of the particular units with in the scope of the study (c) the specification of the kind of information sought concerning those units. What would you like to know if information were free and without error? A complete answer to this question defines the initial research problem. It may later be refined and redefined because of cost or time considerations or because of measurement difficulties, but it establishes a starting point.

The unit of analysis for you is a person, you want to know how persons would respond to mail piece A and mail piece B. Which persons? Are you interested in the 5000 persons on the mailing list? The answer to this question determines the particular units (universe or population) with in the scope of the study. The information sought could be "will A or B generate a higher volume of sales in terms of rupee value from the 5000 names?"

The time dimension is missing: sales for what period of time? A properly defined population must have time and space coordinates. If the mailing is scheduled for October 10,1990, the relevant time period may be from the beginning of October to the end of November. Alternatively, a much longer time dimension may be in view. The space coordinates of the problem definition are those that pertain to the geographic area in which you contemplate possible actions.

2) Research design

The second step in research is the research design—the blue print for the research. The basic issues addressed in research design are:

1) Should the research environment be internally disturbed by the researcher in specified ways—an experimental design—or should the environment be studied as it exists without such disturbances? In our example of the mail order firm, an experimental design is required if the manager is to use mail piece A for one group and mail piece B for the second. A nonexperimental design would require finding past examples in which A and B had been applied—a most unlikely occurrence, particularly for the population defined.
2) How many observations should be made on each unit in the study? when?
3) Should a single sample be chosen from the total population or should a series of samples be chosen from various subgroups of the population?
4) Should a probability or non-probability sampling procedure be adopted for the study?

3) Data collection

The next step in the research is the collection of relevant data. Collection involves the basic definitions for the concepts to be investigated, specific wordings of inquiries to communicate those concepts, delineation of the environment in which the data will be collected, specific field procedures, and the design of instruments for recording the actual data. Data collection looks forward to data analysis; data requirements for various analytical techniques must be anticipated in the data collection phase. Special care must be taken in the collection phase to avoid sources of understatement or overstatement for the various characteristics. If such biases are feared, the researcher should consider whether there are ways of introducing adjustments. These adjustments would be introduced in the analysis phase, but the data must be generated in the collection phase.

The collection phase must consider the diverse tasks of assignment and recruitment of staff, ways of increasing response rates, costs and bias sources under alternative collection approaches, and proper training of personnel. The effect of each of these on accuracy, monetary costs, and time constraints must be evaluated. Finally, the collection phase must be supervised as well as planned. Unfortunately, many well-planned research projects have failed because of inadequate supervision. Procedures which sound good but are inadequately administered lead to invalid results just as much as ill-conceived procedures do.

The "operational definition" is a must in any scientific inquiry and is most obvious in the collection phase. The operational definition is the nitty-gritty of how the details of collection, measurement, and wording are to be handled in the research. It is the practical counter part of the concept developed for the decision maker's action

problem and includes a variety of issues. The issues to be handled include the use of check responses versus open-ended questions, the number of alternatives offered to the respondent, and whether the respondent is to choose the alternative or whether he or she may select several.

Good research demands unambiguous terms. Care must be exercised in the use of modifying adjectives or adverbs. The addition or deletion of a single word can produce drastically different results without clarifying the meaning of those results. Compare the following four questions.

Do you use brand X?

Have you ever used brand X?

Do you regularly use brand X?

Is brand X your favourite brand?

What frequency of use corresponds to each of these four questions? Does the fourth correspond to frequency in any way? The appropriate wording depends on the problem at hand, but no wording can be appropriate unless its meaning is clear. If the precise meaning does not really matter, the research doesn't matter either; so why bother?

The researcher and the decision maker desire data that are as free from error as possible. This is two-pronged:

1) the data collection plan-questions, instruments, and procedures—must be appropriate for the decision maker's problem and
2) the data collection plan must be properly implemented. Implementation requires competent personnel plus supervision. It is easier to obtain valid data initially than to make correction later. Despite this, good research includes verification of data validity on atleast a sample basis.

The researcher should not ignore the possibility that relevant data are already available. A vast amount of historical as well as current statistics, ranging from various census publications to special purpose survey of particular industries, and products are already available through government publications. This type of data is called secondary data and is provided by another source—has an obvious advantage in cost and immediate availability. Its appropriateness for a particular study must be judged separately for each problem. Careful evaluation of secondary sources for the quality of data is necessary. The better sources supply a summary of procedures employed; lacking any basis for appraising the quality of data the researcher should be extremely reluctant to rely on them.

Primary data – data for which the researcher defines the terms and exercises the supervision of the project – must not be automatically construed as "more accurate than secondary data". The secondary sources may be more capable of generating the required data. It may have the resources to obtain more representative and larger samples. It may have interviewers and measuring instruments with unique capabilities in specialised fields.

Errors associated with data are typically classified into two categories: sampling and non-sampling errors.

Sampling errors are differences that arise because a sample rather than a census is employed. Different samples composed of different units would yield different results. The magnitude of the differences among the possible samples is an indication of the amount of sampling error associated with the research plan.

Non-sampling errors arise because the data collection procedures, question wordings, etc. would not yield the "correct" result even if a census were employed. Biases are introduced. Non-sampling errors can not be mathematically appraised; their magnitude is more a subjective appraisal resting upon familiarity with the substantive nature of the investigation and data collection within it.

4) **Data analysis**

The fourth step in research is the analysis. In this stage the data collected are processed in order to summarise the results, whether they may be statements with respect to single characteristic or relationship among characteristics. Data analysis seeks to determine how the units covered in the research project respond to the items under investigation. This may be for individual questions or it may be for sets of questions—seeking to discern whether any patterns exist.

In our example the mail order firm has defined the decision: the use of either A or B. In this situation, if the data were available the manager would simply determine the sum of sales over the 5000 individuals with each mailing piece — a most elementary analytic process. Alternatively, the manager could have subdived the population in the research design in order to study possible differences by market segments. The same type of comparison would be required, but the comparison would be for various subgroups rather than for the entire population.

The manger might also wonder whether certain types of individuals are better prospects than others. Information must be obtained from each unit in the study for those characteristics that the manager hypothesizes are indicators of the better prospects. The data must then be analysed in a manner that is satisfactory for testing the hypothesis. This can be further complicated by asking whether some individuals are "good" prospects regardless of which mailing piece is used, whether others are "good" prospects with only one of the mailing pieces, and finally whether others are not "good" prospects with either mailing piece. This rephrasing will have substantial implications for both data collection and analysis.

Data analysis can be conveniently classified as under:

1) Univariate analysis
2) Bivariate analysis
3) Multivariate analysis

Univariate analysis deals with a single characteristic of interest, bivariate analysis deals with two characteristics of interest, and multivariate analysis deals with more than two characteristics of interest. More on this can be found on another unit under marketing research.

5) **Interpretation of results**

Interpretation of results is the "so what?" of research. Research is wasted and useless unless it influences actions. It seems elementary to say that research results must have relevance for the decision to be made. We state it only because it is ignored so much in practice.

Not only must the results be interpreted into action recommendations but the recommendations must also be communicated to the executive in an understandable manner. It is not enough that the executive comprehend the recommendation; the communication must instill confidence that the recommendation is justified. Technical jargans should be avoided except when absolutely essential. Results should be presented in as simple a manner as possible. If the researcher cannot make the results comprehensible to the executive the researcher may not have sufficient understanding of the problem to warrant adoption of the recommendation.

The line manager who uses research must be conversant with research procedures. This familiarity is needed for three distinct but related reasons.

a) The line manager must adopt or reject research recommendations. Therefore the manager must understand the proper interpretation of research results and the assumptions embodied in them.

b) The line manager poses the initial problem and its environment. Therefore the manager must understand the kinds of questions research can handle and the type of structure required to make a problem "researchable".

c) The line manager is a prime target for "snow jobs" from researchers. Therefore the manager must be capable of appraising the feasibility of research proposals.

Activity 5
The definition of problem is composed of

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Activity 6
List out the sources of Non-sampling error

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Activity 7
Can we reduce sampling error by increasing sample size? Justify your answer

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Activity 8
Data analysis can be classified into:

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Activity 9
Explain the importance of interpretation of results.

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1.5 TYPES OF RESEARCH

On the basis of the fundamental objectives of the research, we can classify research into two types:

1) Exploratory research
2) Conclusive research

1) **Exploratory research**
Many times a decision maker is grappling with broad and poorly defined problems. Attempts to secure better definitions by analytic thinking may be the wrong approach and may even be counter productive – counter productive in the sense that this approach may lead to a definitive answer to the wrong question. Exploratory research uses a less formal approach. It pursues several possibilities simultaneously, and in a sense it is not quite sure of its objective. Exploratory research is designed to provide a background, to familiarise and, as the word implies, just "explore" the general subject. A part of exploratory research is the investigation of relationships among variables without knowing why they are studied. It borders on an idle curiosity approach, differing from it only in that the investigator thinks there may be a payoff in application somewhere in the forest of questions. Three typical approaches in exploratory research are:

a) the literature survey,
b) the experience survey, and
c) the analysis of "insight-stimulating" examples.

The literature search is fast, economical way for researchers to develop a better understanding of a problem area in which they have limited experience. It also familiarises them with past research results, data sources, and the type of data available.

The experience survey concentrates on persons who are particularly knowledgeable in the particular area. Representative samples are not desired. A covering of widely

divergent views is better. Researchers are not looking for conclusions; they are looking for ideas.

The analysis of specific examples is a sort of case study approach, but again researchers are looking for fresh possible divergent views.

2) **Conclusive research**
Exploratory research gives rise to several hypotheses which will have to be tested for drawing definite conclusions. These conclusions when tested for validity lay the structure for decision making. Conclusive research is used for this purpose of testing the hypotheses generated by exploratory research. Conclusive research can be classified as either descriptive or experimental.

Descriptive research
Descriptive research as the name suggests is designed to describe something – for example, the characteristics of users of a given product; the degree to which product use varies with income, age, sex or other characteristics; or the number who saw a specific television commercial. To be of maximum benefit, a descriptive study must collect data for a definite purpose. Descriptive studies vary in the degree to which a specific hypothesis is the guide. It allows both implicit and explicit hypotheses to be tested depending on the research problem. For example, a cereal company may find its sales declining. On the basis of market feedback the company may hypothesise that teenage children do not eat its cereal for breakfast. A descriptive study can then be designed to test this hypothesis.

Experimental research
Experimentation will refer to that process of research in which one or more variables are manipulated under conditions which permit the collection of data which show the effects. Experiments will create artificial situation so that the researcher can obtain the particular data needed and can measure the data accurately. Experiments are artificial in the sense that the situations are usually created for testing purposes. This artificiality is the essence of the experimental method, since it gives researchers more control over the factors they are studying. If they can control the factors which are present in a given situation, they can obtain more conclusive evidence of cause and effect relationships between any two of them. Thus the ability to set up a situation for the express purpose of observing and recording accurately the effect on one factor when another is deliberately changed permits researchers to accept or reject hypothesis beyond reasonable doubt. If the objective is to validate in a resounding manner the cause and effect relationship among variables, then undoubtedly experiments are much more effective than descriptive techniques.

Activity 10
Research can be classified into:

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Activity 11
You are product manager for brand A vanaspati, a nationally distributed brand. For the last four consecutive months, brand A shows a declining trend in sales. You ask the research department to do a study to determine why sales have declined.

Is this an exploratory or conclusive research? Explain your reasons.

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1.6 SUMMARY

We have started the discussion by emphasising that research is the application of

science to the art of management. Research methodology minimises the degree of uncertainty involved in management decisions. Research lays the structure for decision making. Research is not synonymous with common sense. Research is characterised by – systematic, objective, reproducible, relevance, and control.

The role of research in the important areas of management has been briefly covered. The areas include marketing, production, banking, materials, human resource development, and government.

Research process involves the five important steps—problem definition, research design, data collection, data analysis, and interpretation of results. All these steps have been explained in detail with their key elements.

We have dichotomised the types of research into—exploratory, and conclusive. While exploratory research enables the researcher to generate hypotheses, they are tested for validity by the conclusive research. Conclusive research could be further divided into—descriptive, and experimental. While the descriptive procedures merely test the hypotheses, the experimental research establishes in a more effective manner the cause and effect relationships among variables.

1.7 SELF-ASSESSMENT EXERCISES

1) Briefly explain the meaning and importance of each of the following in research.
   a) Systematic b) Objectivity
   c) Control d) Relevance
   e) Reproducible
2) Explain succinctly the role of research in managerial planning and decisions.
3) Name and briefly discuss the five steps of research process.
4) Analyse, criticise, and explain:
   a) Collection, analysis, interpretation, and research design are with in the areas of expertise of the researcher. The researcher who gets too involved in the specification of mangement's question and action is asking for difficulties and problems.
   b) Research "control" of the environment introduces artificial conditions. Objective research is best achieved by recording what happens without "disturbing" the environment.
5) Explain and distinguish with example "primary data" and "secondary data".
6) What are the precautions one should take while administering "Data collection"?
7) Explain briefly why data collection and data analysis should not be separated at the planning stage of any research project.
8) Explain why the line manager must be conversant with research procedures.
9) Discuss with examples "Exploratory research", "Descriptive research", and "Experimental research".

1.8 FURTHER READINGS

Boyd, Westfall, and Stasch, *"Marketing Research Text and Cases"*, All India Traveller Bookseller, New Delhi.

Brown, F.E. *"Marketing Research, a structure for decision making"*, Addison – Wesley Publishing Company.

Kothari, C.R. *"Research Methodology – Methods and Techniques"*, Wiley Eastern Ltd.

Stockton and Clark, *"Introduction to Business and Economic Statistics"* D.B. Taraporevala Sons and Co. Private Limited, Bombay.

UNIT 2 DEFINING RESEARCH PROBLEM AND FORMULATION OF HYPOTHESIS

Objectives

After studying this unit, you should be able to:

- Explain clearly the distinguishing features of research problem
- Discuss the significance and importance of the elements that make up the complete research problem
- Formulate research problem in terms of a hypothesis to be tested.

Structure

2.1 INTRODUCTION

In unit 1 we have discussed at length the importance of research in decision making by delineating the meaning, role, process, and types of research. While discussing the research process, we gave a synopsis of "problem definition". In this unit we propose to give a complete coverage on "defining research problem and formulation of hypothesis", perhaps the most important step from the angle of making sound decisions. Also as problem definition is the first step in research, a complete understanding of all its elements is imperative for making the right decision. A complete problem definition must specify the following:

1) Unit of analysis
2) Time and space boundaries
3) Characteristics of interest
4) Specific environmental conditions

Taken together these four aspects identify the who, when, where, and what to be researched. Now we will dwell in detail all these four elements along with the associated features which are interwoven with the research problem and hypothesis testing.

2.2 POINTS TO PONDER ON RESEARCH PROBLEM

The following points should be kept in mind while defining a research problem:

1) The right question must be addressed if research is to aid decision makers. A correct answer to the wrong question leads either to poor advice or to no advice.
2) Very often in research problem we have a tendency to rationalize and defend our actions once we have embarked upon a particular research plan. The best time to review and consider alternative approaches is in the planning stage. If this is done needless cost of false start and redoing work could be avoided.

3) A good starting point in problem definition is to ask what the decision maker would like to know if the requested information could be obtained without error and without cost.

4) Another good rule to follow is "Never settle on a particular approach" without developing and considering atleast one alternative".

5) The problem definition step of research is the determination and structuring of the decision maker's question. It must be the decision maker's question and not the researcher's question.

6) What decision do you face? If you do not have decision to make, there is no research problem.

7) What are your alternatives? If there are no alternatives to choose, again there is no research problem.

8) What are your criteria for choosing the best alternative? If you do not have criteria for evaluation, again there is no research problem.

9) The researcher must avoid the acceptance of the superficial and the obvious.

Activity 1

Briefly mention advantages of considering nine points mentioned in 2.2 while defining a research problem.

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2.3 UNITS OF ANALYSIS

The individuals or objects whose characteristics are to be measured are called the units of analysis. They may be persons, groups of persons, business establishments, inanimate objects, transactions, monetary units, or just about objects or activity a person can name. Some very interesting communication studies have even used words as the units of analysis. Basically, the units answer the question, "What objects am I interested in?" Consideration of several alternatives for units will sharpen one's thinking concerning the appropriate universe.

To illustrate the selection of units, consider a manufacturer of small electrical motors who wishes to ascertain the extent to which its potential customers know the company exists. The potential customers are basically business entities. But the units of the universe could also be defined as purchasing departments, production departments, engineering departments, or particular individuals within one or more departments. Again we come to all the pervasive question of what alternative actions are being considered by the manufacturer. In terms of these actions, who should be aware of the manufacturer's existence? Is the company considering specific acts that might increase awareness levels for certain groups? These are the sorts of questions that should be considered in specifying the appropriate units of analysis.

Let us go a step further. Is each unit, however defined, equally important? Or does importance vary with the purchasing power of the potential customer? If purchasing power is the critical item, one procedure is to use the units as established by the prior thought pattern and to weight each by the purchasing power of the entity it represents. With this approach, no difficulty or complexity is introduced in the definition of the universe, but a complexity must be introduced later in the processing.

Alternatively, the basic unit of analysis could be defined in terms of transactions rather than in terms of potential buyers. With buyers as units, the universe consists of persons, groups of persons, or business entities. With transactions as units, the universe consists of activities as the focus of interest. Typically, in research, we wish

to classify or measure the units according to some characteristics. Once more we see the interdependence of research decisions: the selection of universe units is best determined only in conjunction with what is to be measured.

Is the manufacturer interested in finding the percentage of buyers who are aware of the company's exsistence? Or is the manufacturer more concerned with the percentage of the transactions in the market place in which the buyer is aware (or unaware) of its existence? The same type of comparison would be required if level of awareness were measured ; here it might be average level of awareness of buyers versus average level per transaction.

Rupee value would be still another basis for establishing units. These rupees could be rupees expended on small electrical motors of the type made by this manufacturer. The objective would then be to determine the percentage of the total rupee value market awareness of the company's existence. This was very to close to what the president had in mind. In theory the president wanted to classify every rupee spent as coming from a buyer who was or was not aware of the company's existence. The same arithmetic result is obtained if buyers are classified according to awareness with each buyer weighted by the rupee volume he or she generates.

The well known management concept of a "decision-making unit" (DMU) often comes into play in defining the units of the universe. But the DMU is usually difficult to define in an unambiguos manner. A purchase that is a wife's decision in one family may be a husband's decision in another and a joint decision in third. How does one cope with this problem? A two step procedure is a possibility. The first stage units are families; within each family the decision maker is identified. The units of the problem universe are the DMU's. Any compromise research universe must be evaluated against that concept, including the possibility that the DMU is a group. The following example from marketing will clarify the concepts.

The specification of the appropriate DMU for industrial products is more difficult than it is for consumer products. The number of persons who have potential involvement is greater. Job designations do not have the same meaning for all organisations. Responsibilities for ultimate decisions vary with size of organization, organizational structure, philosophy of decentralization, plus the personalities involved. The question is further complicated by the fact that some characteristics of interest refer to the organization—for example, size, geographic location, and past purchases—while others, such as preferences education, and attitudes, uniquely refer to specific individuals.

The problem definition, whether for a consumer product or an industrial product, must specify the units of analysis. It is better to err at this stage by specifying conceptually correct units that pose difficult problems in implementations. Compromises in the transition to operational definitions can then be better evaluated. This approach also permits the possibility of using different procedures with different market segments or a multistage approach in identifying the relevant DMU's.

Activity 2

Explain the meaning of DMU with an example.

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2.4 TIME AND SPACE COORDINATES

The time dimension of a decision problem is always the future. Look at the following questions. What should we do the first of next month in order to produce the desired effect the following month? What will consumer response be to our contemplated promotion for the month of November? These questions indicate the futurity aspect of the time dimension of a decision problem. Managers continually run the risk of making the right decision at the wrong time. Opportunities are transient; the

executive who assumes the static environment is doomed to failure. Therefore, it is crucial that the decision maker and the researcher establish the appropriate time reference for the decision.

What is the appropriate time decision for the manufacturer of small electrical motors? The manufacturing company is interested in awareness at the point in time when it contemplates possible actions, either to modify that awareness level or to operate within that constraint. If its decision is to be implemented on January 15, 1991, it would like to know the conditions in the universe on that date. If the implementation would be delayed for 5, 10, or, 20 months, the company would like to know the state of the universe on those dates. Large time consuming capital expenditures may be initiated in the near future, but the size of the expenditure is based upon estimates of conditions at a distant point in time. The problem of road construction and the road's ability to handle peak loads are all too familiar examples. Study of the present or the past is appropriate only in so far as it can indicate the future.

The space coordinates supply the geographic boundaries within which the action is to be taken. In the problem definition, these lines are rarely neat political divisions or subdivisions. Advertising media do not stop abruptly at city or state lines. Retailers and wholesalers usually welcome customers regardless of where the customers reside. Sales territories may, however, be established along country or state lines. In a similar way, licensing by governmental units may determine the appropriate space coordinates. In the absence of such externally imposed constraints, the problem definition, in theory, often includes the whole earth or the total of India. Recognition of this fact in the problem definition will help evaluate the utility of a research universe that is considerably smaller.

The universe of interest may be defined either conceptually or by enumeration. For example all current accounts of a service organization can be obtained from current records. These accounts have specific geographic locations, but the specification of location is neither necessary nor germane to the problem definition. The enumerative approach to universe specification is appropriate so long as the decision maker has that group as his or her target and has a list available.

All Units or Specific Units

It is not sufficient to specify that the units of a problem are housewives, or auto owners, or purchasing agents unless decision maker truly is interested in all persons within the time and space limits. More often the decision maker is interested in employed housewives, or housewives from households with an automatic washer, or housewives who have tried product X. These examples illustrate three different types of modifications applied to units: (1) a characteristic or present state of units, (2) a characteristic of an object associated with the unit rather than a more direct characteristic of the unit itself (households with automatic washer), and (3) past behaviour of the unit (have tried product X). These few examples illustrate the vast scope of ways to limit the particular units of concern.

Instead of specifying a universe of vehicle owners, a tyre manufacturer might specify vehicle owners whose income exceeds a stipulated amount and whose vehicles are not equipped with radial tyres. Any business may select its own target markets, each of which may form a universe worthy of study.

Stipulation of units according to characteristics of objects that are related to the units rather than characteristics of the units themselves sometimes obscure the nature of the units. Are the units **persons** whose vehicles do not have radial tyres or **vehicles** that do not have radial tyres? The proper selection can usually be accomplished by asking what the appropriate base is for calculating percentages or averages. The difference is often critical in the case of industrial products. The percentage of machines leased with maintenance contracts might be very different from the percentages of leasees who lease with maintenance contracts. Failure to distinguish between the two could lead to quite diverse research designs and recommended actions.

Activity 3

Company XYZ wants to make a quick estimate of the total steel requirement in a

particular region to assess the scope for setting up a new steel plant. The company should decide within a year about its action (say before Aug 1991).

Define the appropriate time and space coordinates and also the specific units of analysis for this problem.

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2.5 CHARACTERISTICS OF INTEREST

The characteristics of interest identify what there is about the units that is of concern to the decision maker. These characteristics fall into two categories: the dependent variables and the independent variables. The dependent variables are those of interest for their own sake. For example, in marketing, they often refer to behaviour or attitude towards a firm's offering. Examples are purchases, awareness, opinions, or profits associated with consumer behaviour attitudes. The independent variables included in the problem definition are those characteristics thought to be related to the dependent variables. These variables may either be within the control of the firm (endogenous)—such as advertising, pricing or personnel changes—or beyond the control of the firm (exogenous). Exogenous variables of potential interest cover a multitude of possibilities, varying from competitor and government actions to economic conditions to individual consumer characteristics.

It is impossible to give a complete list of various characteristics that may be of interest to the manager. In order to overcome this impossibility, many practitioners and theorist have suggested a multitude of classification schemes. Indeed it seems that all managers and researchers feel compelled to establish their own classification scheme—and often more than one. No system is optimal for all projects and all discussions; but the 2 * 2 matrix developed by Frank, Massy, and Wind has two principal merits: simplicity and the highlighting of measurement assumptions. This matrix is presented in Table below. The 2 * 2 matrix, of course, yields four cells. Discussion of the separate cells with example from the field of marketing helps clarify the general classification scheme.

	Characteristics	
Measures	**General**	**Situation specific**
Objective	(1)	(3)
Inferred	(2)	(4)

Cell (1)—General objective measures. Cell (1) for example may contain two different types of variables: demographic and socio-economic. The demographic are illustrated by age, sex, stage of life cycle, marital status, tenure, geographic location, and race or ethnic group. The socio-economic variables, usually stress income, education, and occupation either singly or in some combination assumed to be a measures of social class.

These variables do not relate to specific products or market activity. They typically enter marketing research projects as potential explanatory variables for the characteristics of direct interest to the marketing manager rather than as variables of direct interest themselves. Does age – a variable of cell (1) – help discriminate between product users and nonusers? At what stage of life cycle are the families most interested in condominium living? Neither age nor stage of life cycle would of interest in these examples apart from its potential relationship to specific products or companies.

The variables in this cell are objectively measured– once defined there is rarely any question of how they should be measured or the establishment of the appropriate measure for the particular unit. The relevance of the variable for the study may be debated, but there is usually little debate concerning its measures. The measurement of the chronological age, length of time a family has occupied a particular residence, and number of children under six years of age pose little conceptual difficulties.

Cell (2) — General inferred measures. Variables in this cell are general in character and are not directly measurable. Personality traits, intelligence, and life style are illustrations of these variables. Disagreement concerning the proper or best measure of these characteristics is highly likely. Lack of unanimity is common even with respect to the concepts, even more for the operational definitions. The inclusion of these variables in marketing research projects is usually motivated in the same way as those of cell (1): they may be related to marketing variables of more direct interest. Therefore the marketing manager is often more concerned with their predictive power than with the purity or defensibility of their definitions. The proper balance between quantitative and qualitative questions in an intelligence test or the relative merits of aptitude and achievement tests are of little concern to the marketing manager except as the various alternatives are related to product use, a sales person's selling ability, or some other characteristic of direct interest to the firm.

Cell (3)—Situation specific objective measures. Variables in this category are typically behavioural with respect to the market place. Purchase behaviour, brand use, store patronage and loyalty, advertising exposure, and degree of innovation are examples of these variables. Such behaviour is often an ultimate or intermediate goal of the marketing manager. Variables in this cell may be the dependent variable—the crucial "result"—measured in the research. These variables may also be potential independent variables; prior behaviour may aid in understanding or predicting later behaviour either for the same variable or a related variable. For example heavy usage of product may be related to brand loyalty.

Cell (4)—Situation specific inferred measures. Attitudes, intentions, perceptions, and preferences towards specific brands, products, and companies are examples of the typical variables in this category. These variables differ from those in cell (3) because of the fact that they are neither directly measurable nor observable. Also the researchers may disagree in either the conceptual or operational definitions of variables in cell (4). Contrary to the variables in cell (2), the variables in cell (4) may be of direct interest to the marketing manager. Thus these variables are "results" under test in the research; the adequacy of their definitions is therefore critical. The advertising ladder concepts incorporate variables from this cell, establishing mental states which are presumed to lead to and precede purchase and repeat purchase.

It must be mentioned in the passing that the above table of 2*2 matrix can be used to identify and measure the characteristics of interest for any research problem though we have taken examples from marketing.

Characteristics of Interest versus Unit of Analysis

Confusion sometimes arises concerning the difference between the characteristic of interest and the unit of analysis. A manufacturer of drugs is interested in rupee value sales of a particular generic drug. The manufacturer wants to know rupee sales for a group of six states during the period of September 1988-April 1989. Thus the time and space coordinates have been defined for the research universe.

"Rupee value sales" is the characteristics of interest—this is the measure of concern to the drug company. The unit of analysis identifies "on what" or "on whom" the characteristic of interest is measured. The unit of analysis for the drug company may be the individual drug store. The research may collect rupee sales from the individual drug stores, adding them together in order to determine total sales in the six states.

The characteristic of interest is crucial to the management. Its value will serve as the basis for the choosing among alternative actions. The unit of analysis establishes the source for the information. In many cases the unit employed is dictated by convenience rather than the "proper" problem definition. For example, the drug company could generate aggregate sales by using the ultimate consumer as the unit instead of using the drug store. The following table shows these two alternative approaches.

The drug company wants to know total sales (labelled as $\Sigma\Sigma$). This figure can be generated either by (1) determing sales of each separate drug store and summing these values, or (2) determing purchase of each individual customer and summing these values (Refer table). The first approach is based on the drug store as the unit of analysis, collecting the column totals (Σ^1, Σ^2,.....). The second approach is based on the ultimate customer as the unit of analysis, collecting row totals (Σ^A, Σ^B,.....). Since both approaches yield the target characteristic of interest ($\Sigma\Sigma$),

Table 1: Two Alternative Units of Analysis for Determining Sales, Drug Company Problem

Ultimate customer as unit of analysis	Drug store as unit of analysis: Drug store 1	Drug store 2	...	Row Total
Customer A				Σ^A
Customer B				Σ^B
				⋮
COLUMN TOTAL	Σ^1	Σ^2	...	$\Sigma\Sigma'$.

either approach is satisfactory. The choice between the two approaches depends on their respective costs and the extent to which the necessary data can be obtained with accuracy.

Two side issues should also be recognised in choosing between the two alternatives (a) Purchases by resident of six-state area may be made outside of the area or form non drug store outlets. Sales by drug stores in the six-state area may be made to nonresidents. The researcher must decide whether these differences are trivial and, if they aren't, which alternative is better approximation of the true problem. (b) The company may be interested in the shape and distribution of sales (or purchase) among units. If so, the best way to proceed is to use the unit of analysis corresponding to that interest.

The problem could also be defined with other units of analysis. The individual sales person, states are but a few of the possibilities. Again the choice depends on the ease of obtaining the necessary data and the desire for detail concerning the distribution across units.

Activity 4
By following the classification matrix 2*2 discussed above to measure characteristics of interest in a research problem, construct an example in an area other than marketing to explain all the four cells.

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2.6 ENVIRONMENTAL CONDITIONS

Environmental conditions fall within the category of relevant characteristics, but they comprise a special type of relevant characteristic. The characteristics of interest are the target variables. The research is undertaken in order to discover their values. Environmental conditions, however, are of concern because of their possible relationship with the characteristics of interest. What would sales be if prices were Rs. 169 ? Rs. 149 ? What would competitor do if we increased our advertising by 25%? or decreased it by 25% ? How would A's action affect our sales and profits ? What would happen to the supply of oil if the depletion allowance were cut in half/ were removed completely ?

The environmental conditions specified in the research problem are of two types; (1) those beyond the firm's control and (2) those within the firm's control. The firm must adjust to the first and choose wisely with respect to the second. Neither is possible without knowing how the particular variables influence the characteristics of interest. Therefore both types of variables must be introduced into the research problem.

Ideally, the decision maker would like to know the precise value of all relevant, uncontrollable variables. He or she would like to know the plans of all competitors, the state of the economy, availability of raw material, the international climate, fashion changes, and many other relevant factors. The decision maker cannot obtain all this information, but it is frequently possible to identify the factors that seem most

critical to the existing problem. These factors are then incorporated in the problem definition as environmental conditions. They may be specified at a single value — in which case the solution recommended may be inappropriate for other values. Or several values may be specified—in which case alternative recommendations may result, depending on which set of conditions prevail at the decision time. Each problem faced should explicitly include one or more of these environments within the problem definition.

For example, the research cannot study every price, every level and type of advertising support, or every sales training programme. Only a few alternatives can be researched. The research problem must specify those which seem most promising. These specifications are critical ; the research cannot answer unasked questions.

Activity 5
Explain with the help of a suitable example the need for introducing two types of environmental conditions in a research problem.

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2.7 RESEARCH PROBLEM AS HYPOTHESIS TESTING

It is often convenient to structure a research problem in terms of a hypothesis to be tested. The hypothesis must be agreed upon by both the manager and the researcher, although the formal statement is primarily the responsibility of the researcher. In this use of the word, a hypothesis is simply a statement about the universe. It may or may not be true; the research is designed to ascertain the truth. Consider the following pair of hypothesis.

H0: At least 10 % of the viewing audience for "children's" TV shows consists of adults.

H1: Less than 10 % of the viewing audience for "children's" TV shows consists of adults.

First, it should be noted that these hypothesis are worded in such a way that either one or the other is correct. They cannot both be correct, and they cannot both be incorrect. Second, in order for these two hypothesis to be useful in a research decision making situation, the decision maker should choose first act if the first is true, and a second act if the second act is true. Both statements are characteristic of all situations in which a research problem is properly structured in terms of hypothesis testing.

The terminology "state of nature" is often used to refer to the true situation in the universe. For example, the advertising manager for a firm selling a product frequently purchased by adults is considering the possibility of advertising the product on children's TV shows.

Table 2 shows a structuring of the hypothesis with respect to the decision making. In this case, the hypothesis have been constructed so that if H0 is true, the recommendation is to advertise while if H1 is true, the recommendation is not to advertise. This procedure can be extended to any number of alternatives or options. The basic rule is that each hypothesis under test would lead to a specific recommendation if it were true. If any alternatives enumerated would not be adopted regardless of the research findings, those alternatives can be eliminated without any research. If several hypothesis would lead to the same recommendation, there is no

need to identify which of these hypothesis is true—all hypothesis leading to the same alternative can be grouped together into a single hypothesis.

Table 2: States of Nature versus Recommended Decisions. Properly Structured Research Problem

	Recommended decision	
State of nature	Advertise	Don't advertise
H0 true	×	
H1 true		×

It has established the minimum purchasing power required for the medium and large stores as Rs.100 million and Rs.250 million, respectively. A possible structuring of the three hypothesis is

H0 : Total purchasing power is less than Rs. 100 million.
H1: Total purchasing power is between Rs. 100 million and Rs. 250 million.
H2: Total purchasing power is greater than Rs. 250 million.

The acceptance of one of these hypotheses leads directly to one of the three actions contemplated. It is not necessary to determine purchasing power precisely than that indicated in the three hypotheses. A two-stage research project might be indicated. Stage one would establish whether purchasing power were clearly within the values specified by the hypotheses. Only if stage one revealed a figure close to Rs. 100 million or Rs. 250 million would stage two be undertaken. There is no reason to incur the cost of determining purchasing power with precision unless that precision is required in decision making.

Decision making as hypotheses testing is a two-step process with error possibilities at each step. At step one there is the relationship between the states of nature and the action recommended. The percentage of adults in the audience may not be a proper guide to action. The number of adults may be better guide. Rupee value expenditure in the product category may be still better. At step two there is the possibility that the research result may be erroneous with respect to the state of nature. The sample may indicate that the percentage of adults in the audience is less than 10 %. Or the opposite error may occur. Research procedures do not yield certainty with respect to the true state of nature. No matter how careful we are, we may conclude that H0 is true when H1 is true or vice versa. This fact means the decision maker and the researcher must evaluate the seriousness of different kinds of errors. The seriousness of the errors can be appraised only in terms of the actions that will be recommended. No harm occurs until the conclusions have an impact on what the firm does.

Table 3 presents the general situation with two possible states of nature and two alternative actions. Assuming the relationship between the two states of nature and the two action is valid, no error occurs if we conclude that H0 is true and it is true; similarly, no errors occur if we conclude that H1 is true and it is true. Errors occur in each of the other cells.

Table 3:True States of Nature versus Conclusions. Possible Types of Errors

True state of nature	Conclusions	
	H0 true	H1 true
H0 true	No error	Type I error
H1 true	Type 11 error	No error

Consider the format of Table 3 in terms of the problem dealing with advertising on children's TV shows. H0 (at least 10 % of the audience is composed of adults) leads to a recommendation to advertise. H1 (less than 10% of the audience is composed of adults) leads to a recommendation not to advertise. Under the Type 11 error we think H0 is true and recommend in favour of advertising, but less than 10% of the audience is composed of adults. The opposite situation exists with the Type 1 error. We recommend against advertising (thinking H1 is true), but at least 10% of the audience is composed of adults. Which error is more serious—failing to take advantage of an existing opportunity or incurring expenditures ? Placed in those terms, it should be obvious that no general answer can be given to the general question of which error is more serious. The decision maker must carefully evaluate

each specific situation with its unique set of potential risks and benefits. The identification of which error is more serious is not a meaningless intellectual exercise! The analysis can be planned in such a way so as to minimise those errors that are viewed as more serious.

Activity 6
A hypothesis is ---------- universe

State of nature refers to ---------- universe

Activity 7
Consider any research problem of interest to you. Structure it in terms of an appropriate hypothesis to be tested. Also mention the possible errors and recommendations associated with your hypothesis. Illustrate your answer with the help of a suitable example.

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2.8 SUMMARY

One of the most frustrating feelings in the world is to have an answer and wonder what the question was. Unless problems are well defined, research may lead to this position. Only slightly less frustrating is the feeling of having the right answer to the wrong question. Proper problem definition can avoid this difficulty, but the difficulty is more likely to be avoided if many alternatives are considered in the early stages of the formulation of the problem. We have covered all these aspects in detail in this unit at the very beginning under "points to ponder on research problem".

We have then moved on to the problem definition by delineating all its elements. Problem definition can be divided in to four main aspects: the units of analysis, the time and space boundaries, the characteristics of interest, and the specific environmental conditions. We have stressed on the unambiguos delineation of these four aspects while formulating the research problem. The relevant characteristics are the variables of concern to the decision maker in selecting among alternatives. Typical research characteristics can be classified along two dimensions: first, as situation specific or general; and second, as objectively measured or inferred. The environmental conditions are special types of characteristics—variables whose values the decision maker wishes to stipulate. This is in contrast to the typical characteristics whose value is to be determined.

We have then highlighted the importance of structuring a research problem as hypothesis testing by making simple statements about the universe. These statements may or may not be true; the research is designed to ascertain its truth which in turn enables the decision maker to choose the right alternative in his problem environment. Through examples, we have focused on formulation of a research problem as hypothesis testing, evaluation of each specific situation with its benefits and risks, and minimisation of those errors that are more serious.

2.9 SELF-ASSESSMENT EXERCISES

1) Distinguish between the terms within each of the following pairs.
   a) Endogenous variables and exogenous variables.
   b) Characteristics of interest and unit of analysis.
   c) General characteristics and situation specific characteristics.
   d) Objective characteristics and inferred characteristics.
2) Name and briefly explain the four basic parts of a problem definition.

3) Give an original example of a problem in which the unit of analysis is a DMU (Decision-making-unit). Make sure to include a discussion of how to measure the principal characteristic of interest for DMU's which involve more than a single individual.

4) A local supermarket has experienced a decline in unit sales and little change in rupee value sales. Profits have almost vanished. The chief executive in searching for ways to revitalize the operation, was advised to increase the number of hours the market is open for business. He comes to you for advice in structuring a research problem that will provide relevant information for decision making. Define the problem, taking care to:
   a) state the relevant question,
   b) enumerate the alternative answers,
   c) clearly define the units of analysis and characteristics of interest.

   What are the relevant "states of nature" which would lead to the selection of each alternative answer?

5) A sports goods company wishes to test two types of tennis rackets in order to determine which one is "best".
   a) Propose and defend a precise definition of "best".
   b) What is the set of hypotheses that should be tested?
   c) What action would be associated with each hypothesis?

6) Analyse, criticise, and explain:
   a) Specific environmental conditions merely identify the problem situation and would never be subject to control by the researcher.
   b) The unit of analysis for a research problem will usually be either a single physical object or a group of physical objects—recognizing that human beings fall within this concept.
   c) There are two general categories within the term "characteristic of interest": (1) the admissible alternative actions (the independent variables) and (2) characteristics that may be related to these alternative actions (the dependent variables).
   d) Time and space coordinates of the research universe are easier to cope with when the universe corresponds to an existing list.

2.10 FURTHER READINGS

Boyd, Westfall, and Stasch, *"Marketing Research Text and Cases"*, All India Traveller Bookseller, New Delhi.

Brown, F.E. *"Marketing Research, a structure for decision making"*, Addison — Wesley Publishing Company.

Kothari, C.R. *"Research Methodology — Methods and Techniques"*, Wiley Eastern Ltd.

Stockton and Clark, *"Introduction to Business and Economic Statistics"*, D.B. Taraporevala Sons and Co. Private Limited, Bombay.

UNIT 3 EXPERIMENTAL DESIGNS

Objectives

After reading this unit, you should be able to:

- Discuss the various experimental designs as powerful tools to study the cause and effect relationships amongst variables in research.
- Explain the assumptions embodied in the design models.
- Choose the appropriate design model for a specific research problem.

Structure

3.1 INTRODUCTION

As you may recall, we have pointed out in unit 1 of this block that experiments are much more effective than descriptive techniques in establishing the casual. relationships. First, the units to be studied are selected by the researcher and each unit is assigned to the group determined by the researcher. The units do not select their groups, thus avoiding the self-selection bias. Second, a necessary consequence of the first, the researcher administers the predetermined treatment or treatments to the units with in each group.

The use of a control group is almost mandatory in experimental designs. The inclusion of a control group permits a better isolation of the treatment component through a proper design like a simple cross sectional design.

A major contribution that the statisticians have made to experimental design is the development of randomization concept which enables the researcher to reduce the effect of the uncontrolled variables on comparative measures of response to the variables that are under the experimenter's control. Randomization is a useful device for ensuring on the average, that uncontrolled variables do not favour one treatment versus others.

In this unit, we will be discussing some of the major experimental designs which include:

1) Completely Randomized Design
2) Randomized Complete Block Design
3) Latin Square Design
4) Factorial Design
5) Analysis of Covariance

We will describe each of these experimental designs in detail in terms of role, the model, and the assumptions embodied in the model with few illustrations. We will not dwell into the computation aspect and instead focus on interpretation of the results. It is strongly suggested here that you use computer software packages like SPSS, STAT GRAPHICS, and BMD for getting the relevant ANOVA tables as output which can be interpreted by you. The interpretation of the results is much more important than the drudgery of complex computations.

It may be mentioned in the passing that in MS-61, block 5, we have given complete details regarding calculations of the relevant sum of squares and F ratio for hypothesis testing in the case of one way and two way analysis of variance. You please go through the same for understanding the principles of breaking down the total variation into meaningful components of variations. This methodology and principle remains the same in all the designs and therefore with a little more effort you should be able to understand and work out the details. We again reiterate that you use the software packages which have lots of options and flexibilities. You will really enjoy the subject in this way and will be able to understand the intricacies of the models which in turn will enable you to choose the right design for your research problem—be it in medicine, management, social science, etc.

3.2 COMPLETELY RANDOMIZED DESIGN

Frequently an investigator wishes to compare three or more treatments in a single experiment. In a survey, too, he may wish to study several populations; for example, he may be interested in IQ scores from a standard test for students at five schools. Such comparisons could be accomplished by looking at the samples two at a time and comparing the means. Although feasible, this is an inefficient method of comparison for more than two populations.

One reason for its inefficiency is that the standard deviation for the difference between the two sample means is not calculated from all the samples but instead uses samples only from the two populations under immediate consideration. Second, we feel intuitively that we shall almost find a significant difference between at least one pair of means (the extreme ones, e.g.) if we consider enough identical populations. We can no longer trust our level of significance.

Therefore, instead of using two samples at a time, we wish to make a single test to find out whether the students from the five schools are from five populations having the same population mean. The null hypothesis we wish to test is:

H0: $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$. Our reason for making such a test is not that we think five population means may be equal. They probably are unequal. However, if a preliminary test fails to show that the means are unequal, we may feel that the differences are rather small and do not warrant further investigation.

Completely randomized design is primarily concerned with tests for population means. To study the means, it is necessary to "analyze the variance".

Let us consider a particular example. An investigator wished to study the effect of fertilizers on the yield of corn. He divided the field into 24 rectangular plots of the same size and shape. His four treatments consisted of (1) no fertilizer, (2) $K_2O + N$, 3) $K_2O+P_2O_5$, and (4) $N+P_2O_5$. He assigned

Table 1: Yields of Corn Under Four Treatments

Observation	1	2	3	4	5	6	$\sum_{j=1}^{Y} ij$	$\bar{Y}_{i.}$
Treatments								
1. Control	99	40	61	72	76	84	432	72
2. $K_2O + N$	96	84	82	104	99	105	570	95
3. $K_2O + P_2O_5$	63	57	81	59	64	72	396	66
4. $N + P_2O_5$	79	92	91	87	78	71	498	83

$\sum_{i=1}^{4} \sum_{j=1}^{6} Y_{ij} = 1,896$, $\bar{Y}_{..} = 79$

each treatment at random to six of the 24 plots. The yields in bushels per acre, are presented in table 1. Here we use i to denote the number of the treatment and j to refer to the number of the observation. The sample means are designated by $\bar{Y}_{i.}$, where the dot in the second subscript position indicates that we have averaged over the second subscript j; in other words $\bar{Y}_{i.}$ is the mean of all the observations of the ith sample. The overall mean is denoted by $\bar{Y}_{..}$, the two dots indicate that the mean is obtained by summing over both subscripts and then dividing by the total number.

The investigator's purpose is usually to learn to something about the populations from which the samples are drawn. To accomplish this, he needs an underlying model.

For this Model, we assume that our four samples, each consisting of six corn yields, are independent random samples from four populations, that each of the four populations has a normal distribution, and, finally, that the variance of the four populations are equal. The investigator should consider these assumptions carefully.

The four populations means may be designated μ_1, μ_2, μ_3, and μ_4. We arbitrarily divide each of these four means into two parts. The first part is the mean of the four population means, which we call the "overall mean," and the second part is the difference between the mean of each population and the overall mean. In symbols, the means are written as

$\mu_1 = \mu + \alpha_1, \ldots\ldots, \mu_4 = \mu + \alpha_4$, where μ denotes the overall mean and α_i is the difference $\mu_i - \mu$. The overall mean has been chosen in such a way that $\sum_{i=1}^{a} \alpha_i = 0$, where a is the number of treatments (in this case, 4). If in our example the four populations means were $\mu_1 = 70$, $\mu_2 = 100$, $\mu_3 = 70$, $\mu_4 = 80$, we would have $\mu = (70 + 100 + 70 + 80)/4 = 80$. The population means could then be written.

$\mu_1 = \mu + \alpha_1 = 80 + (-10)$
$\mu_2 = \mu + \alpha_2 = 80 + (+20)$
$\mu_3 = \mu + \alpha_3 = 80 + (-10)$
$\mu_4 = \mu + \alpha_4 = 80 + (+0)$.

The difference $\alpha_i = \mu_i - \mu$ is often called the effect of the particular treatment. It should not be confused with α, the probability of rejecting a null hypothesis which is true. In the example, the α_i sum to zero and this is always the case.

We think, then, of a population mean as the sum of two parts : an overall mean (which, as an average of the four population means, may be of little interest to us) and the part that we attribute to the particular treatment. Using this notation, we can summerize the model just described by saying that each observation Y_{ij} is an independent observation from a normally distributed population whose mean is $\mu + \alpha_i$ and whose variance is denoted by σ_e^2. This can be written

$$Y_{ij} \text{ IND } (\mu + \alpha_i, \sigma_e^2), \sum_{i=1}^{a} \alpha_i = 0, \; i = 1,\ldots\ldots,a; \quad j = 1,\ldots\ldots n,$$

Where a is the number of treatments, n is the number of observations on each treatment, and IND is read as "independently normally distributed." In this model, we are studying only these particular a populations.

An equivalent way of writing down the model which is often convenient is

$$Y_{ij} = \mu + \alpha_i + \epsilon_{ij}$$
$$\sum_{i=1}^{a} \alpha_i = 0; \epsilon_{ij} \text{ IND } (0, \sigma_e^2); = i = 1,\ldots\ldots,a; j = 1,\ldots\ldots,n$$

Here we think of a particular corn yield Y_{ij} as made up of its population mean $\mu + \alpha_i$, plus whatever is left over, which we call ϵ_{ij}. In our data, for example, $Y_{23} = 82 = 80 + 20 + (-18)$; therefore, if the mean yield for the second population is 100, $\epsilon_{23} = -18$. These 24 deviations form a random sample of 24 ϵ_{ij}, all from a normal population with zero mean and variance σ_e^2. Note that because in practice we do not know the population means, we cannot know the values of the 24 ϵ_{ij}'s. They can however, be estimated from the sample data.

Format for Analysis of Variance Table for Completely Randomized Design

Source of Variation	Sum of Squares	D F	Mean Square	Computed F value	Table F value
Due to Treatment	$SS_a = n\sum_{i=1}^{a} (\bar{Y}_{i\cdot} - \bar{Y}_{\cdot\cdot})^2$	$a - 1$	$MS_a = SS_a/(a-1)$	MS_a/MS_r	Read at α% from table
Residual	$SS_r = \Sigma\Sigma(Y_{ij} - \bar{Y}_{i\cdot})^2$	$a(n-1)$	$MS_r = SS_r/a(n-1)$		
Total	$SS_t = \Sigma\Sigma(Y_{ij} - \bar{Y}_{\cdot\cdot})^2$	$an - 1$			

Analysis of Variance Table For Corn Yields (Our Illustration)

Source of Variation	Sum of Squares	D F	Mean Squares	Computed F value	Table F value
Due to treatment	2940	3	980	5.99	3.10(at 5%)
Residual	3272	20	163.6		
Total	6212	23			

It may be pointed out here that the format table above is the "Analysis of Variance" Table (often called as ANOVA table)—the general table for a completely randomized design with equal number of observations on each treatment.

The second one is the ANOVA table for our illustration on the yield of corn as influenzed by the four treatments.

We proceed finally to an F test of the null hypothesis that all the four population means are the same. This amounts to:

H_0: $\mu_1=\mu_2=\mu_3=\mu_4$

Since the calculated F value exceeds the table F value at 5% level, we reject H_0 and conclude that the four population means are not the same and that the treatment levels are different.

Activity 1

Suppose an advertising firm wants to test three different themes—Theme A, Theme B, Theme C, for a brand on a sample target audience of 60 people. The firm measures the response on a 0—11 scale. (0 denotes no interest and 11 denotes very high interest in purchasing the advertised brand). How will you go about evaluating the three themes by performing a completely randomized design model? State the null hypothesis. You may assign equal number of observations to each treatment (theme). State clearly the assumptions of this model.

3.3 RANDOMIZED COMPLETE BLOCK DESIGN

In the completely randomized design, treatments are assigned at random. For example, if the treatments are three drugs and there are 24 patients, eight patients are assigned at random to each of the three treatments.

The 24 patients may vary widely in initial condition, and their initial condition may affect their response to the drugs. In the completely randomized design, we try to take care of these differences among the patients by assigning them at random into groups of eight patients. Unfortunately, it is possible that all the patients receiving drug 1 may be comparatively healthy and all those receiving drug 2 may be comparatively unhealthy, even though the assignment was randomly made. By randomization, however, at least we have given each drug an equal chance with respect to the initial condition of the groups. Further more, we can expect that if the experiment is large enough, randomization will roughly equalize the initial condition of the three groups. Besides initial condition, the experimenter may feel that other factors might influence the response to the drugs (e.g., age or weight).

A block design is a much used method for dealing with factors that are known to be important and which the investigator wishes to eliminate rather than to study.

In the randomized complete block design, still with three treatments and 24 patients, the patients are divided into eight blocks, each consisting of three patients. These blocks are formed so that each block is as homogeneous as possible. Each block consists of as many experimental units as there are treatments—three, in this case. The blocks might be easily formed on the basis of age, for example, with blocks 1 and 8 consisting of the three youngest and the three oldest patients, respectively. The individuals in a particular block are as alike as possible. On the other hand, there may be wide differences between the individuals for different blocks.

After the blocks are formed, the three drugs are assigned at random to the three patients within each block. If the blocking has been done on a factor such as initial condition, and if initial condition is important in determining the level of the response, the responses to the drugs will differ widely from block to block. However, because each drug is used exactly once in each block, the design is balanced and the mean treatment responses to the three drugs will be comparable. The differences observed among the drugs should be largely unaffected by initial condition. Below are the eight blocks with a possible treatment assignment.

	Block Number			
Patient Number	1	2	....	8
1	Drug 3	Drug 2	....	Drug 1
2	Drug 1	Drug 1	....	Drug 3
3	Drug 2	Drug 3	....	Drug 2

When the data are gathered, they are arranged in rows according to treatment (drug), and we have

	Block Number			
Drug Number	1	2	....	8
1	Y_{11}	Y_{12}	....	Y_{18}
2	Y_{21}	Y_{22}	....	Y_{28}
3	Y_{31}	Y_{32}	....	Y_{38}

Note that this is a balanced design—each treatment occurs once in each block; thus if we obtain the mean response for drug 1 over the eight blocks, it will be comparable to the mean response for drugs 2 or 3.

This type of design is widely used. For example, industrial material frequently arrives in batches that tend to be homogeneous; thus a batch may be used as a block. In laboratories, to take another case, results often differ from day to day, and therefore days frequently serve as blocks. A common practice is to block out technician effect. In agricultural experiments, the blocks are sometimes separate plots of land. The technique of randomized blocks is a very useful one for removing unwanted variation. Frequently the investigator can obtain significant differences among treatment effects using a smaller sample size with the randomized complete block design than with a completely randomized design.

In planning an experiment it is important to identify in advance the factors that may introduce unwanted variation in the response (i.e., variation not due to the treatment effect) and to block accordingly. If results differ from day to day, days become blocks, and the design should be balanced within days. Each treatment must occur exactly the same number of times within each day, and it must be assigned at random within the day.

The model

We assume that each observation can be described as follows:

$$Y_{ij} = \mu + \alpha_i + \beta_j + \epsilon_{ij} \quad i = 1,.....,a; \quad j = 1,.....b,$$

with

$$\sum_{i=1}^{a} \alpha_i = 0, \sum_{j=1}^{b} \beta_j = 0 \qquad \text{and} \qquad \epsilon_{ij} \text{ IND } (0, \sigma_e^2).$$

Here α_i is the effect of the ith treatment and β_j is the effect of the jth block. Note that the treatments correspond to rows and the blocks correspond to columns. Thus Y_{ij} with i=2 and j=3 denotes the second treatment and the third block.

From the model as just given, we can read four assumptions:

1) The response to the ith treatment in the jth block Y_{ij} is from a normal distribution. (There are ab distributions.)
2) The means of the ab normal distributions can be expressed in the form $\mu+\alpha_i+\beta_j$. This property is often called additivity, or alternatively, no interaction.
3) The variances of the ab populations are equal. This property is known as homoscedasticity.

4) The ϵ_{ij} (deviations from the means) are statistically independent. If we know that ϵ_{11} is large, we have no reason to expect ϵ_{12} to be small (or large, for that matter).

As an example of a randomized complete block design, we use the following data.

Randomized complete block design with three treatments (3 coupon plans and four blocks (Store sizes)

Data represents campa cola sales in number of cases.

Treatment	Block Store 1	Store 2	Store 3	Store 4	$\bar{Y}_{i.}$
Coupon plan 1	20	18	15	11	16
Coupon plan 2	17	14	13	8	13
Coupon plan 3	14	10	7	5	9
$\bar{Y}_{.j}$	17	14	11.7	8	$Y_{..} = 12.7$

Stores are blocked on the basis of the size because we expect some variation in cola sales due to the size of the stores. Store 1 is the largest size, followed by store 2 next largest, and so on. Treatments (coupon plan 1, coupon plan 2, and coupon plan 3) are randomly assigned to test units within each block.

Hypothesis of primary interest—There is no difference amongst treatment effects.

Hypothesis of secondary interest—There is no difference amongst block effects.

Format of Analysis of Variance Table for Randomized Complete Block Design

Format of Analysis of Variance Table for Latin Square Design

Source of Variation	Sums of Squares	D F	Mean Squares	Computed F value	Table F value
Due to Treatments	$SS_a = b\sum_{i=1}^{a} (\bar{Y}_{i.} - \bar{Y}_{..})^2$	a−1	$MS_a = SS_a/(a-1)$	MS_a/MS_e	Read at
Due to Blocks	$SS_b = a\sum_{j=1}^{b} (\bar{Y}_{.j} - \bar{Y}_{..})^2$	b−1	$MS_b = SS_b/(b-1)$	MS_b/MS_e	α % from
Residual	$SS_e = \sum_{i=1}^{a}\sum_{j=1}^{b} (Y_{ij} - \bar{Y}_{i.} + \bar{Y}_{.j} - \bar{Y}_{..})^2$	(a−1) (b−1)	$MS_e = SS_e/(a-1)(b-2)$		table
Total		ab−1			

ANOVA Table for Our Illustration
Coupon Experiment with Blocking for Store Size

Source of Variation	Sum of Squares	D F	Mean Squares	Computed F value	Table F value
Due to Treatments	98.7	2	49.4	70.6	5.14 (at 5%)
Due to Blocks	129.8	3	43.3	61.9	4.76 (at 5%)
Residual	4.2	6	0.7		
Total	232.7	11			

Since the calculated F value exceeds the table F value at 5% level of significance both for treatment effect and block effect, we reject the null hypotheses and conclude that treatment effect is significant and also the block effect is significant.

We conclude that after blocking for store size, the coupon plans do make a difference in sales of cola.

Activity 2

What are the improvements made in the randomized complete block design over the completely randomized design?

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3.4 LATIN SQUARE DESIGN

In the randomized complete block design, the effect of a single factor was removed. It is occasionally possible to remove the effects of two factors simultaneously in the same experiment by using the Latin Square design. In order to use the Latin square design, however, it is necessary to assume that no interaction exists between the treatment effect and either block effect. In addition, the number of treatments must be equal to the number of categories for each of the two factors. We might, for instance, wish to test four detergents, using four methods of application, at four hospitals. A 4×4 Latin square design could then be employed, using each detergent exactly once with each method and exactly once in each hospital. The assignment of detergent could be made as shown in the following table; the roman numeral in the ith row and jth column indicates the detergent that will be used by the ith application method in the jth hospital. As assigned in the Table 2, the first detergent is used in hospital 1 by method 1, in hospital 2 by method 4, in hospital 3 by method 3, and in hospital 4 by method 2. Only 16 observations are needed because of the balanced arrangement used and because of the assumption of no interaction.

Table 2: Latin Square Design Hospital Number

	1	2	3	4
1)	I	II	III	IV
2)	II	III	IV	I
3)	III	IV	I	II
4)	IV	I	II	III

Table 3: Data and Preliminary Calculations on Four Detergents

	1	2	3	4	$\bar{Y}_{i\cdot\cdot}$
1)	8.7(I)	9.2(II)	11.6(III)	9.1(IV)	9.650
2)	7.5(II)	12.7(III)	4.6(IV)	7.3(I)	8.025
3)	14.0(III)	9.2(IV)	5.1(I)	6.7(II)	8.750
4)	11.3(V)	8.7(I)	4.0(II)	12.9(III)	9.225
$\bar{Y}_{\cdot j\cdot}$	10.375	9.950	6.325	9.000	$\bar{Y}_{\cdots}$=8.9125

$\bar{Y}_{\cdot\cdot 1} = (8.7+8.7+5.1+7.3)/4 = 7.45$
$\bar{Y}_{\cdot\cdot 2} = (7.5+9.2+4.0+6.7)/4 = 6.85$
$\bar{Y}_{\cdot\cdot 3} = (14.0+12.7+11.6+12.9)/4 = 12.80$
$\bar{Y}_{\cdot\cdot 4} = (11.3+9.2+4.6+9.1)/4 = 8.55$

The above data table gives the measurements obtained from using the four detergents.

The Model

It is assumed that each observation Y_{ijk} can be expressed as follows:

$Y_{ijk} = \mu + \alpha_i + \beta_j + \gamma_k + \in_{ijk}$, $i = 1,....,p$; $j = 1,....,p$; $k = 1,.....,p$

Where

$$\sum_{i=1}^{p} \alpha_i = \sum_{j=1}^{p} \beta_j = \sum_{k=1}^{p} \gamma_k = 0 \text{ and } \in_{ijk} \text{ IND } (0, \sigma_e^2)$$

Here μ denotes the overall mean response for all p treatments using all p^2 combinations of the two factors; there are thus p^3 population means altogether. In the detergent example. μ is the average of $p^3 = 64$ population means. Each α_i is the part of the mean that is due to the ith row. (method); β_j is the part of the mean that is due to the jth column (hospital); γ_k is the part of the mean due to the kth treatment (detergent).

There are p^3 populations, but we have economized by making an observation on only p^2 populations. In the detergent example, instead of 64 observations, we have only 16.

The assumptions implied by the model are as follows:

1) The p^3 populations are normally distributed.
2) They have equal variances.
3) There is no interaction.

4) The ϵ's are independent of one another.

The assumptions of no interaction is implicit in the statement of the model. We have stated that the mean of Y_{ijk} is $\mu+\alpha_i+\beta_j+\gamma_k$; this indicates that the first detergent has the same effect no matter which hospital is involved and no matter which method is used. Each hospital performs equally well with each method.

The assumption of independent ϵ's would be violated if, for example, half the experiment were conducted at one time and half were conducted six months later.

Format of Analysis of Variance Table for Latin Square Design

Source of Variation (1)	Sums of Squares (2)	DF (3)	Mean Squares (4)	F Computed (6)	F Tabled (7)
Due Rows	$SS_a=p\sum_{i=1}^{p}(\bar{Y}_{i..}-\bar{Y}...)^2$	$p-1$	$MS_a=SS_a/(p-1)$	MS_a/MS_r	Read at
Due Columns	$SS_b=p\sum_{j=1}^{p}(\bar{Y}_{.j.}-\bar{Y}...)^2$	$p-1$	$MS_b=SS_b/(p-1)$	MS_b/MS_r	$\alpha-1$ from
Due Treatments	$SS_c=p\sum_{k=1}^{p}(\bar{Y}_{..k}-\bar{Y}...)^2$	$p-1$	$MS_c=SS_c/(p-1)$	MS_c/MS_r	table
Residual	$SS_r=\sum_{i=1}^{p}\sum_{j=1}^{p}\sum_{k=1}^{p}Y_{ijk}$ $-\bar{Y}_{i..}-\bar{Y}_{j..}-\bar{Y}_{k..}+2\bar{Y}...)^2$	$(p-1)(p-2)$	$MS_r=SS_r/(p-1)(p-2)$		
Total	$\sum_{i=1}^{p}\sum_{j=1}^{p}\sum_{k=1}^{p}(Y_{ijk}-\bar{Y}...)^2$	p^2-1			

Analysis of Variance Table for Detergent Data

Source of Variation (1)	Sums of Squares (2)	DF (3)	Mean Squares (4)	F Computed (6)	F Tabled (7)
Due Method	5,822	3	1,941	1.44	4.76 (at 5%)
Due Hospital	39,672	3	13,224	9.78	4.76 (at 5%)
Due Detergent	86,548	3	28,849	42.68	4.76 (at 5%)
Residual	4,055	6	1,676		
Total	136,097	15			

The hypotheses to be tested are:
H_o: There are no differences among the row means
H_o: There are no differences among the column means
H_o: There are no differences among the treatment means

In our example, the rows are methods, columns are hospitals, and the treatments are the detergents.

The calculated F exceeds the table F at 5% level for hospitals and detergents. Reject H_o and conclude that there are differences in performance among the four detergents; there are differences among the hospitals.

The calculated F is less than the table F at 5% level in the case of the methods. Do not reject H_o and infer that there may be no differences among the four application methods.

The advantage of a Latin square design over the randomized complete block design is that the effect of a second factor is eliminated without increasing the size of the experiment, provided always that no interactions exist.

Activity 3
State the Latin square model with the assumptions clearly embodied in the model.

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3.5 FACTORIAL DESIGN

Often a researcher can use a single experiment advantageously to study two or more different kinds of treatments. For example, in investigating performance of two types of seeds, he may wish to vary the level of fertilizer used during the experiment. If he chose three levels of fertilizer-low, medium, and high-one factor would be "type of seed", the second factor "level of fertilizer". A factorial design, with two factors, would consist of employing all six treatments formed by using each type of seed with each level of fertilizer. Factorial designs can involve more than two factors; however, we consider here the case of two factors only.

A factorial design can also be used in a survey. For example, we might wish to compare three methods of teaching operations research, and at the same time compare the first four grades. We might have records on standardized tests for two classes in each grade taught by each method. The class mean improvement from initial test to final test could be the measure of success. Our data would then consist of two observations on each of 12 (3 × 4) different treatment combinations.

The characteristic of the factorial design is that every level of one factor is used in combination with every level of the other factor. The design is effective for studying the two factors in combination. This implies that factorial designs are appropriate in finding out whether interactions exist between factors.

Some factors can be measured quantitatively, and different levels for them are chosen on an ordered scale; level of fertilizer, dosage level, and temperature are all factors of this type. Other factors involve no obvious underlying continuum and can be said to be qualitative; drug and type of seed are factors of the second type.

As an example of a two-factor design, let us take a study on rye yields involving two types of seed, each used at three fertilizer levels-low, medium, and high. There were available 24 small plots of ground, and the six treatment combinations were assigned at random to 24 plots, 4 plots receiving each treatment. Two tables (Tables 3 & 4) are given below. Table 3 represents the notation and the second gives the actual observations replacing their symbols.

Table 3: Notation for Two Factor Design

	Fertilizer Level			
Seed Type	Low (1)	Medium (2)	High (3)	
1	Y_{111} Y_{112} Y_{113} Y_{114}	Y_{121} Y_{122} Y_{123} Y_{124}	Y_{131} Y_{132} Y_{133} Y_{134}	
	$\overline{Y}_{11\cdot}$	$\overline{Y}_{12\cdot}$	$\overline{Y}_{13\cdot}$	$\overline{Y}_{1\cdot\cdot}$
2	Y_{211} Y_{212} Y_{213} Y_{214}	Y_{221} Y_{222} Y_{223} Y_{224}	Y_{231} Y_{232} Y_{233} Y_{234}	
	$\overline{Y}_{21\cdot}$	$\overline{Y}_{22\cdot}$	$\overline{Y}_{23\cdot}$	$\overline{Y}_{2\cdot\cdot}$
	$\overline{Y}_{\cdot 1\cdot}$	$\overline{Y}_{\cdot 2\cdot}$	$\overline{Y}_{\cdot 3\cdot}$	$\overline{Y}_{\cdots}$

Table 4: Yields of Rye and Their Means (Bushels/Acre)

	Fertilizer Level			
Seed Type	Low	Medium	High	
1	14.3 14.5 11.5 13.6	18.1 17.6 17.1 17.6	17.6 18.2 18.9 18.2	
	$\overline{Y}_{11\cdot}=13.475$	$\overline{Y}_{12\cdot}=17.600$	$\overline{Y}_{13\cdot}=18.225$	$\overline{Y}_{1\cdot\cdot}=16.433$
2	12.6 11.2 11.0 12.1	10.5 12.8 8.3 9.1	15.7 17.5 16.7 16.6	
	$\overline{Y}_{21\cdot}=11.725$	$\overline{Y}_{22\cdot}=10.175$	$\overline{Y}_{23\cdot}=16.625$	$\overline{Y}_{2\cdot\cdot}=12.842$
	$\overline{Y}_{\cdot 1\cdot}=12.600$	$\overline{Y}_{\cdot 2\cdot}=13.888$	$\overline{Y}_{\cdot 3\cdot}=17.425$	$\overline{Y}_{\cdots}=14.638$

A response (in this case yield) is denoted by Y_{ijk}, where i indicates the seed type, j

indicates the fertilizer level, and k is the observation number. For example, Y_{213}, is the yield in the third of the four plots that used seed type 2 and a low fertilizer level. The cell means, denoted by $\bar{Y}_{ij.}$ are the means for each treatment combination. The mean of all 12 observations on the i th seed type is $\bar{Y}_{i..}$; the mean of all 8 observations on the jth fertilizer is $\bar{Y}_{.j.}$; the overall mean of the 24 observations is $\bar{Y}_{...}$.

The Model

$Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \epsilon_{ijk}$, for i=1,.....a; j=1,.....b; k=1,.....n,

Where

- μ = Overall means response;
- α_i = effect of the ith level of the first factor
- β_j = effect of the jth level of the second factor
- $(\alpha\beta)_{ij}$ = interaction between the ith level of the first factor and the jth level of the second factor.
- ϵ_{ijk} = deviation of Y_{ijk} from the population mean response for the ij th population.

$\sum_{i=1}^{a} \alpha_i = \sum_{j=1}^{b} \beta_j = \sum_{i=1}^{a} (\alpha\beta)_{ij} = \sum_{j=1}^{b} (\alpha\beta)_{ij} = 0$ and ϵ_{ijk} IND $(0, \sigma_e^2)$

Format Of Analysis Of Variance For Two Factor Factorial Design

Source of Variation (1)	Sums of Squares (2)	DF (3)	Mean Squares (4)	F Computed (6)	F Tabled (7)
Due A	$SS_a = bn\sum_{i=1}^{a} (\bar{Y}_{i..} - \bar{Y}_{...})^2$	a−1	$MS_a = SS_a/(a-1)$	MS_a/MS_r	Read at α% from table
Due B	$SS_b = an\sum_{j=1}^{b} (\bar{Y}_{.j} - \bar{Y}_{...})^2$	b−1	$MS_b = SS_b/(b-1)$	MS_b/MS_r	
Due AB	$SS_{ab} = n\sum_{i=1}^{a}\sum_{j=1}^{b} (\bar{Y}_{ij.} - \bar{Y}_{i..} - \bar{Y}_{.j.} + \bar{Y}_{...})^2$	(a−1)(b−1)	$MS_{ab} = SS_{ab}/(a-1)(b-1)$	MS_{ab}/MS_r	
Residual	$SS_r = \sum_{i=1}^{a}\sum_{j=1}^{b}\sum_{k=1}^{n} Y_{ijk} - \bar{Y}_{ij.})^2$	ab(n−1)	$MS_r = SS_r/ab(n-1)$		
Total	$SS_t = \sum_{i=1}^{a}\sum_{j=1}^{b}\sum_{k=1}^{n} (Y_{ijk} - \bar{Y}_{...})^2$	abn−1			

ANOVA Table For Our Illustration Problem On Two Types Of Seed With Three Fertilizer Levels

Source of Variation (1)	Sums of Squares (2)	DF (3)	Mean Squares (4)	F Computed (6)	F Tabled (7)
Due Seeds	77.4	1	77.4	63.3	4.41 (at 5%)
Due Fertilizer Levels	99.9	2	49.9	40.9	3.55 (at 5%)
Seed Fertilizer Interaction	44.1	2	22.1	18.0	3.55 (at 5%)
Residual	22.0	18	1.2		
Total	243.4	23			

From the last two columns of the table, we conclude (by comparing the computed F value with table F value) the following:

1) Differences exist between yields from the two seed types.
2) Differences exist among yields from the three levels of fertilizer.
3) Interactions exist between seed type and fertilizer level.

* computed F exceeds table F at 5% significance level for all the three above, leading to rejection of null hypothesis of no difference.

Activity 1

What are the specialities of the factorial designs?

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3.6 ANALYSIS OF COVARIANCE

Analysis of covariance is a combination of the two techniques—analysis of variance and regression. It is the simultaneous study of several regressions.

The purpose of analysis of covariance is to remove the effect of one or more unwanted factors in an analysis of variance. For example, in studying the heights of three populations of children (cyanotic heart disease children, sibs of heart disease children, and "well children"), we may wish to eliminate the effect of age. A variable whose effect one wishes to eliminate by means of a covariance analysis is called a covariate or a concomitant variable.

The analysis of covariance has the following uses:

1) To increase precision in randomized experiments. In such applications the covariate X is a measurement taken on each experimental unit before the treatments are applied that predicts to some degree the final response Y on the unit. By adjusting the treatment means after giving regard to the concomitant variable, we obtain a lower experimental error and more precise comparisons among the treatments. This is probably the commonest use of covariance.

2) To adjust for sources of bias in observational studies. An investigator is studying the relationship between obesity in workers and the physical activity required in their occupations. If obesity is linearly related to age, differences found in obesity among different occupations may be due in part to these age differences. Consequently he adjusts for a possible source of bias in his comparison among occupations.

3) To throw light on the nature of treatment effects in randomized experiments. In an experiment on the effects of soil fumigants on nematodes, which attack some farm crops, significant differences between fumigants were found both in the numbers of nematode cysts and in the yields of crop. This raises the question: can the differences in yields be ascribed to the differences in numbers of nematodes? Analysis of covariance can provide answer to this question.

4) To study regressions in multiple classifications. For example, an investigator is studying the relationship between expenditure per student in schools (Y) and percapita income (X) in large cities. If he has data for a large numbers of cities for each of four years, he may want to examine whether the relationship is same in different sections of the country, or whether it remains the same from year to year. Sometimes the question is whether the relationship is straight or curved.

Because analysis of covariance techniques are complicated, we confine ourselves mainly to the purpose and uses as mentioned above and highlight a practical situation where the covariance analysis can be employed. Those who would like to go deeper, may refer to the book on "Statistical Methods" by Snedecor & Cochran. It is also strongly suggested that you should use SPSS, or Biomedical Programmes for analysis and interpretation of covariance. These packages provide a complete and flexible analysis.

As an example consider the following data on language scores (Y) for students taught by three different methods. Measurements on IQ(X) are also available. Since the students are not assigned at random to the three teaching methods, there may easily be differences in IQ scores among the three groups.

Our obejective is to examine differences in language scores among the three methods after the effect of IQ has been eliminated. Otherwise, if we claim that method I is superior to method II, we may not be able to refute the statement that the observed difference between the methods occurs because the IQs of the students using method I were higher than using method II.

Table 5: Data on language scores (Y) using three teaching methods and IQ scores (X)

		Student									
		1	2	3	4	5	6	7	8	9	10
Method											
1	Y	72	75	85	70	73	86	92	68	91	75
	X	87	119	121	112	100	133	135	109	139	105
2	Y	90	98	73	86	83	90	98	81	84	79
	X	110	128	117	94	107	125	111	80	123	95
3	Y	59	65	67	71	59	61	58	70	59	48
	X	95	120	125	107	85	98	100	138	112	90

The Model

$Y_{ij} = \alpha_{io} + \beta_i X_{ij} + \epsilon_{ij}$, $i=1,.....a$; $j=1,.....n_i$,

Where ϵ_{ij} IND $(0, \sigma_\epsilon^2)$. Y_{ij} and X_{ij} denote the Y and X values for the jth individual on the ith treatment. The number of treatment is a and the number of individuals in the ith sample is n_i. In our example, $a=3$, $n_1=10$, $n_2=10$, $n_3=10$. The model expressed above is clearly that of a separate linear regressions. The assumptions implied are exactly same as in a linear regression.

For our example, the sandard F test of the analysis of covariance leads to the rejection of the null hypothesis of no difference among the three teaching methods. Therefore we infer that the three teaching methods do make difference on the language score after eliminating the effect of IQ. For the complete analysis, use SPSS, SAS, or BIO-medical programmes.

Activity 5

Explain briefly why do you need analysis of covariance in experimental designs?

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3.7 SUMMARY

We began the discussion with a brief introduction on the usefulness of the experimental designs in studying the causal relationship effectively. We have then introduced the simplest of the experimental designs—completely randomized design. The F test of the null hypothesis that no differences exist among the treatment means has been illustrated with a suitable example.

Then the randomized complete block design has been explained as a suitable design for removing an unwanted effect by blocking. The design has been illustrated through a problem on studying the effect of different coupon plans on sales of cola after blocking for store size.

It may be mentioned in the passing that the case of unequal sample size has not been separately dealt with. The procedure remains the same except for some minor modifications in the computations and assumption. Those interested may please go through MS-61 Block 5 for the procedure. Also the random effect and mixed effect models have not been discussed separately and it is suggested that you use the software package which has all these options built into the programme. it may also be added here that the underlying principal of ANOVA (breaking the total variance into meaningful component variance and residual variance) remains unaltered irrespective of any design model. That is why every alternative model has not been individually focused and instead the typical one has been illustrated.

The next in order we have brought out is Latin square design. This is introduced as a powerful design that can be used to remove the effects of two unwanted factors simultaneously when effects are additive and no interaction exists.

We have then moved on to the factorial design which we have conceptualised in case of two factors. We have emphasised that this design is very effective for stu the two factors in combination from the angle of finding whether the interaction exist between factors.

The last model in this unit we have discussed is the analysis of covariance. This is useful technique in experiments or in surveys when the investigator wishes to red the variance and to remove the effect of a factor (concomitant variable or covaria such as age, which may have an appreciable effect on his response variable.

3.8 SELF-ASSESSMENT EXERCISES

1) State clearly the assumptions embodied in all the experimental designs—completely randomized design, randomized complete block design, Latin square design, factorial design, and analysis of covariance.

2) The marketing research department of the Gamma adhesive company is attempting to find some attribute of their gummed labels that can be merchandised as being superior to competitive brands. The manager of the department feels that their strength of their adhesive represents a good promotional point in increasing sales. Accordingly, samples of the company's adhesive and three other brands are tested by an independent research compan The "strength indices" of the four products are as follows.

Trial	Gamma Adhesive	Competitive Adhesive		
		X	Y	Z
1	35	32	22	24
2	11	29	18	19
3	28	17	23	26
4	26	24	17	19
5	32	15	19	22

a) Test the null hypothesis that the means of all treatments are equal
b) Assume now that the trials can be treated as blocks, perform the analysis of the randomized complete block design and compare your answer with part (a)
c) Discuss clearly the advantages of the randomized complete block design over the completely randomized design in the context of this example.

3) A researcher has carried out the following Latin square design:

	B_1	B_2	B_3	B_4
A_1	$C_1 = 13$	$C_2 = 16$	$C_3 = 16$	$C_4 = 14$
A_2	$C_4 = 9$	$C_3 = 17$	$C_2 = 20$	$C_1 = 20$
A_3	$C_3 = 14$	$C_4 = 19$	$C_1 = 17$	$C_2 = 21$
A_4	$C_2 = 15$	$C_1 = 17$	$C_4 = 18$	$C_3 = 19$

The data above refer to unit sales.

Ai = Shelf height $\quad i,j,k = 1,2,3,4,...$
Bj = Number of racings
Ck = Shelf fullness

a) Test the hypothesis that no significant differences exist among sales responses due to shelf height, number of facings, and shelf fullness.
b) Write the complete Latin square model for this problem.

4. Consider the following factorial layout:

Direct Mail	Personal Selling Effort		
	Level 1	Level 2	Level 3
Level 1	40;33	49;47	56;60
Level 2	37;40	47;51	62;56
Level 3	51;47	51;60	73;76

a) Test the null hypothesis that there is no difference in sales due to personal selling effort and direct mail
b) Does a significant interaction exist between personal selling effort and direct mail advertising?

5) a) Distinguish clearly between analysis of variance and analysis of covariance.
   b) Give one practical situation where analysis of covariance will have to be used.

3.9 FURTHER READINGS

Dunn Olive Jean and Virginia A Clarck, "*Applied Statistics*" John Wiley and Sons.

Green Paul E and Donald S. Tull, "*Research for Marketing Decisions*" Prentice Hall of India, New Delhi.

Snedecor, George W, "*Statistical Methods*" The IOWA State University Press, AMES, IOWA, USA (6th Edition).

Notes

UTTAR PRADESH
RAJARSHI TANDON OPEN UNIVERSITY

MBA-4.2 Research Methodology for Management Decisions

Block
2

DATA COLLECTION AND MEASUREMENT

BLOCK 2 DATA COLLECTION AND MEASUREMENT

Block 2 on Data Collection and Measurement consists of three units.
Unit 4 discusses the necessity and usefulness of data collection.

It also distinguishes between primary and secondary data. A few methods of collecting primary data with their merits and demerits are explained. Designing and Pretesting a questionnaire for collection of primary data find a place in this unit. The unit also explains how to go about editing primary data.

The various sources of obtaining secondary data are discussed. The unit concludes by describing how to scrutinise secondary data to assess its suitability, reliability, adequacy and accuracy.

Unit 5 on Sampling and Sampling Designs defines the various sampling concepts and explains the advantages of sampling over complete enumeration. It also describes various probability and non-probability sampling methods.

Unit 6 on Attitude Measurement and Scales explains the type of managerial research problems which utilise the tools of attitude measurement. The unit describes the various issues in attitude measurement and explains various types of scales namely Nominal scale, the Ordinal scales and the Interval scale. Some commonly used scales in research like the Guttman Scale, Thurstone's equal appearing interval scale, the Semantic differential scale, the Likert Scale, the Q-sort technique and Multidimensional scaling also find a place in this unit.

UNIT 4 METHODS AND TECHNIQUES OF DATA COLLECTION

Objectives

After studying this unit, you should be able to :

- discuss the necessity and usefulness of data collection;
- distinguish between primary and secondary data;
- describe different methods of collecting primary data with their merits and demerits;
- design questionnaire for collection of primary data;
- develop skills in conducting interview;
- identify the sources of secondary data;
- examine the reliability, suitability and adequacy of secondary data.

Structure

4.1 INTRODUCTION

The increasingly complex nature of business and government has focused attention on the uses of research methodology in solving managerial problems. The credibility of the results derived from the application of such methodology is dependent upon the upto date information about the various pertinent characters included in the analysis. To illustrate, the demand of disc records has dropped dramatically after cassettes have entered into the market commercially. This information must be taken into consideration for formulating marketing strategy by a dealer selling musical products. Information expressed in appropriate quantitative form are known as data. The necessity and usefulness of information gathering or data collection cannot be overemphasised in government policies. The government must be aware of the actual scenario of the acceptance of family planning before it can formulate any policy in this matter. The components of this scenario are provided by appropriate data to be collected from various families. In industrial disputes regarding wages, cost of living index, a data based indicator of inflation is often accepted as a guideline for arbitration.

In short, neither a business decision nor a governmental decision can be made in a casual manner in the highly involved environment prevailing in this age. It is through appropriate data and their analysis that the decision maker becomes equipped with proper tools of decision making.

4.2 PRIMARY AND SECONDARY DATA

The primary data are those which are collected afresh and for the first time, and thus happen to be original in character. Such data are published by authorities who themselves are responsible for their collection.

The secondary data, on the other hand, are those which have already been collected by some other agency and which have already been processed. Generally speaking, secondary data are information which have previously been collected by some organisation to satisfy its own need but it is being used by the department under reference for an entirely different reason. For example, the census figures are published every tenth year by the Registrar General of India. But the census figures are also used by demographers and other social scientists for planning and research. Thus, the officials of the department of Registrar General will visualise the census figures as primary data. But a demographer using the same census figures to prepare a mortality table will consider them as secondary data.

Even when an organisation is interested to collect primary data it is necessary to take help of various types of secondary data to design a proper sampling scheme. This aspect of the use of secondary data will be covered in the next unit.

Activity 1

State whether the following data are primary or secondary?

i) The Secretary, Merchant Chamber of Commerce is using the figures published in "Reserve Bank of India Bulletin" (Published monthly by Reserve Bank of India) as the basis of forecasting money supply during the next month.

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ii) The Secretary, department of mines is writing a report on various types of mining accidents using the data available in the "Annual Repon of the Chief Inspector of Mine in India" issued by the Office of the Chief Inspector of Mines.

.....

iii) The Textile Commissioner is preparing a repon on the prospect of textile export based on the data available in "Indian Textile Bulletin" published by his own office.

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iv) National Thermal Power Corporation is examining the supply of coal to their thermal power stations using the data available in "Monthly Coal Bulletin" published monthly by the office of the Chief Inspector of Mines.

.....

v) A work study inspector decides about the time taken to perform a particular job on an assembly line on the basis of random observations collected by him.

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vi) The Presidency Surgeon is examining the relationship between cigarette smoking and heart disease based on the data published in "Indian Medical Journal".

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4.3 METHODS OF COLLECTING PRIMARY DATA

The collection of primary data for business research is of paramount importance to assist management in making decisions. Generally, information regarding a large number of characteristics are necessary to analyse any problem pertaining to management. For instance, a study relating to employment in rural areas requires data on income, wages, types of crops and land holdings. The collection of primary data thus requires a great deal of deliberation and expertise. Depending upon the nature of information necessary the following methods of collecting primary data are available.

1) Observation Method

The investigator collects the requisite information personally through observation. For example, in order to study the conditions of students residing in a university, the investigator meets the students in their hostels and collects necessary data after a personal study. The

information about the extent of damage caused by natural calamities like flood can be collected by personal observation by a trained investigator. As the investigator is solely responsible for collection of data by this method, his training, skill and knowledge play an important role on the quality of primary data.

A slight variation of this procedure is indirect oral Investigation where data are collected through indirect sources. Persons who are likely to have information about the problem are interrogated and on the basis of their answers, primary data become available. Most of the Commissions of Enquiry or Committees appointed by Government collect primary data by this method. The accuracy of the primary data collected by this method depends largely upon the type of persons interviewed and hence these persons have to be selected very carefully.

2) Questionnaire Method

A popular and common method of collection of primary data is by personally interviewing individuals, recording their answers in a structured questionnaire. The complete enumeration of Indian decennial census is performed by this method. The enumerators visit the dwellings of individuals and put questions to them which elicit the relevant information about the subject of enquiry. This information is recorded in the questionnaire. Occasionally a part of the questionnaire is unstructured so that the interviewee can feel free to share information about intimate matters with the interviewer. As the data are collected by the field staff personally it is also known as personal interview method.

Much of the accuracy of the collected data, however, depends on the ability and tactfulness of investigators, who should be subjected to special training as to how they should elicit the correct information through friendly discussions.

3) Mailed Questionnaire Method

A set of questions relevant to subject of enquiry are mailed to a selected list of persons with a request to return them duly filled in. Supplementary instructions regarding the definitions of terms used and the methods of filling up the forms should also accompany the questionnaire. This method can only be used when the respondents are literate and can answer the questions in writing. The questions should be very clear without any ambiguity keeping in mind that there is no investigator to help the respondent.

The method of collecting data by mailing the questionnaires to the respondents is most extensively employed in various business and economic surveys. This method saves both time and cost and can cover a large area. The absence of an investigator, however, renders the responses less reliable. The method also suffers from a large degree of non response.

4) Telephone Interview

This method of collecting information consists in contacting respondents on telephone itself. This method is inexpensive but limited in scope as respondents must possess a telephone. The telephone interview method is used in industrial surveys specially in developed regions.

4.4 MERITS AND DEMERITS OF DIFFERENT METHODS OF COLLECTING PRIMARY DATA

Generally speaking, the conditions under which the data are to be obtained will predetermine the method of data collection. If a relatively few items of information are sought quickly covering a number of industries and funds are limited telephone interviews should be recommended for collection of data. If depth interviews and probing techniques are to be employed, it is necessary to employ investigators to collect data. Thus, each method has its uses and none is superior in all situations. The joint use of more than one data collection method is sometimes preferred for a variety of reasons. When a wide geographic area is being covered, the use of mail questionnaires supplemented by personal interviews will yield more reliable results than either method alone.

Two tables, Table 1 reviewing the relative merits and demerits of the principal methods of data collection and Table 2 under different resource level are presented below :

Table 1 : Comparison of Principal Methods of Data Collection

	Personal Interview with Questionnaire		Mailed Questionnaire		Telephone Interview
			Advantages		
i)	Most flexible method of obtaining data	i)	Wider and more representative coverage possible at the same cost	i)	Wider and more representative coverage possible at the same cost
ii)	Identity of respondent known	ii)	No field Staff is required	ii)	No field Staff is required
iii)	Non response very low	iii)	Cost per questionnaire relatively low	iii)	Cost of response low
iv)	Supervision and control possible	iv)	No bias of interviewer	iv)	Quick way of obtaining data
		v)	Respondents can answer question directly		
			Disadvantages		
i)	Most expensive method of collecting data	i)	High degree of non response	i)	Non telephone owners and those with unlisted numbers cannot be reached.
ii)	Considerable supervision necessary	ii)	Questions which require probing cannot be asked	ii)	Interview period is short
iii)	Bias of the investigators present in the responses	iii)	Slowest of all methods of data collection	iii)	Questions which require probing cannot be asked
		iv)	Assumes that the respondent is educated.		

Table 2 : Preferred Data Collection Methods

Funds	Time	Type of Data	Personal Interview	Mail	Telephone
Restricted	Restricted	Few Items			X
Restricted	Restricted	Much Information	X		
Restricted	Ample	Few Items		X	X
Restricted	Ample	Much Information	X	X	
Ample	Restricted	Few Items	X		X
Ample	Restricted	Much Information	X		
Ample	Ample	Few Items	X		X
Ample	Ample	Much Information	X		

Activity 2

State with reason the type of data collection method to be followed in the following cases.

i) A severe drought has damaged the crop in the country. You are required to determine the extent of damage for remedial measures.

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i) A railway accident occurred at a distance of 20 km from New Delhi railway station. You are asked to ascertain the cause of the accident and the extent of disaster.

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iii) The Directorate of Cottage and Small Scale Industries desires to find out the reasons for non payment of loan taken by a number of artisans and small traders. You are asked to find out the reasons of non repayment.

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iv) The new General Manager claims that the telephone service of the city has become vastly improved during the last one year. You are assigned the responsibility of providing a data based report on this claim expeditiously.

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v) A manufacturer of a certain type of electronic product is interested to collect worldwide data on similar product with limited fund. You have to recommend him a suitable data collection method.

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vi) It has been claimed by the Department of family welfare that the publicity over the media has increased the practice of family planning in the rural area. You are asked to collect data to support or refute the claim.

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vii) A company selling a type of household appliance is interested to know the performance of its product from the customers with known addresses who are actually using it. The company is interested to collect data in an appropriate manner.

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Activity 3

Answer true or false

i) Indian decennial census is conducted by personal interview with questionnaire.....

ii) A great deal of interviewer bias is present in mailed questionnaire method of data collection .....

iii) The use of telephone interview method is limited as the interview period is short .....

iv) The highest degree of non response occurs in mailed questionnaire method .....

v) With restricted funds and ample time mailed questionnaire method is the suitable procedure for data collection .....

vi) If the type of data to be collected is sensitive in nature, one should adopt telephones interview .....

vii) Personal interview with questionnaire should be used to find out the average number of persons visiting a post office per day.....

4.5 DESIGNING A QUESTIONNAIRE

A questionnaire is a proforma containing a sequence of questions to elicit information from the interviewees. The questionnaire is used for personal interview. At the same time the questionnaire is also mailed to individuals who are requested to write the answers against each question and to return the completed proforma by post.

The questionnaire is the heart of the primary data collection technique. Hence, its drafting requires utmost skill. The questions must be clear, simple and to the point. They must be well organised from the point of view of the respondent and be formulated in such a manner as to provide the data in so far as possible in the desired form. This is specially true of a mail questionnaire which essentially has to speak for itself. If it is not clear, not only the replies may be vague and of little value but many potential respondents may not bother returning the questionnaire at all.

A questionnaire may be said to possess three main aspects :

1) The General Form

2) The Question Sequence

3) The QuestionWording

1) The General Form

The form of a questionnaire will depend partly on the type of data being sought and partly on the data collection method to be used. The choice lies between two extremes. On the one hand, there is the highly **structured questionnaire** in which all questions and answers are specified and comments in the respondents' own words are held to a minimum. At the other end is the unstructured questionnaire in which the interviewer is provided with a general brief on the sort of information to be obtained but the exact question is largely his own responsibility.

The unstructured questionnaires are useful in carrying out in depth interviews where the aim is to probe for attitudes and reasons. They may also be effectively employed in pretesting, the result of which can be used as a basis for constructing a structured questionnaire at a later stage. Thus, in order to ascertain the expectation of the television viewers about a programme interviews may be conducted with unstructured questionnaires. The resulting range of answers may then be used to prepare a structured questionnaire for use in the main part of the study.

The main disadvantage with an unstructured questionnaire is that it requires personal interview. It cannot be used in the mailed questionnaire method of data collection.

A structured questionnaire usually has fixed alternative answers to each question. They are simple to administer and relatively inexpensive to analyse. The questionnaires have, however, their limitations. It is not possible to record the responses made by the respondent in their own words. They are considered inappropriate in investigations where the aim happens to be to probe for attitudes and feelings.

2) The Question Sequence

The introduction to the questionnaire should be as short and simple as possible. The introductory letter accompanying the mailed questionnaire should also be made very brief. The introduction lays the foundation for establishing the rapport with the respondent in addition to making the interview possible.

Once the rapport is established the questions will generally seek substantive information of value to the study. As a general rule, questions that put too great a strain on the memory or the intellect should be reserved till later. Likewise, questions relating to personal wealth and personal character should be avoided in the beginning.

Following the opening phase should come the questions that are really vital to the interview. Even here, substantive questions should be surrounded by more interesting ones in order that the attention does not slip. Awkward questions, which create the risk that the respondent may discontinue the interview are usually relegated toward the end. By the time the interview has been terminated, some information is already available with the interviewer.

Ideally, the question sequence should conform to the respondents' way of thinking, and this is where unstructured interviews are highly advantageous. The interviewer can rearrange the order of the questions to fit the discussion in each particular case. With structured questionnaire the best that can be done is to determine with pretesting the question sequence which is likely to produce good rapport with most people.

3) The Question Wording

It has been stated that the question wording and formulation are more of an art than a science. Science does enter, however, in testing the stability and the adequacy of replies for business and management decisions. The wording of the questions should be impartial so as not to give a biased picture of the true state of affairs. Colourful adjectives and undue descriptive phrases should be avoided. In general the questions should be worded such that (a) they are easily understood (b) they are simple (c) they are concrete and conform to respondents' way of thinking.

Multiple choice questions constitute the basis of a structured questionnaire, particularly in a mailed questionnaire method. But in addition to these questions various open ended questions are generally inserted to provide a more complete picture of the respondent's feelings and attitudes.

A questionnaire with an objective to collect information concerning the loanees who have taken loan from a bank during the last five years under the Self Employment to Educated Unemployed Youth Scheme is presented below. Note that the first few questions make the interviewer familiar with the subject. The substantive information commences from question 9 but the two embarrassing questions, 11 and 12 is followed by a Sympathetic question 13. Although the questionnaire is structured an unstructured part has been included in the answer of question 14 to record the diversity of replies.

BANK OF NEW DELHI

Self Employment to Educated Unemployed Youth Scheme

1. Questionnaire No .....
2. Name of Loanee .....
3. Address.....
4. Educational Qualifications : (General)

   Below Matriculation ☐

   Matriculation and above but below Graduate ☐

   Graduate and above ☐

5. Educational Qualifications : (Technical)

   None ☐

   Technical Diploma ☐

   Technical Degree ☐

6. Data of Birth.....
7. When did you start your Business? .....

   Not yet started ☐ Less than one year back ☐ One year and above but less than two years back ☐ Two years and above but less than three years back ☐ Three years and above but less than four years back ☐ Four years and above but less than five years back ☐

8. Type of Business

Agro based	☐	Supply of Material	☐
Manufacturing	☐	Retail Selling	☐
Chemical	☐	Transport	☐
Service	☐	Other, please specify	☐

9. From which branch of the bank did you borrow ?

Branch A ☐ Branch B ☐ Branch C ☐ Branch D ☐

10. When did you borrow money ?

Less than one year back	☐
One year and above but less than two years back	☐
Two years and above but less than three years back	☐
Three years and above but less than four years back	☐
Four years and above but less than five years back	☐

11. What was the amount of loan ?

Upto Rs 10,000	☐
Above Rs 10,000 but less than or equal to Rs 25,000	☐
Above Rs 25,000 but less than or equal to Rs 50,000	☐
Above Rs 50,000	☐

12. How many instalments have you repaid so far ?

None	☐
Upto five	☐
More than five but less than or equal to ten	☐
More than ten	☐

13. What difficulties are you facing in your project ?

Lack of customer demand	☐
Lack of raw material	☐
Lack of power	☐
Lack of skilled worker	☐
Difficulty in procuring trade license and other Government papers	☐
Other, please specify	☐

14. Your suggestions to overcome these difficulties

.....

.....

Signature of the Investigator.....

Name of the Investigator.....

Date of Interview.....

Activity 4

The following paragraph shows an unstructured questionnaire.

We want to know about major purchases of goods and services (over Rs 1000) made by the respondent or his family during the last five years. What were the prices and how were they paid for; e.g. cash, instalment, borrowing etc.? Of particular interest are the following :

Television, Refrigerator, Vacation, Children's education.

We are also interested to know if the respondent or members of his family are planning to spend money on any of the above items during the next two years. If they do, we want to have an indication of its cost and its mode of payment.

Prepare a structured Questionnaire on the basis of this unstructured questionnaire.

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Activity 5

A local newspaper wants to ascertain the extent to which the inclusion of a daily stock market page might increase its circulation. Prepare a questionnaire to collect the pertinent information.

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Activity 6

Explain what is wrong in the following forms of questions in a questionnaire.

i) Have you a Savings Account ?

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ii) What is the profession of your husband ?

.....

.....

iii) What is the price you paid for a piece of soap 'Brand A' ?
Why do you prefer it ?

.....

.....

iv) Is the bus service reasonably good ?

.....

.....

v) Isn't this a nice colour ?

.....

.....

vi) How many razor blades do you use annually ?

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vii) Did you decide to buy the scooter after the loan was approved ?

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.....

viii) Do you believe borrowing from personal finance companies is faster and more pleasant than borrowing from banks ?

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4.6 PRETESTING A QUESTIONNAIRE

The pretest is a valuable indicator of the effectiveness of a questionnaire to collect data. The pretesting of questionnaire consists in selecting, approaching and interviewing a small segment in the same manner to be followed in the full scale operation and then analysing the results in the light of the objectives of the study.

We can understand from the pretest whether the replies provide the type of information needed or whether the respondents are misinterpreting any of the questions. In addition, results obtained in a pretest can at times suggest new ideas or hypotheses worthy of further examination.

If a pretest indicates any change of importance, a further pretest may be warranted to review the questionnaire. Thus, the mere fact that the wording of a question originally misunderstood has been changed does not of itself ensure the clarity of the new form. A few interviews with the new question form are highly desirable.

Pretests are sometimes conducted in an informal manner.

Activity 7

You have drafted a questionnaire to find out why employees leave a given company. Pretest your questionnaire and in the light of the results obtained, list out where you would like to make modifications in the questionnaire.

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4.7 EDITING OF PRIMARY DATA

Editing involves reviewing the data collected by investigators to ensure maximum accuracy and unambiguity. It should be done as soon as possible after the data have been collected. If the size of the data is relatively small, it is desirable that only one person edit all the data for the entire study. The different steps of editing are indicated below.

i) **Checking legibility :** Obviously, the data must be legible to be used. If a response is not presented clearly, the concerned investigator should be asked to rewrite it.

ii) **Checking completeness :** An omitted entry on a fully structured questionnaire may mean that no attempt was made to collect data from the respondent or that the investigator simply did not record the data. If the investigator did not record the data,

prompt editing and questioning of the investigator may provide the missing item. If an entry is missing because of the first possible cause, there is not much that can be done, except to make another attempt to get the missing data. Obviously, this requires knowing why the entry is missing.

iii) **Checking consistency** : The editor should examine each questionnaire to check inconsistency or inaccuracy if any, in the statement. The income and expenditure figures may be unduly inconsistent. The age and the date of birth may disagree. The area of an agricultural plot may be unduly large. The concerned investigators should be asked to make the necessary corrections. If there is any repetitive response pattern in the reports of individual investigators they may represent investigator bias or perhaps attempted dishonesty.

Activity 8

To find out why employees leave a given job, you have administered a questionnaire to collect the relevant data. Edit all the data for the study before you proceed to analyse it.

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4.8 TECHNIQUE OF INTERVIEW

The general **qualities that an interviewer should** possess can be identified as extroversion, impartiality to different points of view, friendliness without getting personal, ability to remain calm under many different circumstances, conscientiousness, perseverance, accuracy of reporting and adaptability. In addition, the interviewer must plan in advance and should fully know the problem under consideration. He must choose a suitable time and place so that the interviewee may feel at ease during the interview. In order to establish proper rapport specially in the rural areas if a significant part of the respondents are women, female interviewer must be employed to obtain the responses. If the language of the questionnaire is English, translation in the regional languages must be available so that the interviewer has no ambiguity about the questions.

While collecting data regarding various industrial problems, the interviewer should proceed very cautiously and systematically as the success of his project would depend entirely on the co-operation of the others. The interviewer is also expected to be familiar with all the material already published by the organisation. In an administrative hierarchy, it is preferable to begin interviews by contacting the officials at the middle and lower levels and to collect all relevant material available with them.

The selection, training and supervision of interviewers are very important administrative functions for collection of reliable data.

4.9 COLLECTION OF SECONDARY DATA

Secondary data are data which have been collected and analysed by some other agency. The sources of secondary data could be :

i) **Various publications of Central, State and local governments:** The important official publications are Statistical Abstract, India-Annual; Monthly Abstract of Statistics (both published by Central Statistical Organisation); Indian Agricultural Statistics (Annual) (Published by Ministry of Food and Agriculture); Index Number of Wholesale Prices in India (Weekly) (Published by Ministry of Commerce and Industry); Reserve Bank of India Bulletin (Monthly) (Published by Reserve Bank of India).

ii) **Various publications of foreign governments or of international bodies :** The important publications are publications of international bodies like UNO, FAO, WHO, UNESCO, ILO, Statistical Year Book (Published by the Statistical Office of the United Nations), Yearbook of Labour Statistics (Published by ILO, Geneva).

The secondary data provided by such publications are authentic, but along with other things, one must be specially careful about the units in respect of currency, weight etc. which greatly vary from one country to another.

iii) **Journals of trade, commerce, economics, engineering** etc. published by responsible trade associations, Chambers of Commerce provide secondary data in respect of some important items. Some examples of this kind of publications are "Annual Report of the Chief Inspector of Mines in India" (issued annually by the office of the Chief Inspector of Mines, Dhanbad) and "Indian Textile Bulletin" (issued monthly by the Textile Commissioner, Bombay).

iv) **The other sources of secondary data** are books, magazines and newspapers, reports prepared by various universities, historical documents, diaries, letters, unpublished biographies and autobiographies.

Activity 9

If you were to estimate demand for vegetable oil in India, list out the variables on which you would like to collect secondary data. Also find out the sources where you could obtain secondary data on the variables you have listed.

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4.10 SCRUTINY OF SECONDARY DATA

Primary data are to be scrutinised after the questionnaires are completed by the interviewers. Likewise, the secondary data are to be scrutinised before they are compiled from the source. The scrutiny should be made to assess the **suitability, reliability, adequacy and accuracy** of the data to be compiled and to be used for the proposed study.

1) **Suitability :** The compiler should satisfy himself that the data contained in the publication will be suitable for his study. In particular, the conformity of the definitions, units of measurement and time frame should be checked. For example, one US gallon is different from one British gallon.

2) **Reliability :** The reliability of the secondary data can be ascertained from the collecting agency, mode of collection and the time period of collection. For instance, secondary data collected by a voluntary agency with unskilled investigators are unlikely to be reliable.

3) **Adequacy :** The source of data may be suitable and reliable but the data may not be adequate for the proposed enquiry. The original data may cover a bigger or narrower geographical region or the data may not cover suitable periods. For instance, per capita income of Pakistan prior to 1971 is inadequate for reference during the subsequent periods as it became separated into two different countries with considerable variation in standard of living.

4) **Accuracy :** The user must be satisfied about the accuracy of the secondary data. The process of collecting raw data, the reproduction of processed data in the publication, the degree of accuracy desired and achieved should also be satisfactory and acceptable to the researcher.

4.11 SUMMARY

The pattern of business and industry in the present day environment has become quite complex and involved due to a variety of reasons. Any meaningful decision to be made in this context must be objective and **fact based** in nature. This is achieved by collecting and analysing appropriate data. Data may broadly be divided into two categories, namely **primary data** and **secondary data**. The primary data are those which are collected for the first time by the organisation which is using them. The secondary data, on the other hand, are those which have already been collected by some other agency but also can be used by the

organisation under consideration. Primary data may be collected by **observation, oral investigation, questionnaire method** or by **telephone interviews.** Questionnaires may be used for **data collection by interviewers.** They may also be **mailed to prospective respondents.** The drafting of a good questionnaire requires utmost skill. The process of interviewing also requires a great deal of tact, patience and competence to establish rapport with the respondent. Secondary data are available in various published and unpublished documents. The suitability, reliability, adequacy and accuracy of the secondary data should, however, be ensured before they are used for research problems.

4.12 KEY WORDS

Primary Data are data collected by the organisation itself.

Secondary Data are data collected and processed by some other agency.

Observation Method is the procedure through which the investigator collects information by personal observation.

A Questionnaire is a proforma containing a sequence of questions to elicit information from the interviewees.

The Questionnaire Method is the Method of collecting data by personal visit with a questionnaire.

The Mailed Questionnaire Method is the method of collecting data by mailing questionnaire.

The Telephone Interview Method is the method of collecting data by contacting respondents over telephone.

4.13 SELF-ASSESSMENT EXERCISES

1) Describe the various methods of collecting primary data and comment on their relative advantages and disadvantages.
2) Define secondary data. State their chief sources and point out the dangers involved in their use and the precautions necessary to use them. Illustrate with examples.
3) Which method is most suitable for conducting enquiry regarding family welfare programme in India ? Explain its merits and demerits.
4) Examine the merits and limitations of the observation method in collecting data. Illustrate your answer with suitable examples.
5) What are the guiding considerations in the construction of questionnaire ? Explain.
6) You have been assigned the task of finding the various problems of railway commuters in Bombay. Design a suitable questionnaire to be used in this study.
7) The Chamber of Commerce has appointed you to ascertain the reaction of the Finance Bill, 1990. Design a suitable questionnaire to be mailed to collect information in this matter.

4.14 ANSWERS

Activity 1

(i) secondary (ii) primary (iii) primary (iv) secondary (v) primary (vi) secondary

Activity 2

i) By observation method since the remedial measures have to be adopted quickly. There is hardly anytime for questionnaire design and interview.

ii) By indirect oral investigation from the persons who were present at the time of the accident. Since the accident took place before your arrival to the accident scene only the testimony of these persons can provide the relevant data.

iii) By personal interview with questionnaire as the mailed questionnaire method is unlikely to elicit any response.

iv) Since the claim of the General Manager is relevant to the telephone owners of the city, the telephone interview method is the appropriate procedure of data collection.

v) With a limited fund it is not possible to visit several countries for personal interview. So, the Mailed Questionnaire method is the appropriate method of data collection.

vi) The data should be collected by personal interview with questionnaire. Mailed questionnaire method is unsuitable for rural areas.

vii) As the addresses of the customers are known mailed questionnaire method is the appropriate method of data collection. Personal interview is likely to be quite expensive considering the purpose of the enquiry.

Activity 3

(i) True (ii) False (iii) False (iv) True (v) True (vi) False (vii) False

Activity 6

i) This question is unpleasant to the person who has none and will seem inquisitive who has one and therefore tends to annoy him.

ii) This question is rude. The proper way to elicit this information is to design the question as "Is your husband an engineer, a doctor, a chartered accountant, a professor and so on ?"

iii) The answer to the second question will be influenced by the first question. The brand may be preferred or not preferred due to its price only irrespective of the other qualities of the product.

iv) The question is suggestive and the answer of the interviewee may be biased out of politeness.

v) Wrong due to the same reason as in (iv).

vi) The question is unrealistic as the respondent cannot possibly remember this number. The more realistic question will be to ask, "How many razor blades did you use last week ?"

vii) The question is ambiguous. Neither "Yes" nor "No" gives the correct sequence of events.

viii) The question is ambiguous. It is not clear whether "Yes" means "faster" and/or "more pleasant". The same remark is applicable for "No".

4.15 FURTHER READINGS

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Kothari, C.R. 1989. *Research Methodology Methods and Techniques*, Wiley Eastern Limited : New Delhi.

Sadhu, A.N. and A. Singh. 1980. *Research Methodology in Social Sciences*, Sterling Publishers Private Limited : New Delhi.

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UNIT 5 SAMPLING AND SAMPLING DESIGNS

Objectives

On successful completion of this unit, you should be able to :

- explain the advantage of sampling vis-a-vis census operations;
- identify the population, sample, sampling unit and sampling frame;
- apply probabilistic consideration to use simple random sampling with or without replacement;
- discuss the idea of stratification of a population and to use stratified sampling method to improve precision;
- describe other sampling methods of data collection suitable in relevant cases;
- design a suitable sampling scheme keeping both cost and precision in view;
- explain the use of non probability sampling despite its theoretical weaknesses.

Structure

5.1 INTRODUCTION

The terminology "sampling" indicates the selection of a part of a group or an aggregate with a view to obtaining information about the whole. This aggregate or the totality of all members is known as **Population** although they need not be human beings. The selected part, which is used to ascertain the characteristics of the population is called **Sample**. While choosing a sample, the population is assumed to be composed of individual units or **members**, some of which are included in the sample. The total number of members of the population and the number included in the sample are called **Population Size** and **Sample Size** respectively.

While the definitions of a population and a sample have been introduced in a formal manner in the previous paragraph, the idea of sampling is not really new. The process of generalising on the basis of information collected on a part is really a traditional practice. The annual production of a certain crop in a region is computed on the basis of a sample. The quality of a product coming out of a production process is ascertained on the basis of a sample. The government and its various agencies conduct surveys from time to time to examine various economic and related issues through samples.

With the advancement of management science more sophisticated applications of sampling in business and industry are available. Sampling methodology can be used by an auditor or an accountant to estimate the value of total inventory in the stores without actually inspecting all the items physically. Opinion polls based on samples is used to forecast the result of a forthcoming election.

Activity 1

Define population and sampling unit in each of the following problems.

i) Popularity of family planning among families having more than two children.

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ii) Election for a political office with adult franchise.

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iii) Measurement of the volume of timber available in a forest.

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iv) Annual yield of apple fruit in a hilly district.

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v) Study of birth rate in a district.

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5.2 ADVANTAGE OF SAMPLING OVER CENSUS

The **census or complete enumeration** consists in collecting data from each and every unit from the population. The **sampling** only chooses a part of the units from the population for the same study. The sampling has a number of advantages as compared to complete enumeration due to a variety of reasons.

Less Expensive

The first obvious advantage of sampling is that it is less expensive. If we want to study the consumer reaction before launching a new product it will be much less expensive to carry out a consumer survey based on a sample rather than studying the entire population which is the potential group of customers. Although in decennial census every individual is enumerated, certain aspects of the population are studied on a sample basis with a view to reduce cost.

Less Time Consuming

The smaller size of the sample enables us to collect the data more quickly than to survey all the units of the population even if we are willing to spend money. This is particularly the case if the decision is time bound. An accountant may be interested to know the total inventory value quickly to prepare a periodical report like a monthly balance sheet and a profit and loss account. A detailed study on the inventory is likely to take too long to enable him to prepare the report in time. If we want to measure the consumer price index in a particular month we cannot collect data of all the consumer prices even if the expenditure is not a hinderance. The collection of data on all the consumer items and their processing in all probability are going to take more than a month. Thus when ready, the price index will not serve any meaningful purpose.

Greater Accuracy

It is possible to achieve greater accuracy by using appropriate sampling techniques than by a complete enumeration of all the units of the population. Complete enumeration may result in accuracies of the data. Consider an inspector who is visually inspecting the quality of finishing of a certain machinery. After observing a large number of such items he cannot just distinguish items with defective finish from good one's. Once such inspection fatigue develops the accuracy of examining the population completely is considerably decreased. On the other hand, if a small number of items is observed the basic data will be much more accurate. It is of course true that the conclusion about a population characteristic such as the proportion of defective items from a sample will also introduce error in the system. However, such errors, known as **sampling errors**, can be studied, controlled and probability statements can be made about their magnitude. The accuracy which results due to fatigue of the inspector is known as non **sampling error**. It is difficult to recognise the pattern of the non sampling error and it is not possible to make any comment about its magnitude even probabilistically.

Destructive Enumeration

Sampling is indispensable if the enumeration is destructive. If you are interested in computing the average life of fluorescent lamps supplied in a batch the life of the entire batch cannot be examined to compute the average since this means that the entire supply will be wasted. Thus, in this case there is no other alternative than to examine the life of a sample of lamps and draw an inference about the entire batch.

Activity 2

Name a few research studies carried out in your organisation or the organisation you know of where sample surveys were conducted.

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Activity 3

List out the advantages of sampling over complete enumeration (relative it to the studies in Activity 2).

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5.3 SIMPLE RANDOM SAMPLING

The **representative character** of a sample is ensured by allocating some probability to each unit of the population for being included in the sample. The **simple random sample** assigns equal probability to each unit of the population. The simple random sample can be chosen both **with and without replacement.**

Simple Random Sampling with Replacement

Suppose the population consists of N units and we want to select a sample of size n. In **simple random sampling with replacement** we choose an observation from the population in such a manner that every unit of the population has an **equal chance** of 1/N to be included in the sample. After the first unit is selected its value is recorded and it is again placed back in the population. The second unit is drawn exactly in the same manner as the first unit. This procedure is continued until nth unit of the sample is selected. Clearly, in this case each unit of the population has an equal chance of 1/N to be included in each of the n units of the sample.

Simple Random Sampling without Replacement

In this case when the first unit is chosen every unit of the population has a chance of 1/N to be included in the sample. After the first unit is chosen it is **no longer replaced** in the population. The second unit is selected from the remaining N–1 members of the population so that each unit has a chance of 1/N–1 to be included in the sample. The procedure is continued till nth unit of the sample is chosen with probability $\frac{1}{N-n+1}$

We now consider the operational aspect of selecting a simple random sample.

Random Sampling Numbers

The **random sampling numbers** are collection of digits generated through a probabilisitc mechanism. The numbers have the following properties:

i) The probability that each digit 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, will appear at any particular place is the same, namely 1/10.

ii) The occurrence of any two digits in any two places is **independent** of each other. A Table of Random Sampling Numbers are given below:

Table 1: Random Sampling Numbers

78994	36244	02673	25475	84953	61793	50243.	63423
04909	58485	70686	93930	34880	73059	06823	80257
46582	73570	33004	51795	86477	46730	60460	70345
29242	89792	88634	60285	07190	07795	27011	85941
68104	81339	97090	20601	78940	20228	22803	96070
17156	02182	82504	19880	93747	80910	76260	25136
50711	94789	07171	02103	99057	98775	37997	18325
39419	52409	75095	77720	39729	03205	09313	43545

An Example

Suppose a class has 115 students and you have been asked to selected a sample of size 15 with replacement.

The students are numbered in some order from 1 to 115 so that each student is identified uniquely by a serial number. Since the total number of students 115 is a three digit number we take numbers in groups of three. The student bearing serial number 1 is identified with the nunber 001, the student bearing the serial number 2 is identified with the number 002 and so on. Proceeding in this manner the digit 115 will correspond to the student bearing the serial number 115. The number 116 will again correspond to the student bearing the serial number 1, the number 117 again to the student bearing the serial 2. This process will continue upto 920, the highest multiple of 115 less than 1000. The digits 921-999 and 000 will be rejected.

It is possible to select three digit numbers from the random number table anywhere. However, once a starting position has been selected you should continue to choose numbers according to the given sequence. For the sake of simplicity we start at the beginning row wise. The Table 2 below shows the selection of a sample of size 15 with replacement.

Table 2: Selection of Random Sample with Random Numbers

	Random No. Selected	Remark	Serial No. of the selected student
1	789	Accept	99
2	943	Reject	
2	624	Accept	49
3	402	Accept	57
4	673	Accept	98
5	254	Accept	24
6	758	Accept	58
7	495	Accept	35
8	361	Accept	16
9	793	Accept	103
10	502	Accept	42
11	436	Accept	80
12	342	Accept	112
13	049	Accept	49
14	095	Accept	95
15	848	Accept	43

Note that the student bearing the serial number 49 has been selected twice. This is permissible since the sampling is with replacement.

Activity 4

i) In the example considered select a simple random sample of size fifteen **without replacement** starting at the beginning of the random sample numbers.

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ii) In the example considered what is the probability that each of the 115 students be included in the sample ?

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iii) Why is it necessary to reject numbers from 921 ?

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iv) The data below indicate the number of workers in the factory for twelve factories.

Factory No.	No. of Workers
1	2104
2	1259
3	2030
4	1616
5	2382
6	179
7	2691
8	741
9	768
10	6655
11	14180
12	2812

Select a simple random sample **without replacement** of size four. Start at the **beginning of the third row.** Compute the **average number** of workers per factory based on the sample. Compare this number with the **average number** of workers per factory in the **population.**

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5.4 SAMPLING FRAME

A **Sampling frame** is a list of all the units of the population. The preparation of a sampling frame is sometimes a major practical problem. The frame should always be made upto date and be free from errors of omission and duplication of sampling units.

A **perfect frame** identifies each element once and only once. Perfect frames are seldom available in real life. A frame is subject to several types of defect which may be broadly classified on the following lines.

Incomplete Frame

When some legitimate sampling units of the population are omitted the frame is said to be **incomplete.** If we want to collect information regarding the political opinion of a group of voters on a sample basis, a complete list of voters is necessary to select a sample. But instances are known when such a list is incomplete.

Inaccurate Frame

When some of the sampling units of the population are listed inaccurately or some units which do not actually exist are included, the frame is said to be **inaccurate.** If you use the list of ration cards as a frame to select persons obviously such a frame will be inaccurate as the details about the persons such as age are never updated.

Inadequate Frame

A frame which does not include all units of the population by its structure is an **inadequate frame.** If you use the list of names included in the telephone directory of a city as the frame for selecting a sample to collect information about a consumer product, obviously it will be an inadequate frame. It will include the names of only those persons who have a telephone omitting the majority of the residents of the city.

Out of Date Frame

A frame is **out of date** when it has not been updated although it was accurate, complete and adequate at the time of preparation. The use of census blocks as a frame to select a sample of households is a fairly accurate frame immediately after the decennial census. But thereafter, its reliability as a frame deteriorates in a rapidly growing or rapidly declining area.

Activity 5

Consider the sampling problems indicated in Activity 1. Suggest a suitable frame in each case.

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5.5 PROBABILISTIC ASPECTS OF SAMPLING

Simple random sampling is based on the concept of probability. The use of probability in sampling theory makes it a reliable tool to draw inference or conclusion about the population. Although the types of conclusion or inference can be quite diverse, two particular types of decision making are quite prevalent in problems of business and government.

On various occasions, the management would like to know the percentage or proportion of units in the population with a certain characteristic. An organisation selling consumer product may like to know the proportion of potential consumers using a certain type of cosmetic. The government may like to know the percent of small farmers owning some cultivable land in a rural region. A manufacturer planning to export some product may be interested to ascertain the proportion of defect free units his system is capable of manufacturing.

The performance level of many products in a mass production shows statistical variation. This aspect of quantitative analysis has been discussed in MS-8 Block 3. Thus, we would only indicate the results without details. A manufacturer of fluorescent lamps would like to know the average life of these lamps keeping in mind that there will be variation in life between individual lamps. An investor could be interested to know the prices of a number of stocks. But as the prices vary over the year, he may look for the average price of these stocks over the year.

In the first case, it is assumed that the proportion of units in the population with the specific characteristic is P (unknown) $(0 < P < 1)$ which is also referred to as population proportion. You select a simple random sample (with or without replacement) of size n and find out the number of units in the sample possessing the particular characteristic under consideration. Suppose p is the proportion of units in the sample possessing the characteristic. Then the numerical value of p gives us an indication of the unkown population proportion P. Likewise, the mean characteristic of all the units of the population is unknown. Suppose you select a simple random sample (with or without replacement) of size n and denote by y_1, y_2, ..., y_n the characteristic of these selected units of the sample (such as life of this lamp or the price of the stock on that particular day). The sample mean $\bar{y}$ is

$$\bar{y} = \frac{1}{n} (y_1 + y_2 + ... + y_n)$$

The numerical value of y provides an indication of the population mean m.

The unknown quantities P or m are commonly referred to as **parameters** of the population. The corresponding sample counterparts p or y are known as **estimators**. The quantity p is based on sample observations only. This is why it is also known as a **statistic**. Likewise $\bar{y}$ is also a **statistic**.

It must be recognised that an estimator is also a statistical variable with a sampling distribution. The variance of this sampling distribution is an indicator of the extent of error committed by using an estimator in place of a parameter. In particular, the variance of p, V(p) and the variance of $\bar{y}$, $V(\bar{y})$ are known to be

$V(p) = \frac{PQ}{n}$ (Q = 1 – P), if the sample is selected with replacement.

$V(p) = \frac{PQ}{n} \times \frac{N-n}{N-1}$, if the sample is selected without replacement.

$V(\bar{y}) = \frac{\sigma^2}{n}$, if the sample is selected with replacement.

$V(\bar{y}) = \frac{\sigma^2}{n} \left(\frac{N-n}{N-1}\right)$, if the sample is selected without replacement.

The quantity σ^2 is the **variance** of all the units of the population. This quantity is unknown but its **estimator** on the basis of a simple random sample of size n with observed units $(y_1, y_2, \ldots. y_n)$ is

$$S^2 = \frac{1}{n-1}\left[(y_1 - \bar{y})^2 + \ldots\ldots\ldots + (y_n - \bar{y})^2\right]$$

The estimate of $\frac{PQ}{n}$ is pq/n–1.

It may be observed from the expressions of variances of V(p) and $V(\bar{y})$ that they are virtually identical for sampling with and without replacement when the population size is very large compared to the sample size.

The square root of the variance of an estimator is usually known as its **standard error**. The **standard error** is generally taken as a measure of precision to be achieved by sampling and will be used for developing suitable sampling design in a subsequent section.

Activity 6

A list of 3000 voters of a ward in a city was examined for measuring the accuracy of age of individuals. A random sample of 300 names was taken, which revealed that 51 citizens were shown with wrong ages. Estimate the proportion of voters having a wrong description of age. Estimate the standard error of the estimate if the sampling is done (a) with replacement (b) without replacement.

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5.6 STRATIFIED RANDOM SAMPLING

The simple random sampling may not always provide a representative miniature of the population. Certain segments of a population can easily be under represented when an unrestricted random sample is chosen. Hence, when considerable **heterogeneity** is present in the population with regard to subject matter under study, it is often a good idea to divide the population into segments or **strata** and select a certain number of sampling units from each stratum thus ensuring representation from all relevant segments. Thus for designing a suitable marketing strategy for a consumers durable, the population of consumers may be divided into strata by income level and a certain number of consumers can be selected randomly from each strata.

Speaking formally, the population of N units is subdivided into k sub-populations or strata the ith sub-population having N_i unit (i = 1, 2, ..., k). These sub-populations are non overlapping so that they comprise the whole population such that

$$N_1 + N_2 + \ldots\ldots\ldots + N_k = N$$

A simple random sample (with or without replacement) is selected independently in each stratum, the sample size in the ith stratum being n_i (i = 1, 2, ..., k).Thus the total sample size is $n = n_1 = n_2 = \ldots\ldots\ldots = n_k$.

The stratification should be performed in such a manner that the strata are homogeneous within themselves with respect to the characteristic under study. On the other hand, strata should be heterogeneous between themselves. Sometimes administrative convenience is taken into consideration to stratify the population. For instance, in order to study the problems of railway commuters each railway division may be considered to be a different stratum. In rural areas, the region covering adjacent districts are likely to be homogenous with respect to socio-economic and cultural pattern. Hence they could be included in a common strata. Distribution of consumer products may face different types of problems in rural, urban or hilly areas. These may be considered as separate stratum from the point of view of management.

Allocation of Sample Size in Different Strata

In stratified sampling, the sample to different strata is allocated on the basis of three considerations.

i) The total number of units in the stratum i.e. stratum size

ii) The variability within the stratum

iii) The cost of taking observation per sampling unit each stratum.

From the point of view of management the most effective utilisation of the resources will be achieved if the variance of the estimator is minimised for a fixed budget or the cost of sampling is minimised for a fixed variance of the estimator. In practice, however, two different types of allocation are mostly prevalent.

Proportional Allocation

This procedure of allocation is very common in practice because of its simplicity. The number of sampling units n_i allocated to the ith stratum is proportional to the number of units in the population. Symbolically

$$n_i = n \frac{N_i}{N} ; (i = 1, 2, \ldots\ldots, k)$$

Optimum Allocation

Let C_i be the cost of sampling one unit from stratum i and σ_i^2 be the variance of the units belonging to stratum i. We assume that knowledge about σ_i^2 is available from a previous consumer survey. Then, symbolically

$$n_i = n \frac{N_i \sigma_i / \sqrt{C_i}}{\sum_{i=1}^{k} (N_i \sigma_i / \sqrt{C_i})} ; (i = 1, 2, \ldots k)$$

According to this principle of ascertaining the sample size, the sample size in a particular stratum is larger if (i) the stratum size is larger (ii) the stratum has larger variability and (iii) the sampling cost in the stratum is lower.

An Example

The Table 3 below shows the allocation of a sample of size 400 in seven strata. The strata have been formed according to monthly income of the consumers.

Table 3 : Allocation of Sample According to Different Methods

Monthly Income (Rs)	$\frac{N_i}{N}$	σ_i (Rs)	C_i (Rs)	$\sqrt{C_i}$	n_i (Proportional)	$\frac{N_i \sigma_i / \sqrt{C_i}}{\sum_{i=1}^{k}(N_i \sigma_i / \sqrt{C_i})}$	n_i (Optimum)
Under 2000	.18	100	2.50	1.6	72	.038	15
2000-3999	.31	250	2.00	1.4	124	.189	76
4000-5999	.24	400	2.00	1.4	96	.234	94
6000-7999	.14	700	2.00	1.4	56	.238	95
8000-9999	.07	1000	2.50	1.6	28	.149	60
10000-14999	.04	1200	3.20	1.8	16	.091	36
15000 and above	.02	1800	4.00	2.0	8	.061	24
Total	1.00				400		400

As a market heterogeneity is present among the income strata the optimum allocation differs sharply from the proportional allocation, placing more emphasis on representation from the higher income strata. This is because the higher income group has a large variability.

Activity 7

A bank wants to select a sample of 500 borrowers who have borrowed money during the last one year. The borrowers who have taken loan can be divided into four strata according to occupation with stratum sizes $N_1 = 10000$, $N_2 = 5000$, $N_3 = 3000$, $N_4 = 2000$. What should be the sample sizes in the four stratum with (i) Proportional allocation (ii) Optimum allocation ? In the second case the cost of sampling each unit is Rs 20 irrespective of the occupational classes. But the standard deviations of the characteristic under study : Rs 420. 262.5, 603 and 355 respectively for the four strata.

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5.7 OTHER METHODS OF SAMPLING

Cluster Sampling : In this method of sampling a collection or a **Cluster** of sampling units are selected in a random manner. Then each unit of the cluster is included in the sample.

In order to motivate the use of a **Cluster**, we consider a survey where the sampling units are households in a rural area. If simple random sampling is used to select households they will be located over several villages. On the other hand, a village can be regarded as a **Cluster of households.** We select a few villages randomly and include every household in the selected villages in our sample. Such a sampling procedure will be an illustration of **Cluster Sampling.** It has a number of advantages over simple random sampling.

i) If the households are chosen using simple random sampling, they are likely to be distributed over several villages. Hence from administrative point of view such a selection will involve more cost, more field supervision and more travelling. On the other hand, if a selected village is completely enumerated, the cost involved will be lower and the supervision exercised will be better.

ii) If the households in the sample are distributed over several villages then a frame containing the list of households of each of these villages is necessary for proper identification and selection of the household in the sample. On the other hand, if every

household in a selected village is included in the sample, no sampling frame listing the households in a village is necessary.

iii) If the type of question is of intimate nature an isolated household selected in a village is unlikely to cooperate with the investigators. On the other hand, if every household in a village is visited, a particular household after observing that his neighbours are also being interviewed are likely to offer greater cooperation and as such the quality of the basic data will be more reliable.

In the example presented in this section clusters have been formed based on geographic subdivisions. A village is a natural geographic Cluster of households. A **Cluster sample** with clusters based on geographic subdivisions is known as **area Sample** and the procedure is known as **area Sampling.**

A Cluster sample need not be always formed on geographic consideration. Suppose we want to estimate the proportion of defective machine parts in the inventory. If there are 20,000 items stored in 400 cases of 50 each, then those 400 cases can be considered as clusters. A Cluster sample of ten cases may be randomly selected resulting in a sample of 500 items.

For a given sample size, the variance of an estimator increases or equivalently the estimator becomes **less precise** with a larger cluster size. On the other hand, the **cost decreases** with a larger cluster size. We may balance the two conflicting aspects of the problems by finding out the **Optimum Cluster size** which minimises the variance of the estimator for a fixed cost or minimise the cost for a given level of precision.

Systematic Sampling

The mechanics of taking a systematic sample are very simple. Suppose the population consists of ordered N units (numbered from 1 to N) and a sample of size n is selected from the population in such a way that $\frac{N}{n} = k$ (rounded to the nearest integer). Here k is called sampling interval. In systematic sampling from the first k of the units a unit is selected randomly. Then every kth unit is selected in the sample. As for illustration, suppose k = 20. Then among the first 20 units coming out through the production line one unit is selected randomly. Suppose this is unit number 9. Then we select unit number, 29, 49, ... in our sample till the requisite sample size has been reached.

The main advantage of systematic sampling is its simplicity of selection, Operational Convenience and even spread of the sample over the population. The investigators using this sampling method need not be familiar with the use of random sampling numbers. It has been found very useful in forest surveys for estimating the volume of timber or in fisheries for estimating the total catch of fish. The method can be used even when no formal list of the units of the population is available. As for illustration, a five per cent sample of the household in a locality can be selected by selecting every twentieth household after all the households are ordered in a systematic manner.

Although a systematic sample is not a random sample in the strict sense of the term its performance is quite comparable to a random sample. However, if there is a **hidden periodicity** in the population, systematic sampling will prove to be an inefficient method of sampling. As for illustration, if every twentiffifth unit of a production process is defective a four per cent systematic sample will select all defective or all non defective items depending upon the starting point. Such an orientation is, however, very rare.

Multistage Sampling : The **multistage sampling** procedure is used for large scale enquiry covering large geographical area such as a state. As for illustration, a bank may like to gather information regarding the quality of customer service it is offering in a state. A random sample of districts is selected from the list of districts. From each of the selected districts a number of branches are randomly selected. From each of the selected branches a number of depositors which is the ultimate sample sampling unit is selected randomly for collecting information. The districts are called **first stage** units, the branches are known as the **second stage** units and the depositors are regarded as the **third stage** units. This is an illustration of **three stage sampling,** the third stage units being the **ultimate sampling units.**

The multistage sampling procedure has the advantage that the frame of second stage units is necessary only for the selected first stage units. Likewise, the frame of the third stage units is necessary only for the selected second stage units. The procedure is quite flexible and it permits the use of different selection procedures in different stages. It may also be mentioned

that multistage sampling is the only sampling procedure available in a number of practical situations, such as collecting information about consumers in a large geographical region. This is because no satisfactory sampling frame is available for the ultimate stage units, namely, consumers and the cost of preparing such a frame is prohibitive.

5.8 SAMPLING DESIGN

A **Sampling design** is a definite plan for obtaining a sample from a given population. It refers to the technique or the procedure the business researches would adopt to select units for the sample. It will also indicate the number of units to be included in the sample also known as **Sample size.** Sampling design is determined before data are collected. While developing a sampling design, the management must pay attention to the following points.

Type of Population

The first step in developing any sampling design is to clearly define the aggregate of sampling units, namely, the population. Sometimes the structure of the population is quite unambiguous such as the population of a city or the number of workers in a factory. However, there may be occasions where the composition of the population is not so simple. For example, in the context of advertising a company may like to collect information about the number of television viewers watching the advertisement.

Sampling Unit

The **sampling unit** must be identified before selection of a sample. A sampling unit may be a **natural geographical unit** such as a state, a district, a village or a **constructed unit** such as a house or a flat. It may be a social entity such as a family or a school. It may also be an individual. The management should be able to select appropriate unit so that its objective is achieved.

Type of Sample

You have observed in the previous subsections that starting from simple random sampling, the business researcher has a wide choice of **sampling procedures.** Each procedure has its suitability for the relevant occasion. The type of **frame** necessary also depends upon the sampling procedure being used. As for illustration, the use of **simple random sampling** will require a comprehensive list of the sampling units. But a **two stage sampling** will require the list of **all first stage** units and the list of all **second stage** units in the **selected first stage units only.**

Size of the Sample

There are two basic requirements for the sampling procedure to fulfill. A sample must be representative and it must be **adequate.** When it is **representative,** a sample will be relatively small piece of the population that mirrors the various patterns and subclasses of the population. A sample is **adequate** if it provides an **estimator** with **sufficiently** high precision. It should be remembered in this context that the higher is the precision, the larger is the sample size and more is the cost.

An Example

A market research unit wants to conduct a survey in order to estimate the proportion of smokers smoking a particular brand of cigarette. If it is required to estimate with 90% probability within .02 of the true proportion, how many observations should be taken ?

Suppose, n is the sample size to be determined and p is the observed proportion of smokers. Then if the population size is **sufficiently large,** from section 5.5 irrespective of sampling with or without replacement

$$V(p) = \frac{P(1-P)}{n}$$

The notation P is the **unknown population proportion** of smokers. Further, as indicated in MS-8, section 14.6 for **large** n, p is normally distributed with expectation P (unknown population proportion of smokers) and variance V(p). Since the estimator p should be within .02 of the true proportion P with 90% probability

$$P\left\{ \left| p - P \right| \leq .02 \right\} = .90$$

$$\text{i.e. } P\left\{\left|\frac{\sqrt{n}\,(p-P)}{\sqrt{P\,(1-P)}}\right| \leq \frac{.02\sqrt{n}}{\sqrt{P\,(1-P)}}\right\} = .90$$

$$\text{i.e. } P\left\{|Z| \leq \frac{.02\sqrt{n}}{\sqrt{P\,(1-P)}}\right\} = .90$$

where z is normally distributed with expectation zero and variance one. From the Table of Normal Distribution (Mustafi, 1981)

$$\frac{.02\sqrt{n}}{\sqrt{P\,(1-P)}} = 1.645$$

i.e. $n = 6800\ P\ (1-P)$

Since the maximum value of $P\ (1-P) = \frac{1}{4}$, the sample size necessary is 1700.

Activity 8

What should be the size of the sample (assumed to be large) if in a large consignment of items the population proportion defective is to be estimated within .02 of true value with probability .95?

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5.9 NON PROBABILITY SAMPLING METHODS

Non probability sampling is the sampling procedure which does not provide any basis for estimating the probability that each item in the population possesses to be included in the sample. In such a case, the sampling error is not measurable and the error in the estimator tends to increase sharply because the representativeness of the sample members is questionable. Nevertheless, non probability samples are useful in certain situations. This is the case when the representativeness is not particularly the primary issue. In pretesting a questionnaire, we are interested to ascertain its suitability for the problem under consideration. Non probability sampling methods can be used to contact respondents in this case as the primary aim is to probe for the possible range of answers.

In general, there are three types of non probability sampling that may, under appropriate conditions, be useful in business and government. These are **Convenience, Judgement** and **Quota** sampling.

1) **Convenience Sampling :** Under convenience sampling, as the name implies, the samples are selected at the convenience of the researcher or investigator. Here, we have no way of determining the representativeness of the sample. This results into biased estimates. Therefore, it is not possible to make an estimate of sampling error as the difference between sample estimate and population parameter is unknown both in terms of magnitude and direction. It is therefore suggested that convenience sampling should not be used in both descriptive and causal studies as it is not possible to make any definitive statements about the results from such a sample.

This method may be quite useful in exploratory designs as a basis for generating hypotheses. The method is also useful in testing of questionnaire etc. at the pretest phase of the study. Convenience sampling is extensively used in marketing studies and otherwise. This would be clear from the following examples.

i) Suppose a marketing research study aims at estimating the proportion of Pan (Beetle leave) shops in Delhi which store a particular drink say Maaza. It is decided to take a sample of size 100. What investigator does is to visit 100 Pan shops near his place of residence as it is very convenient to him and observe whether a Pan shop stores Maaza

or not. This is definitely not a representative sample as most Pan shops in Delhi had no chance of being selected. It is only those Pan shops which were near the residence of the investigator had a chance of being selected.

ii) The other example where convenience sampling is often used is in test marketing. There might be some cities whose demographic make ups are approximately the same as national average. While conducting marketing tests for new products, the researcher may take samples of consumers from such cities and obtain consumer evaluations about these products as these are supposed to represent "national" tastes.

iii) A ball pen manufacturing company is interested in knowing the opinions about the ball pen (like smooth flow of ink, resistance to breakage of the cover etc.) it is presently manufacturing with a view to modify it to suit customers need. The job is given to a marketing researcher who visits a college near his place of residence and asks a few students (a convenient sample) their opinion about the ball pen in question.

iv) As another example a researcher might visit a few shops to observe what brand of vegetable oil people are buying so as to make inference about the share of a particular brand he is interested in.

2) **Judgement Sampling :** Judgement sampling is also called purposive sampling. Under this sampling procedure, a researcher deliberately or purposively draws a sample from the population which he thinks is a representative of the population. Needless to mention, all members of the population are not given chance to be selected in the sample. The personal bias of the investigator has a great chance of entering the sample and if the investigator chooses a sample to give results which favours his view point, the entire study may be vitiated.

However, if personal biases are avoided, then the relevant experience and the acquaintance of the investigator with the population may help to choose a relatively representative sample from the population. It is not possible to make an estimate of sampling error as we cannot determine how precise our sample estimates are.

Judgement sampling is used in a number of cases, some of which are mentioned below.

i) Suppose we have a panel of experts to decide about the launching of a new product in the next year. If for some reason or the other, a member drops out from the panel, the chairman of the panel may suggest the name of another person whom he thinks has the same expertise and experience to be a member of the said panel. This new member was chosen deliberately — a case of Judgement sampling.

ii) The method could be used in a study involving the performance of salesmen. The salesmen could be grouped into top-grade and low-grade performer according to certain specified qualities. Having done so, the sales manager may indicate who in his opinion would fall into which category. Needless to mention this is a biased method. However in the absence of any objective data, one might have to resort to this type of sampling.

3) **Quota Sampling :** This is a very commonly used sampling method in marketing research studies. Here the sample is selected on the basis of certain basic parameters such as age, sex, income and occupation that describe the nature of a population so as to make it representative of the population. The investigators or field workers are instructed to choose a sample that conforms to these parameters. The field workers are assigned quotas of the numbers of units satisfying the required characteristics on which data should be collected. However, before collecting data on these units the investigators are supposed to verify that the units qualify these characteristics.

Suppose we are conducting a survey to study the buying behaviour of a product and it is believed that the buying behaviour is greatly influenced by the income level of the consumers. We assume that it is possible to divide our population into three income strata such as high income group, middle income group and low income group. Further it is known that 20% of the population is in high income group, 35% in the middle income group and 45% in the low income group. Suppose it is decided to select a sample of size 200 from the population. Therefore, samples of size 40, 70 and 90 should come from high income, middle income and low income groups respectively. Now the various field workers are assigned quotas to select the sample from each group in such a way that a total sample of 200 is selected in the same proportion as mentioned above. For example, the first field

worker may be assigned a quota of 10 consumer from the high income group, 25 from the middle income group and 40 from the low income group. Similarly the 2nd field worker may be given a different quota and so on such that a total sample of 200 is obtained in the same proportion as discussed earlier.

The above example was a very simple one, suppose we are told further that the buying behaviour is not only influenced by his income but also by his age (categorised as 45 and above or below 45). With this additional character, suppose the distribution of population (universe) is as follows :

Table 4 : Distribution of Population (%)

Income / Age	High Income	Middle Income	Low Income	Total
45 and above	12	10	30	52
below 45	8	25	15	48
Total	20	35	45	100

The above table indicates that in this universe there are 12% of people in the high income group and fall in the age group of 45 and above, there are 25% people in middle income group and below the age of 45 and so on. Suppose, it is decided to take a sample of size 200. Therefore the distribution of the sample conforming to these two parameters (in the same proportion as population) would be as follows :

Table 5 : Distribution of Sample (Numbers)

Income / Age	High Income	Middle Income	Low Income	Total
45 and above	24	20	60	104
below 45	16	50	30	96
Total	40	70	90	200

The above table shows that a sample of 30 should be taken from the population with low income and below the age of 45. Similarly a sample of 20 should be taken from the population with middle income and having age of 45 and above, and so on.

Now, having decided the size of sample falling under each of the six cells ["high income and below 45" "middle income with 45 and above" and so on], we fix the quotas for each of the field worker to collect data conforming to the above norms so as to obtain a total sample of size 200.

At the outset, the Quota sampling procedure might look similar to stratified sampling. However, there is a difference between the two. Under stratified sampling, the field worker selects a random sample from each cell of the population, whereas under Quota sampling the selection of sample is not random. It is left to the judgement of the field worker.

The Quota sampling method has some weaknesses. These are listed below :

i) It is usually difficult to obtain an accurate and up to date proportion of respondent assigned to each cell.

ii) As the number of parameters (control characteristics) associated with the objectives of the study become large, the total number of cells increase. This makes the task of field staff difficult as it may not be easy to get a desired respondent.

iii) It is very important that all of the proper parameters (control characteristics) related to the study in question must be incorporated while taking a sample. The results of the study could be misleading if any relevant parameter is omitted for one reason or the other.

iv) The field workers might like to visit those areas where the chances of the availability of a respondent satisfying certain desired parameters is very high. Further, the field workers

might avoid certain respondents who look unfriendly and live in houses which may not be of good appearance. These factors are likely to make the findings of the study less reliable.

The Quota sampling method has some advantages too. The method has a lower cost and field workers have a free hand to select respondents for each cell to fill their quota. The samples, if selected with care would result into more definitive findings.

Activity 9

Make a list of some research studies where some of the non probability methods could be used. Also justify the choice of a particular sampling method you have selected for a study.

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5.10 SUMMARY

A sample is a part of a group or aggregate selected with a view to obtaining information about the whole group also known as population. The population is composed of a number of units. The total number of units in the population and in the sample are known as the population size and the sample size respectively. The technique of sampling has been used in traditional problems such as estimating the yield of crop or examining the quality of an outgoing product. In addition to these traditional spheres, sampling has been applied successfully in management problems such as estimation of inventory by sampling or in socio-economic problems such as ascertaining the trend of a political process through opinion polls. As compared to census or complete enumeration sampling is less expensive, less time consuming and more accurate. Further sampling is the only method for collecting information when the measurement of the sampling unit is destructive in nature.

A probabilistic sampling attaches some probability to each unit of the population to be included in the sample and in this sense it is a representative sample of the population. A simple random sample attaches equal probability to each unit of the population to be selected in the sample. Operationally, the selection of a random sample is based on a sampling frame containing a list of all the units of population and a table of random sampling numbers.

When the population is heterogeneous we divide the units into several groups each known as a stratum. The strata are so selected that each stratum is as homogeneous as possible while the compositions of two different strata are as heterogeneous as possible. The sampling units are selected from each stratum using simple random sampling. This procedure known as stratified sampling which improves the precision of the estimator.

Another sampling procedure known as cluster sampling is frequently used in consumer survey in rural areas where a number of sampling units are grouped together as clusters. A number of clusters is selected randomly and the units of each cluster are completely enumerated. A cluster sample incurs less expenditure and provides more reliable data. Other sampling methods used in business research are systematic sampling and multistage Sampling.

A sampling design is a suitable scheme for obtaining a sample from a given population. It also indicates the size of the sample to be used keeping the cost and precision in view.

Non probabilistic sampling such as Convenience Sampling, Judgement Sampling and Quota Sampling are sometimes used although representativeness of such a sample cannot be ensured.

5.11 KEY WORDS

Sampling is the selection of a part of a group with a view to obtaining information about the whole.

Population is the aggregate from which a sample is taken.

Sampling Units are units or members which constitute the population.

Population size is the total number of units present in the population.

Sample size is the total number of units in the sample.

Simple Random Sample is a sample where each unit of the population has an equal chance of being included in the sample.

Random Sampling Numbers are a collection of digits generated through a probabilistic mechanism.

A Sampling frame is a list of all the units of the population.

Stratified Random Sample is a sample collected by dividing the entire population into a number of subgroups and selecting a simple random sample from each subgroup.

Cluster Sample is a sample where a collection or cluster of sampling units is selected randomly.

Systematic Sample is a sample where the units are selected at equal interval.

Multistage Sample is a sample where the sampling units are selected through several stages.

A Sampling Design is a definite plan for obtaining a sample from a given population.

Convenience Sampling is a process of selecting a sample based on convenience.

Judgement Sampling is a procedure where the sample is selected through judgement or expertise.

Quota Sampling is a procedure where the sample is selected according to a number of key characteristics.

5.12 SELF-ASSESSMENT EXERCISES

1) Define Population and Sampling unit for selecting a simple random sample in each of the following cases.
   i) Fifty voters of a constituency.
   ii) Twenty-five stocks from the Bombay Stock Exchange.
   iii) Twenty students enrolled in University 'I'.
   iv) One hundred depositors of a branch of a bank.
2) Discuss the advantages of sampling method over census method of data collections.
3) "Sampling is a necessity under certain conditions." Explain with illustrative examples.
4) What is meant by "representativeness" in a Sample ? Explain in what sense a simple random sample is representative of the population ?
5) Show that in simple random sampling **without replacement** each sample of size n from a population of size N has a probability of being selected is $1/\binom{N}{n}$.
6) What are random numbers ? Select with the help of the table of random numbers a simple random sample of size ten without replacement from a population of 121 households.
7) Discuss the importance of sampling frame. What are the possible errors resulting from a faulty sampling frame ?
8) What do you mean by sampling design ? What points should be taken into consideration while developing the sampling design for studying in the problems of domestic airline passengers ?

9) State the formulas for the standard errors of sample mean and sample proportion. Explain how standard error of sample proportion can be used to determine the sample size.

10) What should be sample size so that the proportion of TV owners during the last one year opting for hire purchase scheme is estimated within an error of .03 with probability 0.98 ?

11) Under what circumstances stratified random sampling procedure is considered appropriate ? How would you select such a sample ? Explain by means of an example.

12) A certain population is divided into five strata so that $N_1 = 2000$, $N_2 = 2000$, $N_3 = 1800$, $N_4 = 1700$, $N_5 = 2500$. The respective standard deviations are : $\sigma_1 = 1.6$, $\sigma_2 = 2.0$, $\sigma_3 = 4.4$, $\sigma_4 = 4.8$ and $\sigma_5 = 6.0$. Further, the sampling cost in the first two strata is Rs. 4 per interview and in the remaining three strata the sampling cost is Rs. 6 per interview. How a sample of size 226 should be allocated to five strata with (i) proportional allotment (ii) optimal allotment.

13) Under what circumstances would you recommend (i) cluster sampling (ii) systematic sampling (iii) multistage sampling (iv) non probability sampling. Give an example in each case.

14) Answer true or false

i) In order to gather opinion about a television show I asked the views of my friends, the friends asked about the show to their friends and in this way a sample is selected. The sampling procedure is judgement sampling.

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ii) A cluster sample provides more reliable data because of complete enumeration within a cluster.

.....

iii) A systematic sample can be used even if a formal list of all the units of the population is not available.

.....

iv) The main difficulty with multistage sampling is that we have to prepare a long frame.

.....

v) If the population size and the sample size increase in such a manner that the sample size is always one tenth of the population size, simple random sampling with or without replacement is equivalent.

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vi) In stratified sampling with optimum allocation, if the cost of sampling is equal in each stratum then the strata with larger size will always have a large allocation of sample size.

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5.13 ANSWERS

Activity 1

i) **Population :** All couples living together and whose wife is in the child bearing age group (commonly known as Eligible Couple) with two children.

Sampling Unit : Eligible couple with two children.

ii) **Population :** All eligible voters for the political office i.e. all adults.

Sampling Unit : Eligible voter.

iii) **Population** : All the trees of the forest.

Sampling Unit : Tree

iv) **Population** : All the Apple trees in the district.

Sampling Unit : Apple tree.

v) **Population** : All eligible couples.

Sampling Unit : Wife of the eligible couple.

Activity 4

i)	Random No. selected	Remark	Serial No. of the selected student
1	789	Accept	99
	943	Reject	
2	624	Accept	49
3	402	Accept	57
4	673	Accept	98
5	254	Accept	24
6	758	Accept	68
7	495	Accept	35
8	361	Accept	16
9	793	Accept	103
10	502	Accept	42
11	436	Accept	80
12	342	Accept	112
	049	Reject	
13	095	Accept	95
14	848	Accept	43
15	570	Accept	110

ii) $\frac{1}{115}$

iii) If the numbers from 921 ... 999, 000 are not rejected, the students bearing serial numbers 1 to 80 have a chance of $\frac{9}{1000}$ of being selected. The remaining students have a chance of $\frac{8}{1000}$ of being selected. So each unit of the population does not have equal probability of being included in the sample.

iv)	Random No. selected	Remark	Factory No.selected	No. of workers
1	46	Accept	10	6655
	58	Reject		
2	27	Accept	3	2030
3	35	Accept	11	14180
	70	Reject		
4	33	Accept	9	768

Average No. of workers per factory in the sample 5908.25

Average No. of workers per factory in the population 3118.08

Activity 5

i) The frame of all eligible couples with more than two children should be obtained by census method.

ii) The frame is the voters list which is the list of all adults.

iii) Each tree in the forest should be serially marked. The marked trees form the sampling frame.

iv) Each apple tree in the district is serially marked. The marked apple trees form the sampling frame.

v) The frame of all eligible couples should be obtained by census method.

Activity 6

Estimate $= \frac{51}{300}$

Estimate of the standard error

a) With replacement = .0217

b) Without replacement = .0206

Activity 7

i) $n_1 = 250, n_2 = 125, n_3 = 75, n_4 = 50.$

ii) $n_1 = 261, n_2 = 82, n_3 = 113, n_4 = 44.$

Activity 8

n = 2401

Self-assessment Exercises

1) i) Population : All the voters.

Sampling unit : A voter.

ii) Population : All the stocks listed in Bombay stock exchange.

Sampling unit : A stock.

iii) Population : All the students enrolled in the University 'I'.

Sampling unit : A student.

iv) Population : All the depositors of the branch.

Sampling unit : A depositor.

3) Suppose $p_1, p_2, \ldots, p_n$ be any n units of population. The probability that the first unit selected is p_1, ..., nth unit selected is p_n when the sampling is without replacement is given by

$$\frac{1}{N} \times \frac{1}{N-1} \times \frac{1}{N-2} \times \ldots\ldots\ldots \times \frac{1}{N-n+1}$$

$$= \frac{(N-n)!}{N!}$$

But any permutation of $p_1, p_2, \ldots p_n$ will result in an identical sample. Hence, the probability of selecting the sample whose composition is $(p_1, p_2, \ldots p_n)$ is

$$\frac{(N-n)!\, n!}{N!} = \frac{1}{\binom{N}{n}}$$

10) n = 1508

12) Proportional Allocation

$n_1 = 45, n_2 = 45, n_3 = 41, n_4 = 38, n_5 = 57$

Optimal Allocation

$n_1 = 22$, $n_2 = 28$, $n_3 = 45$, $n_4 = 46$, $n_5 = 85$

14) i) False, it is Convenience Sampling.

ii) True.

iii) True.

iv) False, the sampling frame of the second stage units are required only for the selected first stage units.

v) False, $n/N = 1/10$.

vi) False, the sample size will depend upon both the stratum size and the stratum standard deviation.

5.14 FURTHER READINGS

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UNIT 6 ATTITUDE MEASUREMENT AND SCALES

Objectives

After reading th s unit, you should be able to :

- describe the type of managerial research problems which utilise the tools of attitude measuremer ;
- discuss the t.pe of issues which come up when one attempts the measurement of attitudes;
- explain the different attitude measurement scales, alongwith their strengths and limitations;
- decide for which type of research problems one should go in for specific scale or think of using multidimensional scaling.

Structure

6.1 INTRODUCTION

There are a number of management decisions which are taken in an organisation, from time to time. The decisions may relate to the acquisition or disposal of materials/machines, manufacturing or marketing of products, hiring or firing of employees, opening or closedown of plants, promotion or reversion of personnel, and so on. Some of these decisions may rely on data for which the units of measurement are capable of statistical manipulation. Such data largely refer to quantifiable parameters or numerical properties of a given population. However, there are illustrations of other decisions which may rely primarily on behavioural data or data which is statistically not manipulatable, in the strict sense of the word. The units of measurement of such data are not interchangeable and are not susceptible to rigorous statistical analysis. The major area of utilisation of such data lies in the discipline of marketing where the manager is interested in knowing the attitudes of the current and potential users of his/her product or service towards his/her product or service concept or idea. This knowledge of attitudes could result in decisions which would be sensible and effective. Some illustrations of managerial decisions which rely on attitude measurement are product positioning and market segmentation, advertising message decisions etc.

6.2 ATTITUDES, ATTRIBUTES AND BELIEFS

Before one plunges into the topic of attitude measurement, it will be worthwhile to understand the key terms which figure repeatedly in this topic.

Each object/product/service is believed to be composed of certain characteristics which fulfil certain needs of its user. These needs may be of psychological, physical or social nature. The characteristics of the object under consideration are called its attributes. The term belief refers to judgements made by a user regarding the object possessing certain attributes or not. Finally, the term attitude refers to the predisposition/mental state of individuals/users towards a product/idea/attributes of an object. It also implies the mental readiness to act in a particular manner and influences the individuals's behaviour towards the object/group/organization/person under consideration. The salient factors that go into the building of the overall attitude of the individual towards the object are a) his/her beliefs about the attributes possessed by the object, b) his/her preference or otherwise for those attributes, and c) the relative importance of each attribute to the individual's decision making process.

6.3 ISSUES IN ATTITUDE MEASUREMENT

Measurement implies the process of obtaining information which can be subject to analysis. Attitude measurement relates to the process of measuring an individual's attitude towards an object. When we go for measurement of attitudes or any other parameter, one has to clearly sort out the following :

- "what" has to be measured ?
- "who" is to be measured ?
- the accuracy desired in the measurement
- the costs permissible
- the choices available in the measurement/data collection techniques.

In attitude measurement, the researcher is primarily interested in measuring the "state of mind" of the respondent (s). It may include factors such as awareness, attitudes and decision processes. An interesting characteristics of these measures is that their verification is rather difficult. There is no way to determine whether the answer given by a respondent to the level of liking for a new product, such as ice-cream mix, represents the "truth" or not. The researcher, unless he is a "telepathist", cannot actually observe the states of mind like preference, likes and dislikes, etc. Such things can only be inferred.

It has been stated in the previous section, that attitudes are affected by attributes and beliefs. So, the first step, before embarking on an attitude measurement exercise, is selecting the relevant attributes of the object under investigation. For instance, the salient attributes of a product like "Shrikhand" may be price, shelf life, flavour, and pack size. For a public distribution system they may be quality of grains, prices, outlet working timings, and assurance of availability. It is clearly impossible to measure every attribute of the process/object under consideration. The researcher should settle for the relevant ones only. It is advisable to measure only those attributes which can be related to actions by the respondents. Exploratory research can be helpful in identifying attributes. The methods used could include nondisguised ones like depth interviews and disguised ones like projective techniques. The depth interviews are the most commonly used technique. They use no structured framework for gathering information. The respondents are encouraged to talk about the object under investigation and the investigator tries to uncover its salient attributes in this process. This procedure requires skilled investigators. It is also considered costly and the results are prone to bias errors. The projective techniques attempt to uncover the information from the respondent in an indirect manner. The subject is requested to respond to incomplete stimuli here. In doing so, he/she is believed to reveal elements of attitude towards the object that will not be revealed in response to direct queries. The projective techniques used may include a cartoon test, word association test, sentence completion test, etc. Though these techniques also have some disadvantages, they are used more than the nondisguised methods.

The next important issue in attitude measurement is that "who" is to be measured. It involves people. The question to be posed now is of what kind ? Their education, age, sex, occupation, religion etc. may have a bearing on the choice of the measurement method. The measurement procedure must be designed with the characteristics of the respondents under consideration. For instance, using a mail questionnaire for disinterested or hostile respondents would hardly be the right choice as a research instrument.

The third major issue in attitude measurement is the choices in data collection and measurement techniques. The data collection techniques can be categorised into (a) Questionnaire methods, and (b) Observational methods. Usually questionnaires are used for measuring the attitudes.

The approaches for measuring attitudes are as follows :

1) Self-report inventories
2) Using psychological measures like galvanic skin response or pupillary response
3) Projective techniques like thematic aperception test.

The self-report inventories, also known as attitude scales, involve presenting the subjects with a list containing favourable and unfavourable statements about the research topic and ask whether they agree or disagree with each of them.

Most attitude measurement methods use the self-report technique. However they differ in terms of the way the scales are constructed and used.

The weaknesses of the self-report measures are that :

1) The results are limited to what the individuals know about their attitudes and are willing to relate,
2) The validity of the verbalised attitudes is questionable.

We will be discussing some of these scales, alongwith their characteristics, in the subsequent sections of this unit.

Finally, the last major issue for a managerial researcher here relates to the costs and accuracy desired in the measurement. As has been stated earlier, these type of measurements are never entirely free of inaccuracy. Moreover, cost and accuracy are generally reciprocal properties in measurement. The intimate knowledge of a research instrument can go a long way in the correct interpretation of the results.

Activity 1

List out the salient attributes of the following products.

S.N.	Product	Attributes
1)	Toilet Soap	.....
		.....
		.....
2)	Toothpaste	.....
		.....
		.....
		.....
3)	Briefcase	.....
		.....
		.....
		.....
4)	Colour TV	.....
		.....
		.....
		.....

5) Shoes .....

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6) Camera .....

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Activity 2

You may conduct depth interviews to identify attributes of the products mentioned in Activity 1. Compare it with the one you have already listed out in Activity 1.

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Activity 3

List out the three important issues in attitude measurement.

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6.4 SCALING OF ATTITUDES

Researchers in management have dipped into the bag of tricks of sociologists and psychologists to develop the techniques for measurement of attitudes. Basically, what is done here is to confront the respondent with a number of favourable and unfavourable statements about the subject and find out the exent of his/her agreement or disagreement with them. The object here is to measure people's attitude to ideas, products or service. The scales are usually highly structured. The underlying assumption in attitude scaling is that attitudes determine opinions and decisions about the product/service/idea. To understand the human behaviour, and to influence it in a given direction, it is necessary to understand the opinions and the basic attitudes underlying them.

There are many types of scales and scaling techniques. We have to choose the most appropriate technique to suit the research being done. The statements contained therein have to be prepared in such a way that the answers received can easily be converted into numerical values. The three most commonly used scales are the Nominal scale, the Ordinal scale and the Interval scale. You will note later on that the appropriateness of a statistical method depends upon the type of scale used in data collection.

1) **Nominal Scale :** The nominal scale simply allows the categorization of responses into a number of mutually exclusive categories. There are no relationships between the categories, implying that there is no ranking or ordering. The typical applications of the nominal scale is in classification of responses by social class, "like" or "dislike", "yes" or "no", sex, and so on. The statistical operation possible for nominally scaled data is counting only.

2) **Ordinal Scale :** The ordinal scale allows the respondents to rank some alternatives by some common variable. An illustration of this would be the ranking of three brands of pasteurised milk by a group of consumers on the basis of the perceived quality. Here it is feasible for a user of the product to rank the brands from the best to the worst. However the amount of difference between the ranks cannot be found out. It is only possible to compute positional statistical measures like median and mode for such data.

3) **Interval Scale :** The deficiencies of the nominal and the ordinal scales are taken care of in the interval scale. The scale has an arbitrary zero point with numbers placed at equally appearing intervals. A number of statistical operations including addition, subtraction, and computation of the mean can be done on intervally scaled data.

Mostly the nominal and the ordinal type of scales are used in attitude measurement. However, there are attempts to treat them or convert them into interval scales so as to make the data more amenable to statistical operations. But the reasonability of this assumption should be always tested before making inferences.

Most of the attitude measurement scales used are ordinal in nature, though there is attempt to treat the resulting data as intervally scaled. The simplest possible type of such scale has the respondent classifying the object/issue/product/himself into one among two dichotomous categories. Further refinements may include the provision of additional alternatives denoting the degrees of liking or disliking. These are listed in sequence so that the alternatives form a type of scale. These scales are basically self-report inventories, with a list of favourable and unfavourable statements towards the subject.

The attitude measurement scales can be categorised into those which are unidimensional in nature and those which are multidimensional. The different type of single dimensional attitude measurement scales which are available are graphical and numerical scales, summated scales, paired comparisons, equal-appearing intervals, etc. Some scales of the above-mentioned type will be discussed in the subsequent sections of this unit.

Activity 4

Identify the scale to which the following statements/responses belong.

S.No.	Statement/Response	Scale
1)	Cleaning ability of various floor polish brands	.....
2)	The classification of super-markets by "carry our brand" versus "do not carry our brand"	.....
3)	Awareness of four print advertisement	.....
4)	Does your car has radial tyres — yes or no ?	.....
5)	The fahrenheit scale for measuring temperature	.....
6)	Assignment of number of basketball players	.....
7)	T.V.A looks better than T.V. B	.....

6.5 DETERMINISTIC ATTITUDE MEASUREMENT MODELS: THE GUTTMAN SCALE

In the deterministic attitude measurement techniques the underlying assumption is that each statement has a perfect relationship, of one type or another, with the particular dimension of the attitude being investigated. For instance, let us consider a research study where one is interested in investigating a community's attitude to family planning. The items in the questionnaire which relate to this could consist of the following :

	Yes	No
1) Family planning is the best hope for our country	.....	.....
2) Family planning would lead to healthier children	.....	
3) We should all participate in the family planning programme.	.....	

Usually a person who answers YES to 1, would have a high probability of answering as YES to the subsequent statements. Any person who does not answer as YES to 1 but does answer as YES to 2 would have a high probability of answering YES to the later items. Any set of items that produces a pattern of responses as we have described here is called a Guttman Scale.

Guttman scale analysis is usually applied to dichotomous data, i.e., data with only two values, YES or NO, 0 or 1, agree or disagree, etc. However, a number of reasons have made the Guttman scale and impractical tool for the measurement of attitudes. First, the construction of the scale requires a lot of time and effort. Secondly, there may be very few items existing that may fit the model. Since such scales seldom have more than eight items, they can make only rather gross distinctions among respondents.

Activity 5

Define Dichotomous data.

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Activity 6

Mention two reasons which make Guttman scale an impractical tool for the measurements of attitudes.

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6.6 THURSTONE'S EQUAL-APPEARING INTERVAL SCALE

In this scale we are interested in scaling respondents and not statements. The first step in the scale construction is to scale the attitude statements along the attitude continuum. This is done by asking some "judges" to evaluate the items along some continuum.

The statements are printed on some cards and the judges are asked to sort the statements into 11 groups. The extreme piles represent the most favourable and the most unfavourable statements. The judges are expected to make the intervals between the groups equal. The mean rating by judges is taken as the scale point for each item. Items which are found to be ambiguous or irrelevant are dropped. The items selected for the final scale are such that (a) each item has a small standard deviation of ratings over judges and (b) the mean ratings spread evenly from one end of the rating continuum to the other. The selected items are listed in a random order to form the final scale.

The administration of the scale for the measurement of the attitude of a respondent needs the latter to mark only the items with which he/she agrees. The score for the respondent then is taken as the scale value of the median item endorsed or the average scale value of the items endorsed. For instance, suppose a respondent agrees with items which have scale values as 9, 10, and 11. This would imply that he has a favourable attitude to the object (assuming that score of 11 implies most positive attitude !).

The Thurstone scales are prepared with an odd number of positions, the usual number being 11. The scale has some drawbacks such as the time requirement being fairly high, the influencing of scale positions by the attitudes of the judges, and no information on the degree or intensity of agreement with the different items.

Activity 7

Construct a Thurstone's equal-appearing interval scale for a bank interested in knowing about its image in public by developing a number of statements relating to its service, location and timings, etc.

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6.7 THE SEMANTIC DIFFERENTIAL SCALE

The term Semantic differential scale refers to any collection of rating scales anchored by bipolar adjectives. It is a very flexible approach to obtaining measures of attitudes. The object that is rated is called the "concept" and almost anything can be rated including family planning, cosmetics, Shrikhand, political parties, etc.

Normally, a semantic differential scale is based on a seven-point rating scale for each of a number of attributes relating to the research topic. The extreme points represent the bipolar adjectives with the central category representing neutral. In the semantic differential scale only the extremes have names. The in-between categories have either blank spaces or sometimes a number. Some examples of the scale are as follows :

Good ..... Bad

Honest ..... Dishonest

Progressive ..... Behind the times

The preparation of a semantic differential scale for a study requires expressing the things that could be used to describe the object, and thus serve as a basis for attitude formation, in terms of positive and negative statements. The negative phrase is sometimes put on the left side of the scale and sometimes on the right. This prevents a respondent with a positive attitude from simply checking either the left or right hand sides without reading the describing words.

The scale can be used for a variety of purposes. It can be used to check whether a respondent has a favourable attitude towards the object, which out of three neighbourhood banks has the most appealing profile for housewives, etc.

It is possible to assign points to individual cells in the scale. Then one could arrive at the scores for comparisons of different objects. The Figure 1 gives an example based on image study of three neighbourhood banks among a sample of 100 housewives.

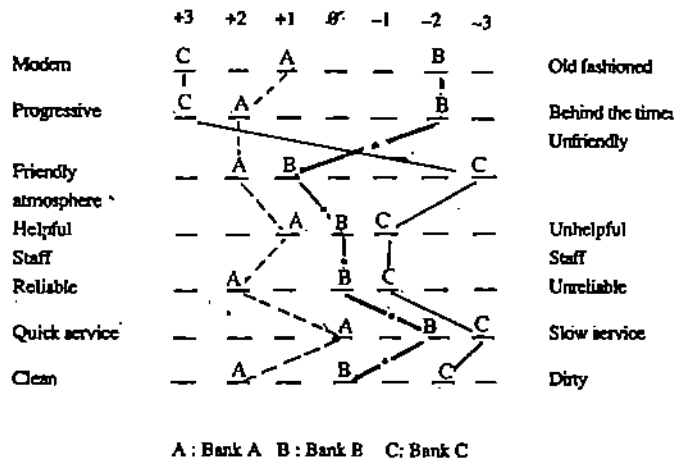

Fig. 1 : Average ratings based on consumers attitude towards neighbourhood banks

The study shown in Fig.1 indicates to a bank manager those aspects in the bank's image which are relatively weak or strong in the eyes of the customers, vis-a-vis what he/she was planning to achieve and how this bank compared the other two neighbourhood banks. The image profiles are based on the scores of each respondent on each dimension and the average total scores for all respondents provides an index of the overall image rating. The maximum score possible for each bank is +21 and minimum possible score is –21. The bank A scored +10, bank B –8, and bank C – 4. These scores are based on each attribute having the same weighting factor of 1. However, in case the researcher wants to weigh the attributes in a different way, it is feasible. This may lead to different image score for the rival banks. For the manager of bank A, we can conclude that the attributes which need immediate attention are service reliability, followed by modernisation and staff attitudes towards the customers.

Activity 8

Use semantic differential technique to develop the profile of three talcum powder producing companies in India.

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6.8 SUMMATIVE MODELS : THE LIKERT SCALE

The summative models assume that the individual items in the scale are monotonically related to the underlying attributes and a summation of the item scores is related linearly to the attitude. In a summative model, one obtains the total score by adding scores on individual items. For the statements that imply negative attitudes, the scoring is reversed. The scales allow an expression of the intensity of feeling. These scales are also called Likert scales. Here, instead of having just "agree" and "disagree" in the scale, we can have intensities varying from "strongly agree" to "strongly disagree".

The scale construction consists of the following steps;

1) Write a large number of statements that concern the particular attitudinal object being investigated. For instance one may be looking at the role of voluntary agencies in providing health services in rural areas. Most of these statements should either be moderately positive or moderately negative. Neutral items are generally avoided in these scales. The items should be evenly divided between positive and negative statements.

2) Administer the pool of statements on a group of respondents who are similar to the population on whom the scale will be used. For example, if we want to study the attitude of housewives the pool should be administered on a group of housewives with similar background to our final population.

3) Assign scale values to the degrees of agreement or disagreement with each item. The particular values may differ from one researcher to another, Sometimes one may adopt the values 1, 2, 3, 4, 5 and sometimes +2, +1, 0, –1, –2. For negative items the directions should be reversed.

4) Calculate a total attitude score for each respondent using the same scaling procedure. The distribution of total scores is then used to refine the list of items. This step is called item analysis.

5) Item analysis : Analyse the responses and select for the scale those items which most clearly differentiate between the highest and lowest scores. This can be done by dividing the respondents into the high and the low scoring categories. The high scorers can be assumed to be with favourable attitudes and the low scorers can be taken as having the least favourable attitudes. If the statement is a good one, then it is safe to expect that the mean score for the favourable group would be greater than the mean score for the unfavourable group. If the mean scores across the two groups, for an item, are found nearly equal or equal, then that statement can be dropped from the scale. One can take the high group as the top twenty-five per cent of all total scores and the low group as

the lowest twenty-five per cent. Alternatively we can divide the respondents into quartiles and compute the median score for each item for the highest twenty-five per cent and the lowest twenty-five per cent of scale scores.

6) The statements remaining in the pruned list are randomly ordered on the scale form. The positive and negative ones are mixed.

7) The scale is now administered on the respondents who are asked to indicate their degree of agreement with the items. A respondent's total score is generated as the sum of his scores on each statement.

The summated scales have certain advantages. They are easy to construct, are highly reliable, and can be adapted to the measurement of many different kinds of attitudes.

Activity 9

How would you use a Likert scale to ascertain the image of colgate toothpaste among some consumers ?

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6.9 THE Q-SORT TECHNIQUE

The Q-sort technique grew out of a more general methodology for the study of verbalized attitudes, preferences etc. The peculiar characteristic of this methodology is that here it is more important to make comparisons among different responses within respondents than between respondents. Thus it is a comparative rather than an absolute rating method.

In the area of management, the application of Q-sort has come up in marketing research. Here the respondents may be requested to enunciate their images of their ideal brands, specified brands and their current brand. The respondent may be given a large number of statements (50-100) describing the characteristics of a product. For instance for a cosmetic product like shampoo he may be asked to compare alternatives with adjectives like "easy to use", "economical", and "safe for children", with instructions to array them along the continuum "least preferred — the ideal shampoo". Essentially what the respondents have done here is to array the attributes along the scale.

The Q-sort technique is faster and less tedious for subjects than paired comparison measures. It also forces the subject to conform to quotas at each point of the scale so as to yield a normal or quasi-normal distribution.

The utility of Q-sort in marketing research is to derive clusters of individuals who display similar preferences, thus representing unique market segments. The objective of Q-sort, thus, is intensive study of individuals.

6.10 MULTIDIMENSIONAL SCALING

In the attitude measurement scales which have been discussed till now the object is measured against each characteristic, one at a time. The measurement process tells little about the relative importance of different characteristics or how the characteristics relate to each other. When these aspects become important, one takes recourse to multidimensional scaling. It is a term used to describe a group of analytical techniques used to study attitudes, specially those relating to perceptions and preferences. These techniques attempt to identify the object attributes that are important to the respondents and to measure their relative importance. The major application of multidimensional scaling in managerial research comes in marketing research. Some of the uses which have already been illustrated in the literature are as follows :

Advertising : It has been applied here to answer questions such as: Which media should be used for getting the desired reach ? If written media is selected then which magazines newspapers to advertise in ?

Market Segmentation Vendor Evaluations
A detailed discussion of Multidimensional Scaling is outside the purview of this unit. Generally the use of this method requires the use of a computer and a number of computer programmes, both on PCs and the larger systems are available. For a detailed discussion on Multidimensional Scaling, please refer Handbook of Marketing Research, Robert Ferber (ed.), pp. 3-44 to 3-61.

6.11 SELECTION OF AN APPROPRIATE ATTITUDE MEASUREMENT SCALE

We have examined in the earlier sections a number of different techniques which are available for the measurement of attitudes. Each has some strengths and some weaknesses. Almost every technique can be used for the measurement of any component of attitudes. But at the same time all techniques are not suitable for all purposes. Then selection of the scale depends on the stage and the size of the research project. The costs of developing and implementing the instrument, reliability and validity of the instrument and the statistical analysis necessary.

Generally, Thurstone's scale, Q-sort and the Semantic differential scale are preferred for preliminary investigation. The Likert scale is used for item analysis. For specific attributes the semantic differential scale is very appropriate.

Overall the semantic differential is simple in concept and results obtained are comparable with more complex, one dimensional methods. Hence, it is widely used.

6.12 LIMITATIONS OF ATTITUDE MEASUREMENT SCALES

The main limitation of these tools is the emphasis on describing attitudes rather than predicting behaviour. This is primarily because of a lack of models that describe the role of attitudes in behaviour.

6.13 SUMMARY

We have briefly examined the role of attitude measurement and scales in managerial research. We started by looking at the type of managerial decisions which need quantification of attitudinal data. Subsequently, we defined some key terms such as attributes, beliefs and attitudes. This was followed by a discussion on the critical issues in attitude measurement. Then the different types of scales, viz., nominal, ordinal, and interval, which feature in this field, were described. This was followed by five important tools/scales of attitude measurement, viz., Guttman, Thurstone's equal-appearing interval, Semantic Differential, Likert's and the Q-sort technique. Simultaneously, the steps in scale construction and their use were also highlighted. A brief discussion of multidimensional scaling followed. Finally, the issues of the selection of an appropriate attitude measurement scale and the limitations of these research tools were discussed.

6.14 KEY WORDS

Attributes : Characteristics of the object, under investigation.

Beliefs : Judgements made by a user regarding the object possessing certain attributes or not.

Attitude : Predisposition of individual(s) towards the attributes of an object.

Measurement: The process of obtaining information, which can be subjected to analysis.

Scale : A collection of statements which can be used for measuring attitudes.

Respondent/Subject : Person on whom an attitude measurement scale is administered.

Bipolar adjectives: A pair of words which have opposite meanings.

6.15 SELF-ASSESSMENT EXERCISES

1) What do you understand by the terms attitude and attitude measurement ? Explain.
2) Which type of managerial research and decisions utilise attitude measurement ? Explain with examples.
3) Review briefly the different types of issues in attitude measurement.
4) Compare and contrast the various attitude measurement techniques. When will you use each of them ? Discuss briefly.
5) In which type of study will you use multidimensional scaling ? Discuss.

6.16 FURTHER READINGS

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Notes

Notes

Notes

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MBA-4.2

Research Methodology For Management Decisions

Block

3

DATA PRESENTATION AND ANALYSIS

BLOCK 3 DATA PRESENTATION AND ANALYSIS

Block 3 on Data Presentation and Analysis consists of four units.

Unit 7 explains the significance of data presentation and describes various types of data classification. A few data tabulation and presentation devices are also developed in this unit.

The subject matter of Unit 8 is Nonparametric tests. These are also called distribution free tests. In these tests researcher does not need to have the knowledge of the distribution of the population parameter being tested. This unit explains the difference between parametric and nonparametric tests. The relevance of and various steps involved in using nonparametric tests are also discussed here. The unit concludes by explaining with the help of appropriate examples how to conduct one sample, two samples and more than two samples nonparametric tests.

Unit 9 on Multivariate Analysis of Data explains various multivariate techniques like multiple regression, discriminant analysis and factor analysis for the analysis of relevant data for a research problem. The emphasis is on interpreting the findings of multivariate analysis in any research study. The unit also explains the use of a particular technique suitable for a particular research problem.

Unit 10 on Model Building and Decision-making explains the concepts of model building and decision-making. It also describes the need for model building in managerial research. The various principles of designing models for different types of managerial research/decision-making situations are also discussed.

UNIT 7 DATA PROCESSING

Objectives

After studying this unit, you should be able to:

- explain the significance of data presentation
- describe various types of data classification
- develop appropriate data tabulation and presentation devices.

Structure

7.1 INTRODUCTION

The data collected from the field has to be processed and analysed as laid down in the research plan. The processing of data primarily mean editing, coding, classification and the tabulation of the data collected so that they are amenable to analysis. In this unit, therefore, we shall concentrate on the various aspects of processing of data. Further, the presentation of data can be either in tabulation forms or through charts. In Unit 6, Block 2 (Data Collection and Analysis) of Quantitative Analysis for Managerial Applications (MS-8), you have been introduced to the basic concepts of presentation of data. You are, therefore, advised to refer to it for better understanding of this unit.

7.2 EDITING OF DATA

The editing of data is a process of examining the raw data to detect errors and omissions and to correct them, if possible, so as to ensure completeness, consistency, accuracy and homogeneity. This will facilitate coding and tabulation of data. In fact, the editing involves a careful scrutiny of the completed questionnaires.

The editing can be done at two stages: field editing and central editing.

Field editing : The field editing consists of review of the reporting forms by the investigator for completing or translating what the latter has written in abbreviated form at the time of interviewing the respondent. This form of editing is necessary in view of the writing of individuals, which vary from individual to individual and sometimes difficult for the tabulator to understand. This sort of editing should be done as soon as possible after the interview, as it may be necessary sometimes to recall the memory. While doing so, care should be taken so that the investigator does not correct the errors of omission by simply guesing what the respondent would have answered if the question was put to him.

Central Editing : Central editing should be carried out when all the forms of schedules have been completed and returned to the headquarters. This type of editing requires that all the forms are thoroughly edited by a single person (editor) in a small field study or a small group of persons in case of a large field study. The editor may correct the obvious errors, such as an entry in a wrong place, entry recorded in daily terms whereas it should have been recorded in weeks/months, etc. Sometimes,

inappropriate or missing replies can also be recorded by the editor by reviewing the other information recorded in the schedule. If necessary, the respondent may be contacted for clarification. All the incorrect replies, which are quite obvious, must be deleted from the schedules.

The editor should be familiar with the instructions and the codes given to the interviewers while editing. The new (corrected) entry made by the editor should be in some distinctive form and they be initialed by the editor. The date of editing may also be recorded on the schedule for any future references.

Activity 1

Define the following :

a) Field editing

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b) Central editing

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Activity 2

Your organisation is conducting a survey to determine the consumption pattern of food items by households in Delhi. You are the head of computer division responsible for editing the raw data from the questionnaires and analysing the same. A filled up set of questionnaires have been sent to you. List out the points on which you would like to concentrate while editing the raw data.

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7.3 CODING OF DATA

Coding is the process of assigning some symbols (either) alphabetical or numerals or (both) to the answers so that the responses can be recorded into a limited number of classes or categories. The classes should be appropriate to the research problem being studied. They must be exhaustive and must be mutually exclusive so that the answer can be placed in one and only one cell in a given category. Further, every class must be defined in terms of only one concept.

The coding is necessary for the efficient analysis of data. The coding decisions should usually be taken at the designing stage of the questionnaire itself so that the likely responses to questions are pre-coded. This simplifies computer tabulation of the data for further analysis. It may be noted that any errors in coding should be eliminated altogether or at least be reduced to the minimum possible level.

7.4 CLASSIFICATION OF DATA

In most research studies, voluminous raw data collected through a survey need to be reduced into homogeneous groups for any meaningful analysis. This necessitates classification of data, which in simple terms is the process of arranging data in groups or classes on the basis of some characteristics. Classification helps in making comparisons and drawing meaningful conclusions. Classification can either be according to attributes or according to numerical characteristics.

In case of classification according to attributes, the data is classified by descriptive characteristics, i.e. sex, caste, education, land holding, etc. The descriptive characteristics refer to qualitative phenomenon which cannot be measured quantitatively, only their presence or absence in an individual item can be observed. This classification can either be simple or manifold. In case of simple classification, also referred to as classification according to dichotomy, each class is divided into two sub-classes and only one attribute is studied, such as employed or unemployed, resident or non-resident, married or unmarried, etc. In case of manifold classification, more than one attributes are considered, and therefore, the classification leads to the formation of a number of classes and sub-classes. For example, industries may be classified as belonging to public sector or private sector. Among each of these broad classes, there can be a second level classification in terms of large and small, which can further be classified (third level) as profit making and loss making, and so on. This process of subclassification is carried keeping in view our basic purpose for which the classification is required. The objectives have to be clearly defined before the classification can be carried out. Further, the attributes should be defined in such a way that there is least possibility of ambiguity concerning the said attributes.

When individual observations possess numerical characteristics, such as height, weight, marks, income, etc. they are classified on the basis of class intervals . For example, persons whose monthly income is between Rs. 1001 and Rs. 1500 may form one group, those whose income is within Rs. 1501 and Rs. 2000 may form another group, and so on. In this manner, the entire data may be divided into a number of groups or classes, which are usually called class-intervals. The number of items in each class is called the frequency of the class. Every class has two limits: an upper limit and a lower limit, which are known as class limits. The difference between these two limits is called the magnitude of the class or the class interval. Several aspects of classification of data has been detailed in Unit 6 (Presentation of Data), Block 2 (Data Collection and Analysis) of Quantitative Analysis for Managerial Applications (MS-8). You are advised to refer to that study material.

Activity 3

Following data refer to monthly salary of 40 employees of an organisation. Tabulate the data using the inclusive and exclusive methods:

1060,	1310,	1255,	750,	1690,	945,	1200,	1050,
2125,	2120,	1190,	1120,	2130,	2240,	2190,	1370,
1440,	2560,	870,	2000,	1870,	1700,	1800,	2375,
1940,	2250,	1460,	1750,	1875,	1165,	2255,	1470,
2060,	2135,	2125,	1760,	1650,	1945,	2000,	2250,

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7.5 STATISTICAL SERIES

A series is defined as a logical or systematic arrangement of observations or items. When the attributes or things are counted, measured or weighed and arranged in an orderly manner, say either discending or ascending order, they constitute a series. When the statistical data pertains to time, the series is said to be historical or time series. The important factor in such series is the chronology. When the data pertains to space, the series is referred to as spacial, and is also known as geographical series. When the data refers to physical conditions such as height, weight, age, etc., the series is referred to as condition series. The following series, for example, refers to special series of regionwise sales of a firm during 1989-90 .

	Region	Sales (Rs. in lakhs)
(i)	Northern	135.00
(ii)	North-eastern	56.00
(iii)	Southern	85.00
(iv)	Central	76.00
(v)	Western	163.00
(vi)	Eastern	68.00

The series can also be classified as individual observations, discrete series and continuous series. In case of series of individual observations, the items are listed singly as distinguished from listing them in groups. In case of discrete series, items are arranged in groups (frequency distribution) showing definite breaks from one point to another and are exactly measurable. The marks obtained by 30 students in a subject grouped together in a series in the following way.

Marks	:	10	20	30	40	50	60	70
No. of students	:	2	3	4	6	8	5	2

In case of continuous series, the items are arranged in class and they can be arranged either in ascending order or discending order of magnitude and their continuity is not broken. At the point at which a class ends, the next begins and thus the continuity is maintained. Monthly consumption of edible oil by 40 families is given below in the form of a continuous series.

Monthly consumption (in kg)	No. of families
0 - 0.5	5
0.5 - 1.0	9
1.0 - 2.0	15
2.0 - 4.0	7
4.0 - 6.0	5
	40

Activity 4

Develop a sample continuous series for data collected from your own work situation.

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7.6 TABLES AS DATA PRESENTATION DEVICES

Statistical data can be presented in the form of tables and graphs. In the tabular form, the classification of data is made with reference to time or some other variables. The graphs are used as a visual form of presentation of data.

The tabulation is used for summarization and condensation of data. It aids in analysis of relationships, trends and other summarization of the given data. The tabulation may be simple or complex. Simple tabulation results in one-way tables, which can be used to answer questions related to one characteristic of the data. The complex tabulation usually results in two way tables, which give information about two interrelated characteristics of the date; three way tables which give information about three interrelated characteristics of data; and still higher order tables, which supply information about several interrelated characteristics of data.

Following are the important characteristics of a table:

i) Every table should have a clear and concise title to make it understandable without reference to the text. This title should always be just above the body of the table.

ii) Every table should be given a distinct number to facilitate easy reference.

iii) Every table should have captions (column headings) and stubs (row headings) and they should be clear and brief.

iv) The units of measurements used must always be indicated.

v) Source or sources from where the data in the table have been obtained must be indicated at the bottom of the table.

vi) Explanatory footnotes, if any, concerning the table should be given beneath the table along with reference symbol.

vii) The columns in the tables may be numbered to facilitate reference.

viii) Abbreviations should be used to the minimum possible extent.

ix) The tables should be logical, clear, accurate and as simple as possible.

x) The arrangement of the data categories in a table may be a chronological, geographical, alphabetical or according to magnitude to facilitate comparison.

xi) Finally, the table must suit the needs and requirements of the research study.

Activity 5

Using your own data source, present the data on any agricultural commodity in a tabular form.

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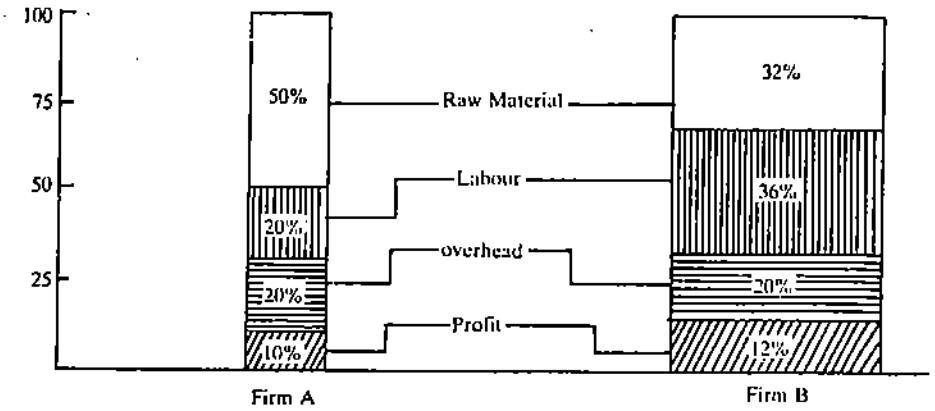
7.7 GRAPHICAL PRESENTATION OF DATA

Several types of graphs or charts are used to present statistical data. Of them, the following are commonly used: bar chart, two dimensional diagrams, pictograms, piecharts and arithmetic chart or line chart. Several of these have been discussed in detail in Unit 6, (Presentation of data). Block 2 (Data Collection and Analysis) of Quantitative Analysis for Managerial Applications (MS-8). You may therefore refer to the said study material. Therefore, charts and graphs not covered are discussed below.

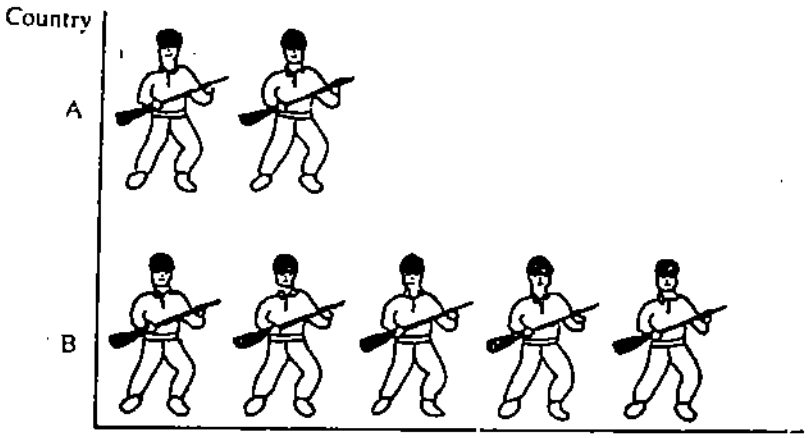
Two dimensional diagrams: The commonly used two dimensional diagrams are rectangular diagrams and squares. In rectangular diagrams the rectangles are used to present the data in the graphic form. These diagrams are used for comparing two sets of data. The height of the rectangle is proportional to the ratio of the data which bear to each other in a given series and the width of the rectangle varies in proportion to the aggregate. Before constructing the rectangular diagram, the data is converted into percentages. A rectangular diagram to the data on cost of production and profits in two firms A and B is given below.

	Firm A		Firm B	
	Absolute (Rs. in Lakhs)	%	Absolute (Rs. in Lakhs)	%
Raw material	75.00	50	120.00	32
Labour	30.00	20	135.00	36
Overheads	30.00	20	75.00	20
Profits	15.00	10	45.00	12

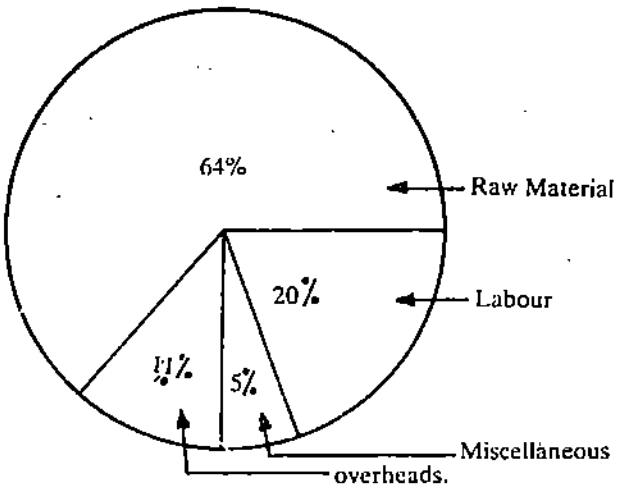
When the difference between two quantities is very large, one bar would become too big and the other too small in a rectangular diagram. To overcome this difficulty, squares are used to present the data. The size of the square is the square roots of the given data.



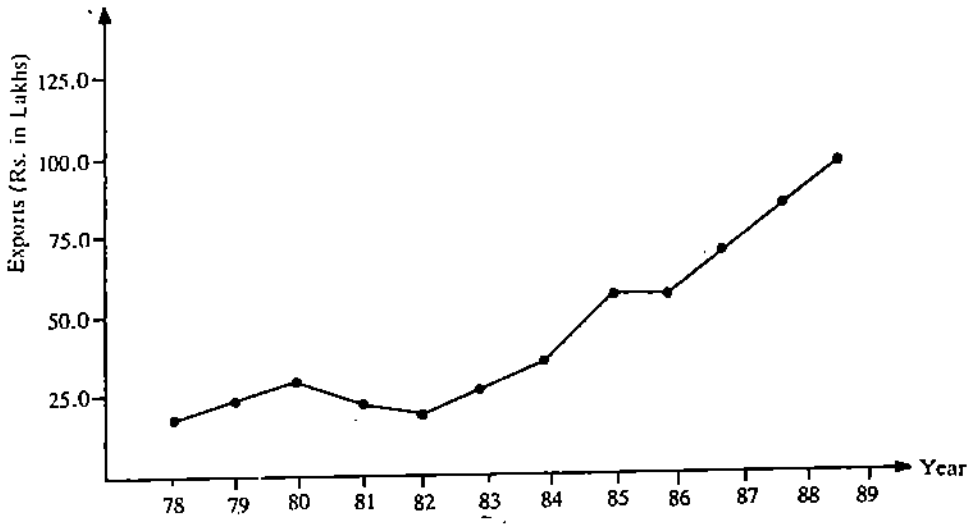
Pictograms : In this form of presentation, data are represented by a picture. For example, population figures are presented by the picture of a human being, production figures of, say motorbikes, is presented by the picture of a motorbike, cattle population is presented by a picture of a cattle and so on. The following figure presents a pictograph showing troops strengths of two countries A and B.



Pie Chart : In a pie chart, different segments of a circle represent percentage contribution of various components to the total. It brings out the relative importance of various components of data. For drawing a pie chart, we construct a circle of any diameter and then the circle is broken into a desired number of segments, angle 360° represents 100 per cent. The cost of production in an industry is presented below in the form of a pie chart.



Line or Arithmetic Chart : The line or arithmetic chart is used to identify the changes or the trend that exist in a series of data. The data on export sales of a company between 1978 and 1989 is presented below in the form of a line chart. Although we can see changes in the data, the presentation of the same on a line chart gives a better



picture of the information. The other forms of presentation of the data have already been discussed in Unit 6, Block 2 of Quantitative Analysis for Managerial Applications (MS-8).

Activity 6
With the help of your own data, draw an appropriate chart to present the same.

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7.8 SUMMARY

We have in this unit discussed the various aspects of data processing. The importance of editing and coding of data before any processing has been emphasised here. In any research studies, the voluminous data can be handled only after classifying the same. The various aspects of classification, summarisation and presentation of data have been discussed.

7.9 SELF-ASSESSMENT EXERCISES

1) Describe, in brief, the importance of editing, coding, classification, tabulation and presentation of data in the context of research study.
2) Discuss the different aspects of classification of data. What are the likely problems encountered in the classification and how they can be handled?
3) Why tabulation is considered essential in a research study? Give the characteristics of a good table.
4) Write briefly about the different forms of data presentation devices.
5) Monthly salary of 32 employees of a firm are given below. Tabulate the data after selecting a suitable class interval.

2250,	1800,	1650,	1760,	3520,	5600,	2450,	2680,
2700,	1680,	3650,	3240,	5850,	3150,	1860,	2425,
4520,	3275,	4215,	3760,	1950,	1850,	3750,	2825,
4500,	3800,	4300,	2750,	4370,	3350,	2375,	3215

6) Profit (Rs.in lakhs) after tax, for a pharmaceutical firm between 1980 and 1988 is given below. Draw a line chart.

1980,	1981,	1982,	1983,	1984,	1985,	1986,	1987,	1988
50.0,	115.0,	127.0,	138.0,	126.0,	115.0,	148.0,	168.0,	195.0

7) Draw a pie chart for comparing the various costs (Rs.in lakhs) of the house building activities in two periods, 1984 and 1989.

	1984	1989
Land cost	0.75	1.00
Material cost	1.00	1.75
Labour cost	0.60	1.00
Fixtures & furnitures	0.40	0.75
Miscellaneous	0.25	0.50

8) The following data relate to the advances to various sectors of a nationalised bank for the year 1989. Present the data in a pie diagram.

Sector	Amount (Rs. in Millions)
Public Sector — Food	1550.0
Public sector — Food	650.0
— Non Food	325.0
Others	2450.0

7.10 FURTHER READINGS

Enns, P.G., 1985. *Business Statistics,* Richard D. Irwin Inc.: Homewood.

Kothari, Cr., 1986. *Research Methodology—Methods and Techniques,* Wiley Eastern; New Delhi.

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UNIT 8 STATISTICAL ANALYSIS AND INTERPRETATION OF DATA: NONPARAMETRIC TESTS

Objectives

On successful completion of this unit, you should be able to

- explain the differences between parametric and nonparametric tests
- describe the relevance of nonparametric tests in data analysis
- discuss the steps involved in the nonparametric test
- design and conduct one sample, two samples and more than two samples nonparametric tests.

Structure

8.1 INTRODUCTION

In Unit 15, Block 4 (Sampling and Sampling Distributions) of Quantitative Analysis for Managerial Decisions (MS-8), you have been introduced to the general class of testing of hypotheses. These tests, popularly known as parametric tests, assume that parameters such as mean, standard deviation, etc. exist and are used to develop a test. For example, a t-test is based upon the comparison of means of two samples. The parametric tests are developed with an assumption that the form of the population distribution was known and that a test concerning a parameter of the distribution was to be made. Tests of hypotheses which deal with population parameters are called parametric tests.

There are situations, particularly in psychological or in market research studies, where in the basic assumptions underlying the parametric tests are not valid or one does not have the knowledge of the distribution of the population parameter being tested. The tests which handle problems of these types are known as nonparametric tests or distribution free tests.

In the recent past, the nonparametric tests have gained importance basically for three reasons:

(i) These tests require no or less restricting assumptions than the corresponding parametric tests,

(ii) these tests are more suitable for analysing ranked, scaled or rated data, and

(iii) these tests involve very few arithmetic computations.

However, it must be understood that when basic assumptions about the parametric tests are valid, the nonparametric tests are less powerful than the parametric tests. Thus, there is a greater risk of accepting a false hypothesis and thus committing a type II error. Secondly, in nonparametric methods, the null hypothesis is somewhat loosely defined thereby, when the null hypothesis is rejected, the nonparametric tests yield less precise conclusions compared to the parametric tests. For example, in parametric tests we have a test for equality of two population means compared to the two population distributions are identical in a nonparametric test. In this case, a rejection of null hypothesis in a parametric test would mean that the two population means are not equal while the rejection of the null hypothesis in the nonparametric test leads to the conclusion that the two population distributions are different, the specific form of the difference between the two distributions is not clearly specified.

The following are some of the typical situations for using nonparametric tests :

i) In a consumer behaviour survey for new package design, the responses are not likely to be normally distributed but clustering around two extreme positions, with a very few respondents giving a neutral response to the package design.

ii) Sometimes, the responses to a question are given in terms of names (nominal data), which cannot be treated as numbers. For example, if we ask young graduates "in which part of the country would you like to take up a job and live", the replies could be north, north-west, west or south, etc. Nominal data can be analysed only by nonparametric methods.

iii) In mailed questionnaire method of survey, more often partially filled questionnaires are received. Nonparametric tests are designed to take the missions data and make necessary adjustments to extract maximum information from the available data.

iv) Nonparametric tests can be used to provide reasonably good results even for very small samples.

8.2 ONE SAMPLE TESTS

The one sample tests are used to answer the questions such as:

i) Is there a significant difference between the observed and expected frequencies?

ii) Is it reasonable to believe that the sample has been drawn from a specified population?

iii) Is it reasonable to accept that the sample is a random sample from some known population?

The tests which are used to obtain answers to the above questions are classified as tests for goodness of fit.

Kolmogorov-Smirnov One Sample Test

This test is used for comparing the distribution on an ordinal scale. The test is concerned with the degree of agreement between the distribution of observed values and some specified theoretical distribution. It determines whether the scores in a sample can reasonably be thought to have come from a population having the theoretical distribution.

Example : A leading paint manufacturer is interested in developing a new colour shade. He is interested in testing four different shades: dark, bright, light and very light. A sample of 160 customers were shown these four shades and following results were obtained: 30 liked the dark shade, 45 liked the bright shade, 60 liked the light shade and the remaining liked the very light shade. The manufacturer wants to know whether the sample results indicate any preference towards the shade?

The test procedure to test the above hypothesis involves specifying the cumulative frequency distribution which would occur given the theoretical distribution under H_o and comparing that with the observed (from the sample) cumulative frequency distribution. The point at which these two distributions show the greatest absolute difference is determined. Reference to the sampling distribution would indicate whether such a difference is likely to be on the basis of chance. The Kolmogorov-Smirnov test assumes that the distribution of the variable being tested in continuous as specified by the cumulative frequency distribution. The test statistic is given by

$$D = \text{maximum } \{|F_0(x) - S_n(x)|\}$$

Where $F_0(x)$ is the theoretical cumulative frequency distribution (under H_0) and $S_n(x)$ is the observed cumulative frequency distribution, with a sample of size n. Statistical Table 1 at the end of this unit gives the critical value for D. If the calculated value of D exceeds this value, the null hypothesis is rejected, i.e. the observed difference is significant.

In our above example, the calculated value of D is obtained as follows :

	Shade Chosen			
	Dark	Bright	Light	Very light
Observed number of customers	30	45	60	25
$S_n(x)$ = observed-cum-distribution	0.1875	0.4688	0.8438	1.0000
$F_0(x)$ = theoretical-cum-distribution	0.25	0.50	0.75	1.00
$\lvert F_0(x) - S_n(x) \rvert$	0.0625	0.0312	0.0938	0
$D = \max \{\lvert F_0^*(x) - S_n(x) \rvert\} = 0.0938$				

For large n and at 5 per cent significance level, the critical value of D is given by $\frac{1.36}{\sqrt{n}}$. This value is equal to 0.1075. As the calculated value of D is less than the critical value, the null hypothesis is not rejected, i.e., any difference in shade preference is only due to chance.

Runs Test for Randomness

In order to draw conclusions about the population on the basis of the sample information, it is necessary that the sample drawn must be random or unbiased. The runs test is used to test the sample for randomness. The test is based on the order or sequence in which the individual observations originally were obtained. A run is defined as a sequence of identical symbols or elements which are followed and proceeded by different types of symbols or elements or by no symbols on either side.

For example, in studying the arrival pattern of customers in a large departmental store, we might observe the following sequence of male (M) and female (F) arrivals :

M M F F F M M F F F M M M M F M M F F M

For this sample of 20 customers, we can observe that there are in all 9 runs. The total number of runs in a sample is an indication of whether or not the sample is random. Too few runs or too many runs indicates lack of independence or nonrandomness. In order to use the runs test, we observe the sequence of occurrence of the $n_1 + n_2 = n$ events (observations) and determine the number of runs, r. If both n_1 and n_2 are equal to or less than 20, then we use the statistical Table 2 at the end of this unit, to find out the critical value for r under H_0 with $0 = 0.05$. If the observed value of r falls within the critical value, we accept H_0. Otherwise, the null hypothesis (H_0) is rejected. If either n_1 or n_2 is larger than 20, we use normal distribution as an approximation to the sampling distribution of r, with

$$\text{Mean} = E(r) = \frac{2n_1 n_2}{n_1 + n_2} + 1$$

and

$$\text{standard deviation} = \text{S.D.}(r) = \sqrt{\frac{2n_1 n_2 (2n_1 n_2 - n_1 - n_2)}{(n_1 + n_2)^2 (n_1 + n_2 - 1)}}$$

The null hypothesis is tested using the test statistics

$$|Z| = \frac{|r - E(r)|}{\text{S.D}(r)}$$

The normal probability table is used to obtain the critical value of Z and the hypothesis H_0 is rejected when the calculated value of Z is greater than the critical value.

In order to study the arrival pattern of customers at a Supermarket, the manager noted down the arrival sequence of customers, sex-wise (M and W denote man and woman arrival). The sequence is:

MM WWW M WW MM WWWW MMM WW MM W MMM WWW
MM WW MM WW M WW MM WW M WW MM WW

In order to conclude the randomness of the arrival pattern of the customers, we can use the runs test.

The hypothesis to be tested here is:

H_0 : The arrival pattern, sex-wise, of the customers at the supermarket is random.
H_1 : The arrival pattern, sex-wise, of the customers at the sup market is not random.

Here

$n_1 = 23, n_2 = 27, r = 24$

$$E(r) = \frac{2n_1 n_2}{n_1 + n_2} + 1$$

$$= \frac{2 \times 23 \times 27}{23 + 27} + 1 = 25.8$$

$$S.D(r) = \sqrt{\frac{2n_1 n_2 (2n_1 n_2 - n_1 - n_2)}{(n_1 + n_2)^2 (n_1 + n_2 - 1)}}$$

$$= \sqrt{\frac{2 \times 23 \times 27 (2 \times 23 \times 27 - 23 - 27)}{(23 + 27)^2 (23 + 27 - 1)}} = 3.48$$

$$|Z| = \frac{|r - E(r)|}{S.D.(r)} = \frac{|24 - 25.8|}{3.48} = 0.52$$

As $\alpha = 0.05$, the critical value of Z is 1.96. As the calculated value of Z is less than the critical value, the null hypothesis is accepted. Thus, the arrival pattern of the customers (sex-wise) is random.

One-Sample Sign Test

In Block 4 of MS-8, all tests concerning means that you have studied are based on the assumption that the samples are taken from a population having roughly the shape of a normal distribution. When this assumption is untenable, the standard tests can be replaced by nonparametric tests. Here we will discuss one such nonparametric tests, namely, sign test.

The one-sample sign test is applicable, when sample is taken from a continuous symmetrical population. In this case, the probability that the sample value is less than mean and the probability a sample value is greater than mean are both $\frac{1}{2}$. Suppose we are testing our null hypothesis H_0: $\mu = \mu_o$ against a suitable alternative hypothesis by using a sample of size n. The procedure adopted in the sign test is very simple. Each sample value greater than μ_o is replaced by a plus sign and each sample value less than μ_o is replaced by a negative sign. We then test the null hypothesis that these plus and minus signs are the values of random variable having a binomial distribution with $p = \frac{1}{2}$. In case any sample value exactly equals μo, we simply omit it.

For a small sample, the test is performed by computing the binomial probabilities (or you may refer to binomial probabilities table). For a large sample, the normal distribution is used as an approximation to the binomial distribution.

Example : It is desired to test the hypothesis that the median value μ of a continuous distribution is 15 against the alternative hypothesis $\mu > 15$. Twenty observations were taken and the following results were obtained :
17, 18, 16, 16, 17, 19, 14, 13, 19, 21, 22, 11, 9, 12, 14, 17, 23, 18, 17, 16

You may use $\alpha = 0.05$ level of significance.

Solution : Replacing each value greater than 15 with a plus sign and each value less than 15 with a minus sign we get:
+ + + + + + − − + + + − − − − + + + + + +

Now the question is whether 14 plus signs observed in 20 trials supports the null hypothesis $p = \frac{1}{2}$ or the alternative hypothesis $p > \frac{1}{2}$.

We can find that for n = 20 and $p = \frac{1}{2}$ the probability of 14 or more successes is 0.05 and since this is less than or equal to $\alpha = 0.05$, we reject the null hypothesis

Therefore, the median value of the distribution is greater than 15.

You may please note that in the above example both np and n (1−p) are greater than 5. Therefore, we could have as well used normal approximation to binomial distribution. We will illustrate this with a different example.

Example : The data given below is on a large industrial plant's daily emission of sulphur oxides (in tons)

17	15	20	29	19	18	22	25	27	9
24	20	17	6	24	14	15	23	24	26
19	23	28	19	16	22	24	17	20	13
19	10	23	18	31	13	20	17	24	14

Use the one-sample sign test to test the null hypothesis that the plant's true average daily emission of sulphur oxide is $\mu = 23.5$ tons against the alternative hypothesis $\mu < 23.5$ tons at the 0.05 level of significance.

Solution : There are 11 plus signs and 29 minus signs.

$H_0 : p = 1/2$
$H_1 : p < 1/2$
$x = 11, n = 40, p = \frac{1}{2}$

$$Z = \frac{x - npo}{\sqrt{npo\,(1-po)}}$$

$$= \frac{11-40\,(1/2)}{\sqrt{40\,(\frac{1}{2})\,(\frac{1}{2})}} = -2.85$$

Absolute value of computed Z ie $|Z| = 2.85$
Absolute value of tabulated Z ie $|Z| = 1.645$
at $\alpha = 0.05$ (Obtained from standard normal table)

Since computed $|Z| >$ tabular $|Z|$, we reject H_0

Therefore, we conclude that plant's true average daily emission of sulfur oxides is less than 23.5 tons.

CHI-Square Test

In certain market research field studies, we have responses which can be classified into two mutually exclusive classes, such as like-dislike, favour-not favour, etc. The Chi-square (X^2) test of goodness of fit is used here tests whether a significant difference exists between the observed number of reponses and an expected number based on the null hypothesis in each category or class. The test statistic used here is

$$X^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$$

Where O_i and E_i are the observed and expected frequencies in the i^{th} class, there bring k classes. For a given level of significance (α), if the calculated value of X^2 is greater than the critical value, the null hypothesis is rejected.

As an illustration, let us consider a textile manufacturer who is interested in studying the customer preference for designs before commencing a commercial production. He conducts a survey of 100 customers all over the country and classifies their responses in the following way:

Prefer: design I 20, design II 30, design III 18 and design IV 32.

X^2 test can be used to test the hypothesis that the customers have no preference for any particular design.

Under the null hypothesis of no preference for any design, the expected (E_i) and the observed (O_i) frequencies can be given as follows:

Preference	Design I	Design II	Design III	Design IV
E	25	25	25	25
O	20	30	18	32

$$X^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$$

$$= \frac{(20-25)^2}{25} + \frac{(30-25)^2}{25} + \frac{(18-25)^2}{25} + \frac{(32-25)^2}{25} = 5.92$$

The critical value of X^2 at 5 per cent level of significance with 3 (= k − 1) degrees of freedom is 7.81473 (see table of X^2 distribution). As the calculated value of X^2 is less than the critical value, the null hypothesis is rejected. Thus, the survey of customers indicates no particular preference for any design.

Activity 1

The following arrangement indicates whether 25 consecutive persons interviewed by a social scientist are for (F) or against (A) an increase in the number of crimes in a certain locality :

F, F, F, F, F, F, A, F, F, F, F, F, A, F, F, F, F, A, A, F, F, F, F, F, F,

Test whether this arrangement of A's and F's may be regarded as random at 5% level of significance.

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Activity 2

An unbiased coin was tossed 30 times and the following sequence of heads (H) and tails (T) was observed:

H H H T T T T H H T T T H H H T T H H H T T T T H H T H H T

Find out the number of runs in the sample.

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Activity 3

In a given year, the average number of days that a (small) sample of 15 wholesalers of drugs and drug sundries required to convert receivables into cash were 33.9, 35.4, 37.3, 40.9, 27.8, 35.5, 34.6, 41.1, 30.0, 43.2, 33.9, 41.3, 32.0, 37.7 and 35.2 days. Use the one-sample sign test to test the null hypothesis $\mu = 32.0$ days against the alternative hypothesis $\mu > 32$ days at the 0.01 level of significance.

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8.3 TWO SAMPLE TESTS

The two sample tests are used to evaluate the effectiveness (or response) of two treatments, two methods, say, teaching or two promotional strategies in marketing. In each of these cases, the sample which has been administered with the treatment is

compared with the one which has been administered with another treatment. For example, while comparing the two advertising strategies on two groups of consumers, one group might react differently compared to the other not because of the advertisement alone, but also because of other factors such as their background, social status, etc. In problems of this type, there can be two independent samples, or the same sample studied again, i.e., before and after the advertising campaign.

The Sign Test

This test is based on the sign of a pair of observations. The test is of particular use when the measurements of observations are on a qualitative basis. Suppose, for example, in a market research study, the researcher selects a panel of 35 people and obtains their attitudes towards the company's product. He then shows an advertisement and gets their response towards the product. For every person whose rating of the product increased, we have a plus sign and for those whose ratings have declined, we have a negative sign and for the one which remains unchanged, the corresponding sample observation is dropped from the analysis.

The null hypothesis to be tested by the sign test is that

$$p(X_A > X_B) = P(X_A < X_B) = 1/2$$

where X_A is the rating before the advertisement (treatment) and X_B is the rating after the advertisement.

In case of small samples, the probability associated with the occurrence of a particular number of +s and −s is determined with the help of the binomial distribution with $p = q = 1/2$, n is the sample size and x is the number of fewer signs.

We will illustrate the test with the help of an example.

Example : To determine the effectiveness of a new traffic control system, the number of accidents that occurred at a random sample of eight dangerous intersections during the four weeks before and the four weeks following the installation of the new system e observed with the following results:

9 and 5	7 and 3	3 and 4	16 and 11
12 and 7	12 and 5	5 and 5	6 and 1

Use the sign test at the level of significance $\alpha = 0.10$ to test the null hypothesis that the new traffic control system is as effective as the old system against the alternative hypothesis that the new system is more effective.

Solution : There are 6 plus signs, 1 minus and we discard one observation. We have to find the probability of 6 or more success in 7 trials with $p = \frac{1}{2}$ It can be found out using

binomial probability distribution that this probability is 0.063 which is less than $\alpha = 0.10$. Therefore, the null hypothesis must be rejected.

Therefore, the new traffic control is more effective.

Please note that if our sample is large, we may use normal approximation to binomial distribution and carry out Z test as explained earlier.

The Median Test

The sign test discussed above can be used only when the observations are paired, i.e., the elements are studied before and after the treatment. This may not always be possible, as we may have samples of different sizes from two populations. In such a situation, median test is appropriate. The median test is used to give information whether the two independent samples belong to the population with the same median.

The procedure involved in the median test is to pool both the samples and then determine the combined median. Then, the two sample observations are tabulated in the form of a 2×2 table with respect to the median in the following way:

Grouping of samples for Median test

	Number of elements		
	Sample I	Sample II	Total
Above the median	a	b	a + b
Below the median	c	d	c + d
Total	a + c	b + d	$n_1 + n_2$

If both the samples are from the population with the same median, 50 per cent of sample's elements will be above the median and the other 50 per cent below the median. If the number of elements ($n_1 + n_2$) in the two samples is small, we find out

$$P = \frac{\binom{n_1}{a}\binom{n_2}{b}}{\binom{n_1 + n_2}{a + b}}$$

If this probability is greater than α the level of significance, the null hypothesis is accepted, i.e., the two samples have been drawn from the same population.

In order to demonstrate the use of median test, let us consider the following example:

Example : Two different fertilizers were used to a sample of eight plots (of same size) each. The farm yield from these plots are given below:

Plot No.	1	2	3	4	5	6	7	8
Fertilizer A	49	32	44	48	51	34	30	42
Fertilizer B	40	45	50	43	37	47	55	57

The researcher would like to test the hypothesis that the two fertilizers yield the same median output. Let the level of significance be 5 per cent.

Solution : The hypothesis to be tested here is that yield by the two fertilizers have the same median.

The median of the combined sample is 44.5 (i.e. the average of 44 and 45) Grouping the sample elements into elements above and below the median, we get

	Fertilizers		
	I	II	Total
Above the median	3	5	8
Below the median	5	3	8

Since the number of elements (i.e. $n_1 + n_2$) is small, we find

$$P = \frac{\binom{n_1}{a}\binom{n_2}{b}}{\binom{n_1 + n_2}{a + b}} = \frac{\binom{8}{3}\binom{8}{5}}{\binom{16}{8}}$$

$$= 0.244$$

As this probability is greater than 0.05, level of significance, the null hypothesis is accepted. Thus the yield by the two fertilizers have the same median.

When $n_1 + n_2$ is large, we use X^2 (Chi-square) test for accepting or rejecting the null hypothesis. The test incorporating the correction for continuity is given below:

$$X^2 = \frac{N\left[|ad - bc| - \frac{N}{2}\right]^2}{(a + b)(c + d)(a + c)(b + d)}$$

Under null hypothesis, the above statistic follows a Chi-square with 1 degree of freedom. Large values of X^2 are significant for the null hypothesis. The tabulated values of X^2 are obtained from Table 3 given at the end of this unit. Let us illustrate the test with the help of an example.

Example : The table below gives the arithmetic addition scores for 27 individuals belonging to two groups. We want to test the hypothesis of no difference between these two sets of score. We may choose a 5 per cent level of significance.

Table : Scores on an addition Test.

X	Y
12	7
16	12
18	14
7	18
6	5
4	16
11	9
12	10
8	14
20	3
18	18
16	9
10	7
	4

Solution : Group X contains 13 scores and group Y, 14. For the set of 27 scores, we compute the median which is found to be 11.

In case both of these distributions come from the same population, half of the X values and half of the Y values would lie above median and half of the X values and half of the Y values would lie below it. A contingency table is set up as follow:

	X	Y	
Above Median	7 a	6 b	13 a + b
Below median	6 c	8 d	14 c + d
	13 a + c	14 b + d	27 N

We compute X^2 as follows :

$$X^2 = \frac{N\left[\,|\,ad - bc\,| - \frac{N}{2}\,\right]^2}{(a+b)(c+d)(a+c)(b+d)}$$

$$= \frac{27\left[\,|56 - 36\,| - \frac{27}{2}\,\right]^2}{(13)(14)(13)(14)}$$

$$= \frac{27\,[\,20 - 13.5\,]^2}{33,124}$$

$$= \frac{27\,(42.25)}{33,124}$$

$$= 0.034$$

Table value of X^2 with 1 degree of freedom = 6.63. Therefore, X^2 value is not significant. Therefore both these distributions come from same population.

The Mann-Whitney U Test

This test is used to test whether the two samples have been drawn from the same population. This is a most powerful nonparametric test as it could be used for both qualitative and quantitative data. It is a very useful alternative to the t test when you may wish to avoid the assumption of t test.

We will discuss the following three cases for this test.
Case I : Very small samples (when neither of the two samples is geater than 8)

Let n_1 and n_2 ($n_1 < n_2$) be the number of elements in the two samples. These samples are pooled together and the elements are arranged in the ascending order of magnitude, the smallest element first and the largest element the last in the ordering. The value of the test statistic U is given as below: Focusing on the sample with lesser in size (i.e., n_1 in number), U is given by the number of times that a score in the group with n_2 elements precedes a score in the group with n_1 elements, in the ranking. For example, let the elements of the two samples be S_1 : 11, 14, 16 and S_2 : 8, 10, 12 and 15, the sample sizes being 3 and 4. These elements are pooled together and are arranged: $8(S_2)$, $10(S_2)$, $11(S_1)$, $12(S_2)$, $14(S_1)$, $15(S_2)$, $16(S_1)$. To obtain the value of U, we consider the elements of the first sample (smaller in size). In the pooled arrangement, no element of the first sample precede elements 8 or 10 of the second sample while one element (11) of S_1 precede 12 of S_2 two elements (11 and 14) of S_1 precede 15 of S_2 thus, $U = 0 + 0 + 1 + 2 = 3$.

To test the null hypothesis that the samples are obtained from the same population against a suitable alternative hypothesis, you may refer to Tables 4.1 to 4.6 at the end of this unit. These six tables are one for each value of n_2, from $n_2 = 3$ to $n_2 = 8$. These tables are used when neither n_1 or n_2 is larger than 8.

To determine the probability under H_0, you need to know only n_1 (the size of the small group), n_2 and U. In the present example, $n_1 = 3$, $n_2 = 4$, and $U = 3$. For $n_2 = 4$ in Table 4.2 it is given that $U \leq 3$ has a probability of occurrence under H_0 of $p = 0.200$. Since this value is greater than $\alpha = 0.05$, the level of significance, we have not got enough evidence to reject H_0. You may please note that the probabilities given to Tables 4.1 to 4.6 are one-sided. For a two-tailed test, the value of p given in the table should be doubled.

Case 2 : When n_2 is between 9 and 20.

When n_2, the size of the larger sample is between 9 and 20, the significance tests are not made using Tables 4.1 to 4.6. Instead, we make use of Tables 5.1 to 5.4. The test procedure will be explained with the help of an example given below:

Example : Suppose we want to compare the mean lifetimes of two kinds of 9 – volt batteries on the basis of the following lifetime (in hours)

Brand A : 6.9, 11.2, 14.0, 13.2, 9.1, 13.9, 16.1, 9.3, 2.4, 6.4, 18.0, 11.5

Brand B : 15.5, 11.1, 16.0, 15.8, 18.2, 13.7, 18.3, 9.0, 17.2, 17.8, 13.0, 15.1

Using the Mann-Whitney U test, test the hypothesis that there is no difference in the mean lifetime of the two kinds of batteries. You may choose a 5 per cent level of significance.

Solution : We arrange the data jointly, as if they comprise one sample, in an increasing order of magnitude. For the data given in the above example, we get the following

2.4	6.4	6.9	9.0	9.1	9.3	11.1	11.2	11.5
A	A	A	B	A	A	B	A	A
13.0	13.2	13.7	13.9	14.0	15.1		15.5	15.8
B	A	B	A	A	B		B	B
16.0	16.1	17.2	17.8	18.0	18.2		18.3	
B	A	B	B	A	B		B	

For each value, we have indicated whether it belongs to brand A or brand B. The rank of 1 is given to the lowest value which is 2.4 in our case. The value 6.4 gets a rank of 2 and so on. You will find that the lifetimes of the brand A batteries occupy

ranks 1,2,3,5,6,8,9,11,13,14,19 and 22 while those of brand B occupy ranks 4,7,10,12,15,16,17,18,20,21,23 and 24.

You may note that there are no ties here between values belonging to different samples. However, if there were ties, each of the tied observations would be assigned the mean of the ranks which they jointly occupy. Suppose, if the fifth and sixth values were same, we would assign each the rank $\frac{5+6}{2} = 5.5$, and if the seventh, eight, and ninth values were the same, we would assign each the rank $\frac{7+8+9}{3} = 8$

The null hypothesis to be tested in this case is :
H_0 : Two samples come from identical populations.
The alternative hypothesis is :
H_1 : Two samples come from different populations.
We obtain the value of U as follows:

$$U_1 = n_1 n_2 + n_1 \frac{(n_1 + 1)}{2} - R_1$$

or

$$U_2 = n_1 n_2 + \frac{n_2 (n_2 + 1)}{2} - R_2$$

Where R_1 is the sum of the ranks of the values of the first sample and R_2 is the sum of the ranks of the values of the second sample.

For our example, we may compute the values of U_1 and U_2 as

$$U_1 = 12.12 + \frac{12(13)}{2} - 113 = 109$$

and

$$U_2 = 12.12 + \frac{12\,(13)}{2} - 187 = 35$$

Please note that $R_1 = 1 + 2 + 3 + 5 + 6 + 8 + 9 + 11 + 13 + 14 + 19 + 22 = 113$

(sum of the ranks of the values of the first sample)

and

$R_2 = 4 + 7 + 10 + 12 + 15 + 16 + 17 + 18 + 20 + 21 + 23 + 24 = 187$
Now the smaller of the two values U_1 and U_2 is our U which equals 35. Please note that $U_1 + U_2 = 109 + 35 = 144$, which equals $n_1 n_2 = 12.12 = 144$.

Finally, since $U = 35$ is less than 37, the value of U 0.05 for two sided test given $n_1 = 12$ and $n_2 = 12$, (Table 5.3), we find that the null hypothesis must be rejected. Therefore, there is difference in the lifetime of two kinds of batteries.

Case 3 : Large sample (n_2 larger than 20)
For large sample, under the null hypothesis, U has a normal distribution with

$$\text{mean} = \frac{(n_1 n_2)}{2} \text{ and S.D.} = \sqrt{\frac{n_1 n_2 (n_1 + n_2 + 1)}{12}}$$

The test statistics is

$$Z = \frac{U - \frac{n_1 n_2}{2}}{\sqrt{\frac{n_1 n_2 (n_1 + n_2 + 1)}{12}}}$$

This value of Z is compared with the critical value (from the normal probability table) and a decision to accept or reject the null hypothesis is taken.

Example : Following are the scores obtained by two groups of students in a competitive examination. Test whether the two groups belong to the same population.

	Scores											
Group A	51	68,	90,	81,	30,	46,	99,	98,	11,	06,	19,	43
Group B	95,	82,	65,	85,	65,	81,	50,	60,	15,	05,	35,	32

Solution : Since these two sample observations are independent, we use the Mann-Whitney U test to test the hypothesis (H_0) that the two samples belong to the same population. We pool both the samples and rank them. This is done as follows :

Score	05,	06,	11,	15,	19,	30,	32,	35,	43,	46,	50,	51
Group	B	A	A	B	A	A	B	B	A	A	B	A
Rank	1	2	3	4	5	6	7	8	9	10	11	12
Score	60,	65	65,	68,	81,	81,	82,	85,	90,	95,	98,	99
Group	B	B	B	A	A	B	B	B	A	B	A	A
Rank	13	14.5	14.5	16	17.5	17.5	19	20	21	22	23	24

We shall consider the sum of the ranks of elements of group A. Thus, we have $R_1 = 148.5$. Therefore,

$$U = n_1 n_2 + \frac{n_1 (n_1 + 1)}{2} - R_1$$

$$= 15 \times 15 + \frac{15 \times 16}{2} - 148.5 = 198.5$$

$$E(U) = \frac{n_1 n_2}{2} = \frac{15 \times 15}{2} = 112.5$$

$$S.D.(U) = \sqrt{\frac{n_1 n_2 (n_1 + n_2 + 1)}{12}} = \sqrt{\frac{15 \times 15 \times 31}{12}} = 24.109$$

$$Z = \frac{U = E(U)}{S.D.(U)} = \frac{196.5 - 112.5}{24.109} = 3.84$$

At 5 per cent significance, the critical value of Z is 1.96. As the calculated value of Z is greater than the critical value, the null hypothesis is rejected. Thus, the two groups of students do not belong to the same population.

Wilcoxon Matched-Pairs Signed Rank Test

You would recall that in the sign test the value of the difference of scores was used only to determine its sign but its magnitude was not taken into account. The Wilcoxon Matched-Pairs signed rank test incorporates this additional information and attaches a greater weight to matched pair which shows a larger difference. This is therefore, a more powerful test than the sign test.

It is very frequent to come across two-related samples. The common examples are—a study where wife and husband are matched or when some subjects are studied before and after experiment or we are trying to compare the output of two machines. The null hypothesis to be tested in this case is that there are no differences in the two groups with respect to the characteristics under study. The test procedure is as follows:

1) Let di represents the difference score for any matched pair. We rank all the di's without regard to their sign, i.e. rank all |di|'s.

2) To each rank, prefix the sign of the difference.

3) If any di = 0, delete it and reduce the sample size accordingly.

4) If there are ties in some of the values of di's assign an average rank to such pairs by averaging their rank positions. Suppose our sample size is 6, and the di values are

$-0.5, -1, -2, -2, 2, 3$
The absolute values are
0.5, 1, 2, 2, 2, 3

We assign a rank of $\frac{3+4+5}{3} = 4$ to each of the third, fourth and fifth pair.

5) The test statistic T is calculated which happens to be smaller sum of like signed ranks. T is obtained by totalling all the ranks with positive signs and totalling separately all the ranks with negative signs. The smaller of these two sum's is T.

6) For the purpose of accepting or rejecting the null hypothesis of no difference between the values of the given pairs of observations at a desired level of significance, we compare the observed value of T with the tabulated value given in Table 6 at the end of this unit. If observed (calculated) value of T is less than or equal to the tabulated value, we reject the null hypothesis.

Let us illustrate the test with the help of following example.

Example : An experiment is conducted to judge the effect of brand name on quality perception. 16 subjects are recruited for the purpose and are asked to taste and compare two samples of product on a set of scale items judged to be ordinal. The following data are obtained :

Pair	Brand A	Brand B
1	73	51
2	43	41
3	47	43
4	53	41
5	58	47
6	47	32
7	52	24
8	58	58
9	38	43
10	61	53
11	56	52
12	56	57
13	34	44
14	55	57
15	65	40
16	75	68

Test the hypothesis, using Wilcoxan Matched-Pairs signed rank test, that there is no difference between the perceived quality of the two samples. Use 5% level of significance.

Solution : The null hypothesis to be tested is

H_0 : There is no difference between the perceived quality of two samples against the alternative hypothesis

H_1 : There is difference between the perceived quality of two samples.

The value of T statistic can be worked out as under :

Pair	Brand A	Brand B	Difference di	Rank of |di|	Rank with sig +	Rank with sig −
1	73	51	22	13	13	.....
2	43	41	2	2.5	2.5	.....
3	47	43	4	4.5	4.5	.....
4	53	41	12	11	11	.....
5	58	47	11	10	10	.....
6	47	32	15	12	12	.....
7	52	24	28	15	15	.....
8	58	58	0	—	—	—

Pair	Brand A	Brand B	Difference di	Rank of |di|	Rank +	with sig −
9	38	43	− 5	6	...	− 6
10	61	53	8	8	8	.....
11	56	52	4	4.5	4.5	.....
12	56	57	− 1	1	....	− 1
13	34	44	− 10	9	....	− 9
14	55	57	− 2	2.5	....	− 2.5
15	65	40	25	14	14	.....
16	75	68	7	7	7	.....
				Total	101.5	− 18.5
				Hence,	T = 18.5	

The pair number 8 is dropped as 'd' value of this is zero and therefore our sample size reduces to $n = (16 - 1) = 15$

For a two-tailed test, the table value of T at 5% level of significance when $n = 15$ is 25. The calculated value of T is 18.5 which is less than the table value of 25. Therefore, the null hypothesis is rejected and we conclude that there is difference between the perceived quality of the two samples.

In the case of large sample where n exceeds 25, the sampling distribution of T is approximately normal with mean $\overline{T} = \frac{n(n+1)}{4}$ and standard deviation

$\overset{\delta}{T} = \sqrt{\frac{n(n+1)(2n+1)}{24}}$ where n = [(number of matched pairs) −− (number of dropped out pairs, if any)]

We compute

$$Z = \frac{T - \frac{n(n+1)}{4}}{\sqrt{\frac{n(n+1)(2n+1)}{24}}}$$

This is a standard normal variable under H_0. We therefore, use standard normal tables to decide the rejection or acceptance of the null hypothesis.

Activity 4

In a farm experiment, two different treatments A and B were applied to four and five randomly selected plots respectively. The yield from these plots are given below. Use an appropriate test to conclude that the two treatments do not effect the yield significantly.

Treatment A : 17, 12, 16, 10

Treatment B : 15, 8, 14, 9, 13

Activity 5

Below are the scores of a group of normals and a group of psychotics on the picture—completion scale of the Wechsler-Bellevue. Test the hypothesis of no difference using the median test.

N (Normal)	P (Psychotics)
6	7
6	2
14	12
13	13
15	8
6	6
8	4
7	2
10	2
14	12
10	
14	

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Activity 6

The following are the weight gains (in pounds) of two random samples of young Turkeys fed two different diets but otherwise kept under identical conditions:

Diet 1 : 16.3, 10.1, 10.7, 13.5, 14.9, 11.8, 14.3, 10.2, 12.0, 14.7, 23.6, 15.1, 14.5, 18.4, 13.2, 14.0

Diet 2 : 21.3, 23.8, 15.4, 19.6, 12.0, 13.9, 18.8, 19.2, 15.3, 20.1, 14.8, 18.9, 20.7, 21.1, 15.8, 16.2

Use the Mann-Whitney U test at the 0.01 level of significance to test the null hypothesis that the two populations sampled have identical distributions against the alternative hypothesis that on the average the second diet produces a greater gain in weight.

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Activity 7

In the data below, column X represents 10 scores of members of a control group in an experiment. Column Y represents the scores of 10 matched individuals who were given the same test after a period of stress. Test the hypothesis of no difference using Wilcoxan matched — pairs signed — ranks test. You may choose 5% level of significance

X	Y
46	36
68	50
60	58
58	40
42	44
43	43
40	29
56	36
38	46
58	48

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8.4 K SAMPLE TESTS

The tests discussed earlier are concerned with one or two samples. There are several situations where we will have to handle more than two samples simultaneously and decide whether or not these samples belong to the same population. For example, in a large unit, a product is produced by several machines simultaneously and samples are drawn from each machine's output to test for quality. The production manager would like to test whether all the machines produce items of same quality.

The Median Test

This test for k samples is an extension of the median test for two samples. Here the elements of all the samples are pooled together and the combined median is found out. Then the sample elements are tabulated in the form of a $2 \times k$ matrix with respect to the combined median. For example, in case of a 3-sample study, the tabulate result would be as follows:

	Number of elements			
	Sample I	Sample II	Sample III	Total
above the median	a	b	c	a + b + c
below the median	d	e	f	d + e + f

If all the sample elements are from the same population or from populations with same median, equal number of observations lie in the two classifications: above the median and below the median. The associated probability is given by

$$P = \frac{\binom{n_1}{a}\binom{n_2}{b}\binom{n_3}{c}}{\binom{n_1+n_2+n_3}{a+b+c}}$$

If this probability is smaller than α, the level of significance, then the null hypothesis is rejected. i.e., the samples do not belong to the same population. For large samples, X^2 test with $(k-1)$ degrees of freedom is used to accept or reject the null hypothesis.

The Kruskal-Wallis Test

In the test, all the elements of different samples are pooled together and they are ranked with the lowest score receiving a rank value of 1. Ties are treated in the usual fashion for ranking data. If all the samples belong to the same population (the null hypothesis), then the sum of the ranks of the elements of each sample would be equal. Let r_i be the sum of the ranks of the elements of the i^{th} sample. The Kruskal-Wallis test uses the X^2-test to test the null hypothesis. The test statistics is given by

$$H = \frac{12}{n(n+1)} \sum_{i=1}^{k} \frac{r_i^2}{n_i} - 3(n+1)$$

where n is the total number of elements in the k samples. H follows a X^2-distribution with $(k-1)$ degrees of freedom. The null hypothesis is rejected if the calculated value of H is greater than X^2.

Example : In an agricultural field experiment, three different fertilizers were used on sample plots and yields were recorded. On the basis of these data, test the hypothesis that there is no significant difference in yields from three different fertilizers.

	Yield (in MT)							
Fertilizer A	2.48,	3.25,	3.94,	3.45	3.0,	4.0,	3.6,	3.87
Fertilizer B	2.84,	3.1,	3.5,	2.27,	3.88,	2.87,	3.27,	2.8
Fertilizer C	3.4,	3.17,	2.85,	2.46,	3.15,	2.69,	2.88,	3.44

Solution : In order to use the Kruskal-Wallis test, we pool the elements and rank them. These rankings are given below:

Yield	2.27,	2.46,	2.48,	2.69,	2.8,	2.84,	2.85,	2.87,	2.88
Rank	1	2	3	4	5	6	7	8	9
Fertilizer	B	C	A	C	B	B	C	B	C
Yield	3.0,	3.1,	3.15,	3.17,	3.25,	3.27,	3.4,	3.44,	3.45
Rank	10	11	12	13	14	15	16	17	18
Fertilizer	A	B	C	C	A	B	C	C	A
Yield	3.5,	3.6,	3.87,	3.88,	3.94,	4.0			
Rank	19	20	21	22	23	24			
Fertilizer	B	A	A	B	A	A			

From the above rankings, we get $r_1 = 133$, $r_2 = 87$ and $r_3 = 80$. Therefore,

$$H = \frac{12}{n(n+1)} \sum_{i=1}^{3} \frac{r_i^2}{n_i} - 3(n+1)$$

$$= \frac{12}{24(25)} \left[\frac{133^2}{8} + \frac{87^2}{8} + \frac{80^2}{8} \right] - 3 \times 25$$

$$= 79.145 - 75 = 4.145$$

The critical value of H from X^2-distribution with two degrees of freedom at 5 per cent level of significance is 5.99. As the calculated value of H is less than critical value, the null hypothesis is accepted. Thus, all the three fertilizers yield the same level of output.

Activity 8

Using the median test for the data given above, draw your conclusions.

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Activity 9

Use the Kruskal-Wallis H test at 5% level of significance to test the null hypothesis that a professional bowler performs equally well with the four bowling balls, given the following results :

Bowling Results in Five Games

With Ball No. A	271	282	257	248	262
With Ball No. B	252	275	302	268	276
With Ball No. C	260	255	239	246	266
With Ball No. D	279	242	297	270	258

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8.5 SUMMARY

In this unit, we have introduced the role of nonparametric statistical tests in the analysis of statistical data. When the basic assumptions underlying the parametric tests are not valid or when one does not have the knowledge of the distribution of the parameter, then the nonparametric tests are the appropriate tests to draw inferences about the hypotheses. These tests are more suitable for analysing ranked, scaled or rated data. However, when the basic assumptions underlying the parametric tests are valid, the nonparametric tests are less powerful than the parametric tests. Therefore, if for such problems nonparametric tests are used, there is a greater risk of accepting a false hypothesis and thus committing a type II error.

These nonparametric tests are grouped into one sample, two sample and k sample tests. One sample tests are used to study whether there is significant difference between observed and expected frequencies, or whether it is reasonable to accept that the sample drawn is a random sample or whether the sample has been drawn from a specified population. The two sample tests are used to study the effectiveness of two treatments, two methods or two strategies, etc. In problems of this type, there can be two independent samples or the same sample elements are studied again. K-sample tests are an extension of two sample tests. Here, instead of two samples we have more than two samples being studied simultaneously.

8.6 SELF-ASSESSMENT EXERCISES

1) Distinguish the differences between parametric and nonparametric tests. What are the importances of nonparametric tests?

2) A sample of three hundred and fifty people were asked their preferences for four brands of tea. 125 preferred brand A, 100 preferred brand B, 60 preferred brand C and the remaining brand D. Does this indicate a brand preference?

3) A manufacturer of biscuits uses a machine to insert randomly one of the two types of gifts in each box. The manufacturer wants randomness so that every purchaser in the neighbourhood does not get the same gift. A sample of 50 successive boxes are chosen to see if the machine is properly mixing the two types of gifts. The examination of these 50 boxes revealed the data on gifts as follows (X and Y represent two different kinds of gifts).

X Y Y X X X Y Y Y X X Y Y X Y Y X X X Y Y X X Y Y
X Y Y X X X X Y Y X X Y Y X X X Y X X Y Y Y

Using the runs test, what will you conclude about the randomness?

4) The following 40 numbers are taken from a two-digited number table :

41,	61,	51,	81,	68,	30,	81,	90,	46,	99,	98,	11,	06,	
12,	18,	16,	19,	43,	95,	82,	65,	85,	65,	81,	00,	50,	
11,	07,	17,	53,	69,	51,	97,	79,	69,	60,	15,	05,	37	40

Test the randomness of the numbers on the basis of runs up and runs down.

5) Two quality assurance managers independently collected samples of 100 articles from a number of sales depots and tested them for quality. The number of defectives per sales depot were as follows:

Manager A 2, 11, 0, 7, 3, 5, 3, 9

Manager B 8, 5, 4, 3, 6, 12, 5

Test the hypothesis that the two managers have the samples from the same lot by (i) median test and (ii) Maan-Whitney U test.

6) The data related to mean life times of two brands of bulbs are given below:

Brand A 475, 400, 450, 425, 430, 445, 460, 435, 415, 410 420
Brand B 418, 525, 500, 435, 455, 440, 465, 505, 415, 505, 395

Using Maan-Whitney U-test, will you conclude that the life times of two brands of bulbs are equal?

7) A market researcher was interested in testing the preference of consumers for two brand of detergent soaps. The consumers were asked to rate the two brands on the cleaniness it provides on a four-point scale. The consumers response is given below:

Consumer Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Rating for A	4	2	1	4	3	3	4	2	1	4	1	1	2	2	4
Rating for B	2	3	2	3	2	4	2	1	1	3	2	2	2	3	3
Consumer Number	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Rating for A	3	3	4	4	4	4	3	3	3	4	4	4	1	3	3
Rating for B	3	2	3	3	2	4	2	1	2	3	1	3	2	4	2

Will you conclude that the effectiveness of the two brands is the same? Use the sign test.

8) A consumer product sold in a departmental store is often purchased on impulse. Three different stores were tried for this product and weekly sales in units for each store were recorded:

Store A	26,	23,	27,	13,	18,	24,	34,	40,	25,	28
Store B	28,	31,	15,	33,	36,	42,	34,	18		
Store C	21,	12,	23,	35,	17,	29,	28,	30,	32	

Using median test and Kruskal-Wallis test, test the hypothesis that there is no difference in the distribution of sales at three different stores.

9) The quantity of serum albumin (gms) per 10 ml in lepers under three different drugs and the control group were as follows:

Serial No.	Control	Drug A	Drug B	Drug C
1	0.39	0.31	0.43	0.36
2	0.31	0.41	0.40	0.37
3	0.32	0.42	0.41	0.38
4	0.42	0.37	0.38	0.42

Serial No.	Control	Drug A	Drug B	Drug C
5	0.40	0.36	0.33	0.38
6	0.36	0.45	0.36	0.30
7	0.34	0.42	0.45	0.35
8	0.37	0.36	0.32	0.36
9	0.35	0.46	0.42	0.38

Using Kruskal-Wallis test, test the hypothesis that the serum albumin content in different groups of persons under different drugs is the same.

8.7 FURTHER READINGS

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Siegel, S. and Castellan, NJ (Jr), 1988, *Nonparametric Statistics for Behavioural Sciences,* (2nd Ed), McGraw-Hill Book Co., New York.

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Table 1

Critical values of D in the Kolmogorov-Smirnov one sample test

Sample size (N)	Level of significance for D = maximum $\lvert F_0(X) - S_N(X)\rvert$				
	.20	.15	.10	.05	.01
1	.900	.925	.950	.975	.995
2	.684	.726	.776	.842	.929
3	.565	.597	.642	.708	.828
4	.494	.525	.564	.624	.733
5	.446	.474	.510	.565	.669
6	.410	.436	.470	.521	.618
7	.381	.405	.438	.486	.577
8	.358	.381	.411	.457	.543
9	.339	.360	.388	.432	.514
10	.322	.342	.368	.410	.490
11	.307	.326	.352	.391	.468
12	.295	.313	.338	.375	.450
13	.284	.302	.325	.361	.433
14	.274	.292	.314	.349	.418
15	.266	.283	.304	.338	.404
16	.258	.274	.295	.328	.392
17	.250	.266	.286	.318	.381
18	.244	.259	.278	.309	.371
19	.237	.252	.272	.301	.363
20	.231	.246	.264	.294	.356
25	.21	.22	.24	.27	.32
30	.19	.20	.22	.24	.29
35	.18	.19	.21	.23	.27
Over 35	$\frac{1.07}{\sqrt{n}}$	$\frac{1.14}{\sqrt{n}}$	$\frac{1.22}{\sqrt{n}}$	$\frac{1.36}{\sqrt{n}}$	$\frac{1.63}{\sqrt{n}}$

Table 2

Critical values of r in the runs test

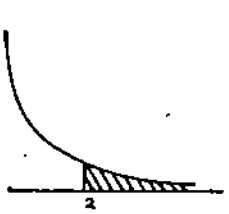
Given in the tables are various critical values of r for values of n_1 and n_2 less than or equal to 20. For the one-sample runs test, any observed value of r which is less than or equal to the smaller value, or is greater than or equal to the larger value in a pair is significant at the $\alpha = .05$ level.

n_2 / n_1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2											2 —	2 —	2 —	2 —	2 —	2 —	2 —	2 —	2 —
3					2 —	2 —	2 —	2 —	2 —	2 —	2 —	2 —	2 —	3 —	3 —	3 —	3 —	3 —	3 —
4				2 9	2 9	2 —	3 —	3 —	3 —	3 —	3 —	3 —	3 —	3 —	4 —	4 —	4 —	4 —	4 —
5			2 9	2 10	3 10	3 11	3 11	3 —	3 —	4 —	4 —	4 —	4 —	4 —	4 —	4 —	5 —	5 —	5 —
6		2 —	2 9	3 10	3 11	3 12	3 12	4 13	4 13	4 13	4 13	5 —	5 —	5 —	5 —	5 —	5 —	6 —	6 —
7		2 —	2 —	3 11	3 12	3 13	4 13	4 14	5 14	5 14	5 14	5 15	5 15	5 15	6 —	6 —	6 —	6 —	6 —
8		2 —	3 —	3 11	3 12	4 13	4 14	5 14	5 15	5 15	6 16	6 16	6 16	6 16	6 17	7 17	7 17	7 17	7 17
9		2 —	3 —	3 —	4 13	4 14	5 14	5 15	5 16	6 16	6 16	6 17	7 17	7 18	7 18	7 18	8 18	8 18	8 18
10		2 —	3 —	3 —	4 13	5 14	5 15	5 16	6 16	6 17	7 17	7 18	7 18	7 18	8 19	8 19	8 19	8 20	9 20
11		2 —	3 —	4 —	4 13	5 14	5 15	6 16	6 17	7 17	7 18	7 19	8 19	8 19	8 20	9 20	9 20	9 21	9 21
12	2 —	2 —	3 —	4 —	4 13	5 14	6 16	6 16	7 17	7 18	7 19	8 19	8 20	8 20	9 21	9 21	9 21	10 22	10 22
13	2 —	2 —	3 —	4 —	5 —	5 15	6 16	6 17	7 18	7 19	8 19	8 20	9 20	9 21	9 21	10 22	10 22	10 23	10 23
14	2 —	2 —	3 —	4 —	5 —	5 15	6 16	7 17	7 18	8 19	8 20	9 20	9 21	9 22	10 22	10 23	10 23	11 24	11 24
15	2 —	3 —	3 —	4 —	5 —	6 15	6 16	7 18	7 18	8 19	8 20	9 21	9 22	10 22	10 23	11 23	11 24	11 24	12 25

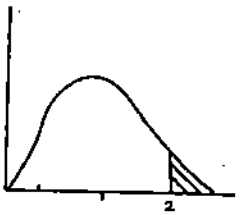
n_2 / n_1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
16	2	3	4	4	5	6	6	7	8	8	9	9	10	10	11	11	11	12	12
	—	—	—	—	—	—	17	18	19	20	21	21	22	23	23	24	25	25	25
17	2	3	4	4	5	6	7	7	8	9	9	10	10	11	11	11	12	12	13
	—	—	—	—	—	—	17	18	19	20	21	22	23	23	24	25	25	26	26
18	2	3	4	5	5	6	7	8	8	9	9	10	10	11	11	12	12	13	13
	—	—	—	—	—	—	17	18	19	20	21	22	23	24	25	25	26	26	27
19	2	3	4	5	6	6	7	8	8	9	10	10	11	11	12	12	13	13	13
	—	—	—	—	—	—	17	18	20	21	22	23	23	24	25	26	26	27	27
20	2	3	4	5	6	6	7	8	9	9	10	10	11	12	12	13	13	13	14
	—	—	—	—	—	—	17	18	20	21	22	23	24	25	25	26	27	27	28

Table 3

Proportions of Area for the X^2 Distribution



For df = 1.2



For df ≥ 30

	Proportion of area										
df	0.995	0.990	0.975	0.950	0.900	0.500	0.100	0.050	0.025	0.010	0.005
1	0.00004	0.00016	0.00098	0.00393	0.0158	0.455	2.71	3.84	5.02	6.63	7.88
2	0.0100	0.0201	0.0506	0.103	0.211	1.386	4.61	5.99	7.38	9.21	10.60
3	0.072	0.115	0.216	0.352	0.584	2.366	6.25	7.81	9.35	11.34	12.84
4	0.207	0.297	0.484	0.711	1.064	3.357	7.78	9.49	11.14	13.28	14.86
5	0.412	0.554	0.831	1.145	1.61	4.251	9.24	11.07	12.83	15.09	16.75
6	0.676	0.872	1.24	1.64	2.20	5.35	10.64	12.59	14.45	16.81	18.55
7	0.989	1.24	1.69	2.17	2.83	6.35	12.02	14.07	16.01	18.48	20.28
8	1.34	1.65	2.18	2.73	3.49	7.34	13.36	15.51	17.53	20.09	21.96
9	1.73	2.09	2.70	3.33	4.17	8.34	14.68	16.92	19.02	21.67	23.59
10	2.16	2.56	3.25	3.94	4.87	9.34	15.99	18.31	20.48	23.21	25.19
11	2.60	3.05	3.82	4.57	5.58	10.34	17.28	19.68	21.92	24.73	26.76
12	3.07	3.57	4.40	5.23	6.30	11.34	18.55	21.03	23.34	26.22	28.30
13	3.57	4.11	5.01	5.89	7.04	12.34	19.81	22.36	24.74	27.69	29.82
14	4.07	4.66	5.63	6.57	7.79	13.34	21.06	23.68	26.12	29.14	31.32
15	4.60	5.23	6.26	7.26	8.55	14.34	22.31	25.00	27.49	30.58	32.80
16	5.14	5.81	6.91	7.96	9.31	15.34	23.54	26.30	28.85	32.00	34.27
17	5.70	6.41	7.56	8.67	10.09	16.34	24.77	27.59	30.19	33.41	35.72
18	6.26	7.01	8.23	9.39	10.86	17.34	25.99	28.87	31.53	34.81	37.16
19	6.84	7.63	8.91	10.12	11.65	18.34	27.20	30.14	32.85	36.19	38.58
20	7.43	8.26	9.59	10.85	12.44	19.34	28.41	31.41	34.17	37.57	40.00
21	8.03	8.90	10.28	11.59	13.24	20.34	29.62	32.67	35.48	38.93	41.40
22	8.64	9.54	10.98	12.34	14.04	21.34	30.81	33.92	36.78	40.29	42.80
23	9.26	10.20	11.69	13.09	14.85	22.34	32.01	35.17	38.08	41.64	44.18
24	9.89	10.86	12.40	13.85	15.66	23.34	33.20	36.42	39.36	42.98	45.56
25	10.52	11.52	13.12	14.61	16.47	24.34	34.38	37.65	40.65	44.31	46.93
26	11.16	12.20	13.84	15.38	17.29	25.34	35.56	38.89	41.92	45.64	48.29
27	11.81	12.83	14.57	16.15	18.11	26.34	36.74	40.11	43.19	46.96	49.64
28	12.46	13.56	15.31	16.93	18.94	27.34	37.92	41.34	44.46	48.28	50.99
29	13.12	14.26	16.05	17.71	19.77	28.34	39.09	42.56	45.72	49.59	52.34
30	13.79	14.95	16.79	18.49	20.60	29.34	40.26	43.77	46.98	50.89	53.67
40	20.71	22.16	24.43	26.51	29.05	39.34	51.81	55.76	59.34	63.34	66.77
50	27.99	29.71	32.36	34.76	37.69	49.33	63.17	67.50	71.42	76.15	79.49
60	35.53	37.43	40.48	43.19	46.46	59.33	74.40	79.08	83.30	88.38	91.95
70	43.28	45.44	48.76	51.74	55.33	69.33	85.53	90.53	95.02	100.4	104.2
80	51.17	53.54	51.17	60.39	64.28	79.33	98.58	101.9	106.6	112.3	116.3
90	59.20	61.75	65.65	69.13	73.29	89.33	107.6	113.1	118.1	124.1	128.3
100	67.33	70.06	74.22	77.93	82.36	99.33	118.5	124.3	129.6	135.8	140.2

Table 4

Table of probabilities associated with values as small as observed values of U in the Mann-Whitney Test

Table 4.1 $n_2 = 3$

n_1 / U	1	2	3
0	.250	.100	.050
1	.500	.200	.100
2	.750	.400	.200
3		.600	.350
4			.560
5			.650

Table 4.2 $n_2 = 4$

n_1 / U	1	2	3	4
0	.200	.067	.028	.014
1	.400	.133	.057	.029
2	.600	.267	.114	.057
3		.400	.200	.100
4		.600	.314	.171
5			.429	.243
6			.571	.343
7				.443
8				.557

Table 4.3 $n_2 = 5$

n_1 / U	1	2	3	4	5
0	.167	.047	.018	.008	.004
1	.333	.095	.036	.016	.008
2	.500	.190	.071	.032	.016
3	.667	.286	.125	.056	.028
4		.429	.196	.095	.018
5		.571	.286	.113	.075
6			.393	.206	.111
7			.500	.278	.155
8			.607	.365	.210
9				.452	.274
10				.548	.345
11					.421
12					.500
13					.579

Table 4.4 $n_2 = 6$

n_1 / U	1	2	3	4	5	6
0	.143	.036	.012	.005	.002	.001
1	.286	.071	.024	.010	.004	.002
2	.428	.143	.048	.019	.009	.004
3	.571	.214	.083	.033	.015	.008
4		.321	.131	.057	.026	.013
5		.429	.190	.086	.041	.021
6		.571	.274	.129	.063	.032
7			.357	.176	.089	.047
8			.452	.238	.123	.066
9			.548	.305	.165	.090
10				.381	.214	.120
11				.457	.268	.155
12				.545	.331	.197
13					.396	.242
14					.465	.294
15					.535	.350
16						.409
17						.469
18						.531

Table 4.5 $n_2 = 7$

Table of probabilities associated with values as small as observed values of U in the Mann-Whitney Test (*Continued*)

n_1 / U	1	2	3	4	5	6	7
0	.125	.028	.008	.003	.001	.001	.000
1	.250	.056	.017	.006	.003	.001	.001
2	.375	.111	.033	.012	.005	.002	.001
3	.500	.167	.058	.021	.009	.004	.002
4	.625	.250	.092	.036	.015	.007	.003
5		.333	.133	.055	.024	.011	.006
6		.444	.192	.082	.037	.017	.009
7		.556	.258	.115	.053	.026	.013
8			.333	.158	.074	.037	.019
9			.417	.206	.101	.051	.027
10			.500	.264	.134	.069	.036
11			.583	.324	.172	.090	.049
12				.391	.216	.117	.064
13				.464	.265	.147	.082
14				.588	.319	.183	.104
15					.378	.223	.130
16					.438	.267	.159
17					.500	.314	.191
18					.562	.365	.228
19						.418	.267
20						.473	.310
21						.527	.355
22							.402
23							.451
24							.500
25							.549

Table 4.6 $n_2 = 8$

Table of probabilities associated with values as small as observed values of U in the Mann-Whitney Test (*Continued*)

n_1 / U	1	2	3	4	5	6	7	8	zNormal	
0	.111	.022	.006	.002	.001	.000	.000	.000	3.308	.001
1	.222	.044	.012	.004	.002	.001	.000	.000	3.203	.001
2	.333	.089	.024	.008	.003	.001	.001	.000	3.098	.001
3	.444	.133	.042	.014	.005	.002	.001	.001	2.993	.001
4	.556	.200	.067	.024	.009	.004	.002	.001	2.888	.002
5		.267	.097	.036	.015	.006	.003	.001	2.783	.003
6		.356	.139	.055	.023	.010	.005	.002	2.678	.004
7		.444	.188	.077	.033	.015	.007	.003	2.573	.005
8		.556	.218	.107	.047	.021	.010	.005	2.468	.007
9			.315	.141	.064	.030	.014	.007	2.363	.009
10			.387	.184	.085	.041	.020	.010	2.258	.012
11			.461	.230	.111	.054	.027	.014	2.153	.016
12			.539	.285	.142	.071	.036	.019	2.048	.020
13				.341	.177	.091	.047	.025	1.913	.026
14				.404	.217	.114	.060	.032	1.833	.033
15				.467	.262	.141	.076	.041	1.733	.044
16				.533	.311	.172	.095	.052	1.628	.052
17					.362	.207	.116	.065	1.523	.064
18					.416	.245	.140	.080	1.418	.078
19					.472	.286	.168	.097	1.313	.094
20					.528	.331	.198	.117	1.208	.113
21						.377	.232	.139	1.102	.135
22						.426	.268	.164	.998	159
23						.475	.306	.191	.893	.185
24						.525	.317	.221	.788	.215
25							.389	.253	.683	.247
26							.433	.287	.578	.282
27							.478	.323	.473	.318
28							.522	.360	.368	.356
29								.399	.263	.396
30								.439	.158	.437
31								.480	.052	.481
32								.520		

Table 5.1 $n_2 = 9$

Table of critical values of U in the Mann-Whitney Test
Critical Values of U for a One-tailed Test at $\alpha = .001$ or for a Two-tailed Test at $\alpha = .002$

n_2 / n_1	9	10	11	12	13	14	15	16	17	18	19	20
1												
2									0	0	0	0
3		0	0	0	1	1	1	2	2	3	3	3
4	1	1	2	2	3	3	4	5	5	6	7	7
5	2	3	4	4	5	6	7	8	9	10	11	12
6	3	5	6	7	8	9	10	11	13	14	15	16
7	5	6	8	9	11	12	14	15	17	18	20	21
8	7	8	10	12	14	15	17	19	21	23	25	26
9	8	10	12	14	17	19	21	23	25	27	29	32
10	10	12	15	17	20	22	24	27	29	32	34	37
11	12	14	17	20	23	25	28	31	34	37	40	42
12	14	17	20	23	26	29	32	35	38	42	45	48
13	15	19	22	25	29	32	36	39	43	46	50	54
14	17	21	24	28	32	36	40	43	47	51	55	59
15	19	23	27	31	35	39	43	48	52	56	60	65
16	21	25	29	34	38	43	47	52	57	61	66	70
17	23	27	32	37	42	46	51	56	61	66	71	76
18	25	29	34	40	45	50	55	60	66	71	77	82
19	26	32	37	42	48	54	59	65	70	76	82	88
20												

Table 5.2

Table of critical values of U in the Mann-Whitney Test (*Continued*)
Critical Values of U for a One-tailed Test at $\alpha = .01$ or for a Two-tailed Test at $\alpha = .02$

n_1 \ n_2	9	10	11	12	13	14	15	16	17	18	19	20
1												
2					0	0	0	0	0	0	1	1
3	1	1	1	2	2	2	3	3	4	4	4	5
4	3	3	4	5	5	6	7	7	8	9	9	10
5	5	6	7	8	9	10	11	12	13	14	15	16
6	7	8	9	11	12	13	15	16	18	19	20	22
7	9	11	12	14	16	17	19	21	23	24	26	28
8	11	13	15	17	20	22	24	26	28	30	32	34
9	14	16	18	21	23	26	28	31	33	36	38	40
10	16	19	22	24	27	30	33	36	38	41	44	47
11	18	22	25	28	31	34	37	41	44	47	50	53
12	21	24	28	31	35	38	42	46	49	53	56	60
13	23	27	31	35	39	43	47	51	55	59	63	67
14	26	30	34	38	43	47	51	56	60	65	69	73
15	28	33	37	42	47	51	56	61	66	70	75	80
16	31	36	41	46	51	56	61	66	71	76	82	87
17	33	38	44	49	55	60	66	71	77	82	88	93
18	36	41	47	53	59	65	70	76	82	88	94	100
19	38	44	50	56	63	69	75	82	88	94	101	107
20	40	47	53	60	67	73	80	87	93	100	107	114

Table 5.3 Table of Critical Values or U in the Mann-Whitney Test (*Continued*)
Critical Values of U for a One-tailed Test at $\alpha = .025$ or for a Two-tailed Test at $\alpha = .05$

n_1 \ n_2	9	10	11	12	13	14	15	16	17	18	19	20
1												
2	0	0	0	1	1	1	1	1	2	2	2	2
3	2	3	3	4	4	5	5	6	6	7	7	8
4	4	5	6	7	8	9	10	11	11	12	13	13
5	7	8	9	11	12	13	14	15	17	18	19	20
6	10	11	13	14	16	17	19	21	22	24	25	27
7	12	14	16	18	20	22	24	26	28	30	32	34
8	15	17	19	22	24	26	29	31	34	36	38	41
9	17	20	23	26	28	31	31	37	39	42	45	48
10	20	23	26	29	33	36	39	42	45	48	52	55
11	23	26	30	33	37	40	44	47	51	55	58	62
12	26	29	33	37	41	45	49	53	57	61	65	69
13	28	33	37	41	45	50	54	59	63	67	72	76
14	31	36	40	45	50	55	59	64	67	74	78	83
15	34	39	44	49	54	59	64	70	75	80	85	90
16	37	42	47	53	59	64	70	75	81	86	92	98
17	39	45	51	57	63	67	75	81	87	93	99	105
18	42	48	55	61	67	74	80	86	93	99	106	112
19	45	52	58	65	72	78	85	92	99	106	113	119
20	48	55	62	69	76	83	90	98	105	112	119	127

Table 5.4 Table of Critical Values of U in the Mann-Whitney Test (*Continued*)
Critical Values of U for a One-tailed Test at $\alpha = .05$ or for a Two-tailed Test at $\alpha = .10$

n_1 \ n_2	9	10	11	12	13	14	15	16	17	18	19	20
1												
2	1	1	1	2	2	2	3	3	3	4	4	4
3	3	3	5	5	6	7	7	8	9	9	10	11
4	6	7	8	9	10	11	12	14	15	16	17	18
5	9	11	12	13	15	16	18	19	20	22	23	25
6	12	14	16	17	19	21	23	25	26	28	30	32
7	15	17	19	21	24	26	28	30	33	35	37	39

n_1 \ n_2	9	10	11	12	13	14	15	16	17	18	19	20
8	18	20	23	26	28	31	33	36	39	44	44	47
9	21	24	27	30	33	36	39	42	45	48	51	54
10	24	27	31	34	37	41	44	48	51	55	58	62
11	27	31	34	38	42	46	50	51	57	61	65	69
12	30	31	38	42	47	51	55	60	64	68	72	77
13	33	37	42	47	51	56	64	65	70	75	80	81
14	36	41	46	51	56	61	66	71	77	82	87	92
15	39	44	50	55	61	66	72	77	88	88	94	100
16	42	48	54	60	65	71	77	83	89	95	101	107
17	45	51	57	64	70	77	83	89	96	102	109	115
18	48	55	61	68	75	82	88	95	102	109	116	123
19	51	58	65	72	80	87	94	101	109	116	123	130
20	51	62	69	77	84	92	100	107	115	123	130	138

Table 6

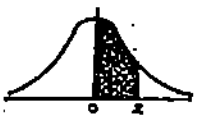
Critical Values of T IN THE WILCOXON MATCHED-PAIRS TEST

	Level of significance for one-tailed test		
	.025	.01	.005
	Level of significance for two-tailed test		
n	.05	.02	.01
6	0	—	—
7	2	0	—
8	4	2	0
9	6	3	2
10	8	5	3
11	11	7	5
12	14	10	7
13	17	13	10
14	21	16	13
15	25	20	16
16	30	24	20
17	35	28	23
18	40	33	28
19	46	38	32
20	52	43	38
21	59	49	43
22	66	56	49
23	73	62	55
24	81	69	61
25	89	77	68

Table 7

Area Under Normal Curve

An entry in the table is the proportion under the entire curve which is between $z = 0$ and a positive value of z. Areas for negative values for z are obtained by symmetry.



Areas of a standard normal distribution

z	.0	0.01	.02	.03	.04	.05	.06	.07	.08	.09
.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0753
.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
.6	.2257	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2517	.2549
.7	.2580	.2611	.2642	.2673	.2903	.2734	.2764	.2794	.2823	.2852
.8	.2881	.2910	.2939	.2967	.2995	.3023	.3051	.3078	.3106	.3133
.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621

z	.0	.001	.02	.03	.04	.05	.06	.07	.08	.09
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4657	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4993	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

UNIT 9 MULTIVARIATE ANALYSIS OF DATA

Objectives

After studying this unit, you should be able to:

- explain the concept of association that takes place between a dependent variable and a set of independent variables
- describe the various multivariate procedures available to analyse associative data in the context of any research problem
- interpret the findings of multivariate analysis in any research study
- use a particular technique of multivariate analysis suitable for a particular business research problem.

Structure

9.1 INTRODUCTION

In MS-8 (Quantitative Analysis for Managerial Applications), we have covered the fundamentals of statistical inference with special emphasis on hypothesis testing as an effective tool for business decisions. Univariate analysis forms the foundation for the development of multivariate analysis, which is the topic of discussion in this unit. While the concept of the univariate analysis will continue to draw our attention time and again, our focus in this unit will be on procedures of multivariate analysis which has emerged as the most striking trend in business research methodology.

Description and analysis of associative data involves studying the relationship and degree of association among several variables and therefore multivariate procedures become imperative. We shall attempt to highlight the procedures. We have discussed here three multivariate techniques, namely Regression Analysis, Discriminant Analysis and Factor Analysis.

Regression analysis finds out the degree or relationship between a dependent variable and a set of independent variables by fitting a statistical equation through the method of least square. Whenever we are interested in the combined influence of several independent variables upon a dependent variable our study is that of multiple regression. For example, demand may be influenced not only by price but also by growth in industrial production, extent of import prices of other goods, consumer's income, taste and preferences etc. Business researchers could use regression for explaining per cent variation in dependent variable caused by a number of independent variables and also problems involving prediction or forecasting.

Discriminant analysis is useful in situations where a total sample could be classified into mutually exclusive and exhaustive groups on the basis of a set of predictor variables. Unlike the regression analysis these predictor variables need not be independent. For example, one may wish to predict whether sales potential in a particular marketing territory will be 'good' or 'bad' based on the territory's personal disposal income, population density and number of retail outlets. You may like to classify a consumer as a user or non-user of one of the five brands of a product based on his age, income and length of time spent in his present job. Here the interest is what variables discriminate well between groups.

Factor analysis provides an approach that reduces a set of variables into one or more underlying variables. The technique groups together those variables that seem to belong together and simultaneously supplies the weighing scheme. For example, one may be interested in the identification of factors that determine the company's image. When the decision maker is overwhelmed by many variables the factor analysis comes to his help in compressing many variables into a few meaningful dimensions, like service orientation, quality level and width of assortment in a research project involving 20 retail chains on 35 factors or variables.

9.2 REGRESSION ANALYSIS

Regression analysis is probably the most widely applied technique amongst the analytical models of association used in business research. Regression analysis attempts to study the relationship between a dependent variable and a set of independent variables (one or more). For example, in demand analysis, demand is versely related to price for normal commodities. We may write $D = A - BP$, where D is the demand which is the dependent variable, P is the unit price of the commodity, an independent variable. This is an example of a simple linear regression equation. The multiple linear regressions model is the prototype of single criterion/multiple predictor association model where we would like to study the combined influence of serveral independent variables upon one dependent variable. In the above example if P is the consumer price index, and Q is the index of industrial production, we may be able to study demand as a function of two independent variables P and Q and write $D = A - BP + C Q$ as a multiple linear regression model.

The objectives of the business researchers in using Regression Analysis are :

1) To study a general underlying pattern connecting the dependent variable and independent variables by establishing a functional relationship between the two. In this equation the degree of relationship is derived which is a matter of interest to the researcher in his study.
2) To use the well-established regression equation for problems involving prediction and forecasting.
3) To study how much of the variation in the dependent variable is explained by the set of independent variables. This would enable him to remove certain unwanted variables from the system. For example, if 95% of variation in demand in a study could be explained by price and consumer rating index, the researcher may drop other factors like industrial production, extent of imports, substitution effect etc. which may contribute only 5% of variation in demand provided all the causal variables are linearly independent.

We proceed by first discussing bivariate (simple) regression involving the dependent variables as a function of one independent variable and then onto multiple regression.

Simple linear regression model is given by

$$Y = \beta_0 + \beta_1 X_1 + \epsilon$$

where Y is the dependent variable,

X_1 is independent variable

ϵ is a random error term

β_0 and β_1 are the regression coefficients to be estimated.

Assumptions of the model

1) The relationship between Y and X_1 is linear.
2) Y is a random variable which follows a normal distribution from which sample values are drawn independently.
3) X_1 is fixed and is non-stochastic (non-random).
4) The means of all these normal distribution of Y as conditioned by X_1 lie on a straight line with slope β_1.
5) ϵ is the error term $\cap$ IND $(0, \sigma^2)$ and independent of X_1.

Computational aspect :

Estimated regression line based on sampling is written as $\hat{Y} = a + bX_i$

a and b are estimates of β_0 and β_1 obtained through the method of least square by minimising the error sum of squares.

We state the normal equations without going into any derivations. The normal equations are :

$$\sum_i Y = na + b \sum X_i$$

$$\sum X_i Y = a \sum X_i + b \sum X_i^2$$

Solve these two simultaneous equations you get the values of a and b.

Total sum of squares = $\Sigma (Y - \hat{Y})^2$
(TSS)

Regression sum of squares = $\Sigma (\hat{Y} - \bar{Y})^2$
(RSS)

Error sum of squares = $\Sigma (Y - \hat{Y})^2$
(ESS)

Form the ANOVA Table for Regression

Source	D.F.	Sum of squares	Mean squares	F ratio
Due to Regression	1	RSS	$\frac{RSS}{1}$	$\frac{RSS}{1} \div \frac{ESS}{(n-2)}$
Due to Error	$n-2$	ESS	$\frac{ESS}{n-2}$	
Total	$n-1$	TSS		

H_0 $\beta_1 = 0$ There is no linear relationship between Y and X_i (Y & X_i are independent).
H_1 $\beta_1 \neq 0$ There is linear relationship between Y and X_i as stated in our model.

If the calculated F exceeds Table F (1, $n-2$) at 5% level, reject H_0 and accept H_1.

Strength of association

It is one thing to find the regression equation after validating the linearity relationship; but at this point we still do not know how strong the association is. In other words, how well does X_i predict Y?

This is measured by the co-efficient of determination

$r^2 = \frac{RSS}{TSS}$ = Variation in Y explained by regression compared to total variation.

Higher the r^2, greater is the degree of relationship.

The product moment correlation or simple correlation co-efficient between Y and X_i is $= \sqrt{r^2} = \sqrt{\frac{RSS}{TSS}}$

r^2 lies between 0 and 1.0 measuring no correlation and 1 measuring perfect correlation.

r lies between -1 and $+1$ and the sign of r is determined by the sign of the sample regression coefficient (b) in the sample regression equation

$$\hat{Y} = a + bX_i$$

Having given a foundation structure with underlying assumptions and possible analysis of the model, we now turn our attention to a numerical example to clarify the concepts. It is needless to mention that analysis of data and interpretation of the results are of paramount importance.

Suppose that a researcher is interested in consumer's attitude towards nutritional diet of a ready-to-eat cereal.

X_1: the amount of protein per standard serving

In the nature of a pretest, the researcher obtains consumer's interval-scaled evaluation of the ten concept descriptions, on a preference rating scale ranging from 1, dislike extremely, upto 9, like extremely well. The data is given below.

Rater	Preference rating (Y)	Protein X_1	
1	3	4	$\Sigma Y = 43 \overline{Y} = 4.3$
2	7	9	
3	2	3	$\Sigma X_1 = 43\ \overline{X}_1 = 4.3$
4	1	1	
5	6	3	$\Sigma Y X_1 = 247$
6	2	4	
7	8	7	$\Sigma X_1^2 = 255$
8	3	3	
9	9	8	
10	2	1	

i) Fit a linear regression model of Y on X_1.

ii) Test the validity of the equation statistically.

iii) What do you think of the strength of association?

Answer

i) The normal equations are

$\Sigma Y = na + b\Sigma X_1$ Here $n = 10$

$\Sigma X_1 Y = a\ \Sigma X_i + b\ \Sigma X_i^2$

i.e. $10a + 43b = 43$

$43a + 255b = 247$

solving these two simultaneous equations

we have $b = 0.886$

$a = 0.491$

Regression Equation is $\hat{Y} = 0.491 + 0.886X_1$

substitute for all X to get Y^s

The regression co-efficient $b = 0.886$ indicates the change in Y per unit change in X_1

ii) Validity of the equation

ANOVA calculation

$$\text{Total sum of squares (TSS)} = \Sigma (Y - \overline{Y})^2$$
$$= (3 - 4.3)^2 + (7 - 4.3)^2 + ... + (2 - 4.3)^2$$
$$= 76.10$$

- $$\text{Regression sum of squares (RSS)} = \Sigma (Y - \overline{Y})^2$$
$$= (4.034 - 4.3)^2 + (8.464 - 4.3)^2 + ...$$
$$+ (1.377 - 4.3)^2 = 55.01$$

- $$\text{Error sum of squares} = \Sigma (\hat{Y} - Y)^2 = (-1.034)^2 + (-1.464)^2 + ... + (0.623)^2$$
$$= 21.09$$

- Table of Actual Vs predicted

Actual Y	Predicted $\hat{Y}$	Error $Y - \hat{Y}$
3	4.034	− 1.034
7	8.464	− 1.464
2	3.148	− 1.148
1	1.377	− 0.377
6	3.148	− 2.852
2	4.034	− 2.034
8	6.692	− 1.308
3	3.148	− 0.148
9	7.579	− 1.422
2	1.377	− 0.623
$\hat{Y} = 4.3$		

ANOVA Table

Source	Degrees of Freedom	Sum of Squares	Mean Squares	F ratio
Due to regression	1	55.01	$\frac{55.01}{1} = 55.01$	$\frac{55.01}{2.64} = 20.84$
Due to error	8	21.09	$\frac{21.09}{8} = 2.64$	
Total	9	76.10		

H_0: There is no relationship of linear type between Y and X_1
i.e. $\beta_1 = 0$
H_1: Y is linearly related to X_1 i.e. $\beta_1 \neq 0$

Interpretation of results
Calculated F = 20.84 exceeds Table F (1,8) = 5.32 at 5% level. Reject H_0 and accept H_1. We conclude Y is a linear function of X_1 with a confidence level of 95%. In other words, preference rating Y is linearly related to amount of (X_1) protein per standard serving of the cereal with a confidence level of 95%. Thus the equation is a valid one.

iii) Strength of association

$$\text{Co-efficient determination } r^2 = \frac{RSS}{TSS} = \frac{55.01}{76.10} = 0.723$$

This implies that 72.3% of the variation in Y is explained by the regression and only 27.7% of the variation is explained by error. The association is strong to enable X_1 to predict Y.

$$r = \sqrt{r^2} = 0.850$$

Here r will have a positive sign since b is positive. Before starting our discussion on the multiple regression, let us give a brief account of the usefulness of simple linear regression in sales forecasting using time series data in which time t is an independent variable.

1) Linear Trend
$Y = a + bt$

If Y represents the sales data collected for the past many years, for example, last 10 years from 1979 to 1988, we normalise the year by taking t = 1 corresponding to 1979. t = 2 for 1980 etc. and t = 10 for 1988. Now, the simple linear regression model can be directly applied to forecast Y (sales), say for 1989 after fitting the regression equation.

2) Trend in semilog form
$Y = ab^t$
Taking log on both sides we have
Log Y = Log a + t log b
This reduces to $Z = A + Bt$

where $Z = \text{Log } y$
$A = \text{Log } a$
$B = \text{Log } b$

This can now be solved as a simple linear regression model for forecast where Z is dependent variable and t is independent variable as before.

3) Double log form
$Y = at^b$
Log Y = log a + b log t
i.e. $Z = A + bT$
where Z = log Y A = log a_1, T = log t.

This can now be sloved as normal bivariate regression equation to forecast sales for the next period.

It is time to introduce the concept of multiple regression model

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 ..... + \beta_k X_k + \epsilon$$

The assumptions are exactly same as simple linear regression except that you add $X_1, X_2, ... X_k$ in the place of X_1 because Y is linearly related to $X_1 ..... X_k$ and our aim is to understand the combined influence of the K factors $X_1, X_2 ..... X_k$ on Y. To understand the concept clearly, let us study a case of 2 independent variables and write the model as

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \epsilon$$

so that $\hat{Y} = a + b X_1 + cX_2$ being the estimated regression equation where we add one more independent variable X_2 in the model. Suppose we extend the previous example of bivariate regression on preference rating Vs. protein (X_1) by adding X_2: the percentage of minimum daily requirements of vitamin D per standard serving. Let us see how the multiple regression model emerges to explain the variation in the dependent variable Y caused by X_1 and X_2. Let us look at the following table giving the data on Y, X_1, and X_2.

Rater	Preference Rating Y	Protein X_1	Vitamin D X_2	
1	3	4	2	
2	7	9	7	$\Sigma Y = 43$
3	2	3	1	$\Sigma X_1 = 43$
4	1	1	2	$\Sigma X_2 = 40$
5	6	3	3	
6	2	4	4	$\Sigma YX_1 = 247$
7	8	7	9	$\Sigma YX_2 = 232$
8	3	3	2	$\Sigma X_1^2 = 255$
9	9	8	7	$\Sigma X_2^2 = 226$
10	2	1	3	$\Sigma X_1X_2 = 229$

The normal equations are:

$$\Sigma Y = Na + b \Sigma X_1 + c \Sigma X_2$$
$$\Sigma YX_1 = a \Sigma X_1 + b \Sigma X_1^2 + c \Sigma X_1 X_2$$
$$\Sigma YX_2 = a \Sigma X_2 + b \Sigma X_1X_2 + c \Sigma X_2^2$$

$$10a + 43b + 40c = 43$$
$$43a + 255b + 229c = 247$$
$$40a + 229b + 226c = 232$$

Solving for a, b and c we have

$$a = 0.247$$
$$b = 0.493$$
$$c = 0.484$$
$$\hat{Y} = 0.247 + 0.493 X_1 + 0.484 X_2$$

Here b and c are called partial regression co-efficients, b = 0.493 denotes the change in $\hat{Y}$ per unit change in X_1 when X_2 is held constant. Similarly c = 0.484 denotes the change in $\hat{Y}$ per unit change in X_2 when X_1 is held constant.

By now you must have noticed the cumbersome calculations involved when the number of variables increase and becomes extremely difficult when the number of variables is more than 3. One has to resort to computer based regression models. In fact it may be mentioned here that all multivariate procedures require the help of computer when the variables and observations are large. As before we can calculate the other co-efficients like R^2 co-efficient of multiple determination and R multiple correlation co-efficient and also ANOVA for hypothesis testing. The author has developed his own user friendly program for multiple regression with a conversational style based on IBM PC MS DOS. We will use the output of the program and interpret the results of our problem which is the most important aspect for us.

Multiple Linear Regression

Number of Variables ? 3
Number of Observations ? 10

WANT TO CHANGE NUMBER OF VARIABLES/NUMBER OF OBSERVATIONS (Y OR N) ? N

NAME OF VARIABLE # 1 ? Y
NAME OF VARIABLE # 2 ? X1
NAME OF VARIABLE # 3 ? X2

DATA GATHERED FOR VARIABLE Y:

PERIOD # 1 ? 3
PERIOD # 2 ? 7
PERIOD # 3 ? 2
PERIOD # 4 ? 1
PERIOD # 5 ? 6
PERIOD # 6 ? 2
PERIOD # 7 ? 8
PERIOD # 8 ? 3
PERIOD # 9 ? 9
PERIOD # 10 ? 2

DATA GATHERED FOR VARIABLE X1:

PERIOD # 1 ? 4
PERIOD # 2 ? 9
PERIOD # 3 ? 3
PERIOD # 4 ? 1
PERIOD # 5 ? 3
PERIOD # 6 ? 4
PERIOD # 7 ? 7
PERIOD # 8 ? 3
PERIOD # 9 ? 8
PERIOD # 10 ? 1

DATA GATHERED FOR VARIABLE X2:

PERIOD # 1 ? 2
PERIOD # 2 ? 7
PERIOD # 3 ? 1
PERIOD # 4 ? 2
PERIOD # 5 ? 3
PERIOD # 6 ? 4
PERIOD # 7 ? 9
PERIOD # 8 ? 2
PERIOD # 9 ? 7
PERIOD # 10 ? 3

Correlation Matrix

1	.85	.85
.85	1	.84
.85	.84	1

Variance Covariance Matrix

2.91	6.9	6.67
6.9	2.79	6.33
6.67	6.33	2.71

Variable	Mean	Std Deviation
Y	4.3	2.907844
X1	4.3	2.790858
X2	4	2.708013

CONTINUE ? Y
CONTINUE ? Y

Regression Equation

Dependent Variable : Y

Independent variable	ESTIMATED COEFFICIENT	BETA %	Errors	T-Test
X1	.49	.49	.34	1.47
X2	.48	.45	.35	1.4
CONSTANT	.2471704			

Determination Co-efficient	=	.78
Correlation Co-efficient	=	.89
F-Test	=	12.65
Degrees of Freedom	=	2.7
Sum of squares of error	=	16.49

CONTINUE?
CONTINUE? Y

TABLE OF RESIDUAL VALUES

#	Observation	Estimation	Residual
1	3	3.18	− .18
2	7	8.07	− 1.07
3	2	2.21	− .21
4	1	1.71	− .71
5	6	3.18	2.82
6	2	4.15	− 2.15
7	8	8.05	− .05
8	3	2.69	.31
9	9	7.57	1.43
10	2	2.19	− .19

CONTINUE ? Y

Analysis of Variance Table

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Ratio
Due to Regression	2	59.61	29.81	12.65
Due to Error	7	16.49	2.36	
Total	9	76.1		

Another Analysis (Type Y or N)?

The program output gives many other statistical analysis which we will not touch upon now, and come to our important tests straightway. The residual or error between Y and $\hat{Y}$ i.e. between actual and forecast on important measure of reliability of the model is printed out for each observation. If you look at the errors, you get a fairly good idea about the model equation. However for validity of the regression equation, you look first at the co-efficient of multiple determination R^2 and multiple correlation co-efficient R. In our example $R^2 = 0.78$ and $R = 0.89$ which is a satisfactory one indicating that the preference rating Y is linearly related to protein intake X_1 and vitamin D intake X_2. It tells that 78% of variation in Y is explained jointly by the variations in X_1 and X_2 jointly.

Hypothesis testing for linearity through ANOVA.

$H_0 : \beta_1 \& \beta_2 = 0 \Rightarrow$ There is no linear relation between Y, X_1 and X_2.
$H_1 : \beta_1 \& \beta_2 \neq 0 \Rightarrow$ There is linear relationship.

Look at the ANOVA
The calculated $F = 12.65$
The table $F(2.7) = 4.74$ at 5% level. Reject H_0 and accept H_1.

That is the linear regression equation between Y & X_1, X_2 is statistically valid. We are 95% confident that preference rating is linearly related to X_1 and X_2 and the equation is $\hat{Y} = 0.247 + 0.49\ X_1 + 0.48X_2$.

Points to ponder on Multiple regression analysis

1) Equation should be validated statistically.
2) For forecasting the dependent variable, the independent variables should be forecast first.
   For example, if demand is a function of price index and production index established by a multiple regression model, then to forecast demand for the next period, it is imperative first to forecast the price index and production index and then substitute them in the model to get the forecast for demand. This is one of the limitations of regression forecasting.
3) When the variables become too many the analysis is complex and very often the market researcher does not know which variables to retain. This problem could be overcome by doing stepwise regression on computer. For example, if demand is a function of 20 variables, we first fit demand equation with 3 important variables which we think affect demand. Suppose $R^2 = 0.85$, that is, 85% of the variation in demand is explained by these variables, we add another two more

variables of importance to make five independent variables. Now if $R^2 = 0.95$ we can as well stop adding further variables as the contribution may not appreciably improve the situation. We can thus visualise demand as a function of just 5 variables. The various permutations of changing and adding variables is possible only with the help of a computer. The important point to remember is that the cut off point for the number of variables to be added should be based on the increase every time you get on R^2. The moment the increase is marginal, stop adding variables.

4) If the independent variables among themselves are highly correlated, then we are facing the problem of 'multicollinearity'. Normally we say that the partial regression co-efficient with respect to X_1 implies change in Y per unit change in X_1 provided $X_2 X_3$ .... are held constant. This poses a serious problem if there is multicollinearity. One way to overcome multicollinearity is to drop certain variables from the model if the corresponding standard error of regression co-efficient are unduly large. Another method is to see whether the original set could be transformed into another linear composite so that the new variables are uncorrelated.

Activity 1

List out the limitations of regression analysis for forecasting.

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Activity 2

In what ways can multiple regression be used to forecast some industry's sales?

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Activity 3

Zippy Cola is studying the effect of its latest advertising campaign. People chosen at random were called and asked how many cans of Zippy Cola they had bought in the past week and how many Zippy Cola advertisements they had either read or seen in the past week.

X (number of ads)	4	9	3	0	1	6	2	5
Y (cans purchased)	12	14	7	6	3	5	6	10

a) Develop the estimating equation that best fits the data.

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b) Calculate the sample co-efficient of determination and interpret it.

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c) Forecast the number of cans purchased when the numbers of advertisements seen or read in the past week were 10.

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9.3 DISCRIMINANT ANALYSIS

It has been pointed out earlier, that the discriminant analysis is a useful tool for situations where the total sample is to be divided into two or more mutually exclusive and collectively exhaustive groups on the basis of a set of predictor variables. For example, a problem involving classifying sales people into successful and unsuccessful; classifying customers into owners or and non-owners of video tape recorder, are examples of discriminant analysis.

Objectives of two group discriminant analysis:

1) Finding linear composites of the predictor variables that enable the analyst to separate the groups by maximising among groups relative to with in-groups variation.
2) Establishing procedures for assigning new individuals, whose profiles but not group identity are known, to one of the two groups.
3) Testing whether significant differences exist between the mean predictor variable profiles of the two groups.
4) Determining which variables account most for intergroup differences in mean profiles.

A numerical example

Let us return to the example involving ready-to-eat cereal was presented in the regression analysis. However, in this problem the ten consumer raters are simply asked to classify the cereal into one of two categories like versus dislike. The data is given below: Here again

X_1 : The amount of protein (in grams) per standard serving.
X_2 : The percentage of minimum daily requirements of vitamin D per standard serving.

Also shown in the data table are the various sums of squares and cross products, the means on X_1 and X_2 of each group, and total sample mean.

Consumer evaluations (like versus dislike) of ten cereals varying in nutritional content

Person	Evaluation	Protein X_1	Vitamin D X_2	X_1^2	X_2^2	X_1X_2
1	Dislike	2	4	4	16	8
2	Dislike	3	2	9	4	6
3	Dislike	4	5	16	25	20
4	Dislike	5	4	25	16	20
5	Dislike	6	7	36	49	42
	Mean	4	4.4	Sum 90	110	96
6	Like	7	6	49	36	42
7	Like	8	4	64	16	32
8	Like	9	7	81	49	63
9	Like	10	6	100	36	60
10	Like	11	9	121	81	99
	Mean	9	6.4 Sum	415	218	296
	Grand Mean	6.5	5.4			
	Standard deviation	3.028	2.011			

The grand mean is $\overline{X}_1 = 6.5\ \overline{X}_2 = 5.4$

We first note from the table that the two groups are much more widely separated on X_1 (Protein) than they are on X_2 (Vitamin D). If we were forced to choose just one of the variables, it would appear that X_1 is a better bet than X_2. However, there is information provided by the group separation on X_2, so we wonder if some linear composite of both X_1 and X_2 could do better than X_1 alone. Accordingly, we have the following linear function :

$Z = K_1X_1 + K_2X_2$ where K_1 and K_2 are the weights that we seek.

But how shall we define variability? In discriminant analysis, we are concerned with the ratio of two sums of squares after the set of scores on the linear composite has been computed. One sum of squared deviations represents the variability of the two group means on the composite around their grand mean. The second sum of squared deviations represents the pooled variability of the individual cases around their respective group means also on the linear composite. One can then find the ratio of the first sum of squares to the second. It is this ratio that is to be maximised through the appropriate selection of K_1 and K_2. Solving for K_1 and K_2 involves a procedure similar to the one encountered in the multiple regression. However, in the present case, we shall want to find a set of sums of squares and cross products that relate to the variation within groups. For ease of calculation let us define $x_1 = X_1 - \overline{X}_1$ and $x_2 = X_2 - \overline{X}_2$ (i.e. each observation measured from its mean).

Solving for K_1 and K_2.

Mean corrected sums of squares and cross products

	Dislikers	Likers	Total
$\Sigma x_1^2 = \Sigma(X_1 - \overline{X}_1)^2 = \Sigma X_1^2 - N\overline{X}_1^2 =$	10	10	20
$\Sigma x_2^2 = \Sigma(X_2 - \overline{X}_2)^2 = \Sigma X_2^2 - N\overline{X}_2^2 =$	13.2	13.2	26.4
$\Sigma x_1 x_2 = \Sigma (X_1 - \overline{X}_1)(X_2 - \overline{X}_2) = \Sigma_1 X_1 X_2 - N\overline{X}_1\overline{X}_2 =$	8	8	16

The normal equations are

$K_1 \Sigma x_1^2 + K_2 \Sigma x_1 x_2 = \overline{X}_1$ (Likers) $- \overline{X}_1$ (dislikers)

$K_1 \Sigma x_1 x_2 + K_2 \Sigma x_2^2 = \overline{X}_2$ (Likers) $- \overline{X}_2$ (Dislikers)

$20\ K_1 + 16\ K_2 = 9 - 4 = 5$

$16\ K_1 + 26.4\ K_2 = 6.4 - 4.4 = 2$

Solving these two simultaneous equations, we have $K_1 = 0.368$, $K_2 = -0.147$
Discriminant function $Z = 0.368X_1 - 0.147X_2$

We can also find discriminants scores for the means of the two groups and the grand mean.

Z (dislikers) $= 0.368\ (4) - 0.147\ (4.4) = 0.824$
Z (likers) $= 0.368\ (9) - 0.147\ (6.4) = 2.368$
Z (grand means) $= 0.368\ (6.5) - 0.147\ (5.4) = 1.596$

We note that the discriminant function "favours" X_1 by giving about 2.5 times the (absolute value) weight ($K_1 = 0.368$ versus $K_2 = -0.147$) to X_1 as is given to X_2.

The discriminant scores of each person are shown below. Each score is computed by the application of the discriminant function to the persons original X_1 and X_2 values.

Dislikers		Likers	
Person	Discriminant Score	Person	Discriminant Score
1	0.148	6	1.691
2	0.809	7	2.353
3	0.735	8	2.279
4	1.250	9	2.794
5	1.176	10	2.721
Mean	0.824	Mean	2.368
	Grand Mean 1.596		

Between group variability:
$5\ (0.824 - 1.596)^2 + 5\ (2.368 - 1.596)^2 = 5.96$
Within group variability
Dislikers $(0.148 - 0.824)^2 + (0.809 - 0.824)^2 + ... + (1.176 - 0.824)^2 = 0.772$

Likers $(1.691 - 2.368)^2 + (2.353 - 2.368)^2 + ... + (2.721 + 2.368)^2 = \dfrac{0.772}{1.544}$

Discriminant criterion $C = \dfrac{5.96}{1.544} = 3.86$

Since the normal equations for solving K_1 and K_2 are obtained by maximising the ratio between group and within group variance the discriminant criterion as

calculated above = 3.86 will be the maximum possible ratio. If we suppress X_2 in the discriminant function and calculate another C, it will be less than 3.86. It is rather interesting that the optimal function $Z = 0.368\ X_1 - 0.147\ X_2$ is a difference function in which X_2 (Vitamin D) receives a negative weight bringing thereby the importance of X_1 to the highest order. This means protein is much more important than Vitamin D.

Classifying the persons

It is all well and good to find the discriminant function, but the question is how to assign the persons to the relevant groups.

	Dislikers	Likers	Total
Mean Score	0.824	2.368	1.596 (Grand Mean)
	0.824 (Dislikers)	1.596 (Midpoint)	2.368 (Likers)

- Assign all cases with discriminant scores that are on the left of the midpoint (1.596) to the disliker group.
- Assign all cases with discriminant scores that are on the right of the midpoint (1.596) to the liker group.

That is all true dislikers will be correctly classified as such and all true likers will be correctly classified. This can be shown by a 2×2 table :

	Assigned by Rule		
True State	Disliker	Liker	Total
Disliker	5	0	5
Liker	0	5	5
Total	5	5	10

Testing Statistical Significance

While the discriminant function does perfectly in classifying the ten cases of the illustration on protein (X_1) and vitamin (X_2) into likers and dislikers, we still have not tested whether the group means differ significantly. This is also based on F ratio which required calculation of Mahalanobis D^2. This calculation of F is little complicated which is normally an output parameter in the standard package like Biomedical computer program and SPSS of IBM. Biomedical computer program of the University of California press is an outstanding software containing all multivariate procedures. For our illustration let us calculate F

$$F = \frac{n_1 n_2 (n_1 + n_2 - m - 1)}{m (n_1 + n_2) (n_1 + n_2 - 2)} \cdot D^2$$

$\sim$ F distribution with $m,\ n_1 + n_2 - m - 1$ d.f.

where n_1 = number of observations in group 1
n_2 = number of observations in group 2
m = number of independent variables
D^2 = Mahalanobis square distance

In our problem $n_1 = 5$
$n_2 = 5$
$m = 2$ (X_1 and X_2)

Simple way of calculating D^2 would be to use the discriminant function

$$D^2 = (n_1 + n_2 - 2)\ (0.368\ (5.0) - 0.147\ (2))$$
$$= 8\ (0.368 \times 5 - 0.147 \times 2) = 12.353$$

You please note that the expression within brackets is the discriminant function $Z = 0.368\ X_1 - 0.147\ X_2$ where X_1 and X_2 are substituted by the respective group means difference : $\overline{X}_1$ (likers) $- \overline{X}_1$ (dislikers) $\overline{X}_2$ (likers) $- \overline{X}_2$ (dislikers)

$$\therefore F = \frac{5 \times 5\ (5 + 5 - 2 - 1)}{2 \times (5 + 5)\ (5 + 5 - 2)} \times 12.353$$

$$= \frac{25 \times 7}{2 \times 10 \times 8} \times 12.353 = 13.511$$

Table F (2,7) = 4.74 at 5% level.

Since the calculated F exceeds table F at 5% level, reject H_0 and accept H_1 i.e. the group means are not equal in importance with a probability of 95%. This clearly validates the relative importance of X_1 far higher than X_2.

Brief remarks on Multiple Discriminant analysis

You would have realised by now the complexity of calculations in the discriminant analysis involving 2 predictors which itself needs computer based solutions when the number of observations increases considerable. Multiple discriminant analysis is invariably carried out by means of computer programs. One of the most flexible and comprehensive programs in BMD-07M of the biomedical program series of the University of California press. SPSS also has all multivariate procedures. It may be mentioned that the basic structure of the bivariate analysis remains same in multiple case also. What is important for you is interpretation of the results and findings of the study.

Activity 4

What are the differences between Regression Analysis and Discriminant Analysis?

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Activity 5

List out a few research studies where Discriminant Analysis has possible applications.

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9.4 FACTOR ANALYSIS

Factor analysis is a generic name given to a class of techniques whose purpose is data reduction and summarisation. Very often market researchers are overwhelmed by the plethora of data. Factor analysis comes to their rescue in reducing the number of variables. Factor analysis does not entail partitioning the data matrix into criterion and predictor subsets; rather interest is centred on relationships involving the whole set of variables. In factor analysis :

1) The analyst is interested in examining the "strength" of the overall association among variables in the sense that he would like to account for this association in terms of a smaller set of linear composites of the original variables that preserve most of the information in the full data set. Often his interest will emphasize description of the data rather than statistical inference.
2) No attempt is made to divide the variables into criterion versus prediction sets.
3) The models are primarily based on linear relationships.

Factor analysis is a "search" technique. The researcher-decision maker does not typically have a clear priori structure of the number of factors to be identified. Cut off points with respect to stopping rules for the analysis are often ad hoc as the output becomes available. Even where the procedures and rules are stipulated in advance, the results are more descriptive than inferential.

The procedure involved in computation of factor analysis is extremely complicated and cannot be carried out effectively without the help of computer. Packages like SPSS, SAS and Biomedical programs (BMD) can be used to analyse various combinations leading to factor reduction. We will make an attempt to conceptualise the scenario of factor analysis with emphasis on the interpretation of figures.

The term "factor analysis" embraces a variety of techniques. Our discussion focuses on one procedure : principal component analysis and the factors derived from the analysis are expressed as linear equations. These linear equations are of the form

$$F_i = a_{1_i} x_1 + a_{2_i} x_2 + a_{3_i} x_3 + ... + a_{m_i} x_m$$

The i factors are derived, and each variable appears in each equation. The a-co-efficients indicate the importance of each variable with respect to a particular factor. Co-efficient of zero indicating the variable is of no significance for the factor. In principal component analysis, the factors are derived sequentially, using criteria of maximum reduction in variance and non-correlation among factors.

Let us go to a specific example to explain factor analysis and its output.

Example : A manufacturer of fabricating parts is interested in identifying the determinants of a successful salesperson. The manufacturer has on file the information shown in the following table. He is wondering whether he could reduce these seven variables to two or three factors, for a meaningful appreciation of the problem.

Data Matrix for Factor Analysis of seven variables (14 sales people)

Sales person	Height (X_1)	Weight (X_2)	Educations (X_3)	Age (X_4)	No. of Children (X_5)	Size of household (X_6)	IQ (X_7)
1	67	155	12	27	0	2	102
2	69	175	11	35	3	6	92
3	71	170	14	32	1	3	111
4	70	160	16	25	0	1	115
5	72	180	12	36	2	4	108
6	69	170	11	41	3	5	90
7	74	195	13	30	1	2	114
8	68	160	16	32	1	3	118
9	70	175	12	45	4	6	121
10	71	180	13	24	0	2	92
11	66	145	10	39	2	4	100
12	75	210	16	26	0	1	109
13	70	160	12	31	0	3	102
14	71	175	13	43	3	5	112

Can we now collapse the seven variables into three factors? Intuition might suggest the presence of three primary factors: A maturity factor revealed in age/children/size of household, physical size as shown by height and weight, and intelligence or training as revealed by education and IQ.

The sales people data have been analysed by the SAS program. This program accepts data in the original units, automatically transforming them into standard scores. The three factors derived from the sales people data by a principal component analysis (SAS program) are presented below :

Three-factor results with seven variables.

	Sales people characteristics Factor			
Variable	I	II	III	Communality
Height	0.59038	0.72170	−0.30331	0.96140
Weight	0.45256	0.75932	−0.44273	0.97738
Education	0.80252	0.18513	0.42631	0.86006
Age	−0.86689	0.41116	0.18733	0.95564
No. of children	−0.84930	0.49247	0.05883	0.96730
Size of household	−0.92582	0.30007	−0.01953	0.94756
IQ	0.28761	0.46696	0.80524	0.94918
Sum of squares	3.61007	1.85136	1.15709	
Variance summarised	0.51572	0.26448	0.16530	0.94550

Factor Loading: The co-efficients in the factor equations are called "factor loadings" They appear above in each factor column, corresponding to each variable. The equations are :

$$F_1 = 0.59038x_1 + 0.45256x_2 + 0.80252x_3 - 0.86689x_4 - 0.84930x_5 - 0.92582x_6 + 0.28761x_7$$

$$F_2 = 0.72170x_1 + 0.75932x_2 + 0.18513x_3 + 0.41116x_4 + 0.49247x_5 + 0.30007x_6 + 0.46696x_7$$

$$F_3 = -0.30331x_1 - 0.44273x_2 + 0.42631x_3 + 0.18733x_4 + 0.5883x_5 - 0.01953x_6 + 0.80524x_7$$

The factor loadings depict the relative importance of each variable with respect to a particular factor. In all the three equations, education (x_3) and IQ (x_7) have got positive loading factor indicating that they are variables of importance in determining the success of sales person.

Variance summarised : Factor analysis employs the criterion of maximum reduction of variance — variance found in the initial set of variables. Each factor contributes to reduction. In our example Factor I accounts for 51.6 per cent of the total variance. Factor II for 26.4 per cent and Factor III for 16.5 per cent. Together the three factors "explain" almost 95 per cent of the variance.

Communality : In the ideal solution the factors derived will explain 100 per cent of the variance in each of the original variables, "communality" measures the percentage of the variance in the original variables that is captured by the combination of factors in the solution. Thus a communality is computed for each of the original variables. Each variables communality might be thought of as showing the extent to which it is revealed by the system of factors. In our example the communality is over 85 per cent for every variable. Thus the three factors seem to capture the underlying dimensions involved in these variables.

There is yet another analysis called varimax rotation, after we get the initial results. This could be employed if needed by the analyst. We do not intend to dwell on this and those who want to go into this aspect can use SAS program for varimax rotation.

In the concluding remarks, it should be mentioned that there are two important subjective issues which should be properly resolved before employing factor analysis model. They are :

1) How many factors should be employed in attempting to reduce the data? What criteria should be used in establishing that number?
2) The labelling of the factors is purely intuitive and subjective.

Activity 6
Mention briefly the purpose and uses of factor analysis.

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9.5 SUMMARY

In this unit, we have given a brief introduction of the multivariate tools and their applicability in the relevant problem areas.

We started the discussion with the regression analysis, which is probably the most widely used technique amongst the analytical models of association. We have started

the simple linear regression model first to introduce the concept of regression and then moved on to the multiple linear regression mode. All the underlying assumptions of the model have been explained. Both the bivariate and multivariate regression models have been illustrated using the example of preference rating as a function of protein intakes, and vitamin D intake perception in the case of a ready-to-eat cereal. The concept of testing the linear equation, contribution made by regression in explaining variation in dependent variables and strength of association have all been explained using ANOVA table. A brief account of the role of regression in sales forecasting involving time series analysis has also been given. The need for resorting to computer solutions for large number of variables and observations has been brought out with an actual print out of the example already discussed. The concept of stepwise regression and the problems encountered in any regression analysis have also been explained.

Next, we have gone to the discriminant analysis technique—a technique when the interest is to classify the groups on the basis of a set of predictor variables. We have explained the concept of separation by giving examples of classifying sales people into successful and unsuccessful, customers into owners and non-owners etc. As before, we have begun the discussion with discriminant function involving two predictor variables using the example of 'ready-to-eat cereal problem' but with a difference—classifying the persons into liker group and disliker group. The discriminant function, the discriminant criterion and the assignment rule have all been explained. Testing the statistical significance using F test based on Mahalanobis D^2 has also been carried out. We have pointed out that the multiple discriminant analysis involving more than two predictor variables require the use of computer although the basic structure of the model does not change.

Factor analysis is the last multivariate tool that we have discussed in this unit. We have first mentioned that the fundamental objective of factor analysis is to reduce the number of variables in the data matrix. Then it has been pointed out that the computation of any factor analysis involves very complex calculation which will have to be solved using computer packages like SAS. The concepts of "factor loading", "variance summarised" and "communality" have been explained using one practical example that has been solved by SAS program. The subjective issues like "how many factors?" "what criteria to decide this number?" and "labelling of the factors" have been mentioned at the end.

As concluding remarks, it may be mentioned here that 1) all multivariate procedures can be more effectively solved using standard computer packages when the number of variables and number of observations increase significantly, 2) what is more important is the ability to interpret the results of the market research study involving multivariate analysis.

9.6 SELF-ASSESSMENT EXERCISES

1) a) In a demand forecasting study involving a normal commodity, two simple linear regression models are fitted :
   $D = 8.5 + 0.22p$ ($r^2 = 0.75$)
   $\text{Log } D = 1.3 + 0.10 \log p$ ($r^2 = 0.80$)
   i) which model would you prefer and why?
   ii) mention the dependent and independent variables.

   b) A manufacturer of industrial supplies developed the following model for predicting the number of sales per month

   $$Y = 41 + .3X_1 + .05X_2 - 7X_3 + 10X_4$$

   where Y = Sales per month
   X_1 = Number of manufacturing firms
   X_2 = Number of wholesale and retail firms
   X_3 = Number of competing firms
   X_4 = Number of full-time company sales people.

i) Explain the correct interpretation of all estimated parameters in the equation.
ii) If $R^2 = 0.49$, what does this figure mean to you?
iii) Explain how you will go about testing the validity of this multiple linear regression equation.

2) The following discriminant function was developed to classify sales persons into successful and unsuccessful sales person
$Z = 0.53\ X_1 + 2.1X_2 + 1.5X_3$

where X_1 = no. of sales call made by sales persons.
X_2 = no. of customers developed by sales persons.
X_3 = no. of units sold by sales person.

The following decision rule was developed.

if $Z \geq 10$, classify the sales person as successful
if $Z < 10$, classify the sales person as unsuccessful.

The sales persons A and B were considered for promotion on the basis of being classified as successful or unsuccessful. Only the successful sales person would be promoted. The relevant data on A and B is given below:

	A	B
X_1	10	11
X_2	2	1.5
X_3	1	0.5

whom will you promote?

3) A large sample of people were asked to rate how much they liked each of 5 beverages— coffee, tea, milk, fruit juice and soft drinks. Through factor analysis, factor loadings was obtained.

	Factors			
	I	II	III	Communality
Coffee	− .219	.363	− .338	0.2939
Tea	− .137	.682	− .307	0.5781
Milk	.514	− .213	− .277	0.3611
Fruit Juice	.485	− .117	115	0.2621
Soft drinks	− .358	− .635	− .534	0.8165
Sum of squares	0.6943	1.0592	0.5584	
Variance summarised	0.1389	0.2118	0.1117	0.4624

a) Write the linear equations for all the three factors.

b) Interpret the loading co-efficients, variance summarised and communality values of this table.

9.7 FURTHER READINGS

F.E. Brown, 1980, *Marketing Research*, Addison-Wesley Publishing Company.

Paul E. Green and Donald S. Tull, 1986, *Research for Marketing Decisions*, Prentice-Hall of India Pvt. Ltd.

Boyd, Westfall and Stasch, 1988, *Marketing Research Text and Cases*, D. Irwin Inc. Homewood, Illinois.

U.K. Srivastava, G.V., 1983, *Quantitative Techniques for Managerial Decision Making*, Wiley Eastern Limited.

UNIT 10 MODEL BUILDING AND DECISION-MAKING

Objectives

After reading this unit, you should be able to :

- explain the concepts of model building and decision-making;
- discuss the need for model building in managerial research;
- relate the different types of models to different decision-making situations;
- describe the principles of designing models for different types of managerial research/decision-making situations.

Structure

10.1 INTRODUCTION

A manager, whichever type of organisation he/she works in, very often faces situations where he/she has to decide/choose among two or more alternative courses of action. These are called decision-making situations. An illustration of such a situation would be the point of time when you possibly took the decision to join/take up this management programme. Possibly, you had a number of alternative management education programmes to choose from. Or, at worst, maybe you had admission in this programme only. Even in that extreme type of situation you had a choice — whether to join the programme or not! You have, depending upon your own decision-making process, made the decision.

The different types of managerial decisions have been categorised in the following manner ;

1) Routine/Repetitive/Programmable vs. Nonroutine/Nonprogrammable decisions.
2) Operating vs. Strategic decisions.

The routine/repetitive/programmable decisions are those which can be taken care of by the manager by resorting to standard operating procedures (also called "sops" in managerial parlance). Such decisions the manager has to take fairly often and he/she knows the information required to facilitate them. Usually the decision maker has knowledge in the form of "this is what you do" or "this is how you process" for such decision-making situations. Examples of these decisions could be processing a loan application in a financial institution and supplier selection by a materials manager in a manufacturing organisation.

The non-repetitive/non-programmable/strategic decisions are those which have a fairly long-term effect in an organisation. Their characteristics are such that no routine methods, in terms of standard operating procedures, can be developed for taking care of them. The element of subjectivity/judgement in such decision-making is fairly high. Since the type of problem faced by the decision maker may vary considerably from one situation to another, the information needs and the processing required to arrive at the decision may also be quite different.

The decision-making process followed may consist, broadly, of some or all of the steps given below :

1) Problem definition;
2) Identifying objectives, criteria and goals;
3) Generation/Enumeration of alternative courses of action;
4) Evaluation of alternatives;
5) Selection/choosing the "best" alternative;
6) Implementation of the selected alternative.

All the above steps are critical in decision-making situations. However, in the fourth and fifth steps; i.e., evaluation and selection, models play a fairly important role. In this unit we will concentrate on Model Building and Decision-making.

Activity 1

Suppose you have recently bought a Texla Colour TV for your house. Describe briefly the decision process you have gone through before making this choice.

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10.2 MODELS AND MODELLING

Many managerial decision-making situations in organisations are quite complex. So, managers often take recourse to models to arrive at decisions.

Model : The term 'model' has several connotations. The dictionary meaning of this word is "a representation of a thing". It is also defined as the body of information about a system gathered for the purpose of studying the system. It is also stated as the specification of a set of variables and their interrelationships, designed to represent some real system or process in whole or in part. All the above given definitions are helpful to us.

of Modelling : Models can be understood in terms of their structure and purpose. The purpose of modelling for managers is to help them in decision-making. The term 'structure' in models refers to the relationships of the different components of the model.

In case of large, complex and untried problem situations the manager is vary about taking decisions based on intuitions. A wrong decision can possibly land the organisation in dire straits. Here modelling comes in handy. It is possible for the manager to model the decision-making situation and try out the alternatives on it to enable him to select the "best" one. This can be compared to non-destructive testing in case of manufacturing organisations.

Presentation of Models : There are different forms through which Models can be presented. They are as follows:

1) Verbal or prose models.
2) Graphical/conceptual models.
3) Mathematical models.
4) Logical flow models.

Verbal Models : The verbal models use everyday English as the language of representation. An example of such model from the area of materials management would be as follows :

> "The price of materials is related to the quantum of purchases for many items. As the quantum of purchases increases, the unit procurement price exhibits a decrease in a step-wise fashion. However, beyond a particular price level no further discounts are available."

Graphical Models : The graphical models are more specific than verbal models. They depict the interrelationships between the different variables or parts of the model in diagrammatic or picture form. They improve exposition, facilitate discussions and guide analysis. The development of mathematical models usually follows graphical models. An example of a graphical model in the area of project management is given in Figure.

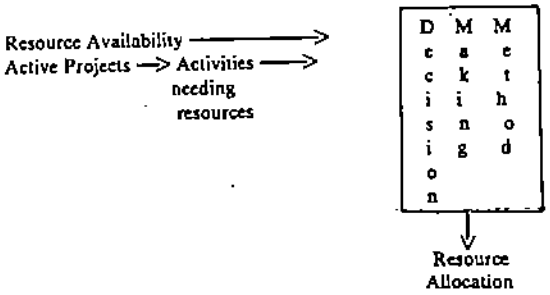

Fig. 1: A diagrammatic model of decision-making for Resource-Constrained Projects

Mathematical Models : The mathematical models describe the relationships between the variables in terms of mathematical equations or inequalities. Most of these include clearly the objectives, the uncertainties and the variables. These models have the following advantages:

1) They can be used for a wide variety of analysis.
2) They can be translated into computer programs.

The example of a mathematical model that is very often used by materials managers is the Economic Order Quantity (EOQ). It gives the optimal order quantity (Q) for a product in terms of its annual demand (A), the ordering cost per order (Co), the inventory carrying cost per unit (Ci) and the purchase cost per unit (Cp). The model equation is as follows :

$$Q = \sqrt{(2 * A * Co/Ci * Cp)}$$

Logical Flow Models : The logical flow models are a special class of diagrammatic models. Here, the model is expressed in form of symbols which are usually used in computer programming and software development. These models are very useful for situations which require multiple decision points and alternative paths. These models, once one is familiar with the symbols used, are fairly easy to follow. An example of such a model for a materials procurement situation with quantity discounts allowed, is as given in Figure 2.

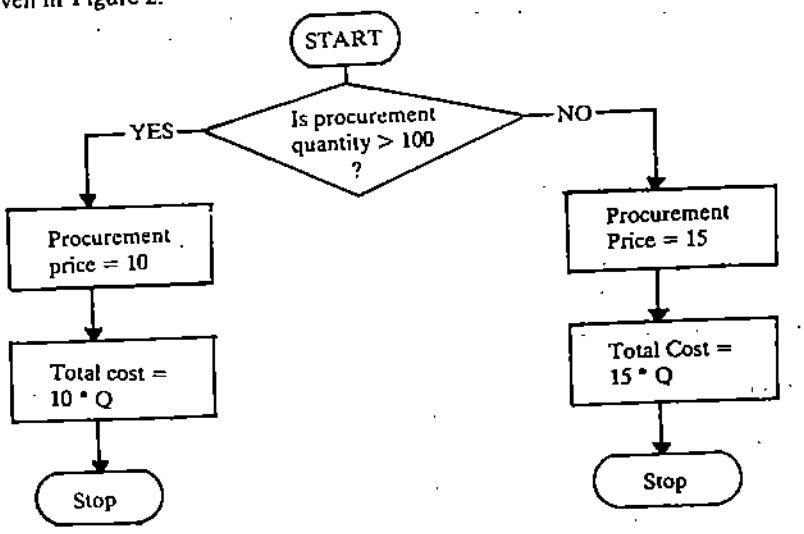

Fig. 2: A logical flow model for material procurement decisions with quantitative discounts allowed.

Activity 2
Mention below a mathematical model which has been used for sales forecasting by your organisation or any organisation you know of.

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Activity 3
Think of a production decision situation and present it diagrammatically using logical flow model.

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10.3 ROLE OF MODELLING IN RESEARCH IN MANAGERIAL DECISION-MAKING : AN ILLUSTRATION

In the previous sections of this unit we have tried to explore the topics of model building and decision-making. However, we confined ourselves to bits and pieces of each concept and their illustration in a comprehensive decision-making situation has not been attempted. In this section we will look at a managerial decision-making situation in totality and try to understand the type of modelling which may prove of use to the decision maker.

The example we will consider here is the case of a co-operative state level milk and milk products marketing federation. The federation has a number of district level dairies affiliated to it, each having capacity to process raw milk and convert it into a number of milk products like cheese, butter, milk powders, ghee, shrikhand, etc. The diagrammatic model of the processes in this set up is depicted in Figure 3.

The typical problems faced by the managers in such organisations are that : (a) the amount of milk procurement by the individual district dairies is uncertain, (b) there are limited processing capacities for different products, and (c) the product demands are uncertain and show large fluctuations across seasons, months and even weekdays.

The type of decisions which have to be made in such a set up can be viewed as a combination of short/intermediate term and long-term ones. The short-term decisions are typically product-mix decisions like deciding : (1) where to produce which product and (2) when to produce it. The profitability of the organisation depends to a great extent on the ability of the management to make these decisions optimally. The long-term decisions relate to (1) the capacity creation decisions such as which type of new capacity to create, when, and at which location(s) and (2) which new products to go in for. Needless to say, this is a rather complex decision-making situation and intuitive or experience based decisions may be way off from the optimal ones. Modelling of the decision-making process and the interrelationships here can prove very useful.

In absence of a large integrated model, a researcher could attempt to model different subsystems in this set up. For instance, time series forecasting based models could prove useful for taking care of the milk procurement subsystem; for the product demand forecasting one could take recourse, again, to time series or regression based models; and for product-mix decisions one could develop Linear Programming based models.

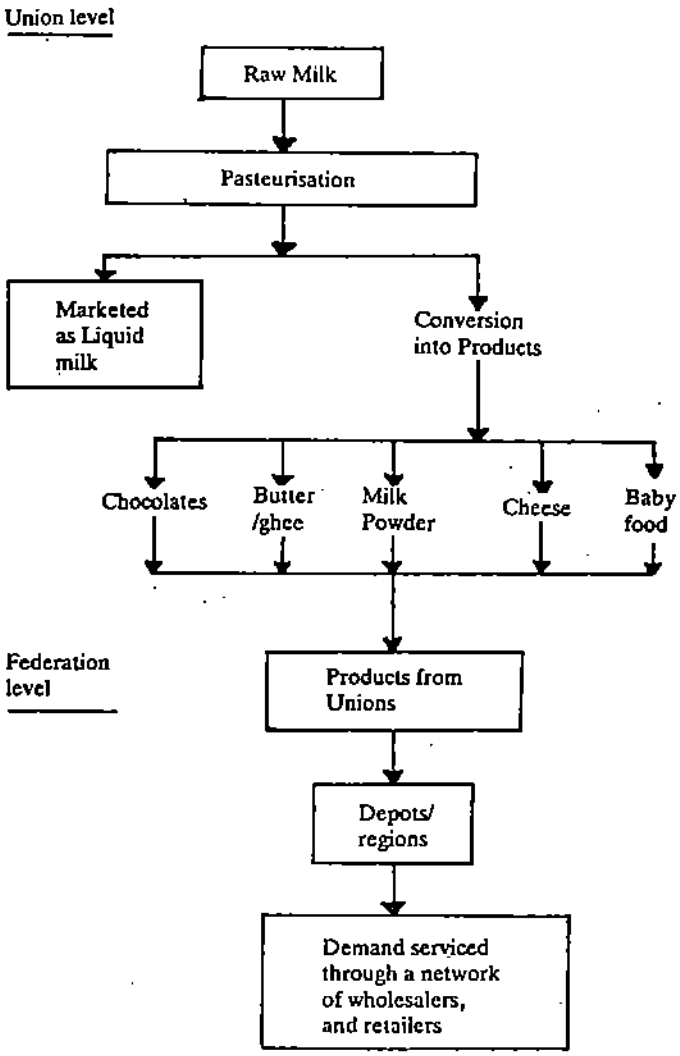

Fig. 3: A diagrammatic model of the interrelationships in a Milk Marketing Federation.

We have in this section seen a real life, complex managerial decision-making situation and looked at the possible models the researcher could propose to improve the decision-making. Similar models could be built for other decision-making situations.

Activity 4
Briefly describe a complex managerial decision-making situation and decide the various possible models that could be used for decision-making.

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10.4 TYPES OF MODELS

Models in managerial/system studies have been classified in many ways. The dimensions in describing the models are : (a) Physical vs. Mathematical, (b) Macro vs. Micro, (c) Static vs. Dynamic : (d) Analytical vs. Numerical and (e) Deterministic vs. Stochastic.

Physical Models: In physical models a scaled down replica of the actual system is very often created. These models are usually used by engineers and scientists. In managerial research one finds the utilisation of physical models in the realm of marketing in testing of alternative packaging concepts.

Mathematical Models: The mathematical models use symbolic notation and equations to represent a decision-making situation. The system attributes are represented by variables and the activities by mathematical functions that interrelate the variables. We have earlier seen the Economic order quantity model as an illustration of such a model (please refer Section 10.2).

Macro vs. Micro Models: The terms macro and micro in modelling are also referred to as aggregative and disaggregative respectively. The macro models present a holistic picture of a decision-making situation in terms of aggregates. The micro models include explicit representations of the individual components of the system.

Static vs. Dynamic Models : The difference between the Static and Dynamic models is vis-a-vis the consideration of time as an element in the model. Static models assume the system to be in a balance state and show the values and relationships for that only. Dynamic models, however, follow the changes over time that result from the system activities. Obviously, the dynamic models are more complex and more difficult to build than the static models. At the same time, they are more powerful and more useful for most real life situations.

Analytical Numerical Models : The analytical and the numerical models refer to the procedures used to solve mathematical models. Mathematical models that use analytical techniques (meaning deductive reasoning) can be classified as analytical type models. Those which require a numerical computational technique can be called numerical type mathematical models.

Deterministic vs. Stochastic Models : The final way of classifying models is into the deterministic and the probabilistic/stochastic ones. The stochastic models explicitly take into consideration the uncertainty that is present in the decision-making process being modelled. We have seen this type of situation cropping up in the case of the milk marketing federation decision-making. The demand for the products and the milk procurement, in this situation (please refer Section 10.3) are uncertain. When we explicitly build up these uncertainties into our milk federation model then it gets transformed from a deterministic to a stochastic/probabilistic type of model.

Activity 5

Give an example each of the following models used for decision-making.

(a) Macro Model

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(b) Micro Model

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(c) Deterministic Model

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(d) Stochastic Model

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10.5 OBJECTIVES OF MODELLING

The objectives or purposes which underlie the construction of models may vary from one decision-making situation to another. In one case it may be used for explanation purposes whereas in another it may be used to arrive at the optimum course of action. The different purposes for which modelling is attempted can be categorised as follows :

1) Description of the system functioning.
2) Prediction of the future.
3) Helping the decision maker/manager decide what to do.

The first purpose is to describe or explain a system and the processes therein. Such models help the researcher or the manager in understanding complex, interactive systems or processes. The understanding, in many situations, results in improved decision-making. An example of this can be quoted from consumer behaviour problems in the realm of marketing. Utilising these models the manager can understand the differences in buying pattern of household groups. This can help him in designing hopefully, improved marketing strategies.

The second objective of modelling is to predict future events. Sometimes the models developed for the description/explanation can be utilised for prediction purposes also. Of course, the assumption made here is that the past behaviour is an important indicator of the future. The predictive models provide valuable inputs for managerial decision-making.

The last major objective of modelling is to provide the manager inputs on what he should do in a decision-making situation. The objective of modelling here is to optimize the decision of the manager subject to the constraints within which he is operating. For instance, a materials manager may like to order the materials for his organisation in such a manner that the total annual inventory related costs are minimum, and the working capital never exceeds a limit specified by the top management or a bank. The objective of modelling, in this situation, would be to arrive at the optimal material ordering policies.

Activity 6

You may go through various issues of any management journal(s). It is vary likely that you may come across a regression model for estimating, sales, advertisement expenditure, price or any other variable. Discuss how the model may be used for the following :

(i) Explanation purposes

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(ii) Prediction of the future value of the dependent variable.

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(iii) Helping the decision maker decide what to do to achieve a given object.

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10.6 MODEL BUILDING/MODEL DEVELOPMENT

The approach used for model building or model development for managerial decision-making will vary from one situation to another. However, we can enumerate a number of generalized steps which can be considered as being common to most modelling efforts. The steps are :

1) Identifying and formulating the decision problem.
2) Identifying the objective(s) of the decision maker(s).
3) System elements identification and block building.
4) Determining the relevance of different aspects of the system.
5) Choosing and evaluating a model form.
6) Model calibration.
7) Implementation.

The decision problem for which the researcher intends to develop a model needs to be identified and formulated properly. Precise problem formulation can lead one to the right type of solution methodology. This process can require a fair amount of effort. Improper identification of the problem can lead to solutions for problems which either do not exist or are not important enough. A classic illustration of this is the case of a manager stating that the cause of bad performance of his company was the costing system being followed. A careful analysis of the situation by a consultant indicated that the actual problem lay elsewhere, i.e., the improper product-mix being produced by the company. One can easily see here the radically different solutions/models which could emerge for the rather different identifications of the problem!

The problem identification is accompanied by understanding the decision process and the objective(s) of the decision maker(s). Very often, specially in case of complex problems, one may run into situations of multiple conflicting objectives. Determination of the dominant objective, trading-off between the objectives, and weighting the objectives could be some ways of taking care of this problem. The typical objectives which could feature in such models can be maximising profits, minimizing costs, maximizing employment, maximizing welfare, and so on.

The next major step in model building is description of the system in terms of blocks. Each of the blocks is a part of the system which has a few input variables and a few output variables. The decision-making system as a whole can be described in terms of interconnections between blocks and can be represented pictorially as a simple block diagram. For instance, we can represent a typical marketing system in form of a block diagram (please refer Figure 4). However, one should continuously question the relevance of the different blocks vis-a-vis the problem definition and the objectives. Inclusion of the not so relevant segments in the model increases the model complexity and solution effort.

A number of alternative modelling forms or structures may be possible. For instance, in modelling marketing decision-making situations, one may ask questions such as whether the model justifies assumptions of linearity, non-linearity (but linearizable) and so on. Depending upon the modelling situation one may recommend the appropriate modelling form. The model selection should be made considering its appropriateness for the situation. One could evaluate it on criteria like theoretical soundness, goodness of fit to the historical data, and possibility of producing decisions which are acceptable in the given context.

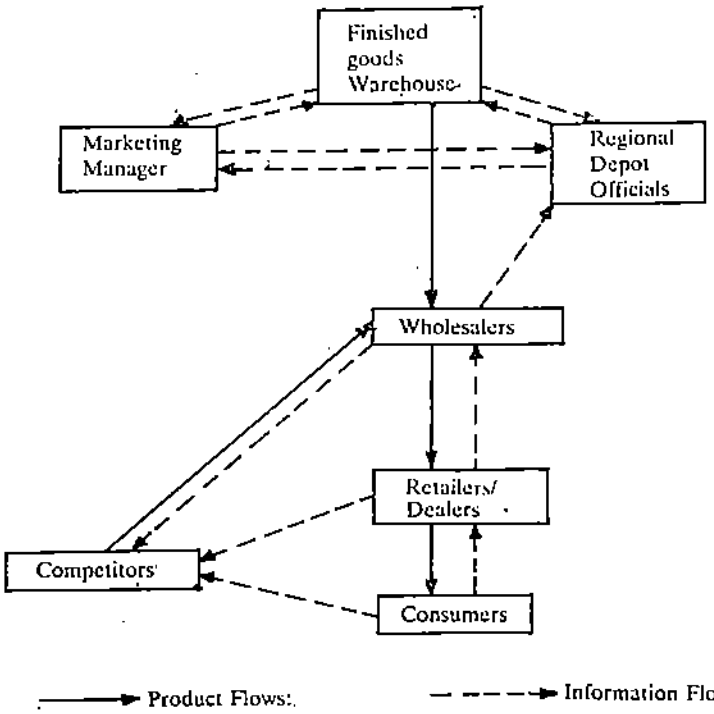

Fig. 4: A Model of the Product and Information Flows in a Competitive Marketing Systems.

The final steps in the model development process are related to model calibration and implementation. This involves assigning values to the parameters in the mode. When sample data is available then we can use statistical techniques for calibration. However, in situations where little or no data is available, one has to take recourse to subjective procedures. Model implementation involves training the support personnel and the management on system use procedures. Documentation of the model and procedures for continuous review and modifications are also important here.

Activity 7

You are the personnel manager of a construction company. If you were asked to build a model to forecast the manpower requirements of both skilled and non-skilled workers for the next five year, list out the steps you may consider for building the model.

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10.7 MODEL VALIDATION

When a model of a decision-making situation is ready a final question about its validity should always be raised. The modeller should check whether the model represents the real life situation and is of use to the decision maker.

A number of criteria have been proposed for model validation. The ones which are considered important for managerial applications are face validity, statistical validity and use validity.

In face validity, among other things, we are concerned about the validity of the model structure. One attempts to find whether the model does things which are consistent with managerial experience and intuition. This improves the likelihood of the model actually being used.

In statistical validity we try to evaluate the quality of relationships being used in the model. The use validity criteria may vary with the intended use of the model. For instance, for descriptive models one would place emphasis on face validity and goodness of fit.

10.8 SIMULATION MODELS

Simulation models are a distinct class of quantitative models, usually computer based, which are found to be of use for complex decision problems. The term 'simulation' is used to describe a procedure of establishing a model and deriving a solution numerically. A series of trial and error experiments are conducted on the model to predict the behaviour of the system over a period of time. In this way the operation of the real system can be replicated. This is also a technique which is used for decision-making under conditions of uncertainty. Generally, simulation is used for modelling in conditions where mathematical formulation and solution of model are not feasible. This methodology has been used in numerous types of decision problems ranging from queuing and inventory management to energy policy modelling. A detailed discussion of simulation is beyond the purview of this unit. For those of you who would like to read more on this, we would recommend a comprehensive text like Gordon (1987) or Shenoy et., al. (1983).

10.9 SUMMARY

In this unit we have briefly examined the role of models in managerial decision-making research. We have also examined the different types of managerial decisions and the process of decision-making. This was followed by a discussion on the type of models and their characteristics. A specific model was discussed describing the decision-making scenario in a milk marketing federation. We noted that there could be three types of modelling objectives viz., descriptive, predictive and normative. A brief description of the model development and validation processes followed. Finally, a brief exposure to simulation models was provided.

10.10 KEY WORDS

Decision : Arriving at a choice amongst alternatives

Model : Body of information about a system gathered for the purpose of studying the system

Block : A part of the system being modelled

Validation : Checking whether the model actually replicates the actual system.

Simulation : A technique for studying alternative courses of action by building a model of system under investigation.

10.11 SELF-ASSESSMENT EXERCISES

1) What do you understand by the term decision-making? What is the role of models in managerial decision-making? Explain.
2) Briefly review the different types of models alongwith their characteristics.
3) Take a complex decision-making situation in your organisation. Try to identify the blocks in it along with their interrelationships. Try to prepare a graphical model of this decision-making situation.
4) What are the purposes of modelling? Discuss.

10.12 FURTHER READINGS

Bass, Bernard M., 1983. *Organizational Decision Making,* Irwin, Illinois.

Gordon, Geoffrey, 1987. *System Simulation,* PHI, New Delhi.

Ferber, Robert (ed.)., 1974. *Handbook of Marketing Research.* McGraw-Hill, New York.

Lilien, Gary L. and Philip Kotler, 1983. *Marketing Decision Making; A Model Building Approach,* Harper & Row, New York.

Shenoy, GVS, et al., 1983. *Quantitative Techniques for Managerial Decision Making,* Wiley Eastern, 1983.

Notes

Notes

Uttar Pradesh
Rajarshi Tandon Open University

MBA-4.2 MBA-4.2

Research Methodology For Management Decisions

Block

4

REPORT WRITING AND PRESENTATION

BLOCK 4 REPORT WRITING AND PRESENTATION

Block 4 on Report Writing and Presentation consists of three units.

Unit 11 on substance of reports explains various types of reports. The unit also discusses how to prepare a proposal for a report and review the draft of a report.

Unit 12 deals with formats of reports. It distinguishes between and explains various parts of a report. The unit also gives guidelines for typing of a report and also for its editing by using the copy reading and proof reading symbols.

Unit 13 on presentation of a report discusses the various components of presentation skills and also lists out the suggestions for preparation of AV aids, usefulness of AV aids, and the care a presenter has to take while presenting a report.

6) Equipment and facilities required

7) Schedule—target dates for completing
   a) Library research
   b) Primary research
   c) Data organization and analysis
   d) Outlining the report
   e) First draft
   f) Final draft

8) Likely product or tentative outline

9) Cost estimates

10) Bibliography

Activity 1

Decide on a topic on which you would like to do a report, do a preliminary library survey on the topic, write a proposal, and check whether it answers all the questions indicated under the information to be given in a proposal.

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11.3 CATEGORIES OF REPORT

Reports fall into three major categories:

1) Information oriented

2) Decision oriented

3) Research oriented

The substance and focus of the content determines the category. However, a report may contain characteristics of more than one category.

Information Reports

In describing any person, object, situation, or concept, the following seven questions (6 Ws+1 H) help to convey a comprehensive picture:

Subject/Object	Action	Reason
WHO?	WHAT?	WHY?
WHOM?	WHEN?	
	WHERE?	
	HOW?	

Therefore, the comprehensiveness of an information or descriptive report can be checked by iteratively asking:

WHO does WHAT to WHOM

WHEN, WHERE, HOW

and WHY?

Information reports are the first step to understand the existing situation (for instance, business, economic, technological, labour, market, or research scenario reports) or what has been discussed or decided (for instance, the minutes of a meeting) form the foundation for subsequent decision reports and research reports.

Decision Reports

Decision reports adopt the following steps of the problem solving approach:

1) Identifying the problem

2) Constructing the criteria

3) Generating and evaluating the options
4) Making a decision
5) Drawing up an action plan
6) Working out a contingency plan

Problem

The problem is the beginning and the end of decision making. A start with a wrong problem, a wrong hypothesis, or a wrong assumption will only solve a non-existing problem or create a new problem.

In defining the problem, identify the following elements:

1) What *is* the situation, and what *should* it be? This question sets the overall objective for the problem.
2) What are the *symptoms*, and what are the *causes?*
3) What is the *central* issue, and what are the *subordinate* issues?
4) What are the *decision areas*, and what needs to be done immediately, in the short term, medium term, or long term?

For analysing a problem, Kepner and Tregoe (See under suggested readings) recommend sorting out the information under *what, where, when* and *extent* across what *is* and what *is not*, the *distinctiveness in the* situation, and *changes* which may have taken place as follows:

	Is	Is not	Distinctiveness in Is	Change
What?				
Where?				
When?				
Extent?				

After this analysis, compare the deduced causes with the actual or observed ones.

Constructing the Criteria

Words like aim, goal, objective, intention, purpose, and criterion are used sometimes synonymously or with different meanings. Here the first five words are treated as synonymous and are recognized at the problem definition stage itself while identifying what the situation *is* and *should be*.

However, to bring the *existing* situation to what it *should be*, criteria or yardsticks are used to evaluate options. Criteria link the problem definition with the option generation and evaluation.

In constructing the criteria, SWOT analysis is useful. Recognize the *strengths* and the *weaknesses* of the decision maker and the organization and the *opportunities* available and *threats* confronting the decision maker and the organization in a given situation. This analysis helps in constructing the criteria which in turn help in evaluating the options against the feasibility of implementation.

Further, ensure and explicitly clarify the following:

1) The criteria arise out of the problem definition and are not independent of it.
2) They are measurable or observable as much as possible. However, non-quantifiable criteria are not ignored merely because they cannot be quantified.
3) They are prioritized and tradeoffs are recognized.
4) They encompass a holistic view—economics, personal, organizational, and societal considerations.
5) They are not loaded or one-sided. Both pro and con aspects are considered.

Generating and Evaluating the Options

In generating options, creativity is required. Sometimes the options are obvious. But one can look beyond the obvious.

Once a set of options have been generated, they are shortlisted and ranked by priority or their probability of meeting the objectives, identified in the problem definition.

Then the options are evaluated against the criteria and possible implications in implementation without losing track of the main objective of what the situation *should be*. The evaluation process demands logical and critical thinking.

The presentation of evaluation is structured by criteria or options depending upon which structure is easy to understand For instance, if the criteria are few and options are many, the presentation will be easy to understand if it is structured by criteria. But if the options are few and criteria are many, the presentation will be effective if it is structured according to options.

Making a decision

The decision or recommendation flows out of the evaluation of the options, provided the thinking process has been logical so far.

The recommendation should be an adequate response to the problem and implementable.

Drawing up an action plan

Even the best analysis can go waste if attention is not paid to the action plan. The action steps and their consequences should be visualized to avoid being caught unawares. Be clear of who does what, when, where, and how. Even at this stage we have to go through the problem solving steps in a futuristic scenario—what problems do we anticipate, what objectives and criteria would we like to pursue, what options would be open to us, and what choices can we make under what circumstances?

Working out a contingency plan

Administrators, executives, and managers thrive on optimism and confidence to get things done. Yet, if something can go wrong, it is likely to go wrong. They should have the parachute ready to bail out. The contingency plan must emerge from the action plan. There is need to think of how to achieve the second best objective if the first one is not feasible.

Conclusion

The problem solving approach helps only when one can question oneself again and again at every stage and bring to bear various thought processes to do a comprehensive analysis and synthesis. Then only will the administrator, executive, or manager be able to genuinely share his her thoughts with the reader.

If the problem solving approach and steps are used merely as a form filling exercise, a superficial analysis and report will result. An attractive package does not necessarily mean a good product.

An executive report is not a summary of the view and information that a decision maker has elicited but an analysis and synthesis of an integrated decision or recommendation. Thinking through a decision making situation is an iterative act.

A good decision report is structured sequentially but reflects comprehensively the iterative thinking process of the decision maker(s).

Research Reports

Research reports contribute to the growth of subject literature. They pave the way for new information, significant hypotheses, and innovative and rigorous methods of research and measurement. They broadly have the following organization:

1) Literature survey to find gaps in knowledge.
2) Nature and scope of the study, hypothesis to be tested, and significance and utility of the study.

3) Methodology for collecting data, conducting the experiment, and analysing the data.
4) Description and analysis of the experiment and data.
5) Findings.
6) Conclusions.
7) Recommendations.
8) Suggestions for further research.
9) Backup evidence and data.

Describe a strike or any other serious incident that has recently occurred in your organisation and check whether your description answers all the questions indicated under descriptive reporting.

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Activity 3

Take a report of your organisation and check whether the problem solving approach or descriptive approach has been used. If you were to rewrite the report, what will be your contents outline and what stages would you do to improve the report.

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11.4 REVIEWING THE DRAFT

The report should be thoroughly reviewed and edited before the final report is submitted. The following questions will help to review the draft:

1) Author's purpose?
2) Reader's profile?
3) Content?
4) Language and tone?
5) Length?
6) Appearance?

Author's Purpose

The lack of clarity and explicitness in the communication purpose leads to two major problems: (1) confusion in determining the mix of content, language and tone, length, and looks and (2) misinterpretation of the message.

Reader's Profile

The readership may consist of one or more persons or one or more groups. If more than one person or segment are involved, check whether all of them are on the same wavelength. If not, segregate the common interest areas from the special interest ones. Then decide on the types and parts of the report which can satisfy various reader groups.

Think of the organisation and social membership and hierarchical level of the reader. An executive writing a report, for instance, should know whether the reader is an insider or an outsider to the organization or the cultural system, an immediate boss

or a boss who is two or three rungs removed, a colleague or a subordinate. An understanding of the reader on these lines helps the author to modulate the content, language, and tone to suit the reader.

The major discriminating features of the reader's profile are the cultural, social, religious, ideological, educational, economic, and age.

Also pay attention to the reader's interest and familiarity of the subject and the language. Otherwise, you may be pitching the communication either too high or too low.

Content

The content is the crucial communication axle between the author and the reader. Attention should be given to the content's focus, its organization, accuracy of facts, and logic of arguments. These are discussed below:

Focus: Failure to prune and polish the content's focus makes the report as diffused as an amateur's photograph. All the wisdom of an author cannot be wrapped up in a few pages. Only the essentials required for the purpose can be covered.

The focus should be clarified right in first few paragraphs to attract the reader's attention and hold it. This is the first and last chance to catch the reader's attention. The main theme, presentation scheme, author's purpose, and intended readership should be indicated right in the beginning. The appropriate style and tone of the language should be set into motion right from the first sentence and be kept up till the end.

Organization: The focus is the foundation for the rest of the content. If any material is added or deleted in the text, check the focus delineated in the beginning to see whether any changes are required in the foundation. If needed, change either the focus or the text to get the consistency. Otherwise, different messages may emerge from the communication and confuse the reader.

Then ensure that:

1) the discussion is organized step-by-step into parts, sub-parts, and paragraphs,
2) the arguments of each section and paragraph flow smoothly into the next one, and
3) too many ideas are not crammed into one section.

To check that the various parts of the report and ideas are sequenced effectively, constantly ask whether a different sequence would be easier for the reader's comprehension.

Examine the structure of paragraphs. The most recommended structure for paragraphs in recent years has been the "inverted pyramid" style.

First, this style calls for putting forward the most important point first and then going down in priority. The idea is to put forward as much essential information as possible to the readers before their attention wavers or is lost.

Second, the style calls for putting forward the conclusion first or the main topic or theme in the very first sentence of the paragraph and then substantiating or supporting it with information and evidence in the order of priority beginning with the most essential or important at the top. The idea is that even if the reader skims through the first sentences of paragraphs, he/she should be able to get the gist of the content.

Accuracy of Facts: Authors can lose their credibility if they fail to check the accuracy of facts, figures, quotations, and references. A discerning reader can easily check the internal consistency of the report by comparing information across pages and sections.

Evaluation of Information: Decision makers often lack data or information. Not all that they want is available. Therefore, they have to constantly ask: What is the minimum data required for the decision, what is available, what can be got within the available time and money, and what cannot be obtained? Sometimes they have to make assumptions to fill up the gaps.

Facts, figures, and opinions have to be interpreted to become evidence for throwing light on an issue. Facts and figures do not speak for themselves. Only their interpretation makes an argument.

For effective communication, logic is a dependable tool in convincing the reader of the reasonableness of the points of view. But how can we make sense out of confusing and constantly changing situations? How can we recognize unreasonableness of the seemingly reasonable arguments? We can do it by

- Analysing the situation.
- X-raying the facts through their smoke screens—words, opinions, and assumptions.
- Examining the inference process.
- Capsulizing and concretizing the ideas.

Situational Analysis: What is good in one situation may not necessarily be so in another and that one situation may appear to be similar and yet be different. We have to list and arrange (either mentally or on paper) *the elements and the actors of a situation* to understand the dynamics of the situation. We can map out the territory on the basis of who *did* and *said* what to whom.

Elements, which shape a situation, could be of various kinds. Decision to buy or not to buy a new machine; decision to postpone the decision on the new machine; installing or not installing the new machine; decision to buy from one and not the other; X, Y, Z companies quoting different prices for the same product; the government's decision to make a statutory requirement of giving X amount of bonus; the company's offer of Y amount of bonus to its employees; workers threatening to go on strike; the boss having a poor opinion about the subordinate; X having certain image in the company; X being granted leave while Y has been refused leave; X telling Y that Z is a fine fellow—all such elements shape a situation.

Actors in a situation also matter. The managing director's request often get treated as an order. A colleague's request remains a request. And a subordinate's request remains in the basket for consideration in due course of time. If two or three workers ask for a change in timings, the manager may not consider the event as serious. If 80 per cent of the workers ask for it, the significance drastically changes; the manager will hasten to find a solution.

In arranging the elements and actors, we can try to understand the rules of the game—*opportunities and threats* inherent in the situation. If a strike is on, for example, we can identify the areas of agreement and disagreement, items on which the management will bend its back to avoid a strike, items on which the management's tail will be up, and power that the management can and cannot draw from the government and the situation within the country or the timing of the happening. It is such opportunities and threats which help the management to form the strategy for solution.

In arranging the elements of a situation, we must *check whether the element is relevant to the situation.* If it is, we consider it in ordering the elements. If not, we ignore it. For example, at the year end when the financial statements are being prepared, the death of the chief accountant may contribute to a serious situation; but the death of a worker will be inconsequential. However, if a company has launched a family planning programme for its workers, the death of even a worker due to an operation can jeopardize the whole programme; but the death of even the managing director in such a situation will be inconsequential.

The elements of a situation can be structured along the following dimensions depending on the situation: a) time, b) space, c) quantity, d) quality, e) cost, and f) hierarchy.

Each dimension offers a two-pronged fork—a) the relationship of the element to others and b) the magnitude of the element itself.

The *time sequence* among elements helps in understanding the situation. If the production has been going down, for instance, it is possible to attribute its cause to a

new procedure that has been introduced. But if production drop was noticed even before the procedure was introduced, the latter cannot be the cause for the former—at the most it could have aggravated the problem. Moreover, finding out the events at the starting point of the production may help in focussing the attention on causes of the problem.

An understanding of the *spatial arrangement* of element adds to the understanding of the situation. For example, if three plants—A, B, and C in that order—are in straight line at different distances, we know that plant B is between plant A and plant C. If they are located in a triangle, plant A could be at equidistance from plant B and plant C. If we are planning for a common processing facility at a central plant, we know that we can locate the facility in plant B in the first case and in plant A in the second case. Moreover, the information about the space available in each plant helps us to check whether it matches with the space required for the new facility.

Similarly, each element can be ranked according to *quantity* and *quality*, and each element's available quantity and quality can be checked against the requirement.

The *cost dimension* help, like the earlier four dimensions, in ranking elements and comparing each element against the requirement. But it has third fork. *It can also provide an all-inclusive comparative picture of various elements.* The cost dimension can include within it the time, space, quantity, and quality dimensions when they are quantified in money terms.

Finally, the *hierarchical dimension* is the most difficult one to understand and pinpoint. The elements and actors in this dimension are constantly changing. Today's colleague may be tomorrow's boss. Hierarchical positions within the company will broadly indicate the authority, power, influence, and responsibility each actor wields. Moreover, the secretary to the boss sometimes commands power which is not reflected by his/her position in the organizational chart.

The structuring of elements and actors across different dimensions helps in examining various elements and their relationships and in focussing on the decision making area or the problem.

X-Raying of Facts : *Facts often get shaded by three smoke screens—words, opinions, and assumptions.*

The hazy picture of facts that we get at first sight gives us the feeling that we have understood the facts. Yet the real shape of the facts eludes us unless we x-ray the facts through the smoke screens. Unless we understand the facts in their real form, our conclusions may be way off the reality.

The meaning of the same *word* for the writer and the reader may be different. If a company says that its staff is "disciplined", what does it mean? Does it mean that they have "a high commitment to work, a task, or a cause"? Does it mean that they are "obedient yes-men"? Does it mean that they are "punctual"? Does it mean that they are "faithful and loyal"? Does it mean that they are "polite"? It could mean some of these, all of these, or something else what the company considers as discipline. Can we break through this smoke screen of "discipline" to find out what the reality is?

Opinion is another smoke screen which envelops facts. When a personnel manager, for example, says that Mr. X is 58 years old and he will be retiring in another two years, the statements can be checked. One can cross check from Mr. X's personnel file whether he is 58 and from the company policy whether the retirement age for the employee is 60. But when the personnel manager writes about Ms. Y, who is being considered for a training programme, that she is "too old to learn", the age of Ms. Y can be any where say between 21 and 60. In fact, the opinion of the personnel manager may have been based on observations other than age. Therefore, facts and observations on which this opinion has been based need to be ascertained before agreeing or disagreeing with the personnel manager's recommendation.

The third smoke screen is made up of *assumptions*. When there is a gap in the information or an uncertainty about the future events, we make assumptions, which if they are not recognized as assumptions, escape the scrutiny and pass off as facts.

Assumptions can be of two kinds: illustrative and critical: An *illustrative* assumption helps to describe a process or a result concretely so that further arguments can be built. For example, if the price of product X is Rs. 10 per piece and an excise levy of 10 per cent *ad valorem* is assumed, the effective price to the customer is Rs. 11. If the tax is 20 per cent, the effective price is Rs. 12. Here, the assumptions about the percentage of excise duty are made to explain how the *effective* price to the customer will vary depending on the percentage of tax.

However, if a company feels that the demand of its product will remain unchanged at a price of Rs. 11 but will fall drastically at Rs. 12, it will seriously think before the budget session of Parliament about the impact of change in the tax structure. If it assumes the rate at 10 per cent, it has no cause for worry. If it assumes that the rate will be 20 per cent or between 10 per cent and 20 per cent, it has to examine the impact of tax on the demand for the product. Therefore, the assumption in this situation about the likely tax rate is *critical* because it affects the decision.

Then how can we penetrate the smoke screens to see the facts as they are? A three-pronged attack may be useful. First concretize all general statements. Second, check against the actual. Third, examine contradictions in evidence.

Statement qualified by general words like "all", "almost all", "most", "the majority", "the minority", "few", and "some" can distort the picture of the actual situation. When a company says that the majority of its employees are satisfied workers, it may mean that 251 workers out of 500 are happy. The arithmetic is correct, but the representation of the gravity of the situation is doubtful. When a company says that only a few of its employees are disgruntled and does not reveal that these few are the opinion leaders, it may not be projecting the true picture.

General adjectives or qualifying words hide facts. When a manager says that X is a *good* employee or an *average* employee, it is not clear what X is capable of doing or not doing. We can arrive at the actual profile of X only when the manager spells out concretely what is meant by good and whether X has been actually rated against those criteria. However, labels like "good", "average", and "bad" keep floating unchallenged.

Having concretized the generic words to understand what is actually meant, *check whether the socalled facts are really facts.* When someone, for example, claims that he/she belong to X, Y, Z category and hence eligible to a certain privilege, ascertain first whether he/she really belongs to the privileged category or not. Often rules and procedures are quoted by memory to help or hinder someone. Check whether such a rule or procedure really exists, or had existed and changed over time, or is being anticipated to be introduced, or never existed except in the mind of the person quoting it.

Often we come across *contradictory observations* about an item when only one of them can be true. For example, X may report that machine Y has broken down. But Z may report that machine Y is in working condition. The contradiction needs to be examined. Maybe X and Z are talking about two different machines. Or X and Z are talking of two jobs of which the machine at present can do one and cannot do the other. Or X and Z are picking on each other. Unless such contradictions of facts are recognized and challenged, facts will continue to elude and delude us.

Inference Process : *The first step in examining the inference process is to understand the cause-and-effect relationship.*

When a company, for example, begins to lose its market share, the marketing manager investigates with the assumption that there is a cause or a set of causes underlying the loss of market share. Unless the cause(s) is clearly understood, the attempt to change the effect is likely to be a shot in the dark.

The next step is to draw conclusions from facts and observations through deductive (general to specific) and/or inductive (specific to general) reasoning processes.

Deductive Inference : If a universal or general principle is known or has been proved to be true, conclusions can be drawn from it about individuals falling in that universe. Let us take an example:

I) No leave was granted to the employees of company X on a certain date.

2) Y is an employee of company X.

3) Therefore, Y was not granted leave on that date.

In using this kind of reasoning, we should make sure that the universal principle is true and the linkage between the universal principle and the individual is relevant; otherwise the conclusion drawn in a particular situation may or may not be valid. If some employees were granted leave and some were not, we cannot be sure into which category Y falls. Much worse will be the situation if Y is not an employee of the company; the universal principle stated will then have no relevance to Y, and, therefore, it cannot be concluded definitely whether Y was granted leave or not.

Inductive Inference : When universal or general principles are not available, conclusions are drawn on the basis of observations of individual units in a universe. The basic assumption in inductive reasoning is that the particular units partake of the universal character.

If a company, for example, wants to find out the customer reaction to a new product or service, one method is to ask all the customers about it. But the number of customers may be so large that the company has to resort to sampling. From the sample reaction, it can then generalize or interpret likely response to the new product or service.

When inductive inference is being drawn from sampling, we must guard against some loopholes:

First, is the sample relevant?

Second, is the method right?

Third, the existence of causes other than the ones identified cannot be ruled out without careful scrutiny. For example, a manager may generalize that the employees want job security because some of them had left the company for lower wages. Another manager may conclude from talking to the same workers that they left because they lived at far-off places from the plant.

Fourth, opinions may change. Therefore, feedback collected today may not necessarily hold good tomorrow when the action is taken.

Capsulization and Concretization: Capsulization involves both a) miniaturization of the main theme and identification of the high points of evidence and arguments and b) chewing ideas bit-by-bit. It dispels the fog or impression that long-winded arguments or lengthy reports create. By understanding the main ideas and the main points in a nutshell or a skeleton form, we can map out the territory and identify the traps.

Concretization involves use of a) specific words and b) visualization. The statement that plant A is "10 km away" from plant B is more specific than plant A is "very far" or "quite close" to plant B. Instead of saying that the new policy of the government is "generally favourable" or "generally unfavourable" to the organization, we can specify the implications—say in rupees and paise. We can translate the favourableness or unfavourableness through the balance sheet and the income statement. We can specify in implementation terms the new opportunities and threats to our business.

Traps of Logic : In playing the trap detection game, we should recognize the following common traps:

1) Avoidance

2) Diversion

3) Stacking the deck

4) Either-or

The avoidance trap can be recognized when one begins by saying, "I am not concerned with..." or "How am I concerned with..." Another form of avoidance is what is commonly known as "pass the buck". The buck could be passed upwards, downwards, or sideways. All of us play it to avoid taking the decision or applying

ourselves to the problem on hand. The more sophisticated form of avoidance is much-can-be-said-on-both-sides technique used when one has to make a choice.

The diversion trap operates mainly on diverting the attention from the main theme or agrument.

One diversionary technique is to side-track the main issue. If the general manager is discussing a strike on hand with the plant manager, the latter may fritter away the time by talking about the general climate or history of unionism in the country, or general absenteeism of the workers or the promotion of a person in another plant, or for that matter he may talk about the weather.

Another kind of diversion can be provided by emotional appeal. Both the management and the union use the technique by appealing to fairness, prestige and prejudice. Appeals and insinuations on both sides divert the attention from the real issue. If a case of reinstatement of an employee who has been fired for malpractice is discussed, the real issue of whether the employee has been guilty or not is wrapped up in emotional terms of victimization.

Another diversionary tag is to project self-confidence—a tool often used by salesmen. The way the salesman talks or carries himself may numb the purchase manager from examining whether the selling company can provide after-sales service or some critical issues before making the purchase.

One more diversionary technique is to cite an authority. The chairman or the managing director wants it done this way, or all the world over it is done that way, or the Bible—whatever book you swear by—says so are common indicators of this technique.

Stacking-the-deck trap is sprung by citing only facts that support an argument and ignoring unfavourable ones. A manager who is interested in promoting subordinate X may quote facts which help to build X's case and suppress the weak points. Moreover, the weak points of other contenders may be highlighted and their plus points blanked out. Similarly, a purchase manager, who is interested in helping a supplier, may stack up all the plus points of the favoured supplier and all the minus points of other suppliers. Moreover, the manager may gloss over contradictions in the recommendation. Supplier X may be rejected for inability to provide after-sales service. But in the same breath, supplier Y may be recommended without telling his inability also to provide the expected after-sales service.

The either-or trap (i.e., either this or that only) is aimed at limiting the thinking to only two choices without proving that only two choices are feasible in a given situation. The attention is fixed only to black or white and is not allowed to examine the possibilities of grey areas or any other colour. Either one is a friend or an enemy. All other possibilities are ruled out. When a manager argues that product A is to be bought from supplier X or supplier Y, the mind is closed to the choice of a mix or a supplier Z. Of course, such an argument becomes valid if it is proven that neither grey nor any other colour exists in the given situation.

Language and Tone

Since the purpose of communication is to make the reader understand the message, use the vocabulary and sentence structures which the reader understands. The terminology and language structures of a subject specialist are not familiar to non-specialist. Even among the specialists, sometimes there are differences in the usage of terminology and language structures. For effective communication, the author has to climb down or climb up to the reader's level—a difficult adjustment for many of us to make.

Abstract phrases are difficult to comprehend. Concrete phrases are easy to understand. For example, a word like "freedom" is abstract unless it is followed by a definition or an example. "This is better" or "that is good or bad" are oft-made judgements. But the reader finds it difficult to understand "better than what" or "good or bad by what criteria". Generic adjectives and adverbs sabotage the effectiveness of communication. For example, instead of merely stating that XYZ company is a *large* company, the author can also indicate the various dimensions

(e.g., sales, profits, and employees) which lead to the conclusion that the company is large.

Finally, the tone of the language also matters. It can make the reader receive, ignore or reject the message. Executives have to differentiate and modulate the tone of writing to superiors, peers, and subordinates.

Length

How long should the report be? This is a matter to be judged by the author keeping in mind the purpose, the subject, and the reader's interest. Shorter the content, the more attractive it is to the reader. But it cannot be so brief as to miss the essential points and the linkages in the flow of arguments and force the reader to ask for more information. If the length does not match with the reader's interest and patience, the author has to rework and scale down the purpose, the focus, or the content.

Check the readability of paragraphs. As a thumb rule, paragraphs should not exceed eight typed lines, sentences should not exceed more than three typed lines, and punctuated pauses should not go over two typed lines.

In short, the communication should be like a capsule. It should be small enough to swallow but powerful enough to act.

Here are a few suggestions to save words:

1) Cut out repetitions, unless they are meant for sharpening the message.
2) Take out redundancies. (Instead of "takes 10 minutes of time", write "takes 10 minutes". Instead of "The profit increased to the tune of Rs. 50 lakh", write "The profit increased to Rs. 50 lakh".)
3) Use active voice. (Instead of "The balance sheet is given in Exhibit I", write "Exhibit I gives the balance sheet".)
4) Use shorter and direct verbs. (Instead of "They had done investigations in the matter", write "They had investigated the matter". Instead of "To make a comparison of these two divisions", write "To compare these two divisions".)
5) Eliminate weighty expressions. (Instead of "The demand will fall in the event of price going up", write "The demand will fall if the price goes up".)
6) Make concrete adjectives. (instead of "The company incurred a loss of Rs. 20,000", write "The company incurred Rs. 20,000 loss" or even better "The company lost Rs. 20,000".)
7) Strike out *it* and *there*. (Instead of "There was no machine available", write "No machine was available".)
8) Use abbreviations which are more familiar than their expanded forms. (Instead of "United Nations Educational, Scientific, and Cultural Organization", write "UNESCO".) (See 7.5)
9) Use pronouns wherever possible. If confusion arises, clarify the pronoun by name or by words like "former" or "latter". (Note the difference between "former" and "farmer" and between "latter" and "later".) Note the modern trend of avoiding the use of "he" alone as a generic pronoun unless if suits the context. If a generic pronoun is needed, use "he/she", or rephrase the sentence to drop it, or use plural nouns and pronouns.
10) Use the full name of a person at the first reference. Then use only the short name, preferably the last name in a formal report.

Appearance

The novelty or presentation is as important as the originality of ideas. Both are products of creativity and criticalness. Presentation attracts the readers, and the content holds their attention. Both the product and the package are equally important.

Activity 4

Take one of your recent reports. Analyse it by going through the steps indicated for reviewing a draft. Write down what improvements and where you would make in your report.

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11.5 SUMMARY

In this unit, we have discussed the steps involved in preparation of a proposal for a report. Three categories of reports namely Information reports, Decision reports and Research reports have been explained. The steps involved in writing various types of reports are also discussed. Before a final report is submitted, the report should be thoroughly reviewed and edited. The unit concludes by answering certain questions for reviewing the draft of a report.

11.6 SELF-ASSESSMENT EXERCISES

1) Take a paragraph at random from any report and analyse whether the first sentence contains the conclusion or announces the topic and the rest of the paragraph substantiates the first sentence. If not rewrite the paragraph in the inverted pyramid style.

2) Write a performance report on any of your subordinates. Check whether you have qualified and explained all the general adjectives like "sincere" and "hard working" you have used to describe the person.

3) Take a management case and analyse it. Write a report using the format suggested for decision making reports. Identify the mental process you have gone through using creative, logical, and critical thinking at different stages of solving the problem and writing the report.

4) Take any managerial decision that was taken in your organization and of which you are aware of the information and the process through which it has gone through. Analyse the problem solving steps that have gone through and the improvement that you would suggest if the same situation has to be faced all over again.

11.7 FURTHER READINGS

Gallagher, J. William, *"Report Writing for Management"*, Addison-Wesley

Golen, P. Steven, *"Report Writing for Business and Industry"*, Business Communication Service

Kepner H. Charles and Benjamin B. Tregoe, *"The Rational Manager"*, McGraw-Hill Book Company (1965)

Sharma, R.C and Krishna Mohan, *"Business Correspondence and Report Writing"*, Tata McGraw-Hill.

Wright, C., *"Report Writing"*, Witherby & Co. England.

UNIT 12 FORMATS OF REPORTS

Objectives

After going through this unit, you should be able to:

- Distinguish between various parts of a report
- Explain the different parts of a report
- Instruct the typist as to how he/she should go about typing the report.
- Edit any report by using the copy reading and proof reading symbols.

Structure

12.1 INTRODUCTION

In the last unit, we have explained the steps one should follow while writing a proposal for any type of report. The subject matter of various types of reports was also discussed. It was also explained as to how one should go about editing the draft of a report. The next stage is understanding the Formats of Reports which is the subject matter of this unit. It explains the contents of Cover and the Title Page. We should also understand as to what goes into Introductory pages, Text and Reference Section of a report. Once this is known there is a standard format in which the report should be typed. Therefore, a few pages are devoted in this unit on typing instructions. Once the report is typed, it should be edited by using the copy reading and proof reading symbols. This forms the concluding section of this unit.

12.2 PARTS OF A REPORT

The different parts of a report are:

1) Cover and the title page
2) Introductory pages
   a) Foreword
   b) Preface
   c) Acknowledgement
   d) Table of contents
   e) Lists of tables and illustrations
   f) Summary
3) Text
   a) Headings
   b) Quotations
   c) Footnotes
   d) Exhibits
4) Reference section
   a) Appendices

b) Bibliography
c) Glossary (if required)

12.3 COVER AND THE TITLE PAGE

The cover and the title page of a report contain the following information:

1). Title of the subject or project
2) Presented to whom
3) On what date
4) For what purpose
5) Written by whom

If there is any restriction on the circulation of the report, it is indicated (e.g., "For Official Use Only") in the top right corner of the cover and the title page.

Examples of the cover and the title page for research reports, conference papers, committee/consulting/administrative reports, and student reports are given below.

Example of the Cover and the Title Page for a Research Report

Research Monograph No. 10

CRISIS IN THE SUGAR INDUSTRY

S. Ramesh Chander
Professor
School of Management
Regional University, Ahmedabad

Council of Management Research
New Delhi
1 January 1986

Example of the Cover and the Title Page for a Conference Paper

CRISIS IN THE SUGAR INDUSTRY

A Paper
Presented to the National Economic Conference
held at the
School of Management
Regional University, Ahmedabad

on
1 January 1986
by
Ramesh Chander
Professor
Institute of Business
National University, Jaipur

Example of the Cover and the Title Page
for a Committee/Consulting/Administrative Report

For Official Use Only

WORKING CAPITAL REQUIREMENTS
OF
RAJPUR TEXTILE MILL

Presented to the
Managing Director
Rajpur Textile Mill

on
1 January 1986
by
Professor Ramesh Chander
and
Professor Ramesh Kumar

School of Management
Regional University, Ahmedabad

Example of the Cover and the Title Page
for a Student Report

CRISIS IN THE SUGAR INDUSTRY

A Paper
Presented to
Professor Ramesh Chander
School of Management, Regional University

on
1 January 1986
in Partial Fulfilment
of the Requirements for the
Managerial Economics Course in the
Master of Business Administration Programme
by
Ramesh Kumar

Activity 1
Take any report which has been recently prepared in your organisation and check whether cover and title page contain all the essential information. If not, prepare a new cover and title page.

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12.4 INTRODUCTORY PAGES

The introductory pages are given lower case Roman numerals (e.g., i, ii, iii). Arabic numerals (e.g., 1, 2, 3) are used from the first page of the introduction. The introductory pages contain the following:

1) Foreword
2) Preface
3) Acknowledgement
4) Table of contents
5) Lists of Tables and Illustrations
6) Summary

1) Foreword

The first page of the foreword is not numbered, but it is counted among the introductory pages. Usually a foreword is one page or even shorter. If a foreword is more than a page, subsequent pages of the foreword are numbered in lower case Roman numerals.

The foreword is written by someone other than the author. It is written by an authority on the subject or the sponsor of the research or the book and introduces the author and the work to the reader.

At the end of the foreword, the writer's name appears on the right side. On the left side, address and place of writing the foreword, and date appear. Name, address, place and date are put in italics.

2) Preface

The first page of the preface is not numbered, but it is counted among the introductory pages. Subsequent pages of the preface are numbered in lower case Roman numerals.

The preface is written by the author to indicate how the subject was chosen, its importance and need, and the focus of the book's content, purpose, and audience.

At the end of the preface, the author's name is given on the right side. On the left side, address and place of writing the preface, and date appear. Name, address, place and date are put in italics.

3) Acknowledgement

If the acknowledgement section is short, it is treated as a part of the preface. If it is long, it is put in a separate section.

The first page of the acknowledgement is not numbered, but it is counted among the introductory pages. Subsequent pages of the acknowledgement are numbered in lower case Roman numerals.

At the end of the acknowledgement, only the author's name appears in italics in the right-hand corner.

4) Table of Contents

In writing the table of contents, great care should be taken. The contents sheet is both a summary and a guide to the various segments of the book. The table of contents should cover all the essential parts of the book and yet be brief enough to be clear and attractive.

The first page is not numbered, but the subsequent pages are numbered in lower case Roman numerals.

The heading TABLE OF CONTENTS or CONTENTS in all capital letters appears at the top. On the left side, foreword, preface, acknowledgement, and numbers and titles of sections, chapters, centre heads, centre subheads, and side heads are listed. On the right side, the corresponding page numbers are given. The page numbers are aligned on the right.

The section and chapter titles are put in all capital letters. The centre head is put in capital and lower case letters. The centre subheads and side heads are put in lower case letters, except the first letter of the first word and proper nouns.

The classification of the headings can be done in the traditional or decimal system in the declining order as follows:

Traditional Classification	Decimal Classification
I.	1.
A.	1.1
1.	1.1.1
a.	a.

The headings of the text can be indented in a step form to visually highlight the classification.

At the end of the headings of the text, references to appendices, bibliography, glossary, and index appear. These references are put in all capital letters from the margin.

Samples of contents sheet in traditional and decimal classification follow.

Example of the Contents Sheet in Traditional Classification

CONTENTS

Example of the Contents Sheet in Decimal Classification

CONTENTS

5) Lists of Tables and Illustrations

Lists of tables and illustrations follow the table of contents. Each list starts on a separate page. If the items in each list are few, both the lists are put on the same page but under different headings.

The headings for these lists may be in all capital letters—LIST OF TABLES, LIST OF ILLUSTRATIONS, TABLES, or ILLUSTRATIONS, and they follow the format of the heading that is used on the contents page—TABLE OF CONTENTS or CONTENTS.

Only the first letter of the main words are capitalised in writting the titles of tables and illustrations.

The second and subsequent lines of an item are indented. The page number appears against the first, second, or third line where the item's description ends.

Tables and illustrations are numbered continuously in serial order throughout the book in Arabic numerals (e.g., 1, 2, 3,) or in the decimal form (e.g., 1.1, 2.1, 2.2., 3.1). In the latter classification, the first number refers to the chapter number and the second one to the serial order of the table or illustration within the chapter.

Example

TABLES

6) Summary

A report invariably carries an abstract or an executive summary in the initial pages as a help to the busy researcher or executive. The summary is positioned immediately before or after the contents sheet. The summary and the contents together provide an overview to the reader. The length of the summary may vary from 100 words to 1,000 words.

In a short report, the preface itself becomes the summary. In a long report, the summary is given in the first chapter of the text.

The summary should highlight the following essential information:

1) What is the study about?
2) What is the extent and limitation of the coverage?
3) What is the significance and need for the study?
4) What kind of data has been used?
5) What research methodology has been used?
6) What are the findings and conclusions?
7) What are the incidental findings, if any?
8) How can the conclusions be used and by whom?
9) What are the recommendations and the suggested action Plan?

Activity 2

Take a report you have recently written and examine whether the introductory pages contain all the sections indicated in this unit. If not, put in these sections if they are necessary for the report.

12.5 TEXT

The subject matter of Text is divided into the following:
1) Headings
2) Quotations
3) Footnotes
4) Exhibits

1) Headings
The following types of headings are common :

1) Centre Head (All caps, without underlining)
2) Centre Subhead (Caps and lower case, underlined)
3) Side Head (All caps, without underlining)
4) Side Head (Caps and lower case underlined)
5) Paragraph Head followed by a colon (caps and lower case, underlined)

Which combination of headings to use depends on the number of classifications or divisions that a chapter has.

Centre Head : A centre head is typed in all capital letters. If the title is long, the inverted pyramid style (i.e., the second line shorter than the first, the third line shorter than the second) is used. All caps headings are not underlined; underlining is unnecessary because capital letters are enough to attract the reader's attention.

Example

CHALKING OUT A PROGRAMME FOR
IMPORT SUBSTITUTION AND
EXPORT PROMOTION

Centre Subhead : The first letter of the first and the last word and all nouns, adjectives, verbs and adverbs in the title are capitalized. Articles, prepositions, and conjunctions are not capitalized.

Example

Chalking out a Programme for
Import Substitution and
Export Promotion

Side Heads : Words in the side head are either written in all capitals or capitalized as in the centre subhead and underlined.

Example
Import Substitution and Export Promotion

Paragraph Head : Words in a paragraph head are capitalized as in the centre subhead and underlined. At the end, a colon appears, and then the paragraph starts.

Example
Import Substitution and Export Promotion: The Seventh Five-Year Plan of India has attempted.....

2) Quotations
Quotation Marks : Double quotation marks (" ") are used. A quotation within a quotation is put in single quotation marks (' '). *Example:* He said, "To the selfish, 'freedom' is synonymous with licence."

Punctuation and Quotation Marks: The quotation mark is put *after* the comma and the full stop. (*Example:* "To the selfish," he said, "freedom is synonymous with licence.") But the quotation mark is put *before* the semi-colon and colon. (*Example:* The following are methods of "realistic learning": case method, tutorial method,

group discussions and business games.) The quotation mark is put *before or after* the question mark or the exclamation mark depending on the sense. *Examples:* 1) He asked, "Did you write to Ramesh?" 2) What do you mean by "freedom"?

," ?" "?"

." ." ?"

When to Use Quotation Marks: Quotation marks are used for 1) a directly quoted passage or word, 2) a word or phrase to the emphasized, and 3) titles of articles, chapters, sections of a book, reports, and unpublished works.

How to Quote: a) All quotations should correspond exactly to the original in *wording, spelling, and punctuation.* b) Quotations up to three typewritten lines are run into the text. c) Direct quotations over three typewritten lines are set in indented paragraphs. Quotation marks are not used for indented paragraphs.

Five Ways of Introducing a Quotation:

a) *Introduction:* He said, "The primary test of success in a negotiation is the presence of goodwill on both sides."

b) *Interpolation :* "The primary test of success in a negotiation," he said, "is the presence of goodwill on both sides."

c) *End Reference :* "The primary test of success in a negotiation is the presence of goodwill on both sides," he said.

d) *Indented Paragraph :* He said:

> For the workers no real advance in their standard of living possible without steady increase in productivity because any increase in wages generally, beyond certain narrow units, would otherwise be nullified by a rise in prices.

e) *Running into a Sentence :* He recommended that "joint management councils be set up in all establishments in the public as well as private sector in which conditions favourable to the success of the scheme exist".

Omission in a Quotation

a) Omission of a word or words from the quotation is indicated by ellipsis, i.e., *three dots (. . .).*

b) Omission of a whole paragraph is indicated by a line of dots.

Author's Comments in a Quotation

a) Comments of the author in a quotation are separated by brackets [ ].

b) If there is an obvious error in the original source, it is quoted as in the original source. The author can indicate that he is doing so by [*sic*].

3) Footnotes

Types of Footnotes : A footnote either indicates the source of the reference or provides an explanation which is not important enough to include in the text.

In the traditional system, both kinds of footnotes are treated in the same form and are included either at the bottom of the page or at the end of the chapter or book.

In the modern system, explanatory footnotes are put at the bottom of the page and are linked with the text with a footnote number. But source references are incorporated within the text and are supplemented by a bibliographical note at the end of the chapter or book.

Rationale of Footnotes : Footnotes help the readers to check the accuracy of the interpretation of the source by going to the source if they want to. They are also an acknowledgement of the author's indebtedness to the sources. They lend authority to the work and help the readers to distinguish between the author's own contribution and that of others.

Where to Put the Footnote : Footnotes appear at the bottom of the page or at the end of the chapter or report (before the appendices section).

Numbering of Footnotes

a) For any editorial comment on the chapter or title, an asterisk is used.

b) In the text Arabic numerals are used for footnoting. Each new chapter begins with number 1.

c) The number is typed half a space above the line or within parentheses. No space is given between the number and the word. No punctuation mark is used after the number.

d) The number is placed at the end of a sentence or, if necessary to clarify the meaning, at the end of the relevant word or phrase. Commonly the number appears after the last quotation mark. In an indented paragraph, the number appears at the end of the last sentence in the quotation.

Footnotes at the Bottom of the Page

a) After the last line of the text, three spaces are given and a 15-space line is drawn to separate the footnotes from the text. Then three spaces are given and the first footnote is typed.

b) Each footnote is typed in single space. Between two footnotes, two spaces are given.

c) The first line of each footnote is indented five spaces, and the rest of the lines are started from the regular margin.

d) Footnotes should not overflow from one page to another. If the last footnote of a page has to be carried over to the next page, the carry-over portion is typed at the bottom of the next page before the footnote references of that page begin. The footnote of the first page is broken in the middle of a sentence so that the reader is made to turn to the next page to read the rest of the footnote.

Separated Reference Notes and Explanatory Notes

Within the text, immediately after a quotation or a paraphrased statement, the last name of the author, year of publication, and page number (Rao, 1981, p. 101) are indicated within parentheses. If more than one publication of the author in the same year are referred to, a letter is added after the year of publication (Rao, 1981 (a), p. 101).

If the author's name is mentioned in the text in introducing the quotation or the paraphrased statement, the reference to the name in the parentheses is dropped. If the year is also mentioned in the text, the reference to the year in the parentheses is also dropped.

The source references are elaborated in notes at the end of the article, chapter, or book. The reference notes are presented in a bibliographical form.

The explanatory notes are presented as in the traditional footnote form with a number at the appropriate place in the text and the explanatory footnote at the bottom of the page.

Examples of Footnote Entries

Comparative examples of footnote and bibliographical entries are given under the bibliography section.

Comparative examples of traditional and modern footnoting forms follow.

Example of Traditional Footnoting

HISTORY OF CORONET

The first issue of *Coronet* put out by Esquire, Inc., was dated November 1936. It appeared "with a five-color cover, [carrying] drawings, etchings, and color reproductions of Raphael and Rembrandt in addition to fiction, articles, and photographs." (1)

Esquire described the contents of *Coronet* in an advertisement as follows:
The book-size magazine of popular culture is a "believe-it-or-not" of money's worth, for the many-sided CORONET is truly four magazine in one: It's a magnificently illustrated journal of the fine arts; it's a breath-takingly beautiful "picture magazine" of unforgettable photographs; it's a full-strength satire and humor magazine; and a distinguished general magazine...Each issue is an entertaining education in "things you never knew till now"—a liberal culture course in capsule form—a little college in your coat pocket:(2)

Within 48 hours, according to its first publisher, David A. Smart, the 250,000 copies of the first issue were sold out. (3)

1) Theodore Peterson, *Magazines in the Twentieth Century* (Urbana: University of Illinois Press, 1964), pp. 342-3.

2) *Esquire*, December 1936, p. 322. For complete discussion on format and contents of the magazine, see Chap. IV.

3) Peterson, *op. cit.*, p. 343. For the names of all the editors and publishers of the magazine, see Chap. III.

Example of Modern Footnoting

HISTORY OF CORONET

The first issue of *Coronet* put out by Esquire, Inc., was dated November 1936. It appeared with a five-color cover, [carrying] drawings, etchings, and color-reproductions of Raphael and Rembrandt in addition to fiction, articles, and photographs (Peterson, 1964, pp. 342-3).

Esquire (December 1936, p. 322) described the contents of Coronet in an advertisement as follows:

The book-size magazine of popular culture is a "believe-it-or-not" or money's worth, for the many-sided CORONET is truly four magazines in one: It's a magnificently illustrated journal of the fine arts; it's a breath-takingly beautiful "picture magazine" of unforgettable photographs; it's a full-strength satire and humor magazine; and a distinguished general magazine...Each issue is an entertaining education in "things you never knew till now"—a liberal culture course in capsule form—a little college in your coat pocket.(1)

Within 48 hours, according to its first publisher, David A. Smart, the 250,000 copies of the first issue were sold out (Peterson, 1964, p. 343. (2)

1) For complete discussion on format and contents of the magazine, see Chap. IV.

2) For the names of all editors and publishers of the magazine, see Chap. III.

NOTES

[At the end of the Chapter]

Peterson, Theodore, *Magazines in the Twentieth Century*. Urbana: University of Illinois Press, 1964.

---

4) Exhibits

TABLES

Reference and Interpretation

Before a table is introduced, it is referred in the text (e.g., see Table 1.1; refer to Table 1.1; as in Table 1.1; Table 1.1 indicates). A table is meant only to expand, clarify, or give visual explanation rather than stand by itself. The text should highlight the table's focus and conclusions.

An example of a good match between the text and the table is quoted below from Anne Anastasi's *Fields of Applied Psychology* (New York: McGraw-Hill Book Company, 1964), page 146:

The Communication Process : Industrial psychologists have investigated the communication process from many angles. Some have been concerned with the relative effectiveness of different media. In one such study (11) information was transmitted by five different methods in various departments of an industrial plant. Later, tests were administered to determine how much the individual employees had actually received and retained. The results are shown in Table 10. It will be noted that the combination of oral and written communication gave the best results but that oral only was more effective than written only. Bulletin board and grapevine yielded the poorest results.

Table 10 Mean Information Test Scores of Employees Receiving Communication through Different Media (From Dahle, 11, p. 245)

Medium	No. of Employees	Mean Test Score*
Combined oral and written	102	7.70
Oral Only	94	6.17
Written only	109	4.91
Bulletin board	115	3.72
Grapevine only (control group)	108	3.56

* All differences are significant at the 5 per cent level or better except that between the last two means in the column.

Identification

a) Each table is given a number, title, and, if needed, a subtitle. All identifications are centred.

b) Arabic numerals, instead of Roman numerals or capital letters, are recommended for numbering the tables. Usually technical monographs and books contain many tables. As the number increases, Roman numerals become unfamiliar to the reader. Roman numerals also occupy more space than Arabic numerals. If there are more than 26 tables, capital letters will not be sufficient to identify them.

Tables can be numbered consecutively throughout the chapter as 1.1, 1.2, 1.3,...wherein the first number refers to the chapter and the second number to the table.

c) For the title and subtitle, all capital letters are used.

d) Abbreviations and symbols are not used in the title or subtitle.

Body

a) Column headings are typed vertically, and abbrevations are used as space-savers. If uncommon abbreviations are used, they are explained in footnotes. The main words of column headings are capitalized and underlined if column rules are not used.

b) Identifications of measurement units (e.g., Rs., $) are put in column headings.

c) Column numbers are usually avoided. But they are used if references are made to columns (e.g., Col. 1, or the total of Cols. 1 and 4) either in the text or in the table.

d) The row captions are aligned on the left. But the numbers are aligned on the right. If there is a sub-caption, it is indented three spaces inside. Single space is used throughout. Between the caption and the sub-caption double space is given. If the captions run into two or more lines, the serial numbers corresponding to the captions are aligned.

Example

Table 1.1
Changes in Indices of Industrial Production
(Base : 1956=100)

Period	General Index	Basic Industries	Capital Goods	Inter-mediate Goods	Consumer Goods
Plan I*	+26.0 (+5.0)	n.a	n.a.	n.a.	n.a.
Plan II	+30.8 (+5.9)	+67.2** (+11.9)	+50.1 (+11.3)	+21.3 (+5.0)	+14.7 (+3.5)
Plan III	+38.7*** (+6.8)	+55.0 (+7.1)	+98.1 (+14.8)	+36.0 (+6.4)	+28.7 (+5.2)

Source : Reserve Bank of India Bulletin, June 1957.
Abbreviation : n.a. = not available.
Symbol : ( ) Figures in parentheses represent annual rate of increase.
* Data for Plan I are estimated.
** . . . . . .
*** . . . . . .

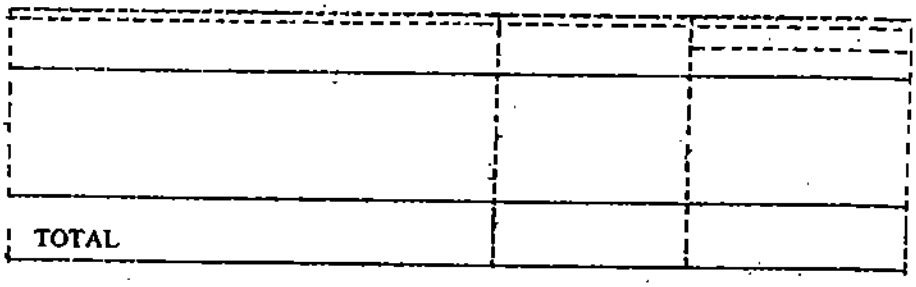
Example

Expenditure Heads			Amount (Rs.)
1)	Miscellaneous Expenses		
	a.	Training Programme	1,83,770.31
	b.	High Yielding Varieties Project	16,593.44
	c.	Chair for Management Practices	18,000.00
	d.	Subsidized Programme	31,230.67
2)	Amount Transferred to Reserve or Specific Funds		
	a.	Fund for conveyance advance to officers and staff	1,00,000.00
	b.	Fund for scholarships	1,75,000.00
Total			5,24,594.42

Column Rules

a) Column rules are used only if they increase legibility. The white space between columns is sufficient to act as a divider.

b) If rules are used, the following box format may be followed:



References

a) Immediately after the table, the source of the table is indicated.

b) After the source, abbreviations and symbols are explained.

c) Then the footnotes to the table are given.

d) For footnote sequencing, the order from top to bottom (column) and from left to right (row) is followed.

e) No text matter appears between the table's body and its references.

Paper

a) If the table occupies more than one-half space of a page, it is typed on a separate sheet.

b) If the table is typed in continuation with the text on one page, three spaces are given between the text matter and the table both at the top and the bottom of the table to visually separate the table from the text.

c) Tables are usually typed lengthwise. If the number of columns cannot be accommodated, the table is typed widthwise on a separate sheet.

d) If the table is typed widthwise, the top of the table will be on the binding side.

e) If the table cannot be accommodated within the size of the paper used for the text matter, a bigger paper is used. The sheet is then folded in from the right-hand side and up from the bottom. The fold, on either side, should be one inch inside the right and bottom edge of the text paper. Otherwise, trimming the report after binding will be very difficult.

f) The page numbers are typed consecutively with the text page. Even if the table is typed widthwise, the page number is typed vertically on the top where it would have been if the page was typed lengthwise. Otherwise the page number will disappear in the binding edge.

Continuation Page

a) If the table is continued on the second page, only the identification mark TABLE 1.1 Continued is enough. There is no need to repeat the title and subtitle.

b) On the continuation page, column and row captions are repeated to facilitate quick reference.

c) The totals of the previous page are repeated at the top within the columns of the second page. In the row captions, indications such as **Carried forward** and **Brought forward** are given.

Checklist

Relevance, accuracy, and clarity are of utmost importance in tables. When entering the table, check the following:

1) Have the explanation and reference to the table been given in the text?
2) It is essential to have the table for clarity and extra information?
3) Is the representation of the data *comprehensive* and *understandable*?
4) Is the table number correct?
5) Are the title and subtitle clear and concise?
6) Are the column headings clearly classified?
7) Are the row captions clearly classified?
8) Are the data accurately entered and represented?
9) Are the totals and other computations correct?
10) Has the source been given?
11) Have all the uncommon abbreviations been spelt out?
12) Have all footnote entries been made?
13) If column rules are used, have all rules been properly drawn?

Illustrations
Illustrations cover charts, graphs, diagrams, and maps. Most of the instructions given for tables hold good for illustrations.

Identification
Illustrations are identified as FIGURE, CHART, MAP, or DIAGRAM. The identification marks (i.e., number title, and, if any, subtitle) are put at the bottom, because an illustration, unlike a table, is studied from bottom upwards.

Activity 3
Take a report that you have recently written and examine the following:

a) Check the presentation of quotations and footnotes. Rewrite the references both in traditional and modern format.

.....

.....

.....

b) Go through the exhibits in the report and compare against the checklist given in this unit. Improve the presentation of exhibits and prune them down to the bare minimum required. Rewrite the explanation to them in the text.

.....

.....

.....

12.6 REFERENCE SECTION

This section follows the text. First comes the appendices section, then the bibliography and glossary. Each section is separated by a divider page on which only the words APPENDICES, BIBLIOGRAPHY, or GLOSSARY in all capital letters appear.

All reference section pages are numbered in Arabic numerals in continuation with the page numbers of the text.

1) Appendices

What Goes into an Appendix
a) Supplementary or secondary references are put in the appendices section. But all primary reference material of immediate importance to the reader is incorporated in the text. The appendices help the author to authenticate the thesis and help the reader to check the data.

b) The material that is usually put in the appendices is indicated below:
1) Original data
2) Long tables
3) Long quotations
4) Supportive legal decisions, laws, and documents
5) Illustrative material

6) Extensive computations
7) Questionnaires and letters
8) Schedules or forms used in collecting data
9) Case studies/histories
10) Transcripts of interviews

Numbering of Appendices
The appendices can be serialized with capital letters (Appendix A, Appendix B) to differentiate from the chapter or table numbers.

References to Appendices
a) In the text, reader's attention is drawn to the appendices as in the case of tables.

b) All appendices are listed in the table of contents.

2) Bibliographies
Positioning of the Bibliography
The bibliography comes after the appendices section and is separated from it by a division sheet written BIBLIOGRAPHY. It is listed as a major section in all capital letters in the table of content.

A bibliography contains the source of every reference cited in the footnote and any other relevant works that the author has consulted. It gives the reader an idea of th literature available on the subject and that has influenced or aided the author.

Bibliographical Information
The following information is given for each bibliographical reference:

Books

1) Author(s)
2) Title (underlined)
3) Place of publication
4) Publisher
5) Date of publication
6) Number of pages

Magazines and Newspapers

1) Author(s)
2) Title of the article (within quotation mark
3) Title of the magazine (underlined)
4) Volume number (Roman numerals)
5) Serial number (Arabic numerals)
6) Date of issue
7) Page numbersof the article

Types of Bibliographies
The title of a bibliography should indicate what type of items are listed.

Some common varieties of bibliographies are given below:
a) **Bibliography of Works cited** lists only those items which have been referred to in the text.

b) **Selected Bibliography** contains only those items which the author thinks are of primary interest to the reader and indicates the criteria used for selecting the items.

c) **Annotated Bibliography** gives a brief description of each item to help the reader to find out the usefulness of the book.

Difference between Bibliographical and Footnote Entries
The formats of bibliography and footnote differ in the following respects:

a) In a bibliography, the first line of an item begins at the left margin and the subsequent lines are indented. But in a footnote, the first line is indented and the subsequent lines of the item begin at the left margin.

b) In a bibliography, the last name of the author is given first (Kumar, Arvind), but in a footnote the first name is given first (Arvind Kumar).

c) A bibliography is arranged within a section in the alphabetical order of the last name of the author or in the alphabetical order of the title of the work, or in the chronological order of publication. But footnotes are arranged in the sequence in which they have been referred to in the text.

d) Punctuation marks in a bibliography and in a footnote are different.

e) In a bibliography the total number of pages of a book (205 pp.) or page numbers of the article (1-21) are given, while in a footnote only the specific page (p. 21) or pages cited (pp. 3-5) are given.

How to Make a Bibliography

Solutions to some of the difficulties commonly faced in writing a bibliography are given below:

a) When the bibliography is long, items are classified for easy reference according to 1) format like books, periodicals, and newspapers, 2) subject or theme, or 3) chronological order.

b) If the name of the author is not given, the title of the book or the article appears first. "A", "An", and "The" in the beginning of the title are ignored for determining the alphabetical order; however, the article appears in the listing if it is a part of the title.

c) An author's works written in collaboration with others are listed after the works which he has written alone.

d) If there are more than three authors, the symbol *et al.* is used after the first author's name and other names are omitted.

e) If two or more works of an author are listed, the author's name is written for the first time, and for subsequent items a 10-space line is drawn where the author's name should appear.

f) Within the works of an author, the order is determined by the alphabetical order of the title of the work or the date of publication.

g) If two or more persons have written the book, the names are listed in the order mentioned in the book or article.

Examples of Bibliographical and Footnote Entries

ONE AUTHOR

Bibliography

Basu, Amrendra. *Consumer Price Index : Theory, Practice and Use in India.* Calcutta: Modern Book Agency, 1963. 175 pp.

Footnote

1 Amrendra Basu, *Consumer Price Index : Theory, Practice and Use in India* (Calcutta: Modern Book Agency, 1963), p. 10.

TWO AUTHORS

Bibliography

Singh, Mohinder; and Pandya, J.F. *Government Publications of India.* Delhi: Metropolitan Book Co. Pvt. Ltd., 1967. 270 pp.

Footnote

1 Mohinder Singh and J.F. Pandya, *Government Publications of India* (Delhi: Metropolitan Book Co. Pvt. Ltd., 1967. p. 21.

THREE AUTHORS

Bibliography

Mote, V.L.; Malya, M. Meenakshi; and Saha, Jahar. *Tables for Capital Investment Analysis.* Ahmedabad: Indian Institute of Management, 1986. 36 pp.

Footnote

V.L. Mote, M. Meenakshi Malya, and Jahar Saha, *Tables for Capital Investment Analysis* Ahmedabad: Indian Institute of Management, 1968) p. 10.

MORE THAN THREE AUTHORS

Bibliography

Desai, D.K., *et al., Studies in Block Development and Cooperative Organisation.* Ahmedabad: Indian Institute of Management, 1966. 382 pp.

Footnote

D.K. Desai, *et al., Studies in Block Development and Cooperative Organisation.* (Ahmedabad : Indian Institute of Management, 1966) p. 10

EDITED BOOK

Bibliography

Basu, G. (ed). *Indian Tax Laws and Foreigners Having Investment in India or Having Business Connections in or with India.* Calcutta: Oxford Book & Stationery, 1962. 140 pp.

Footnote

1 G. Basu (ed), *Indian Tax Laws and Foreigners Having Investment in India or Having Business Connections in or with India.* (Calcutta: Oxford Book & Stationery, 1962) p. 10

TRANSLATION

Bibliography

Bata, Thomas. *How I Began.* Trans. Jan Baros. Batanagar: Club for Graduates of Bata School, 1942. 332 pp.

Footnote

1 Thomas Bata, *How I Began.* Trans. Jan Baros. (Batanagar: Club for Graduates of Bata School, 1942) p.10

ARTICLE IN A BOOK

Bibliography

Argyris, Chris, "Individual Actualization in Complex Organizations", *Organization and Administration: A Book of Readings,* Ishwar Dayal and Kamini Adhikari. Bombay: Progressive Corpn., 1969. 2-50.

Footnote

1 Chris Argyris, "Individual Actualization in Complex Organizations", *Organization and Administration: A Book of Readings,* Ishwar Dayal and Kamini Adhikari. (Bombay: Progressive Corpn., 1969) p. 10.

DIFFERENT EDITIONS

Bibliography

Basu, Durga Das. *Shorter Constitution of India.* 5th edn. Calcutta: S.C. Sarkar, 1967. 250 pp.

Footnote

1 Durga Das Basu, *Shorter Constitution of India.* (5th edn. Calcutta: S.C. Sarkar, 1967) p. 10.

MORE THAN ONE VOLUME

Bibliography

Myrdal, Gunnar. *Asian Drama: An Inquiry into the Poverty of Nations.* 3 Vols. New York: The Twentieth Century Fund, 1968.

Footnote

1 Gunnar Myrdal, *Asian Drama: An Inquiry into the Poverty of Nations.* 3 Vols. (New York: The Twentieth Century Fund, 1968), I, 20.

PART OF A SERIES

Bibliography

Decentralization : Strategy and Structure, Alumni Conference Series, 1967. Ahmedabad: Indian Institute of Management, 1968. 161 pp.

Footnote

1 *Decentralization : Strategy and Structure* (Alumni Conference Series, 1967; Ahmedabad: Indian Institute of Management, 1968), p. 10

GOVERNMENT PUBLICATION

Bibliography

Ministry of Law, Government of India. *The Copyright Act, 1957 (14 of 1957).* Delhi: The Manager of Publications, 1960. 32 pp.

Footnote

1 Ministry of Law, Government of India: *The Copyright Act, 1957 (14 of 1957).* (Delhi: The Manager of Publications, 1960), p. 10.

MIMEOGRAPHED OR PHOTOCOPIED MATERIAL

Bibliography

Rao, G.N. "A Life Table Approach to Wastage in Education", Jaipur: University of Rajasthan, 1958. 121 pp. (Mimeographed)

Footnote

1 G.N. Rao, "A Life Table Approach to Wastage in Education", (Jaipur: University of Rajasthan, 1958), p.10. (Mimeographed)

ARTICLE IN A JOURNAL

Bibliography

Gandhi, Ved P. "Taxation of Agricultural Incomes", *Industrial Times,* X, 12, (15 June 1968), 8.

Footnote

1 Ved P. Gandhi, "Taxation of Agricultural Incomes", *Industrial Times,* X, 12, (15 June 1968), 8.

ARTICLE IN A NEWSPAPER

Bibliography

Gandhi, Ved. P. "Will the Budget Achieve Its Aims? Certain Doubts", *The Economic Times,* VIII, 2, (8 March 1968), 5.

Footnote

1 Ved P. Gandhi, "Will the Budget Achieve Its Aims? Certain Doubts", *The Economic Times,* VIII, 2, (8 March 1968), 5.

BOOK REVIEW

Bibliography

Desai, D.K. "Review of *Application of Programming Techniques to Indian Farming Conditions* by S.S. Jain and A.S. Kahlar", *Indian Journal of Agricultural Economics,* XXIII, 1, (Jan-Mar 1968), 91-94.

Footnote

1 D.K. Desai, "Review of *Application of Programming Techniques to Indian Farming Conditions* by S.S. Jain and A.S. Kahlar", *Indian Journal of Agricultural Economics,* XXIII, 1, (Jan-Mar 1968), 92.

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Bibliography

Aggarwal, S.C. "Modern trends in Production Planning and Control", *Management Review* (Baroda Management Association), VII, I, (Nov 1967), 17-19.

Footnote

1 S.C. Aggarwal, "Modern trends in Production Planning and Control", *Management Review* (Baroda Management Association), VII, I, (Nov 1967), 18.

CONFERENCE PAPER

Bibliography

Bhattacharya, S.K. "Control Techniques and Their Applicability." Paper read at the Ahmedabad Management Association, Ahmedabad, 22 Nov 1967. 12 pp. (Mimeographed)

Footnote

1, S.K. Bhattacharya, "Control Techniques and Their Applicability." Paper read at the Ahmedabad Management Association, Ahmedabad, 22 Nov 1967. p.11 (Mimeographed)

MORE THAN ONE ITEM OF AN AUTHOR

Bibliography

Shah, B.G. "Farm Finance: A Few important Issues", *Artha Vikas*, IV, I, (Jan 1968), 38-45.

———. "Manpower Development for Banks", *The Economic Times*, VIII, 3, (26 June 1968), 5.

3) Glossary

What is a Glossary : A glossary is a short dictionary giving definitions and examples of terms and phrases which are technical, used in a special connotation by the author, unfamiliar to the reader, or foreign to the language in which the book is written. It is listed as a major section in all capital letters in the table of contents.

Positioning of a Glossary : The glossary appears after the bibliography. It may also appear in the introductory pages of a book after the lists of tables and illustrations.

Order of Listing : Items are listed in alphabetical and normal order. *Example :* **Centre Heading** is listed under C and not under H.

Activity 4

Take any report and check whether bibliography is presented in the standard form. If not, rewrite the bibliography.

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Activity 5

Examine the appendices to any report. Are all of them essential for understanding the theme of the report. Can they be pruned?

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12.7 TYPING INSTRUCTIONS

For typing of a report, the following should be kept in mind.

Paper

a) Quarto-size, white, thick, unruled paper is used for manuscripts.

b) Typing is done on only one side of the paper.

Margins

The following margins may be followed :

Left	=	1.5 in.
Right	=	1 in.

Top and bottom = 1 in. (But on the first page of every major division, e.g., beginning of a chapter give 3 in. space at the top.
give 3 in. space at the top.

Uniform margins make the typescript look neat.

Indention

a) The first line of a regular paragraph is indented five spaces from the margin.

b) All lines in an indented paragraph are indented five spaces from the margin. But the first line of an indented paragraph, if it has a paragraph beginning, is indented 10 spaces from the margin.

Example :

The increase in taxation on commodities through excise duties and custom duties has increased the tax and therefore the prices.

Spacing between Lines

a) The whole manuscript is typed in double space, except indented paragraphs, tables, and footnotes, which are usually in single space. Wherever single space is used, double space is given between paragraphs or sets of items.

b) Triple space is given 1) before a paragraph head and 2) before and after a centre head, centre subhead, side head, indented paragraph, or table.

Spacing within a Sentence

Between words	1 space
After a semi-colon	2 spaces
After a colon	2 spaces
After a comma	1 space
After a full stop	2 spaces
Before the first parenthesis or bracket	1 space
After the last parenthesis	1 space

No space is given in the following cases:

a) Between the last letter and the comma, semi-colon, colon, exclamation mark, question mark, last parenthesis, and last bracket.

b) Between the first quotation mark and the following word.

c) Between the last quotation mark and the last quoted word or punctuation.

d) Between the dash and the words preceding or following it.

e) Between hyphenated words.

f) Between the bar (/) and the words preceding or following it.

12.8 COPY READING

The copy reader's symbols are used for instructing the typist or secretary. But the proof reading symbols are used for instructing the printer. Some symbols are common. But the symbols for proof reading are more than for copy reading. (Copy reading symbols with explanations are given at the end of this unit in Appendix A.)

12.9 PROOF READING

Types of Proofs

a) Usually the printer sends galley proofs (also known as first proofs), page proofs, and engraver's proofs (wherever photographs or other illustrations are involved) If required, revised proofs at any stage are sent. For a high quality work, the printer provides a dummy, which is also called machine proof or press proof.

b) The galley proof is the one which is not divided into pages. Galleys, the short name for galley proofs, are in single column set in the line width of the text and

sometimes as long as 24 inches. The second stage is that of page proofs, which give an idea what each page will contain and look like. Dummy is the final stage which represents the printed version before copies are run off.

How to Proof Read

a) A good proof reader has *accuracy* to pin-point all the mistakes, *clarity* in giving instructions to the printer, and *speed* for meeting the printer's deadlines.

b) Correction marks are indicated at two places 1) within the line where the correction is to be carried out and 2) in the margin against the corresponding line giving the instruction. If there are two or more corrections in a line, both the right and left margins are used for instructions. The sequence of instructions corresponds to the sequence of marks within the line in order from left to right. Each instruction is separated by a bar (/).

c) Instructions are never given at the place of correction. The printer only goes through the margins and never reads through the proofs. If the instruction is not in the margin, the printer will miss it.

d) The proof may be marked preferably with a red ballpoint pen. The red colour shows up better in the background of black ink and darkness of the composing room. Avoid red ink or pencil. Ink spreads on the cheap paper used for proofs and pencil marks are not sharp.

e) To catch as many errors as possible, proof may be read four times as follows:

1) Ask another person to read the copy aloud while you go through the proofs.

2) Read the proof alone without somebody reading from the copy.

3) Check all the headings and subheadings.

4). Check all the cross references.

Above all, remember proofs have to be read letter by letter rather than word by word.

f) Proofs are meant to be *corrected* but not *edited*. Additions and deletions at the proof stage, commonly known as author's alterations (AA), are time consuming and very expensive. The cost of making these alterations are passed on to the author. Large-scale editing will upset the layout of the pages also. But if the mistake is very glaring, edit it at the proof stage rather than let it go into the final print.

(Proof reading symbols with explanations are given at the end of this unit in Appendix B.)

Returning the Proofs

a) Proofs must be returned to the printer according to the agreed schedule. The delay on author's part upset scheduling of the machines and other operations of the printer and the publisher.

b) The manuscript is also returned with the proofs. The printer uses the manuscript for his checking and record in case any suit for damages is filed. The manuscript becomes the property of the printer.

The author can use the duplicate of the manuscript for correcting. Then the printer need not send the original copy back and forth.

c) Sometimes printers send two proof copies—one for the author's record and the other for returning to the printer.

d) For security, either hand deliver the proofs or send in a registered cover.

Activity 6

Take any report and edit it using copy reading and proof reading symbols.

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12.10 SUMMARY

In this unit, we have discussed the various parts of a report. They are divided into cover and Title Page, Introductory Pages, Text and Reference Section. Cover and Title Page have these components (a) Title of the subject or Project (b) Presented to whom (c) on what date (d) for what purpose (e) written by whom. The Introductory pages contain (a) Foreward (b) Preface (c) Acknowledgement (d) Table of contents (e) Listing of Tables and Illustrations and (f) Summary. The subject matter of Text is divided into (a) Headings (b) Quotations (c) Footnotes (d) Exhibits. Reference section follows the Text. It contains (a) Appendices (b) Bibliography and (c) Glossary. Each of these heads and subheads are explained with the help of examples.

The unit also explains the typing instructions which should be followed while typing the report. The unit concludes by explaining how one goes about proof reading the report.

12.11 SELF-ASSESSMENT EXERCISES

Take a report that you have recently written and examine the following:

1) Does the cover and the title page contain all the essential information? If not, prepare a new cover and title page.
2) Do the introductory pages contain all the sections indicated in this unit? If not, put in these sections if they are necessary for the report.
3) Is the table of contents comprehensive? If not, prepare a fresh table of contents. For practice, prepare the contents both in traditional and decimal classifications.
4) Read through the headings in the report. Improve the wording, sequence, and presentation of the headings. Rewrite the contents page according to the new headings inside the report.
5) Does your report contain the executive summary? If yes, check whether it is comprehensive? If not, write an executive summary.
6) Check the presentation of quotations and footnotes. Rewrite the references both in traditional and modern format.
7) Go through the exhibits in the report and compare against the checklist given in this unit. Improve the presentation of the exhibits and prune them down to the bare minimum required. Rewrite the explanation to them in the text.
8) Examine the appendices to the report. Are all of them essential for understanding the theme of the report? Can they be pruned?
9) Is the bibliography presented in the standard form? If not, rewrite the bibliography.
10) Edit your report using the copy reading and proof reading symbols.

12.12 FURTHER READINGS

Gallagher, J. William, *"Report Writing for Management"*, Addison-Wesley

Golen, P. Stevan, *"Report Writing for Business and Industry"*, Business Communication Service

Sharma R.C. and Krishan Mohan, *"Business Correspondence and Report Writing"*, Tata McGraw-Hill

Wright, C., *"Report Writing"*, Witherby & Co England

APPENDIX A

Copy Reading Symbols

Additions and Deletions

Insert the letter or word	Institute
Delete	~~The Institute~~

Capital Letters and Small Letters

Use capital letter	indian Institute of Management
Use small letter	Indian Institute Of Management
Use all capital letters	Indian Institute of Management
The letters underlined three times should be in capitals and the rest in the small letters	INDIAN INSTITUTE OF MANAGEMENT

Closeup and Separation

Bring them together	Ins tute
Give space between the two letters	IndianInstitute

Transposition

Transpose the letter	Institu
Transpose the word	Indian Institute Management of

Numbers and Abbreviations

Spell out	9 means write it as nine
Use the numeral	Ten means write the number 10
Abbreviate	Indian Institute of Management,Ahmedabad means write it as IIMA
Spell out	Co. means write it as Company

Indention

Put it in the centre	Indian Institute Management
Push the word or line to the right margin indicated	Indian Institute of Management
Push the word or line to the left margin indicated	← Indian Institute of Management
New paragraph	¶
No paragraph break	*No* ¶

Miscellaneous

Ignore the correction under which dots are put	Indian ~~Institute of Management~~ Stet

APPENDIX B

Proof Reading Symbols

Instruction in the margin	*Mark in the copy*	*Explanation*
Type Faces		
bf	The Institute	Set in bold face type
bf ital	The Institute	Set in bold face italics
uc	The Institute	Set in capital letters
lc	The Institute	Set in small letters
lf	The Institute	Set in light face
rom	*The Institute*	Set in Roman type
wf	The Institute	Wrong font
ital	The Institute	Set in italics
uc/lc	THE INSTITUTE	Set the main letters in caps and the rest in small letters
Insert		
i	The Institute	Caret indicates the place where the insertion has to be made
	The Institutes	Insert apostrophe

ʷ/ʷ	The Institute	Insert quotation marks
[/]	Ahmedabad	Insert brackets
(/)	Ahmedabad	Insert parentheses
ʌ	Indian Institute of Management Ahmedabad	Insert comma
;/	The Institute	Insert semi-colon
⊙	The Institute's activities are	Insert colon
⊙	These are the Institute's activities	Insert full stop
?	What are the activities of the Institute	Insert question mark
⊙	Oh	Insert exclamation mark
-/	Semi annual	Insert hyphen
/--/	The two Institutes at Ahmedabad and Calcutta	Insert dash
₂	HO	Insert subscript
²	A + B = C	Insert superscript
Spacing		
#	TheInstitute	Give space
⌒	Insti tute	Close up
eq#	Indian/Institute/of Management/at/Ahmedabad	Correct uneven spacing
eq#	Indian Institute of Management at Ahmedabad and other institutions	Equalize leading or space between lines
Movement of Position		
tr	Institute	transpose
⌐¬	Ins itute	Move up
L_	Ins itute	Move down
[	Institute	Move to the left
]	Institute	Move to the right
][	]INSTITUTE[	Put in the centre
Miscellaneous		
ℌ	The ~~Indian~~ Institute	Delete
¶	The Institute...	Paragraph
No ¶	The Institute	No paragraph
ɔ	Institute	Invert the letter
———	Institute	Straighten the line
‖	The Institute The Institute The nstitute	Correct the alignment
⊗	The stitute	Broken letter
Stet	~~The~~ Institute	Ignore the correction

UNIT 13 PRESENTATION OF A REPORT

Objectives

After reading this unit, you should be able to :

- Distinguish between various components of presentation skills.
- Describe the elements of presentation.
- Discuss the usefulness of AV aids.
- Enumerate suggestions for preparing of AV aids.
- Explain the use of AV materials.
- Suggest to a presenter the care he has to take while presenting a report

Structure

13.1 INTRODUCTION

In the last unit, we explained the various parts of a report. The next stage is presentation of a report.

Presentation has become an important communication medium in organizations because a report is understood better if it is accompanied by a presentation. The readers can enter into a dialogue with the author(s) of the report to share the thinking process that the author(s) has gone through in writing the report. Therefore, the manager is expected to have as much facility in presentation as he is expected to have in report writing.

Presentation skills include the ability to mix in the right proportion various elements of

1) communication dimensions,

2) presentation package, and

3) use of audio-visual aids to achieve the given purpose with an audience.

Moreover, the presenter needs to acquire the public conversation (rather than public speaking or oratory) skills.

13.2 COMMUNICATION DIMENSIONS

The major elements of communication dimension, which are relevant to a presentation, are :

1) Purpose
2) Audience
3) Media
4) Message
5) Time
6) Place
7) Cost

While preparing for presentation, the presenter has to ask searching questions to understand each of the above mentioned dimensions of communication and find the right mix to serve his purpose. This process makes the presentation both a science and an art.

1) Purpose

The first step is to think through the purpose of the presentation and to focus it sharply. The presenter can try to achieve a variety of purposes. Some instances of presentation purposes are as follows:

Informing?
Selling?
Exploring?
Decision making?
Persuading?
Changing attitude or behaviour?

Within each of these, the focus can be sharpened by breaking them into subsets. For example, if it is a decision making situation, would the presenter be interested in persuading the audience to

a) accept a decision which has already been taken
b) vote on a decision
c) provide feedback for decision making
d) take a decision, or
e) explore areas which need attention for decision making at a later time.

Depending on the purpose, the elements of the communication mix, presentation package, and AV aids have to be adjusted to get the right effect.

2) Audience

In a presentation, multiple audiences interact at the same time. The sender and the receivers of the message keep changing roles through clarification queries, question and answer, dialogue, and discussion. It is a live and dynamic situation in which the presenter shapes the message in the open.

The audience interest can be held on if the presenter focuses on issues of their immediate interest and allows them to participate in understanding the information. One way monologue is a sure way to dampen the audience enthusiasm and interest.

3) Media

In a presentation, sound, sight, and body language come into play. Therefore, the coordination of all three at one shot becomes an important aspect of presentation.

Moreover, a presentation helps to broaden or open up the horizon of thought. Therefore, to treat presentation as an extension of written medium by projecting written data on the screen and making the audience read it is a self-defeating and expensive proposition. Also concentrating on any one medium—sight or sound—failing to take full advantage of the potentialities of presentation.

Since presentation is more suited for interaction, reading from a prepared text or delivering a memorized speech puts a barrier between the audience and the presenter However, notes, as memory aids, cannot be dispensed with for an organized presentation.

The notes can be telegraphic and on 3×5 inch cards which the presenter can see at one glance and be on his way. Often, the OHP transparencies are sufficient as memory aids. A notecard may look as follows:

Outline
1) Communication mix
2) Presentation package
3) AV tools
4) Presenter's poise

4) Message

The presenter has to think of the focus of the message—its breadth and depth—as much as a writer does. But the dimensions are different. The presenter cannot get as much depth and complexity as a writer can achieve. Therefore, the focus of a presentation has to be different from that of a report.

A presentation concentrating on a single theme or a few major strands of a theme is more comprehensible to the audience and leaves a more lasting impression than the one with too many diverse issues.

Organization of the message is as important in presentation as in writing. Confused organization confuses the audience and leads them to focus their attention on unimportant or unintended issues.

Next, concretization of the message in presentation is as important as in good writing. However, the presentation, because it combines sound and sight media, helps to concretize the message more than the written medium. One step further in concretization leads to visualization of ideas and hearing of actual sounds : only the presentation medium helps to achieve this level of concretization.

Since the presentation situation is built on interaction between the presenter and the audience, the emotional content of the message and the audience should be considered. Concretization at the emotional level reinforces the logical concretization of the message. Even simple words like "our company", "my company", "your company", and "the company" carry emotional and attutidinal connotations. These phrases reflect in a way where the presenter stands in respect to the company and the audience. In this respect, the presenter's body language also comes into play.

5) Time

The element of time in a presentation situation depends on various factors like availability of the room, audience, and presenter. The presenter can select the right time if he has the choice. Presentations immediately after lunch, for instance, fail to hold the attention of the audience.

Another major aspect is how much time is given to the presenter to make the presentation. This is a crucial dimension which decides the length and the overall communication mix.

The timing or sequencing of the message or its various parts is also significant. Is your audience prepared for it? When can you get their maximum attention?

6) Place

The presenter may not have much choice in selecting the place. But to make the best use of the place and the facilities available will depend on the presenter. Whether the room is square or rectangular, whether it is large or small enough for the audience, whether the seating arrangement is fixed or movable are some examples of the questions which bother a presenter. On the room arrangement depend the kind of audio-visual tools that can be used and the type of interaction that the presenter can have with the audience.

An examination of the following elements of a room will help in finding the right mix for an effective presentation:

1) Room dimensions
2) Seating
3) Number of people expected
4) Space available for the presenter
5) AV equipments available

7) Cost

The preparation of a good presentation is time consuming and expensive. The presenter should ask himself a) whether he is trying to achieve through presentation what he could have easily achieved through written communication and b) whether he could use cheaper production methods and aids than the ones he has chosen to put across the message.

Activity 1

You want to describe the major events of your college life to a group of your friends. You make a 3 minutes presentation and ask for their reactions to presentations and their suggestions for improvement on the focus of the presentation theme. List-out the suggestions they make to you.

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13.3 PRESENTATION PACKAGE

The presentation package could be as follows:

1) Pre-presentation handout if necessary to prepare the audience for understanding the presentation.
2) Presentation.
3) Two-way feedback between the audience and the presenter and among the audience members through question and answer or discussion.
4) Post-presentation handout if necessary to reinforce the message or help recall.

Activity 2

Yours is a consulting organisation which undertakes business research studies. A prospective client visits your organisation and wants to know the types of job your organisation undertakes. What sort of pre-presentation handouts would you prepare before making a presentation to him?

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13.4 AUDIO-VISUAL AIDS

Audio-visual aids can be broadly classified as follows:

I) Audio
   1) Tape recorder
   2) Gramaphone or compact disc

II) Visual

Non-Projected

1) Blackboard
2) Bulletin boards or flip charts
3) Models

Projected

1) Epidiascope
2) Overhead
3) Slide
4) Film strip
5) Tachistoscope (Slide projector with a timer)

Audio-Visual

1) Film (8 mm, 16 mm)
2) Video cassette

Usefulness of AV Aids

Since AV aids help in recreating reality in a miniature form through visuals and sound, greater CREDIBILITY and CLARITY can be achieved in presentation.

Since both sound and sight senses are activated at the same time along with the body language, CONCENTRATION, RETENTION, and RECALL can be obtained in presentation.

AV aids can also help in collapsing DISTANCE and TIME. They help us to present to the audience materials and experiences from far-off places and from different times in the past to make the message concrete and clear.

Suggestions for Preparing of AV Aids

1) *Organize* the material into small modules.
2) Do not put more than *seven or eight lines* on a transparency.
3) Use *as few words* as possible. Use telegraphic style, abbreviations, and symbols which the audience can understand.
4) *Visualize or picture* your ideas if possible.
5) Make the pictures and letters bright enough to be *visible* from a distance.
6) Make the letters big and thick enough to be *read* by all.
7) Use *light colours*, like yellow, light blue, or pink for background. Use dark or *bright colours* like red, black, orange, or green for pictures and letters to improve *visibility*. Note that black or red letters on a yellow background have the highest visibility.
8) Make the *sound* material audible, pleasing in tone, varied and synchronized with visuals.
9) Finally, before presentation, *check* the audibility, visibility, and readability of your AV materials, if possible, in the actual place of presentation.

How to Use Some AV Materials

Blackboard

1) Plan
   What goes on it?
   When goes on it?
   Where is it to be entered?
   What is to be retained and what is to be erased?
2) In planning the arrangement of materials on the blackboard, it will help to mentally divide the blackboard space into different parts:
   Top half/Bottom half
   Left Column Middle Column Right Column
3) For writing on the blackboard, break the chalk into two pieces and use the soft inner side for writing to avoid the squeaking noise. Hold the chalk like a brush to get large and thick letters. Use different coloured chalks to differentiate the segments of the subject matter.
4) The more time you take to write on the blackboard, the longer is your back to the audience, and the longer you hide the message from them. Use the blackboard for short spans of time. Develop a telegraphic language and a shorthand which your audience can understand. Words with only consonants (dropping the vowels) can be easily recognized.
5) Check at the end of the session:
   a) Does the material on the blackboard look neat and organized?
   b) Does it contain only material which is essential to recall your message?
   c) Is your writing visible and readable to the audience?

Bulletin Boards

The following materials are used for bulletin boards:
Wood Pulp

Felt Thermocole
Steel (Magnetic) and Prestograph sign boards are also available.
Bulletin boards are useful for exhibiting samples and drawings.

Flip Charts

1) Can be an extension to the blackboard and the overhead projector.
2) Back and forth referencing can be done.
3) Useful, like the blackboard, for interactive communication. Flipcharts, like OHP transparencies, can be prepared before hand.

Felt Board

1) Useful for demonstrating changes.
2) Use sand paper strips or any stick on material at the back of the paper for sticking to the felt.
3) Materials tend to fall off after a few minutes.

Overhad Projector

1) It can project a) transparencies, b) cutouts and outlines (Silhouette) of small objects, c) negatives, d) material on transparent glass, and e) transparent colours
2) Writing on the transparencies at the time of presentation is possible.
3) While using the projector, the speaker can face the audience—an advantage not available with the blackboard.
4) Can work in ordinary light—an advantage not available with the opaque projector (epidiascope), slide projector, or film projector.
5) More matter can be accommodated than on a blackboard.
6) Highly flexible:
Matter can be exposed either for long periods or short periods.
Material can be partially hidden if needed.
Material can be referred back and forth.
7) Material can be pretested before putting on slide or film strip.
8) Printed material can be transferred to the transparencies through photocopying.
9) Only line drawings can be reproduced.

Note : Switch off the projector whenever not needed to protect it from overheating.

Making of Transparencies

1) Thin plastic sheets and acetate or triacetate films can be used for making transparencies. Plastic sheets are cheaper than acetate or triacetate sheets.
2) Can write on plastic sheets and films with OHP pens. While writing on a transparency put a graph paper underneath the transparency to be able to write uniformly big letters.
3) Photocopying can be done on plastic sheets and films.
4) Acetate or triacetate films can be used for writing with OHP pens having transparent colours.
5) OHP pens come in two kinds—permanent and non-permanent. Erasing is not possible when permanent ink is used. A special erasure pen is available to remove a word or two if needed. But transparencies written with non-permanent ink can be washed by water and reused.

Opaque Projector (Epidiascope)

1) Useful for projecting non-transparent material—printed paper, cloth, or small objects—in actual colours.
2) Dark room is essential.

Slides

1) Can be made in black and white or in colour. Best for highlighting coloured and halftone pictures.
2) Can be synchronized with running commentary on tape recorder.
3) Presentation sequence can be changed.
4) Useful for showing on and off during the talk.
5) Audience attention can be held for about 30 minutes.

Film Strips

1) Film strips give a feeling of continuity.
2) Can be synchronized with running commentary on the tape recoder.
3) Can be made in black and white and in colour.
4) Once the strip is made, the sequence of the material cannot be changed.
5) Audience attention cannot be held for more than 10 to 15 minutes.

Films

1) When you make a film, be clear of the purpose. Check whether your purpose is to:
   a) communicate information (documentaries of actual events or reenacted events serve this purpose).
   b) change attitudes (dramatization of ideal reactions or situations).
   c) Develop skills (giving step-by-step close-ups of an operation).
   d) Develop interest (using unusual-effects).
   e) Raise issue (using open-ended techniques).

Activity 3

You have recently read a book and your friends want you to make a brief presentation about it. How would you go about preparing and handling of audio-visual materials?

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13.5 PRESENTER'S POISE

The presenter himself is an essential part of the presentation. His poise and confidence matter a lot in putting across the ideas.

First, the presenter's posture and movement on the dias or at the speaking place and his hand gestures indicate the level of confidence of the presenter. Slouching positions, leg crossing, rubbing hands or wild gesticulation, or hands in pockets indicate lack of authority and confidence in the presenter. Sometimes the presenter's habits may become dysfunctional because they draw the attention of the audience away from the main theme.

Second, the presenter's ability to maintain eye contact with the audience and keep his facial expressions suited to the subject become also important. Lack of eye contact with the total audience, not with just one or two persons in the audience, indicate lack of confidence in the presenter. Moreover, the presenter will not be able to

get non-verbal cues from the audience of their interest and understanding throughout the presentation.

Finally, the fluency, pace of delivery, level of the voice, and command of the language signal to the audience the level of confidence and preparedness of the presenter.

The only way that presenters can gain confidence is to repeatedly take the opportunity to make presentations, analyse their presentations for improvement, and observe experienced presenters in action. Only thorough preparedness and involvement with the subject help presenters to overcome their inhibitions and fears and gain confidence.

Activity 4

Suppose you have made a 3-minute presentation to a group of friends describing your future career plans. Ask for their reactions to the presentation and their suggestions for improvement on your presentation confidence and behaviour.

List out the suggestions below:

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13.6 SUMMARY

In this unit, we have discussed various components of presentation skills. These include 1) communication dimensions, 2) presentation package, and 3) use of audio-visual aids.

The important elements of communication dimensions namely (a) Purpose (b) Audience (c) Media (d) Message (e) Time (f) Place and (g) Cost are explained. These elements have a great relevance to a presentation. The various components of presentation package are also mentioned. Under the heading Audio-Visual Aids, we have explained the usefulness of AV aids. Also, suggestions for preparing of AV aids are described in this unit. The unit also explains how to use some AV material.

Presenter's Poise is one of the most important part of presentation. The unit concludes by suggesting as to what should presenter do in putting across his ideas.

13.7 SELF-ASSESSMENT EXERCISES

1) Take any of the following topics, prepare for a presentation of 3 minutes, and deliver it to a group of friends or colleagues. Ask for their reactions to presentations and their suggestions for improvement on

a) the focus of the presentation theme,

b) the preparation and handling of the audio-visual materials, and

c) your presentation confidence and behaviour.

Suggested Topics

1) Introduce yourself to a group of visitors.

2) Introduce a colleague of yours to your club members.

3) Describe your college to a group of your friends.

4) Talk about your parents or any relatives who have influenced you the most to a group of friends.

5) Describe any interesting habits or hobbies of yours to a group of your colleagues.

6) Describe the working of a machine to a group of non-technical people.

7) Give your comments on any significant national or international event to a group of your colleagues.

2) After you have done a few 3-minute presentations and gained confidence, take any recent report of your organization and make a 30-minute presentation to your colleagues.

13.8 FURTHER READINGS

Gallagher, J. William, *"Report Writing for Management"*, Addison-Wesley

Golen, P Steven, *"Report Writing for Business and Industry"* Business Communication Service

Sharma, R.C. and Krishna Mohan, *"Business Correspondence and Report Writing"*, Tata McGraw-Hill

Wright, C., *"Report Writing"*, Witherby & Co. England.

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