RESEARCH METHODOLOGY

MCOM

Semester - I

MCOM - 105

SHRI VENKATESHWARA UNIVERSITY

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SYLLABI-BOOK MAPPING TABLE

Research Methodology

Syllabi	Mapping in Book
Unit 1 **Concept and Nature of Research:** Objectives of Research, Criteria of a Good Research, Social Science Research, Business Research, Approaches to Research - Qualitative and Quantitative Research, Types of Research - Pure and Applied Research, Descriptive and Analytical Research, Exploratory and Empirical Research, Case Study Research, Research Methodology, Difficulties of Social Science Research in India.	**Unit 1:** Meaning and Concepts of Research Methodology **(Pages 3-48)**
Unit II **Research Design:** Features of a Good Research Design, Defining Research Problem, Components of Research Problem, Selection and Formulation of Research Problem; Formulation of Hypothesis, Types of Research Design Research Design for Experimental, Exploratory and Descriptive Research.	**Unit 2:** Research Design **(Pages 49-90)**
Unit III **Sampling Design:** Meaning and Significance of Sample, Sampling Process, Principles of Sampling: Essentials of a Good Sample, Methods of Sampling: Random Sampling, Stratified Sampling, Judgment or Purposive Sampling, Double and Multistage Sampling; Determination of Sample Size.	**Unit 3:** Sampling Design **(Pages 91-131)**
Unit IV **Data Collection:** Types of Data, Methods of Collection of Primary Data, Collection of Secondary Data and Limitations of Secondary Data.	**Unit 4:** Methods of Data Collection **(Pages 133-158)**
Unit V **Data Processing, Analysis and Interpretation:** Steps in Data Processing, Editing, Coding, Classification and Tabulation, Analysis and Interpretation of Data.	**Unit 5:** Data Processing, Analysis and Interpretation **(Pages 159-179)**
Unit VI **Test of Significance and Analysis of Variance (ANOVA):** Testing of Hypothesis, Z-Test, Chi-Squire Test and F-Test; ANOVA: Meaning, Basics Principles and Assumptions, One-Way and Two-Way ANOVA.	**Unit 6:** Test of Significance and Analysis of Variance (ANOVA) **(Pages 181-250)**
Unit VII **Report Writing:** Types of Report, Steps in Report Writing, Format of Report, Presentation Style.	**Unit 7:** Report Writing **(Pages 251-268)**

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INTRODUCTION

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Research is the search for knowledge or a systematic investigation in order to establish facts. The basic aim of research is to discover, interpret and develop methods and systems to advance human knowledge on diverse scientific matters. Methodology of research refers to the way research can be conducted. It is also known as the process of collecting data for various research projects. Research methodology is, thus, the science of studying how research is conducted scientifically. It helps to understand both the products as well as the process of scientific enquiry. A research process involves selection and formulation of a research problem, research design, sample strategy or sample design, as well as the interpretation and preparation of research report. Research can be undertaken in the form of descriptive/survey research, applied or fundamental research, quantitative or qualitative research, conceptual or empirical research, and also some other types of specific research.

One can also define research as a scientific and systematic pursuit of information on a specific topic. Scientifically, research can also be termed as scientific investigation. Thus, research and scientific enquiry can be considered synonymous. Consequently, research is a more specialized form of scientific enquiry which in turn is the result of gathering of data, information and facts for the specific purpose. There are several types of research designs depending on the type of research study being conducted. The quality of a good research design depends on the extent of its flexibility, efficiency and economy.

A few important factors in research methodology include the validity and reliability of research data and the level of ethics. A job is considered half done if the data analysis is conducted properly. Formulation of appropriate research questions and sampling probable or non-probable factors are followed by measurement using survey and scaling techniques. A research design is a systematic plan for collecting and utilizing data so that the desired information can be obtained with sufficient accuracy. Therefore, research design is the means of obtaining reliable, authentic and generalized data. Research methodology is a very important function in today's business environment. There are many new trends in research methodology through which an organization can function in this dynamic environment.

This book, *Research Methodology*, has been designed keeping in mind the self-instructional mode or SIM format, wherein each unit begins with an 'Introduction' to the topic and is followed by an outline of the 'Unit Objectives'. The detailed content is then presented in a simple and structured from, interspersed with 'Check Your Progress' questions to test the student's understanding. A 'Summary' of the content, along with a list of 'Key Terms' and a set of 'Questions and Exercises' is provided at the end of each unit for effective recapitulation. Relevant examples/illustrations have been included for better understanding of the topics.

UNIT 1 MEANING AND CONCEPTS OF RESEARCH METHODOLOGY

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Structure

1.0 INTRODUCTION

In this unit, you will learn about the significant features of research methodology. Research, in the layman’s terms, means the search for knowledge. Scientific research is a systematic and objective way of seeking answers to certain questions that require inquiry and insight or that have been raised on a particular topic. The purpose of research, therefore, is to discover and develop an organized body of knowledge in any discipline. Research is a journey of discovery. It is a solution-oriented inquiry that must be objective and repeatable. It should inspire and guide further studies and should foster applications. Research will provide practical benefits if it can provide advanced understanding of a discipline or suggest ways to handle some situations that we confront.

Scientific research involves controlled observations, analysis of empirical data and interpretation of findings. This can further lead to the development of concepts, generalizations, etc., on the basis of which theories could be formulated. Such an investigation could help in determining cause and effect relationship. The ultimate aim of social science research is the control and prediction of behaviour.

This unit will give you the meaning of research and the definition of social research. It will familiarize you with the possible types of research orientation, significance of research and also explain the research process.

1.1 UNIT OBJECTIVES

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

- Explain the meaning, objectives and significance of research
- Define what social research is
- Understand the objectives and types of research
- Interpret the significance of research
- Discuss the distinction between research methods and methodology
- Evaluate the research processes
- Discuss the significance of research methods in social science
- Explain the objectives of scientific inquiry
- Describe the various types of research planning
- Discuss the role of social research
- Explain the significance of social science research and business research

1.2 RESEARCH: MEANING, OBJECTIVES AND SIGNIFICANCE

Research in common parlance refers to search for knowledge. One can also define research as a scientific and systematic search for pertinent information on a specific topic. In fact, research is an art of scientific investigation. According to the *Advanced Learner's Dictionary of Current English*, '*Research is a careful investigation or enquiry, especially a thorough search for new facts in any branch of knowledge*.' Redman and Mory (1923) defined research as a '*Systematized effort to gain new knowledge*.' Some people consider research as a voyage of discovery that involves movement from the known to the unknown.

Research in a technical sense is an academic activity. Clifford Woody defined research as '*An activity that comprises defining and redefining problems, formulating a hypothesis; collecting, organizing and evaluating data; making deductions and reaching conclusions; and carefully testing the conclusions to determine if they support the formulated hypothesis*.' D. Slesinger and M. Stephenson, in the *Encyclopaedia of Social Sciences*, defined research as '*The manipulation of things, concepts or symbols for the purpose of generalizing, extending, correcting or verifying the knowledge, whether that knowledge aids in the construction of theory or in the practice of an art*.' Research is thus an original contribution to the existing stock of knowledge making for its advancement.

1.2.1 Principles of Research

The basic principles of research include a systematic process to identify a question or problem, set forth a plan of action to answer the question or resolve the problem, and

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meticulously collect and analyse data. In conducting any research it is crucial to choose the right method and design for a specific researchable problem. All research is different. However, the following factors are common to all good pieces of research:

- It is based on empirical data.
- It involves precise observations and measurements.
- It is aimed at developing theories, principles and generalizations.
- There are systematic, logical procedures involved.
- It is replicable.
- The findings of the research need to be reported.

1.2.2 Objectives of Research

The objective of any research is to find answers to questions through the application of scientific procedures. The main aim of any research is exploring the hidden or undiscovered truth. Even though each research study has a specific objective, the research objectives in general can be categorized into the following broad categories:

- **Exploratory or Formulative Research Studies:** These are aimed at gaining familiarity with a particular phenomenon or at gaining new insights into it.
- **Descriptive Research Studies:** These are aimed at accurately portraying the characteristics of a particular event, phenomenon, individual or situation.
- **Diagnostic Research Studies:** These studies try to determine the frequency with which something occurs.
- **Hypothesis Testing Research Studies:** These studies test a hypothesis and determine a causal relationship between the variables.

1.2.3 Research: Significance and Approach

Research involves developing a scientific temperament and logical thinking. The significance of research-based answers can never be underestimated. The role of research is specially important in the fields of Economics, Business, Governance, etc. Here research helps in finding solutions to problems encountered in real life. Decision-making is facilitated by applied research. Research is also of special significance in the operational and planning processes of business and industry. Here logical and analytical techniques are applied to business problems to maximize profits and minimize costs. Motivational research is another key tool in understanding consumer behaviour and health related issues. Responsible citizenship concerns can all be addressed through good research findings. Social relationships involving issues like attitudes, interpersonal helping behaviour, etc.; and environmental concerns like crowding, crime, fatigue, productivity and other practical issues are all capable of being addressed well by scientific research.

Social science research is extremely significant in terms of providing practical guidance in solving human problems of immediate nature.

Research is also important as a career for those in the field of academics. It could be a career option for professionals who wish to undertake research to gain new insights and idea generation. Research also fosters creative thinking, and new theorizations.

Approaches to Research

Quantitative approach and qualitative approach are the two basic approaches to research. These two paradigms are based on two different and competing ways of understanding the world. These competing ways of comprehending the world are reflected in the way the research data is collected (for example, words versus numbers), and the perspective of the researcher (perspective versus objective). The perspectives of the participants are very critical.

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(i) Quantitative Approach: If there has been one overwhelming consensus among academic psychologists on a single point over the past few decades, it is that the best empirical research in the field is firmly grounded in quantitative methods. In this approach, data is generated in quantitative form, and then that data is subjected to rigorous quantitative analysis in a rigid and formal fashion. Inferential, experimental and simulation approaches are the sub-classifications of quantitative approach. Inferential approach to research focuses on survey research where databases are built by studying samples of population and then these databases are used to infer characteristics or relationships in populations. In experimental approach, greater control is exercised over the research environment and often, some independent variables are controlled or manipulated to record their effects on dependent variables. In simulation approach, an artificial environment is constructed within which relevant data and information is generated. This way, the dynamic behaviours of a system are observed under controlled conditions.

(ii) Qualitative Approach: This approach to research is concerned with subjective assessment of attitudes, opinions and behaviour. Research in such a situation is a function of researcher's insight and impressions. Such an approach to research generates results either in non-quantitative form or in the forms which are not subjected to rigorous quantitative analysis.

Table 1.1 provides us with types of research, methods employed and techniques used by these types of research.

Table 1.1 *Types of Research*

	Type	Methods	Techniques
1.	*Library Research*	(i) Analysis of historical records	Recording of notes, content analysis, tape and film listening and manipulations, reference and abstract guides, content analysis.
		(ii) Analysis of documents	
2.	*Field Research*	(i) Non-participant direct observation	Observational behavioural scales, use of score cards, etc.
		(ii) Participant observation	Interactional recording, possible use of tape recorders, photographic techniques.
		(iii) Mass observation	Recording mass behaviour, interview using independent observers in public places.
		(iv) Mail questionnaire	Identification of social and economic background of respondents.
		(v) Opinionnaire	Use of attitude scales, projective techniques, use of goniometric scales.
		(vi) Personal interview	Interviewer uses a detailed schedule with open and closed questions.
		(vii) Focused interview	Interviewer focuses attention upon a given experience and its effects.
		(viii) Group interview	Small groups of respondents are interviewed simultaneously.
		(ix) Telephone survey	Used as a survey technique for information and for discerning opinion; may also be used as followup questionnaire.
		(x) Case study and life history	Cross-sectional collection of data for intensive analysis, longitudinal collection of data of intensive character.
3.	*Laboratory Research*	Small group study of random behaviour, play and role analysis	Use of audio-visual recording devices, use of observers, etc.

1.2.4 Methods versus Methodology

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Research Methods: They refer to all the methods the researchers use while studying the research problems and while conducting research operations. In general, the research methods can be categorized into the following three groups:

(i) The first group includes the methods that are concerned with the data collection.

(ii) The second includes the statistical techniques needed for mapping relationships between the unknowns and the data.

(iii) The third group contains the methods necessary to evaluate the accuracy of the results obtained.

Research Methodology: It is the procedure that helps to systematically proceed in steps to solve a research problem. Research methodology is a broader concept that includes not only the research methods; but also the logic behind the research methods in the context of a particular research study; and it explains the reasons for using particular research methods and statistical techniques. Research methodology also defines how the data should be evaluated to get the appropriate results.

1.2.5 Applications of Research in Business Decisions

The role and significance of research in aiding business decision is very significant. The question one might ask here is about the critical importance of research in different areas of management. Is it most relevant in marketing? Do financial and production decisions really need research assistance? Does the method or process of research change with the functional area? Figure 1.1 explains the complete research process.

The answer to all the above questions is NO. Business managers in each field—whether human resources or production, marketing or finance—are constantly being confronted by problem situations that require effective and actionable decision making. Most of these decisions require additional information or information evaluation, which can be best addressed by research. While the nature of the decision problem might be singularly unique to the manager, organization and situation, broadly for the sake of understanding, it is possible to categorize them under different heads.

Marketing Function

This is one area of business where research is the lifeline and is carried out on a vast array of topics and is conducted both in-house by the organization itself and outsourced to external agencies. Broader industry- or product-category-specific studies are also carried out by market research agencies and sold as reports for assisting in business decisions. Studies like these could be:

- Market potential analysis; market segmentation analysis and demand estimation.
- Market structure analysis which includes market size, players and market share of the key players.
- Sales and retail audits of product categories by players and regions as well as national sales; consumer and business trend analysis—sometimes including short- and long-term forecasting.

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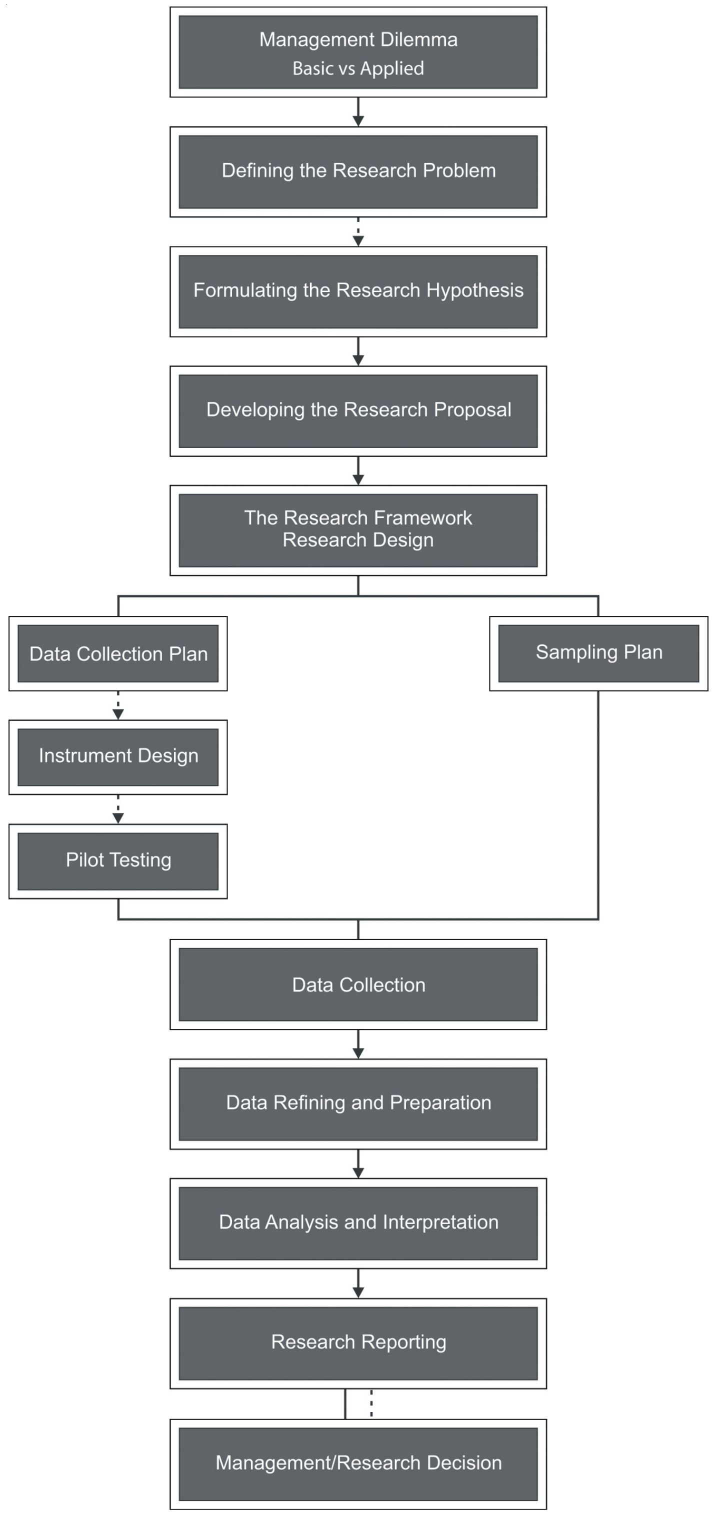

Fig. 1.1 *The Process of Research*

However, it is to be understood that the above mentioned areas need not always be outsourced; sometimes they might be handled by a dedicated research or new product development department in the organizations. Other than these, an organization also carries out researches related to all four Ps of marketing, such as:

- **Product Research:** This would include new product research; product testing and development; product differentiation and positioning; testing and evaluating

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new products and packaging research; brand research—including equity to tracks and imaging studies.

- **Pricing Research:** This includes price determination research; evaluating customer value; competitor pricing strategies; alternative pricing models and implications.
- **Promotional Research:** This includes everything from designing of the communication mix to design of advertisements, copy testing, measuring the impact of alternative media vehicles, impact of competitors' strategy.
- **Place Research:** This includes locational analysis, design and planning of distribution channels and measuring the effectiveness of the distribution network.

These days, with the onset of increased competition and the need to convert customers into committed customers, Customer Relationship Management (CRM), customer satisfaction, loyalty studies and lead user analysis are also areas in which significant research is being carried out.

Personnel and Human Resource Management

Human Resources (HR) and organizational behaviour is an area which involves basic or fundamental research as a lot of academic, macro level research may be adapted and implemented by organizations into their policies and programmes. Applied HR research by contrast is more predictive and solution oriented. Though there are a number of academic and organizational areas in which research is conducted, yet some key contemporary areas which seem to attract more research are as follows:

- **Performance Management:** This includes leadership analysis development and evaluation; organizational climate and work environment studies; talent and aptitude analysis and management; organizational change implementation, management and effectiveness analysis.
- **Employee Selection and Staffing:** This includes pre and on-the-job employee assessment and analysis; staffing studies.
- **Organizational Planning and Development:** This includes culture assessment—either organization specific or the study of individual and merged culture analysis for mergers and acquisitions; manpower planning and development.
- **Incentive and Benefit Studies:** These include job analysis and performance appraisal studies; recognition and reward studies, hierarchical compensation analysis; employee benefits and reward analysis, both within the organization and industry best practices.
- **Training and Development:** These include training need gap analysis; training development modules; monitoring and assessing impact and effectiveness of training.
- **Other Areas:** Other areas include employee relationship analysis; labour studies; negotiation and wage settlement studies; absenteeism and accident analysis; turnover and attrition studies and work-life balance analysis.

Critical success factor analysis and employer branding are some emerging areas in which HR research is being carried out. The first is a participative form of management technique, developed by Rockart (1981) in which the employees of an organization identify their critical success factors and help in customizing and incorporating them in developing the mission and vision of their organization. The idea is that a synchronized

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objective will benefit both the individual and the organization, and which will lead to a commitment and ownership on the part of the employees. Employer branding is another area which is being actively investigated as the customer perception (in this case it is the internal customer, i.e., the employee) about the employer or the employing organization has a strong and direct impact on his intentions to stay or leave. Thus, this is a subjective qualitative construct which can have hazardous effect on organizational effectiveness and efficiency.

Financial and Accounting Research

The area of financial and accounting research is so vast that it is difficult to provide a pen sketch of the research areas. In this section, we are providing just a brief overview of some research topics:

- **Asset Pricing, Corporate Finance and Capital Markets:** The focus here is on stock market response to corporate actions (IPOs or Initial Public Offerings, takeovers and mergers), financial reporting (earnings and firm specific announcements) and the impact of factors on returns, e.g., liquidity and volume.
- **Financial Derivatives and Interest Rate and Credit Risk Modeling:** This includes analysing interest rate derivatives, development and validation of corporate credit rating models and associated derivatives; analysing corporate decision-making and investment risk appraisal.
- **Market Based Accounting Research:** This includes analysis of corporate financial reporting behaviour; accounting-based valuations; evaluation and usage of accounting information by investors and evaluation of management compensation schemes.
- **Auditing and Accountability:** This includes both private and public sector accounting studies, analysis of audit regulations; analysis of different audit methodologies; governance and accountability of audit committees.
- **Financial Econometrics:** This includes modelling and forecasting in volatility, risk estimation and analysis.
- **Other Areas:** Other related areas of investigation are in merchant banking and insurance sector and business policy and economics areas.

Considering the nature of the decision required in this area, the research is a mix of historical and empirical research. Behavioural finance is a new and contemporary area in which, probably, for the first time subjective and perceptual variables are being studied for their predictive value in determining consumer sentiments.

Production and Operation Management

This area of management is one in which quantifiable implementation of the research results takes on huge cost and process implications. Research in this area is highly focused and problem specific. The decision areas in which research studies are carried out are as follows:

- Operation planning which includes product/service design and development; resource allocation and capacity planning.
- Demand forecasting and decision analysis.
- Process planning which includes production scheduling and material requirement management; work design planning and monitoring.

Check Your Progress

1. On what type of data is a research based?
2. Name the emerging areas where HR research is being carried out.
3. Does the method of research change with the functional area?

- Project management and maintenance management studies.
- Logistics and supply chain, and inventory management analysis.
- Quality estimation and assurance studies which include Total Quality Management (TQM) and quality certification analysis.

This area of management also invites academic research which might be macro and general but helps in developing technologies, such as JIT (Just-In-Time) technology and EOQ (Economy Order Quantity)—an inventory management model which are then adapted by organizations for optimizing operations.

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Cross-Functional Research

Business management being an integrated amalgamation of all these and other areas sometimes requires a unified thought and approach to research. These studies require an open orientation where experts from across the disciplines contribute to and gain from the study. For example, an area, such as new product development requires the commitment of the marketing, production and consumer insights team to exploit new opportunities. Other areas requiring cross functional efforts are:

- Corporate governance and ethics—the role of social values and ethics and their integration into a company's working is an area that is of critical significance to any organization.
- Technical support systems, enterprise resource planning systems, knowledge management, and data mining and warehousing are integrated areas requiring research on managing coordinated efforts across divisions.
- Ecological and environmental analysis; legal analysis of managerial actions; human rights and discrimination studies.

1.3 RESEARCH PROCESS

Research process includes steps or a series of actions and logical sequence of those steps to carry out research effectively. The various steps in a research process are not mutually separate, exclusive or discrete, but they at the same time need not always follow each other. The researcher, at each step, anticipates subsequent steps and the requirements.

1.3.1 Steps of Research Process

The tentative order of the steps and the procedural guidelines of the research process are as given below:

(i) **Formulating the Research Problem:** At the very beginning of research, the researcher must clearly define the research problem, i.e., the area of interest, the matter to be inquired into, etc. The problem, before being solved, is initially stated in a broader perspective and then the researcher arrives at the specific question by gradually reducing the ambiguities, if any. Then, immediately after formulating the problem, the feasibility of different solutions is studied before choosing the right solution.

(ii) **Extensive Literature Survey:** After formulating the research problem, a brief summary of it should be prepared—this is an essential step. While writing a Ph.D. thesis the researcher has to prepare a synopsis of the topic and submit it to

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the appropriate committee or research board for approval. Synopsis preparation needs extensive survey of the literature connected with the problem.

(iii) Development of a Working Hypothesis: After surveying the literature, the researcher should clearly state the working hypothesis, which is a tentative assumption made before testing it in logical or empirical sequences. Hypothesis must be as specific as possible and should be limited to the intended research. This helps to choose the right process.

(iv) Preparing the Research Design: The next step, after clearly defining the research problem, is preparing the suitable research design. The research design includes the conceptual framework within which research would be carried out. A good and planned research design helps to carry out the study in an efficient manner saving time and resources. It helps to gather the most useful information and assists in arriving at the accurate results. Simply put, a good research design facilitates the collection of relevant evidence with minimal expenditure of money, effort, time and other resources.

(v) Determining Sample Design: A universe or population includes all the items under inquiry. If all the items in the population are inquired then such an inquiry is called census inquiry. In a census survey, all the items are covered and so the highest accuracy is obtained. But this may not be practicable in surveys involving a big population. Census surveys need huge amounts of time, money and energy. Hence, quite often it is wise to select only a few items from the universe for study purposes. Technically, such a small and convenient number of items selected, is called a **sample**. Specified plan of the size and method of collecting the sample is technically known as **sample design**.

(vi) Collecting the Data: In most cases, the data at hand is insufficient and there is always a need of fresh data. There are different ways of collecting the appropriate data which differ considerably in terms of relevance, expenditure, time and other resources. Therefore, the researcher must select the most appropriate method of collecting the data after considering objective of the research, the nature of investigation, time and financial resources available, scope of the inquiry and the desired degree of accuracy.

(vii) Execution of the Project: This is an important step in the research process because if the execution proceeds on the correct lines, the collected data would be dependable, adequate and accurate. Therefore, systematic and timely execution of a project plays a crucial role in ensuring the right results at the end.

(viii) Analysis of Data: After collecting the data, the next step is analysing the data. The data analysis includes a number of closely-related operations like specifying different categories of data, differentiating and tabulating the data into different categories, applying the statistical techniques and formulae to the data, doing the right calculations and then drawing statistical inferences. Various tests, such as Chi-square test, *t*-test, *F*-test, etc., help in data analysis.

(ix) Hypothesis Testing: After analysing the data, the researcher should test the working hypothesis against the statistical inferences obtained after analysing the data. The question that should be answered now is: Do the findings support the working hypothesis or do they contradict?

(x) Generalizations and Interpretation: If a hypothesis is tested and upheld sufficient number of times, the researcher can arrive at a generalization. The degree of success of a research is calculated on the basis of how much the arrived generalizations are close to the acceptability. If the researcher starts with no hypothesis, the researcher will interpret his findings on the basis of some existing theory and this is known as **interpretation**. The process of interpretation often triggers new questions which lead to further researches.

(xi) Preparation of the Report or the Thesis: Finally, the researcher has to prepare the report of what has been studied. Report must be written with great care keeping the following layout in mind:

(a) **The Preliminary Pages:** These pages of the report should contain the title, the date, acknowledgments, foreword, table of contents, list of tables, list of graphs and charts (if any).

(b) **The Main Text:** The main text of the report should have introduction, summary of findings, main report, conclusion and suggestions for future research.

(c) **The Closure:** At the end of the report, appendices should be listed in respect of all technical data, followed by bibliography. Index terms should also be given specially in a published research report. All references should be cited as per the research writing formats.

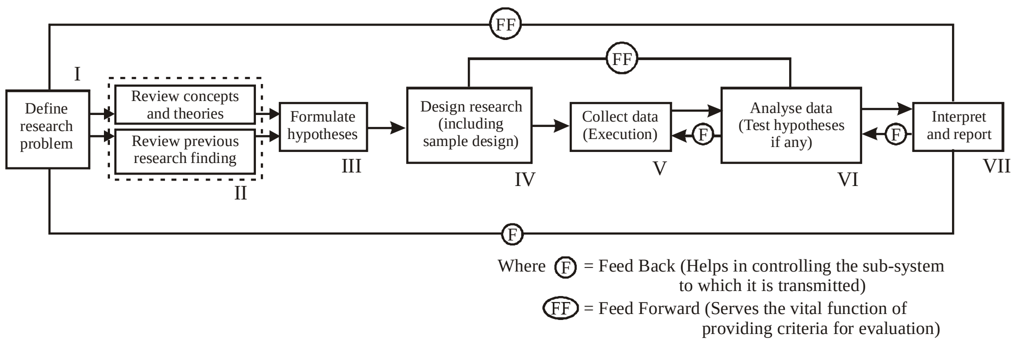

***Fig. 1.2** Research Process*

In Figure 1.2, the flow chart indicates the sequential steps to be followed in the research process. One must start with defining the research problem along with reviewing the relevant literature in the field to become familiar with the concepts and theories relevant to the issue to be investigated. The next step is the formulation of the hypothesis, which is followed by the research design and sample selection. Then the collection of data and its analysis is to be attempted. After that the interpretation and the report writing stages complete the research report. These have to be written step by step and then edited and refined several times before preparing the final report.

1.3.2 Criteria of Good Research

Whatever be the type of research one undertakes, certain common criteria of good scientific methods have to be followed. A good research follows logical methods, is systematic, and structured in accordance with well defined sets of rules and practices to enable the researcher in arriving at dependable conclusions. Both, deductive reasoning and inductive reasoning, should be followed for meaningful research.

Good research also implies obtaining reliable data which provides sound validity to the research findings.

The following principles underlie a good research criteria:

- The aim and objective of the research being conducted should be clearly specified.

- The research procedure should be replicable so that if the research needs to be continued or repeated, it can be done easily.
- The research design should be so chosen that the results are as objective as possible.
- Interpretation of any research should be done keeping in mind the flaws in the procedural design and the extent to which it has an effect on the results.
- Research should be carried out systematically. It should progress in pre-defined stages, and researchers should avoid using their intuition or guesswork to arrive at conclusions.
- Research should be logical so that it is meaningful, and help in decision-making.
- Research should be empirical as far as possible.
- The results of the research should only be used and generalized for the population for which the data provides an adequate basis.
- The validity and reliability of the data used in research should be double checked.
- Further, good research produces results that are examinable by peers, methodologies that can be replicated, and knowledge that can be applied to real-world situations.

1.3.3 Problems Encountered by Researchers in India

There are some common problems faced by researchers in developing countries and India is no exception. Basically, there is a dearth of the tools required for good research. Many of the universities and research institutions are now providing computers with Internet connection to researchers but the facilities provided are not adequate. Luckily, the costs of both hardware and Internet bandwidth are coming down. While Indian researchers now have easy access to these tools, there is still the problem of low visibility of papers published by them. Indian researchers are often demotivated to continue further research. Other factors like lack of scientific training in the methodology of research and a non-existent code of conduct also serve as challenges for the Indian researcher. There is also insufficient interaction between researchers and the end-users. End-users of research are the ones who stand to benefit from research and if they are not made aware of the benefit they can gain, getting sponsors to provide funds for research would be difficult.

There is also a lack of safeguards against any violation of confidentiality in data collection. Research studies that overlap lead to unnecessary repetition. There is an absence of research culture in our country.

Other problems that Indian researchers face that are common to developing countries are:

- Limited or no access to international research journals.
- Lack of infrastructure except in a few metropolitan cities.
- Low investment in research due to financial constraints.
- Inadequate library facilities and where such facilities exist, they are not easily accessible.
- Poor encouragement to do research.

These problems need to be surmounted effectively in order to promote research as a professional activity.

1.3.4 Qualitative Methods

Qualitative research is gaining a lot of importance in the social sciences. There are specific methods with different assumptions and objectives. These are intrinsic to all types of research. The steps of the research process and the procedures for collecting data and analysing and interpreting it are different.

Today, inductive strategies are increasingly used in research instead of starting from the basics and testing them empirically. Traditionally psychology and other social sciences have used the model presented by the natural sciences for developing quantitative and standardized methods. The guiding principles have been identifying the causes and effects and the measures have been quantity phenomena. These have permitted generalizations and the formulation of laws. Causal relations are studied under controlled conditions and observations have been classified in terms of their frequency and distribution. Studies have been made as objective as possible. For a long time, psychological research has depended on experimented designs for study as the mainstay.

The results of social sciences are not applied in daily life as the methodological precisions are far too removed from every day problems and situations. The goal of subject and situation-related research can be achieved with qualitative research in a meaningful way.

It is important to recognize that not all questions of research can be studied empirically. Sometimes methods are not available for study purposes. Complex social science problems are not easy to be put into the mould of empirical investigations. It is not easy to reduce complex situations to simple and single variables for the sake of studying. The entire complex situations are rendered rather simplistic and therefore, often inappropriate. The subjectivities of the researcher and those being studied are part of the qualitative research process. The qualitative researchers are soft, understanding, open and descriptive strategies. This is in opposition to the hard experimental, standardizing and quantifying approaches.

Definitions of Qualitative Research

It is a method of inquiry used in many different academic disciplines, traditionally in the social sciences. It is a set of research techniques in which data is obtained from a relatively small group of respondents and not analysed with statistical techniques.

Qualitative research follows an inductive research process and involves the collection and analysis of qualitative (i.e, non-numerical) data to search for patterns, themes and holistic features.

There is no formal quantitative framework used to generate projections in qualitative research. It is concerned with understanding the processes, which underlie various behavioural patterns. 'Qualitative' is primarily concerned with the 'why' of investigations. Case study, observation and ethnography are considered forms of qualitative research. Results are not usually considered generalizable, but are often transferable. It is a subjective form of research that relies on analysis of controlled observations of the researcher. This type of research yields extensive narrative data, which include detailed descriptions of what has been observed.

Here, collection of non-numerical data using interviews, observations and open-ended questions, to gather meaning from non-quantified narrative information, are

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involved. It is a form of research that derives data from observations, interviews or verbal interactions and focuses on the meanings and interpretations of the participants.

This is a way to study people or systems by interacting with and observing the subjects regularly. It is a free-form research technique that is used to gain insight into the underlying issues surrounding a research problem by gathering non-statistical feedback and opinions rooted in people's feelings, attitudes, motivations, values and perceptions, often from small samples, also called soft data.

It involves gathering and analysing of data based on the interviewees' own perceptions or experiences in order to provide insight into their beliefs about their circumstances rather than measurable data. Subjective information is obtained from groups and in-depth interviews and participant observation. Qualitative research is generally conducted on a small group. It looks at phenomena like attitudes, perceptions, etc.

The Aim of Qualitative Research

The primary aim of qualitative research is to gain insights into any phenomena of interest to the researcher. For example, one is interested in studying mental disorders. Epidemiological studies show the frequency of schizophrenia and the distribution of this disorder in a population. The finding is that it is higher in the lower socio-economic classes. These correlations have been well-established by empirical quantitative data. However, it is not clear whether the conditions of living in the lower economic conditions foster the development of schizophrenia or people with schizophrenia get marginalized and drop into the lower economic strata of society. Often studies fail to capture the contextual perspective of the illness. What is the subjective experience of being schizophrenic? How do the family members deal with this illness? What are the benefits of institutionalizing such a patient? How do professionals view women with schizophrenia? These are some of the relevant questions that qualitative research seeks to find answers to.

For qualitative research on the mental illness, the researcher starts with the patient, his/her relatives and the professionals involved and their perspectives. It also analyses the interactions in dealing with the illness for all concerned. The different viewpoints are significant in this type of research. Communications between, the investigator, patients, psychiatrists and others in the field, are part of the knowledge about the disease. The subjectivities of the investigator a well as that of the patient, constitute part of the research process. The researcher's reflections, frustrations, feelings, impressions, and so on, all become part of the legitimate data in their own right in the context of dealing with patients involving the illness.

Qualitative research is:

- A return to narratives, language and communication.
- Questions about the specific, particular and concrete problems.
- A study of the local contexts, instead of universals.
- Putting problems to be studied in their temporal and historical context. And also to describe and explain them are considered different approaches to qualitative research.

The approaches have different theoretical assumptions:

1. **Subjective:** This refers to individuals attribute that are based on their activities and surrounding environments.
2. **Interpretation:** This meaning is derived from and arises out of social interaction that one has with ones fellows.

These meanings are handled and modified through interpretations by people while dealing with various interactions.

'*The researcher has to see the world from the angle of the subject, he/she studies*' (Toulmin, 1990). This means that methodologically, the researcher has to reconstruct the subject's view point in various ways. This is in the form of subjective theories people have in explaining different aspects of the world. For example, The role of punishment in disciplining children; How the universe was formed?, etc. Here, autobiographical narratives, biographical reports, etc., are all significant as methods.

Making of Social Reality: Ethno methodology is one of the techniques used for studying how people construct their own social reality. Garfunkel (1987) proposed this method. Here, everyday activities are analysed in terms of their social context as to why some activities occur everyday. All these are viewed as visibly rational and reportable for all the practical purposes. This research is based on conversation analysis.

Conversation analysis is based on following three basic assumptions:

1. Interaction is structurally organized.
2. Conversation are context shaped and context renewed.
3. Conversational details cannot be dismissed as disorderly or irrelevant.

Cultural framing of social and subjective reality and cultural systems determine the perception and making of social reality (see Table 1.2).

Table 1.2 *Theoretical Position in Qualitative Research*

	Subjects' Points of View	**Making of Social Realities**	**Cultural Framing of Social Realities**
Traditional theoretical background	Symbolic interactionism	Ethnomethodology	Structuralism, psycholanalysis
Recent development in social sciences	Interpretive interactionism	Studies of work	Poststructuralism
Recent developments in psychology	Research programme 'subjective theories'	Discursive psychology	Social representations
Common features	Verstehen as epistemological principle Reconstructing cases as starting point Construction of reality as basis Text as empirical material		

Source: Flick, *An Introduction to Quantitative Research*, 1998.

Qualitative Approaches

Qualitative approach is a method of enquiry used to conduct qualitative research. This approach describes the main objective of the qualitative research along with the role of researcher or researchers and the process and format of data analysis. There are four major qualitative approaches to research, which are as follows:

(i) Ethnography (ii) Phenomenology

(iii) Field Research (iv) Ground Theory

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Ethnography: The field of Anthropology initiates the Ethnographic approach to qualitative research. The main emphasis in ethnography is to study an entire culture. It has been observed that previously the notion of culture was combined with the elements of ethnicity and geographical locations, for instance, the culture of Germantown in Pennsylvania, US. The immigrants in this area are descendants from Alsace in southwestern Germany and Switzerland who settled in Pennsylvania in the Eighteenth century. These immigrants and their descendants came to be known as Pennsylvania Dutch. However, the concept of 'culture' has been widened to include virtually any group or organization. Hence, we can study the culture of a business or a specifically-defined group, such as the Rotary Club.

Ethnography is considered a broad area of study with a great variety of practitioners and methods. The most common ethnographic approach is participant observation in a field research. Here, ethnographers become a part of the culture and actively participate in daily life while recording their observations made in the field study. Unlike grounded theory, there is no pre-decided limitation as to what will be observed and there is also no real ending point in an ethnographic study.

Phenomenology: The subject of Phenomenology has a two-dimensional approach. It is sometimes considered to be a philosophical perspective as well as an approach to qualitative methodology. It has been known to have a longstanding history in several social research disciplines, such as sociology, psychology and social work. The study of phenomenology focuses on people's subjective experiences and interpretations of the world. This means that phenomenologists want to understand how the world is perceived by others.

Field Research: This broad approach is a method of collecting qualitative data. The researcher mainly goes out in the field to observe a phenomenon and its effects in a natural environment or in place of its origin. This relates mostly to the method of participant observation. The notes taken by the field researcher are coded and analysed in numerous different ways.

Grounded Theory: The Grounded Theory was developed by Glaser and Strauss in the 1960s. This qualitative approach is a method of developing theory relating to the phenomena of interest. This is however not to be confused as an attempt of abstract theorizing as the theory needs to be grounded or rooted in observation. The Grounded Theory is very complex and repetitive. Research is initiated with a set of generative questions which guide the research. An important point to remember is that these questions are not intended to be static or confining in nature. Once the researcher begins to collect data, the core theoretical concepts are identified. These theoretical concepts need to be linked with the data. The early phase of research is a long and tedious process and might even take months to be completed. The later phases of research are more focused on verification and summary. The main aim is to combine the effort to evolve one core category that is central to the research. Several key analytical strategies are adopted by researchers in the Grounded Theory, which are as follows:

(i) **Coding:** Through the process of coding qualitative data is categorized on the basis of its implications and details of these categories. In the early stages, researchers do not use coding, considering the data in minute detail while developing some initial categories. In the later stages, selective coding is put to use through which a researcher systematically codes the data in terms of the core concepts.

(ii) **Notes:** Taking notes or memoing which is used to maintain a record of the researcher's ideas and thoughts as and when they evolve in the process of the study. Memoing is not to be confused with extensive marginal notes and comments. In the early stages of research, the memos tend to be very open and later on they are increasingly focused on the core concepts of the research.

(iii) Integrative Diagrams and Sessions: These tools help to put all the data together in a systematic way with respects to the emerging theory. Diagrams can be in any form of graphics which are useful at that point of research. These graphics may be in the form of maps, graphs and in some cases simple cartoons which can act as summarizing devices. This process of integration is best done in group sessions where each and every member of the research team is able to interact and share ideas to enhance knowledge about the research.

A researcher approaches a conceptually dense theory as new observations lead to new links which eventually lead to more revisions in the theory and in some cases more data collection. In this method, the core concept is identified and researched in detail. In this type of research method, the research probably never ends and could continue indefinitely. The main feature of a Grounded Theory is that it does not have a clearly demarcated point for ending a study. The project ends when the researcher decides to quit. In the end, the researcher is left with a well-considered explanation for a phenomenon of interest, i.e., the Grounded Theory. The Grounded Theory can be explained in words and is usually presented with much of the contextually relevant detail collected.

Construction of Reality

A social representation is understood as a system of values, ideas and practices with a twofold function: First to establish an order which will enable individuals to orient themselves properly in their material and social world and to master it; and secondly to enable communication to take place among the members of a community by providing them with a code for social exchange and a code for naming and classifying unambiguously the various aspects of their world and their individual and group history.

Qualitative research aims at understanding an event from the inside. It is the view of one subject or subject(s), the social situation or the cultural or social rules relevant for a situation that have to be understood. A single case is analysed before a general statement is made.

1. First a single subject theory.
2. Then a single conversation.
3. And then a single cases is reconstructed.
4. Later other case studies are used as a comparison.
5. Then a typology or different subjective theories are developed.

The reality studied by qualitative research is not a given reality, but as constructed by different ‘actors’. How crucial an actor is, is determined by the theoretical position adopted to study the process of construction.

In the process of reconstruction, texts are used for empirical analysis. The view of the subject is presented as his/her subjective theory. For example, belief in astrology where the course of interaction is recorded and transcribed and then the reconstructions of latent structures of manning are formulated from the texts (i.e., what is told and the actions that follow, e.g., matching of horoscopes). The status of the texts will be determined by the theoretical position held.

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Texts and Realities in Qualitative Research

Texts are considered significant for the following three purposes in qualitative research:

1. Texts are not only the essential data, but the basis for interpreting and communicating the findings as well.
2. Texts are seen as an instrument for interpretation of social reality.
3. Interviews comprise the data that are transformed into texts.

Hereafter the Text is Used as a Substitute for the Reality

Text making of the world involves first degree and second degree constructions. Realities are actively produced by the participants through the meanings ascribed to certain events and objects. This is what qualitative researchers seek to study. These ideas of social events in a social field may compete, conflict or succeed and are shared and taken for real. This is how reality is constructed (see Figure 1.3).

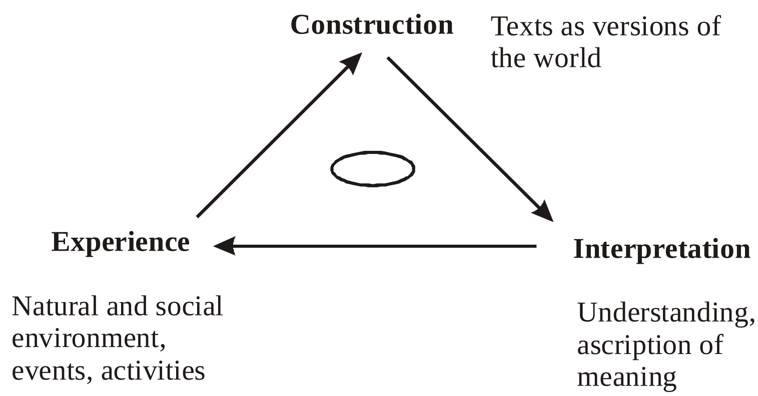

Fig. 1.3 *Realities*

Source: Flick, *An Introduction to Quantitative Research*, 1998.

Strictly speaking there are no such things as facts, pure and simple. All facts are from the outset selected from a universal context by the activities of our mind. They are, therefore, always interpreted facts, either facts looked at as detached from their context by an artificial abstraction or facts considered in their particular setting. In either case, they carry their interpretational inner and outer horizons.

For Goodman (1978), the world is socially constructed through different forms of knowledge—from everyday knowledge to science and art as the ways of making the world. Social research is an analysis of such ways of world making and the constructive efforts of the participants in everyday life. A central idea in this context is the distinction between first degree and second degree constructions—first degree is the construct made by an actor. The constructs of the constructs made by the actor in the social scene is the second degree. The exploration of the general principles, according to which man organizes his experiences in daily life and those of the social world, is the first task of the methodology of social sciences.

So, there could be multiple social realities. Social science research encounters the world it wishes to study only in those versions as constructions by the subjects. So, there are subjective constructions by the participants and subjective constructions by the researchers. Knowledge of the world is not just found in the world, rather it is built into it. Worlds are made from other worlds. A big part of research involves reconstructing life stories or biographies in interviews

Theories in Qualitative Research

To begin with, qualitative research is circular, not linear like in quantitative research. In this type of research, theories undergo revisions, evaluation, construction and reconstruction. They are versions of perspectives through which the world is seen.

Each formulation has its own perspective hidden within it. The perception in turn feeds back into the social construction of this perspective and thereafter the world around us. So, theories are mere preliminaries and relative. When the version is developed further additional interpretations become possible of the new material and so on. So, there is a pre-understanding from which all study starts. Glasser and Strauss suggest a circular model for qualitative research.

Linear and Circular Models of Research Process

There is no one single definition or agreed model for the research process. Various models or frameworks have been proposed to describe how research is carried out. Linear and circular models are important among them.

- **Linear Models:** Linear models describe different chronological steps or tasks to be carried out in pursuing a research project. These models are a valuable way of thinking about some types of research, such as surveys. However, they do not satisfactorily describe the complexities of the 'thinking processes' behind research. Linear model questions or hypotheses are refined as the researcher explores concepts and ideas derived from their data or observations. This model of research provides headings for research proposals, funding applications and research reports.
- **Circular Models:** Circular models describe research as an iterative process, analogous to learning. The research questions or hypotheses are refined as the researcher explores concepts and ideas derived from their data or observations. The research describes predominantly well the processes involved in qualitative research.

Formulating Research Questions in Qualitative Research

The questions and the format used for the response are the fundamental elements of a survey. Thus, while formulating questions, it should be ensured that they are not too lengthy. The questions to be asked should be clear. While doing any research work, you should always utilize standard language and leave out scientific jargon or words that are lengthy and make your questions ambiguous. Prior to undertaking research activities, pre-testing or piloting questions in focus groups is very helpful in formulating the right questions for specific issues. If you succeed in identifying factors within the responses, it will help you develop consistent data and remove redundant questions. This serves as a test to ensure that the researcher and the respondents have interpreted the questions in the similar way. This provides for reliability testing and eliminating any inconsistencies or potential prejudices that may be present. Questions should be asked in the order of increasing sensitivity so that a level of comfort with the respondents is built.

Examples of Formulating Good Research Questions

Question 1: Suppose your survey question is: 'Do you know that people are testing a vaccine against hook worm?' This may not be good question. First, this type of information should be included in the informed consent that every participant will receive prior to voluntarily participating in the study. Further, the question does not assess whether the respondent was actually aware that researchers were testing a vaccine against hook

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worm. Thus, the question should be re-phrased as: 'Do you know what is being tested?' If the respondent replies 'yes', the next question should ask: 'What is being tested?'

Question 2: Suppose you, as a researcher ask the next question: 'Are the researchers doing good work in your community?' As this question is being asked by a researcher, almost 100 per cent of the respondents would say 'yes' in response to this question in the research study. So, you should re-phrase this question as: **'**Do you believe that the researchers will have a positive or negative impact on your community?'

Question 3: Suppose your next question is: 'Do you know what a vaccine does?' Such questions cannot be utilized to assess whether the respondent actually knows what a vaccine does. A follow-up question is necessary to assess actual knowledge.Thus, you need to re-phrase your question as: 'Do you know what a vaccine does?' If the respondent responds 'yes', then the follow-up question must be 'What does a vaccine do?

Research questions exist in the investigators personal biography and social context. Certain issues are brought to the fore and others ignored. The research questions can be of two types: Those oriented towards describing states (which kind, how often, etc.) and Those oriented towards describing process (causes, strategies, etc.). A researcher can enter the field of study as: a stranger, visitor or as an insider. The best role to adopt is that of an insider. The set of realities presented would be most similar in the role of an insider and ideal for qualitative research.

Sampling Strategies in Qualitative Research

Instead of selecting a sample, the complete collection method is used in qualities research. The sample is pre-determined by certain criteria, e.g., a certain disease, age, gender, region, marital status, etc.

Sample is also defined gradually. They are made on the basis of the groups to be compared or may focus on specific persons. The sample is chosen on the basis of new insights for developing a theory. Groups or persons chosen for the sample are stopped when saturation is reached, i.e., nothing new could emerge hereafter.

Samples of Gradual Selection

Table 1.3 shows the difference between theoretical and statistical sampling.

Table 1.3 *Theoretical Versus Statstical Sampling*

Theoretical Sampling	**Statistical Sampling**
Extension of the basic population is not known in advance.	Extension of the basic population is known in advance.
Features of the basic population are not known in advance.	Distribution of features in the basic population can be estimated.
Repeated drawing of sampling elements with criteria to be defined again in each step.	One-shot drawing of a sample following a plan defined in advance.
Sample size is not defined in advance.	Sample size is defined in advance.
Sampling is finished when theoretical saturation has been reached.	Sampling is finished when the whole sample has been studied.

Source: Flick, *An Introduction to Quantitative Research*, 1998.

Sampling proceeds according to relevance, not representations; and width and depth as the aim of a sample, not representativeness.

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Table 1.4 *Sampling Strategies*

Sampling Strategies in Qualitative Research
• A *priori* determination • Complete collection • Theoretical sampling • Extreme case sampling • Typical case sampling • Maximal variation sampling • Intensity sampling • Critical case sampling • Sensitive case sampling • Convenience sampling • Primary selection • Secondary selection

Source: Flick, *An Introduction to Quantitative Research*, 1998.

The objective of the sampling strategies (see Table 1.4) is to provide richness of information. It also helps in obtaining relevant information. It is an intense attempt at data sampling. Interviews should be non-directive, specific, average, in-depth and should have personal context and content.

Sample selection is based on the principle of gradual selection. It is always purposive sampling, not random sampling. Palton gives the following concrete suggestions:

- Integrate purposively extreme or deviant cases. Cases of successes or failures are chosen and analysed. This is thought to help in understanding the whole field.
- Another feature is to select typical cases. These are the average for the group. This means looking at the field from the centre and from the inside.
- To choose a maximal variation sample—here, the idea is to integrate only a few cases, but which are as different as possible. This is aimed at obtaining the range of variation and differentiation in a field.
- Choosing cases on the basis of intensity—here, the expectation is that the interesting features, processes and experiences that go with this would be integrated in the study and compared.
- Selection of critical cases is done to enhance the functioning of the study, by virtue of its richness.
- Choice of sensitive cases—these are to be included due to their explosive force and, therefore, the unique prospect of studying them making it special.
- Finally, the concept of convenience in selection—these are included because of easy access, reduced effort and decreased time when people, money, etc., are limited.

Cases are Considered as Samples

Each case is thought to have following five representative aspects:

(i) A single case is understood as an 'individualized universal.' It is viewed as a result of specific individual socialization against the general background, e.g., a physician or psychologist trying to understand a disorder. Such a socialization can be understood in the social context, leading to different subjective opinions, attitudes, etc. This gets to be displayed in the actual interview situation.

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(ii) To understand the 'individualized universal', the case is seen in a specific context in which the individual acts and which he/she represents to others. So, the doctor or social worker orients his or her practices to the institutions under which these difficulties arise, e.g., a dysfunctional family, night shift work, etc.

(iii) An individual case is also seen as a specific form of professionalization, e.g., information engineer, social worker, etc. Therefore, the training of the professional individual and the actions that arise from that context got to be studied and analysed. Therefore, different professionals approach the same problem differently. This makes a given case a unique sample.

(iv) The case also develops its subjectivity because of the specific stock of knowledge and the corresponding ways of acting and perceiving come into play.

(v) The case also represents an interactive mode of context and activity.

Sampling decisions cannot be made in isolation. The appropriateness of the content and the strategy together determine the selection. It may be difficult to make generally valid statements on the basis of a single study, but it is also equally difficult to give deep descriptions and explanations of a case based on the principles of random sampling. This is the strongest argument of the qualitative researcher. Since sampling strategies are meant to disclose a given field, it can start from the extreme, the negative, the critical and the deviant cases and thereafter form the extremities of the field. It can also start from the inside, which is the case of the typical or the developed cases. There, sampling can start from those cases which are as far different as possible in their variation. This precludes the need for homogeneity in the sampling. Sampling decisions determine what becomes the empirical material in the form of texts and what is taken from the texts and how it is used.

1.3.5 Different Types of Interviews for Qualitative Research

The following are the different types of interviews for qualitative research:

The Focused Interview

- **First Part:** It has unstructured questions, like 'What did you like most about'?
- **Second Part:** Semi-structured questions—they are left open-ended for being able to get a feel about a given rule.
- **Third Part:** Structured questions like 'Was the lecture informative'?

Problem-Centred Interview

It involves asking questions like 'How open do you show the allergy'?

- **Object-Orientation to Determine a Problem:** Do you see yourself as healthy or unhealthy?
- **Process Orientation:** Do you search the Internet to know more about your allergy?

Expert Interview

This type of interview is directive, stronger and guided.

Ethnographic Interview

Here the project is explained in descriptive and structural questions.

Narrative Interview

Here knowledge and experiences are presented. This is called a generative narrative. This is to obtain or elicit answers on a theme of study.

Episodic Interview

Here episodes are presented as a source of knowledge in terms of circumstances or events. Then the semantic knowledge (the meaning) attached to the events is studied through the narration.

Group Discussions

Observing the responses of a small group at one time is called a group discussion. An explanation is given about a topic, procedure, etc. Members are introduced as a warm up act and then asked to discuss the topic. The opinions given by the members are got from the verbal data. Statements and thoughts are gathered. This is a dynamic process in operation.

Focus Groups

Here the focus is on the interaction among members. A focus group is a form of qualitative research in which a group of people are asked about their perceptions, opinions, beliefs and attitudes towards a product, service, concept, advertisement, idea or packaging.

All the above methods are used for collecting verbal data. The method to be chosen is on the basis of its appropriateness.

Visual Data

Visual data are made up of what we can see. We learn what is considered to be worthy of our attention. Visual data may be recorded in a number of ways, e.g., described in a notebook, on a Dictaphone or digital equivalent, or remembered in a diary. Visual data may also be recorded on film or encoded digitally and reproduced as a still or moving image.

Observation

Observations can be of the following types:

- Covert vs. Overt Observation
- Non-Participant vs. Participant Observation
- Systematic vs. Unsystematic Observation
- Natural vs. Artificial Situation Observation
- Self-Observation vs. Observing Others

Phases of Observation

Authors like Adler and Adler (1994), Denzin (1989b) and Spradley (1980) name the phases of an observation as:

- The selection of a setting, i.e., where and when the interesting processes and persons can be observed.
- The definition of what is to be documented in the observation and in every case.
- The training of the observers in order to standardize such focuses.

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- Descriptive observations which provide an initial general presentation of the field.
- Focused observations which concentrate more and more on aspects that are relevant to the research question.
- Selective observations which are intended to purposively grasp only central aspects.

The end of the observation, when theoretical saturation has been reached (Glaser and Strauss, 1967), i.e., further observations do not provide any fresh knowledge.

Ethnography

The ethnographer participates, overtly or covertly, in people's daily lives for an extended period of time, watching what happens, listening to what is said, asking questions. He collects whatever data are available to throw light on the issues with which he or she is concerned. He may show photos to the interviewer while interviewing and sometimes he may use film analysis questions or micro analysis of the clips done.

Coding and Categorizing

The interpretation of data lies at the core of qualitative research. For this purpose coding and categorizing are crucial. The texts obtained can either be augmented by alteration or paraphrased, summarized or categorized.

The Process of Coding

There are following three types of coding:

(i) Open Coding

(ii) Axial Coding

(iii) Selective Coding

These are ways of handling the textual material. Coding is the process by which data are broken down, conceptualized and put back together. The coding is initially done closely to the text as possible and then made more abstract. Categorizing refers to the summarizing of such concepts. Another way of coding is by themes. These are useful for comparisons.

Content Analysis

This is a classical procedure for analysing textual material. This includes both visual and interview data. The categorizing done earlier is used and modified, as required.

- First step is to select the relevant parts of a text.
- Second is to analyse the data with who, what, when, whom, how etc., questions.

The coding unit presents the smallest element. The categories provide the larger unit while the contextual unit determines the largest elements for analysis.

Techniques of Content Analysis

Three basic techniques are:

1. **Paraphrasing the Material:** Here the less relevant details are skipped (first reduction).
2. **Bundling and Summarizing:** Similar paraphrases are grouped together (second reduction).
3. **Generalization:** Summarizing at higher level of abstraction.

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Sequential Analysis

In order to analyse the elements or statements, it is necessary to put things contextually. Here sequential analysis is useful. Any idea is put in social order, which also gives the understanding of the interactions that occur. So, the contents are presented in a reliable way in the best possible context.

Conversations, discourses, narratives are all interpreted using sequential analyses.

Making Qualitative Research Reliable and Valid

The legitimacy of this type of research has always been criticized. One of the ways to achieve reliability is to train the observers before they enter the field and evaluate the observations. This is to improve comparability. Certain conventionalized procedures for field notes are an example of increasing reliability. Table 1.5 shows different symbols used for reality.

Table 1.5 *Symbols for Reliability*

Sign	Convention	Use
“ ”	Double quotation marks	Verbatim quotes
‘ ’	Single quotation marks	Paraphrases
( )	Parentheses	Contextual data or fieldworker’s interpretations
< >	Angled brackets	Emic concepts (of the member)
/ /	Slash	Etic concepts (of the researcher)
——	Solid line	Beginning or end of a segment

Source: Adapted from Kirk and Miller 1986; Silverman, 1993.

Validity

This has received more attention than reliability. Certain guidelines have been proposed with this in mind.

Subjectivity

Subjectivity analyses a subject and his/her feelings, perspectives, desires and beliefs. The expression is in contrast with the term ‘objectivity’ in philosophy.

Subjectivity highlights the specific discerning interpretations of all the aspects of experiences. They are distinctive for all the individuals experiencing them—the *qualia* that are only available to an individual’s consciousness. Even though the causes of experience are believed to be ‘objective’ and available to all (just like the wavelength of a particular beam of light), the experiences in themselves are just available to the subject (the quality of the colour itself).

Subjectivity generally exists in theories, concepts or measurements, against the effort of those trying to be objective. In most of the fields, the effort is to remove subjectivity from scientific or mathematical statements or experiments. Many fields, such as physics, biology, computer science and chemistry are striving to remove subjectivity from their theories, methodologies and results, although it constitutes a major part of the process of experimentation in these fields presently.

In spite of this, subjectivity is the only means for experiencing the world, mathematically, scientifically or otherwise. In fact, people share a human subjectivity, as well as individual subjectivity. All the theories and philosophies which dictate the understanding of science, mathematics, literature and all the concepts about the world are based on human or individual perspective. To a large part, the creation of philosophies is within itself subjective, along with the concept of creation of ideas or discovery.

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This expression is in contrast with 'objectivity'. It is used to describe people as 'seeing' the universe precisely for what it is from a standpoint free from human perception and 'its influences, human cultural interventions, past experience and expectation of the result'.

1.3.6 Process of Documentation of Qualitative Research

For interview data, the spoken words are edited and transcribed. For observational data, the documentation involves recording the actions and interactions. In both these the contextual enrichment of the data is an important aspect of the documentation process. The procedures involve the texts, which becomes the basis for analyses. There are four steps in documenting data:

(i) Recording the data.

(ii) Editing the data.

(iii) Constructing a new reality in and from the produced text.

(iv) This is the way in which the construction of reality in qualitative research takes place.

Audio-visual acoustic and visual recordings are all part of the new recording possibilities of data collection. However, what is worrisome is that the presence of the recorder and the recording instruments could affect the recording. Here the least intrusive of the equipments are to be used and the minimal presence of people is suggested in the observation areas.

For field notes, the qualitative researcher is told to take notes and record the observations immediately. Since the researcher is usually the one who partakes action in research to a large extent, it is also suggested that notes be completed after ending the study. The researcher should spend as much time on noting the observations as was spent for carrying out the observation—the general rule of thumb for effective documentation. This is how reality is to be produced from the field notes. Along with this, the protocols of diaries should also be maintained for corroboration.

Field Notes Documentation

The field notes documentation are given below:

- Condense conversations into single words, sentences, etc.
- Expand the anecdotes from interviews and observations.
- The field-work journal must have an account of experiences, mistakes, problem, insights, etc.
- Notes and interpretations can start as soon as the field study commences and till the completion of the study.

Research Diary

The documentation for research diary are given below:

- Keep diaries updated, as a documentation procedure.
- Compare, if more than one researcher is involved.
- Catch interesting events in the diary.
- Only document that which is essential.
- Make recordings immediately after an event.

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Transcription

When language analysis is involved, the focus in transcription should be to obtain the maximum exactness in classifying the statements, pauses, hesitations, etc., (see Table 1.6).

Table 1.6 *Transcription*

[	Overlapping speech: The precise point at which one person begins speaking whilst the other is still talking or at which both begin speaking simultaneously, resulting in overlapping speech.
(0/2) 'Aw:::':	Pauses: Within and between speaker turns, in seconds. Extend sounds: Sound stretches shown by colons, in proportion to the length of the stretch.
Word: 'fishi-': '.hhhh':	Underlining shows stress or emphasis. A hyphen indicates that a word/sound is broken off. Audible intakes of breath are transcribed as '.hhhh' (the number of h's is proportional to the length of the breath).
WORD: (words…):	Increase in amplitude is shown by capital letters. Parentheses bound uncertain transcription, including the transcriber's 'best guess'.

Source: Flick, *An Introduction to Quantitative Research*, 1998.

Texts produced in the following way are the nearly constructed realities:

- The research should talk less and listen as much as possible.
- Produce notes as exactly as possible.
- Bring data to unify as early as possible.
- The readers of the notes must be able to see for themselves clearly which persons are providing enough data.
- The reports should be open and clear.
- The researcher should seek feedback on findings/representations.
- Presentations should be balanced between the various aspects observed/recorded.
- Writing should be as accurate as possible.

These steps seek to improve validity by sensitizing the researcher to qualitative research.

Procedural validity is sought to be achieved by the following different relationships at work in research:

- The relationship between what is observed (behaviours, rituals, meanings, etc.) and the lager cultural, historical and organizational contexts within which the observations are made (the substance).
- The relationship among the observed, the observer and the setting (the context).
- The issue of perspective (or point of view), of the observers' or the members', used to render an interpretation of the ethnographic data (the interpretation).
- The role of the reader in the final product (the audience).
- The issue of relationship, rhetorical or authorial style used by the author(s) to render the description and/or interpretation (the style).

Here validation involves the entire research process.

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Triangulation

This is a term used for combining the methods in qualitative research. Four types of triangulations are suggested:

- **Data Triangulation:** It involves using different data sources in rating persons, places and situations
- **Investigator Triangulation:** Here different interviewers or observers are used with a view to minimizing errors/biases.
- **Theory Triangulation:** It involves approaching data with multiple perspectives and hypotheses in mind. Various types of orientations are placed side by side to see their usefulness for producing knowledge
- **Methodological Triangulation:** It involves combining different methods, such as combing questionnaire with an interview or using different sub-scales for measuring a phenomenon.

Triangulation is seen as a concept for validating results obtained with individual methods. These are thought to enrich and complete knowledge and lessen the limitations of individual methods used singly. These are the ways social realities are sought to be studied systematically. Triangulation is seen as a means to increase the scope, depth and consistency of knowledge through methodological means.

Analytic Induction: Here the attempt is to understand and explain the exception that is deviant to a hypothesis in a systematic way to interpret results. It is a case of looking at negative data to be able to substantiate the general.

New criteria to evaluate qualitative research:

1. Trustworthiness
2. Credibility
3. Dependability
4. Transferability
5. Conformability

Credibility can be increased by persistent observation, and triangulation of methods, researchers and data.

Democratization of qualitative research is achieved by using constant comparative methods for interpreting texts. This is carried out by the following way:

1. Comparing incidents of each category.
2. Integrating categories, by properties/time, etc.
3. Delimiting the theory.
4. Writing the theory.

This is a continuous growth process. Contrasting cases and ideal type analysis are carried out so that pure cases can be tracked and the understanding of the individual case be made more systematic.

Comparisons of old and new criteria for the qualitative field:

Old	New
Objective	Conformability
Reliability	Dependability/Auditability
Internal Validity	Credibility/Authenticity
External Validity	Transferability/Fittingness
Utilization/Application	Action/Orientation

Check Your Progress

4. What are the significant components of the main text of a research report?
5. What type of research process does qualitative research follow?
6. What is the main objective of the sampling strategies?
7. Define the term focus group.

1.4 TYPES OF RESEARCH

Research may be of various types. The basic types are as follows:

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1.4.1 Descriptive versus Analytical Research

Descriptive research includes different kinds of fact-finding inquiries and surveys. The main objective of this research is describing the state of conditions as it exits at the present moment. For descriptive research studies in the social sciences, we often use the term ex-post-facto research method the main characteristic of which is that the researcher has no control over the variables; he can report only what has happened or what is happening. Used often for descriptive studies, most ex-post-facto research projects, seek to measure such phenomena as preferences of people, frequency of shopping, or similar data. The methods used in descriptive research include all kinds of survey, comparative and correlation methods. Descriptive research attempts to determine, describe or identify *what* is. The descriptive research uses description, classification, measurement and comparison to describe what phenomena are.

On the other hand, in analytical research, the researcher uses the information and facts already available, and analyses them to make a critical evaluation. Analytical research attempts to establish *why* it is that way or how it came to be. The analytical research usually concerns itself with cause-effect relationships.

For example, examining the changes in the family structure in modern India is an example of descriptive research; while explaining *why* and *how* the nuclear family system has become popular in the country over time is an example of analytical research.

Example of Descriptive and Analytical Research

Examining the fluctuations of US international trade balance during 1974-1995 is an example of descriptive research; while explaining *why* and *how* US trade balance move in a particular way over time is an example of analytical research. Another example: Starting from late 1986, the value of US Dollar value has steadily increased against the Japanese Yen and German Mark. Examining the magnitude of this trend in the value of US dollar is another example of descriptive research; while explaining *how* and *why* this surge in the value of the US dollar is occuring. If one attempts to explain *how* and *why* this surge in the value of US dollar is going to affect the US economy, as well as the economies of Japan and Germany, this is another example of analytical research

1.4.2 Basic Research versus Applied Research

Research can be either fundamental (basic or pure) or action oriented (applied) research. Fundamental research focuses on finding generalizations and formulating theories. It is the research done for knowledge enhancement; the research which does not have immediate commercial potential; and the research which is done for human welfare, animal welfare and plant kingdom welfare. For example, research on the institution of marriage came into being is an example of basic or fundamental research. Here the main motivation is to expand man's knowledge and not to create or invent something. Basic research lays down the foundation for the applied research.

Applied research is designed to solve practical problem of the modern world, rather than to acquire knowledge for the sake of knowledge. Its goal is to improve the human condition. It focuses on analysis and solving social and real life problems. This

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research is usually conducted on large scale basis and is expensive. Thus, it often conducted with the support of some financing agency like government, public corporation, World Bank, United Nations Children's Fund (UNICEF or United Nations International Children's Emergency Fund), University Grant Commission (UGC), etc. Examples of applied research topics include persuasion, eyewitness memory, clinical treatments of psychological disorders, behavioral interventions for children with autism, decision making, etc.

Example of Basic and Applied Research

Some examples of basic researches are given below:

- How did the universe begin?
- What are protons, neutrons and electrons composed of?
- How do slime molds reproduce?
- What is the specific genetic code of the fruit fly?

Some examples of applied researches are given below:

- Improve agricultural crop production.
- Treat or cure a specific disease.
- Improve the energy efficiency of homes, offices or modes of transportation.

1.4.3 Quantitative versus Qualitative Research

In social sciences, quantitative research is the systematic empirical investigation of quantitative properties and phenomena and their relationships. The process of measurement is vital to quantitative research since it establishes fundamental connection between empirical observation and mathematical expression of quantitative relationships. In quantitative research, statistics is the most widely used branch of mathematics. Statistical methods are used extensively for social, economic and commercial research. Quantitative research using statistical methods begins with the collection of data, based on the hypothesis or theory. The study of the relationship between dietary intake and measurable physiological effects, such as weight loss, is an example of quantitative research.

Qualitative research is a non-qualitative type of analysis. It refers to the meanings, definitions, characteristics, symbols, metaphors and description of things. It is much more subjective and uses very different methods of collecting information, primarily individual, in-depth interviews and focus groups. In this type of research, small numbers of people are interviewed in depth and or a relatively small number of focus groups are conducted. Qualitative research can be further classified into many sub-types. Phenomenology is a type of qualitative research in which the researcher attempts to understand how one or more individuals experience a phenomenon. For example, if the researcher interviews 25 victims of the Bhopal Tragedy about their experience of the tragedy, it is a case of phenomenological research. Ethnography is another form of qualitative research, which focuses on describing the culture of a group of people. For example, the researcher might decide to go and live with the tribal in the north-east region of the country and study the culture and the educational practices prevalent in the region. Case study is also a form of qualitative research that is focused on providing a detailed account of one or more cases.

Examples of Qualitative and Quantitative Research

Some examples of qualitative researches are given below:

- A patient's description of their pain rather than a measure of pain.
- Measuring product awareness.
- Perceptions of domestic violence.
- Interactions between clients and workers in a public agency.

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Some examples of quantitative researches are given below:

- Clinical trials or the National Census, which counts people and households.
- Surveys regarding preferences towards certain brands or products, which give a large mass of data that can be utilized to arrive at conclusions.
- Percentage amounts of all the elements that make up earth's atmosphere.
- Support for candidate in an election.

1.4.4 Conceptual versus Empirical Research

Conceptual research is that related to some abstract idea(s) or theory. It is generally used by philosophers and thinkers to develop new concepts or to reinterpret existing ones. In a conceptual research, a concept is chosen for examination, and the research involves quantifying and tallying its presence. 'Scoping of Vulnerability Definitions of Polio'—–the research done by the United Nations University Institute for Environment and Human Security (UNU-EHS) is an example of conceptual research. As part of the Global Pulse initiative's design and development phase, the UNU-EHS conducted a series of research to help the project gain a better understanding of how different communities of practice use the term 'Vulnerability'. As part of the research, UNU-EHS analysed 76 definitions of vulnerability used by UN agencies, NGOs (Non Governmental Organizations), scientific organizations and academia. In addition, the Institute's researchers scanned through 68 reports to draw out key lessons for the development of vulnerability indicator sets.

Example of Conceptual Research

The development of psychoanalysis as a science and clinical practice is an example of conceptual research. Research has clarified, formulated and reformulated psychoanalytic concepts permitting to better shape the findings emerging in the clinical setting. By enhancing clarity and explicitness in concept usage it has facilitated the integration of existing psychoanalytic thinking as well as the development of new ways of looking at clinical and extra-clinical data.

Empirical research, on the other hand, relies only on real experiences and observations. It is data-based research and its conclusions can be verified by observations or experiments. It is also called experimental type of research. In empirical research, all facts are obtained at first hand, at their source, and at times by stimulating the production of desired information. To prove a given hypothesis, the evidence gathered through empirical studies and experiments is considered to be the most powerful and accurate. Research design varies by field and by the question being investigated. Many researchers combine qualitative and quantitative forms of analysis to better answer questions which cannot be studied in laboratory settings, particularly in the social sciences and in education. In some fields, empirical research may begin with a research question. For example: 'Does listening to vocal music during the learning of a word list have an effect on later

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memory for these words?' This question is tested through experimentation in a lab. Usually, a researcher has a certain theory regarding the topic under investigation. Based on this theory, some statements or hypotheses are proposed, for example, 'listening to vocal music has a negative effect on learning a word list'. From these hypotheses, predictions about specific events are derived, for example, 'people who study a word list while listening to vocal music will remember fewer words on a later memory test than people who study a word list in silence'. These predictions are then tested with a suitable experiment. Depending on the outcomes of the experiment, the theory on which the hypotheses and predictions were based will be supported or not.

Examples of Empirical Research

Some examples of empirical researches questions may include the following:

- What is the effect of working during high school (or college) on GPA, i.e., Grade Point Average?
- Are police officers compensated for working in higher-risk environments?
- Do gun control laws reduce violent crimes?
- Is there a marriage premium for professional athletes (or other types of workers)?

1.4.5 Some Other Types of Research

All other types of research are variants or combinations of the approaches just discussed. Research can also be classified based on the conditions in which research is carried out, for example, the purpose of research, the environment in which research is done, the time required to accomplish research, etc. From the time point of view, research can be regarded either as one-time or longitudinal research. If the research is confined to a single time-period, it is called one-time research whereas the research carried over several time-periods is considered as longitudinal research. Depending upon the environment in which research is to be carried out, it can be termed as laboratory research or field-setting research or simulation research. Clinical or diagnostic research involves using case-study methods or in-depth approaches into the causes or events. Clinical or diagnostic research methods also use very deep probing data gathering devices and very small samples to obtain the necessary data. Historical Research method uses historical sources like documents, archaeological remains, archives, old information, etc., to study past events and ideas, including the ideas, thoughts, philosophy of persons and groups at distant time periods. Conclusion-oriented and decision-oriented research are two other classifications. In conclusion-oriented research, a researcher is free to pick up a problem, redesign the enquiry as he proceeds and conceptualize as he sees fit. In decision-oriented research, the researcher needs to take the decision-maker into confidence and take his suggestions at every stage of his research. This has to be completely focused.

1.4.6 Social Research

Society is an amalgamation of individuals with different needs, aspirations and goals in life. However, social individuals are also associated with each other through shared interests, familial bonds and common objectives. Social research is basically research conducted by social scientists in order to analyse a vast breadth of social phenomena. The methods used in social research find their roots in classical sociology and statistics. Social research methods may be divided into two broad divisions. These are: Qualitative and Quantitative methods. While the former approaches social phenomena through quantifiable evidence, the latter approaches social phenomena through observation,

Check Your Progress

8. What is the main characteristic of ex-post - facto research method?
9. 'Scoping of Vulnerability Definitions of Polio' is an example of which type of research?
10. On which two features does the empirical research rely?

communication with partners and analysis of text. However, the choice of method depends largely on what the scientist wishes to investigate. Prof. Bent Flyvbjerg of Oxford University maintains that the divide between the quality and quantity oriented camps in social research is clearly unfortunate as good research methods require a combination of both.

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Definitions

While C.A. Moser defines social research as: '*Social research is a systematized investigation to gain new knowledge about social phenomenon and problems'*, P.V. Young maintains: *'Social research is a scientific undertaking which by means of logical methods, aim to discover new facts or old facts and to analyse their sequences, interrelationships, casual explanations and natural laws which govern them.*'

Objectivity in Social Research

Social scientists are often influenced by their biases, passions, likes and dislikes and preconceived notions. These are seen to interfere with the scientific objectivity that they would need while researching on social sciences. Objectivity is the capacity to represent truthfully and without prejudice, the results of one's research. A social researcher needs to be aware of his personal biases and prejudices and take adequate care that these do not affect the objectivity of the research. Max Weber, an exponent in social research argued, that actually, the thoughts and beliefs of the researchers *should* affect their topics of study. However, the social scientist needs to be value-neutral once the research question has been framed. Objectivity can be attained by sharing the results of research with experts who then may be asked to critically examine them. In his *Logic of Scientific Discovery* (1959), Karl Popper maintained that *confirmation* and *refutation* are the essence of scientific discovery. Social researchers publish their work so that their work can be scrutinized by others. Journals have dedicated teams to decide whether the research material lives up to the standard of the journal and should, therefore, be published. Once a research material is published, other scholars look at it critically, especially when they do not agree with the findings.

Some others may wish to replicate the study by changing the strategies and settings to check if the conclusion would remain the same.

Types of Sociological Researches

Sociologists employ a variety of methods to learn about the social world. These methods are not mutually exclusive. Since each research method has strengths and weaknesses, a good research strategy may use several of them. Appelbaum and Chambliss (1997:40) hold that the principal methods of social research include survey and fieldwork.

Characteristics of Social Research

Social research possesses certain unique characteristics. These are:

- Social research is directed towards finding solutions for social problems.
- It emphasizes the development of generalizations, theories and principles that help in predicting future occurrences.
- It is primarily based on empirical/observable experience.
- It requires meticulous observation.

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- Though it may appear to be unsystematic, social research most often involves carefully designed procedure
- It requires an expert researcher who is already acquainted with the previous nuances of the problem.
- It is characterized by patient and unhurried activity.

1.5 RESEARCH METHODS IN SOCIAL SCIENCES

Science refers to organized knowledge, but this knowledge and these facts are seldom conclusive. New experiences and additional information constantly change previous findings and replace them with generalizations that confirm the latest bodies of findings.

A scientific enquiry is an investigation or experiment carried out to dispel or confirm various scientific theories. Most scientific enquiries are done practically in laboratories with specialized equipment.

The scientific method is based on techniques used to investigate phenomena, acquire new knowledge or correct and integrate previous knowledge. Any method is termed scientific when the inquiry is based on experiential and computable evidences subject to specific principles of reasoning. As per the *Oxford English Dictionary*, '*The scientific method is a method or procedure that has characterized natural science since the 17th century, consisting in systematic observation, measurement, and experiment, and the formulation, testing, and modification of hypotheses*.'

The key characteristic of the scientific method is that researchers can support a theory when the predictions given for any specific theory are confirmed and challenge a theory when its predictions prove false, even though procedures differ from one field of inquiry to another. Theories that include extensive domains of inquiry may combine many independently derived hypotheses together in a logical and supportive structure. Theories are developed on the basis of scientific inquiry and are normally intended to be objective so as to reduce biased interpretations of results. The overall process of theory development involves making assumptions by defining hypotheses and deriving predictions as logical consequences. The experiments are then carried out based on those defined predictions to establish whether the original assumption was correct. The scientific method steps are used to establish a theory.

Objectives of Scientific Inquiry

The objective of a scientific inquiry is to acquire knowledge in the form of testable explanations that can predict the results of future experiments. The more enhanced an explanation is at making predictions, the more beneficial it is in proving the predictions that it is correct. The most successful explanations that elucidate and formulate accurate predictions for broad range of conditions are termed as scientific theories. The power of a theory is related to how long it has persisted without distortion of its core principles.

Scientific Enquiry Skills

There are many scientific enquiry skills that must be observed in order to develop scientific theory. Some of which are as follows:

- Raising/asking questions.
- Ways of enquiry.

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- Predicting and hypothesizing.
- Making careful observations.
- Using tools accurately and safely.
- Making a record of evidence to present their findings.
- Considering significant evidences.
- Evaluating reliable evidences and findings accurate results.
- Developing ideas from evidence.

The same is the case with social sciences. The scientific method can also be applied to subjects in social sciences.

Steps in Scientific Method

The steps involved in scientific method are as follows:

(i) Collection of data as per the problem at hand, according to some adequate plan and their systematic observation.

(ii) Observations are made with a well defined purpose and they are recorded in definite terms.

(iii) Classification and organization of data on the basis of similarities, variations, activities, causes and results.

(iv) Generalization of data for the purpose of formulating principles and theories. The principles and theories must be specifically defined so that it can solve the problems in the related field.

(v) Verification of generalizations through controlled experiments by tested prediction of results and by repetition of experiments. Correlation coefficient of original and verification of results is also calculated and probable errors are estimated. It is also determined whether the error lies in procedure or apparatus.

(vi) Assumptions and limitations are noted down on the basis of verification of results.

(vii) Reporting the research in detail.

(viii) Announcement of the results before the general public for practical use.

Steps in Scientific Process

The steps involved in a scientific process are as follows:

(i) ***Purposeful Observation:*** Observation should be accurate and extensive, and it must be done under various controlled conditions.

(ii) ***Analysis-Synthesis:*** This include the following:
- The essential elements in a problematic situation must be picked out by analysis.
- Similarities as well as dissimilarities must be isolated.
- Exceptions are to be given special attention.

(iii) ***Selective Recall:*** A wide range of experiences is essential. These methods suffer from the normal errors caused due to poor memory of people (sample) and also from selective recall on the part of the individual. The memory follows a specific pattern to recall certain facts and may forget some other.

(iv) ***Hypothesis:*** It is nothing but a tentative solution to the problem. There may be more than one solution depending on the nature of the problem.

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(v) ***Verification by Inference and Experiment:*** Here only one variable is manipulated and judgment is made on the adequacy and accuracy of data.

Redman and Mory define research as a '*Systematized effort to gain new knowledge*'. According to Clifford Woody, '*Research includes defining and redefining problems, formulating hypothesis or suggested solutions; collecting, organizing and evaluating data; and making deductions*'.

Scientific Theory

Theories are systematic statements that explain a particular segment of phenomenon by specifying certain relationship among variables.

Kerlinger has defined a theory as: '*…A set of interrelated constructs (concepts), definitions and propositions that present a systematic view of phenomena by specifying relationship among variables with the purpose of explaining and predicting the phenomena*'.

A theory can be explained on the basis of following concepts:

(i) Theory is a set of interrelated concepts, definitions and propositions.

(ii) The interrelated concepts and definitions in a theory help us to understand the phenomena in a systematic manner.

(iii) Theory establishes a relationship among various variables in a systematic manner. With the help of this relationship, we can predict the future nature of the phenomena.

(iv) A theory helps us to formulate a hypothesis on the basis of which future research can be based.

Social Science and Research

Research plays a very significant role in the field of social science. In order to study the importance and relationship between social science and research, social research is conducted or undertaken. The research that attempts to measure, describe, explain and predict the social and economic phenomena or social behaviour of human beings is known as 'social research'.

One of the main objectives of conducting social research is to find out information about the behaviour of an individual and solutions to the problems related to human relations. The outcome of social research provides the following benefits:

- It helps professionals in earning their livelihood.
- It helps students in knowing how to write a report for various findings.
- It helps philosophers to think on wider new perspectives.
- It helps in developing new styles for creative work.

In order to conduct social research and examine the social life of human beings, social scientists use different methods. 'Quantitative' and 'Qualitative' are the two methods of research that are generally used by social scientists to conduct a research. In quantitative method, numerical data is collected and then analysed in order to measure the social phenomena. Qualitative method is basically the study of data, such as words, pictures and objects. However, the data collected with the help of this method is not very effective and cannot be generalized very easily.

Social research is very helpful for a country as it helps the government to explore the following:

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- Social and Economic Structures.
- Social Attitudes.
- Social Values and Behaviours.
- Factors Motivating Individuals and Groups of a Society.

Researchers share a close relationship with government analysts, such as economists, statisticians and operational researchers. The relationship between researchers and government analysts is very much essential in order to find out high quality research data. Social research also informs about development, implementation and evaluation of a wide range of government policies.

Social research also helps to examine the consequences of government policies and economic changes in an organization, and the effects of globalization and its impact on small-scale and cottage industries.

Research Planning

An organization, in order to conduct a research in its work environment, has to first prepare a research plan. Research planning helps design a research plan, which consists of information related to the process of implementing a research. Organizations design research plan to gain knowledge about the market value of their products, services and programmes. The more effective and efficient the research plan, the shorter is the time to complete the research. An efficient research plan must focus on the main objective of the research.

Types of Research Planning

There are several types of planning that helps in implementing a research. The two major types of research planning are as follows:

(i) **Primary:** It involves collecting the data about a given subject through various research methods, such as surveys, interviews and observations, and analysing the data to use its findings and results for planning. Primary research can be used for business, personal and academic purposes.

(ii) **Secondary:** It involves evaluating the results of primary research planning. It provides a broader perspective and contains reference to the relevant documents related to primary research planning.

Research Planning Considerations

The following considerations are to be kept in mind while planning a research:

- The purpose for which the research is being done.
- The audiences, such as bankers, employees and customers for whom the research is being done.
- The information that is needed to make the decision for planning a research.
- The sources, such as employees and customers from which information should be collected.
- The way in which information is collected. For example, questionnaires, interviews and observing staff helps in collecting the information.
- The accurate time in which information is to be collected and analysed.
- The requirement and availability of resources for collecting the information.

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Designing a Research Plan

A research plan is designed to perform the research efficiently. To design a research plan, you need to perform the following steps:

(i) **Identifying the Need of the Research:** The first step in planning a research is to identify the need of the research. The objective of identifying the problem must be clearly stated; otherwise, the objective of the research cannot be achieved. Before implementing the research, a researcher must have an adequate knowledge of the area in which the research is to be done. By acquiring adequate knowledge in a specific area, a researcher can easily identify the problem efficiently.

(ii) **Selecting the Research Method:** A researcher uses all research methods to collect data and determine the most appropriate method. Selecting the right method enables the researcher to collect data in the right manner and plan the research without any difficulty. A researcher must be confident about the methods used and the findings.

(iii) **Collecting Data:** Data collection is a process of systematic gathering of data for a particular purpose. The various sources that can be used for collecting data are interviews, questionnaires and existing records. An interview is a data collection technique that involves oral questioning one by one or as a group. A questionnaire is another data collection technique in which written questions are presented to the people which are to be answered by them. Existing records technique involves collecting data by using already available data collected by other researchers. This saves time and reduces the chances of errors.

(iv) **Analysing the Collected Data:** It is a process of applying some systematic techniques to evaluate the data. A good researcher starts thinking how he/she will analyse the data, long before the data is actually analysed. The analysed data is then used for implementing the research.

(v) **Documenting the Analysed Data:** The last and the most important step in planning a research is the documentation of the findings from the analysed data. The money and the time incurred in the research project are wasted if the findings are not documented or communicated effectively. It is very important to provide the collected information to other researchers so that they can check if there is any error in the findings.

1.6 ROLE OF SOCIAL RESEARCH

Research plays a very significant role in social sciences. In order to study the importance and relationship between social science and research, social research is conducted or undertaken. The research conducted to measure, describe, explain and predict the social phenomena of human beings is known as social research. Gathering information about human behaviour and finding solutions to human relations-related problems is one of the important objectives of social research. The outcomes of social research provide the following benefits:

1. It helps professionals earn their livelihood.
2. It helps students in knowing how to write a report for various findings.
3. It helps philosophers in new thinking.
4. It helps develop new styles for creative work.

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In order to conduct a social research and examine the social life of human beings, social scientists use different methods. Quantitative and qualitative are the two methods of research that are generally used by social scientists to conduct a research. In quantitative method, numerical data is collected and then analysed in order to measure social phenomena. Qualitative method is basically the study of data, such as words, pictures and objects. However, the data collected with the help of this method is not very effective and cannot be generalized very easily.

Social research is very helpful for a country as it helps the government explore the following things:

1. Social and economic structures.
2. Social attitudes.
3. Social values and behaviours.
4. Factors motivating the individuals and groups of a society.

Researchers share a close relationship with the government analysts, such as economists, statisticians and operational researchers, which is necessary for getting data of a high quality. Social research also provides information pertaining to the development, implementation and evaluation of government policies.

Social research also helps examine the consequences of government policies and economic changes in an organization and the effects of globalization and its impact on small-scale and cottage industries.

1.7 SIMILARITIES AND DIFFERENCES BETWEEN SOCIAL SCIENCE RESEARCH AND BUSINESS RESEARCH

'Social Science Research' is the research, that is, generally accomplished by social scientists. Social scientists conduct these researches in a systematic plan. But the research methods of social science vary along a quantitative/qualitative dimension. In order to analyse a vast breadth of social phenomena, a vast range of methods are employed by the social scientists. Social phenomena includes the survey from data of census derived from millions of people to the in-depth analysis of a single agents' social experiences as well as it also includes monitoring of contemporary streets, to the investigation of ancient historical documents. The methods of social science research are rooted in classical sociology. But it should be noted that statistics have formed the basis for research in other disciplines, such as political science, media studies, program evaluation and market research. For some particular research techniques social scientists are divided into camps of support. In social science research method both qualitative and quantitative approaches involve a systematic interaction between theory and data. Very often the choice of method depends mainly on what the researcher intends to investigate. For example, across the whole population a researcher may concern with drawing a statistical generalization which may administer a survey questionnaire to a representative sample population. A researcher who seeks full contextual understanding of social actions of an individual may choose ethnographic participant observation or open-ended interviews. These studies will be commonly combined or triangulate, quantitative and qualitative methods as part of a multi-strategy design.

'Business Research' is a systematic method and a scientific procedure of data collection, compilation, analysis, interpretation and implication pertaining to any business

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problem. Business research helps the decision-maker by providing the scientific information. Business research either substantiates the intuitive knowledge of the decision-maker or opens the doors of new acquired knowledge in a scientific manner. In 2007, Zikmund defined the business research as '*The systematic and objective process of gathering, recording, and analysing data for aid in making business decisions*'. In 2009, Cooper and Schindler defined business research as a '*Systematic enquiry that provides information to guide managerial decisions*'.

In business research the data collection procedure is conducted in a scientific and systematic manner which means that data cannot be collected haphazardly as well as the data collection cannot be initiated abruptly. In general, business research refers to any type of researching done when starting or running any kind of business. For example, starting any type of business requires research into the target customer and the competition to create a business plan.

Business research involves establishing objectives and gathering relevant information to obtain the answer to a business issue. Business research can be conducted to answer a business-related question, such as: What is the target market of the product? Business research can also be used to solve a business-related problem, such as determining how to decrease the amount of excess inventory on hand. Adequate planning and information-gathering are essential to derive results for your business.

Business information can be gathered primarily during business research. Such information can be exploratory or specific. Exploratory information defines a specific problem and is obtained through open-ended question-and-answer sessions conducted with small groups. When exploratory information identifies a problem, possible solutions are obtained from specific data. Specific information gathering is costly and time-consuming, has a precise scope and requires a formal and structured approach to interviews. An example of primary research is the submission of direct mail questionnaires or online surveys; these usually include an added incentive, such as a discount on the individual's next purchase.

Secondary business information is obtained from third-parties, such as government agencies, media sources and trade associations. This type of information is easier to obtain, requires less effort and can be cost-effective, as long as the source of the information is reliable. For example, statistics from government agencies, such as the US Census Bureau and the Small Business Administration, provide a wealth of information that can be used to obtain answers to your business research questions.

Check Your Progress

11. What do you mean by scientific method?
12. What is the objective of scientific inquiry?
13. What is research according to Redman and Mory, and Clifford Woody?
14. How social research can help a country?
15. List two major types of research planning.
16. Why research plan is designed?
17. What does social phenomena includes?
18. What is business research according to Zikmund?

1.8 SUMMARY

- Research is done to find the solution to a problem, or to know more about something, or to know new things.
- Scientific research involves systematic, controlled, empirical and critical examination of a hypothesis or proposition about the relations in a phenomenon.
- The various types of research are: descriptive, analytical, applied, fundamental, conceptual, empirical, quantitative and qualitative research.
- Research involves developing a scientific temper and logical thinking. The significance of research-based answers can never be underestimated.
- At the very beginning of research, the researcher must clearly define the research problem, i.e., the area of interest, the matter to be inquired into, etc.

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- After conducting the research, the researcher has to prepare the report of what has been studied. Report must be written with great care.
- Interpretation of any research should be done keeping in mind the flaws in the procedural design and the extent to which it has an effect on the results.
- The validity and reliability of the data used in research should be double checked.
- The role of research is especially important in the fields of Economics, Business, Governance, etc. The research helps in finding solutions to problems encountered in real life.
- Linear models of research process describe different chronological steps or tasks to be carried out in pursuing a research project.
- Circular models of research process describe research as an iterative process, analogous to learning.
- Instead of selecting a sample, the complete collection method is used in qualities research. The sample is pre-determined by certain criteria, e.g., a certain disease, age, gender, region, marital status, etc.
- The object of sampling strategies is to provide richness of information. It also helps in obtaining relevant information. It is an intense attempt at data sampling.
- Sampling decisions cannot be made in isolation. The appropriateness of the content and the strategy together determine the selection.
- Interviews should be non-directive, specific, average, in-depth and should have personal context and content.
- Research is of special significance in the operational and planning processes of business and industry. The logical and analytical techniques are applied to business problems to maximize profits and minimize costs.
- Motivational research is another key tool in understanding consumer behaviour and health related issues.
- Responsible citizenship concerns can be addressed through good research findings.
- Social relationships involving issues like attitudes, interpersonal helping behaviour, environmental concerns like crowding, crime, fatigue, productivity and other practical issues are all capable of being addressed well by scientific research.
- The research process follows a particular order. The steps include-formulating the research problem; extensive literature survey; development of a working hypothesis; preparing the research design; determining sample design; collecting the data; execution of the project; analysis of data; hypothesis-testing; generalizations and interpretations.
- Social research is basically research conducted by social scientists in order to analyse a vast breadth of social phenomena.
- The methods used in social research find their roots in classical sociology and statistics. Social research methods may be divided into two broad divisions: qualitative and quantitative methods.
- Qualitative method of social research approaches social phenomena through quantifiable evidence, while the quantitative method approaches social phenomena through observation, communication with partners and analysis of text. The choice of method depends largely on what the scientist wishes to investigate.

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- Science refers to organized knowledge, but this knowledge and these facts are seldom conclusive. New experiences and additional information constantly change previous findings and replace them with generalizations that confirm the latest bodies of findings.
- A scientific enquiry is an investigation or experiment carried out to dispel or confirm various scientific theories. Most scientific enquiries are done practically in labouratories with specialized equipment.
- The scientific method is based on techniques used to investigate phenomena, acquire new knowledge or correct and integrate previous knowledge. Any method is termed scientific when the inquiry is based on experiential and computable evidences subject to specific principles of reasoning.
- The key characteristic of the scientific method is that researchers support a theory when the predictions given for any specific theory are confirmed and challenge a theory when its predictions prove false, even though procedures differ from one field of inquiry to another.
- The objective of a scientific inquiry is to acquire knowledge in the form of testable explanations that can predict the results of future experiments. The more enhanced an explanation is at making predictions, the more beneficial it is in proving the predictions that it is correct.
- Theories are systematic statements that explain a particular segment of phenomenon by specifying certain relationship among variables.
- Research plays a very significant role in the field of social science. In order to study the importance and relationship between social science and research, social research is conducted or undertaken.
- The research that attempts to measure, describe, explain and predict the social and economic phenomena or social behavior of human beings is known as 'Social Research'.
- In order to conduct social research and examine the social life of human beings, social scientists use different methods. Quantitative and qualitative are the two methods of research that are generally used by social scientists to conduct a research. In quantitative method, numerical data is collected and then analysed in order to measure the social phenomena. Qualitative method is basically the study of data, such as words, pictures and objects.
- An organization, in order to conduct a research in its work environment, has to first prepare a research plan. Research planning helps design a research plan, which consists of information related to the process of implementing a research.
- Research plays a very significant role in social sciences. In order to study the importance and relationship between social science and research, social research is conducted or undertaken.
- In order to conduct a social research and examine the social life of human beings, social scientists use different methods.
- Researchers share a close relationship with the government analysts, such as economists, statisticians and operational researchers, which is necessary for getting data of a high quality. Social research also provides information pertaining to the development, implementation and evaluation of government policies.

- Social research also helps examine the consequences of government policies and economic changes in an organization and the effects of globalization and its impact on small-scale and cottage industries.
- Social science research include the researches which are generally accomplished by social scientists. Social scientists conduct these researches in a systematic plan. But the research methods of social science vary along a quantitative/qualitative dimension.
- Social phenomena includes the survey from data of census derived from millions of people to the in-depth analysis of a single agents' social experiences as well as it also includes monitoring of contemporary streets, to the investigation of ancient historical documents.
- Business research is a systematic method and a scientific procedure of data collection, compilation, analysis, interpretation and implication pertaining to any business problem. Business research helps the decision-maker by providing the scientific information.
- In business research the data collection procedure is conducted in a scientific and systematic manner which means that data cannot be collected haphazardly as well as the data collection cannot be initiated abruptly. In general, business research refers to any type of researching done when starting or running any kind of business.

1.9 KEY TERMS

õ **Fundamental research:** Focuses on finding generalizations and formulating theories

õ **Applied research:** Aims at finding a solution for an immediate problem facing a society or a business/industrial organization

õ **Conceptual research:** Concerned with some abstract theories and ideas

õ **Empirical research:** Relies only on real experiences and observations

õ **Quantitative approach:** The data is in the form of quantities which is then subjected to mathematical and statistical approaches

õ **Qualitative approach:** Deals with data that cannot be strictly quantified, for example, opinions, tastes and attitudes

õ **Social research**: Conducted by social scientists in order to analyse a vast breadth of social phenomena

- **Scientific enquiry:** It is an investigation or experiment carried out to dispel or confirm various scientific theories
- **Collecting data:** It is a process of systematic gathering of data for a particular purpose
- **Social science research:** It is the research, that is, generally accomplished by social scientists in a systematic plan
- **Business research:** It is a systematic method and a scientific procedure of data collection, compilation, analysis, interpretation and implication pertaining to any business problem

1.10 ANSWERS TO 'CHECK YOUR PROGRESS'

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1. A research is based on empirical data.
2. Critical success factor analysis and employer branding are some of the emerging areas where HR research is being carried out.
3. No, the method of research does not change with the functional area.
4. The main text of a research report should have introduction, summary of findings, main report, conclusion and suggestions for future research.
5. Qualitative research follows an inductive research process and involves the collection and analysis of qualitative data to search for patterns, themes and holistic features.
6. The main objective of the sampling strategies is to provide richness of information.
7. A focus group is a form of qualitative research in which a group of people are asked about their perceptions, opinions and beliefs towards a product, service, concept, advertisement, idea or packaging.
8. The main characteristic of the ex-post-facto research method is that the researcher has no control over the variables; he can report only what has happened or what is happening.
9. 'Scoping of Vulnerability Definitions of Polio' is a research done by the United Nations University Institute for Environment and Human Security (UNU-EHS) and is an example of conceptual research.
10. Empirical research relies on (i) Real experiences and (ii) Observations.
11. The scientific method is a method or procedure that has characterized natural science since the 17th century, consisting in systematic observation, measurement, and experiment, and the formulation, testing, and modification of hypotheses.
12. The objective of a scientific inquiry is to acquire knowledge in the form of testable explanations that can predict the results of future experiments.
13. Redman and Mory define research as a 'Systematized effort to gain new knowledge'. According to Clifford Woody, 'Research includes defining and redefining problems, formulating hypothesis or suggested solutions; collecting, organizing and evaluating data; and making deductions'.
14. Social research is very helpful for a country as it helps the government to explore the following things:
    - Social and economic structures.
    - Social attitudes.
    - Social values and behaviours.
    - Factors motivating individuals and groups of a society.
15. Two major types of research planning are primary research and secondary research.
16. A research plan is designed to perform the research efficiently.
17. Social phenomena includes the survey from data of census derived from millions of people to the in-depth analysis of a single agents' social experiences as well as

it also includes monitoring of contemporary streets, to the investigation of ancient historical documents.

18. In 2007, Zikmund defined the business research as 'The systematic and objective process of gathering, recording, and analysing data for aid in making business decisions'.

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1.11 QUESTIONS AND EXERCISES

Short-Answer Questions

1. Define the term research.
2. What are the objectives of research?
3. List the decision areas where research studies are carried out.
4. On what assumptions is conversion analysis based?
5. What do you understand by phenomenology?
6. What are the key characteristics of scientific method?
7. Define the term hypothesis.
8. What are the benefits of social research?
9. What do you mean by research planning?
10. What do you mean by social science research?
11. Give an example of social research.
12. Define the term business research.
13. What is the main objective of business research?

Long-Answer Questions

1. Discuss the objectives and significance of research. Also explain the significance of research in business decisions.
2. Write a detailed note on the research process.
3. Differentiate between qualitative and quantitative research giving suitable examples.
4. Write a comparative note on the various types of research.
5. Describe the functions and significance of research methods that are used in social sciences.
6. Explain the steps that are conducted in scientific method.
7. Discuss the objectives of social science and social research.
8. Describe the various types of research planning.
9. Explain how a research plan can be designed.
10. Discuss the role of social research.
11. Explain the functions of social science research.
12. Discuss the role of business research.

1.12 FURTHER READING

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UNIT 2 RESEARCH DESIGN

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Structure

2.0 INTRODUCTION

In this unit, you will learn about the specificaion of research design. A research design is a conceptual framework for conducting research. Before embarking on a research, it is imperative that a researcher prepares a design for his research. This is the basic blueprint on which will rest all his future course of action. Research design as well as sample strategy or sample design form very crucial components of a research process. A research design can be defined as a plan and a systematic procedure for collecting the data and performing analysis on that data for the purpose of research. In social research too, a social scientist needs to prepare a design that provides a direction for analysing the problem, preparing a sample, collecting data from the sample, analysing this data and finally gathering inference from the process. A research design depends to a large extent on the type of research study that is being conducted. If the research study is exploratory, then major emphasis is on the discovery of ideas. The formation of two similar groups that are equivalent to each other is ensured by randomly assigning people or participants into two groups from a common pool of people or participants. A conclusive research design is more structured and formal than an exploratory research design because it is based on large representative samples and the data obtained is subjected to quantitative analysis.

Research design provides the details for how a research study is supposed to be performed. A good research design will ensure that the information gathered is relevant

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to the research questions and also that it was collected economically and objectively. The basic requirement of a good research is to provide a framework and guidelines to the researchers in the most accurate and efficient manner. Research design, thus, plays a pivotal role in the entire research process and can be classified into exploratory research design and conclusive research design. The conclusive research design is further categorized into descriptive and casual research. Descriptive research has two sections — cross-sectional design and longitudinal design. The cross-sectional design is classified into single cross-sectional design and multi cross-sectional design. Finally, you will learn about experimental design in detail.

2.1 UNIT OBJECTIVES

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

- Understand the significance of research design
- Define research design and explain its concepts
- Assess the need for formulating a research design
- Understand the various types of research designs
- Formulate and classify research design
- Discuss exploratory, descriptive and experimental research designs

2.2 FEATURES OF GOOD DESIGN

Whatever be the type of research one undertakes, certain common criteria of good scientific methods have to be followed. A good research follows logical methods, is systematic, and structured in accordance with well defined sets of rules and practices to enable the researcher in arriving at dependable conclusions. Both, deductive reasoning and inductive reasoning, should be followed for meaningful research.

Good research also implies obtaining reliable data which provides sound validity to the research findings.

The following principles underlie a good research criteria:

- The aim and objective of the research being conducted should be clearly specified.
- The research procedure should be replicable so that if the research needs to be continued or repeated, it can be done easily.
- The research design should be so chosen that the results are as objective as possible.
- Interpretation of any research should be done keeping in mind the flaws in the procedural design and the extent to which it has an effect on the results.
- Research should be carried out systematically. It should progress in pre-defined stages, and researchers should avoid using their intuition or guesswork to arrive at conclusions.
- Research should be logical so that it is meaningful, and help in decision-making.
- Research should be empirical as far as possible.

- The results of the research should only be used and generalized for the population for which the data provides an adequate basis.
- The validity and reliability of the data used in research should be double checked.
- Further, good research produces results that are examinable by peers, methodologies that can be replicated, and knowledge that can be applied to real world situations.

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2.3 RESEARCH DESIGN

The meaning and concepts of research design are discussed as follows:

2.3.1 Meaning and Concepts of a Research Design

A research design is a conceptual framework for conducting research. It is a blueprint for collecting, measuring and analysing data. Research designs deal with the What, Where, When and How of an inquiry. Several questions in the following list have to be answered before starting a research work.

- What is the study and who is doing the research?
- Why is the study being conduced?
- Where will it be done?
- What type of data is to be collected?
- What is the timeframe for the study?
- What techniques will be used for data collection?
- How will it be analysed?
- What kind of report will be prepared?
- What will be the costs involved?
- Who are the personnel for doing the study?

Keeping these in mind, the design can be sub-divided into specific areas for clarity:

- **Sampling Design:** Methods of selecting the items for observation for the study.
- **Observational Design:** The conditions under which the observations are to be carried out.
- **Statistical Design:** The data gathering and analysis methods.
- **Operational Design Features:** The entire procedure for carrying out the study.

2.3.2 Hypothetical Research Design

Once you have established the *what* of the study, i.e., the research problem, the next step is the *how* of the study, which specifies the method of achieving the stated research objectives in the best possible manner.

As stated earlier, different paradigms will guide the selection of the gamut of techniques available. These differences in approach have led to varying definitions of what constitutes a research design.

Green *et al*. (2008) defines research designs as,

'The specification of methods and procedures for acquiring the information needed. It is the overall operational pattern or framework of the project that stipulates what information is to be collected from which sources by what procedures. If it is a good design, it will insure that the information obtained is relevant to the research questions and that it was collected by objective and economical procedures'.

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Thyer (1993) states that,

> *'A traditional research design is a blueprint or detailed plan for how a research study is to be completed—operationalizing variables so they can be measured, selecting a sample of interest to study, collecting data to be used as a basis for testing hypotheses, and analysing the results'.*

The essential requirement of the design is thus to provide a framework and direction to the investigation in the most efficient manner. Sellitz *et al.* (1962) state that

> *'A research design is the arrangement of conditions for collection and analysis of data in a manner that aims to combine relevance to the research purpose with economy in procedure'.*

One of the most comprehensive and holistic definition has been given by Kerlinger (1995). He refers to a research design as,

> *'….. a plan, structure and strategy of investigation so conceived as to obtain answers to research questions or problems. The plan is the complete scheme or programme of the research. It includes an outline of what the investigator will do from writing the hypotheses and their operational implications to the final analysis of data'.*

Thus, the formulated design must ensure three basic tenets:

(a) Convert the research question and the stated assumptions/hypotheses into operational variables that can be measured.

(b) Specify the process that would be followed to complete the above task, as efficiently and economically as possible.

(c) Specify the 'control mechanism(s)' that would be used to ensure that the effect of other variables that could impact the outcome of the study have been controlled.

The important consideration is that none of these assumptions can be foregone; all of them must be addressed succinctly and adequately in the design for it to be able to lead on to the methods to be used for collecting the problem-specific information. Thus, it follows the problem definition stage and precedes the data collection stage. However, this is not an irreversible step. Sometimes when the researcher is operationally defining the variables for study, it might emerge that the research question needs to be restructured and consecutively the approach for data collection also might oscillate from the quantitative to the qualitative or vice versa.

At this juncture, one needs to understand the distinction between research design and research method. While the design is the specific framework that has been created to seek answers to the research question, the research method is the technique to collect the information required to answer the research problem, given the created framework.

Thus, research designs have a critical and directive role to play in the research process. The execution details of the research question to be investigated are referred to as the research design.

Features of a Good Research Design

The important features of a good research design are that it is:

- A plan that identifies the resources and the type of information needed.
- The strategy for gathering data.
- An estimate of time, costs, etc.

So, the research design needs to have a clear research problem procedure for data collection, the population to be studied and the type of data analysis that has to be carried out.

Need for a Research Design

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For smooth conduct of the study, for efficient data gathering and analysis and for economy and effectiveness, research designs must be planned well in advance and with great care. Good designs help to obtain reliable results.

Characteristics of Good Design

- It should seek to minimize bias and maximize reliability of the data obtained.
- It should give the least possible experimental error.
- It should be as objective as possible.

No single design should be used for all types of research problems. Reporting on the purpose of the study, the type of data needed and other considerations determine the design to be chosen.

2.3.3 Formulation of Research Design

Once the researcher has identified the research scope and objectives, he has also established his/her epistemological position. This could be positivistic—in which case the method of enquiry would necessarily be scientific and empirical. Subsequently, this would require a statistical method of analysis (Ackroyd, 1996). The constructivists on the other hand argue for methods that are richer and more applicable to the social sciences, unlike the more pedantic experimental approach. Qualitative is a more definitive choice here than the quantitative (Atkinson and Hammersley, 1994). Yet another approach is the principle of triangulation (Jick, 1979), which advocates the simultaneous or a sequential use of the qualitative and quantitative methods of investigation. The proponents state that when the findings from diverse methods are collated, then the results are richer, more holistic and this, in turn, improves the sanctity of the analysis.

The formulated research questions are then, through a comprehensive theoretical review, put into a practical perspective. The conceptual design thus developed requires and entails specifications of the variables under study as well as approach to the analysis. This might in turn lead to a refining or rephrasing of the defined research questions. Thus, the formulation of the research design is not a stagnant stage in the research process; rather, it is an ongoing backward and forward integrated process by itself.

An Illustration: Let us take the example of the organic food study. The formulated research problem was:

To investigate the consumer decision-making process for organic food products and to segment the market according to the basket size.

On conducting an extensive review of the literature, it was found that organic consumption is not always a self-driven choice; rather, it could be the seller who might influence the product choice. Thus, a research design was formulated to study the organic consumer's decision stages. However, once the design is selected and a proposed sampling plan is developed, the next step required is that the constructs and the variables to be studied must be operationalized. On defining the organic consumer, we realized the significance of the psychographics of the individual—the attitude, interest and opinion—

which were extremely critical. Thus, to get a holistic view, one needs to look at the psychographic profile of the existing consumer, as well as of the potential consumer with a similar mindset. This led to a revision of the research question:

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To investigate the consumer decision-making process for organic food products and to segment the market—existing and potential—according to their psychographic profile.

2.3.4 Important Elements of Research Design

The elements of research design are as follows:

1. **Dependent and Independent Variables:** A variable is any unit that can have different quantitative values, e.g., height, loudness, etc. Qualitative units are attributes, e.g., honest, extroverted, shy, etc. Largely quantitative variables are continuous, e.g., age is a continuous variable while 'students' is a non-continuous variable.
   (a) An antecedent variable is an independent variable.
   (b) A consequent variable is a dependent variable.
   (c) Height is a variable dependent on age where age is an independent variable
   (d) Height is sex related, so height is a dependent variable.
   (e) Age and sex are independent variables.
   (f) Behaviour changes as a function of the manipulation is an independent variable.
   (g) The Independent Variable (IV) is the one that is manipulated. It is under the control of the experimenter, generally. This variable is also called the experimental variable. The effect of the experimental variable is reflected on the dependent variable, e.g., knowledge of results improves learning. Here providing knowledge of results are the independent variables and the improvement in learning is the Dependent Variable (DVs).
2. **Extraneous Variables:** Variables unrelated to the study but having an influence on the dependent variable are called extraneous variables. Examination results studied to be a function of the methods of studying. Results are DVs and the methods of study are IVs. However, intelligence also plays a part in the results. This becomes an extraneous variable, and affects the outcome. Such an influence is known as the experimental error.
3. **Control:** This implies any attempt to minimize the influence of the extraneous factor(s) or variable(s). The attempt is to keep the experimental conditions well controlled.
4. **Confounding or Compounding Influence**: When the external factors cannot be controlled, they are thought to compound the outcome(s).
5. **Research Hypothesis:** When a hypothesised relationship is to be tested scientifically, it is called hypothesis testing. A hypothesis is a hunch. It should have one IV and one DV, as part of the design.
6. **Experimental and Non-Experimental Hypotheses Testing Research**: When a hypothesis is to be tested, it is known as a hypothesis testing research. Here the experimental variable is manipulated. When the IV is not manipulated, it is called as non-experimental hypothesis testing research. For example, how age affects memory. Here people of different ages are tested on a memory task. The

memory is determined by calculating a coefficient of correlation between the sets of obtained scores. This is a non-experimental hypothesis testing research.

7. **Experimental and Control Groups:** The control group is exposed to the regular conditions. The experimental group is exposed to the experimental variable. The experimental group receives the experimental variable. This enables comparison in terms of the outcome on the dependent variable.
8. **Treatments:** The conditions under which the two groups are studied is the treatment procedure.
9. **Experiment:** The procedure for testing a hypothesis or attempts to establish the veracity of a relationship is known as an experiment.
10. **Experimental Unit(s):** The predetermined block or conditions where different treatments are applied is called an experimental unit.

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2.3.5 Different Research Designs

Designs can be categorized as:

(a) Exploratory Study Design
(b) Descriptive Study Design
(c) Diagnostic Study Design
(d) Hypothesis-Testing Study Design

Exploratory Study Design: The purpose here is to do a preliminary study to be able to formulate a research design later. Such a design needs to be flexible to be altered, depending on what the explorations yield. These designs are based on survey of the literature, survey of the experiences encountered and analysis of insights or intuitions.

Explanatory research focuses on why questions. For example, research on why the crime rate is high in a country, why some types of crime are increasing or why the rate is higher in some countries than in others is an explanatory research. Answering the 'why' questions involves developing causal explanations, which argue that a phenomenon (for example, income level) is affected by a factor X (for example, gender). Some causal explanations will be simple, whereas others will be more complex. For example, you may argue that there is a direct effect of gender on income (i.e., simple gender discrimination). You may argue for a causal chain, such as that gender affects choice of field of training which in turn affects occupational options, which are linked to opportunities for promotion, which, in turn, affect income level.

Research Design for Descriptive and Diagnostic Research: These designs must be tight and well planned.

Steps in this type of design:

- State objective(s) and design methods of data collection.
- Select samples, suitably collect data, analyse and report results.
- Questionnaires, interviews, case-studies and observations are used extensively.

Although some people dismiss descriptive research as 'mere description', good description is fundamental to the research enterprise as it adds immensely to our knowledge of the shape and nature of our society. Descriptions can be concrete or

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abstract. For example, a relatively concrete description may explain the ethnic mix of a community, the changing age profile of a population or the gender mix of a workplace. On the other hand, the description may ask more abstract questions like 'Is the level of social inequality increasing or declining?', 'How secular is society?', or 'How much poverty is there in this community?', and so on.

Good description provokes the 'Why' questions of explanatory research. For example, if you detect greater social polarization (i.e., the rich are getting richer and the poor are getting poorer) over the last two decades, you are forced to ask 'Why is this happening?' But before asking 'Why?', you need to be sure about the fact and dimensions of the phenomenon of increasing polarization. It is all very well to develop elaborate theories as to why society might be more polarized now than in the recent past, but if the basic premise is wrong (i.e., society is not becoming more polarized), then any effort to describe a non-existent phenomenon is meaningless.

As far as the research design is concerned, the descriptive and diagnostic studies share common requirements. Thus, you may group these two types of research studies together. In designing descriptive or diagnostic research, the researcher must be able to define clearly what is to be measured, and must find adequate methods for measuring it, along with a clear cut definition of the population he or she wants to study. Since the aim is to obtain complete and accurate information in the said research, the procedure to be used must be carefully planned. The research design must make enough provision for protection against bias, and must maximize reliability. Table 2.1 gives a summary of research design.

Table 2.1 *Summary of Research Designs*

Research Design	**Type of Study**	
	Exploratory or Formulative	Descriptive/Diagnostic
Overall Design	Flexible design (design must provide opportunity for considering different aspects of the problem)	Right design (design must make enough provision for protection against bias and must maximize reliability)
(i) Sampling Design	Non-probability sampling design (purpose or judgment sampling)	Probability sampling design (random sampling)
(ii) Statistical Design	No pre-planned design for analysis	Pre-planned design for analysis
(iii) Observational Design	Unstructured instrument for collection of data	Structured or well thought out instruments for collection of data
(iv) Operational Design	No fixed decisions about the operational procedures	Advanced decisions about operational procedures

Source: C.R. Kothari, *Research Methodology: Methods and Techniques*, 1995.

Research Design in Hypothesis Testing: This is the type of research design in which the researcher tests the hypotheses of causal relationships between variables. Such research requires procedures that will not only reduce bias and increase reliability,

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but also permit drawing inferences about causality. Normally, experiments meet these requirements. Therefore, such a research design is better known as experimental research design. The aim of an experimental research is to investigate the possible cause-and-effect relationship by manipulating one independent variable to influence the other variable(s) in the experimental group, and by controlling the other relevant variables, and measuring the effects of the manipulation by some statistical means. Investigation of the effects of two methods of teaching a twelfth-grade history programme as a function of class size (e.g., large and small) and levels of student intelligence (e.g., high, average, low), using random assignment of teachers and students-by-intelligence-level to method and class size is an example of hypothesis-testing or experimental research design.

2.3.6 Classification of Research Designs

The researcher has a number of designs available to him for investigating the research objectives. There are various typologies that can be adopted for classifying them. The classification that is universally followed and is simple to comprehend is the one based upon the objective or the purpose of the study. A simple classification that is based upon the research needs ranging from simple and loosely structured to the specific and more formally structured is given in Figure 2.1. This depiction shows the two types of researches—exploratory and conclusive as separate design options, with subcategories in each.

The demarcation between the designs in practice is not this compartmentalized. Thus, a more appropriate approach would be to view the designs on a continuum as in Figure 2.2. Hence, in case the research objective is diffused and requires a fine-tuning and refinement, one uses the exploratory design, this might lead to the slightly more concrete descriptive design—here one describes all the aspects of the construct and concepts under study. This leads to a more structured and controlled causal research design.

Exploratory Research Design

Exploratory designs, as stated earlier, are the simplest and most loosely structured designs. As the name suggests, the basic objective of the study is to explore and obtain clarity about the problem situation. It is flexible in its approach and mostly involves a qualitative investigation. The sample size is not strictly representative and at times it might only involve unstructured interviews with a couple of subject experts. The essential purpose of the study is to:

- Define and conceptualize the research problem to be investigated.
- Explore and evaluate the diverse and multiple research opportunities.
- Assist in the development and formulation of the research hypotheses.
- Operationalize and define the variables and constructs under study.
- Identify the possible nature of relationships that might exist between the variables under study.
- Explore the external factors and variables that might impact the research.

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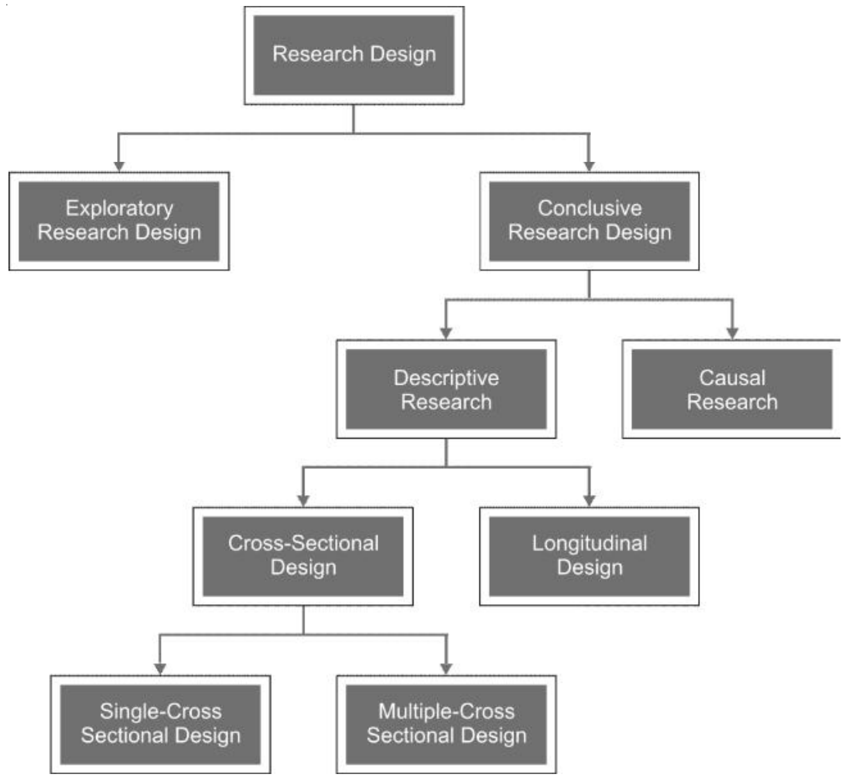

Fig. 2.1 *Classification of Research Designs*

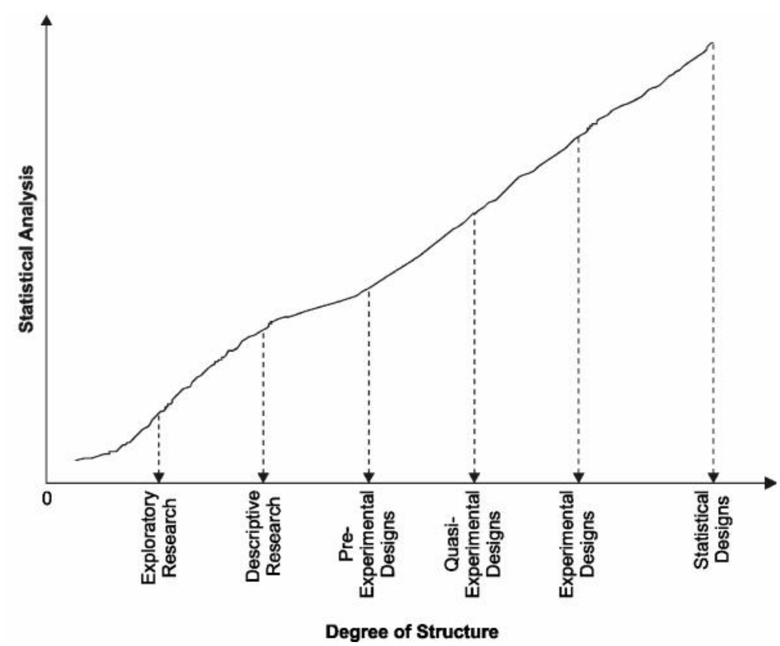

Fig. 2.2 *Research Designs—A Continuous Process*

For example, a university professor might decide to do an exploratory analysis of the new channels of distribution that are being utilized by the marketers to promote and sell products and services. To accomplish this, a structured and defined methodology might not be essential as the basic objective is to understand the new paradigms for inclusion in the course curriculum. In case the findings are of interest, the same may lead to a more structured, academic, basic research or an applied problem where one may want to establish the efficacy of different methods.

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However, no matter what the scientific orientation and the research objective might be, the researcher can make use of a wide variety of established methods and techniques for conducting an exploratory research, like secondary data sources, unstructured or structured observations, expert interviews and focus group discussions with the concerned respondent group. Most of these techniques are dealt with in detail in the subsequent chapters; however, we will discuss them in brief in the context of their usage in exploratory research.

Secondary Resource Analysis

Secondary sources of data, as the name suggests, are data in terms of the details of previously collected findings in facts and figures—which have been authenticated and published. An added advantage of secondary data is that it can be represented in a relatively easier way and is less expensive. Secondary data is a fast and inexpensive way of collecting information. The past details can sometimes point out to the researcher that his proposed research is redundant and has already been established earlier. Secondly, the researcher might find that a small but significant aspect of the construct or the environment has not been addressed and might require a full-fledged research to explain some unpredictable results. For example, a marketer might have extensively studied the potential of the different channels of communication for promoting a 'home maintenance service' in Greater Mumbai. However, there is no impact of any mix that he has tested. An anthropologist research associate, on going through the findings, postulated the need for studying the potential of WOM (Word Of Mouth) in a close-knit and predominantly Parsi colony where this might be the most effective culture-dependent technique that would work. Thus, such insights might provide leads for carrying out an experimental and conclusive research subsequently.

Another valuable secondary resource is the compiled and readily available data bases of the entire industry, business or construct. These might be available on free and public domains or through a structured acquisition process and cost. These are both government and non-government publications and would have varying levels of authentication and sampling base. Based on the research constraints and the level of accuracy required, the researcher might decide to make use of them.

Comprehensive Case Method

Another secondary source which can serve as a technique for conducting an exploratory research is the case study method. It merits separate mention as it is intricately designed and reveals a comprehensive and complete presentation of facts, as they occur, in a single entity. This in-depth study is focused on a single unit of analysis. This unit could be an individual employee or a customer; an organization or a complete country analysis might also be the case of interest. They are by their nature, generally, post-hoc studies and report those incidences which might have occurred earlier. The scenario is reproduced based upon the secondary information and a primary recounting by those involved in the occurrence. Thus, there might be an element of bias as the data, in most cases, becomes a judgemental analysis rather than a simple recounting of events.

For example, BCA Corporation wants to implement a performance appraisal system in the organization and is debating between the merits of a traditional appraisal system and a 360° appraisal system. For a historical understanding of the two techniques, the HR director makes use of the theoretical works done on the constructs. However, the roll-out plans and repercussions and the management issue were not very clear. This could be better understood when they studied in-depth case studies on Allied Association which had implemented traditional appraisal formats, and Surakhsha International-360° systems. Thus, the two exploratory researches carried out were sufficient to arrive at a decision in terms of what would work best for the organization.

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Expert Opinion Survey

There might be a situation at times when the topic of a research is such that there is no previous information available on it. Thus, in these cases, it is advisable to seek help from the experts who might be able to provide some valuable insights based upon their experience in the field or with the concept. This approach of collecting particulars from significant and erudite people is referred to as the expert opinion survey. This methodology might be formal and structured and might be useful when being authenticated or supported by a secondary/primary research or it might be fluid and unstructured and might require an in-depth interviewing of the expert. For example, the evaluation of the merit of marketing organic food products in the domestic Indian market cannot be done with the help of secondary data as no such structured data sources exist. In this case the following can be contacted:

- Doctors and dieticians as experts would be able to provide information about the products and the level to which they would advocate organic food products as a healthier alternative.
- Chefs who are experimental and innovative and might look at providing a better value to the clients. However, this would require evaluating their level of awareness and perspective on the viability of providing organically prepared dishes.
- Pragmatic retailers who are looking at new ways of generating footfalls and conversions by offering contemporary and futuristic products. Again, awareness about the product, past experience with selling healthier lifestyle products would need to be probed to gauge their positive or negative reactions to the new marketing initiatives.

These could be useful in measuring the viability of the proposed plan. Discussions with knowledgeable people may reveal some information regarding who might be considered as potential consumers. Secondly, the question whether a healthy proposition or a lifestyle proposition would work better to capture the targeted consumers needs to be examined.

Thus, this method can play a directional role in shaping the research study. However, a note of caution is also necessary as by its very nature it is a loosely structured and skewed method; thus supporting it with some secondary data or subsequently validating the presumptions through a primary research is recommended. Another aspect to be kept in mind is that no expert, no matter how vast and significant his experience is, can be solely relied upon to arrive at any conclusions, as in the example stated above. It is also advisable to quiz different expert sources. Notwithstanding these constraints, this technique is of great value to any researcher, no matter what his/her area of interest is. The more varied the perspective, more Gestaltian is the research approach, which will result in a meaningful contribution to the field of study.

Focus Group Discussions

Another alternative approach to interviewing is to carry out discussions with significant individuals associated with the problem under study. This technique, though originally rooted in sociology, is actively used in all branches of behavioural sciences. However, it has a

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special significance in management and here also it is staunchly advocated and used for consumer and motivational research studies. In a typical focus group, there is a carefully selected small set of individuals representative of the larger respondent population under study. It is called a focus group as the selected members discuss the concerned topic for the duration of 90 minutes to, sometimes, two hours. Usually the group comprises six to ten individuals. The number thus stated is because less than six would not be able to throw enough perspectives for the discussion and there might emerge a one-sided or a skewed discussion on the topic. On the other hand, more than ten might lead to more confusion rather than any fruitful discussion and that would be unwieldy to manage. Generally, these discussions are carried out in neutral settings by a trained observer, also referred to as the moderator. The moderator, in most cases, does not participate in the discussion. His prime objective is to manage a relatively non-structured and informal discussion. He initiates the process and then maneouvres it to the desired information needs. Sometimes, there is more than one observer to record the verbal and non-verbal content of the discussion. The conduction and recording of the dialogue requires considerable skill and behavioural understanding and the management of group dynamics. In the organic food product study, the focus group discussions were carried out with the typical consumers/buyers of grocery products. The objective was to establish the level of awareness about health hazards, environmental concerns and awareness of organic food products. A series of such focus group discussions carried out across four metros—Delhi, Mumbai, Bengaluru and Hyderabad—revealed that even though the new age consumer was concerned about health, the awareness about organic products was extremely low to non-existent.

Two-Tiered Research Design

Once an exploratory study using a loosely structured exploratory design is over, the researcher would have a greater clarity and direction, leading subsequently to a more structured research that he might undertake. Thus, he would manage to achieve the following:

- A comprehensive and focused research question, which will clearly indicate the orientation the study intends to take.
- Find out through various sources as listed above that the need for a conclusive research study is not there and the decision-maker can make use of the exploratory results to assist in the decision-making.
- Develop both the general and the specific hypotheses or presumptions of the likelihood of certain trends or outcomes.
- Developed clarity on the framework and methodology best suited to achieve the formulated research objectives.

This might be the first rung of a two-tiered research design where the first step is to formulate the research question and the second-tier is more formal and structured and refers to the design framework defined earlier in the chapter. In most instances, the researchers avoid the first rung and move on to the second, due to the additional cost and time involved. However, it is advocated strongly that the exploratory stage can be extremely significant in reducing the risks of ambiguous and redundant research objectives.

Descriptive Research Designs

A descriptive research design is more structured and formal in nature. As the name implies, the objective of these studies is to provide a comprehensive and detailed explanation of the phenomena under study. The intended objective might be to:

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- Give a detailed sketch or profile of the respondent population being studied. This might require a structured primary collation of the information to understand the concerned population. For example, a marketer to design his advertising and sales promotion campaign for high-end watches, would require a holistic profile of the population which buys high-end luxury products. Thus a descriptive study, which generates data on the *who, what, when, where, why* and *how* of luxury accessory brand purchase would be the design necessary to fulfil the research objectives.
- There might be a temporal component to this design, that is, the description might be in a stagnant time period or be stretched across collecting the relevant information in different stages in a stipulated time period.
- The studies are also carried out to measure the simultaneous occurrence of certain phenomena or variables. For example, a researcher who wants to establish the relationship between market flux and investment behaviour might carry out a descriptive research to establish the correlation between the two variables under study.

Conducting Descriptive Research

Descriptive research , as we stated earlier, is a framework used for a conclusive research. It, however, lacks the precision and accuracy of experimental designs, yet it lends itself to a wide spectrum of situations and is more frequently used in business research. Based on the temporal collection of the research information, descriptive research is further subdivided into two categories: cross-sectional studies and longitudinal studies.

(i) Cross-Sectional Studies

As the name suggests, the study involves a slice of the population just as in scientific experiments one takes a cross-section of the leaf or the cheek cells to study the cell structure under the microscope, similarly one takes a current subdivision of the population and studies the nature of the relevant variables being investigated.

There are two essential characteristics of cross-sectional studies:

- The cross-sectional study is carried out at a single moment in time and thus the applicability is most relevant for a specific period. For example, a cross-sectional study on the attitude of Americans towards Asians, pre and post 9/11, was vastly different and a study done in 2011 would reveal a different attitude and behaviour towards the population which might not be absolutely in line with that found earlier.
- Secondly, these studies are carried out on a section of respondents from the population units under study (e.g., organizational employees, voters, consumers, industry sectors). This sample is under consideration and under investigation only for the time coordinate of the study.

Illustrative Case: A Danish icecream company wanted to find out how to target the Indian consumer to indulge in high-end icecreams. Thus, they outsourced to a local market research firm to find out the dessert consumption habits of an upper class, metro Indian consumer. The study was conducted in March–May 2008 on 1000 Indian metro consumers in the upper income bracket.

The consumer survey conducted revealed that most Indians have a sweet tooth and prefer to eat their specific regional concoctions at home. However, when they are out, they love experimenting and generally look at exotic, foreign desserts or if lost for choice, opt for an icecream, especially in summer. The highlights of the findings were as follows:

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- 92.6 per cent of the sample stated icecream as the first plus the second choice.
- 81 per cent stated icecream as their first choice.
- Regional brands were the popular choice of most consumers.
- The recall of foreign brands was, however, only 15 per cent in the total population.
- The recall of foreign brands amongst globetrotters (who had made at least five trips to a foreign country in the last two years) was 39 per cent.
- 92 per cent agreed with the statement that a person's social status is an important determinant of who he/she is.
- 76 per cent believed that what you eat and 85 per cent believed where you eat is influenced by the social class you belong to.
- 83 per cent usually eat out once every fortnight, 72 per cent eat out once every weekend.
- 64 per cent eat an icecream outside at least once a week.
- 61.5 per cent were willing to experiment with exotic desserts, even if they were exorbitantly priced.

The icecream company concluded from the findings that the market, at least in the metros, was ready. However, it was a niche segment and a better audience base could be found amongst the savvy urban Indian traveller. Another conclusion was that even though the icecream was healthy and natural, it would have to take a lifestyle positioning in order to melt the Indian heart.

There are also situations in which the population being studied is not of a homogeneous nature and there is a divergence in the characteristics under study. Thus it becomes essential to study the sub-segments independently. This variation of the design is termed as *multiple cross-sectional studies*. Usually this multi-sample analysis is carried out at the same moment in time. However, there might be instances when the data is obtained from different samples at different time intervals and then they are compared. *Cohort analysis* is the name given to such cross-sectional surveys conducted on different sample groups at different time intervals. Cohorts are essentially groups of people who share a time zone or have experienced an event that took place at a particular time period. For example, in the 9/11 case, if we study and compare the attitudes of middle-aged Americans versus teenaged Americans towards Asians post the event, it would be a cohort analysis.

The technique is especially useful in predicting election results, cohorts of males–females, different religious sects, urban–rural or region-wise cohorts are studied by leading opinion poll experts like Nielsen, Gallup and others.

Cross-sectionals studies are extremely useful to study current patterns of behaviour or opinion. However, respondent's likelihood of future decisions or delving too far in the past to determine the difference between the present and the past behaviour is not a wise choice. In such cases, a study that is anchored for information collection at different moments in time is a better technique. The results would be more reliable and valid. The advantage would be that rather than relying on the respondent's memory or prediction, an actual monitoring of behaviour patterns would happen over time.

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(ii) Longitudinal Studies

A single sample of the identified population that is studied over a stretched period of time is termed as a longitudinal study design. A panel of consumers specifically chosen to study their grocery purchase pattern is an example of a longitudinal design. There are certain distinguishing features of the same:

- The study involves the selection of a representative panel, or a group of individuals that typically represent the population under study.
- The second feature involves the repeated measurement of the group over fixed intervals of time. This measurement is specifically made for the variables under study.
- A distinguishing and mandatory feature of the design is that once the sample is selected, it needs to stay constant over the period of the study. That means the number of panel members has to be the same. Thus, in case a panel member due to some reason leaves the panel, it is critical to replace him/her with a representative member from the population under study.

Thus, the two descriptive designs basically differ in their temporal component and secondly on the stability of the sample unit selection over time. However, which one is selected depends upon the research objectives. Also though they are visualized conceptually as two ends of a continuum, in practice the two might merge or complement each other in usage.

For example, a management school that has just started a Post Graduate Diploma in Management (PGDM) in human resource management wants to ascertain the stakeholders' (students, recruiters, programme faculty) attitude towards the programme structure and student quality and to monitor and alter the programme, relative to the changes in those attitudes over time. Specifically, suppose the B-school wants to measure this six-monthly, at the time of placements and six months after the trainee has worked on the job. For this objective, the ideal design would be the longitudinal design. However, this might work for the recruiter population but cannot be used for student effectiveness as a cross-section of that year's pass outs would need to be studied. Thus, it might not require the formulation of a fixed panel of respondents for this purpose and instead a cross-sectional sample might be used for the post-training analysis. However, the faculty sample could be a fixed panel selected for monitoring the change over time.

For determining a change or consistency on the measured variable over time, the ideal design is the longitudinal studies. These are sometimes referred to as the *time series design* due to the repeated measurement overtime.

Repeated measurements, as stated above, can be derived from the same sample, kept constant over time or on a representative but different group selected for every study stage. Even though the two collections would be under the domain of a longitudinal design, the obtained results and conclusions might be vastly different. This would be clear from the illustrative case given below.

Illustrative Case: The customer portfolio management division of a large private bank wanted to study the investment behaviour of bank customers in government instruments, mutual funds and securities, bullion and fixed deposits. This analysis was done for every quarter in a year for a period of five years. The survey was done on a different but stock sample of 1000 bank customers for each quarter and the results obtained are shown in Table 2.2. Two conclusions pertaining to the researcher's attitude emerged. First, government instruments were the most popular option, with approximately 45 per cent customers. Second, the overall percentage of the division amongst the other three options is more or less stable over time.

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Table 2.2 *Results of Longitudinal Bank Investment Study*

Use Of	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Government Instruments	45	43	43	45
MF and Others	21	17	18	15
Bullion	15	22	21	19
FD	19	18	18	21
Total	100	100	100	100

Another option that the bank had was to form a panel of the regular customers and assess their periodic investments in these instruments; here the same group of people would be interviewed in the five-year period. The findings and conclusions obtained here would be slightly different, in case the sample remained the same. Such a panel study, in addition to indicating an overall investment behaviour, would have made it possible to monitor the options balanced between each other by the same group over time, and also how overall the quarter still showed a uniform pattern. This data will be available only if the customers studied remain constant at each data collection phase.

To illustrate the advantage of longitudinal data, let us consider two cases. The results from the two are presented in Tables 2.3 and 2.4. In both the tables, the figures, the values under 'Row Total' represent the total investment made in the instrument Quarter 1 and the numbers under 'Column Total' represent the behaviour at the end of Quarter 2. The overall investment spread is the same at the end of each time period. Thus, the results of the study as indicated earlier still hold true. However, the two tables contain additional information about the movement of the decision taken.

The first row of the numbers in Table 2.3 reveals that of the 45 consumers who invested in goverment securities in Period 1, 25 invested in the same in Quarter 2, 5 moved to mutual funds, 10 to bullion and 5 got FDs made. Now consider the first row of numbers in Table 2.4. These numbers reveal that of the 45 consumers who invested in government securities, 43 still invested in the same in Period 2, 1 put his money in mutual funds and one switched to bullion. The other investment options in the two cases can be similarly interpreted.

Thus, in Case 1, the investors who play safe and invest only in the fixed deposits more or less demonstrate the same behaviour. However, the other investors fluctuate between options. In Case 2, however, the investors are more rigid and conservative and remain with the same options.

Such longitudinal study using the same section of respondents thus provides more accurate data than one using a series of different samples. These kinds of panels are defined as true panels and the ones using a different group every time are called omnibus panels.

Advantages of a true panel are that it has a more committed sample group that is likely to tolerate extended or long data collecting sessions. Secondly, the profile information is a one-time task and need not be collected every time. Thus, a useful respondent time can be spent on collecting some research-specific information.

However, the problem is getting a committed group of people for the entire study period. Secondly, there is an element of mortality and attrition where the members of the panel might leave midway and the replaced new recruits might be vastly different and could skew the results in an absolutely different direction. A third disadvantage is the highly structured study situation which might be responsible for a consistent and structured behaviour, which might not be the case in the real or field conditions.

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To deal with this, the research agencies making use of such panels try to make certain that people behave normally and do not demonstrate exaggerated or artificial behaviour. Also steps are taken to get new members who match the behaviour of the leaving members. Thirdly, after a certain period of time, the panel members are changed so that new perspectives can be obtained.

Thus, there are advantages and drawbacks in both the descriptive designs, the level of accuracy required, the nature of the monitored behaviour and the degree of influence of demographic and psychographic variables determines the design decision; or the researcher might decide to use a combination of the two for more accurate results.

Table 2.3 *Investment Behaviour of Regular Consumers: Case 1*

Customer Investments Quarter 1	Customer Investments Quarter 2			FD	Row Total
	Govt. Instruments	MF and Others	Bullion		
Govt. inst.	25	5	10	5	45
MF and Others	8	4	9	0	21
Bullion	4	8	3	0	15
FD	6	0	0	13	19
Column Total	43	17	22	18	100

Table 2.4 *Investment Behaviour of Regular Consumers: Case 2*

Customer Investments Quarter 1	Customer investments Quarter 2			FD	Row Total
	Government Instruments	MF and Others	Bullion		
Govt. Instruments	43	0	1	1	45
MF and Others	0	16	3	2	21
Bullion	0	1	13	1	15
FD	0	0	5	14	19
Column Total	43	17	22	18	100

2.3.7 Research Design in Social Research

Social phenomena are often understood with the help of social research. In order to gather correct understanding of social phenomena, we need to apply appropriate research design in collecting data about people and their behaviour. This is absolutely essential to comprehend the complexities of human behaviour. Both quantitative and qualitative research methods are used in a social research design. While the former approach helps us understand the quantifying evidence and applies statistics in analysing the gathered data, the latter tries to achieve understanding through subjective analysis of subjects. This section discusses four types of research design that are generally followed in social research.

Types of Social Research Design

The following are the significant types of social research design:

(i) Experimental Research Design

As in normal statistical fields, social research also has a design called experimental research design. In an experimental design, a social scientist exercises certain control over the set of variables with which he is working. Experiments are conducted with a view to negate or refute existing theories and hypothesis. The social researcher begins the experiment with a problem statement, and then formulates a hypothesis. The experiment is then carried out and he checks if his hypothesis stands correct. When a number of experiments show the same result, a theory is formed which is published as reported document. For example, an experiment is carried out to find out the amount of a toxin that cause symptoms to animals used in experimentations, referred to generally as 'guinea pigs'. This experimentation need not be done only in laboratories.

(ii) Case Study Research Design

A case study is a research design that focuses on a single case rather than dealing with a sample of a large population. For example, a careful determination of the factors that led to the success or failure of a community project may be conducted.

(iii) Longitudinal Research Design

A longitudinal research design involves collection of data over a period of time. This is further subdivided into three types namely trend study, cohort study and panel study.

(a) Trend Study: A trend study is a type of longitudinal research design that looks into the particular characteristic of the population over a specific period of time. For example, a researcher might want to study the people's preference for projects, whether government or non-government, in their community. Respondents of the study vary across study periods.

(b) Cohort Study: A cohort study is a type of longitudinal research design where a cohort is tracked over extended periods of time. A cohort is a group of individuals who have shared a particular time together during a particular time span; for example, an experiment on the Jaroya tribe of the Andaman would form a cohort study.The Jarawa (also called Jarwa) are one of the indigenous peoples of the Andaman Islands. Their present numbers are estimated at between 250-400 individuals. Since they have largely shunned interactions with outsiders, many particulars of their society, culture and traditions are poorly understood.

(c) Panel Study: A panel study is a type of longitudinal research design that involves collection of data from a *panel*, or the same set of people over several points in time by measuring specific dependent variable identified by the researcher to achieve a study objective. It is possible to predict cause-effect relationship from the data gathered. Panel study is usually done when it is difficult to analyse a case-study which is only a one-shot deal. People's changing attitudes and behaviour can be detected. For example, cause-effect relationship may be investigated between the number of faculty research outputs and the amount of time given for research as work load over three years.

(iv) Cross-Sectional Research Design

This is one of the commonly-used methods in social research design. It gathers data from a cross-section of a population. For example, a contingent valuation study asks a sample of a population regarding their willingness-to-pay to preserve a given forest ecosystem accessible to them. In order to gather accurate information on social problems and social phenomena, choosing the correct social research design is imperative. Thus, a thorough understanding of various research methods and designs is absolutely necessary for all serious social researchers.

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2.3.8 Defining the Research Problem

The first and the most important step of the research process is to identify the path of enquiry in the form of a research problem. It is like the onset of a journey, in this instance the research journey, and the identification of the problem gives an indication of the expected result being sought. A research problem can be defined as a gap or uncertainty in the decision makers' existing body of knowledge which inhibits efficient decision-making. Sometimes it may so happen that there might be multiple reasons for these gaps and identifying one of these and pursuing its solution, might be the problem. As Kerlinger (1986) states, 'If one wants to solve a problem, one must generally know what the problem is. It can be said that a large part of the problem lies in knowing what one is trying to do.' The defined research problem might be classified as simple or complex (Hicks, 1991). Simple problems are those that are easy to comprehend and their components and identified relationships are linear and easy to understand, e.g., the relation between cigarette smoking and lung cancer. Complex problems on the other hand, talks about interrelationship between antecedents and subsequently with the consequential component. Sometimes the relation might be further impacted by the moderating effect of external variables as well, e.g., the effect of job autonomy and organizational commitment on work exhaustion, at the same time considering the interacting (combined) effect of autonomy and commitment. This might be further different for males and females. These kinds of problems require a model or framework to be developed to define the research approach.

A gap or uncertainty which hampers the process of efficient decision-making in a given body of knowledge is called a research problem.

Thus, the significance of a clear and well-defined research problem cannot be overemphasized, as an ambiguous and general issue does not lend itself to scientific enquiry. Even though different researchers have their own methodology and perspective in formulating the research topic, a general framework which might assist in problem formulation is given below.

Problem Identification Process

The problem recognition process invariably starts with the decision maker and some difficulty or decision dilemma that he/she might be facing. This is an action oriented problem that addresses the question of what the decision maker should do. Sometimes, this might be related to actual and immediate difficulties faced by the manager (applied research) or gaps experienced in the existing body of knowledge (basic research). The broad decision problem has to be narrowed down to information oriented problem which focuses on the data or information required to arrive at any meaningful conclusion. Given in Figure 2.3 is a set of decision problems and the subsequent research problems that might address them.

Problem identification process is action oriented and requires a narrowing down of a broad decision problem to the level of information oriented problem in order to arrive at a meaningful conclusion.

Management Decision Problem

The entire process explained above begins with the acknowledgement and identification of the difficulty encountered by the business manager/researcher. If the manager is skilled enough and the nature of the problem requires to be resolved by him or her alone, the problem identification process is handled by him or her, else he or she outsources it to a researcher or a research agency. This step requires the author to carry out a problem appraisal, which would involve a comprehensive audit of the origin and symptoms of the diagnosed business problem. For illustration, let us take the first problem listed in the Figure 2.3. An organic farmer and trader in Uttarakhand, Nirmal farms, wants to sell his organic food products in the domestic Indian market. However, he is not aware if this is a viable business opportunity and since he does not have the expertise or time to undertake any research to aid in the formulation of the marketing strategy, he decides to outsource the study.

> The management can also outsource the **problem identification process** to a research agency in case of lack of time, means or knowledge regarding the market pulse.

Discussion with Subject Experts

The next step involves getting the problem in the right perspective through discussions with industry and subject experts. These individuals are knowledgeable about the industry as well as the organization. They could be found both within and outside the company. The information on the current and probable scenario required is obtained with the assistance of a semi-structured interview. Thus, the researcher must have a predetermined set of questions related to the doubts experienced in problem formulation. It should be remembered that the purpose of the interview is simply to gain clarity on the problem area and not to arrive at any kind of conclusions or solutions to the problem. For example, for the organic food study, the researcher might decide to go to food experts in the Ministry for Food and Agriculture or agricultural economists or retailers stocking health food as well as doctors and dieticians. This data however is not sufficient in most cases while in other cases, accessibility to subject experts might be an extremely difficult task as they might not be available. The information should, in practice, be supplemented with secondary data in the form of theoretical as well as organizational facts.

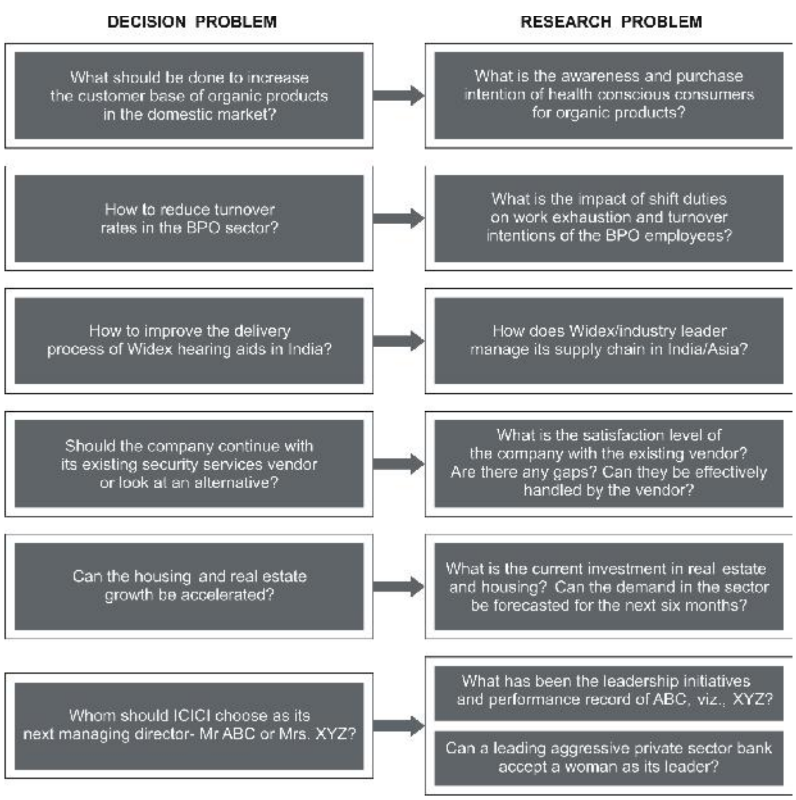

Fig. 2.3 *Converting Management Decision Problem into Research Problem*

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Review of Existing Literature

A literature review is a comprehensive compilation of the information obtained from published and unpublished sources of data in the specific area of interest to the researcher. This may include journals, newspapers, magazines, reports, government publications, and also computerized databases. The advantage of the survey is that it provides different perspectives and methodologies to be used to investigate the problem, as well as identify possible variables that may need to be investigated. Second, the survey might also uncover the fact that the research problem being considered has already been investigated and this might be useful in solving the decision dilemma. It also helps in narrowing the scope of the study into a manageable research problem that is relevant, significant and testable.

A **literature review** involves a comprehensive compilation of the information obtained from both published and unpublished sources of data which belong to the specific interest area of the researcher.

Once the data has been collected from different sources, the researcher must collate all information together in a cogent and logical manner instead of just listing the previous findings. This documentation must avoid plagiarism and ensure that the list of earlier studies is presented in the researcher's own words. The logical and theoretical framework developed on the basis of past studies should be able to provide the foundation for the problem statement.

The reporting should cite clearly the author and the year of the study. There are several internationally accepted forms of citing references and quoting from published sources. The *Publication Manual of the American Psychological Association* (2001) and the *Chicago Manual of Style* (1993) are academically accepted as referencing styles in management.

To illustrate the significance of a literature review, given below is a small part of a literature review done on organic purchase.

Research indicates organic is better quality food. The pesticide residue in conventional food is almost three times the amount found in organic food. Baker *et al.* (2002) found that on an average, conventional food is more than five times likely to have chemical residue than organic samples. Pesticides toxicity has been found to have detrimental effects on infants, pregnant women and general public (National Research Council, 1993; Ma *et al.*, 2002; Guillete *et al*., 1998) Major factors that promote growth in organic market are consumer awareness of health, environmental issues and food scandals (Yossefi and Willer, 2002).

This paragraph helps justify the relevance and importance of organic versus non organic food products as well as identify variables that might contribute positively to the growth in consumption of organic products.

Organizational Analysis

Another significant source for deriving the research problem is the industry and organizational data. In case the researcher/investigator is the manager himself/herself, the data might be easily available. However, in case the study is outsourced, the detailed background information of the organization must be compiled, as it serves as the environmental context in which the research problem has to be defined. It is to be remembered at this juncture that the organizational context might not be essential in case of basic research, where the nature of study is more generic.

This data needs to include the organizational demographics—origin and history of the firm; size, assets, nature of business, location and resources; management philosophy and policies as well as the detailed organizational structure, with the job descriptions.

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> An organizational analysis is based on data regarding the origin and history of the firm including its size, assets, nature of business, location and resources. It assists in arriving at the research problem.

Qualitative Survey

Sometimes the expert interview, secondary data and organizational information might not be enough to define the problem. In such a case, an exploratory qualitative survey might be required to get an insight into the behavioural or perceptual aspects of the problem. These might be based on small samples and might make use of focus group discussions or pilot surveys with the respondent population to help uncover relevant and topical issues which might have a significant bearing on the problem definition.

In the organic food research, focused group discussions with young and old consumers revealed the level of awareness about organic food and consumer sentiments related to purchase of more expensive but a healthy alternative food product.

Management Research Problem

Once the audit process of secondary review and interviews and survey is over, the researcher is ready to focus and define the issues of concern, that need to be investigated further, in the form of an unambiguous and clearly-defined research problem. Once again it is essential to remember that simply using the word 'problem' does not mean there is something wrong that has to be corrected, it simply indicates the gaps in information or knowledge base available to the researcher. These might be the reason for his inability to take the correct decision. Second, identifying all possible dimensions of the problem might be a monumental and impossible task for the researcher. For example, the lack of sales of a new product launch could be due to consumer perceptions about the product, ineffective supply chain, gaps in the distribution network, competitor offerings or advertising ineffectiveness. It is the researcher who has to identify and then refine the most probable cause of the problem and formalize it as the research problem. This would be achieved through the four preliminary investigative steps indicated above.

> A variable, in general, is a symbol to which we can assign numerals or values. It can be dichotomous, discrete or indefinite.

Last, the researcher must be able to isolate the underlying issues from the symptoms of the problem. For example, in the organic food study, the manufacturer has an outlet in an up market area in Delhi, and is constantly doing some attractive sales promotion but there is no substantial increase in sales. Here the real problem is lack of awareness and motivation on the part of the consumer about the benefits of organic food. Thus the low sales are primarily a consequence of lack of awareness and purchase intention.

2.3.9 Components of Research Problem

To address the problems of clarity and focus, we need to understand the components of a well defined problem. These are:

The Unit of Analysis: The researcher must specify in the problem statement the individual(s) from whom the research information is to be collected and on whom the research results are applicable. This could be the entire organization, departments, groups or individuals. In the organic food study, for example, the retailer who has to be targeted for stocking the product as well as the end consumer could be the unit of analysis. Thus, the information required for decision might sometimes require investigation at multiple levels.

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The **unit of analysis** is that particular source from which the required information is obtained. It can be individual(s), department, organization or an industry.

Research Variables: The research problem also requires identification of the key variables under the particular study. To carry out an investigation, it becomes imperative to convert the concepts and constructs to be studied into empirically testable and observable variables. A variable is generally a symbol to which we assign numerals or values. A variable may be dichotomous in nature, that is, it can possess only two values such as male-female or customer–non-customer. Values that can only fit into prescribed number of categories are discrete variables, for example, very important (1) to very unimportant (5). There are still others that possess an indefinite set, e.g., age, income and production data.

Variables can be further classified into five categories, depending on the role they play in the problem under consideration.

A **dependent variable (DV)** is measurable and quantifiable variable in nature. It is the most crucial variable to be analysed in a given research study.

• *Dependent Variable:* The most important variable to be studied and analysed in research study is the dependent variable (DV). The entire research process is involved in either describing this variable or investigating the probable causes of the observed effect. Thus, this in essence has to be reduced to a measurable and quantifiable variable. For example, in the organic food study, the consumer's purchase intentions and the retailers stocking intentions as well as sales of organic food products in the domestic market, could all serve as the dependent variable.

A financial researcher might be interested in investigating the Indian consumers' investment behaviour, post the recent financial slow down. In another study, the HR head at Cognizant Technologies would like to study the organizational commitment and turnover intentions of short and long tenure employees in the company.

Hence, as can be seen from the above examples, it might be possible that in the same study there might be more than one dependent variable.

• *Independent Variable:* Any variable that can be stated as influencing or impacting the dependent variable is referred to as an independent variable (IV). More often than not, the task of the research study is to establish the causality of the relationship between the independent and the dependent variable(s). The proposed relations are then tested through various research designs.

In the organic food study, the consumers' attitude towards healthy lifestyle could impact their organic purchase intention. Thus, attitude becomes the independent and intention the dependent variable. Another researcher might want to assess the impact of job autonomy and role stress on the organizational commitment of the employees; here job autonomy and role stress are independent variables.

• *Moderating Variables:* Moderating variables are the ones that have a strong contingent effect on the relationship between the independent and dependent variables. These variables have to be considered in the expected pattern of relationship as they modify the direction as well as the magnitude of the independent–dependent association. In the organic food study, the strength of the relation between attitude and intention might be modified by the education and the income level of the buyer. Here, education and income are the Moderating Variables (MVs).

Moderating variables (MVs) are the ones that have a strong contingent effect on the relationship between the independent and dependent variables. They have the potential to modify the direction and magnitude of the above stated association.

In a consulting firm, the management is looking at the option of introducing flexi-time work schedule. Thus, a study might need to be taken to see whether there will be an increase in productivity of each individual worker (DV) subsequent to the introduction of a flexi-time (IV) work schedule.

In real time situations and actual work settings, this proposition might need to be revised to take into account other impacting variables. This second independent variable might need to be introduced because it has a significant contribution on the stated relationship. Thus, we might like to modify the above statement as follows:

There will be an increase in productivity of each individual worker (DV) subsequent to the introduction of a flexi-time (IV) work schedule, especially amongst women employees (MV).

There might be instances when confusion might arise between a moderating variable and an independent variable.

Consider the following situation:

Proposition 1: Turnover intention (DV) is an inverse function of organizational commitment (IV), especially for workers who have a higher job satisfaction level (MV).

While another study might have the following proposition to test.

Proposition 2: Turnover intention (DV) is an inverse function of job satisfaction (IV), especially for workers who have a higher organizational commitment (MV).

Thus, the two propositions are studying the relation between the same three variables. However the decision to classify one as independent and the other as moderating depends on the research interest of the decision maker.

• *Intervening Variables:* An intervening variable (IVV) has a temporal connotation to it. It generally follows the occurrence of the independent variable and precedes the dependent variable. Tuckman (1972) defines it as 'that factor which theoretically affects the observed phenomena but cannot be seen, measured, or manipulated; its effects must be inferred from the effects of the independent variable and moderator variables on the observed phenomenon.'

An **intervening variable (IVV)** is a temporal occurrence which follows the independent variable and precedes the dependent variable.

For example, in the previous case, There is an increase in job satisfaction (IVV) of each individual worker, subsequent to the introduction of a flexi-time (IV) work schedule, which eventually affects the Individual's productivity (DV), especially amongst women employees (MV). Another example would be, the introduction of an electronic advertisement for the new diet drink (IV) will result in increased brand awareness (IVV), which in turn will impact the first quarter sales (DV).This would be significantly higher amongst the younger female population (MV).

• *Extraneous Variables:* Besides the moderating and intervening variables, there might still exist a number of extraneous variables (EVs) which could affect the defined relationship but might have been excluded from the study. These would most often account for the chance variations observed in the research investigation. For example, a tyrannical boss; family pressures or nature of the industry could impact the flexi-time impact, but since these would be applicable to individual cases, they might not heavily

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impact the direction of the findings. However, in case the effect is substantial, the researcher might try to block their effect by using an experimental and a control group (This concept will be discussed later in the section on experimental designs).

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> **Extraneous variables (EV)** are responsible for the chance variations that are often observed in a research investigation. In most cases, they are limited to a peculiar group.

At this stage, we can clearly distinguish between the different kinds of variables discussed above. An independent variable is the prime antecedent condition which is qualified as explaining the variance in the dependent variable; the intervening variable follows the occurrence of the independent variable and may in turn impact the dependent variable; the moderating variable is a contributing variable which might impact the defined relationship; the extraneous variables are outside the domain of the study and responsible for chance variations, but in some instances, their effect might need to be controlled.

2.3.10 Selection and Formulation of Research Problem

Having identified and defined the variables under study, the next step requires operationalizing the stated relationship in the form of a theoretical framework. This is an outcome of the problem audit conducted prior to defining the research problem; it can be best understood as a schema or network of the probable relationship between the identified variables. Another advantage of the model is that it clearly demonstrates the expected direction of the relationships between the concepts. There is also an indication of whether the relationship would be positive or negative.

This step however is not mandatory as sometimes the objective of the research is to explore the probable variables that might explain the observed phenomena (DV) and the outcome of the study helps to theorize and propose a conceptual model.

The theoretical framework, once formulated, is a powerful driving force behind the research process and ought to be comprehensively developed. It requires a thorough understanding of both theory and opinion.

> A **theoretical framework** is a schema or network of the probable relationship between the identified variables. It is a powerful driving force behind the research process.

Given below is a predictive model for turnover intentions developed to explain the high rate of attrition amongst BPO professionals. Once validated, it is of course possible to test it in different contexts and differing respondent population.

The Turnover Intention Model

The proposed model to predict turnover intention is specified as mentioned below:

$$TI = f(WE, OC, A, MS, TWE) \quad \ldots(1)$$

Where,
TI = Turnover intention
WE = Work exhaustion
OC = Organizational commitment
A = Age
MS = Marital status
TWE = Total work experience

The theoretical construct of work exhaustion is influenced by Perceived Workload (PWL), Fairness Of Reward (FOR), Job Autonomy (JA) and Work Family Conflict (WFC) [Adapted from Ahuja, Chudoba and Kacmar, 2007] . This can be mathematically written as:

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$$WE = f(PWL, FOR, JA, WFC) \quad ...(2)$$

A theoretical framework can be explained verbally as a **verbal model**, in a graphical form as a **graphical model** and can be reduced to mathematical equations and represented as a **mathematical model**.

Similarly, Organizational Commitment depends upon Job Autonomy, Work–Family Conflict, Fairness of Reward and Work Exhaustion (WE) [Adapted from—Ahuja, Chudoba and Kacmar, 2007]. Therefore, this can be stated mathematically as,

$$OC = f(JA, WFC, FOR, WE) \quad ...(3)$$

The model is diagrammatically represented in Figure 2.4.

The formulated framework has been explained verbally as a ***verbal model***. The flowchart of the relationship between independent and intervening variables has been demonstrated in graphical form as a ***graphical model*** and the same have been also reduced to three mathematical equations specifying the relationship between the same in the form of a ***mathematical model***. What needs to be understood is that all three compliment each other and are basically representatives of the same framework.

Statement of Research Objectives

Next, the research question(s) that were formulated need to be broken down and spelt out as tasks or objectives that need to be met in order to answer the research question.

Research objectives are to be formulated according to the basic, thrust areas of the research which are crucial to the study being conducted.

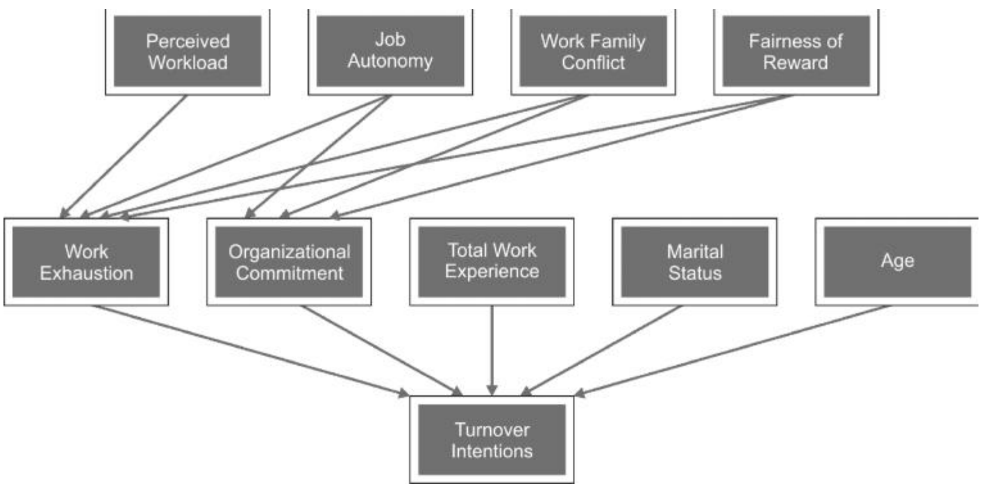

Fig. 2.4 *Proposed Model for Turnover Intention*

Based on the framework of the study, the researcher has to numerically list the thrust areas of research. This section makes active use of verbs such as 'to find out', 'to determine', 'to establish', and 'to measure' so as to spell out the objectives of the study. In certain cases, the main objectives of the study might need to be broken down into sub-objectives which clearly state the tasks to be accomplished.

In the organic food research, the objectives and sub-objectives of the study were as follows:

1. *To study the existing organic market*: This would involve:
   - To categorize the organic products available in Delhi into grain, snacks, herbs, pickles, squashes and fruits and vegetables;
   - To estimate the demand pattern of various products for each of the above categories;

- To understand the marketing strategies adopted by different players for promoting and propagating organic products.

2. *Consumer diagnostic research:* This would entail:
   - To study the existing consumer profile, i.e., perception and attitudes towards organic products and purchase and consumption patterns;
   - To study the potential customers in terms of consumer segments, level of awareness, perception and attitude towards health and organic products;
3. *Opinion survey:* To assess the awareness and opinions of experts such as doctors, dieticians and chefs in order to understand organic consumption and propagation;
4. *Retail market:* This would involve:
   - To find the gap between demand and supply for existing retailers;
   - To forecast demand estimates by considering the existing as well as potential retailers.

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2.3.11 Formulation of the Research Hypotheses

Problem identification and formulation process culminates in the hypotheses formulation stage. Any assumption that the researcher makes on the probable direction of the results that might be obtained on completion of the research process is termed as a ***hypothesis.*** Unlike the research problem that generally takes on a question form, the hypotheses is always in a declarative form. The statements thus formulated can lend themselves to empirical enquiry. Kerlinger (1986) defines a hypothesis as '…a conjectual statement of the relationship between two or more variables.' According to Grinnell (1993), 'A hypotheses is written in such a way that it can be proven or disproven by valid and reliable data—it is in order to obtain these data that we perform our study'.

While designing any hypotheses, there are a few criteria that the researcher must fulfil. These are:

- A hypothesis must be formulated in simple, clear, and declarative form. A broad hypothesis might not be empirically testable. Thus, it might be advisable to make the hypothesis unidimensional, and to be testing only one relationship between only two variables at a time.
  - *Consumer liking for the electronic advertisement for the new diet drink will have positive impact on brand awareness of the drink.*
  - *High organizational commitment will lead to lower turnover intention*.
- A hypothesis must be measurable and quantifiable so that the statistical authenticity of the relationship can be established.
- A hypothesis is a conjectual statement based on the existing literature and theories about the topic and not based on the gut feel or subjective judgement of the researcher.
- The validation of the hypothesis would necessarily involve testing the statistical significance of the hypothesized relation. For example, the above two hypotheses would need to use correlation and regression analysis respectively to test the stated relationship.

The formulated hypothesis could be of two types:

> A hypothesis can be **descriptive** or **relational**, while the former is a statement about the magnitude, trend or behaviour of a population under study, the latter typically states the expected relationship between two variables.

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Descriptive Hypothesis: This is simply a statement about the magnitude, trend or behaviour of a population under study. Based on past records, the researcher makes some presumptions about the variable under study. For example:

- Students from the pure science background score 90–95 per cent on a course on Quantitative Methods.
- The current advertisement for the diet drink will have a 20–25 per cent recall rate.
- The attrition rate in the BPO sector is almost 33 per cent.
- The literacy rate in the city of Indore is 100 per cent.

Relational Hypothesis: These are the typical kind of hypotheses which state the expected relationship between two variables. While stating the relation if the researcher makes use of words such as increase, decrease, less than or more than, the hypothesis is stated to be directional or one-tailed hypothesis.

For example,

- Higher the likeability of the advertisement, the higher is the recall rate.
- Higher the work exhaustion experienced by the BPO professional, higher is the turnover intention of the person.

However, sometimes the researcher might not have reasonable supportive data to hypothesize the expected direction of the relationship. In this case, he or she would leave the hypothesis as non-directional or two-tailed.

For example,

- There is a relation between quality of working life and job satisfaction experienced by employees.
- Ban on smoking has an impact on the cigarette sales.
- Anxiety is related to performance.

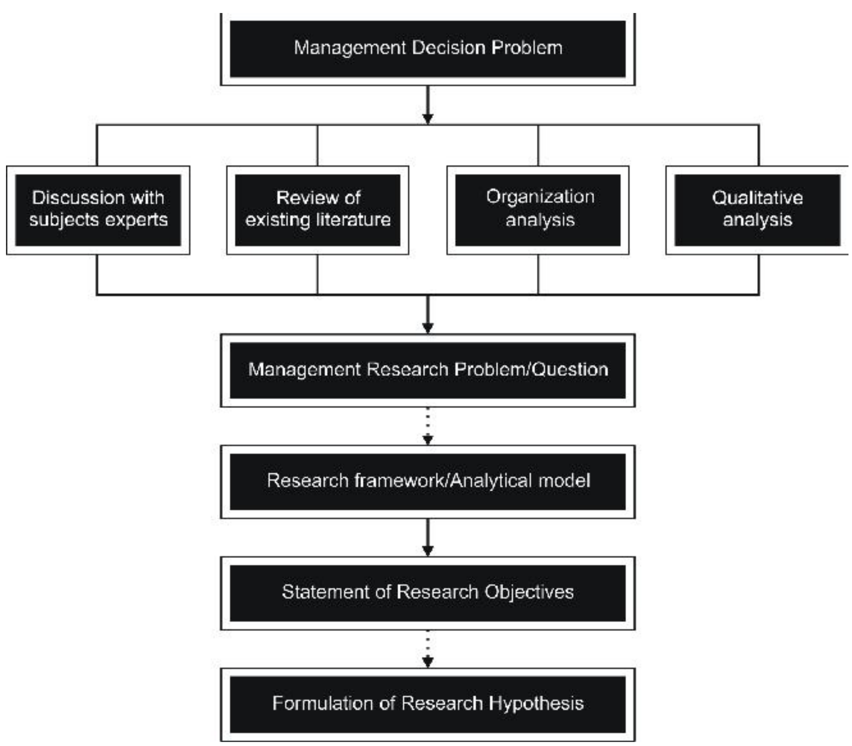

Fig. 2.5 *Problem Identification Process*

2.4 EXPERIMENTAL DESIGN

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Experimental design can be classified as pre-experimental, quasi-experimental, true experimental and statistical. Pre-experimental designs include the one-shot case study, the one-group pre-test–post-test design and the static group comparison. Tests included under quasi-experimental designs are time series and multiple time series. True-experimental designs include pre-test–post-test control group, post-test–only control group, and Solomon four–group design. The statistical designs include completely randomized design, randomized blocks, factorial and Latin square designs. To have a glimpse of the classification, these are presented in Figure 2.6.

2.4.1 Pre-Experimental Design

Pre-experimental designs do not make use of any randomization procedures to control the extraneous variables. Therefore, the internal validity of such designs is questionable. Three designs included in this category are elaborated below:

(i) **One-Shot Case Study:** This design is also known as the after–only design and may be presented symbolically as:

$$X \quad O$$

This means that only one test group is subjected to the treatment (X) and then a measurement on the dependent variable is taken (O). It may be noted that the symbol R does not appear in this design. This means there was no random assignment of test units to the treatment group. This means that the test units were either self-selected or arbitrarily selected by the researcher. In the sales training programme example, the sales manager might have chosen those sales people whom he likes or may ask the sales people to volunteer for the training programme.

Let us examine another example here. The objective is to study the impact of an extra ten day credit period (X) on a credit card payment time (O) and one decides to study the relationship/impact by offering this to the customers who make an average usage of ₹ 25,000/- per month. The problem in this case would be that no measure was taken to establish their payment behaviour prior to the extended period. Hence, no valid conclusion can be made from this design. There is no pre-treatment observation on performance. The level of 'O' might be affected by several uncontrolled extraneous factors like history, maturation, selection bias and test unit mortality. These uncontrolled extraneous variables will confound the experiment and render the design internally invalid.

(ii) **One-Group Pre-Test–Post-Test Design:** This design is also called before–after without control group design. This design may be written symbolically as:

$$O_1 \quad X \quad O_2$$

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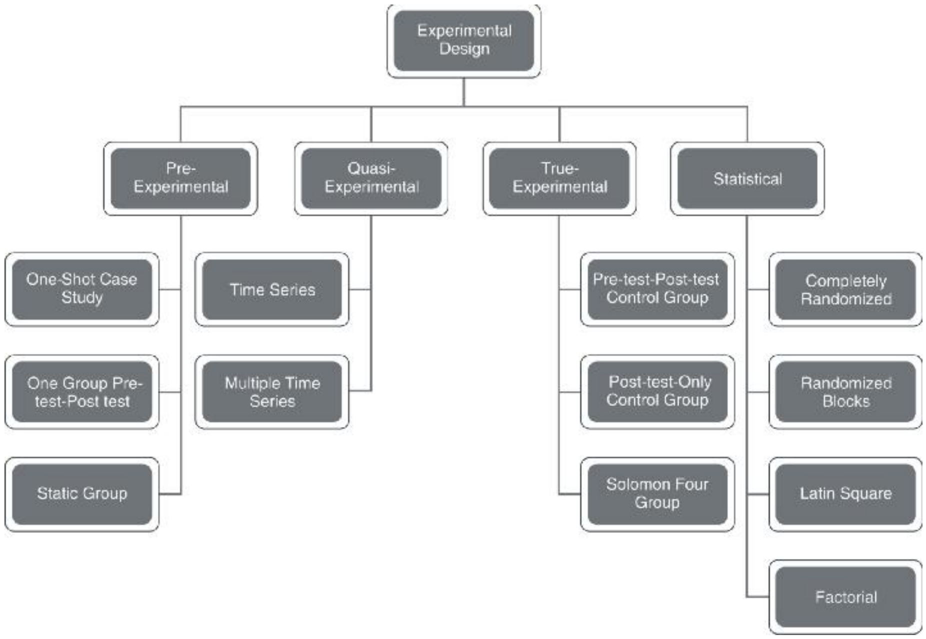

Fig. 2.6 *Classification of Experimental Designs*

In this design also, test units are not selected at random as the symbol 'R' is not appearing here. The test units are subjected to the treatment *X* and both pre-treatment (O_1) and post-treatment measurement (O_2) are taken. For instance, in the credit card example, one might take the payment time before and after the extended ten-day period. One may be tempted to compute treatment effect as $O_2 – O_1$, which may not be really so, as this difference could be the result of many uncontrolled extraneous factors like history, maturation, testing, instrumentation, regression, selection and mortality. This would make the design invalid for making any causal inferences on account of the following reasons:

- The economic condition might have changed during the two periods (history).
- The test units may mature over time (maturation).
- The pre-test measurement on the test units may influence the performance (testing).
- The prices of goods might have changed over time (instrumentation).
- Test units might not have been selected at random (selection bias).
- Some test units might have left before the experiment was complete (mortality).
- Test units might be self-selected on the basis of the current poor performance and may have a better period ahead because of sheer luck (regression).

(iii) **Static Group Comparison:** This design is symbolically written as:

Group 1	–	X	O_1
Group 2	–		O_2

This design uses two treatment groups. Test units in both the groups are not selected at random. The first group, called the experimental group, is subjected to the treatment X, whereas the second group, namely, the control group, is not subjected to any treatment. Both groups are measured only after the treatment has been presented. Thus, it is critical to understand that in this design the exposure

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as well as the experimental treatment is not under the control of the researcher. Consider the following example:

A study wants to assess the relationship of 'family support' (measured by the presence of domestic help or spouse/family's help in carrying out domestic chores) with the work–life balance of BPO women employees. Here, the presence or absence of help is ascertained and then we can measure the work–life balance. Thus the design is essentially *ex-post facto* and any segregation into experimental or control group is not made by the researcher.

The treatment effect could be measured by $O_1 – O_2$. However, this difference could be attributed to at least selection bias and mortality. Moreover, since the test units are not selected at random, the two groups could differ prior to the application of treatment. All these are sufficient to make the design invalid for drawing any causal inferences.

2.4.2 Quasi-Experimental Designs

In quasi-experimental design the researcher can control when measurements are taken and on whom they are taken. However, this design lacks complete control of scheduling of treatment and also lacks the ability to randomize test units' exposure to treatments. As the experimental control is lacking, the possibility of getting confounded results is very high. Therefore, the researchers should be aware of what variables are not controlled and the effects of such variables should be incorporated into the findings. There are two forms of quasi-experimental designs.

(i) **Time Series Design:** This design involves a series of periodic measurements on the dependent variable for a group of test unit. The treatment *X* is then administered and a series of periodic measurements are again taken to measure the effect of treatment. This design may be written symbolically as:

$$O_1 \ O_2 \ O_3 \ O_4 \ X \quad O_5 \ O_6 \ O_7 \ O_8$$

The above is a quasi-experimental design since there is no randomization of treatment to test units. Further, the timing of treatment presentation as well as which of the test units are exposed to the treatment may not be within the researcher's control. Because of the multiple observations in time series design, the effect of maturation, main testing effect, instrumentation and statistical regression can be ruled out. If test units are selected at random, selection bias can be reduced. Further, if a strong measure like giving certain incentives to the respondents is introduced, mortality effect can more or less be controlled.

The major drawback of this experiment is the inability of a researcher to control the effect of history. The results of the experiment may be affected by an interactive testing effect because multiple measurements are made on these test units. If a researcher could keep a record of key changes in various unusual economic activities and if no changes are found, one can reasonably conclude that the treatment has exerted an effect on test unit.

This design may look similar to the one group pre-test-post-test design given by O_4 X O_5. However, there are differences as in case of time series design, a number of periodic measurements are taken both before and after the application of the treatment. But in the case of one group pre-test–post-test design, one measurement is taken prior to the treatment and one after that.

The results of taking multiple measurements can be compared with one group pre-test – post-test design. This is shown in Figure 2.7, where *X* (treatment) is the new advertising campaign and the measurement on dependent variable represents the market share at certain periodic intervals. Six different scenarios (A to F) are presented.

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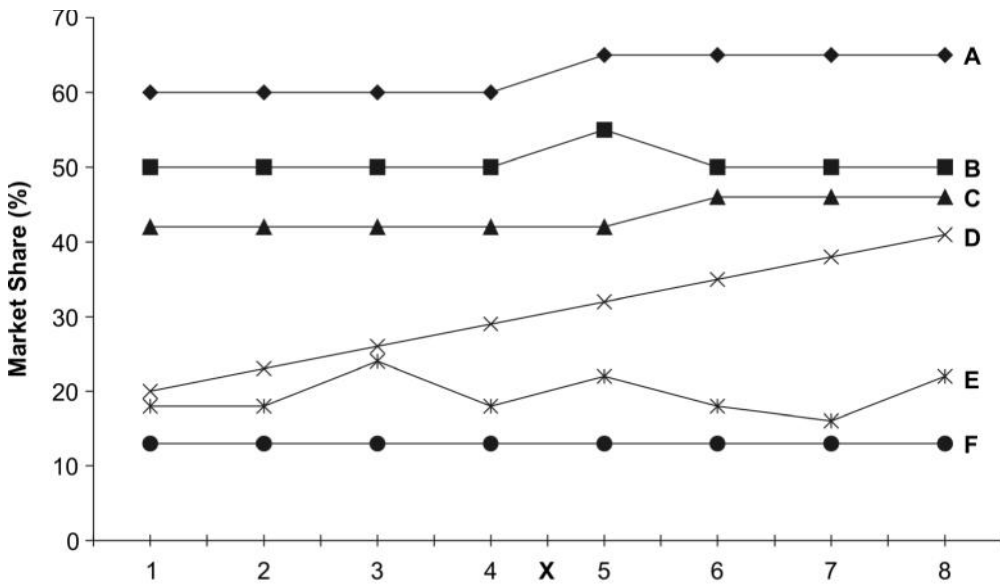
The case of one group pre-test–post-test design would be shown as O_4 X O_5 and the analysis of the results would indicate some positive effects of the new advertising campaign in situations A, B, D and E, whereas in situations C and F, advertising would not be having any effect. The conclusion in the case of time series design would be as follows:



Source: Adopted with modification from Thomas C. Kinnear & James R. Taylor, "Marketing Research: An Applied Approach, McGraw-Hill, Inc., Fifth Edition

Fig. 2.7 *Possible Results of a Time Series Experiment*

- In situation A, the campaign had a short-run positive effect, after which market share was sustained.
- In situation B, the new advertising campaign had a short-run positive effect. The rise in market share was temporary. The market share reverts to the level which was there before the application of the treatment.
- In situation C, the treatment had a delayed positive effect and, accordingly, it took longer time to appear.
- In situation D, E, and F the changes that occur after the application of treatment are in line with what occurred prior to the application of treatment. Therefore, the new advertising campaign had no effect on the market share.

Therefore it is seen that by taking multiple observations, the results have altogether different interpretations and inferences.

(ii) **Multiple Time Series Design:** In this design, one more group called the 'control group' is added to the time series design. The design may be diagrammed symbolically as:

Experimental Group:	O_1	O_2	O_3	O_4	X	O_5	O_6	O_7	O_8
Control Group:	O'_1	O'_2	O'_3	O'_4		O'_5	O'_6	O'_7	O'_8

The experimental group is subjected to the treatment X, whereas the control group is without any treatment. Taking the example of the sales training programme,

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the sales training would represent treatment, and observations O_1, O_2, O_3 ... would represent sales volume of this group. The test unit of the control group would compromise sales people who are not sent for the training programme. The measurement on the sales volume is denoted by O'_1, O'_2, O'_3, ..., etc. The measurement on the sales for both the groups is taken after the training programme. The treatment effect (sales training) is found by comparing the average sales of the two groups before and after the training programme. The major drawback of this design is the possibility of the interactive effect in the experimental group.

2.4.3 True Experimental Designs

In true experimental designs, researchers can randomly assign test units and treatments to an experimental group. Here, the researcher is able to eliminate the effect of extraneous variables from both the experimental and control group. Randomization procedure allows the researcher the use of statistical techniques for analysing the experimental results. Included in this category are the following:

(i) **Pre-Test–Post-Test Control Group:** This design is also called before-after with control group. It is symbolically presented as:

Experimental Group:	R	O_1	X	O_2
Control Group:	R	O_3		O_4

In this design, test units in both experimental and control group are selected at random at the same time. The experimental group is subjected to the treatment X, whereas in the control group, there is no treatment applied. Pre-test measurements O_1 and O_3 are taken in the experimental and control group at the same time. Similarly, post-test measurements O_2 and O_4 are taken for the experimental and the control group at the same time. All the extraneous variables operate equally on both the experimental and control group because of randomization. Therefore, the only difference in the two groups is the effect of treatment in the experimental group.

If the difference in the post-test and pre-test measurements of experimental and control group is denoted by A and B respectively, then

$A = O_2 - O_1$ = Treatment + Extraneous variables

$B = O_4 - O_3$ = Extraneous variables

The extraneous variables would include history, maturation, testing, instrumentation, statistical regression, selection bias and test unit mortality. However, it may be worth noting that the interactive testing effect would be present only in the experimental group and would be missing in the control group. This is because only the experimental group is subjected to the treatment. Therefore $A - B = (O_2 - O_1) - (O_4 - O_3)$ = Treatment effect which would include interactive testing effect. Therefore, it is doubtful to generalize the results of the experiment.

(ii) **Post-Test – Only Control Group Design:** This design is also named as after-only with one control group and is presented symbolically as:

Experimental Group:	R	X	O_1
Control Group:	R		O_2

Here, the test units in both the experimental and the control group are selected at random. The experimental group is subjected to the treatment X, and post-test measurements are taken on both experimental (O_1) and control group (O_2) at the same time. The post-test measurement (O_1) on experimental group comprises treatment effect and all other extraneous variables, whereas O_2 comprises only extraneous variables. Therefore, the difference in the post-test measurement of experimental and control group is taken as a measure of treatment effect. Hence,

$$\begin{aligned} O_1 - O_2 &= \text{(Treatment effect + Extraneous factors)} - \text{(Extraneous factors)} \\ &= \text{Treatment effect} \end{aligned}$$

As pre-test measurement is absent, the effect of instrumentation and interactive testing effect is ruled out. As there is a random assignment of test units to both the groups, it can be approximately assumed that both the groups were equal prior to the application of treatment to the experimental group. Further, one can always assume that the test units' mortality affects each group equally. One can always justify these assumptions by taking a large randomized sample. This design is widely used in marketing research.

(iii) **Solomon Four-Group Design:** This design is also called four-group six-study design. This is also referred to as 'ideal controlled experiment'. As will be seen, this design helps the researcher to remove the influence of extraneous variables and also that of the interactive testing effect. This design is symbolically presented as:

Experiment Group 1	R	O_1	X	O_2
Control Group 1	R	O_3	O_4	
Experiment Group 2	R		X	O_5
Control Group 2	R		O_6	

In the above design test units are selected at random in all the four groups. It is seen that the Experimental Group 2 and Control Group 2 are not given any pre-test measurement, whereas Experimental Group 1 and Control Group 1 are subjected to pre-test measurement O_1 and O_3, respectively. Both Experimental Groups 1 and 2 are subjected to the same treatment X at the same time.

As the Eexperimental Group 2 and Control Group 2 are not subjected to pre-test measurement, we would need their estimates to remove the influence of extraneous variables and interactive testing effect. As test units from all the four groups are chosen at random, it can be assumed that all the four groups are equal before experiment. Therefore, the pre-test measurements O_1 and O_3 on Experimental and Control Group 1 can be used as an estimate of the pre-test measurement of Experimental and Control Group 2. The results of difference of various post-test and pre-test measurement would give the following results:

Experimental Group 1:

$$\begin{aligned} O_2 - O_1 = {} & \text{Treatment effect + Extraneous factors without} \\ & \text{interactive testing effect + Interactive testing effect} \qquad \text{...(i)} \end{aligned}$$

Control Group 1:

$$O_4 - O_3 = \text{Extraneous factors without interactive testing effect} \qquad \text{...(ii)}$$

As this group was not subjected to any treatment, there would not be any interactive testing effect.

Experimental Group 2:

$$\begin{aligned} O_5 - O_1 = {} & \text{Treatment effect + Extraneous factors without} \\ & \text{interactive testing effect} \qquad \text{...(iii)} \end{aligned}$$

$$O_5 - O_3 = \text{Treatment effect + Extraneous factors without testing effect} \quad \text{...(iv)}$$

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As there was actually no pre-test measurement, the interactive testing effect cannot occur here.

Control Group 2:

$$O_6 - O_1 = \text{(Extraneous factors without testing effect)} \quad \text{...(v)}$$

$$O_6 - O_3 = \text{(Extraneous factors without testing effect)} \quad \text{...(vi)}$$

As the group was not subjected to any treatment, the difference in measurement would only indicate the effect of extraneous factors without interactive testing effect.

By taking the average of Equations (v) and (vi), one gets:

$$O_6 - \frac{O_1 + O_3}{2} = \text{(Extraneous factors without testing effect)} \quad \text{...(vii)}$$

By taking the average of Equations (iii) and (iv), one obtains:

$$O_5 - \frac{O_1 + O_3}{2} = \text{Treatment effect + Extraneous factors without testing effect} \quad \text{...(viii)}$$

By subtracting Equation (vii) from Equation (viii), one obtains:

$$\left(O_5 - \frac{O_1 + O_3}{2}\right) - \left(O_6 \frac{O_1 + O_3}{2}\right) = O_5 - O_6 = \text{Treatment effect}$$

By subtracting Equation (viii) from Equation (i), one obtains:

$$O_2 - O_1 - \left(O_5 - \frac{O_1 + O_3}{2}\right) = \text{Interacting testing effect}$$

Therefore, this design has helped not only in measuring the effect of treatment, but also in obtaining magnitude of the interactive testing effect and extraneous factors.

To conduct this experimental design, the time and cost required are enormous and therefore, this design is not commonly used in research. However, as seen, this experimental design guarantees the maximum internal validity. In businesses where establishing cause-and-effect relationship is very crucial for survival, this design is useful.

2.4.4 Statistical Designs

Statistical designs allow for statistical control and analysis of external variables. The main advantages of statistical design are the following:

- The effect of more than one level of independent variable on the dependent variable can be manipulated.
- The effect of more than one independent variable can be examined.
- The effect of specific extraneous variable can be controlled.

Included in this category are the following designs:

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(i) **Completely Randomized Design:** This design is used when a researcher is investigating the effect of one independent variable on the dependent variable. The independent variable is required to be measured in nominal scale i.e. it should have a number of categories. Each of the categories of the independent variable is considered as the treatment. The basic assumption of this design is that there are no differences in the test units. All the test units are treated alike and randomly assigned to the test groups. This means that there are no extraneous variables that could influence the outcome.

Suppose we know that the sales of a product is influenced by the price level. In this case, sales are a dependent variable and the price is the independent variable. Let there be three levels of price, namely, low, medium and high. We wish to determine the most effective price level i.e. at which price level the sale is highest. Here the test units are the stores which are randomly assigned to the three treatment level. The average sales for each price level is computed and examined to see whether there is any significant difference in the sale at various price levels. The statistical technique to test for such a difference is called ANalysis Of VAriance (ANOVA).

This design suffers from the main limitation that it does not take into account the effect of extraneous variables on the dependent variable. The possible extraneous variables in the present example could be the size of the store, the competitor's price and price of the substitute product in question. This design assumes that all the extraneous factors have the same influence on all the test units which may not be true in reality. This design is very simple and inexpensive to conduct.

(ii) **Randomized Block Design:** As discussed, the main limitation of the complete randomized design is that all extraneous variables were assumed to be constant over all the treatment groups. This may not be true. There may be extraneous variables influencing the dependent variable. In the randomized block design it is possible to separate the influence of one extraneous variable on a particular dependent variable, thereby providing a clear picture of the impact of treatment on test units.

In the example considered in the completely randomized design, the price level (low, medium and high) was considered as an independent variable and all the test units (stores) were assumed to be more or less equal. However, all stores may not be of the same size and, therefore, can be classified as small, medium and large size stores. In this design, the extraneous variable, like the size of the store could be treated as different blocks. Now the treatments are randomly assigned to the blocks in such a way so that each treatment appears in each block at least once. The purpose of forming these blocks is that it is hoped that the scores of the test units within each block would be more or less homogeneous when the treatment is absent. What is assumed here is that block (size of the store) is correlated with the dependent variable (sales). It may be noted that blocking is done prior to the application of the treatment.

In this experiment one might randomly assign 12 small-sized stores to three price levels in such a way that there are four stores for each of the three price levels. Similarly, 12 medium-sized stores and 12 large-sized stores may be randomly assigned to three price levels. Now the technique of analysis of variance could be employed to analyse the effect of treatment on the dependent variable and to

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separate out the influence of extraneous variable (size of store) from the experiment.

(iii) **Latin Square Design:** This design is employed when the researcher is interested in separating out the influence of two extraneous variables. Suppose the interest is to study the influence of price (treatment) on sales. Let there be three levels of price categorizes, namely, Low (X_1), Medium (X_2) and High (X_3). The sales could be influenced by two extraneous variables, namely, store size and type of packaging. For the application of the Latin square design, the number of categories of two extraneous variables should be equal to the number of levels of treatments. This is a necessary condition for the use of Latin square design. The store could be of size – Small (1), Medium (2) and Large (3) and type of packaging could be I, II and III. The Table 2.5 below presents the layout of the Latin square design.

Table 2.5 *Latin Square Design for Various Levels of Price*

	Store Size	Packaging		
		I	II	III
1	(Small)	X1	X2	X3
2	(Medium)	X2	X3	X1
3	(Large)	X3	X1	X2

It may be noted that the rows and columns represent those extraneous variables whose effect is to be controlled and measured. There are three categories of row variable (size of store) and three categories of column variable (type of packaging). This would result in 3 × 3 Latin square.

One point that has to be kept in mind is that the treatment should be assigned randomly to cells in such a way that each treatment occurs once and only once in each row and in each column. The treatments exhibited in Table 2.3 satisfy this condition.

Use of this design helps to measure statistically the effect of a treatment on the dependent variable and also the measurement of an error resulting from two extraneous variables. This design, indeed has a very complex setup and is quite expensive to execute.

(iv) **Factorial Design:** A factorial design may be employed to measure the effect of two or more independent variables at various levels. The factorial designs allow for interaction between the variables. An interaction is said to take place when the simultaneous effect of two or more variables is different from the sum of their individual effects. An individual may have a high preference for mangoes and may also like icecream, which does not mean that he would like mango icecream, leading to an interaction.

The sales of a product may be influenced by two factors, namely, price level and store size. There may be three levels of price—Low (A_1), Medium (A_2) and High (A_3). The store size could be categorized into Small (B_1) and Big (B_2). This could be conceptualized as a two-factor design with information reported in the form of a table. In the table, each level of one factor may be presented as a row and each level of another variable would be presented as a column. This example could be summarized in the form of a table having three rows and two columns. This would require 3 × 2 = 6 cells. Therefore, six different level of treatment combinations would be produced each with a specific level of price and store size. The respondents would be randomly selected and randomly assigned to the six cells. The tabular presentation of 3 × 2 factorial design is given in Table 2.6.

Table 2.6 *3 × 2 Factorial Design for Price Level and Store Size*

Price	**Store**	
	Small (B_1)	Big (B_2)
Low Level (A1)	A_1B_1	A_1B_2
Medium Level (A2)	A_2B_1	A_2B_2
High Level (A3)	A_3B_1	A_3B_2

Respondents in each cell receive a specified treatment combination. For example, respondents in the upper left hand corner cell would face small level of price and small store. Similarly, the respondents in the lower right hand corner cell will be subjected to both high price level and big store.

The main advantages of factorial design are:

- It is possible to measure the main effects and interaction effect of two or more independent variables at various levels.
- It allows a saving of time and effort because all observations are employed to study the effects of each factor.
- The conclusion reached using factorial design has broader applications as each factor is studied with different combinations of other factors.

The limitation of this design is that the number of combinations (number of cells) increases with increased number of factors and levels. However, a fractional factorial design could be used if interest is in studying only a few of the interactions or main effects.

- Experiments are used to infer causality where the researcher actively manipulates one or more causal variables and measure their effects on the dependent variable. There are three necessary conditions for inferring causality: (i) Concomitant variation (ii) Time order of occurrence of variables, and (iii) The absence of other possible causal factors. Various concepts like independent variables (treatments), test units, dependent variables, exogenous variables are used in conducting an experiment. An experiment can be conducted under different environmental conditions, namely, laboratory and field. The researcher has two goals while conducting an experiment: (i) To keep the internal validity of the experiment very high and (ii) To make generalization of the results of the experiments to a wider population. Internal validity is concerned with examining the absence of all the causal factors except the one whose influence is being examined on the dependent variable. External validity, on the other hand, refers to the generalization of the results of the experiment. There are various factors affecting the internal validity of the experiment. These are history, maturation, testing, instrumentation, statistical regression, selection bias and test units' mortality. Similarly, there are factors influencing the external validity of an experiment. Some of the factors may be common to both the internal and the external validity of the experiment. The methods of controlling the effects of extraneous variables are also discussed.

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Check Your Progress

1. Define the term research design?
2. Which research is considered to be a framework for a conclusive research?
3. Define case study with an example.
4. What is the area of focus in a trend research?
5. What is research design?
6. What is the objective of exploratory research design?
7. Classify the experimental design.
8. What is the use of factorial design?

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- Experimental designs are classified into pre-experimental, quasi-experimental, true-experimental and statistical design. Under pre-experimental design are included (i) One-shot case study, (ii) One-group pre-test post-test design and (iii) Static group comparison. The pre-experimental designs do not make use of randomization procedure in order to control the extraneous variables. Therefore, the internal validity of such experiments remains doubtful. Under quasi-experimental design are discussed (i) Time series design and (ii) Multiple time series design. In these designs the researcher has control over when the measurements are to be taken and on whom they are taken. However, the design lacks complete control of scheduling of treatment and also lacks ability to randomize test units exposure to treatments. Included in the category of true-experimental design are (i) Pre-test–post-test control group, (ii) Post-test–only control group and (iii) Solomon four-group design. In these designs, the researcher can randomly assign test units and treatments to experimental groups. The researcher is able to eliminate the effect of extraneous variables from both control and experimental groups. The statistical designs covered here are (i) Completely randomized design, (ii) Randomized block design, (iii) Latin square design, and (iv) Factorial design. The statistical designs help to (i) Study the effect of more than one level of independent variables on the dependent variable; (ii) Study the effect of more than one independent variable and (iii) The effect of specific extraneous variables.

2.5 SUMMARY

- A research design is a conceptual framework for conducting research. It is a blueprint for collecting, measuring and analyzing data. Research designs deal with the What, Where, When and How of an inquiry.
- Exploratory designs are the simplest and most loosely structured designs.
- The focus group technique, though originally rooted in sociology, is actively used in all branches of behavioral sciences. In a typical focus group, there is a carefully selected small set of individual representative of the larger respondent population under study.
- Cross-sectional study involves a slice of the population just as in scientific experiments one takes a cross-section of the leaf or the cheek cells to study the cell structure under the microscope, similarly one takes a current subdivision of the population and studies the nature of the relevant variables being investigated.
- A single sample of the identified population that is studied over a stretched period of time is termed as a longitudinal study design. A panel of consumers specifically chosen to study their grocery purchase pattern is an example of a longitudinal design.
- Selecting a part of the ‘universe’ with a view to draw conclusions about the ‘universe’ or ‘population’ for a study is known as sampling. A researcher uses sampling for saving time and costs as a selected sample is a replica of the population.
- A population is the aggregate of all the cases that conform to the researcher’s designated set of specifications. Therefore, the term people may mean all the residents of India, or those engaged in factory work, or women, boys under the

age of 20 and so on, as defined by the researcher. By specification all the boys under 20 would be included in the population of India, can be referred to as a sub-population or stratum with reference to the main population.

- A census is a count of all the elements in a population and a determination of the distribution of their characteristics, based on the information obtained for each of the elements. It is economical in terms of time, effort and money to get the desired information for only some of the elements than for all of them.
- When we select some of the elements with the intention of finding out something about the population from which they are taken, we refer to that group of elements as a sample. The expectation here is that what we find out about the sample is true of the population as a whole. This depends on the way the sample is selected.
- A measure use based on the entire population is called a parameter. A sample is any number of persons selected to represent the population according to some rule or plan. So, a sample is a smaller representation of the population. A measure based on a sample is known as a statistic.
- A sample is obtained according to a 'plan'. A sample design is a technique for selecting the items for a sample. The size of the sample means the number of items to be included in the sample. Sample design should be determined before data collection and the sample should be designed to suit the study.
- While designing a sample, the universe or set of objects to be studied need to be determined; sampling unit or the group from which sample is to be drawn needs to be decided; service list is the sampling from a list index or other population records from which the sample is to be drawn; size of the sample needs to be determined; factors to be studied have to be determined; budgetary constraints have to be kept in mind while drawing the sample.

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2.6 KEY TERMS

- **Extraneous variables:** Variables unrelated to the study but having an influence on the dependent variable
- **Exploratory designs:** The basic objective of this design is to explore and obtain clarity about the problem situation
- **Expert opinion survey:** The approach of collecting particulars from significant and erudite people

2.7 ANSWERS TO 'CHECK YOUR POGRESS'

1. A research design is a conceptual framework for conducting research. It is a blueprint for collecting, measuring and analysing data. Research designs deal with the What, Where, When and How of an inquiry.
2. Descriptive research is considered to be a framework for a conclusive research.
3. A case study is a research design that focuses on a single case rather than dealing with a sample of a large population. For example, a careful determination of the factors that led to the success or failure of a community project may be conducted.
4. A trend study focuses on a particular characteristic of the population over a specific period of time.

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5. Research design is a detailed plan of how a research study is to be completed.
6. The basic objective of exploratory research design is to explore and obtain clarity about the problem situation.
7. Experimental design can be classified as pre-experimental, quasi-experimental, true experimental and statistical.
8. Factorial design is used to measure the effect of two or more independent variables at various levels.

2.8 QUESTIONS AND EXERCISES

Short-Answer Questions

1. What is a research design?
2. What are the characteristics of a good research design?
3. What do you mean by two-tiered research design?
4. What is the significance of census and sample survey in sampling?

Long-Answer Questions

1. Explain briefly the significance of research design in a research process.
2. Evaluate the importance of research design in the social research scenario.
3. Explain experimental design with the help of diagrams.

2.9 FURTHER READING

Michael, V. P. 2012. *Research Methodology in Management*. New Delhi: Himalaya Publishing House.

Kothari, C R. 2014. *Research Methodology: Methods and Techniques*, 3rd edition. New Delhi: New Age International.

Saunders, Mark, Adrian Thornhill and Philip Lewis. 2009. *Research Methods for Business Students*, 5th edition. New Jersey: Pearson Education.

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UNIT 3 SAMPLING DESIGN

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Structure

3.0 INTRODUCTION

In this unit, you will learn about the significant features of sampling design. Sampling, however, is generally quite a complicated process. The two basic reasons due to which there are at times incorrect inferences in sampling are systematic bias and errors in sampling procedures. Such errors can lead to completely wrong results and hence completely wrong piece of information. Hence, it is necessary that a person carrying out a research has a thorough knowledge and experience of all the statistical and other techniques used in sampling design and research design.

3.1 UNIT OBJECTIVES

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

- Explain the sampling process
- Discuss the criteria of selecting a sampling process
- Describe the concept of standard error
- Understand the criteria and steps for selecting a sampling procedure
- Explain the characteristics of a good sample design
- Discuss the significance of probability and non-probability sampling

3.2 MEANING AND SIGNIFICANCE OF SAMPLE

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A part of population is called sample. Selecting a part of the universe with a view to draw conclusions about the 'universe' or 'population' for a study is called sampling

Fundamentals of Sampling

All items in any field of inquiry constitute a 'universe' or 'population. A complete enumeration of all the items in the 'population' is known as a census inquiry. It can be presumed that in such an inquiry, when all items are covered, no element of chance is left and the highest level of accuracy is obtained. But in practice this may not be true. Even the slightest element of bias in such an enquiry will get larger as the number of observation increases. Moreover, there is no way of checking the element of bias or its extent except through a re-survey or use of sample checks. Besides, this type of inquiry involves a great deal of time, money and energy. Therefore, when the field of inquiry is large, this method becomes difficult to adopt because of the resources involved. At times, this method is practically beyond the reach of ordinary researchers. Perhaps, government is the only institution which can get the complete enumeration carried out. Even the government adopts this in very rare cases such as population census which is conducted once in a decade. Further, many times it is not possible to examine each and every component in the population, and sometimes it is not possible to obtain sufficiently accurate results by studying only a part of total population. In such cases the utility of census surveysare pretty limited.

However, it needs to be emphasized that when the universe is small, it is no use resorting to a simple survey. When field studies are undertaken in practical life, consideration of time and cost invariably leads to a selection of respondents i.e., selecting of only a few. The respondents selected should be as representative of the total population as possible in order to produce a miniature cross-section. The selected respondents constitute what is technically called a 'Sample' and the process is called 'Sampling Technique'. The survey so conducted is known as 'Sample Survey'. If explained lgebraically, it would read such as let the population size be N and if a part of size n (which is < N) of this population is selected according to some rule for studying some characteristics of the population, the group consisting of these n units is known as 'Sample'. The researcher must prepare a sample design for his study, i.e., he must know how a sample should be selected and of what size such a sample would be.

A sample design is a definite plan for obtaining a sample from a given population. It refers to the technique or the procedure the researcher adopts while selecting components for the sample. Sample design may as well lay down the number if items to be included in the sample, i.e., the size of the sample. Sample design is determined before data are collected. There are many sample designs available from which a researcher can choose. Some designs are relatively more precise and easier to apply compared to others. A researcher must select/prepare a sample design which should be reliable and appropriate for his research study.

Some Fundamental Definitions

Some fundamental concepts related to sampling are discussed as follows.

(i) **Universe or Population:** The total number of items in any field of study is called the universe. The population refers to the total units or items about which

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information is required. The attributes that are the object of the study are called the characteristics and the units possessing them are known as elementary units. The aggregate of such units is the population.

All units in any field of study constitute the universe. All elementary units are the population. Often the two terms are used interchangeably, however, research needs a distinction. The population or universe can be of two types: (i) Finite and (ii) Infinite.

A finite population consists of fixed number of elements and the elements can be enumerated totally, e.g., the number of students in a state. The symbol N is used to depict the number of elements or items of a finite population.

An infinite is the one where all the elements cannot be observed, at least theoretically, e.g., the number of stars in the sky. In a sense, a very large finite population is an infinite population.

(ii) **Sample:** It is a subset of the population. It comprises only some elements of the population. If out of the 350 mechanical engineers employed in an organization, 30 are surveyed regarding their intention to leave the organization in the next six months, these 30 members would constitute the sample.

(iii) **Sampling Unit:** A sampling unit is a single member of the sample. If a sample of 50 students is taken from a population of 200 MBA students in a business school, then each of the 50 students is a sampling unit. Another example could be that if a sample of 50 patients is taken from a hospital to understand their perception about the services of the hospital, each of the 50 patients is a sampling unit.

(iv) **Sampling:** It is a process of selecting an adequate number of elements from the population so that the study of the sample will not only help in understanding the characteristics of the population but will also enable us to generalize the results. We will see later that there are two types of sampling designs—probability sampling design and non-probability sampling design.

(v) Parameter: As per definition, a parameter is an arbitrary constant whose value characterizes a member of a system (as a family of curves); also it is a quantity (as a mean or variance) that describes a statistical population. A parameter is a value, usually unknown (and which therefore has to be estimated), used to represent a certain population characteristic. For example, the population mean is a parameter that is often used to indicate the average value of a quantity. Within a population, a parameter is a fixed value which does not vary. Each sample drawn from the population has its own value of any statistic that is used to estimate this parameter. For example, the mean of the data in a sample is used to give information about the overall mean in the population from which that sample was drawn. Parameters are often assigned Greek letters Sigma (s) whereas statistics are assigned Roman letters (s). A statistical parameter is a parameter that indexes a family of probability distributions. It can be regarded as a numerical characteristic of a population or a model.

(vi) Statistic: A statistic (singular) is a single measure of some attributes of a sample, for example its arithmetic mean value. It is calculated by applying a function (statistical algorithm) to the values of the items of the sample, which are known together as a set of data. More formally, statistical theory defines a statistic as a function of a sample where the function itself is independent of the sample's distribution; that is, the function can be stated before realization of the data. The

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term statistic is used both for the function and for the value of the function on a given sample.

A statistic is distinct from a statistical parameter, which is not computable because often the population is much too large to examine and measure all its items. However, a statistic, when used to estimate a population parameter, is called an estimator. For example, the sample mean is a statistic that estimates the population mean, which is a parameter.

When a statistic (a function) is being used for a specific purpose, it may be referred to by a name indicating its purpose: in descriptive statistics, a descriptive statistic is used to describe the data; in estimation theory, an estimator is used to estimate a parameter of the distribution (population); in statistical hypothesis testing, a test statistic is used to test a hypothesis. However, a single statistic can be used for multiple purposes – for example the sample mean can be used to describe a data set, to estimate the population mean, or to test a hypothesis.

(vii) **Standard Error:** As per definition the 'Standard Error' is the standard deviation of the sampling distribution of a statistic. Standard error is a statistical term that measures the accuracy with which a sample represents a population. In statistics, sample mean deviates from the actual mean of a population; this deviation is the standard error. Thus the term 'standard error' is used to refer to the standard deviation of various sample statistics, such as the mean or median. The 'standard error of the mean' refers to the standard deviation of the distribution of sample means taken from a population. The smaller the standard error, the more representative the sample will be of the overall population. The standard error is also inversely proportional to the sample size; the larger the sample size, the smaller the standard error because the statistic will approach the actual value.

(viii) **Sampling Frame:** The elementary units that form the basis of the sampling process are known as sampling units. A list of all such sampling units is referred to as the sampling frame. The sampling frame is a list of items from which the sample is drawn. For research, a frame of the population is to be constructed which will enable the researcher to draw the sample, e.g., names from the census records or telephone directory, etc., for conducting a study on a sample that is drawn from the frame. Telephone directory is a frame, from which names are drawn to get the sample.

(ix) **Sampling Design:** Sampling design helps in obtaining a sample from the frame. It is the procedure or technique for obtaining those sampling units from which inferences can be made. The sampling design has to be prepared well in advance before undertaking any research.

(x) **Statistic(s) and Parameter(s):** A statistic is the characteristic of the sample whereas the parameter is the characteristic of the population. Sampling analysis involves estimating the parameter from the statistic.

(xi) **Sampling Error:** This refers to any inaccuracy which is spotted in the information collected because only a small portion of the population is included in the study. The sampling errors are also known as error variances. These arise out of sampling and are usually random variations in the sample estimates around the true population values.

Sampling error = Frame error + Chance error + Response error

Sampling errors decrease as the homogeny of the universe increases. Sampling error is usually worked out as the product of the article value at a certain level of significance and the standard error.

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Non-sampling errors also occur while collecting data. But these cannot be measured. Since the sample and not the universe is studied, work proceeds fast. This is a big advantage for research.

(xii) **Sample Distribution:** For example, say, from a population of 30,000, a random of 300 people is chosen for a given study. The observed data are arranged in a frequency distribution, e.g., fertility rate. This type of distribution is called sample distribution.

(xiii) **Population Distribution:** If the fertility rates of all the 30,000 people of the population are obtained and arranged in a frequency distribution, it is known as population distribution. Since the forms and parameters are not ordinarily known, an estimate of these two characteristics of population is made from the sample distribution. So, if the sample distribution is normal, one can assume that the population distribution is also normal.

3.2.1 Principle of Sampling

On the basis of sample study we can predict and generalise the behaviour of mass phenomena. This is possible because there is no statistical population whose elements would vary from each other (one another) without limit. For example, wheat varies to a limited extent in colour, protein content, length, weight etc., it can always be identified as wheat. Similarly, apples of the same tree may vary in size, colour, taste, weight etc., but they can always be identified as apples. Thus, we find that although diversity is a universal quality of mass data, every population has characteristic properties with limited variation. This makes possible the selection of a relatively small unbiased random sample that can portray well the traits of the population.

There are two important laws on which the theory of sampling is based:

1. Law of 'Statistical Regularity' and
2. Law of 'Inertia of Large numbers'

Law of Statistical Regularity

This law is derived from the mathematical theory of probability. In the words of king: 'The law of statistical regularity lays down that a moderately large no. of items chosen at random from a large group are almost sure on the average to possess the characteristics of the large group'. In other words, this law points out that if a sample is taken at random from a population, it is likely to possess almost the same characteristics as that of the population. This law directs our attention to one very important point, that is, the desirability of choosing the sample at random.

By random selection we mean a selection where each and every item of the population has an equal chance of being selected in the sample. In other words, the selection must not be made by deliberate exercise of one's discretion. A sample selected in this manner would be representative of the population. If this condition is satisfied, it is possible for one to depict fairly accurately the characteristics of the population by studying only a part of it. Hence, this law is of practical significance because it makes possible a considerable reduction of the work necessary before any conclusion is drawn regarding

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a large universe. For example, if one intends to make a study of the average height of the students of Delhi University, it is not necessary to measure the heights of each and every student. A few students may be selected at random from every college, their heights measured and the average height of university students in general may be inferred.

It should be noted that the results derived from the sample data may be different from that of the population. This is for the simple reason that the sample is only a part of the whole universe. For example, the average height of the students of Delhi University may come out to be 160 cm by census method whereas it may be 159 cm or 161 cm for the sample taken. It should be just a coincidence if the height comes out to be exactly 160 cm under both the methods. However, there would not be much difference in the results derived if the sample is representative of the universe.

Law of Inertia of Large Numbers

This law is a corollary of the law of statistical regularity. It is of great significance in the theory of sampling. It states that, other things being equal, larger the size of the sample, more accurate the results are likely to be. This is because large numbers are more stable as compared to small ones. The difference in the aggregate result is likely to be insignificant, when the number in the sample is large, because when large numbers are considered, the variations in the component parts tend to balance each other and therefore, the variation in the aggregate is insignificant. For example, if a coin is tossed 10 times, we should expecit equal no. of heads and tails, i.e., 5 each. But since the experiment is tried a small no. of times, it is likely that we may not get exactly 5 heads and 5 tails. The result may be a combination of 9 heads and 1 tail, or 8 heads and 2 tails, or 7 heads and 3 tails. If the same experiment is carried out 1000 times the chance of 500 heads and 500 tails would be very high i.e., the result would be very near to 50% heads and 50% tails.

The basic reason for such likelihood is that the experiment has been carried out a sufficiently large no. of times and possibility of variation in one direction compensating for others in a different direction is greater. If at one time we get continuously 5 heads, it is likely that at any other time we may get continuously 5 tails and so on, and for the experiment as a whole the no. of heads and tails may be more or less equal. Similarly, if it is intended to study the variation in the production of rice over a no. of years and data are collected from one or two States only, the result would reflect large variations in production due to the favourable factors in operation. If, on the other hand, figures of production are collected for all the States in India, it is quite likely that we find little variation in the aggregate. This does not mean that the production would remain constant for all the years. It only implies that the changes in the production of the individual States will be counterbalanced so as to reflect smaller variations in production for the country as a whole.

3.2.2 Essentials of Good Sample

If the sample results are to have any worthwhile meaning, it is necessary that a sample possesses the following essentials :

(i) ***Representativeness* :** A sample should be so selected that it truly represents the universe otherwise the results obtained may be misleading. To ensure representativeness, the random method of selection should be used.

(ii) ***Adequacy* :** The size of sample should be adequate, otherwise it may not represent the characteristics of the universe.

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(iii) ***Independence*** **:** All items of the sample should be selected independently of one another and all items of the universe should have the same chance of being selected in the sample. By independence of selection we mean that the selection of a particular item in one draw has influence on the probabilities of selection in any other draw.

(iv) ***Homogeneity*** **:** When we talk of homogeneity, we mean that there is no basic difference in the nature of units of the universe and that of the sample. If two samples from the same universe are taken, they should give more or less the same unit.

3.2.3 Methods of Sampling

The various methods of sampling can be grouped under two broad heads : Probability sampling (also known as random sampling) and non-probability (or non-randon) sampling.

Probability Sampling Methods: Probability sampling methods are those in which every item in the universe has a known chance, or probability, of being chosen for the sample. This implies that the selection of sample items is independent of the person making the study — that is, the sampling operation is controlled so objectively that the items will be chosen strictly at random.

Non-Probability Sampling Methods: Non-probability sampling methods are those which do not provide every item in the universe with a known chance of being included in the sample. The selection process is, at least, partially subjective. It may be noted that the team 'random sample' is not used to describe the data in the sample but the process employed in selecting the sample. Randomness is thus a property of the sampling procedure instead of an individual sample. As such, randomness can enter processed sampling in a no. of ways and hence random samples may be of many kinds.

Advantages of Probability Sampling: The following are the basic advantages of probability sampling methods :

(i) It does not depend upon the existence of detailed information about the universe for its effectiveness.

(ii) Probability sampling provides estimates which are essentially unbiased and have measurable precision.

(iii) It is possible to evaluate the relative efficiency of various sample designs only when probability sampling is used.

Limitations of Probability Sampling: Despite the great advantages of probability sampling techniques mentioned above, it has certain limitations because of which non-probability sampling is quite often used in practice. These limitations are :

(i) Probability sampling requires a very high level of skill and experience for its use.

(ii) It requires a lot of time to plan and execute a probability sample.

(iii) The costs involved in probability sampling are generally large as compared to non-probability sampling.

Non-random sampling is a process of sample selection without the use of randomization. In other words, a non-random sample is selected on a basis other than the probability consideration such as convenience, judgement etc.

The most important difference between random and non-random sampling is that whereas the pattern of sampling variability can be ascertained in case of random sampling, in non-random sampling, there is no way of knowing the pattern of variability in the process.

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I. Non-Probability Sampling Methods

(i) Judgement Sampling.

(ii) Convenience Sampling

(iii) Quota Sampling

II. Probability Sampling Methods

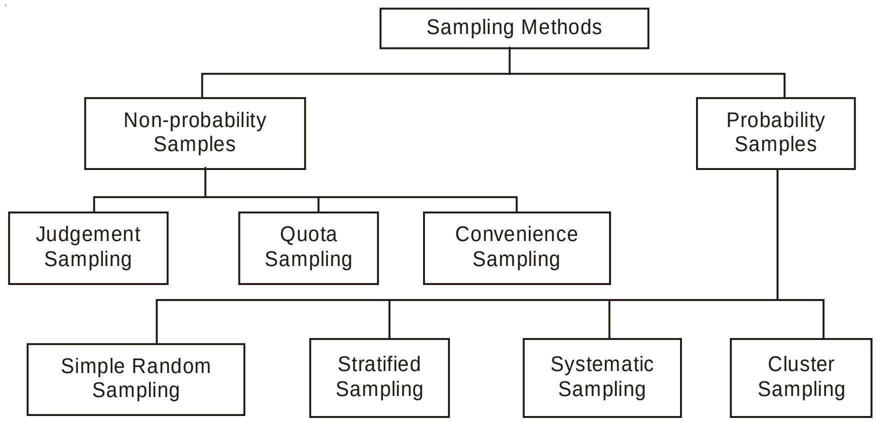
(a) Simple or Unrestricted Random Sampling and

(b) Restricted Random Sampling

  (i) Stratified Sampling

  (ii) Systematic Sampling

  (iii) Cluster Sampling



Non-Probability Sampling Methods

Judgement Sampling

In this method of sampling, the choice of sample items depends exclusively on the judgement of the investigator. In other words, the investigator exercises his judgement in the choice and includes those items in the sample which he thinks are most typical of the universe with regard to the characteristics under investigation. For example if sample of ten students is to be selected from a class of sixty for analysing the spending habits of students, the investigator would select 10 students, who, in his opinion, are representation of the class.

Merits

Though the principles of sampling theory are not applicable to judgement sampling, the method is sometimes used in solving many types of economic and business problems. The use of judgement sampling is justified under a variety of circumstances :

(i) When only a small no. of sampling units is in the universe, simple random selection may miss the more important elements, whereas judgement selection would certainly include them in the sample.

(ii) When we want to study some unknown traits of a population, some of whose characteristics are known, we may then stratify the population according to these known properties and select sampling units from each stratum on the basis of judgement. This method is used to obtain a more representative sample.

(iii) In solving everyday business problems and making public policy decisions, executives and public officials are often pressed for time and can not wait for probability sample designs. Judgement sampling is then the only practical method to arrive at solutions to their urgent problems.

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Limitations

(i) This method is not scientific because the population units to be sampled may be affected by the personal prejudice or bias of the investigator. Thus, judgement sampling involves the risk that the investigator may establish foregone conclusions by including those items in the sample which conform to his preconceived notions. For example, if an investigator holds the view that the wages of workers in a certain establishment are very low, and if he adopts the judgement sampling method, he may include only those workers in the sample whose wages are low and thereby establish his point of view which may be far from the truth. Since an element of subjectiveness is possible, this method cannot be recommended for general use.

(ii) There is no objective way of evaluating the reliability of sample results.

The success of this method depends upon the excellence in judgement. If the individual making decisions is knowledgeable about the population and has good judgement, then the resulting sample may be representative, otherwise the inferences based on the sample may be erroneous. It may be noted that even if a judgement sample is reasonably representative, there is no objective method for determining the size or likelihood of sample error. This is a big defect of the method.

Convenience Sampling

A convenience sample is obtained by selecting convenient population units.

The method of convenience sampling is also called the *chunk*. A chunk refers to that fraction of the population being investigated which is selected neither by probability nor by judgement but by *convenience.* A sample obtained from readily available lists such as automobile registrations, telephone directories, etc., is a convenience sample and not a random sample even if the sample is drawn at random from the lists. If a person is to submit a project report on labour management relations in textile industry and he takes a textile mill close to his office and interviews some people over there, he is following the convenience sampling method. Convenience samples are prone to bias by their very nature—selecting population elements which are convenient to choose almost always make them special or different from the rest of the elements in the population in some way.

Hence the results obtained by following convenience sampling method can hardly be representative of the population—they are generally biased and unsatisfactory. However, convenience sampling is often used for making pilot studies. Questions may be tested and preliminary information may be obtained by the chunk before the final sampling design is decided upon.

Quota Sampling

Quota Sampling is a type of judgement sampling and is perhaps the most commonly used sampling technique in non-probability category. In a quota sample, quotas are set up according to some specified characteristics, such as so many in each of several income

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groups, so many in each age, so many with certain political or religious affiliations, and so on. Each interviewer is then told to interview a certain no. of persons which constitutes his *quota*. Within the quota, the selection of sample items depends on personal judgement. For example, in a radio listening survey, the interviewers may be told to interview 500 people living in a certain area and that out of every 100 persons interviewed 60 are to be housewives, 25 farmers and 15 children under the age of 15. Within these quotas the interviewer is free to select the people to be interviewed. The cost per person interviewed may be relatively small for a quota sample but there are numerous opportunities for bias which may invalidate the results. For example, interviewers may miss farmers working in the fields or talk with those houswives who are at home. If a person refuses to respond, the interviewer simply selects someone else. Because of the risk of personal prejudice and bias entering the process of selection, the quota sampling is not widely used in practical work.

Quota sampling and stratified random sampling are similar in as much as in both methods the universe is divided into parts and the total sample is allocated among the parts. However, the two procedures diverge radically. In stratified random sampling, the sample within each stratum is chosen at random. In quota sampling, the sampling within each cell is not done at random, the field representatives are given wide latitude in the selection of respondents to meet their quotas.

Quota sampling is often used in public opinion studies. It occasionally provides satisfactory results if the interviewers are carefully trained and if they follow their instructions closely. It is often found that since the choice of respondents within a cell is left to the field representatives, the more accessible and articulate people within a cell will usually be the ones who are interviewed. Slight negligence on the part of interviewers may lead to interviewing ineligible respondents. Even with alert and conscientious field representatives it is often difficult to determine such control category as age, income, educational qualifications, etc.

Probability Sampling Method

Simple Unrestricted Random Sampling

Simple random sampling refers to that sampling technique in which each and every unit of the population has an equal opportunity of being selected in the sample. In simple random sampling, which items get selected in the sample is just a matter of chance — personal bias of the investigator does not influence the selection. It should be noted that the word 'random' does not mean 'haphazard' or 'hit-or-miss' — it rather means that the selection process is such that the chance only determines which items shall be included in the sample. As pointed out by Chou, when a sample of size n is drawn from a population with N elements, the sample is a 'simple random sample' if any of the following is true. And, if any of the following is true, so are the other two.

(i) All n items of the sample are selected independently of one another and all N items in the population have the same chance of being included in the sample. By independence of selection we mean that the selection of a particular item in one draw has no influence on the probabilities of selection in any other draw.

(ii) At each selection, all remaining items in the population have the same chance of being drawn. If sampling is made with replacement, i.e., when each unit drawn from the population is replaced prior to drawing the next unit, each item has a probability of $\frac{1}{N}$ of being drawn at each selection. If sampling is without replacement, i.e., when each unit drawn from the population is not replaced prior to drawing the next unit, the probability of selection of each item remaining in the population at the first draw is $\frac{1}{N}$, at the second draw is $\frac{1}{(N-1)}$, at the third draw is $\frac{1}{(N-2)}$, and so on. It should be noted that sampling with replacement has very limited and special use in statistics — we are mostly concerned with sampling without replacement.

(iii) All the possible samples of a given size *n* are equally likely to be selected.

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To ensure randomness of selection one may adopt either the Lottery method or consult table of random numbers.

Lottery method entails numbering/coding all the items of the universe on separate slips of identical size, shape and colour and folding them and mixed up in a container or drum. A blindfold selection (after shuffling them well) is then made of the no. of slips required to constitute the desired sample size.

The Lottery method discussed above becomes quite cumbersome as the size of the population increases. An alternative method of random selection is that of using the table of random numbers (or generate a required string of pseudo-random numbers).

Merits

(i) Since the selection of items in the sample depends entirely on chance, there is no possibility of personal bias affecting the results.

(ii) As compared to judgement sampling a random sample represents the universe in a better way. As the size of the sample increases, it becomes increasingly representative of the population.

(iii) The analys it can easily assess the accuracy of this estimate because sampling errors follow the pinciples of chance. The theory of random sampling is further developed than that of any other type of sampling which enables the analyst to provide the most reliable information at the least cost.

Limitations

(i) The use of simple random sampling necessitates a completely catalogued universe from which to draw the sample. But it is often difficult for the investigator to have up-to-date lists of all the items of the population to be sampled. This restricts the use of this method in economic and business data where very often we have to employ restricted random sampling designs.

(ii) The size of the sample required to ensure statistical reliability is usually larger under random sampling than stratified sampling.

(iii) From the point of view of field survey it has been claimed that cases selected by random sampling tend to be too widely dispersed geographically and that the time and cost of collecting data become too large.

(iv) Random sampling may produce the most non-random looking results. For example, thirteen cards from a well-shuffled pack of playing cards may consist of one unit. But the probability of this kind of occurrence is very, very low.

Restricted Random Sampling

Stratified Sampling

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Stratified random sampling or simply stratified random is one of the random methods which, by using the available information concerning the population, attempts to design a more efficient sample than obtained by the simple random procedure.

While applying stratified random sampling technique, the procedure followed is given below :

(i) The universe to be sampled is subdivided (or stratified) into groups which are mutually exclusive and collectively exhaustive.

(ii) A simple random sample is then chosen independently from each group.

This sampling procedure differs from simple random sampling in that in the latter the sample items are chosen at random from the entire universe. In stratified random sampling, the sampling is designed so that a designated no. of items is chosen from each stratum. In simple random sampling, the distribution of the sample among strata is left entirely to chance.

Process of Selection of a Stratified Random Sample

- **Basis of Stratification:** As a general rule, strata are created on the basis of a variable known to be correlated with the variable of interest and for which information on each universe element is known. Strata should be constructed in a way which will minimize differences among sampling units within strata, and maximize difference among strata. The knowledge of the traits of the population can go a long way in the process of stratification. The purpose of stratification is to increase the efficiency of sampling by dividing a heterogeneous universe in such a way that (i) There is as great a homogeneity as possible within each stratum and (ii) A marked difference is possible between the strata.
- **Number of Strata:** The practical considerations limit the no. of strata that is feasible, costs of adding more strata may soon outrun benefits. As a generalisation, more than six strata may be undesirable.
- **Sample Size within Strata:** While deciding this, we can use either a proportionate or disproportionate allocation. In proportionate allocation, one samples each stratum in proportion to its relative weight. In disproportion allocation, this is not the case. It may be pointed out that proportionate allocation approach is simple and if all one knows about each stratum is the no. of items in that stratum, it is generally also the preferred procedure. In disproportionate sampling, the different strata are sampled at different rates.

  As a general rule when variability among observations within a stratum is high, one samples that stratum at a higher rate than for strata with less internal variation.
- **Proportionate and Disproportionate Stratified Sample:** In a proportionate stratified sampling plan, the no. of items drawn from each stratum is proportional to the size of the stratum. For example, if the population is divided into five groups, their respective sizes being 10, 15, 20, 25 and 30 per cent of the population and a sample of 1000 is drawn, the desired proportionate sample may be obtained in the following manner.

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From stratum one, 1000 × (10/100)	=	100 items
From stratum two, 1000 × (15/100)	=	150 items
From stratum three, 1000 × (20/100)	=	200 items
From stratum four, 1000 × (25/100)	=	250 items
From stratum five, 1000 × (30/100)	=	300 items
Total	=	1000 items

Proportionate stratification yields a sample that represents the universe with respect to the proportion in each stratum in the population. This procedure is satisfactory if there is no great difference in dispersion from stratum to stratum. But, it is certainly not the most efficient procedure, especially when there is considerable variation in different strata. This indicate that in order to obtain maximum efficiency in stratification, we should assign greater representation to a stratum with a larger dispersion and smaller representation to one with small variation.

In disproportionate stratified sampling, an equal no. of cases is taken from each stratum regardless of how the stratum is represented in the universe. Thus, in the preceding example, an equal no. of items (200) from each stratum may be drawn. In practice, disproportionate stratified random sampling is common when sampling from a highly variable universe, wherein the variation of the measurements differs greatly from stratum to stratum.

Merits

(i) It is more representative.

(ii) It ensures greater accuracy.

(iii) It facilitates greater geographical concentration.

Limitations

(i) Each stratum must contain, as far as possible, homogeneous items as otherwise the results may not be reliable. If proper stratification of the population is not done, the sample may have the effect of bias.

(ii) The items from each stratum should be selected at random. But this may be difficult to achieve in the absence of skilled sampling supervisors and a random selection within each stratum may not be ensured.

(iii) Because of the likelihood that a stratified sample will be more widely distributed geographically than a random sample, cost per observation may be quite high.

Systematic Sampling

This method of sampling is also known as quasi-random sampling method. This is because once the initial starting point is determined, the remainder of the items selected for the sample are predetermined by the sampling interval.

A systematic sample is formed by selecting one unit at random and then selecting additional units at evenly spaced intervals until the sample has been formed. This method is popularly used in those cases where a complete list of the population from which sample is to be drawn is available. The list may be prepared in alphabetical, geographical, numerical or some other order. The items are then serially numbered. The first item is selected at random generally by following the Lottery method. Subsequent items are

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selected by taking every Kth item from the list where 'K' stands for the sampling interval or sampling ratio, i.e., the ratio of population size to the size of the sample. Symbolically

$$K = \frac{N}{n}$$

where $K =$ sampling interval

$N =$ universe size

and $n =$ sample size

Notes:

1. While calculating K, it is possible that we get a fractional value. In such a case, we should use approximation procedure, i.e., if the fraction is less than 0.5, it should be omitted and if it is more than 0.5, it should be taken as 1. If it is exactly 0.5, it should be omitted if the number is even and should be taken as 1, if the number is odd. This is based on the principle that the number after approximation should preferably be even. For example, if the no. of students is, respectively, 1020, 1150 and 1100 and we want to take a sample of 200, then K shall be :

(i) $K = \frac{1020}{200} = 5.1$ or 5

(ii) $K = \frac{1150}{200} = 5.75$ or 6

(iii) $K = \frac{1100}{200} = 5.5$ or 6.

If out of say 96 students (with roll numbers from 1 to 6) it is desired to take a sample of 10 students using Systematic Sampling method then we have $K = \frac{N}{n} = \frac{96}{10} = 6.9$ or 10. And from 1 to 96 roll numbers, the first student (between 1 and K, i.e., here between 1 and 10) will be selected at random and then we go on taking every Kth student. Suppose the first student comes out to be 5th. Then the sample would consist of the following roll numbers:

5, 15, 25, 35, 45, 55, 65,75, 85, 95.

2. Systematic sampling is relatively a simple technique and may be more efficient statistically than simple random sampling provided the lists are arranged wholly at random. However, it is rarely that this requirement is fulfilled. The nearest approach to randomness is provided by alphabetical lists such as are found in telephone directory although even these may have certain non-random characteristics.

Merits

(i) It is simple and convenient to adopt.

(ii) The time and work involved in sampling by this method are relatively less.

(iii) The results obtained are also found to be generally satisfactory provided care is taken to see that no periodic features associated with the sampling interval.

(iv) If populations are sufficiently large, systematic sampling can often be expected to yield results similar to those obtained by proportionate stratified random sampling.

Limitations

(i) It becomes less representative if we are dealing with populations having 'hidden periodicities'.

(ii) Also if the population is ordered in a systematic way, with respect to the characteristics the investigator is interested in, then it is possible that only certain types of items will be included in the population, or at least more of certain types than others. For instance, in a study of workers' wages, the list may be such that every tenth worker on the list gets wages above ₹ 2000 per month.

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Multistage Sampling or Cluster Sampling

Under this method, the random selection is made of primary, intermediate and final (or the ultimate) units from a given population or stratum. There are several stages in which the sampling process is carried out. At first, the stage units are sampled by some suitable method, such as simple random sampling. Then, a sample of second stage units is selected from each of the selected first stage units, again by some suitable method which may be the same as or different from the method employed for the first stage units.

Further stages may be added as required. The procedure may be illustrated as follows :

Suppose in a particular survey, we wish to take a sample of 1000 students from Delhi University, we may take college—primary units—as the first stage, then draw departments as the second stage and choose students as the third and last stage. In another example, if we are to choose a sample of 10,000 households from the State of Andhra Pradesh, we may take districts–primary units—as the first stage, then choose a no. of villages/towns/mandals (second stage) and then select a no. of households from each village/town/mandal (third stage).

Merits

(i) It introduces flexibility in the sampling method which is lacking in the other methods. It enables existing divisions and sub-divisions of the population to be used as units at various stages, and permits the field work to be concentrated and yet large area to be covered.

(ii) Another advantage of the method is that subdivision into second stage units (ie, the construction of the second stage frame) need be carried out for only those first stage units which are included in the sample. It is therefore, particularly valuable in surveys of underdeveloped areas where no frame is generally sufficiently detailed and accurate for subdivision of the material into reasonably small sampling units.

Limitations

However, a multistage sample is in general less accurate than a sample containing the same noumber of final stage units which have been selected by some suitable single stage process.

3.2.4 Sampling Process

Sampling theory deals with the relationships between a population and random samples drawn from the same. Population or a universe is an aggregate of items with common traits. A universe constitutes the totalilty of the components about which a researcher seeks to study. The universe may be finite or infinite. Finite universe contains a definite number or items. In an infinite unverse the number of items is indefinite.

Universe may be either hypothetical or real. In the hypothetical case, the universe does not exist and one only imagines the items constituting it. Tossing a coin and throwing the dice can be cited as examples of a hypothetical universe. The real universe consists of concrete objects.

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Sample is that part of the universe which is selected at random for the purpose of survey.

Sampling theory mainly deals with the relationship between a parameter and a statistic. The theory estimates the properties of the population on the basis of the sample and also evaluates the precision of the estimate. This is known as statistical induction or statistical inference as it attempts to draw the inference concerning the universe from the sample. To use this inductive method, first follow a deductive argument—imagine a universe (finite or infinite) and investigate the behaviour of the samples drawn from this universe applying the laws of probability. Such methodology is known as sampling theory. The objectives of the theory are listed below:

(i) **Statistical Estimation***:* This consists of estimating the unknown population parameters from a knowledge of statistical measures based on sample studies. The estimate can either be a point estimate or an interval estimate. Point estimate is a single estimate expressed in the form of a single figure, while interval estimate has two limits, viz., the upper limit and the lower limit within which the parameter value may lie, interval estimates are the ones which are often used in statistical induction.

(ii) **Statistical Inference:** The sampling theory helps in arriving at generalizations about the population/universe from the studies based on samples drawn from it. It also helps in testing the accuracy of such generalizations.

The theory of sampling can also be studied under two heads: (i) The sampling of attributes and (ii) The sampling of variables in the context of large and small samples. A small sample is one that has thirty items or less whereas a large sample has more than thirty items. When studying the qualitative characteristics of all items in a population, one obtains statistics of attributes in the form of two classes—one in which the attribute is present and the second where it is absent. The presence of an attribute may be termed as a 'Success' and its absence a 'Failure'.

The theory can also be applied in the context of statistics of variables (i.e., data relating to some characteristic concerning population which can be estimated). The objectives are:

- To compare the observed and expected values of the sample and to determine if the difference can be ascribed to the fluctuations of sampling.
- To estimate the population parameters from the sample.
- To find out the degree of reliability of the estimate.

The tests of significance used in dealing with problems arising in studying large samples are different from those used for small samples. This is because, the assumptions that one has to make in the case of large samples do not hold good for small samples. It is assumed in case of large samples that the sampling distribution tends to be normal and the sample values are approximately close to the population values. This helps in applying what is known as the *Z*-test. When *n* is large, the probability of a sample value of the statistic deviating from the parameter by more than three times its standard error is very small (it is 0.0027 as per table giving area under normal curve). The *Z*-test, thus is applied to find out the degree of reliability of a statistic in case of large samples. One, of course, needs to work out appropriate standard errors as they will enable one to give the limits within which the parameter values would lie or would enable one to judge whether the difference happens to be significant or not. For example, $\bar{X} \pm 3\sigma_{\bar{x}}$ would give the range within which the parameter mean value is expected to vary with 99.73 per cent confidence level.

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The sampling theory that is applied for large samples is not applicable in the case of small samples because in the case of samples, one cannot assume that the sampling distribution is approximately normal. A different technique is required for handling small samples in particular when the population parameters are unknown. Sir William S. Gosset developed a significance test, known as student's *t* test, based on *t* distribution. His was a significant contribution to the theory of sampling, applicable in case of small samples. Student's *t* test is used when two conditions are fulfilled: the sample size is thirty or less and the population variance is not known. While using *t* test, one assumes that in the population from which the sample has been drawn:

- The sample is randomly drawn.
- Observations are independent.
- There is no measurement error.
- And that in the case of two samples where equality of the two population means is to be tested, one assumes that the population variances are equal.

3.2.5 Concept of Standard Error

The standard deviation of the sampling distribution of a statistic is known as its Standard Error (S.E.) and it is considered the key in sampling theory. The utility of the concept of standard error in statistical induction lays in:

(i) The standard error helps in testing whether the difference between the observed and the expected frequencies would arise due to chance. The usual criterion followed is to find out if a difference is less than three times the S.E. The difference is supposed to arise as a matter of chance. If the difference is equal to or more than thrice the S.E., the chance fails to account for it, and the conclusion drawn is that it is a significant difference. The criterion is based on the fact that at ± 3 S.E., the normal curve covers an area of 99.73 per cent. Sometimes the criterion of two S.E. is also used in place of 3 S.E. Thus the standard error is an important measure in significance tests or in examining hypotheses. If the estimated parameter differs from the calculated statistic by more than 1.96 times the S.E., the difference is taken as significant at 5 per cent level of significance. In other words, the difference is outside the limits, i.e., it lies in the 5 per cent area (2.5 per cent on both sides) outside the 95 per cent area of the sampling distribution. Hence one can conclude with 95 per cent confidence that the said difference is not due to fluctuations of sampling. In such a case, the hypothesis that there is no difference is rejected at 5 per cent level of significance.

    But if the difference is less than 1.98 times the S.E., then it is considered not significant at 5 per cent level. It can then be said with 95 per cent confidence that it is because of the fluctuations of sampling. In such a case, the null hypothesis stands true. 1.96 is the critical value at 5 per cent level. The product of the critical value at a certain level of significance and S.E. is described as 'sampling error' at that particular level of significance. One can test the difference at certain other levels of significance as well depending upon one's requirement. Table 3.1 illustrates the criteria for judging significance at various important levels.

Table 3.1 *Criteria for Judging Significance at Various Important Levels*

Significance Level	Confidence Level	Critical Value	Sampling Error	Confidence Limits	Difference Significant If	Difference Insignificant If
5.0%	95.0%	1.96	1.96σ	$\pm$1.96σ	$\geq$ 1.96σ	$\leq$ 1.96σ
1.0%	99.0%	2.5758	2.5758σ	$\pm$2.5758σ	$\geq$ 2.5758σ	$\leq$ 2.5758σ
2.7%	99.73%	3	3σ	$\pm$3σ	$\geq$ 3σ	$\leq$ 3σ
4.55%	95.45%	2	2σ	$\pm$2σ	$\geq$ 2σ	$\leq$ 2σ

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(ii) The S.E.also provides a good measure of reliability and precision of a sample. The smaller the S.E., the greater the uniformity of sampling distribution and, therefore, greater the reliability of the sample. Conversely, the greater the S.E., the greater is the difference between observed and expected frequencies. In such a case, the unreliability of the sample is higher. The size of S.E., depends upon the sample size to a large extent and it varies inversely with the size of the sample. If reliability factor is to be doubled, i.e., reducing S.E. to 1/2 of its existing magnitude, the sample size should be increased four-fold.

(iii) The S.E. also enables one to specify the limits within which the parameters of the population with a specified degree of confidence. Such an interval is known as confidence interval. The following table gives the percentage of samples having their mean values within a range of population mean (μ) ± S.E.

Range	Per Cent Values
μ $\pm$1 S.E.	68.27%
μ $\pm$2 S.E.	95.45%
μ $\pm$3 S.E.	99.73%
μ $\pm$1.96 S.E.	95.00%
μ $\pm$2.5758 S.E.	99.00%

Important formulae for computing the standard errors concerning various measures based on samples are given as follows:

(a) In Case of Sampling of Attributes:

(i) Standard error of number of successes = $\sqrt{n \cdot p \cdot q}$

Where,

n = Number of events inn each sample.

p = Probability of success in each event.

q = Probability of failure in each event.

(ii) Standard error of proportion of successes = $\sqrt{\dfrac{p \cdot q}{n}}$

(iii) Standard error of the difference between proportions of two samples:

Where,

p = Best estimate of proportion of the population and is worked out as under:

$$p = \sqrt{p \cdot q\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}$$

$q = 1 - q$

n_1 = Number of events in sample one

n_2 = Number of events in sample two

Note: Instead of the above formula, we use the following formula:

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$$\sigma_{p_1 - p_2} = \sqrt{\frac{p_1 q_1}{n_1} + \frac{p_2 q_2}{n_2}}$$

When samples are drawn from two heterogeneous populations and where we cannot have the best estimate of proportion in the universe on the basis of the given sample data. Such a situation often arises in the study of association of attributes.

(b) In Case of Sampling of Variables (Large Samples):

(i) Standard error of mean when population standard deviation is known:

$$\sigma_{\bar{x}} = \frac{\sigma_p}{\sqrt{n}}$$

Where,

σ_p = Standard deviation of population

n = Number of items in the sample

Note: This formula is used even when *n* is 30 or less.

(ii) Standard error of mean population standard deviation is unknown:

$$\sigma_{\bar{x}} = \frac{\sigma_s}{\sqrt{n}}$$

Where,

σ_2 = Standard deviation of the sample and is worked out as under

$$\sigma_s = \sqrt{\frac{\Sigma(X_i - \bar{X})^2}{n-1}}$$

n = Number of items in the sample

(iii) Standard error of standard deviation when population standard deviation is known:

$$\sigma_{\sigma_s} = \frac{\sigma_p}{\sqrt{2n}}$$

(iv) Standard error of standard deviation when population standard deviation is unknown:

$$\sigma_{\sigma_s} = \frac{\sigma_s}{\sqrt{2n}}$$

$$\sigma_s = \sqrt{\frac{\Sigma(X_i - \bar{X})^2}{n-1}}$$

Where,

n = Number of items in the sample.

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(v) Standard error of the coefficient of simple correlation:

$$\sigma_r = \frac{1-r^2}{\sqrt{n}}$$

Where,

r = Coefficient of simple correlation

n = Number of items in the sample

(c) When Two Samples are Drawn from the Same Population:

$$\sigma_{\bar{X}_1-\bar{X}_2} = \sqrt{\sigma_p^2\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}$$

(If σ_p is not known, sample standard deviation for combined samples (σ_{s12}) may be substituted).

(d) When Two Samples are Drawn from Different Populations:

$$\sigma_{\bar{X}_1-\bar{X}_2} = \sqrt{\frac{(\sigma_{p_1})^2}{n_1}+\frac{(\sigma_{p_2})^2}{n_2}}$$

(If σ_{p1} and σ_{p2} are not known, then in their places σ_{s1} and σ_{s2} respectively, may be substituted.)

(e) In Case of Sampling of Variables (Small Samples):

(i) Standard error of mean when σ_p is unknown:

$$\sigma_{s_{1,2}} = \sqrt{\frac{n_1(\sigma_{s_1})^2+n_2(\sigma_{s_2})^2+n_1(\bar{X}_1-\bar{X}_{1,2})^2+n_2(\bar{X}_2-\bar{X}_{1,2})^2}{n_1+n_2}}$$

Where, $\bar{X}_{1,2} = \dfrac{n_1(\bar{X}_1)+n_2(\bar{X}_2)}{n_1+n_2}$

Notes: 1. All the above formulae apply only for infinite population. In cse the population is finte, sampling is done without replacement and the sample size is more than 5 per cent of the population, the finite population multiplier must be used in the S.E formulae. For example, SE_x for finite population will go as given below:

$$SE_{\bar{X}} = \frac{\sigma_p}{\sqrt{n}}\cdot\sqrt{\frac{(N-n)}{(N-1)}}$$

Cases in which the population is very large in relation to the size of the sample, the finite population multiplier is close to one and has little effect on the calculation of S.E. In such a case where the sampling fraction is less than 0.05, the finite population multiplier is not generally used.

$$\sigma_{\bar{X}} = \frac{\sigma_s}{\sqrt{n}} = \sqrt{\frac{\frac{\Sigma(X_i-\bar{X})^2}{n-1}}{\sqrt{n}}}$$

2. Standard error of difference between two sample means when σ_p is unknown

$$\sigma_{\bar{X}_1-\bar{X}_2} = \sqrt{\frac{\Sigma(X_{1i}-\bar{X}_1)^2+\Sigma(X_{2i}-\bar{X}_2)^2}{n_1+n_2-2}}\cdot\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}$$

3.2.6 Census and Sample Survey

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A population is the aggregate of all the cases that conform to the researcher's designated set of specifications. Therefore, the term people may mean all the residents of India, or those engaged in factory work, or women, boys under the age of 20 and so on, as defined by the researcher. By specification all the boys under 20 would be included in the population of India, can be referred to as a **sub-population** or **stratum** with reference to the main population.

A stratum may be defined by one or more specifications that divide a population into mutually exclusive segments, e.g., a given population may be subdivided into strata of males under the age of 21 and females under age of 21. Similarly, one can have a stratum based on education, income, etc.

A single member of a population is known as an element. Often, one wants to know how certain characteristics of the elements are distributed in a population, e.g., one wants to the age distribution of people who have a particular political preference.

A census is a count of all the elements in a population and a determination of the distribution of their characteristics, based on the information obtained for each of the elements. It is economical in terms of time, effort and money to get the desired information for only some of the elements than for all of them.

When we select some of the elements with the intention of finding out something about the population from which they are taken, we refer to that group of elements as a sample. The expectation here is that what we find out about the sample is true of the population as a whole. This depends on the way the sample is selected.

A measure use based on the entire population is called a **parameter**. A sample is any number of persons selected to represent the population according to some rule or plan. So, a sample is a smaller representation of the population. A measure based on a sample is known as a **statistic**.

All items in a field of inquiry are thought to constitute a universe or a population. A complete enumeration of all the items in the population is called a census inquiry. It is presumed that a census enquiry gives the highest possible accuracy. In practice, this may not be so. Even the slightest error may get magnified as the observations increase. However, such a census type of enquiry costs lots of time, money and effort. Therefore, a smaller sample is chosen for study. The methods used to select samples are called sampling techniques. The survey that follows is called a sample survey.

Factors influencing decisions while drawing a sample are:

- **Size of the Population:** When the population size is large; the selection of a sample becomes necessary.
- **Costs Involved in Obtaining the Elements:** If the cost is reasonable; the sampling inquiry is facilitated.
- **Convenience of Availability of the Elements:** Each of these factors is important for deciding to select a sample, for study.

A sample is obtained according to a 'Plan'. A sample design is a technique for selecting the items for a sample. The size of the sample means the number of items to be included in the sample. Sample design should be determined before data collection and the sample should be designed to suit the study.

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In a research study, we are generally interested in studying the characteristics of a population. Suppose, in a town there are two thousand households and we are interested in estimating the proportion of those households who spend their summer vacations in a hill station. This information can be obtained by asking every household in that town. If all the households in a population are asked to provide information, such a survey is called a census. There is an alternative way of obtaining the same information by choosing a subset of all the two thousand households and asking them for the same information. This subset is called a sample. Based upon the information obtained from the sample, a generalization about the population characteristic could be made. However, that sample has to be representative of the population. For a sample to be a representative of the population, the distribution of sampling units in the sample has to be in the same proportion as the elements in the population. For example, if in a town there are 50, 35 and 15 per cent households in lower, middle and upper income groups, then a sample taken from this population should have the same proportions in for it to be representative. There are several advantages of sample over census.

- Sample saves time and cost. Consider as an example that we are interested in estimating the monthly average household expenditure on food items by the people of Delhi. It is known that the population of Delhi is approximately 1.2 crore. Now, if we assume that there are five members per household, it would mean that the population comprises approximately twenty-four lakh households. Collecting data on the expenditure of each of the twenty-four lakh households on food items would be a very time-consuming and expensive exercise. This is because you will need to hire a number of investigators and train them before you conduct the survey on the twenty-four lakh households. Instead, if a sample of, say, twenty households is chosen, the task would not only be finished faster but will be in expensive, too.
- Many times a decision-maker may not have too much of time to wait till all the information is available. Therefore, a sample could come to his rescue.
- There are situations where a sample is the only option. When we want to estimate the average life of fluorescent bulbs, what is done is that they are burnt out completely. If we go for a complete enumeration there would not be anything left for use. Another example could be testing the quality of a photographic film. To test the quality, we need to expose it completely and the moment it is exposed it gets destroyed. Therefore, sample is the only choice.
- The study of a sample instead of complete enumeration may, at times, produce more reliable results. This is because by studying a sample, fatigue is reduced and fewer errors occur while collecting the data, especially when a large number of elements are involved.

A census is appropriate when the population size is small, e.g., the number of public sector banks in the country. Suppose the researcher is interested in collecting information from the top management of a bank regarding their views on the monetary policy announced by the Reserve Bank of India (RBI), in this case, a complete enumeration may be possible as the population size is not very large. As another example, consider a business school in Mumbai that enrolls a few students from Europe, East Africa, South East Asia and the Middle East. These students would have their own problems in settling down in the Indian environment because of the differences in social, cultural and environmental factors. To understand their concerns, a survey of population may be more appropriate. Therefore, a survey of population could be used when there is a lot of heterogeneity in the variables of interest and the population size is small.

NOTES

Exhibit 3.1

1995 was an important year for the disability sector in India. It was the year when The Disability Act was passed. It was in that period that the disability sector also recognised one basic fact - that in the absence of correct statistics, people with disabilities will never get counted! It was promised to us by the then Government that appropriate data will be collected in Census 2001.

The arguments for not including disability in Census 2001 were:

1. The Census on disability that was conducted in 1981 was not successful. It did not give a correct estimate of disabled people in our country. The Census Commission was made responsible for this failure and hence, the practice was discontinued.
2. The Enumerators will find it difficult to elicit information from the respondents regarding the type of disability, etc.
3. People with disabilities will hide their disability or that their families will not be forthcoming with the information.

The fundamental strength and value of the Census comes from its universal coverage and its freedom from sampling error. Another advantage of the Census is that the statistics on persons with disabilities can be analysed by a wide range of other Census variables (such as, age, marital status, income, labour force status, family status, etc.) and then compared with the results for the total population. What is more, the Census can give estimates for small areas and small populations, which is usually not possible in Sample Surveys because of their sample size limitations. No doubt that the Census may have problems with under-estimation of persons with disabilities, particularly with mild disability and children and older persons with disabilities and hence can provide only a crude measure of disability. If these problems of under-estimation are taken into account while analysing the data, the Population Census can provide baseline information on frequency and distribution of disability in the population. This frequency and distribution data is essential for policy planning and fund allocation according to the region. Data obtained in the Census can then be utilized for the development of representative surveys and studies where more detailed information can be collected on persons with disabilities. The data obtained through the Population Census could be used to reduce the inherent disadvantage of limited sample size prevalent in sample surveys. The ideal approach would then be the use of Population Census as a screening device and use it to improve the efficiency of the sample selection in a Sample Survey and thereby reduce its costs as well!

On 11th June, the Government made an official announcement that disability has been included in Census 2001.

The inclusion of disability in Census 2001 is a major victory for all of us in the disability sector. This whole Census episode symbolizes the status of disability in our country. It took us so many rallies, dharnas, sit-ins, etc., to convince the Government about something so simple and logical as this! On the positive side, we can now confidently say that the disability sector has finally arrived. This victory has once again proved that there is a greater strength for all of us in cross-disability unity!

Now, the bigger challenge before us is that we have to ensure that this exercise is conducted in a proper manner.

Source: http://www.disabilityworld.org/01-02_01/news/census.htm NATIONAL CENTRE FOR PROMOTION OF EMPLOYMENT FOR DISABLED PEOPLE – accessed on 8 February, 2012.

NOTES

Uses of Sampling in Real Life

In our day-to-day life we make use of the concept of sampling. There is hardly any person who has not made use of the concept in a real-life situation. Consider the following examples:

- Suppose you go to a grocery shop to purchase rice. You have been instructed by your mother to purchase good quality rice. On reaching the grocery shop you have the choice of buying the rice from any one of three bags. What is generally done is that you pick up a handful of rice from each bag, examine its quality and then decide about which bag's rice is to be bought. The concept of sampling is being used here as a handpick from each bag is a sample and examining the quality is a process by which you are trying to assess the quality of all the rice in the bag.
- Suppose you have a guest for dinner at your residence. Your mother prepares a number of dishes and before the guest arrives, she may give you a tablespoon of each of the dish to taste and tell her whether all the ingredients are in the right proportion or not. Again, a sample is being taken from each of the dish to know how each of them tastes.
- You go to a bookshop to buy a magazine. Before you decide to buy it, you may flip through its pages to know whether the contents of the magazines are of interest to you or not. Again, a sample of pages is taken from the magazine.

Exhibit 3.2 *Qualitative Research Design*

Qualitative research design may be divided into two types: Parallel sampling and Nested sampling designs. A body of sampling strategies that helps in credible comparisons of two or more cases represents parallel sampling design. In pair-wise sampling design, designs can involve comparing each case to all others in the sample. In subgroup sampling design, it can involve comparing subgroups of cases. Generally, research questions determine the sampling design that has to be used. Sampling strategies that encourage credible comparisons of two or more members of the same sub group, where one or more members of the subgroup represent a sub-sample of cases is known as a nested sampling design. Nested sampling designs are more useful for grounded theorists as theoretical sampling is the characteristic of grounded theory design.

3.2.7 Criteria and Steps for Selecting a Sampling Procedure

The following are the steps of sample design:

- **Type of Universe:** Define the universe or set of objects to be studied. The universe can be finite or infinite. In the finite universe, the number of items is certain, while in the infinite universe, it is uncertain. An example of the former is the number of industrialists in a country, and the latter, the number of stars in the sky.
- **Sampling Unit:** This is the group from which the sample is to be drawn. For example, a population unit can be in terms of people's age, gender, etc., and a housing unit like bungalow, flat, etc., or an educational unit like university, college, school, etc.
- **Service List:** The sampling from a list index or other population records from which the sample is to be drawn, e.g., prepare all the items in the universe from which the selection of the sample can be made. It should be comprehensive, correct and reliable, so that the sample becomes representative.

- **Size of the Sample:** This refers to the number if items to be selected from the population, to constitute the sample. An optimum sample size should be reliable, flexible and representative. The size could be determined by the precision with which estimations are needed. Cost considerations also come into play, here.
- **Parameters of Interest:** This involves the type of measures needed from the sample. What factors you want to study.
- **Budgetary Constraints:** This refers to the practical problems about the size of the sample and costs associated with the collection of data from the sample.

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Criteria of Selecting a Sampling Procedure

Sampling is a complicated process. A researcher has to identify all the factors that can affect the sample. The various criteria related to choice of sampling procedure are as follows:

- **Purpose:** Purpose of a survey helps in selection of a particular method of sampling to the researcher. The particular method of sampling choice depends on the geographical area of the survey and size and nature of the study.
- **Measurability:** The application of statistical inference theory requires computation of the sampling error from the sample itself. Probability samples only allow such computation. Hence, where the research objectives require statistical inference, the sample should be drawn by applying simple random sampling method or stratified random sampling method, depending whether the population is homogeneous or heterogeneous.
- **Degree of Precision:** Desired level of precision of the result of the survey decides the method adopted for sampling.
- **Information about Population:** Details of information available about the population to be studied helps in deciding the method of sampling. If no data is available about population, it is difficult to apply probability random sampling. In this condition non-probability sampling method can be used for gaining the idea of population.
- **Nature of Population:** Whether population is homogeneous or heterogeneous is decided by the variables that is being studied. Simple random sampling can be used for homogeneous population and if the population is heterogeneous, then stratified random sampling is a better option.
- **Geographical Area of Study and Size of Population:** Multi-stage, cluster sampling is used for the study of wide geographical are as and large size of population.
- **Financial Resources:** Availability of finance decides the need of sampling method.
- **Time Limitation:** Time limit to complete a study decides the method of sampling.

There are three principles that guide sampling theory. These methods are as follows:

1. In majority of cases of sampling there is a huge difference between the sample statistics and the true population mean, which is attributable to the selection of the units in the sample.
2. The greater the sample size; the more accurate will be the estimate of the true population mean.

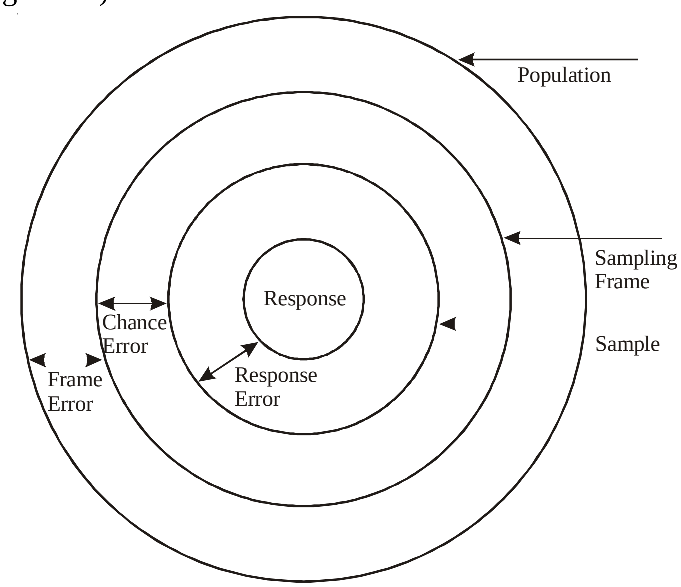
3. The greater the difference in the variable of the study in a population for a given sample size, the greater will be the difference between the sample statistics and the true population mean.

NOTES

Systemic Bias and Sampling Errors

There are two reasons for incorrect inferences arising out of sampling. They are as follows:

1. **Systemic Bias:** This bias can arise from one or more of the following reasons:
   - (i) ***Inappropriate Sampling:*** This means there is a bias in the representation of the universe, from where the sample is drawn,
   - (ii) ***Defective Measuring Device:*** A physical measuring device is faulty or the questionnaire or the interviewer has a bias. This defect would lead to a systematic bias.
   - (iii) ***Non-Responding:*** Inability to sample all the individuals initially included in the sample, could give rise to a bias.
   - (iv) ***Indeterminacy Principle:*** Individuals act differently while being observed. This can cause a systematic bias.
   - (v) ***Natural Bias in the Reporting of the Data:*** For example, people understate their incomes when the government asks for it, but overstate when social status is involved. In psychological surveys there is a tendency to give a 'Right' answer, rather than a true one.
2. **Sampling Errors:** These are random variations in the sample estimate around the true population mean. Sampling errors are errors that arise from the inaccurate sampling and they generally happen to be random variations (when sampling is random) in the sample estimates around the true population values (see Figure 3.1).



Sampling Error = Frame Error
+ Chance Error + Response Error
(If we add measurement error or the non-sampling error to sampling error, we get total error)

Fig. 3.1 *Sampling Error*

Source: C.R. Kothari, *Research Methodology: Methods and Techniques*, 1995.

Sampling error = Frame error + Chance error + Response error

Sampling error is compensatory in nature and the expected value of such an error happens to be equal to zero. The magnetite of the sampling error depends on the nature of the universe. A larger sample design is yet another way to reduce sampling error. Select a sample procedure that helps control systematic bias and sampling error.

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3.2.8 Characteristics of a Good Sample Design

The following are the criteria of a good sample design:

- Sample design should take care of the every possible sampling error.
- Sample design should be chosen judiciously, keeping costs in mind.
- Sample design must attempt to control systematic bias in the best possible way.
- Sample findings should be applied with a reasonable level of confidence.

Different Types of Sample Design

For selecting elements on the representation basis, the sample may be obtained by using either probability sampling or non-probability sampling. Probability sampling is based on random selection whereas non-probability sampling is based on non-random sampling.

On element selection basis, the sample may be either restricted or unrestricted. When each sample element is drawn individually from the population at large, the sample is known as unrestricted sample. All the other forms of sampling are covered under the term restricted sample. Figure 3.2 shows the simplified process of sampling.

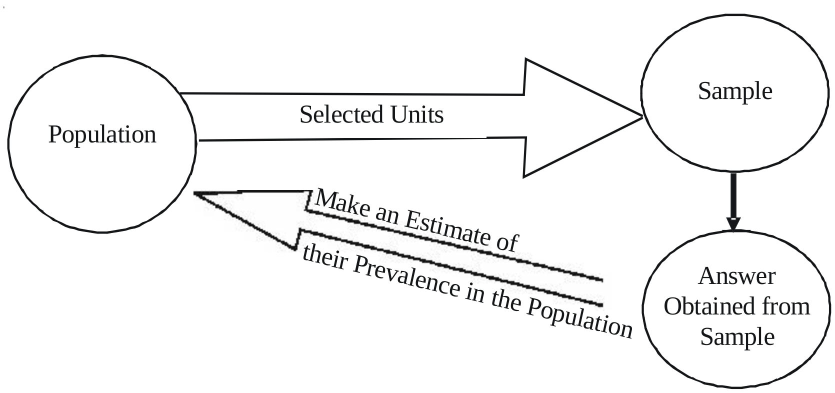

Fig. 3.2 *Sampling Process*

There are some advantages and disadvantages of simple random sampling. These are given as follows:

Advantages

The advantages of simple random sampling are:

- It is a representative sample.
- It is assumed that all the characteristics of the population are reflected in the sample.
- This is the easiest and simplest of all probability sampling methods.
- This random sampling can be applied in conjunction with many other probability sampling methods.
- The sampling error can be easily estimated.

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Disadvantages

The disadvantages of simple random sampling are:

- It is difficult to ensure that the smaller elements that exist in a population are included in the sample. For example, in a population of 500 persons, only 12 people are dialectic. The sample size is only 50. The chance that they would be included is very slim.
- The simple random sampling method cannot fully avail of certain information available in the sample. For example, if one knows that there is a population of children, who are bright, dull, those who are artistic, etc., all these elements cannot be brought into the sample.
- Sampling error is greater in the random sample than in a stratified random sample. To minimize the error stratified random sample is used.

Random Sample from an Infinitive Universe

Under this sampling design, the entire population (universe) is divided into strata (groups), which are mutually exclusive and collectively exhaustive. By mutually exclusive, it is meant that if an element belongs to one stratum, it cannot belong to any other stratum. Strata are collectively exhaustive if all the elements of various strata put together completely cover all the elements of the population. The elements are selected using a simple random sampling independently from each group.

There are two reasons for using a stratified random sampling rather than a simple random sampling. One is that the researchers are often interested in obtaining data about the component parts of a universe. For example, the researcher may be interested in knowing the average monthly sales of cell phones in large, medium and small stores. In such a case, separate sampling from within each stratum would be called for. The second reason for using a stratified random sampling is that it is more efficient as compared to a simple random sampling. This is because dividing the population into various strata increases the representativness of the sampling as the elements of each stratum are homogeneous to each other.

There are certain issues that may be of interest while setting up a stratified random sample. These are as follows:

What criteria should be used for stratifying the universe (population)?

The criteria for stratification should be related to the objectives of the study. The entire population should be stratified in such a way that the elements are homogeneous within the strata, whereas there should be heterogeneity between strata. As an example, if the interest is to estimate the expenditure of households on entertainment, the appropriate criteria for stratification would be the household income. This is because the expenditure on entertainment and household income are highly correlated. As another example, if the objective of the study is to estimate the amount of money spent on cosmetics, then, gender could be used as an appropriate criteria for stratification. This is because it is known that though both men and women use cosmetics, the expenditure by women is much more than that of their male counterparts. Someone may argue out that gender may no longer remain the appropriate criteria if it is not backed by income. Therefore, the researcher might have to use two or more criteria for stratification depending upon the problem in hand. This would only increase the number of strata thereby making the sampling difficult.

Generally stratification is done on the basis of demographic variables like age, income, education and gender. Customers are usually stratified on the basis of life stages and income levels to study their buying patterns. Companies may be stratified according to size, industry, profits for analysing the stock market reactions.

How many strata should be constructed?

Going by common sense, as many strata as possible should be used so that the elements of each stratum will be as homogeneous as possible. However, it may not be practical to increase the number of strata and, therefore, the number may have to be limited. Too many strata may complicate the survey and make preparation and tabulation difficult. Costs of adding more strata may be more than the benefit obtained. Further, the researcher may end up the practical difficulty of preparing a separate sampling frame as the simple random samples are to be drawn from each stratum.

What should be appropriate number of samples size to be taken in each stratum?

This question pertains to the number of observations to be taken out from each stratum. At the outset, one needs to determine the total sample size for the universe and then allocate it between each stratum. This may be explained as follows:

Let there be a population of size N. Let this population be divided into three strata based on a certain criterion. Let N_1, N_2 and N_3 denote the size of strata 1, 2 and 3, respectively, such that $N = N_1 + N_2 + N_3$. These strata are mutually exclusive and collectively exhaustive. Each of these three strata could be treated as three populations. Now, if a total sample of size n is to be taken from the population, the question arises that how much of the sample should be taken from strata 1, 2 and 3, respectively, so that the sum total of sample sizes from each strata adds up to n.

Let the size of the sample from first, second and third strata be n_1, n_2, and n_3, respectively such that $n = n_1 + n_2 + n_3$. Then, there are two schemes that may be used to determine the values of n_i, ($i = 1, 2, 3$) from each strata. These are proportionate and disproportionate allocation schemes.

Proportionate Allocation Scheme

In this scheme, the size of the sample in each stratum is proportional to the size of the population of the strata. As an example, if a bank wants to conduct a survey to understand the problems that its customers are facing, it may be appropriate to divide them into three strata based upon the size of their deposits with the bank. If we have 10,000 customers of a bank in such a way that 1,500 of them are big account holders (having deposits more than ₹ 10 lakh), 3,500 of them are medium sized account holders (having deposits of more than ₹ 2 lakh but less than ₹ 10 lakh), the remaining 5,000 are small account holders (having deposits of less than ₹ 2 lakh). Suppose the total budget for sampling is fixed at ₹ 20,000 and the cost of sampling a unit (customer) is ₹ 20. If a sample of 100 is to be chosen from all the three strata, the size of the sample from Strata 1 would be as follows:

$$n_1 = n + \frac{N_1}{N} = 100 \times \frac{1500}{10000} = 15$$

The size of sample from Strata 2 would be:

$$n_2 = n + \frac{N_2}{N} = 100 \times \frac{3500}{10000} = 35$$

The size of sample from strata 3 would be:

$$n_3 = n + \frac{N_3}{N} = 100 \times \frac{5000}{10000} = 50$$

NOTES

This way the size of the sample chosen from each stratum is proportional to the size of the stratum. Once you have determined the sample size from each stratum, one may use the simple random sampling or the systematic sampling or any other sampling design to take out samples from each of the strata.

Disproportionate Allocation

As per the proportionate allocation explained above, the sizes of the samples from Strata 1, 2 and 3 are 15, 35 and 50, respectively. As it is known that the cost of sampling of a unit is ₹ 20 irrespective of the strata from where the sample is drawn, the bank would naturally be more interested in drawing a large sample from Stratum 1, which has the big customers, as it gets most of its business from Strata 1. In other words, the bank may follow a disproportionate allocation of sample as the importance of each stratum is not the same from the point of view of the bank. The bank may like to take a sample of 45 from Strata 1 and 40 and 15 from Strata 2 and 3, respectively. Also, a large sample may be desired from the strata having more variability.

3.3 SAMPLE VS. CENSUS

In a research study, we are generally interested in studying the characteristics of a population. Suppose in a town there are 2 lakh households and we are interested in estimating the proportion of those households who spend their summer vacations in a hill station. This information can be obtained by asking every household in that town. If all the households in a population are asked to provide information, such a survey is called a census. There is an alternative way of obtaining the same information by choosing a subset of all the two lakh households and asking them for the same information. This subset is called a sample. Based upon the information obtained from the sample, a generalization about the population characteristic could be made. However, that sample has to be representative of the population. For a sample to be a representative of the population, the distribution of sampling units in the sample has to be in the same proportion as the elements in the population. For example, if in a town there are 50, 35 and 15 per cent households in lower, middle and upper income groups, then a sample taken from this population should have the same proportions for it to be representative. There are several advantages of sample over census.

- Sample saves time and cost. Consider as an example that we are interested in estimating the monthly average household expenditure on food items by the people of Delhi. It is known that the population of Delhi is approximately 1.2 crore. Now, if we assume that there are five members per household, it would mean that the population comprises approximately 24 lakh households. Collecting data on the expenditure of each of the 24 lakh households on food items would be a very time-consuming and expensive exercise. This is because you will need to hire a number of investigators and train them before you conduct the survey on the 24 lakh households. Instead, if a sample of, say, 2000 households is chosen, the task would not only be finished faster but will be in expensive, too.

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- Many times a decision-maker may not have too much of time to wait till all the information is available. Therefore, a sample could come to his rescue.
- There are situations where a sample is the only option. When we want to estimate the average life of fluorescent bulbs, what is done is that they are burnt out completely. If we go for a complete enumeration there would not be anything left for use. Another example could be testing the quality of a photographic film. To test the quality, we need to expose it completely and the moment it is exposed it gets destroyed. Therefore, sample is the only choice.
- The study of a sample instead of complete enumeration may, at times, produce more reliable results. This is because by studying a sample, fatigue is reduced and fewer errors occur while collecting the data, especially when a large number of elements are involved.

A census is appropriate when the population size is small, e.g., the number of public sector banks in the country. Suppose the researcher is interested in collecting information from the top management of a bank regarding their views on the monetary policy announced by the Reserve Bank of India (RBI), in this case, a complete enumeration may be possible as the population size is not very large. As another example, consider a business school having a few students from Europe, East Africa, South East Asia and the Middle East. These students would have their own problems in settling down in the Indian environment because of the differences in social, cultural and environmental factors. To understand their concerns, a survey of population may be more appropriate. Therefore, a survey of population could be used when there is a lot of heterogeneity in the variables of interest and the population size is small.

Sampling design refers to the process of selecting samples from a population. There are two types of sampling designs—probability sampling design and non-probability sampling design. Probability sampling designs are used in conclusive research. In a probability sampling design, each and every element of the population has a known chance of being selected in the sample. The known chance does not mean equal chance. Simple random sampling is a special case of probability sampling design where every element of the population has both known and equal chance of being selected in the sample. In case of non-probability sampling design, the elements of the population do not have any known chance of being selected in the sample. These sampling designs are used in exploratory research.

3.3.1 Probability and Non-Probability Sampling

Under this, the following sampling designs would be covered—Simple Random Sampling With Replacement (SRSWR), Simple Random Sampling Without Replacement (SRSWOR), systematic sampling, stratified random sampling and cluster sampling.

Simple Random Sampling with Replacement

Under this scheme, a list of all the elements of the population from where the samples to be drawn is prepared. If there are 1000 elements in the population, we write the identification number or the name of all the 1000 elements on 1000 different slips. These are put in a box and shuffled properly. If there are 20 elements to be selected from the population, the simple random sampling procedure involves selecting a slip from the box and reading of the identification number. Once this is done, the chosen slip is put back to

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the box and again a slip is picked up and the identification number is read from that slip. This process continues till a sample of 20 is selected. Please note that the first element is chosen with a probability of 1/1000, the second one is also selected with the same probability and so are all the subsequent elements of the population.

An alternative way of selecting the samples from the population is by using random number tables. Table 3.2 gives an illustrative example of random numbers.

Table 3.2 *Random Numbers*

I	II	III	IV	V
2807	0495	6183	7871	9559
8016	5732	3448	0164	2367
1322	4678	8034	1139	1474
0843	4625	7407	9987	5734
2364	1187	4565	2343	9786
4885	8755	4355	5465	0575
3406	4678	5950	7222	8494
5927	6010	7545	8979	1041
4447	3476	9140	0736	2332
4968	7553	1073	2493	4251
7489	1630	2330	4250	6170
4010	2707	3925	6007	8089
6531	9784	5520	7764	0008
7052	3861	7115	9521	2192
6573	2793	8710	2127	3846
8094	3205	2030	3035	5765
8615	6092	1900	4792	7684
9136	4016	3495	6549	9603
9656	5246	5090	8306	1522
2017	8323	1685	3006	3441

Table 3.2 gives four-digit random numbers arranged in 20 rows and five columns. These random numbers can be generated by a computer programmed to scramble numbers. The logic for generating random number is that any number can be constructed from numbers 0 to 9. The probability that any one digit from 0 through 9 will appear is the same as that for any other digit and the appearance of the numbers is statistically independent. Further, the probability of one sequence of digits occurring is the same as that for any other sequence of the same length.

The use of random number table for selecting samples could be illustrated through an example. Suppose there are 75 students in a class and it is decided to select 15 out of the 75 students. These students can be numbered from 01 to 75. Now, to pick up 15 students using random numbers and following the scheme of simple random sampling with replacement, we proceed as follows:

- With eyes closed, we place our finger on a number on the random number table. Suppose it is on the first row and the first column of our table. Now, we go down the first two columns and choose two-digit random numbers running from 01 to 75. If any number greater than 75 appears, it gets rejected. This way, the first number to be selected would be 28. The second number is 80, which would be rejected as we are choosing numbers from 01 to 75. The next selected number would be 13, followed by 08, 23, 48, 34, 59, 44, 49, 74, 40, 65, 70 and 65. Note that 65 has appeared twice. Since we are using the scheme of simple random sampling with replacement, we would retain it. This way we have selected 14 samples. The 15th number selected would be 20. In brief, the scheme explained above states that any number greater than the population size (in this case 75) is rejected and only the numbers from 01 to 75 are selected. A number may get repeated because simple random sampling scheme is done with replacement.

Simple Random Sampling without Replacement

In the case of simple random sample without replacement, the procedure is identical to what was explained in the case of simple random sampling with replacement. The only difference here is that the chosen slip is not placed back in the box. This way, the first unit would be selected with the probability of 1/1000, second unit with the probability of 1/999, the third will be selected with a probability of 1/998 and so on, till we select the required number of elements (in this case, 15) in our sample.

The simple random sampling (with or without replacement) is not used in a consumer research. This is because in a consumer research the population size is usually very large, which creates problems in the preparation of a sampling frame. For example, there is a large number of consumers of soft drinks, pizza, shampoo, soap, chocolate, etc. However, these (SRSWR and SRSWOR) designs could be useful when the population size is very small, for example, the number of steel/aluminum-producing companies in India and the number of banks in India. Since the population size is quite small, the preparation of a sampling frame does not create any problem.

Another problem with these (SRSWR and SRSWOR) designs is that we may not get a representative sample using such a scheme. Consider an example of a locality having 10,000 households, out of which 5,000 belong to low-income group, 3,500 belong to middle income group and the remaining 1,500 belong to high-income group. Suppose it is decided to take a sample of 100 households using the simple random sampling. The selected sample may not contain even a single household belonging to the high- and middle-income group and only the low-income households may get selected, thus, resulting in a non-representative sample.

3.3.2 Determination of Sample Size

The size of a sample depends upon the basic characteristics of the population, the type of information required from the survey and the cost involved. Therefore, a sample may vary in size for several reasons. The size of the population does not influence the size of the sample as will be shown later on.

There are various methods of determining the sample size in practice:

- Researchers may arbitrary decide the size of sample without giving any explicit consideration to the accuracy of the sample results or the cost of sampling. This arbitrary approach should be avoided.
- For some of the projects, the total budget for the field survey (usually mentioned) in a project proposal is allocated. If the cost of sampling per sample unit is known, one can easily obtain the sample size by dividing the total budget allocation by the cost of sampling per unit. This method concentrates only on

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the cost aspect of sampling, rather than the value of information obtained from such a sample.

- There are other researchers who decide on the sample size based on what was done by the other researchers in similar studies. Again, this approach cannot be a substitute for the formal scientific approach.
- The most commonly used approach for determining the size of sample is the confidence interval approach covered under inferential statistics. Below will be discussed this approach while determining the size of a sample for estimating population mean and population proportion. In a confidence interval approach, the following points are taken into account for determining the sample size in estimation of problems involving means:
  - (a) **The Variability of the Population:** It would be seen that the higher the variability as measured by the population standard deviation, larger will be the size of the sample. If the standard deviation of the population is unknown, a researcher may use the estimates of the standard deviation from previous studies. Alternatively, the estimates of the population standard deviation can be computed from the sample data.
  - (b) **The Confidence Attached to the Estimate:** It is a matter of judgement, how much confidence you want to attach to your estimate. Assuming a normal distribution, the higher the confidence the researcher wants for the estimate, larger will be sample size. This is because the value of the standard normal ordinate 'Z' will vary accordingly. For a 90 per cent confidence, the value of 'Z' would be 1.645 and for a 95 per cent confidence, the corresponding 'Z' value would be 1.96, and so on. It would be seen later that a higher confidence would lead to a larger 'Z' value.
  - (c) **The Allowable Error or Margin of Error:** How accurate do we want our estimate to be is again a matter of judgement of the researcher. It will of course depend upon the objectives of the study and the consequence resulting from the higher inaccuracy. If the researcher seeks greater precision, the resulting sample size would be large.

Sample Size for Estimating Population Mean

We have learnt in the central limit theorem that the sampling distribution of the sample mean ($\bar{X}$) follows a normal distribution with a mean μ and a standard error irrespective of the shape of population distribution whenever the sample size is large. Symbolically, it may be written as:

$$\bar{X} \cap \mathrm{N}\left(\mu, \sigma_{\bar{\mathrm{X}}}\right)$$

$$n \times 30$$

The above also holds true whenever samples are drawn from normal population. However, in that case, the requirement of a large sample is not there. The various notations are explained as under:

$\bar{X}$ = Sample mean

μ = Population mean

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$\sigma_{\bar{X}}$	=	Standard error of mean
n	=	Sample size
N	=	Population size
σ	=	Population standard deviation

The value of:

$$\pm_{\bar{X}} = \frac{\sigma}{\sqrt{n}} \text{ (When samples are drawn from an infinite population)}$$

$$= \frac{\sigma}{\sqrt{n}}\sqrt{\frac{N-n}{N-1}} \text{ (When samples are drawn from a infinite population)}$$

The expression $\sqrt{\frac{N-n}{N-1}}$ is called the finite population multiplier and need not be used while sampling from a finite population provided $\frac{n}{N}$<0.05.

The standard normal variate Z may be written as:

$$Z = \frac{\bar{X}-\mu}{\sigma_{\bar{X}}}$$

$$Z = \frac{\bar{X}-\mu}{\frac{\sigma}{\sqrt{n}}}$$

$$Z = \frac{\bar{X}-\mu}{\sigma}\sqrt{n}$$

$$Z = \frac{e\sqrt{n}}{\sigma}$$

Where $\bar{X} - \mu = e =$ Margin of error

$$n = \frac{Z^2\sigma^2}{e^2}$$

It may be noted from above that the size of the sample is directly proportional to the variability in the population and the value of Z for a confidence interval. It varies inversely with the size of the error. It may also be noted that the size of a sample does not depend upon the size of population. Below are given some worked out examples for the determination of a sample size.

Example 3.1: An economist is interested in estimating the average monthly household expenditure on food items by the households of a town. Based on past data, it is estimated that the standard deviation of the population on the monthly expenditure on food item is ₹ 30. With allowable error set at ₹ 7, estimate the sample size required at a 90 per cent confidence.

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Solution: The solution is obtained as follows:

90 per cent confidence $\Rightarrow Z = 1.645$

$$e = ₹\,7$$

$$\sigma = ₹\,30$$

$$n = \frac{Z^2\sigma^2}{e^2}$$

$$= \frac{(1.645)^2\,(30)^2}{(7)^2}$$

$$= 49.7025$$

$$= 50 \text{ (approx)}$$

Example 3.2: You are given a population with a standard deviation of 8.6. Determine the sample size needed to estimate the mean of the population within ± 0.5 with a 99 per cent confidence.

Solution: The solution is obtained as follows:

90 per cent confidence $\Rightarrow Z = 2.575$

$$e = \pm 0.5$$

$$\sigma = 8.6$$

$$n = \frac{Z^2\sigma^2}{e^2}$$

$$= \frac{(2.575)^2\,(8.6)^2}{(0.5)^2}$$

$$= 1961.60$$

$$= 1962 \text{ (approx)}$$

Example 3.3: It is desired to estimate the mean life time of a certain kind of vacuum cleaner. Given that the population standard deviation $\sigma = 320$ days, how large a sample is needed to be able to assert with a confidence level of 96 per cent that the mean of the sample will differ from the population mean by less than 45 days?

Solution: The solution is obtained as follows:

96 per cent confidence $\Rightarrow Z = 2.055$

$$e = 45$$

$$\sigma = 320$$

$$n = \frac{Z^2\sigma^2}{e^2}$$

$$= \frac{(2.055)^2\,(320)^2}{(45)^2}$$

$$= 213.55$$

$$= 214 \text{ (approx)}$$

Determination of Sample Size for Estimating the Population Proportion:

If the sample proportion $\bar{p}$ is used to estimate the population proportion p, the standard error of $\bar{p}\left(\sigma_{\bar{p}}\right)$ would be $\sqrt{\frac{pq}{n}}$, where $q = 1 - p$. Now assuming normal distribution, we have

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$$\bar{p} \cap N\left(p, \sqrt{\frac{pq}{n}}\right)$$

Therefore, $$Z = \frac{\bar{p} - p}{\sqrt{\frac{pq}{n}}}$$

Therefore, margin of error $e = \bar{p} - p = Z\sqrt{\frac{pq}{n}}$

$$Z = \frac{e}{\sqrt{\frac{pq}{n}}}$$

$$Z = \frac{e\sqrt{n}}{\sqrt{pq}}$$

$$n = \frac{Z^2 pq}{e^2}$$

The above formula will be used if the value of population proportion p is known. If, however, p is unknown, we substitute the maximum value of pq in the above formula. It can be shown that the maximum value of pq is ¼ when p = ½ and q = ½.

Points to be Noted for Sample Size Determination

There are certain issues to be kept in mind before applying the formulas for the determination of sample size in this chapter. First of all, these formulas are applicable for simple random sampling only. Further, they relate to the sample size needed for the estimation of a particular characteristic of interest. In a survey, a researcher needs to estimate several characteristics of interests and each one of them may require a different sample size. In case the universe is divided into different strata, the accuracy required for determining the sample size for each strata may be different. However, the present method will not able to serve the requirement. Lastly, the formulas for sample size must be based upon adequate information about the universe.

3.4 SUMMARY

- A sample design is a definite plan for obtaining a sample from a given population. It refers to the technique or the procedure the researcher adopts while selecting components for the sample.
- Sample design may as well lay down the number if items to be included in the sample, i.e., the size of the sample. Sample design is determined before data are collected.

Check Your Progress

1. Define the term sample design.
2. Name the two laws on which the theory of sampling is based.
3. What is a chunk?
4. How are the quota sampling and stratified random sampling similar?
5. What do you understand by the term census?
6. List the principles that guide sampling theory.
7. On what factor does the size of a sample depend?

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- All units in any field of study constitute the universe. All elementary units are the population. Often the two terms are used interchangeably, however, research needs a distinction. The population or universe can be of two types: (i) Finite and (ii) Infinite.
- A finite population consists of fixed number of elements and the elements can be enumerated totally, e.g., the number of students in a state. The symbol N is used to depict the number of elements or items of a finite population.
- An infinite is the one where all the elements cannot be observed, at least theoretically, e.g., the number of stars in the sky. In a sense, a very large finite population is an infinite population.
- On the basis of sample study we can predict and generalize the behaviour of mass phenomena. This is possible because there is no statistical population whose elements would vary from each other (one another) without limit.
- Law of Statistical Regularity is derived from the mathematical theory of probability. In the words of king: 'The law of statistical regularity lays down that a moderately large no. of items chosen at random from a large group are almost sure on the average to possess the characteristics of the large group'.
- 'Law of Inertia of Large Numbers' is a corollary of the law of statistical regularity. It is of great significance in the theory of sampling. It states that, other things being equal, larger the size of the sample, more accurate the results are likely to be.
- The various methods of sampling can be grouped under two broad heads : Probability sampling (also known as random sampling) and non-probability (or non-randon) sampling.
- Probability sampling methods are those in which every item in the universe has a known chance, or probability, of being chosen for the sample. This implies that the selection of sample items is independent of the person making the study — that is, the sampling operation is controlled so objectively that the items will be chosen strictly at random.
- Non-probability sampling methods are those which do not provide every item in the universe with a known chance of being included in the sample. The selection process is, at least, partially subjective.
- In judgement sampling, the choice of sample items depends exclusively on the judgement of the investigator. In other words, the investigator exercises his judgement in the choice and includes those items in the sample which he thinks are most typical of the universe with regard to the characteristics under investigation.
- A convenience sample is obtained by selecting convenient population units. The method of convenience sampling is also called the chunk.
- A chunk refers to that fraction of the population being investigated which is selected neither by probability nor by judgement but by convenience.
- Simple random sampling refers to that sampling technique in which each and every unit of the population has an equal opportunity of being selected in the sample.

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- Stratified random sampling or simply stratified random is one of the random methods which, by using the available information concerning the population, attempts to design a more efficient sample than obtained by the simple random procedure.
- Systematic sampling method of sampling is also known as quasi-random sampling method. This is because once the initial starting point is determined, the remainder of the items selected for the sample are predetermined by the sampling interval.
- Under Multistage Sampling or Cluster Sampling method, the random selection is made of primary, intermediate and final (or the ultimate) units from a given population or stratum. There are several stages in which the sampling process is carried out.
- The standard deviation of the sampling distribution of a statistic is known as its Standard Error (S.E.) and it is considered the key in sampling theory.
- A census is a count of all the elements in a population and a determination of the distribution of their characteristics, based on the information obtained for each of the elements. It is economical in terms of time, effort and money to get the desired information for only some of the elements than for all of them.
- A measure based on the entire population is called a parameter. A sample is any number of persons selected to represent the population according to some rule or plan. So, a sample is a smaller representation of the population. A measure based on a sample is known as a statistic.
- For selecting elements on the representation basis, the sample may be obtained by using either probability sampling or non-probability sampling. Probability sampling is based on random selection whereas non-probability sampling is based on non-random sampling.
- The size of a sample depends upon the basic characteristics of the population, the type of information required from the survey and the cost involved. Therefore, a sample may vary in size for several reasons. The size of the population does not influence the size of the sample.

3.5 KEY TERMS

- **Sample:** A sample is any number of persons selected to represent the population according to some rule or plan
- **Sampling frame:** It comprises all the elements of a population with proper identification that is available to us for selection at any stage of sampling
- **Inference:** A conclusion reached on the basis of evidence and reasoning
- **Variation:** A change or difference in condition, amount or level, typically with certain limits
- **Stratum:** A layer or a series of layers of rock in the ground
- **Allocation:** The action or process of allocating or distributing something

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3.6 ANSWERS TO 'CHECK YOUR POGRESS'

1. A sample design is a definite plan for obtaining a sample from a given population. It refers to the technique or the procedure the researcher adopts while selecting components for the sample. Sample design may as well lay down the number if items to be included in the sample, i.e., the size of the sample.
2. There are two important laws on which the theory of sampling is based:
   - Law of 'Statistical Regularity'
   - Law of 'Inertia of Large Numbers'
3. The method of convenience sampling is also called the chunk. A chunk refers to that fraction of the population being investigated which is selected neither by probability nor by judgement but by convenience.
4. Quota sampling and stratified random sampling are similar in as much as in both methods the universe is divided into parts and the total sample is allocated among the parts. However, the two procedures diverge radically. In stratified random sampling, the sample within each stratum is chosen at random. In quota sampling, the sampling within each cell is not done at random, the field representatives are given wide latitude in the selection of respondents to meet their quotas.
5. A census is a count of all the elements in a population and a determination of the distribution of their characteristics, based on the information obtained for each of the elements. It is economical in terms of time, effort and money to get the desired information for only some of the elements than for all of them.
6. The three principles that guide sampling theory are as follows:
   - In majority of cases of sampling there is a huge difference between the sample statistics and the true population mean, which is attributable to the selection of the units in the sample.
   - The greater the sample size; the more accurate will be the estimate of the true population mean.
   - The greater the difference in the variable of the study in a population for a given sample size, the greater will be the difference between the sample statistics and the true population mean.
7. The size of a sample depends upon the basic characteristics of the population, the type of information required from the survey and the cost involved. Therefore, a sample may vary in size for several reasons. The size of the population does not influence the size of the sample.

3.7 QUESTIONS AND EXERCISES

Short-Answer Questions

1. What is the significance of census and sample survey in sampling?
2. What are the uses of sampling in real life?
3. What are the advantages of a simple random sampling?
4. List the various statistical processes.

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5. What is secondary resource analysis?
6. What do you mean by expert opinion survey?
7. Define the term population in the context of research.
8. Write the main advantage of systematic sampling design.
9. Why convenience sampling is used?
10. What is judgmental sampling?
11. Define the term stratified sampling.
12. What do you mean by quota sampling?

Long-Answer Questions

1. Describe the elements and steps involved in a sampling design.
2. Elaborate the use of various methods of sampling.
3. Write a descriptive note on sampling process.
4. Discuss the concept and types of research design.
5. Explain sampling and non-sampling error with the help of examples.
6. Describe probability and non-probability sampling techniques.
7. Write a note on cluster sampling.
8. Explain the criteria and procedure of selecting a sample.
9. Discuss the uses of sampling in real life.
10. How is sample size determined? Describe with the help of an example.

3.8 FURTHER READING

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UNIT 4 METHODS OF DATA COLLECTION

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Structure

4.0 INTRODUCTION

In this unit, you will learn about the various methods of data collection. The data collection methods have been categorized into primary and secondary data collection methods. Primary data can be obtained through observations or through direct communication with the persons associated with the selected subject by performing surveys or descriptive research. This type of data is the data specially collected in a research by the researcher. These are products of experiments, surveys, interviews, or observations conducted in the research. Primary data is generated and collected through specific tools of data collection, like questionnaires, by the researcher. The methods of primary data collection, such as observation method, interview method and survey method have been presented in detail.

Secondary data is the type of data which has already been collected and tested by other investigators. While making use of secondary data, researchers must carefully examine the available data to decide whether the data is suitable for the subject under study or not. This unit will discuss methods and various instruments used in data collection. It will also analyse reliability and validity of these data in management research. An important form of data collection is the questionnaire form. All the important aspects of this form of data collection are discussed in this unit.

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4.1 UNIT OBJECTIVES

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

- Explain the primary and secondary methods of data collection
- Discuss various instruments used in data collection
- Assess the reliability and validity of collected data
- Describe the format of questionnaire design
- Evaluate the types of measurement scales
- Interpret the survey technique of data collection

4.2 PRIMARY DATA: COLLECTION METHODS AND INSTRUMENTS

Primary data is the information collected during the course of an experiment in experimental research. It can also be obtained through observation or through direct communication with the person associated with the selected subject by conducting surveys and interviews. There are several methods of collecting primary data. Some of these are:

- Observation
- Interviews
- Questionnaires
- Schedules
- Surveys

4.2.1 Observation Method

Observation is the most common method of studying behavioural sciences. It is not a scientific method, but it becomes a scientific tool when used for formulating the purpose of a research. In this method, the information collected by the researcher is totally based on his observation. If the researcher is studying different brands of shoes, he will not ask the person wearing the shoes of that particular brand. Rather, he will observe it himself and then come to some conclusion.

The main advantage of this method is that there are no chances of partiality if the observation is done accurately. Second, the information or the data collected through observation is related to what is currently happening and is not affected by past behaviour or future intentions. Third, this method is independent of a person's willingness to respond and does not require much cooperation on the part of the person, as it happens to be the case in the interview or questionnaire methods. The observation method is suitable in those situations where the respondent is not capable, for some reason, of expressing the feelings verbally.

In the observation method, researchers must keep in mind the following points:

- What should be observed?
- How should the observation be recorded?
- How can the accuracy of observation be ensured?

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Types of Observation Methods

Observation methods can be categorized into different types depending on various factors, such as style for recording observed information, data needed for observation and activity of the observer. The different types of observation methods are as follows:

- **Structured Observation**: It is an observation method in which the following points need to be considered:
  - o Careful definition of the matter that needs to be observed.
  - o Identification of the style that must be used to record the observed information.
  - o Standardization of the condition of observation.
  - o Selection of the data required for observation.
- **Unstructured Observation**: It is an observation method in which a definition of the matter to be observed, the style to be recorded, standardized conditions of observation and selection of the required data of observation are not known to the researcher. This method is most appropriate where an explored study of the matter under observation is required.
- **Participant Observation**: It is an observation method in which the observer is a member of the group he is observing, in order to understand the needs and the problems faced by the group better. For example, a team leader observes all his team members and does the same work as his team members. There are several advantages of participant observation, which are stated as follows:
  - o The researcher is able to record the natural behaviour of the group.
  - o The researcher can even gather information, which could not easily be obtained if he observes in a disinterested fashion.
  - o The researcher can even verify the truth of the statements made by the informants in the context of the questionnaires or a schedule.
- **Non-Participant Observation**: It is an observation method in which the observer is not a member of the group under observation. This method has a disadvantage—the observer is unable to understand what the team members are feeling.
- **Disguised Observation**: It is an observation method in which the members of the group are unaware of the fact that they are being observed.
- **Controlled Observation**: Observation that takes place according to definite pre-arranged plans, involving experimental procedures is called controlled observation.
- **Uncontrolled Observation**: Observation that takes place in a natural setting is called uncontrolled observation. The main aim of this method is to have spontaneous picture of the situation and for this the prime requirement is sufficient time.

Limitations of Observation Method

Though the observation method provides different ways of studying behavioural science, there are some limitations in using these methods. These limitations are as follows:

- An observation method is generally expensive.
- It provides very limited information on the observed matter.
- It may be affected by some unwanted factors; for example, people who are not involved in direct observation might create problems while collecting data through the observation method.

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4.2.2 Interview Method

An interview is a method of collecting data that involves presentation of oral and verbal stimuli and the reply is in oral and verbal responses. The most common method of interview is personal interview.

Personal Interview

A personal interview involves two persons, i.e., the interviewer and the interviewee. The interviewer is the person who questions the interviewee. There is a face-to-face discussion between them. There can be more than one interviewer while taking a personal interview. There are two types of interviews: direct personal interview and indirect oral interview.

In a direct personal interview, the interviewer collects information from the concerned sources. He should be present at the site from where the data has to be collected. This method is most appropriate for intensive investigations, but this method may not be suitable in situations where a direct contact with the concerned person is not possible. In such cases, an indirect oral examination or investigation takes place where the interviewer cross-examines the interviewee to check his knowledge about the problem under investigation. The information exchanged between the interviewee and the interviewer is recorded for future reference.

A personal interview can be of the following types:

- **Structured Interview**: If the personal interview takes place in a structured way, it is called a structured interview. In this type of personal interview, the set of questions to be asked is predefined and the techniques used to record the information are highly standardized. Structured interviews are economical, as they do not require much information from the interviewer and are used as the main technique to collect information for descriptive research studies. The following are samples of structured interview questions:
  - o What is the main function of your production department?
  - o Why do we need to check an order for clearing a product when they have already been cleared for production?
- **Unstructured Interview**: If the personal interview takes place in an unstructured way, it means that the questions to be asked to the interviewee are decided at the time of interview. In this type of personal interview, the set of questions to be asked is not predetermined and there no standardized techniques are used. A list of additional questions is provided to the interviewer and it depends on him to ask them or not. This method depends upon deep knowledge and greater skills of the interviewer. You can use an unstructured interview as the main technique to collect information in the explorative manner and formulate research studies. The following are samples of unstructured interview questions:
  - o How would you evaluate the benefits of new machinery that is installed in your production department?
  - o If you are provided with a choice, how would you have designed the present production department?

4.2.3 Surveys Method

A survey is a scientific process of acquiring data and opinion from the public. Researchers undertake surveys in order to determine the opinion of the public regarding products, candidates and other topics; for example, a sample of voters is surveyed before an election to determine how the public perceives the candidates and their issues. A manufacturer makes a survey of the potential market before introducing a new product. The information acquired from the public is used to develop new products, improve services and for various other purposes. Thus, a survey is an important key to improve or maintain the quality of life.

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The process of conducting a survey is a complex task. In order to conduct a survey, a large number of skilled and trained persons is required. There are many ways in which data for a survey can be collected, such as by phone, mail and the Internet.

The principle focus of a survey is on the design and collection of data in which many intricacies involved are frequently overlooked. However, a researcher, while conducting a survey, also gives attention to the need for proper evaluation of the survey data as well as its proper analysis. A researcher collects the information or data by means of standardized questions so that every individual surveyed responds to exactly the same questions. The results of the surveys are presented in the form of summaries, such as statistical tables and charts.

Those who conduct a survey are typically large organizations, government agencies and institutions who know that listening carefully to the consumers is important for their success. Researchers cannot divulge the name of the client for whom they are undertaking the survey because if the respondents get to know the name of the organization, it might create a bias in their responses. Researchers only reveal the name of the organizations as and when they are directed to do so.

4.2.4 Other Methods

There are some other methods that are also used for data collection. These are as follows:

- **Warranty Cards**: These are cards that dealers use for collecting information regarding their products. The information required is printed in the form of questions on the warranty cards, which are placed inside the package along with the product. The consumer is requested to fill the card and post it back to the dealer.
- **Distributor or Store Audits**: Distributors and manufactures, through their salesmen, conduct distributor or store audits at regular intervals. Retailers also get their stores audited by salesmen and use the information to estimate the market size, market share, seasonal purchasing pattern, and so on. The data is not by questioning, but by observation; for example, while doing an audit for grocery, a sample of stores is visited periodically and data is recorded on inventories either by observation or by copying the data from store records. The advantage of this method is that it offers the most efficient way to evaluate the effect of different techniques on sales.
- **Pantry Audits**: Pantry audit is used to estimate the consumption of goods at the consumer level. In this type of audit, the researcher collects information, such as list of different products, quantities of each product and the prices of each product consumed. All this data is recorded by observing the consumer’s pantry. The main objective of a pantry audit is to determine which brand and type of product is being used by which category of consumer, assuming that the contents of the pantry accurately signify their favourites. Pantry audits do not require a series of operations; only one visit is enough to determine the actual preferences of the

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consumers. An important drawback of pantry audits is that it is not possible to determine the actual preferences of consumers only from the audit data.

- **Consumer Panels**: A consumer panel is an extension of the pantry audit. In this technique, the daily record of a set of consumers is maintained to obtain information about consumer preferences. Later, these records are provided to the officers investigating the consumer preferences. Alternatively, you can say that a consumer panel includes a sample of consumers who are interviewed over a fixed interval of time. Consumer panels are of two types:
  - o **Transitory Consumer Panel:** A transitory consumer panel is set up in order to determine the influence of a particular phenomenon. A transitory consumer panel is performed on a before-and-after basis. This means that the panel examines the consumer response before and after implementing a particular phenomenon. In this technique, the initial interview of the consumers is conducted before implementing the phenomenon. A second round of interview is conducted after that phenomenon has occurred, to determine the changes in consumer attitude, if any. Such panels are mostly used in advertising and social research.
  - o **Continuing Consumer Panel**: A continuing consumer panel is set up for an indefinite period of time to obtain data about certain aspects of the attitude of consumers over a particular period of time. This panel acts as a general-purpose panel to help investigators on different subjects. Such panels are mostly used in the areas of consumer expenditure, public opinion, radio and TV listenership.
- **Use of Mechanical Devices**: Mechanical devices are extensively used to obtain information related to consumers. The devices used for collecting information are as follows:
  - o **Eye Camera**: These are used to collect information about the focus of the respondents on a specific portion of a sketch or diagram or written material. The information collected with the help of eye cameras is used to design advertising material.
  - o **Pupilometric Camera**: These are used to record the dilation of pupils because of a visual stimulus. The extent of dilation of pupils helps determine the amount of interest produced by the stimulus.
  - o **Psychogalavanometer**: It is used to measure the degree of body excitement aroused by a visual stimulus.
  - o **Motion Picture Camera**: It is used to record the body movements language of a buyer when he/she decides whether to buy a particular product from a shop or a big store.
- **Projective Techniques**: These are also known as direct interviewing techniques. These techniques were developed by psychologists to collect data about the primary reason, desire or intention of respondents by using projections. In a projective technique, while providing information about a particular topic, the respondent automatically projects his/her own attitude or feelings on that subject. The projective technique is mostly used in inspirational research and in attitude surveys. Some of the important projective techniques are as follows:

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- o **Word Association Test**: It is a test that provides information regarding words that have maximum correlation.
- o **Sentence Completion Test**: It is an extension of the word association test. In this technique, the informant is asked to complete a sentence in order to determine the perception of the informant about a topic.
- o **Story Completion Test**: It is a technique where the informant is given a story to help focus on the given subject and then asked to give the conclusion for the story.
- o **Verbal Projection Test**: It is a technique where the informant is asked to give a comment or an explanation on a particular topic.
- o **Play Technique**: It is the technique where the informants are given a situation and are asked to perform for improving the situation. For this, the informants are given various roles.
- o **Quizzes, Tests and Examinations**: It is a technique that helps in extracting information regarding specific ability of the candidates on various subjects.
- o **Sociometry:** It is the technique that describes social relationships among individuals in a group.

- **Depth Interview:** These interviews are designed to determine the underlying reason and desire of the consumer. This technique is most commonly used in inspirational research. In a depth interview, the interviewer needs to explore the hidden needs, desires and feelings of the respondents, so it is necessary for the interviewer to be a skilled one. Therefore, the researchers and interviewers must be given proper training before they start the work. This is not an easy task and takes a great deal of time.

  A depth interview can either be projective or non-projective. Projective interviews involve indirect questions that are not very closely related to the subject under study, whereas in non-projective interviews, the interview questions are subject-specific. Non-projective interviews are sufficient enough to provide details about the psycho-social behaviour of consumers.
- **Content Analysis:** This is a data collection technique that involves analysis of documentary materials, such as books, magazines, newspapers and the contents of all the verbal materials.

4.3 SECONDARY DATA: COLLECTION METHODS AND INSTRUMENTS

Secondary data is the data which has already been collected and examined earlier by other investigators. While making use of the secondary data, the investigator has to first determine the sources from where the secondary data can be obtained. In this method, the researcher is not at all aware of the problems related to how the data was originally collected. The secondary data can either be published data or unpublished data. Published data is available mostly from the following sources:

- Publications of the central, state or local governments.
- Publications of foreign governments.
- Technical and trade journals.

Check Your Progress

1. What is primary data?
2. List the methods of collecting primary data?
3. What is a survey?

- Books, magazines and newspapers.
- Reports prepared by research scholars, universities and economists.
- Public records, statistics and historical documents.

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The sources of unpublished data include diaries, letters, unpublished biographies and autobiographies. While making use of secondary data, researchers must carefully examine the available data to decide whether the data is suitable for the subject under study or not. The characteristics that a researcher must ensure in the secondary data before using it are stated as follows:

- **Reliability of Data**: The secondary data available on a particular subject must be reliable. The reliability of secondary data can be determined by obtaining answers to the following questions:
  - Who collected the data?
  - What were the data sources?
  - Was the data collected using proper methods?
  - At what time was it collected?
  - Was there any bias on the part of the compiler?
  - What was the level of accuracy desired?
  - Was the desired level of accuracy achieved?
- **Suitability of Data**: The secondary data available on a particular subject must be suitable for that subject. The data suitable for one subject may not be suitable for another. Therefore, the researcher should properly examine the available data and verify the definitions of different terms and the units of data collection before using that data.
- **Adequacy of Data**: The secondary data available should be adequate in terms of accuracy. If the accuracy level of the available data is lower than what is required, the data is considered inadequate.

4.3.1 Selection of Appropriate Method for Data Collection

Various methods are available for a researcher to use in the collection of data on a particular subject. The factors that a researcher must consider for selection of the appropriate method for data collection are as follows:

- **Nature, Scope and Object of Enquiry**: This is an important factor that must be considered while selecting the data collection method. The selected data collection method should suit the type of enquiry to be performed by the researcher. This factor helps determine whether the data available is sufficient or some other information is required to be collected.
- **Availability of Funds**: Availability of funds also determines the data collection method to be used. If the researcher is provided with only a limited amount of funds, then he will be bound to select a comparatively cheaper method, which may or may not be as effective and efficient as some expensive methods.
- **Time Factor**: The amount of time available for a particular research project should also be considered while selecting the data collection method. Some methods take relatively greater amount of time as compared to the others. Therefore, the researcher must select the method that suits the time limitations of the project.
- **Precision Required**: The precision level required for a particular project also determines the method that should be selected for data collection.

4.3.2 Case Study Method

The case study method is the most common method of collecting secondary data. It is mainly used for the purpose of qualitative analysis. It involves a thorough and complete examination of a social unit. A social unit can either be a person, a family, an institution, a cultural group or even the entire community. A case study involves in-depth study of a particular subject. The case study method emphasizes on the complete investigation of only restricted number of events related to a subject and the relationship between the different events. The main objective of a case study is to determine the factors that are responsible for the behaviour patterns of the given unit in totality.

In the words of the eminent researcher H.Odum, '*The case study method is a technique by which individual factor, whether it be an individual or just an episode in the life of an individual or a group, is analysed in its relationship to any other in the group*'. Thus, a fairly exhaustive study of a person or group is known as life or case study. Burgess has used the words, the 'Social Microscope' for the 'Case Study' method. Another researcher, Pauline V. Young, has defined the concept of case study as a '*Comprehensive study of a social unit of a person, a group, a social institution, a district, or a community*'. In short, case study is a method that involves qualitative analysis of an individual or a situation or an institution.

Characteristics of the Case Study Method

The following are certain characteristics of the case study method:

- In this method, the researcher is allowed to take one or more than one social unit for study. Instead of a social unit, the researcher can also select a situation for study.
- This method involves intensive study of the selected unit. As each unit is studied for its minute details, the study takes a long period of time. This helps ensure the correctness of the information collected about a particular unit.
- This method helps to determine the complex factors of a particular unit.
- It also helps to determine the integrity of the selected unit with the other units.
- This method follows the qualitative approach rather than the quantitative approach.
- In the case study method, efforts are made to determine the mutual interelationship of the causal factors.

Evolution and Scope of the Case Study Method

In the field of sociology, the case study method is an extensively used research technique. Frederic Le Play introduced this method in the field of social investigation. Herbert Spencer was the first to make use of case materials in his comparative study of different cultures. This method is also used by anthropologists, historians, novelists and dramatists to solve their problems related to their areas of interest. Even management experts use this method to obtain clues of certain management problems. Conclusively, the case study method is used in different disciplines.

Major Phases of the Case Study Method

The major phases involved in case study method are as follows:

- Identification and resolution of the status of the phenomenon or the unit to be examined.
- Accumulation of data and selection of the phenomenon.

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- Investigation of the history of the selected phenomenon.
- Analysis and recognition of informal factors related to the selected phenomenon.
- Application of corrective measures.
- Review of programme to identify the effectiveness of the treatment applied.

Advantages of the Case Study Method

Some of the important advantages of the case study method are as follows:

- As the case study method involves exhaustive study of a particular unit, the complete behaviour pattern of the concerned unit is understood. According to Charles Horton Cooley, case study deepens our perception and gives us a clearer insight into life. It gets at behaviour directly and not by an indirect and abstract approach.
- With the help of a case study, a researcher can obtain genuine and progressive record of personal experiences.
- It helps a researcher determine the natural history of the selected unit. It also helps determine the relationship of the selected unit with the social factors of the surrounding environment.
- It also helps frame relevant hypotheses along with the data, which may be helpful in testing them.
- It helps obtain in-depth knowledge of a particular subject, which is possible neither with the help of the observation method nor with the help of the schedule method.
- The researcher is allowed to use one or more than one method under this method, depending upon the situation. Alternatively, the use of different methods, such as depth interviews, questionnaires, documents, study reports of individuals and letters is possible in case of case study.
- It helps determine the nature of the selected unit along with the nature of the universe.
- It helps increase the experience of the researcher, which in turn enhances his/her analysing ability and skills.
- It enables the researcher to observe social changes.
- It helps obtain conclusions and maintain continuity in the research process.
- It helps obtain data necessary for taking decisions on some management problems.

Limitations of the Case Study Method

Some of the important limitations of this method are as follows:

- The situations of case study are mostly incomparable.
- According to Read Bain, case data is significant data as it does not provide any knowledge of the impersonal, universal, non-ethical, non-practical and repetitive aspects of a phenomenon.
- There are always some chances of false generalization because there are no specific rules of data collection.
- It is a time-taking technique and requires a lot of expenditure.
- It is based on certain assumptions which may not be true in some cases. This decreases the usefulness of the case data collected for a particular social unit.
- It can be used only in a limited geographic area.

Check Your Progress

4. What is secondary data?
5. What is the case study method?

4.3.3 Limitations of Secondary Data

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- **Applicability of data:** What one needs to remember in case of secondary data is the purpose for which the information was collected. It was unique to that study and thus cannot be an absolute fit for the current research. As a result of this, the information might not be applicable or relevant for the current objective. (Denscombe, 1998). The typical differences that emerge in such cases are with relation to the variables and the units being used to measure it. For example, market optimism or buoyancy by one researcher might be reflected by the consumer's spending in that quarter; while one might be interested in measuring buoyancy in terms of the investment in equity and growth funds.

  Another significant difference is in terms of the time period. The information that none might be using for the current research might have been collected in a different time coordinate or in a different environment. The implication of this divergence in the research base is that there might be multiple modifying variables, which might not be apparent like the socio-cultural environment, climatic effects and political factors. However, these might be responsible for skewing the direction of the findings.

- **Accuracy of data:** While application of the data might be an issue, there is a sincere concern before one relies on the information gathered by another source—that is the level of trust one can have on the same. The concerns are three: Who, Why and How? The first level of accuracy depends upon who was the investigator or the investigative agency. The reputation of the organization/person becomes extremely critical in establishing the truth of the findings as well as believing the inferences drawn in the quoted research. The second is the reason for collecting the data. For example, if a certain political party collects information on the potential voters and an independent market research agency collects information on the spread of the opinions—positive and negative—towards various political parties, one is more likely to rely on the second source. The reliability would be higher due to the reasons given below:

Since the agency specializes in conducting opinion polls and has a vast experience as well as a respondent base, the chances of error would be minimized.

The political party might have a hidden agenda of securing the campaign sponsorship through the survey conducted, while the independent body would be free from this bias. Last but not the least is the data collection process of the study in terms of sample selection and sampling characteristics used to identify the respondent population. This is very important as this would be a clear indicator of the applicability of the results when extrapolating to the larger population.

4.4 EXPERIMENTAL METHOD

Experimental research refers to the research activity wherein the manipulation of variables takes place and the resultant effect on other variables is studied. It provides a logical and structured basis for answering questions. The experimental researchers manipulate the environment, stimuli or applications and observe the impact of this manipulation on the condition or behaviour of the subject. The manipulation that they undertake is deliberate and systematic.

Experimentation is the testing of hypotheses. Once the experimenters have defined a situation or issue, they formulate a preliminary solution or hypothesis. They then apply

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their observations of the controlled variable relationships in order to test, and then confirm or reject the hypothesis.

Experimentation is the classic method of experimenting in a science laboratory where elements are manipulated and effects observed can be controlled. It is the most sophisticated, exacting and powerful method for discovering and developing an organized body of knowledge.

According to J.W. Best, '*Experimental research is the description and analysis of what will be or what will occur under carefully controlled condition*'.

4.4.1 Characteristics of Experimental Research

Experimental research is based on highly rigorous procedures and aims at producing reliable and valid conclusions. By looking at the various designs and procedures used, one can formulate some essential characteristics of experimental research which distinguish it from other types of research methods like survey and historical methods.

- **Pre-Experimental Statistical Equivalence of Subjects in Different Groups:** This pre-condition is achieved by random selection and assignment of subjects to different groups. This procedure is essential to meet the threat of selection differences to the internal validity of the results.
- **Use of At Least Two Groups or Conditions that can be Compared:** An experiment cannot be conducted with one group of subjects or one condition at a time. The intent of the experimenter is to compare the effect of one condition on one group with the effect of a different condition on another equivalent group. An experiment may take the shape of a comparison of the effect of one condition on a group of subjects and the effect of another condition on the same group.
- **Manipulation of the Independent Variable:** It is perhaps the most distinct feature of experimental research. Manipulation stands for the process of assignment of different values or magnitudes or conditions or levels of the independent variable to different groups.
- **Measurement of Dependent Variable in Quantifiable Form:** This distinguishes experimental research from descriptive, qualitative or analytical research.
- **Use of Inferential Statistics:** This is done to make probability statements about the results, and thus meet the requirements of imperfect measurements on which the behavioural sciences base their generalization.
- **Control of Extraneous Variables:** Though applicable to any other type of research, control of extraneous variables is the *sine qua non* of true experimental designs and the experimenter makes a determined effort to achieve it. It helps the experimenter to eliminate the possibility of any other plausible rival hypothesis claiming to explain the result.

4.4.2 Steps in Experimental Research

The steps in experimental research are as follows:

(i) **Survey of the Literature Relating to the Problem:** In experimentation, the researcher needs to acquire up-to-date information relating to the problem.

(ii) **Selection and Definition of the Problem:** It needs a rigorous logical analysis and definition of the problem in precise terms. The variables to be studied are defined in operational terms clearly and unambiguously. It helps the researcher to convert the problem into a hypothesis that can be verified or refuted by the experimental data.

(iii) Statement of Hypotheses: Hypotheses are the heart of experimental research. They suggest that an antecedent condition or phenomenon is related to the occurrence of another condition, phenomenon, event or effect. To test a hypothesis, the researcher attempts to control all the conditions except the independent variable. Therefore, he should give sufficient attention to the formulation of hypotheses. The experimental plant and statistical procedures help him in the testing of hypotheses and contribute little in the development of theories or advancement of knowledge. However, the hypotheses developed or derived from existing theories contribute to the development of new theories and knowledge.

(iv) Construction of Experimental Plan: Experimental plan refers to the conceptual framework within which the experiment is to be conducted. According to Van Dalen, an experimental plan represents all elements, conditions, phenomena, and relations of consequences so as to:

- Identify the non-experimental variables.
- Identify the most appropriate research design.
- Identify a sample of subjects that will suitably represent the target population, form groups of these subjects and decide on the experiments which will be conducted on each group.
- Choose or develop an instrument that can be deployed to measure the results of the experiment.
- Lay out the data collection process and conduct a pilot study to test the instrument and the research design and state the hypotheses.

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4.4.3 Variables

A **variable** is any feature or aspect of an event, function or process that, with its presence and nature, affects some other event or process which is being studied. According to Kerlinger, '*Variable is a property that takes on different value*'.

Types of Variables

The following are the various types of variables:

- ***Independent Variables*:** These are conditions or characteristics that are manipulated by the researcher in order to identify their relationship to observed phenomena. In the field of educational research, for instance, a specific teaching method or a variety, of teaching material are types of independent variables.

  The two kinds of independent variables are:

  (i) ***Treatment Variables*:** These are variables which can be manipulated by the researcher and to which he assigns subjects.

  (ii) ***Organism or Attribute Variables*:** These are factors, such as age, sex, race, religion etc., which cannot be manipulated.

- ***Dependent Variables*:** Dependent variables represent characteristics that alter, appear or vanish as a consequence of introduction, change or removal of independent variables. The dependent variable may be a test score or achievement of a student in a test, the number of errors or measured speed in performing a task.
- ***Confounding Variables*:** A confounding variable is one which is not the subject of the study but is statistically related with the independent variable. Hence, changes in the confounding variable track the changes in the independent variable.

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This creates a situation wherein subjects in a particular condition differ unintentionally from subjects in another condition. This is not a good result for the experiment which is attempting to create a situation wherein there is no difference between conditions other than the difference in the independent variable. This phenomenon enables us to conclude that the manipulation undertaken directly causes differences in the dependent variable. However, if there is another variable besides the independent variable that is also changing, then the confounding variable is the likely cause of the difference. An example of a common confounding variable is that when the researcher has not randomly assigned participants to groups, and some individual difference, such as ability, confidence, shyness, height, looks, etc., acts as a confounding variable. For instance, any experiment that involves both men and women is naturally afflicted with confounding variables, one of the most apparent being that males and females operate under diverse social environments. This should not be confused to mean that gender comparison studies have no value, or that other studies in which random assignment is not employed have no value; it only means that the researcher must apply more caution in interpreting the results and drawing conclusions.

Let us consider an instance wherein an educational psychologist is keen to measure how effective is a new learning strategy that he has developed. He assigns students randomly to two groups and each of the students study materials on a specific topic for a defined time period. One group deploys the new strategy that the psychologist has developed, while the other uses any strategy that they prefer. Subsequently, each participant takes a test on the materials. One of the obvious confounding variables in this study would be advance knowledge of the topic of the study. This variable will affect the test results, no matter which strategy is used. Because of an extraneous variable of this nature, there will be a level of inconsistency within and between the groups. It would obviously be the preferred situation if all students had the exact same level of pre-knowledge. In any event, the experimenter, by randomly assigning the groups, has already taken an important step to ensure the likelihood that the extraneous variable will equivalently affect the two groups.

Let us imagine an experiment being undertaken to measure the effect that noise has on concentration. Assume that there are 50 subjects each in quiet and noisy environments. Table 4.1 below illustrates the ideal or perfect version of this experiment. 'IV' and 'EV' represent the Independent Variable and External Variables, respectively. Note that (see Table 4.1), the only difference between the two conditions is the IV, which indicates that the noise level varies from low to high in the two conditions. All the other variables are controlled and are exactly the same for the two conditions. Therefore, any difference in the concentration levels of subjects between the two conditions must have been caused by the independent variable.

Table 4.1 *Determining the Impact of Internal and External Variables*

Variables	Quiet Condition N = 50	Noisy Condition N = 50
Noise Level (IV)	Low	High
IQ (EV)	Average	Average
Room Temperature (EV)	68 degrees	68 degrees
Sex of Subjects (EV)	60 per cent F	60 per cent F
Task Difficulty (EV)	Moderate	Moderate
Time of Day (EV)	All different times between 9–5	All different times between 9–5
Etc. (EV)	Same as Noisy Environment	Same as Quiet Environment
Etc. (EV)	Same as Noisy Environment	Same as Quiet Environment

An Ideal Experiment

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Now consider another version of this experiment wherein some of the other variables differ across conditions. These are confounding variables (highlighted below) and the experiment being conducted is not ideal. In this experiment, if the concentration levels of subjects vary between the two conditions this may have been caused by the independent variable, *but it could also have been caused by one or more of the confounding variables.* For instance, if the subjects in the noisy environment have lower concentration levels, is it because it was louder, too hot or because they were tested in the afternoon? It is not possible to tell and therefore, this is less than ideal.

Variables	Quiet Condition	Noisy Condition
Noise Level (IV)	Low	High
IQ (EV)	Average	Average
Room Temperature (EV)	68 degrees	82 degrees
Sex of Subjects (EV)	60 per cent F	60 per cent F
Task Difficulty (EV)	Moderate	Moderate
Time of Day (EV)	Morning	Afternoon
Etc. (EV)	Same as Noisy Environment	Same as Quiet Environment
Etc. (EV)	Same as Noisy Environment	Same as Quiet Environment

A Non-Ideal Experiment

Controlling the Confounding Variables

There are ways by which the extraneous variables may be controlled to ensure that they do not become confounding variables. All people-related variables can be controlled through the process of random assignment which will most likely ensure that the subjects will be equally intelligent, outgoing, committed, etc. Random assignment does not necessarily ensure that this is the case for every extraneous variable in every experiment. However, when a sample is large, it works very well and the researcher's motives for using this method will never be questioned.

One of the way in which situation variables or task variables can be controlled is basically by keeping them constant. For instance, in the noise-concentration experiment above, we could adjust the thermostat and thereby keep the room temperature constant and test all the subjects in the same room. We would, of course, hold the difficulty of the tasks constant by giving all subjects in both environments the same task. It is common practice for instructions to be written or recorded and presented to each subject in exactly the same way.

At time, the researcher cannot hold a situation or task variable constant. In these situations too, random assignment can be of great help. Consider a situation where the same room is not available for testing the two groups and, in fact, one group is tested on a Monday in Room 1 and the other group on a Tuesday in Room 2. In this situation, we can use random assignment which can result in half the Monday subjects in Condition A and the rest in Condition B, and the same for the Tuesday subjects. Hence both conditions will have roughly the same percentage of subjects tested in Room 1 and 2. On the other hand, consider what would happen if we did not use random assignment and instead tested the Monday subjects in Condition A and the Tuesday subjects in Condition B. In this situation, we have two confounding variables. Subjects in Condition A were tested on different days of the week and in different rooms from those in Condition B. Any

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difference in the results could have been caused by one or more of the independent variable, the day of the week, or the room.

In other words, confounding variables are those aspects of a study or sample that might influence the dependent variable and whose effect may be confused with the effects of the independent variable. Confounding variables are of two types:

(a) ***Intervening Variables*****:** In many types of behavioural research, the relationship between independent and dependent variables is not a simple one of stimulus to response. Certain variables that cannot be controlled or measured directly may have an important effect on the outcome. These modifying variables intervene between the cause and the effect. For example, in a classroom language experiment, a researcher is interested in determining the effect of immediate reinforcement on learning the parts of speech. He suspects that certain factors or variables other than the one being studied may be influencing the result, even though they cannot be observed directly. These factors may be anxiety, fatigue or motivation. These factors cannot be ignored. Rather they must be controlled as much as possible through the use of appropriate design. For example, a variable (as memory) whose effect occurs between the treatment in a psychological experiment (as the presentation of a stimulus) and the outcome (as a response) is difficult to anticipate or is unanticipated, and may confuse the results.

(b) ***Extraneous Variables*****:** These are variables that are not the subject of an experiment but may have an impact on the results. Hence, extraneous variables are uncontrolled and could significantly influence the results of a study. Often we find that research conclusions need to be questioned further because of the influence of extraneous variables. For instance, a popular study was conducted to compare, the effectiveness of three methods of social science teaching. Ongoing, regular classes were used, and the researchers were not able to randomize or control the key variables as teacher quality, enthusiasm or experience. Hence, the influence of these variables could be mistaken for that of an independent variable.

For instance, in a study which attempts to measure the effect of temperature in a classroom on students' concentration levels, noise coming into the class through doors or windows can influence the results and is therefore an extraneous variable. This may be controlled by soundproofing the room, which illustrates how the extraneous variable may be controlled in order to eliminate its influence on the results of the test.

The following are the types of extraneous variables:

- Subject variables pertain specifically to the people being studied. These people's characteristics, such as age, gender, health status, mood, background, etc., are likely to affect their actions.
- Experimental variables pertain to the persons conducting the experiment. Factors, such as gender, racial bias or language influence how a person behaves.
- Situational variables represent the environment factors which were prevalent at the time when the study or research was conducted. These include the temperature, humidity, lighting, and the time of day, and could have a bearing on the outcome of the experiment.
- Continuous variable is one wherein, any value is possible within the range of the limits of the variable. For instance, the variable 'time taken to run the marathon' is continuous since it could take 2 hours 30 minutes or 3 hours 15 minutes to run the marathon. On the other hand, the variable 'number of days

in a month that a worker came to office' is not a continuous variable since it is not possible to come to office on 14.32 days.

- Discrete variable is one that does not take on all values within the limits of the variable. For instance, the response to a five-point rating scale must only have the specific values of 1, 2, 3, 4 or 5. It cannot have a decimal value, such as 3.6. Similarly this variable cannot be in the form of 1.3 persons.
- Quantitative variable is any variable that can be measured numerically or on a quantitative scale, at an ordinal, interval or ratio scale. For example, a person's wages, the speed of a car or the person's waist size are all quantitative variables.
- Qualitative variables are also known as categorical variables. These variables vary with no natural sense of ordering. They are, therefore, measured on the quality or characteristic. For example, eye colour (black, brown or blue) is a qualitative variable, as are a person's looks (pretty, handsome, ugly, etc.). Qualitative variables may be converted to appear numeric, but this conversion is meaningless and of no real value (as in Male = 1, Female = 2).

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4.4.4 Experimental Designs

The various experimental designs have been discussed in this section.

(a) Single Group Design: In this design study is carried out on a single group. Experiments can be conducted in the following ways:

(i) ***The One-Shot Case Study*:** This is a single group studied only once. A group is introduced to a treatment or condition and then observed for changes which are attributed to the treatment. This is like an ex-post-facto method in which on the basis of a dependent variable, an independent variable is looked for.

(ii) ***One Group Before after Design*:** This design entails the inclusion of a pre-test in order to establish base level scores. For instance, to use this design in a study of college performance, we could compare college grades prior to gaining the experience to the grades after completing a semester of work experience. In this design, we subtract the score of pre-test from post-test and see the differences. This difference is seen using a '*t*' test.

(iii) ***Time Series Designs*:** Time series designs refer to the pre-testing and post-testing of one group of subjects at different intervals. In this design, continuous observation is carried out till a clear result is not seen. The purpose is to establish the long-term effects of treatment and can often lead to the number of pre- and post-tests varying from just one each, to many. At times, there is a period of interruption between tests so as to assess the strength of the treatment over a long time frame.

(iv) ***Counterbalanced Design*:** Experiments that use counterbalanced design are effective ways to avoid the pitfalls of repeated measures, where the subjects are exposed to treatments one after the other.

Typically in an experiment, the order in which the treatments are administered can affect the behaviour of the subjects. It may also elicit a false response due to fatigue or any other external factors which may have a bearing on the behaviour of the subjects. To control or neutralize this, researchers use a counterbalanced design, which helps to reduce the adverse effects of the order of treatment or other factors on the results.

Counterbalancing helps to avoid confounding among variables. Take for example an experiment in which subjects are tested on both, auditory reaction time task and

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visual reaction time task. If each and every subject were first tested on the auditory reaction time task and then on the visual reaction time task, the type of task and the order of presentation would be confounded. If the visual reaction time was lower, we would not be sure whether reaction time to a visual stimulus is 'really' faster to an auditory stimulus, as it is quite likely that the subjects would have learned something while performing the auditory task which led to an improvement of their performance on the visual task.

(b) Two Equivalent Group Design

(i) ***Static Group Comparison Study:*** This design attempts to make up for the lack of a control group but falls short in relation to showing if a change has occurred. In this group, no treatment is given but only observation is carried out in a natural way of two groups, e.g., observation of the monkeys living in a city and observation of other monkeys living in the jungle. It is fair to mention here that in these groups nothing is manipulated as this design does not include any pre-testing and therefore any difference between the two groups prior to the study is unknown.

(ii) ***Post-Test Equivalent Groups Design*****:** Randomization as well as the comparison of both the control and experimental group, are used in studies of this nature. Each group is chosen and assigned randomly and presented with either the treatment or a type of control. Post-tests are subsequently administered to each subject to establish whether or not a difference exists between the two groups. While this is close to being the best possible method, it falls short on account of its lack of a pre-test measure. It is not possible to establish if the difference that seems to exist at the end of the study actually represents a change from the difference at the beginning of the study. Hence, while randomization mixes the subjects well, it does not necessarily create an equivalency between the two groups.

(iii) ***Pre-Test Post-Test Equivalent Groups Design*****:** This is the most effective as well as the most difficult method in terms of demonstrating cause and effect. The pre-test post-test equivalent groups design ensures the presence of a control group as well as a measure of change. Importantly, it also adds a pre-test thereby assessing any differences that existed between the groups prior to the study taking place. In order to apply this method, we select students at random and then segregate them into one of two groups. We would subsequently evaluate the previous semester's grades for each group in order to arrive at a mean grade point average. The treatment (work experience) would be applied to one group, whereas a control would be applied to the other.

It is critical that the two groups be treated similarly in order to control for variables, such as socialization, so the control group may participate in an activity, such as a softball league while the other group participates in the work experience programme. The experiment ends at the end of the semester, and the semester's grades are compared. If it is found that the grade change for the experimental group was significantly different from the grade change of the control group, one could conclude that a semester of work experience results in a significant difference in grades when compared to a semester of non-work related activity programme.

(iv) ***Counterbalanced Randomized Two Groups Design:*** In this design, the group is divided in two parts on a random basis. This design is also called 'rotation design'.

The simplest type of counterbalanced measure design is used when there are two possible conditions, A and B. As with the standard repeated measures design, the researchers want to test every subject for both conditions. They divide the subjects into two groups—one group is treated with condition A, followed by condition B, and the other is tested with condition B followed by condition A as shown in Figure 4.1.

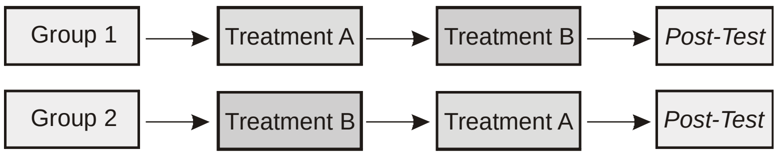

Fig. 4.1 *Experiment to Show Counterbalanced Measure Design*

(c) Solomon Four Group Design: The sample is randomly divided into four groups. Two of the groups are experimental samples, whereas the other two groups experience no experimental manipulation of variables. Two groups receive a pre-test and a post-test. Two groups receive only a post-test. Table 4.2 shows the effect of a particular teaching method on the groups.

Table 4.2 *Solomon Four Group Design*

Group		Pre-Test	Treatment	Post-Test
a)	R	No	No	No
b)	R	No	Yes	No
c)	R	Yes	No	No
d)	R	Yes	Yes	No

Table 4.3 shows a teaching experiment using the Solomon design where testing before and without treatment have similar results, whilst results after teaching are significantly improved. This indicates that the treatment is effective and not subject to priming or learning effects.

Table 4.3 *Pre-and Post-Testing*

Group		Pre-Test	Treatment	Post-Test	Pre-Result	Post-Result
a)	R	No	No	No	3	10
b)	R	No	Yes	No	4	5
c)	R	Yes	No	No		9
d)	R	Yes	Yes	No		3

4.4.5 Internal and External Validity in Experimental Research

Internal Validity

Internal validity is considered as a property of scientific studies which indicates the extent to which an underlying conclusion based on a study is warranted. This type of warrant is constituted by the extent to which a study minimizes systematic error or

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'bias'. If a causal relation between two variables is properly demonstrated then the inferences are said to possess internal validity. A fundamental inference may be based on a relation when the following three criteria are satisfied:

1. The 'cause' precedes the 'effect' in time (temporal precedence).
2. The 'cause' and the 'effect' are related (covariation).
3. There are no plausible alternative explanations for the observed covariation (non-spuriousness).

Internal validity refers to the ability of a research design for providing an adequate test of an hypothesis and the ability to rule out all plausible explanations for the results but the explanation being tested. For example, let us consider that a researcher decides that a particular medication prevents the development of heart disease because he found that research participants who took the medication developed lower rates of heart disease than those who never took the medication. This interpretation of the study's results is likely to be correct, however, only if the study has high internal validity. In order to have high internal validity, the research design must have controlled the directionality and third-variable problems, as well as for the effects of other extraneous variables. In short, the researcher would have needed to perform an experimental study in which:

- Participants were randomly assigned to the experimental and control groups.
- Participants did not know whether they were taking the medication.

The most internally valid studies are experimental studies because they are better than correlational and case studies at controlling for the directionality and third-variable problems, as well as for the effects of other extraneous variables.

Threats to Internal Validity

The following are the various threats to internal validity:

Ambiguous Temporal Precedence: Lack of precision about the occurrence of variable, i.e., which variable occurred first, may yield confusion that which variable is the cause and which is the effect.

Confounding: Confounding is a major threat to the validity of fundamental inferences. Changes in the dependent variable may rather be attributed to the existence or variations in the degree of a third variable which is related to the manipulated variable. Rival hypotheses to the original fundamental inference hypothesis of the researcher may be developed where spurious relationships cannot be ruled out.

Selection Bias: It refers to the problem that, at pre-test, differences between the existing groups that may interact with the independent variable and thus be 'responsible' for the observed outcome. Researchers and participants bring to the experiment a myriad of characteristics, some learned and others inherent. For example, sex, weight, hair, eye, and skin color, personality, mental capabilities and physical abilities, etc. Attitudes like motivation or willingness to participate can also be involved. If an unequal number of test subjects have similar subject-related variables during the selection step of the research study, then there is a threat to the internal validity.

Repeated Testing: It is also referred to as testing effects. Repeatedly measuring or testing the participants may lead to bias. Participants of the testing may remember the correct answers or may be conditioned to know that they are being tested. Repeatedly performing the same or similar intelligence tests usually leads to score gains instead of concluding that the underlying skills have changed for good. This type of threat to internal validity provides good rival hypotheses.

Regression towards the Mean: When subjects are selected on the basis of extreme scores (one far away from the mean) during a test then this type of threat occurs. For example, in a testing when children with the bad reading scores are selected for participating in a reading course, improvements in the reading at the end of the course might be due to regression toward the mean and not the course's effectiveness actually. If the children had been tested again before the course started, they would likely have obtained better scores anyway.

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External Validity

External Validity is considered as the validity of generalized (causal or fundamental) inferences in scientific studies. It is typically based on experiments as experimental validity. In other words, it is the degree to which the outcomes of a study can be generalized to other situations and people.

If inferences about cause and effect relationships which are based on a particular scientific study may be generalized from the unique and characteristics settings, procedures and participants to other populations and conditions then they are said to possess external validity. Causal inferences possessing high degrees of external validity can reasonably be expected to apply:

- To the target population of the study, i.e., from which the sample was drawn. It is also referred to as population validity.
- To the universe of other populations, i.e., across time and space.

An experiment using human participants often employ small samples which are obtained from a single geographic location or with characteristics features is considered as the most common threat to external validity. Due to this reason, one cannot be certain that the conclusions drawn about cause and effect relationships do actually apply to people in other geographic locations or without these particular features.

External validity refers to the ability of a research design for providing outcomes that can be generalized to other situations, especially to real-life situations. For instance, if the researcher in the hypothetical heart disease medication study found that the medication, under controlled conditions, prevented the development of heart disease in research participants, he would want to generalize these findings to state that the medication will prevent heart disease in the general population. However, let us consider that the research design required the elimination of many potential participants, such as people who abuse alcohol or other drugs, suffer from diabetes, weigh more than average for their height, and have never suffered from a mood or anxiety disorder. These are common risk factors for heart disease and, by eliminating these factors; the outcomes of the study would provide little evidence that the medication will be effective for people with these risk factors. In other words, the study would have low external validity and, hence, its outcomes to the general population could not be generalized.

This commonly happens in tests of antidepressant medications. Because researchers want to make sure that the antidepressant effects of the medications being tested are not hidden by the effects of extraneous variables, they often have excluded potential participants with one or more of the following characteristics:

- People who are addicted to alcohol or illicit drugs.
- People who take various medications.
- People who have anxiety disorders (such as, phobic disorders).

- People who suffer from depression with psychosis.
- People with mild depression (because they would show only a small response to the medication).

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If a study excluded people with these characteristic features, then most of the participants suffering from depression would be excluded from the final pool of participants. The outcomes of the study, therefore, would provide little information about how most depressed people will respond to the medication.

Threats to External Validity

A threat to external validity is an explanation of how you might be wrong in making a generalization. Usually, generalization is limited when the cause, i.e., independent variable depends on other factors; therefore, all threats to external validity interact with the independent variable.

- **Aptitude-Treatment Interaction:** The sample may have specific characteristic features that may interact with the independent variable, limiting generalization. For example, inferences based on comparative psychotherapy studies often employ specific samples (e.g. volunteers, highly depressed, no comorbidity). If psychotherapy is found effective for these sample patients, will it also be effective for non-volunteers or the mildly depressed or patients with concurrent other disorders?
- **Situation:** All situational features, such as treatment conditions, time, location, lighting, noise, treatment administration, investigator, timing, scope and extent of measurement, etc., of a study potentially limit generalization.
- **Pre-Test Effects:** If cause and effect relationships can only be found when pre-tests are carried out, then this also limits the generality of the findings.
- **Post-Test Effects:** If cause and effect relationships can only be found when post-tests are carried out, then this also limits the generality of the findings.
- **Reactivity (Placebo, Novelty and Hawthorne Effects):** If cause and effect relationships are found they might not be generalized to other situations if the effects found only occurred as an effect of studying the situation.
- **Rosenthal Effects:** Inferences about cause-consequence relationships may not be able to generalize to other investigators or researchers.

4.5 DOCUMENTARY METHOD

With the Division of Qualitative Research on Human Development the development of the documentary method is closely associated. In the 1920s, this methodology was first put forward by Karl Mannheim and then Harold Garfinkel again takes up it in 1960s. The documentary method first became fruitful for empirical research in the social sciences in 1983 in its current form, through the work of Ralf Bohnsack at the Institute of Sociology at the University of Erlangen-Nuremberg, originally in connection with the group discussion process.

At the Division of Qualitative Research on Human Development at Freie Universität Berlin, this method was further developed especially in the context of larger research projects on youth and deviance. At present documentary method now applies in a broad field throughout the social sciences and education, even extending as far as

Check Your Progress

6. Define the term 'experimental research'.
7. What is a pre-test and a post-test?

information technology and medicine. The application of documentary method range from research into childhood, youth, and gender and adult education to medical sociology, research on policy and organizational cultures, and research on rituals and media use analysis.

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The methodical or methodological spectrum covers discussion analysis and the group discussion process, analysis of interviews, participatory observation, and evaluation research and even includes image and video analysis.

The documentary method forms the methodological foundation for the research conducted at the Center for Qualitative Evaluation and Social Research (CES).

Qualitative technique seeks to describe or explain psycho-social events from the point of view of people involved. It is not easy to provide explanations if there are no defined thoughts or ideas to start with. The researcher takes this into consideration and has an open mind while undertaking collection and analysis of data. In the qualitative technique, the data that is collected is usually derived from interviews that are conducted individually or in groups, participant or non-participant observations, notes in diaries and other documented studies or analysis.

The qualitative technique provides depth and detailed information for a research. Depth and detail emerge through direct questioning and careful descriptions. The extent of depth and detail will vary depending upon the nature and purpose of a particular study. The responses to open-ended questions in a questionnaire are detailed and comprehensive. These responses are neither systematic nor standardized. However, they permit the researcher to understand situations as seen and felt by him. Since the responses to open-ended questions are longer and detailed, they help the researcher to understand in depth the points of view of other people, their level of emotions, their characteristics, their attitudes and values, and their experiences.

The data gathered through participant observation or interviews are also descriptive in nature. These strategies are most comprehensive for fully understanding the complexities of a particular situation. Participant observation provides detailed first hand information to the researcher about a social event. Data gathered through participant observation generally includes: (i) Description of the setting of the social situation; (ii) Activities that take place in the setting; and (iii) Description about people who participated in the activities and their extrinsic behaviour during the activities. The descriptions may be in the form of field notes, specifying some basic information pertaining to the place where the observation takes place, the persons present during the observation, nature of the settings, type and nature of various types of interactions and activities during the observation. The field notes taken during observation contain direct quotations from the people who participated in the observation as well as the observer's own feelings and reactions.

It is not possible to find out what is in other individuals' minds while observing their extrinsic behaviour. Through participant observation, it is difficult for an observer to know the feelings, thoughts and intentions of others and also about the behaviours that took place in earlier situations. However, through open-ended/unstructured interviews, it is possible to find out what had happened earlier or what could not be observed during the participant observation. It provides a framework within which the researcher should be able to gather information from people conveniently and accurately. The information mostly pertains to a programme, the reaction of participants about the programme and the type of change the participants perceive in them after their involvement in the programme. The data are mostly in the form of responses to structured and unstructured

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questions put to the respondents by the researcher during an informal conversation. The responses are generally direct quotations from respondents in their own words and provide details about situations, events, people, experience, behaviours, values, customs, etc. The information gathered during or after an interview includes notes taken by an interviewer along with his detailed comments about what people say about their experiences, what they think and feel about the phenomena under study, and what they know about the phenomena.

Social sciences researchers use several qualitative methods by which they explore diverse issues. These are:

- ***Phenomenology*:** This is a philosophy or a method of inquiry that is used in education. Phenomenology entails the researcher trying to access individuals' 'life worlds'—their world of experiences. It is where consciousness exists.
- ***Ethnography*:** This is derived from anthropology and usually involves observation of participants and obtaining information through natural inquiry. It reveals a very comprehensive understanding of behaviours and interactions, which are set within specific social and cultural contexts.
- ***Narrative Analysis*:** This is a method that is deployed to study the structure and the content of the stories that people narrate about the important events in their lives. It helps us to understand the ways people arrive at meaning in their lives.
- ***Grounded Theory*:** This method was created to be used in sociology. It is based largely on interviews but may also rely on observation and documentary sources in order to develop new theoretical accounts of social situations and interactions. It provides a well defined approach for data analysis.

4.6 SUMMARY

- Primary data is the information collected during the course of an experiment in experimental research.
- Observation methods can be categorized into different types depending on various factors, such as style for recording observed information, data needed for observation and activity of the observer.
- An interview is a method of collecting data that involves presentation of oral and verbal stimuli and the reply is in oral and verbal responses.
- A personal interview involves two persons, i.e., the interviewer and the interviewee; the interviewer is the person who questions the interviewee.
- The principle focus of a survey is on the design and collection of data in which many intricacies involved are frequently overlooked.
- Depth interview is designed to determine the underlying reason and desire of the consumer.
- The sources of unpublished data include diaries, letters, unpublished biographies and autobiographies.
- Case study method is a technique by which individual factor, whether it is an individual or just an episode in the life of an individual or a group, is analysed in its relationship to any other in the group.

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- Researchers undertake surveys in order to determine the opinion of the public regarding products, candidates and other topics.
- The qualitative technique provides depth and detailed information for research. Depth and detail emerge through direct questioning and careful descriptions and will vary depending upon the nature and purpose of a particular study.
- In the quantitative technique, the data are studied from a variety of angles to explore the new facts. Analysis requires an observant, flexible and open-mind. It is worthwhile to prepare a plan of analysis before the actual collection of data.
- The data gathered through participant observation or interviews are also descriptive in nature. These strategies are most comprehensive for fully understanding the complexities of a particular situation.

4.7 KEY TERMS

- **Structured observation:** It is the most common method of studying behavioral sciences
- **Disguised observation:** It is an observation method in which the members of the same group are unaware of the fact that they are being observed
- **Warranty cards:** These are cards that dealer use for collecting information regarding their products
- **Phenomenology:** This is a philosophy or a method of inquiry that is used in education

4.8 ANSWERS TO 'CHECK YOUR PROGRESS'

1. Primary data is the information collected during the course of an experiment in experimental research.
2. There are several methods of collecting primary data. Some of these are:
    - Observation
    - Interviews
    - Questionnaires
    - Schedules
    - Surveys
3. A survey is a scientific process of acquiring data and opinion from the public. Researchers undertake surveys in order to determine the opinion of the public regarding products, candidates and other topics.
4. Secondary data is the data which has already been collected and examined earlier by other investigators.
5. Case study method is the most common method of collecting secondary data.
6. In experimental research, variables are manipulated and their effect upon other variables is studied. Experimental research provides a systematic and logical method for answering the question. Experimenters manipulate certain stimuli, treatment or environmental conditions and observe how the condition or behaviour of the subject is affected or changed. Their manipulation is deliberate and systematic.

7. A pre-test is the test that is administered to the subjects before the independent variable and a post-test is the test that is administered to the subjects after the independent variable is applied.

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4.9 QUESTIONS AND EXERCISES

Short-Answer Questions

1. Write down the methods of collecting primary data.
2. What is the most common method of interview?
3. Name the most commonly used method of data collection.
4. What is the most common method of collecting secondary data?
5. Who first forwarded the documentary method?

Long-Answer Questions

1. What do you understand by primary data? Describe the methods of collecting primary data.
2. Describible the methods and instruments of collecting secondary data.
3. Explain the process of conducting a survey.
4. Explain the various types of interview.
5. Discuss the characteristics and significance of case study method.
6. Elaborate the characteristics of experimental research.
7. Write the steps required in performing the experimental research.
8. Discuss the significance of documentary method in research.

4.10 FURTHER READING

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UNIT 5 DATA PROCESSING, ANALYSIS AND INTERPRETATION

Structure

5.0 INTRODUCTION

In this unit, you will learn about the various methods of data processing, analysis and interpretation. Research does not merely refer to the process of collection of data. Research also needs proper analysis of the data that has been collected. Analysing and manipulating the data by performing various functions is called processing of data. In this unit, you will understand that processing of data is essential for ensuring that all the relevant data has been collected for performing comparisons and analysis. This unit will also help you understand the different data classification methods. Tabulation means placing the results and data collected from research in a tabular form. Tabulation enables the researcher to arrange data in a concise and logical order.

Analysis of data refers to transforming the data with the aim of extracting some useful information which, in turn, facilitates drawing of useful conclusions. The techniques of data interpretation will be also discussed in this unit. Data interpretation refers to the identification of trends in different variables.

5.1 UNIT OBJECTIVES

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

- Discuss the different data processing methods
- Explain the process of tabulation, coding and editing of data

- Classify different types of data
- Learn the various data analysis techniques
- Describe the methods of interpreting data

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5.2 DATA PROCESSING

As already mentioned, research does not merely consist of data that is collected. Research is incomplete without proper analysis of the collected data. **Processing** of data involves analysis and manipulation of the collected data by performing various functions. The data has to be processed in accordance with the outline laid down at the time of developing the research plan. Processing of data is essential for ensuring that all relevant data has been collected for performing comparisons and analyses. The functions that can be performed on data are as follows:

- Editing
- Coding
- Tabulation
- Classification

Usually, experts are of the opinion that processing and analysis of data are inter-related. Therefore, they should be thought as one and the same thing. It is argued that analysis of data generally involves a number of closely-related operations, which are carried out with the objective of summarizing the collected data and organizing it in such a way that they are able to answer the research questions associated with it.

However, in technical terms, the processing of data involves data representation in such a way that it is open to analysis. Similarly, analysis of data is defined as the computation of certain measures along with searching for the patterns of relationship that may exist among data groups.

5.2.1 Editing of Data

Editing of data involves the testing of data collection instruments in order to ensure maximum accuracy. This includes checking the legibility, consistency and completeness of the data. The editing process aims at avoiding equivocation and ambiguity. The collected raw data is also examined to detect errors and omissions, if any. A careful scrutiny is performed on the completed questionnaires and schedules to assure that the data has the following features:

- Accuracy
- Consistency
- Unity
- Uniformity
- Effective Arrangement

The stages at which editing should be performed are as follows:

- **Field Editing:** This involves reviewing the reporting forms by the investigator, that are written in abbreviated or illegible form by the informant at the time of recording the respondent's responses. Such type of editing must be done immediately after the interview. If performed after some time, such editing becomes complicated for the researcher, as it is difficult to decipher any particular individual's writing style. The investigator needs to be careful while doing such kind of editing and restrain the researcher from correcting errors or omission by guesswork.

- **Central Editing:** This kind of editing involves a thorough editing of the entire data by a single editor or a team of editors. Such editing takes place when all the schedules created according to the research plan have been completed and returned to the researcher. Editors correct errors such as data recorded in the wrong place or data recorded in months when it should be recorded in weeks. They can provide an appropriate answer to incorrect or missing replies by reviewing the other information in the schedule. At times, the respondent can be contacted for clarification. In some cases, if the answer is inappropriate or incomplete and an accurate answer cannot be determined on any basis, then the editor should delete or remove that answer from the collected data. He/she can put a note as 'no answer' in such a case. The answers that can be easily deciphered as wrong should be dropped from the final results.

Besides using the above-mentioned methods according to the data source, the researcher should also keep in mind certain points while doing the editing, and which are as follows:

- Familiarity with the instructions given to interviewers and coders
- Know-how of editing instructions
- Single-line striking for deleting an original entry
- Standardized and distinctive editing of data
- Initializing all the answers that have been changed

5.2.2 Advantages of Editing

In any research either the raw data is collected or the secondary data is used as per the requirement of research. The data that is collected must be properly edited before it is used. Even the secondary data needs editing as per specifications. Thus, data editing is an analysis of the data sources for a data warehouse to clarify the structure, content, relationships and derivation rules of the data. Editing of data helps not only to understand anomalies and to assess data quality, but also to discover, register and assess metadata. The result of the edited data analysis is used both strategically, to determine suitability of the source systems, and tactically to identify problems. The key objectives of data editing are as follows:

- To ensure the accuracy of data.
- To establish the consistency of data.
- To determine whether or not the data are complete.
- To ensure the coherence of aggregated data.
- To obtain the best possible data available.

Characteristically, data editing is the process of examining the data available in an existing data source, for example a database or a file and collecting statistics and information about that data. The purpose of these statistics is to:

- Find out how the existing data can be used for specific purposes.
- Tagging the data with keywords, descriptions or assigning it to a category.
- Give metrics on data quality including whether the data conforms to particular standards or patterns.

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- Assess the risk involved in integrating data for new applications, including the challenges.
- Assess whether metadata accurately describes the actual values in the source database.
- Understand data challenges.
- Organize master data management where key data is needed or to do data governance for improving data quality.

Typically the editing process can also be a valuable tool in assessing the quality of the data by indicating the required modifications. By indicating potential causes of problems, editing can also be an effective way of avoiding the need to repeat the survey. Thus, editing of data has the following significances:

- Improves data quality.
- Improves clarity, readability, organization of data.
- Gives concise, cohesive, error-free data.
- Clearly communicates complex ideas of data.
- Clarifies scientific value of researched data.
- Emphasizes novelty and significance of data.
- Produces a gain in the yield of the fieldwork, that is, to minimize the number of responses excluded from analysis.
- Improves the validity of the findings, that is, to remove systematic errors that may lead to bias.
- Improves the correspondence between the structure of the questionnaire and that of the responses, the net effect being the easing of further tabulation and analysis.
- Users have more confidence in data which are internally consistent because such consistency reflects on the entire process of data collection and preparation.

Thus, data should be edited before being presented as information. This action ensures that the information provided is accurate, complete and consistent. No matter what type of data you are working with, certain edits are performed on all surveys. Data editing can be performed manually, with the assistance of computer programming, or a combination of both techniques. It depends on the medium (electronic, paper) by which the data are submitted.

There are two levels of data editing—***micro editing*** and ***macro editing***.

Micro editing corrects the data at the record level. This process detects errors in data through checks of the individual data records. The intent at this point is to determine the consistency of the data and correct the individual data records.

Macro editing also detects errors in data, but does this through the analysis of aggregate data (totals). The data are compared with data from other surveys, administrative files or earlier versions of the same data. This process determines the compatibility of data.

Why Data Editing?

There are many situations which are responsible for the inaccuracy of data or errors in data files. The following are some of the common situations when errors can be introduced into the data:

- A respondent could have misunderstood a question.
- A respondent or an interviewer could have checked the wrong response.
- An interviewer could have miscoded or misunderstood a written response.
- An interviewer could have forgotten to ask a question or record the answer.
- A respondent could have provided inaccurate responses.

Data Errors

Data editing should detect and minimize errors, such as:

- Unasked Questions
- Unrecorded Answers
- Inappropriate Responses

An inaccurate response can occur as a result of carelessness or a deliberate effort to give misleading answers. It can also occur if some of the answers require mathematical calculations. For example, converting days into hours or annual income into weekly income increases the possibility of making mistakes.

The data can be perfectly edited by applying the following editing rules:

Rule 1: The first step is to apply rules to the data to be edited, i.e., factors to be taken into consideration. These rules are determined by the expert knowledge of a subject matter specialist, the structure of the questionnaire, the history of the data, and any other related surveys or data.

Rule 2: Expert knowledge can come from a variety of sources. The specialist could be an analyst who has extensive experience with the type of data being edited. An expert could also be one of the survey sponsors who are acquainted with the relationships between the data.

Rule 3: The layout and structure of the questionnaire will also impact the rules for editing data. For example, sometimes respondents are instructed to skip certain questions if the questions do not apply to them or their situation. This specification must be respected and incorporated into the editing rules.

Rule 4: Lastly, other surveys relating to the same sort of variables or characteristics are used in order to establish some of the rules for editing data.

Data Editing Types

The following are the various types of data edits:

- **Validity Edits:** It looks at one question field or cell at a time. They check to ensure the record identifiers, invalid characters, and values have been accounted for; essential fields have been completed (e.g., no quantity field is left blank where a number is required); specified units of measure have been properly used; and the reporting time is within the specified limits.
- **Range Edits:** These are similar to validity edits in that they look at one field at a time. The purpose of this type of edit is to ensure that the values, ratios and calculations fall within the pre-established limits.
- **Duplication Edits:** It examines one full record at a time. These types of edits check for duplicated records, making certain that a respondent or a survey item has only been recorded once. A duplication edit also checks to ensure that the

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respondent does not appear in the survey universe more than once, especially if there has been a name change. Finally, it ensures that the data have been entered into the system only once.

- **Consistency Edits:** It compares different answers from the same record to ensure that they are coherent with one another. These edits verify that if a figure is reported in one section, a corresponding figure is reported in another.
- **Historical Edits:** These are used to compare survey answers in current and previous surveys. For example, any dramatic changes since the last survey will be flagged. The ratios and calculations are also compared, and any percentage variance that falls outside the established limits will be noted and questioned.
- **Statistical Edits:** It looks at the entire set of data. This type of edit is performed only after all other edits have been applied and the data have been corrected. The data are compiled and all extreme values, suspicious data and outliers are rejected.
- **Miscellaneous Edits:** It fall in the range of special reporting arrangements; dynamic edits particular to the survey; correct classification checks; changes to physical addresses, locations and/or contacts; and legibility edits, i.e., making sure the figures or symbols are recognizable and easy to read.

Data editing is influenced by the complexity of the questionnaire. Complexity refers to the length, as well as the number of questions asked. It also includes the detail of questions and the range of subject matter that the questionnaire may cover. In some cases, the terminology of a question can be very technical. For these types of surveys, special reporting arrangements and industry specific edits may occur.

5.2.3 Coding of Data

Coding of data can be defined as representing the data symbolically using some predefined rules. Once data is coded and summarized, the researcher can analyse it and relationships can be found among various categories.

Checklist for Coding

The checklist enables the researcher to put the responses of the individuals into a limited number of categories or classes, which should possess the following important characteristics:

- Classes should be appropriate and in accordance with the research problem under consideration.
- There must be a class for every data element.
- There should be mutual exclusivity, which means that a specific answer can be placed in one and only one cell of a given category set.
- The classes should be one-dimensional. This means that every class is defined in terms of only one concept.

Significance of Coding

Coding of data is necessary for efficient analysis. It facilitates classification of data into a small number of classes. Thus, only important and critical information that is required for analysis is retained in the research. Coding decisions are usually taken at the designing stage of the questionnaire. This makes it possible to pre-code the questionnaire choices which, in turn, is helpful for computer tabulation.

However, in case of hand coding, some standard method may be used. One such method is to code in the margin with a coloured pencil. Another method is to transcribe data from the questionnaire to a coding sheet. Whatever method is adopted, you should note that coding errors are altogether eliminated or reduced to the minimum level.

5.2.4 Classification of Data

Research studies involve extensive collection of raw data and usage of the data to implement a research plan. To make the research plan easier, the data needs to be classified in different groups for understanding the relationship among different phases of research plan. Classification of data involves arrangement of data in groups or classes on the basis of some common characteristics. The methods of classification can be divided under the following two headings:

- Classification according to attributes
- Classification according to class intervals

Figure 5.1 shows the classification of data.

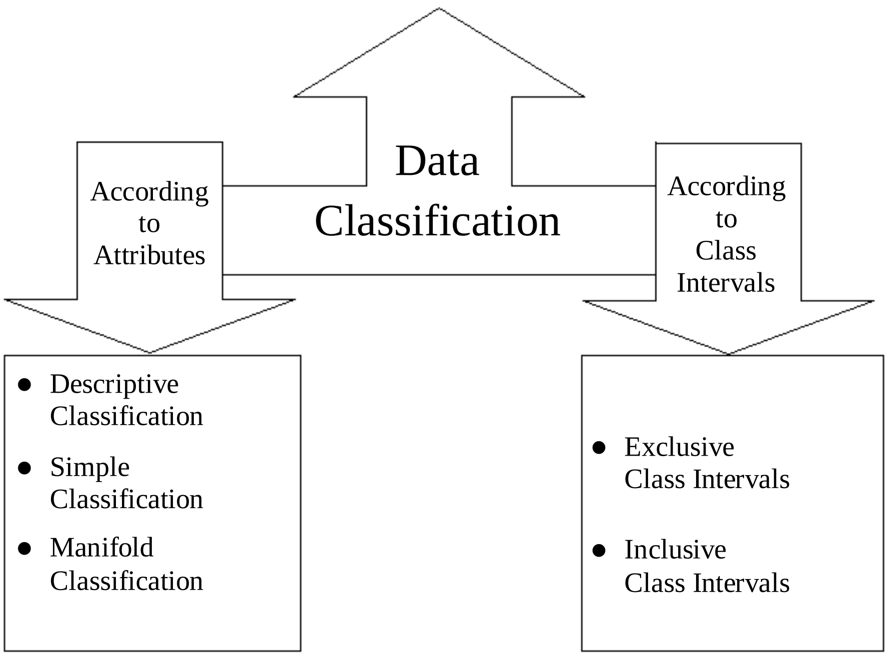

Fig. 5.1 *Data Classification*

Classification of Data According to Attributes

Data is classified on the basis of similar features, as follows:

- **Descriptive Classification:** This classification is performed according to the qualitative features and attributes, which cannot be measured quantitatively. These features can be either present or absent in an individual or an element. The features related to descriptive classification of attributes, can be literacy, sex, honesty, solidity, etc.
- **Simple Classification:** In this type of classification, the elements of data are categorized as those possessing the concerned attribute and those that do not.
- **Manifold Classification:** In this type of classification, two or more attributes are considered simultaneously and the data is categorized into a number of classes

on the basis of those attributes. The total number of classes of final order is given by 2^n, where n = number of attributes considered.

Classification of Data According to Class Intervals

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Classifying data according to class intervals is a quantitative phenomenon. Class intervals help categorize data which has similar numerical characteristics such as income, production, age, weight, etc. Data can be measured with certain statistical tools like mean, mode and median. The different categories of data according to class intervals are as follows:

- **Statistics of Variables:** This term refers to measurable attributes, as these typically vary over time or between individuals. The variables can be discrete, i.e., taking values from a countable or finite set, continuous, i.e., having a continuous distribution function or neither. This concept of a variable is widely utilized in the social, natural, medical sciences.
- **Class Intervals:** These refer to a range of values of a variable. This interval is used to calibrate the scale of a variable in order to tabulate the frequency distribution of a sample. A suitable example of such data classification can be the categorizing of birth rate in a country. In this case, babies aged 0–1 year will form a group; those aged 2–5 years will form another group, and so on. The entire data is thus categorized into several numbers of groups or classes or in other words, class intervals. Each class interval has an upper limit as well as a lower limit, which is defined as 'the class limit.' The difference between two class limits is known as class magnitude. The classes can have equal or unequal class magnitudes.

  The number of elements in a given class is called the frequency of the given class interval. All class intervals, with their respective frequencies, are taken together and described in a tabular form called the frequency distribution.

Problems Related to Classification of Data

The problems related to classification of data on the basis of class intervals are divided into the following three categories:

(a) Number of Classes and Their Magnitude: There are differences regarding the number of classes into which data can be classified. As such, there are no predefined rules for classification of data. It all depends upon the skill and experience of the researcher. The researcher should display the data in such a way that it should be clear and meaningful to the analyst.

As regards the magnitude of classes, it is usually held that class intervals should be of equal magnitude, but in some cases unequal magnitudes may result in better classification. It is the researcher's objective and judgement that plays a significant role in this regard. In general, multiples of two, five and ten are preferred while determining class magnitudes. H.A. Sturges suggested the following formula for determining the size of class interval:

$$i = R/(1 + 3.3 \log N)$$

where,

i = size of class interval

R = Range (difference between the values of the largest element and smallest element among the given elements)

N = Number of items to be grouped

Sometimes, data may contain one or two or very few elements with very high or very low values. In such cases, the researcher can use an open-ended interval in the overall frequency distribution. Such intervals can be expressed below two years; or twelve years and above. However, such intervals are not desirable, yet cannot be avoided.

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(b) Choice of Class Limits: While choosing class limits, the researcher must determine the mid-point of a class interval. A mid-point is generally derived by taking the sum of the upper and lower limit, of a class and then dividing it by two. The actual average of elements of that class interval should remain as close to each other as possible. In accordance with this principle, the class limits should be located at multiples of two, five, ten, twenty and hundred and such other figures. The class limits can generally be stated in any of the following forms:

- o **Exclusive Type Class Intervals:** These intervals are usually stated as follows:
  - 10–20
  - 20–30
  - 30–40
  - 40–50

  These intervals should be read in the following way:
  - 10 and under 20
  - 20 and under 30
  - 30 and under 40
  - 40 and under 50

  In the exclusive type of class interval, the elements whose values are equal to the upper limit of a class are grouped in the next higher class. For example, an item whose value is exactly thirty would be put in 30–40-class interval and not in 20–30-class interval. In other words, an exclusive type of class interval is that in which the upper limit of a class interval is excluded and items with values less than the upper limit, but not less than the lower limit, are put in the given class interval.
- o **Inclusive Type Class Intervals:** These intervals are normally stated as follows:
  - 11–20
  - 21–30
  - 31–40
  - 41–50

  This should be read as follows:
  - 11 and under 21
  - 21 and under 31
  - 31 and under 41
  - 41 and under 51

  In this method, the upper limit of a class interval is also included in the concerning class interval. Thus, an element whose value is twenty will be put in 11–20-class interval. The stated upper limit of the class interval 11–20 is

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twenty but the real upper limit is 20.999999 and as such 11–20 class interval really means eleven and under twenty-one. When data to be classified happens to be a discrete one, then the inclusive type of classification should be applied. But when data happens to be a continuous one, the exclusive type of class intervals can be used.

(c) Determining the Frequency of Each Class: The frequency of each class can be determined using tally sheets or mechanical aids. In tally sheets, the class groups are written on a sheet of paper and for each item a stroke (a small vertical line) is marked against the class group in which it falls. The general practice is that after every four small vertical lines in a class group, the fifth line for the element falling in the same group is indicated as a diagonal line through the above said four lines. This enables the researcher to perform the counting of elements in each one of the class groups. Table 5.1 shows a hypothetical tally sheet.

Table 5.1 *Sample of a Tally Sheet*

Income groups (Rupees)	Tally mark	Number of families (Class frequency)
Below 600	卌 卌 卌 III	15
601-900	卌 卌 I	9
901-1300	卌 卌 卌 卌 卌 卌 I	25
1301-1500	卌 卌 卌 IIII	16
1501 and above	卌 卌 II	10
Total		75

In case of large inquiries and surveys, class frequencies can be determined by means of mechanical aids, i.e., with the help of machines. Such machines function either manually or automatically and run on electricity and can sort cards at a speed of around 25,000 cards per hour. Although this method increases the speed, it is an expensive method.

5.2.5 Tabulation of Data

In simple terms, tabulation means placing the data collected and results from research in a tabular form.

Methods of Tabulation

Tabulation can be done by hand or mechanically using various electronic devices. Several factors like the size and type of study, cost considerations, time pressures and availability of tabulating machines decide the choice of tabulation. Relatively, large data requires computer tabulation. Hand tabulation is preferred in case of small inquiries, when the number of questionnaires is small and they are of relatively short length. The different methods used in hand tabulation are as follows:

- ***Direct Tally Method:*** This method involves simple codes, where the researcher can directly tally from the questionnaire. The codes are written on a sheet of paper called tally sheet and for each response, a stroke is marked against the code in which it falls. Usually, after every four strokes against a particular code, the fifth response is indicated by drawing a diagonal or horizontal line through the strokes. These groups are easy to count and the data is sorted against each code conveniently.

- ***List and Tally Method:*** In this method, code responses may be transcribed into a large worksheet, allowing a line for each questionnaire. This facilitates listing of a large number of questionnaires in one worksheet. The tallies are then made for each question.
- ***Card Sort Method:*** This is the most flexible hand tabulation method, where the data is recorded on special cards of convenient sizes and shapes with a series of holes. Each hole in the card stands for a code. When the cards are stacked, a needle passes through a particular hole, thus representing a particular code. These cards are then segregated and counted. In this way, frequencies of various codes can be found out by a repetition of this technique.

Significance of Tabulation

Tabulation enables the researcher to arrange data in a concise and logical order. It summarizes the raw data and displays the same in a compact form for further analysis. It helps in the orderly arrangement of data in rows and columns. The various advantages of tabulation of data are as follows:

- A table saves space and reduces descriptive and explanatory statements to a minimum.
- It facilitates and eases the comparison process.
- The summation of elements and detection of omissions and errors become easy due to a tabular description.
- A table provides a basis for statistical computations.

Checklist for Tables

A table should communicate the required information to the reader in such a way that it becomes easy for him/her to read, comprehend and recall the information when required. There are certain conventions to be followed during tabulation, which are as follows:

- All tables should have a clear, precise and adequate title to make them intelligible enough without any reference to the text.
- Tables should be featured with clarity and readability.
- Every table should be given a distinct number to facilitate easy reference.
- The table should be of an appropriate size and tally with the required information.
- The columns and rows should be headed with bold font letters. It is a general rule to include independent variables in the left column or first row and dependent variables in the bottom row or right column.
- Displaying of numbers should be neat and readable.
- Explanatory footnotes, if any, regarding the table should be placed directly beneath the table, along with the reference symbols used in the table.
- The source of the table should be indicated just below the table.
- The table should contain thick lines to separate data of one class from data of another class and thin lines to separate the different subdivisions of each class.
- All column figures should be properly aligned.
- Abbreviations should be avoided in a table to the best possible extent.
- If the volume of data happens to be large, then it should not be crowded in a single table. It makes the table unwieldy and inconvenient.

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Tabulation can also be classified into complex or simple. The former type of tabulation gives information about one or more groups of independent variables, whereas the latter shows the division of data into two or more categories.

5.3 ANALYSIS AND INTERPRETATION OF DATA

Analysis of data is the process of transformating data for the purpose of extracting useful information, which in turn facilitates the discovery of some useful conclusions. Finding conclusions from the analysed data is known as interpretation of data. However, if the analysis is done, in the case of experimental data or survey, then the value of the unknown parameters of the population and hypothesis testing is estimated.

Analysis of data can be either descriptive or inferential. Inferential analysis is also known as statistical analysis. Descriptive analysis is used to describe the basic features of the data in a study such as persons, work groups and organizations. Inferential analysis is used to make inferences from the data, which means that we are trying to understand some process and make some possible predictions based on this understanding.

5.3.1 Types of Analysis

The various types of analyses are as follows:

- **Multiple Regression Analysis:** This type of analysis is used to predict a single dependent variable by a set of independent variables. In multiple regression analysis, the independent variables are not correlated to each other.
- **Multiple Discriminant Analysis:** In multiple discriminant analysis, there is one single dependent variable, which is very difficult to measure. One of the main objectives of this type of analysis is to understand group differences and predict the likelihood that an entity, i.e., an individual or an object, belongs to a particular class or group based on several metric-independent variables.
- **Canonical Correlation Analysis:** It is a method for assessing the relationship between variables. This analysis also allows you to investigate the relationship between two sets of variables.

Univariate, Bivariate and Multivariate Analysis

Many types of analyses are performed according to the variance that exists in the data. Such analyses is carried out to check if the differences between three or more variables are significant enough to evaluate them statistically. There are three types of such analyses, namely univariate, bivariate and multivariate analyses.

(i) Univariate Analysis: In this analysis, only a single variable is taken into consideration. It is usually the first activity pursued while analysing the data. It is performed with the purpose of describing each variable in terms of mean, median or mode, and variability. Examples of such analysis are averages or a set of cases that may come under a specific category amidst a whole sample.

(ii) Bivariate Analysis: This type of analysis examines the relationship between two variables. It tries to find the extent of association that exists among these variables. Thus, a bivariate analysis may help you; for example, to find whether the variables of irregular meals and migraine headaches are associated and up to what extent. Here, the two variables are thus statistically measured simultaneously.

(iii) Multivariate Analysis: This type of analysis involves observation and analysis of three or more than three statistical variables at a time. Such an analysis is performed using statistical tests or even in a tabular format. Thus, for example, you can study the variables of age, educational qualification and annual income of a given set of population at the same time using the multivariate analysis method.

Usually, these types of analyses are more convenient when performed in a tabular format. This involves, using a cross-classification or contingency table. Such a table is made of two columns and two rows, showing the frequencies of two variables that are displayed in rows and columns. This is more popularly known as constructing the bivariate table. Traditionally, the independent variable is displayed in columns and the dependent ones in rows. A multivariate table, if related to the same data, is the result of combining the bivariate tables. In this case, each bivariate table is known as a partial table. Usually, a multivariate table is created with the purpose of explaining or replicating the primary relationship that is found in the bivariate table. Tables 5.2(a) and (b) show an example of a bivariate table and a multivariate table respectively.

Table 5.2(a) *Bivariate Table*

	1991	**1992**	**1993**
Percentage of students failed	33 per cent	38 per cent	42 per cent
Percentage of students passed	67 per cent	62 per cent	58 per cent

Table 5.2(b) *Multivariate Table*

	1991	**1992**	**1993**
	First Attempt	Second Attempt	Third Attempt
Percentage of students who passed in Maths	27 per cent	35 per cent	–
Percentage of students who passed in English	53 per cent	60 per cent	44 per cent

Although the data in both tables is related, except the variable of 'attempts', the multivariate table has been displayed separately in this example. However, you should note that the tables have dealt simultaneously with two or more variables of the data.

5.3.2 Data Interpretation

Data interpretation refers to the identification of trends in different variables. The researcher uses statistics for this purpose. The researcher is required to be familiar with the knowledge of the scales of measurement. This enables him/her to choose the appropriate statistical method for his/her research project. The scales of measurement facilitate the allotment of numerical values to characteristics adhering to any specific rules. This measurement is also related to such levels of measurement of data like nominal, ordinal and internal and ratio levels. These levels can be explained as follows:

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- **Nominal Measurement:** The nominal measurement assigns a numeral value to a specific characteristic. It is the fundamental form of measurement. The nominal measurement calculates the lowest level of data available for measurement.
- **Ordinal Measurement:** This type of measurement involves allotting a specific feature to numeral value in terms of a specific order. The ordinal scale displays the way in which an entity is measured. The ordinal scale of measurement is used to calculate and derive data pertaining to the median, percentage, rank order, correlations and percentile.
- **Interval Measurement:** A researcher can depict the difference between the first aspect of a data and another aspect using this level of measurement. The interval scale of measurement is useful for the researcher in several ways. It can be applied in the calculation of arithmetic mean, averages, standard deviations and determining the correlation between different variables.
- **Ratio Measurement:** In this method, there are fixed proportions (ratio) between the number numerical and the amount of the characteristics that it represents. A researcher should remember while measuring the ratio levels that a fixed zero point exists. The ratio level of measurement facilitates researchers in determining, if the aspects possess any certain characteristic. Almost any type of arithmetical calculations can be executed using this scale of measurement.

The most important feature of any measuring scale is its reliability and validity, which is explained as follows:

- **Reliability:** It is the term used to deal with accuracy. A scale measurement can be said to be reliable, when it exactly measures, only that what it is supposed to measure. In other words, when the same researcher repeats a test, i.e., with a different group but resembling the original group, he/she should get the same results as the former.
- **Validity:** According to Leedy, validity is the assessment of the soundness and the effectiveness of the measuring instrument. There are three types of validity, which can be stated as follows:
  - o ***Content Validity:*** It deals with the accuracy with which an instrument measures the factors or content of the course or situations of the research study.
  - o ***Prognostic Validity:*** It depends on the possibility to make judgements from results obtained by the concerned measuring instrument. The judgement is future oriented.
  - o ***Simultaneous Validity:*** This involves comparing of one measuring instrument with another; one that measures the same characteristic and is available immediately.

Check Your Progress

1. List the various functions that can be performed on data.
2. What is the significance of coding?
3. What are the various factors that decide the choice of tabulation?
4. What is nominal measurement?

5.4 QUANTITATIVE TECHNIQUES OF DATA ANALYSIS

A researcher needs to be familiar with the various quantitative techniques in order to analyse and interpret the data. Certain statistical methods in quantitative techniques are available that can be used for analysing the data so that appropriate methods can be used in the research study. There are certain basic statistical methods which can be classified into the following three groups:

- Descriptive statistics
- Inferential statistics
- Measures of central tendency and dispersion

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5.4.1 Descriptive Statistics

According to Smith, descriptive statistics is the formulation of rules and procedures where the data can be placed in a useful and significant order. The foundation of applicability of descriptive statistics is the need for complete data presentation. The most important and general methods used in descriptive statistics are as follows:

- **Ratios:** This indicates the relative frequency of the various variables to one another.
- **Percentages:** Percentages (%) can be derived by multiplying a ratio with 100. It is, thus, a ratio representing a standard unit of 100.
- **Frequency Table:** It is a means to tabulate the rate of recurrence of data. Data arranged in such a manner is known as distribution. In case of a large distribution tendency, larger class intervals are used. This facilitates the researcher to acquire a more orderly system.
- **Histogram:** It is the graphic representation of a frequency distribution table. The main advantage of graphical representation of data in the form of histogram is that data can be interpreted immediately.
- **Frequency Polygon:** It is used for the representation of data in the form of a polygon. In this method, a dot that represents the highest score is placed in the middle of the class interval. Linking these dots derives a frequency polygon. An additional class is sometimes added at the end of the line with the purpose of creating an anchor.
- **Cumulative Frequency Curve:** The procedure of finding frequency curve involves adding frequency by starting from the bottom of the class interval and adding class by class. This facilitates the representation of the number of persons that perform below the class interval. A researcher can derive a curve from the cumulative frequency tables, with the purpose of reflecting data in a graphic manner.

5.4.2 Inferential Statistics

Inferential statistics enable researchers to explore unknown data. Researchers can make deductions or statements using inferential statistics with regard to the broad population as the samples from which the known data is drawn. These methods are called the inferential or inductive statistics. These methods include the following common techniques:

- **Estimation:** Estimation is the calculated approximation of a result, which is usable, even if the input data may be incomplete or uncertain. It involves deriving the approximate calculation of a quantity or a degree or worth, for example, drawing an estimate of what it would cost; or deriving a rough idea how long it would take.
- **Prediction:** A prediction is a statement or claim that a particular event will surely occur in future. It is based on observation, experience and scientific reasoning of what will happen in given circumstances or situation.
- **Hypothesis Testing:** Hypothesis is a proposed explanation, whose validity can be tested. The hypothesis testing attempts to validate or disprove the preconceived ideas. In creating a hypothesis, one thinks of a possible explanation for a remarked behaviour. The hypothesis dictates the data selected to be analysed for further interpretations.

There are also two chief statistical methods based on the tendency of data to cluster or scatter. These methods are known as measures of central tendency and measures of dispersion.

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5.4.3 Measures of Central Tendency and Dispersion

Central tendency refers to the central point around which the data revolves. The measures of central tendency help know the point about which items have a tendency to cluster. This measure is supposed to be the representative figure for the entire mass of data. The measure of central tendency is also called the statistical average. The most common techniques used in central tendency are as follows:

- **Mode:** Mode refers to the score, value or category of the variable observed more frequently. It is also known as the arithmetic average. The mode in data distribution is that element around which there is maximum concentration. In general, mode is the size of the element, which has the maximum frequency. Mode is mostly useful in the study of popular sizes like that of shoes, shirts, and so on.
- **Median:** Median refers to the middle value of a series of data arranged in an increasing order. It divides the series into two halves. In one half, all values are less than the median, whereas in the other half they all have values more than the median. Thus, for example, if the values of the items arranged in the ascending order are fifty, 66, 75, 80, 90, 95, 100, then the value of the fourth element, i.e., 80 is the value of the median. This is because the median divides frequencies into two equal parts. It can also be described as the fiftieth percentile. The formula for median can be written as follows:

$$\text{Median}\,(M) = \text{Value of}\left(\frac{n+1}{2}\right)\text{th item}$$

Median is a positional average and is used only in the context of qualitative phenomena; for example, in estimating intelligence, in sociological fields.

Mean: Mean refers to the measure of central tendencies that is derived by the addition of all scores and dividing them by the number of scores. It is the simplest tool of measuring the central tendency and is the most widely used measure. It is chiefly used in summarizing the essential features of a series and in facilitating data comparison. It is used in further statistical calculations and is better compared to the simple averages, especially in economics and social studies, where direct quantitative measurements are possible. The formula for mean can be stated as follows:

$$\text{Mean (or } \bar{X})^* = \frac{\sum X_i}{n} = \frac{X_1 + X_2 + \ldots + X_n}{n}$$

where $\bar{X}$ = The symbol we use for mean (pronounced as $\bar{X}$ bar)

$\sum$ = Symbol for summation

X_i = Value of the ith item X, i = 1, 2,...., n

n = total number of items

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*If we use assumed average A, then mean would be worked out as follows:

$$\bar{X} = A + \frac{\sum (X_i - A)}{n} \quad or \quad \bar{X} = A + \frac{\sum f_i(X_i - A)}{\sum f_i}$$

in case of frequency distribution.

This is also known as the short cut method of finding $\bar{X}$.
In case of frequency distribution, you can work out mean in this way:

$$\bar{X} = \frac{\sum f_i X_i}{\sum f_i} = \frac{f_1 X_1 + f_2 X_2 + ... + f_n X_n}{f_1 + f_1 + ... + f_n = n}$$

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Sometimes, instead of calculating the simple mean, as stated above, you may calculate the weighted mean for a realistic average. The weighted mean can be worked out as follows:

$$\bar{X}_w = \frac{\sum w_i X_i}{\sum w_i}$$

Where $\bar{X}_w$ = Weighted mean

w_i = Weight of ith item X

X_i = Value of the ith item X

The measure of dispersion, on the other hand, defines how much the scores in a sample vary from one another. Although, average can indicate a series only as best as a single figure can, it cannot show the scatter of values of elements of a variable in the series around the true value of average. The measures of dispersion are used to calculate this scatter value of different variables. The most commonly used devices in measures of dispersion are as follows:

- **Range:** Range refers to the simplest possible measure of dispersion and is defined as the difference between the values of the extreme items of a series. Thus, the formula for range can be stated as follows:

$$\text{Range} = \begin{pmatrix}\text{Highest value of} \\ \text{an item in a series}\end{pmatrix} - \begin{pmatrix}\text{Lowest value of} \\ \text{an item in a series}\end{pmatrix}$$

  Range is useful as it provides an idea of variability very quickly.

- **Mean Deviation:** The average of the difference of the values of elements from the average value of the series is known as mean deviation. Such a difference is technically described as deviation. While calculating the mean deviation, the minus sign of deviations is ignored while taking their total for obtaining sum of the mean deviation. The formula for deriving the mean deviation is as follows:

$$\text{Mean deviation from mean}\left(¢_{\bar{X}}\right) = \frac{\sum | X_i - \bar{X} |}{n},$$

if deviations, $| X_i - \bar{X} |$, are obtained from arithmetic average

Mean deviation

$$\text{from median}\left(¢_m\right) = \frac{\sum | X_i - M |}{n},$$

if deviations, $| X_i - M |$ are obtained from median

$$\text{Mean deviation from mode}(¢_z) = \frac{\sum | X_i - Z |}{n},$$

if deviations $\sum | X_i - Z |$ are obtained from mode

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where ¢ = symbol for mean deviation (pronounced as delta)

X_i = ith values of the variable X

n = number of elements

$\bar{X}$ = Arithmetic average

M = Median

Z = Mode

- **Standard Deviation:** Standard deviation is the calculation of the dispersion of a distribution of scores. It is the most widely used measure of dispersion of a series and is commonly denoted by the symbol σ (sigma). It can be defined as the square root of the average of squares of deviations, when such deviations for the values of individual items in a series are obtained from the arithmetic average. It is derived using the following formula:

$$\text{Standard deviation}(\pm) = \sqrt{\frac{\Sigma f_i \left(X_i - \bar{X}\right)^2}{\Sigma f_i}}$$

in case of frequency distribution

where f_i means the frequency of the ith item.

Standard deviation is used mostly in research studies and is regarded as the most satisfactory measure of dispersion in a series. It is less affected by fluctuations of sampling. It is commonly used in the context of estimation and testing of hypotheses.

To conclude, we can infer that statistical methods enable the researcher to accurately utilize the gathered information. This in turn helps him/her to be more specific in describing the findings.

5.4.4 Diagrammatic Representation of Data

The diagrammatic representation of data is concerned with the presentation of data to readers or users by means of images. It helps the reader to explore, make sense of and communicate the data. Like good writing, good graphical displays of data communicate ideas with clarity, precision and efficiency.

Significance of Diagrammatic Representation of Data

The diagrammatic representation of data aims at facilitating an easy understanding of the information on the part of the reader. As such, it is advisable to provide a diagrammatic representation of data in a research study for the following reasons:

- It provides the reader with a qualitative understanding of the information contents.
- It presents any kind of information—be it data, processes, relations or concepts.
- Diagrammatic representation allows the researcher to use a variety of graphical entities, for example, points, lines, shapes, images, text and attributes like colour, size, position and shape for an effective data representation.
- It facilitates an easy understanding by means of detection, measurement, and comparison techniques and provides the information from multiple viewpoints.

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Checklist for Diagrammatic Representation

The diagrammatic representation of data uses a set of techniques to turn information data into visual insight. It aims to give the data a meaningful representation by exploiting the perceptive capabilities of the human eye. As such, a good diagrammatic representation should have the following characteristics:

- A diagrammatic representation of data should be effective enough. The viewer should be able to easily interpret the information provided by the diagram.
- It should be accurate. The representation should be such that it facilitates correct quantitative evaluation.
- It should not offend the reader's senses. For example, a complicated diagrammatic representation with several patterns may confuse the reader and make it difficult to keep track of data.
- The diagram should be adaptable in the sense that it should serve the multiple needs of the reader.
- The diagram should be provided with an elaborate title, which should be self-explanatory.
- Any unnecessary representation should be deleted or any cluster of information that is not required should be eliminated.

Common techniques of diagrammatic representation

The diagrammatic representation of data uses the following most common techniques for effective data representation:

- **Charts:** Charts provide information using tabulation, bars or pies. Here, data is displayed in the form of bars that can be arranged vertically or horizontally. Charts make it easier for readers to understand large quantities of data and relationship between different variables of collected data.
- **Graphs:** A graph displays the data by indicating the relationship among the different variables, usually cast along x and y-axes. They consist of a finite number of dots called vertices, joined by a finite number of curved or straight-line segments called edges. Graphs are especially useful in data pertaining to the structure or relationships.
- **Plots:** In visualization terms, a plot can be defined as a drawing created by moving a pen across a two-dimensional drawing surface with precisely defined movements and strokes. Plots can be of single or multi-dimensions and represent data scientifically or geographically.
- **Maps:** A map, in simple terms, means the visual representation of an area. It is a symbolic depiction, highlighting relationships between elements of that space such as objects, regions and themes. It is one of the most effective tools in representing the location of data.
- **Images:** Image, in diagrammatic representation, means the representation of any data in two dimensions, intensity and colour. In such a representation, the values of each element are related to a specific intensity or colour. .

Check Your Progress

5. Define the term estimation.
6. What is a range?

NOTES

5.5 SUMMARY

- Research does not merely involve data collection. It also needs proper analysis of collected data.
- Analysis and manipulation of data by performing various functions is called processing of data. Processing of data ensures that all the relevant data has been collected for performing comparisons and analyses.
- The functions that can be performed on data are editing, coding, tabulation and classification.
- Analysis is the act of transforming the data with the aim of extracting some useful information which, in turn, facilitates arriving at some useful conclusions.

5.6 KEY TERMS

- **Processing:** Involves analysis and manipulation of the collected data by performing various functions
- **Coding of data:** Representing the data symbolically using some predefined rules
- **Analysis of data:** The process of transforma-ting data for the purpose of extracting useful information
- **Data interpretation:** Refers to the identification of trends in different variables. The researcher uses statistics for this purpose
- **Central tendency:** Refers to the central point around which the data revolves

5.7 ANSWERS TO 'CHECK YOUR PROGRESS'

1. The functions that can be performed on data are as follows:
   - Editing
   - Coding
   - Tabulation
   - Classification
2. Coding of data is necessary for efficient analysis. It facilitates classification of data into a small number of classes. Thus, only important and critical information that is required for analysis is retained in the research.
3. Several factors like the size and type of study, cost considerations, time pressures and availability of tabulating machines decide the choice of tabulation.
4. The nominal measurement assigns a numeral value to a specific characteristic. It is the fundamental form of measurement. The nominal measurement calculates the lowest level of data available for measurement.
5. Estimation is the calculated approximation of a result, which is usable, even if the input data may be incomplete or uncertain. It involves deriving the approximate calculation of a quantity or a degree or worth.
6. Range refers to the simplest possible measure of dispersion and is defined as the difference between the values of the extreme items of a series.

5.8 QUESTIONS AND EXERCISES

NOTES

Short-Answer Questions

1. Write a note on data editing.
2. Distinguish between data classification according to attributes and according to class intervals.
3. Explain the significance of tabulation.
4. Describe inferential statistics.
5. Write briefly about standard deviation.

Long-Answer Questions

1. Briefly describe the process and significance of coding of data.
2. Enumerate and elaborate on the methods of tabulation.
3. Explain the significance of descriptive statistics.
4. Discuss the various measures of central tendency.

5.9 FURTHER READING

Michael, V. P. 2012. *Research Methodology in Management*. New Delhi: Himalaya Publishing House.

Kothari, C R. 2014. *Research Methodology: Methods and Techniques*, 3rd edition. New Delhi: New Age International.

Saunders, Mark, Adrian Thornhill and Philip Lewis. 2009. *Research Methods for Business Students,* 5th edition. New Jersey: Pearson Education.

Levin, Richard I. 1984. *Statistics for Management,* 3rd edition. United States: Prentice-Hall.

UNIT 6 TEST OF SIGNIFICANCE AND ANALYSIS OF VARIANCE (ANOVA)

NOTES

Structure

6.0 INTRODUCTION

In this unit, you will learn about the test of significance and analysis of variance (ANOVA). A hypothesis is an assumption or a statement that may or may not be true. The hypothesis is tested on the basis of information obtained from a sample. Hypothesis tests are widely used in business and industry for making decisions. Instead of asking, for example, what the mean assessed value of an apartment in a multistoried building is, one may be interested in knowing whether or not the assessed value equals some particular value, say 80 lakh. Some other examples could be whether a new drug is more effective than the existing drug based on the sample data, and whether the proportion of smokers in a class is different from 0.30. The testing procedures are generally explained in any text on statistics. The technique has found applications in the fields of economics, psychology, sociology, business and industry. It becomes handy in situations where we want to compare the means of more than two populations. R.A. Fisher developed the theory concerning ANOVA. The basic principle underlying the technique is that the total variation in the dependent variable is broken into two parts—one which can be attributed to some specific causes and the other that may be attributed to chance. The one which is attributed to the specific causes is called the variation between samples and the one which is attributed to chance is termed as the variation within samples.

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6.1 UNIT OBJECTIVES

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

- Describe hypothesis and steps of testing hypothesis
- Analyse parametric and non-parametric tests
- Evaluate the one-way and two-way ANOVA

6.2 HYPOTHESIS TESTING

A hypothesis is an assumption or a statement that may or may not be true. The hypothesis is tested on the basis of information obtained from a sample. Hypothesis tests are widely used in business and industry for making decisions. Instead of asking, for example, what the mean assessed value of an apartment in a multistoried building is, one may be interested in knowing whether or not the assessed value equals some particular value, say ₹ 80 lakh. Some other examples could be whether a new drug is more effective than the existing drug based on the sample data, and whether the proportion of smokers in a class is different from 0.30. The testing procedures are generally explained in any text on statistics. For the sake of revision, below are listed some concepts that are useful for carrying out a testing of hypothesis exercise.

Null hypothesis: The hypotheses that are proposed with the intent of receiving a rejection for them are called null hypotheses. This requires that we hypothesize the opposite of what is desired to be proved. For example, if we want to show that sales and advertisement expenditure are related, we formulate the null hypothesis that they are not related. Similarly, if we want to conclude that the new sales training programme is effective, we formulate the null hypothesis that the new training programme is not effective, and if we want to prove that the average wages of skilled workers in town 1 is greater than that of town 2, we formulate the null hypotheses that there is no difference in the average wages of the skilled workers in both the towns. Since we hypothesize that sales and advertisement are not related, new training programme is not effective and the average wages of skilled workers in both the towns are equal, we call such hypotheses null hypotheses and denote them as H_0.

Alternative hypotheses: Rejection of null hypotheses leads to the acceptance of alternative hypotheses. The rejection of null hypothesis indicates that the relationship between variables (e.g., sales and advertisement expenditure) or the difference between means (e.g., wages of skilled workers in town 1 and town 2) or the difference between proportions have statistical significance and the acceptance of the null hypotheses indicates that these differences are due to chance. As already mentioned, the alternative hypotheses specify that values/relation which the researcher believes hold true. The alternative hypotheses can cover a whole range of values rather than a single point. The alternative hypotheses are denoted by H_1.

One-tailed and two-tailed tests: A test is called one-sided (or one-tailed) only if the null hypothesis gets rejected when a value of the test statistic falls in one specified tail of the distribution. Further, the test is called two-sided (or two-tailed) if null hypothesis

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gets rejected when a value of the test statistic falls in either one or the other of the two tails of its sampling distribution. For example, consider a soft drink bottling plant which dispenses soft drinks in bottles of 300 ml capacity. The bottling is done through an automatic plant. An overfilling of bottle (liquid content more than 300 ml) means a huge loss to the company given the large volume of sales. An underfilling means the customers are getting less than 300 ml of the drink when they are paying for 300 ml. This could bring bad reputation to the company. The company wants to avoid both overfilling and underfilling. Therefore, it would prefer to test the hypothesis whether the mean content of the bottles is different from 300 ml. This hypothesis could be written as:

H_0 : $\mu = 300$ ml.

H_1 : $\mu \neq 300$ ml.

The hypotheses stated above are called two-tailed or two-sided hypotheses.

However, if the concern is the overfilling of bottles, it could be stated as:

H_0 : $\mu = 300$ ml.

H_1 : $\mu > 300$ ml.

Such hypotheses are called one-tailed or one-sided hypotheses and the researcher would be interested in the upper tail (right hand tail) of the distribution. If however, the concern is loss of reputation of the company (underfilling of the bottles), the hypothesis may be stated as:

H_0 : $\mu = 300$ ml.

H_1 : $\mu < 300$ ml.

The hypothesis stated above is also called one-tailed test and the researcher would be interested in the lower tail (left hand tail) of the distribution.

At this stage we advice the reader to turn to the descriptive and relational hypotheses narrated in statement form and reduce them to a statistical H_0 as well as the corresponding alternative hypotheses as H_1.

Type I and type II error: The acceptance or rejection of a hypothesis is based upon sample results and there is always a possibility of sample not being representative of the population. This could result in errors as a consequence of which inferences drawn could be wrong. The situation could be depicted as given in Figure 6.1.

	Accept H_0	Reject H_0
H_0 True	Correct decision	Type 1 Error
H_0 False	Type II Error	Correct decision

Fig. 6.1 *Type I and Type II Errors*

If null hypothesis H_0 is true and is accepted or H_0 when false is rejected, the decision is correct in either case. However, if the hypothesis H_0 is rejected when it is actually true, the researcher is committing what is called a Type I error. The probability of committing a Type I error is denoted by alpha (α). This is termed as the level of significance. Similarly, if the null hypothesis H_0 when false is accepted, the researcher is committing an error called Type II error. The probability of committing a Type II error is denoted by beta (β). The expression $1 - \beta$ is called power of test.

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6.2.1 Steps in Testing of Hypothesis Exercise

The following steps are followed in testing of a hypothesis:

Setting up of a hypothesis: First step is to establish the hypothesis to be tested. As it is known, these statistical hypotheses are generally assumptions about the value of the population parameter; the hypothesis specifies a single value or a range of values for two different hypotheses rather than constructing a single hypothesis. These two hypotheses are generally referred to as the (1) null hypotheses denoted by H_0 and (2) alternative hypothesis denoted by H_1.

The null hypothesis is the hypothesis of the population parameter taking a specified value. In case of two populations, the null hypothesis is of no difference or the difference taking a specified value. The hypothesis that is different from the null hypothesis is the alternative hypothesis. If the null hypothesis H_0 is rejected based upon the sample information, the alternative hypothesis H_1 is accepted. Therefore, the two hypotheses are constructed in such a way that if one is true, the other one is false and vice versa. There can also be situations where the researcher is interested in establishing the relationship between any two variables. In such a case, a null hypothesis is set as the hypothesis of no relationship between those two variables; whereas the alternative hypothesis is the hypothesis of the relationship between variables. The rejection of the null hypothesis indicates that the differences/relationship have a statistical significance and the acceptance of the null hypothesis means that any difference/relationship is due to chance.

6.2.2 Significance Level as Confidence Level

Setting up of a suitable significance level: The next step in the testing of hypotheses exercise is to choose a suitable level of significance. The level of significance denoted by a is chosen before drawing any sample. The level of significance denotes the probability of rejecting the null hypothesis when it is true. The value of a varies from problem to problem, but usually it is taken as either 5 per cent or 1 per cent. A 5 per cent level of significance means that there are 5 chances out of hundred that a null hypothesis will get rejected when it should be accepted. This means that the researcher is 95 per cent confident that a right decision has been taken. Therefore, it is seen that the confidence with which a researcher rejects or accepts a null hypothesis depends upon the level of significance. When the null hypothesis is rejected at any level of significance, the test result is said to be significant. Further, if a hypothesis is rejected at 1 per cent level, it must also be rejected at 5 per cent significance level.

Determination of a test statistic: The next step is to determine a suitable test statistic and its distribution. As would be seen later, the test statistic could be t, Z, χ^2 or F, depending upon various assumptions to be discussed later in the book.

Determination of critical region: Before a sample is drawn from the population, it is very important to specify the values of test statistic that will lead to rejection or acceptance of the null hypothesis. The one that leads to the rejection of null hypothesis is called the critical region. Given a level of significance, α, the optimal critical region for a two-tailed test consists of that $\alpha/2$ per cent area in the right hand tail of the distribution plus that $\alpha/2$ per cent in the left hand tail of the distribution where that null hypothesis is rejected. Therefore, establishing a critical region is similar to determining a 100 $(1 - \alpha)$ per cent confidence interval.

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Computing the value of test-statistic: The next step is to compute the value of the test statistic based upon a random sample of size n. Once the value of test statistic is computed, one needs to examine whether the sample results fall in the critical region or in the acceptance region.

Making decision: The hypothesis may be rejected or accepted depending upon whether the value of the test statistic falls in the rejection or the acceptance region. Management decisions are based upon the statistical decision of either rejecting or accepting the null hypothesis.

If the hypothesis is being tested at 5 per cent level of significance, it would be rejected if the observed results have a probability less than 5 per cent. In such a case, the difference between the sample statistic and the hypothesized population parameter is considered to be significant. On the other hand, if the hypothesis is accepted, the difference between the sample statistic and the hypothesized population parameter is not regarded as significant and can be attributed to chance.

6.2.3 Concept of Degrees of Freedom

In statistics, the number of **degrees of freedom** is the number of values in the final calculation of a statistic that are free to vary. The number of independent ways by which a dynamic system can move without violating any constraint imposed on it, is called degree of freedom. In other words, the degree of freedom can be defined as the minimum number of independent coordinates that can specify the position of the system completely.

Estimates of statistical parameters can be based upon different amounts of information or data. The number of independent pieces of information that go into the estimate of a parameter is called the degrees of freedom. In general, the degrees of freedom of an estimate of a parameter is equal to the number of independent scores that go into the estimate minus the number of parameters used as intermediate steps in the estimation of the parameter itself (i.e., the sample variance has N-1 degrees of freedom, since it is computed from N random scores minus the only 1 parameter estimated as intermediate step, which is the sample mean).

Mathematically, 'Degrees of Freedom' is the number of dimensions of the domain of a random vector, or essentially the number of 'free' components, i.e., how many components need to be known before the vector is fully determined. The term is most often used in the context of linear models (linear regression, analysis of variance), where certain random vectors are constrained to lie in linear subspaces, and the number of degrees of freedom is the dimension of the subspace. The degrees of freedom are also commonly associated with the squared lengths or 'sum of squares' of the coordinates of such vectors, and the parameters of 'Chi-squared' and other distributions that arise in associated statistical testing problems.

Notation

In equations, the typical symbol for degrees of freedom is¬ (lowercase Greek letter nu). In text and tables, the abbreviation "df" is commonly used. R.A. Fisher used *n* to symbolize degrees of freedom (writing *n*à for sample size) but modern usage typically reserves *n* for sample size.

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Residuals

A common way to think of degrees of freedom is as the number of independent pieces of information available to estimate another piece of information. More concretely, the number of degrees of freedom is the number of independent observations in a sample of data that are available to estimate a parameter of the population from which that sample is drawn. For example, if we have two observations, when calculating the mean we have two independent observations; however, when calculating the variance, we have only one independent observation, since the two observations are equally distant from the mean.

In fitting statistical models to data, the vectors of residuals are constrained to lie in a space of smaller dimension than the number of components in the vector. That smaller dimension is the number of **degrees of freedom for error**.

Linear Regression

Perhaps the simplest example is this. Suppose

$$X_1, \ldots, X_n$$

are random variables each with expected value μ, and let

$$\bar{X}_n = \frac{X_1 + \ldots + X_n}{n}$$

be the "sample mean." Then the quantities

$$X_i - \bar{X}_n$$

are residuals that may be considered estimates of the errors $X_i - \mu$. The sum of the residuals (unlike the sum of the errors) is necessarily 0. If one knows the values of any $n - 1$ of the residuals, one can thus find the last one. That means they are constrained to lie in a space of dimension $n - 1$. One says that **"there are $n - 1$ degrees of freedom for errors."**

An only slightly less simple example is that of least squares estimation of a and b in the model

$$Y_i = a + bx_i + e_i \text{ for } i = 1, \ldots, n$$

where x_i are given, but e_i and hence Y_i are random. Let $\hat{a}$ and $\hat{b}$ be the least-squares estimates of a and b. Then the residuals

$$e_i = y_i - \left(\hat{a} + \hat{b}x_i\right)$$

are constrained to lie within the space defined by the two equations

$$e_1 + \ldots + e_n = 0,$$

$$x_1 e_1 + \ldots + x_n e_n = 0.$$

One says that **there are $n - 2$ degrees of freedom for error.**

Note about notation: the capital letter Y is used in specifying the model, while lower-case y in the definition of the residuals; that is because the former are hypothesized random variables and the latter are actual data.

We can generalize this to multiple regression involving p parameters and covariates (e.g., $p-1$ predictors and one mean), in which case the cost in *degrees of freedom of the fit* is p.

Degrees of Freedom of a Random Vector

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Geometrically, the degrees of freedom can be interpreted as the dimension of certain vector subspaces. As a starting point, suppose that we have a sample of n independent normally distributed observations,

$$X_1, \ldots, X_n.$$

This can be represented as an n-dimensional random vector:

$$\begin{pmatrix} X_1 \\ \vdots \\ X_n \end{pmatrix}.$$

Since this random vector can lie anywhere in n-dimensional space, it has n degrees of freedom.

Now, let $\bar{X}$ be the sample mean. The random vector can be decomposed as the sum of the sample mean plus a vector of residuals:

$$\begin{pmatrix} X_1 \\ \vdots \\ X_n \end{pmatrix} = \bar{X}\begin{pmatrix} 1 \\ \vdots \\ 1 \end{pmatrix} + \begin{pmatrix} X_1 - \bar{X} \\ \vdots \\ X_n - \bar{X} \end{pmatrix}.$$

The first vector on the right-hand side is constrained to be a multiple of the vector of 1's, and the only free quantity is $\bar{X}$. It therefore has 1 degree of freedom.

The second vector is constrained by the relation $\sum_{i=1}^{n}(X_i - \bar{X}) = 0$. The first $n-1$ components of this vector can be anything. However, once you know the first $n-1$ components, the constraint tells you the value of the nth component. Therefore, this vector has $n-1$ degrees of freedom.

Mathematically, the first vector is the orthogonal, or least-squares, projection of the data vector onto the subspace spanned by the vector of 1's. The 1 degree of freedom is the dimension of this subspace. The second residual vector is the least squares projection onto the $(n-1)$-dimensional orthogonal complement of this subspace, and has $n-1$ degrees of freedom.

In statistical testing applications, often one isn't directly interested in the component vectors, but rather in their squared lengths. In the example above, the residual sum-of-squares is

$$\sum_{i=1}^{n}(X_i - \bar{X})^2 = \left\| \begin{matrix} X_1 - \bar{X} \\ \vdots \\ X_n - \bar{X} \end{matrix} \right\|^2.$$

If the data points X_i are normally distributed with mean 0 and variance σ^2, then the residual sum of squares has a scaled chi-squared distribution (scaled by the factor σ^2), with $n-1$ degrees of freedom. The degrees of freedom, here a parameter of the distribution, can still be interpreted as the dimension of an underlying vector subspace.

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Likewise, the one-sample *t*-test statistic,

$$\frac{\sqrt{n}(\bar{X}-\mu_0)}{\sqrt{\sum_{i=1}^{n}(X_i-\bar{X})^2/(n-1)}}$$

follows a Student's *t* distribution with $n - 1$ degrees of freedom when the hypothesized mean μ_0 is correct. Again, the degrees of freedom arises from the residual vector in the denominator.

Degrees of Freedom in Linear Models

The demonstration of the t and chi-squared distributions for one-sample problems above is the simplest example where degrees of freedom arise. However, similar geometry and vector decompositions underlie much of the theory of linear models, including linear regression and analysis of variance. An explicit example based on comparison of three means is presented here; the geometry of linear models is discussed in more complete detail by Christensen (2002).

Suppose independent observations are made for three populations $X_1, \ldots, X_n$,$Y_1, \ldots, Y_n$ and $Z_1, \ldots, Z_n$. The restriction to three groups and equal sample sizes simplifies notation, but the ideas are easily generalized.

The observations can be decomposed as:

$$\begin{aligned} X_i &= \bar{M} + (\bar{X} - \bar{M}) + (X_i - \bar{X}) \\ Y_i &= \bar{M} + (\bar{Y} - \bar{M}) + (Y_i - \bar{Y}) \\ Z_i &= \bar{M} + (\bar{Z} - \bar{M}) + (Z_i - \bar{Z}) \end{aligned}$$

where $\bar{X}, \bar{Y}, \bar{Z}$ are the means of the individual samples, and $\bar{M} = (\bar{X} + \bar{Y} + \bar{Z})/3$ is the mean of all 3*n* observations. In vector notation this decomposition can be written as:

$$\begin{pmatrix} X_1 \\ \vdots \\ X_n \\ Y_1 \\ \vdots \\ Y_n \\ Z_1 \\ \vdots \\ Z_n \end{pmatrix} = \bar{M}\begin{pmatrix} 1 \\ \vdots \\ 1 \\ 1 \\ \vdots \\ 1 \\ 1 \\ \vdots \\ 1 \end{pmatrix} + \begin{pmatrix} \bar{X}-\bar{M} \\ \vdots \\ \bar{X}-\bar{M} \\ \bar{Y}-\bar{M} \\ \vdots \\ \bar{Y}-\bar{M} \\ \bar{Z}-\bar{M} \\ \vdots \\ \bar{Z}-\bar{M} \end{pmatrix} + \begin{pmatrix} X_1-\bar{X} \\ \vdots \\ X_n-\bar{X} \\ Y_1-\bar{Y} \\ \vdots \\ Y_n-\bar{Y} \\ Z_1-\bar{Z} \\ \vdots \\ Z_n-\bar{Z} \end{pmatrix}.$$

The observation vector, on the left-hand side, has 3*n* degrees of freedom. On the right-hand side, the first vector has one degree of freedom (or dimension) for the overall mean. The second vector depends on three random variables $\bar{X}-\bar{M}$, $\bar{Y}-\bar{M}$, and $\overline{Z}-\overline{M}$. However, these must sum to 0 and so are constrained; the vector therefore must lie in a 2-dimensional subspace, and has 2 degrees of freedom. The remaining 3*n* – 3 degrees of freedom are in the residual vector (made up of *n* – 1 degrees of freedom within each of the populations).

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Sum of Squares and Degrees of Freedom

In statistical testing problems, one usually is not interested in the component vectors themselves, but rather in their squared lengths, or Sum of Squares. The degrees of freedom associated with a sum-of-squares is the degrees of freedom of the corresponding component vectors.

The three-population example above is an example of one-way Analysis of Variance. The model, or treatment, sum-of-squares is the squared length of the second vector,

$$SSTr = n(\bar{X} - \bar{M})^2 + n(\bar{Y} - \bar{M})^2 + n(\bar{Z} - \bar{M})^2$$

with 2 degrees of freedom. The residual, or error, sum-of-squares is

$$SSE = \sum_{i=1}^{n}(X_i - \bar{X})^2 + \sum_{i=1}^{n}(Y_i - \bar{Y})^2 + \sum_{i=1}^{n}(Z_i - \bar{Z})^2$$

with 3(n-1) degrees of freedom. Of course, introductory books on ANOVA usually state formulae without showing the vectors, but it is this underlying geometry that gives rise to SS formulae, and shows how to unambiguously determine the degrees of freedom in any given situation.

Under the null hypothesis of no difference between population means (and assuming that standard ANOVA regularity assumptions are satisfied) the sums of squares have scaled chi-squared distributions, with the corresponding degrees of freedom. The F-test statistic is the ratio, after scaling by the degrees of freedom. If there is no difference between population means this ratio follows an F distribution with 2 and $3n - 3$ degrees of freedom.

Degrees of Freedom Parameters in Probability Distributions

Several commonly encountered statistical distributions (Student's t, Chi-Squared, F) have parameters that are commonly referred to as *degrees of freedom*. This terminology simply reflects that in many applications where these distributions occur, the parameter corresponds to the degrees of freedom of an underlying random vector, as in the preceding ANOVA example. Another simple example is: if $X_i; i = 1, \ldots, n$ are independent normal (μ, σ^2) random variables, the statistic

$$\frac{\sum_{i=1}^{n}(X_i - \bar{X})^2}{\sigma^2}$$

follows a chi-squared distribution with n–1 degrees of freedom. Here, the degrees of freedom arises from the residual sum-of-squares in the numerator, and in turn the n–1 degrees of freedom of the underlying residual vector $\{X_i - \bar{X}\}$.

In the application of these distributions to linear models, the degrees of freedom parameters can take only integer values. The underlying families of distributions allow fractional values for the degrees of freedom parameters, which can arise in more sophisticated uses. One set of examples is problems where chi-squared approximations based on effective degrees of freedom are used. In other applications, such as modelling heavy-tailed data, a t or F distribution may be used as an empirical model. In these cases, there is no particular *degrees of freedom* interpretation to the distribution parameters, even though the terminology may continue to be used.

NOTES

Effective Degrees of Freedom

Many regression methods, including ridge regression, linear smoothers and smoothing splines are not based on ordinary least squares projections, but rather on regularized (generalized and/or penalized) least-squares, and so degrees of freedom defined in terms of dimensionality is generally not useful for these procedures. However, these procedures are still linear in the observations, and the fitted values of the regression can be expressed in the form

$$\hat{y} = Hy,$$

where $\hat{y}$ is the vector of fitted values at each of the original covariate values from the fitted model, y is the original vector of responses, and H is the hat matrix or, more generally, smoother matrix.

For statistical inference, sums-of-squares can still be formed: the model sum-of-squares is $||Hy||^2$; the residual sum-of-squares is $||y - Hy||^2$. However, because H does not correspond to an ordinary least-squares fit (i.e. is not an orthogonal projection), these sums-of-squares no longer have (scaled, non-central) chi-squared distributions, and dimensionally defined degrees of freedom are not useful.

The *effective degrees of freedom* of the fit can be defined in various ways to implement goodness of fit tests, cross-validation and other inferential procedures. Here one can distinguish between *regression effective degrees of freedom* and *residual effective degrees of freedom*.

Regression Effective Degrees of Freedom

Regarding the former, appropriate definitions can include the trace of the hat matrix, tr(H), the trace of the quadratic form of the hat matrix, tr($H'H$), the form tr($2H - HH'$), or the Satterthwaite approximation, $\text{tr}(H'H)^2/\text{tr}(H'HH'H)$. In the case of linear regression, the hat matrix H is $X(X'X)^{-1}X'$, and all these definitions reduce to the usual degrees of freedom. Notice that

$$\text{tr}(H) = \sum_i h_{ii} = \sum_i \frac{\partial \hat{y}_i}{\partial y_i},$$

i.e., the regression (not residual) degrees of freedom in linear models are 'the sum of the sensitivities of the fitted values with respect to the observed response values'.

Residual Effective Degrees of Freedom

There are corresponding definitions of residual effective degrees of freedom (redf), with H replaced by $I - H$. For example, if the goal is to estimate error variance, the redf would be defined as $\text{tr}((I-H)'(I-H))$, and the unbiased estimate is (with $\hat{r} = y - Hy$),

$$\hat{\sigma}^2 = \frac{\|\hat{r}\|^2}{\text{tr}\left((I-H)'(I-H)\right)},$$

or:

$$\hat{\sigma}^2 = \frac{\|\hat{r}\|^2}{n - \text{tr}(2H - HH')} = \frac{\|\hat{r}\|^2}{n - 2\,\text{tr}(H) + \text{tr}(HH')} \approx \frac{\|\hat{r}\|^2}{n - 1.25\,\text{tr}(H) + 0.5}.$$

The last approximation above reduces the computational cost from $O(n^2)$ to only $O(n)$. In general the numerator would be the objective function being minimized; e.g., if the hat matrix includes an observation covariance matrix, p, then $\|\hat{r}\|^2$ becomes $\hat{r}'\Sigma^{-1}\hat{r}$.

NOTES

Other Formulations

Note that unlike in the original case, non-integer degrees of freedom are allowed, though the value must usually still be constrained between 0 and n.

Consider, as an example, the k-nearest neighbour smoother, which is the average of the k nearest measured values to the given point. Then, at each of the n measured points, the weight of the original value on the linear combination that makes up the predicted value is just $1/k$. Thus, the trace of the hat matrix is n/k. Thus the smooth costs n/k effective degrees of freedom.

As another example, consider the existence of nearly duplicated observations. Naive application of classical formula, $n-p$, would lead to over-estimation of the residuals degree of freedom, as if each observation were independent. More realistically, though, the hat matrix $H = X(X'\Sigma^{-1}X)^{-1}X'\Sigma^{-1}$ would involve an observation covariance matrix ρ indicating the non-zero correlation among observations. The more general formulation of effective degree of freedom would result in a more realistic estimate for, e.g., the error variance σ^2.

Similar concepts are the *equivalent degrees of freedom* in non-parametric regression, the *degree of freedom of signal* in atmospheric studies, and the *non-integer degree of freedom* in geodesy.

Alternative

The residual sum-of-squares $||y - Hy||^2$ has a generalized chi-squared distribution, and the theory associated with this distribution provides an alternative route to the answers provided above.

6.2.4 Test Statistic for Testing Hypothesis about Population Mean

In this section, we will take up the test of hypothesis about population mean in a case of single population and the difference between the two means for two populations.

One of the important things that have to be kept in mind is the use of an appropriate test statistic. In case the sample size is large ($n > 30$), Z statistic would be used. For a small sample size ($n \leq 30$), a further question regarding the knowledge of population standard deviation (σ) is asked. If the population standard deviation σ is known, a Z statistic can be used. However, if σ is unknown and is estimated using sample data, a t test with appropriate degrees of freedom is used under the assumption that the sample is drawn from a normal population. It is assumed that the readers have the knowledge of Z and t distribution from the course on statistics. However, these would be briefly reviewed at the appropriate place. Table 6.1 summarizes the appropriateness of the test statistic for conducting a test of hypothesis regarding the population mean.

Table 6.1 *Appropriateness of Test Statistic in Testing Hypotheses about Means*

Sample Size	Knowledge of Population Standard Deviation (±)	
	Known	Not Known
Large ($n > 30$)	Z	Z
Small ($n \leq 30$)	Z	t

6.2.5 Test Concerning Means – Case of Single Population

In this section, a number of illustrations will be taken up to explain the test of hypothesis concerning mean. Two cases of large sample and small samples will be taken up.

NOTES

Case of large sample

As mentioned earlier, in case the sample size n is large or small but the value of the population standard deviation is known, a Z test is appropriate. There can be alternate cases of two- tailed and one-tailed tests of hypotheses. Corresponding to the null hypothesis $H_0 : \mu = \mu_0$, the following criteria could be formulated as shown in Table 6.2.

Table 6.2 *Criteria for Accepting or Rejecting Null Hypothesis under Different Cases of Alternative Hypotheses*

S.No.	Alternative Hypothesis	Reject the Null Hypothesis if	Accept the Null Hypothesis if
1.	$\mu < \mu_0$	$Z < -Z_\alpha$	$Z \geq -Z_\alpha$
2.	$\mu > \mu_0$	$Z > Z_\alpha$	$Z \leq Z_\alpha$
3.	$\mu \neq \mu_0$	$Z < -Z_{\alpha/2}$ Or $Z > Z_{\alpha/2}$	$-Z_{\alpha/2} \leq Z \leq Z_{\alpha/2}$

The test statistic is given by,

$$Z = \frac{\overline{X} - \mu_{H_0}}{\frac{\sigma}{\sqrt{n}}}$$

Where,

$\overline{X}$ = Sample mean

σ = Population standard deviation

μ_{H_0} = The value of μ under the assumption that the null hypothesis is true

n = Size of sample

If the population standard deviation σ is unknown, the sample standard deviation

$$s = \sqrt{\frac{1}{n-1}\Sigma(X - \overline{X})^2}$$

is used as an estimate of σ. It may be noted that $Z\alpha$ and $Z_{\alpha/2}$ are Z values such that the area to the right under the standard normal distribution is α and $\alpha/2$ respectively. Below are solved examples using the above concepts.

Example 6.1: A sample of 200 bulbs made by a company give a lifetime mean of 1540 hours with a standard deviation of 42 hours. Is it likely that the sample has been drawn from a population with a mean lifetime of 1500 hours? You may use 5 per cent level of significance.

Solution:

In the above example, the sample size is large (n = 200), sample mean ($\overline{X}$) equals 1540 hours and the sample standard deviation (s) is equal to 42 hours. The null and alternative hypotheses can be written as:

$H_0 : \mu = 1500$ hrs

$H_1 : \mu \neq 1500$ hrs

It is a two-tailed test with level of significance (α) to be equal to 0.05. Since n is large (n > 30), though population standard deviation σ is unknown, one can use Z test.

NOTES

The test statistics are given by:

$$Z = \frac{\overline{X} - \mu_{H_0}}{\underset{x}{\sigma}}$$

Where, μ_{H_0} = Value of μ under the assumption that the null hypothesis is true

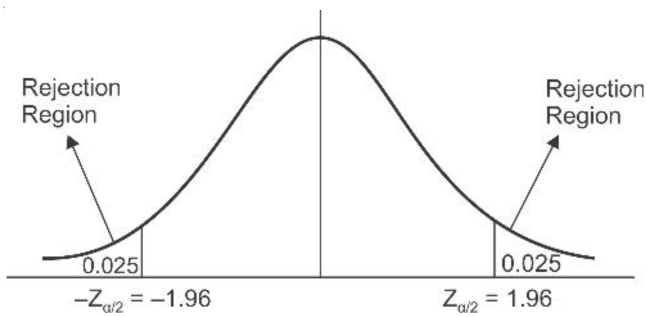
$\hat{\underset{x}{\sigma}}$ = Estimated standard error of mean

Here $\mu_{H0} = 1500$, $\hat{\underset{x}{\sigma}} = \frac{\hat{\sigma}}{\sqrt{n}} = \frac{s}{\sqrt{n}} = \frac{42}{\sqrt{200}} = 2.97$

(Note that $\hat{\sigma}$ is estimated value of σ.)

$$Z = \frac{\overline{X} - \mu_{H_0}}{\frac{s}{\sqrt{n}}} = \frac{1540 - 1500}{2.97} = \frac{40}{2.97} = 13.47$$

The value of $\alpha = 0.05$ and since it is a two-tailed test, the critical value Z is given by $-Z_{\alpha/2}$ and $Z_{\alpha/2}$ which could be obtained as per the standard normal table:



Rejection Regions for Example 6.1

Since the computed value of Z = 13.47 lies in the rejection region, the null hypothesis is rejected. Therefore, it can be concluded that the average life of the bulb is significantly different from 1500 hours.

Alternative Approach to the Test of Hypothesis

There is an alternative approach called probability approach or simply p value approach to test the hypothesis. Under this approach, the researcher does not have to refer to Z table to determine the critical value. Referring to Example 6.1, the p value can be calculated as follows:

$p = P(Z > 13.47) + P(Z < -13.47)$

We know that the problem is that of a two-sided test and Z has a symmetric distribution, therefore,

$p = 2P(Z > 13.47) = 2 \times 0 = 0$

Now, the decision rule is:

Reject H_0 if $p \leq \alpha$

Accept H_0 if $p > \alpha$

NOTES

In this example, $\alpha = 0.05$ and p value is less than α, so the null hypothesis is rejected. Therefore, it may be noted that the same conclusion is arrived at and there is no need to look at the critical value of Z as given in the statistical table. These days, most computer software like SPSS, EXCEL, SAS, MINITAB provide both the computed value of test statistic and the corresponding p value. Please note that the p value provided there is for the two-sided test. In case the problem is of a one-sided test, the reported p value is divided by 2 to obtain the desired p value for the problem and then compared with alpha (α), the level of significance so as to either accept or reject the null hypothesis. This is possible since Z distribution is a symmetrical distribution.

Example 6.2: On a typing test, a random sample of 36 graduates of a secretarial school averaged 73.6 words with a standard deviation of 8.10 words per minute. Test an employer's claim that the school's graduates average less than 75.0 words per minute using the 5 per cent level of significance.

Solution:

$H_0 : \mu = 75$

$H_1 : \mu < 75$

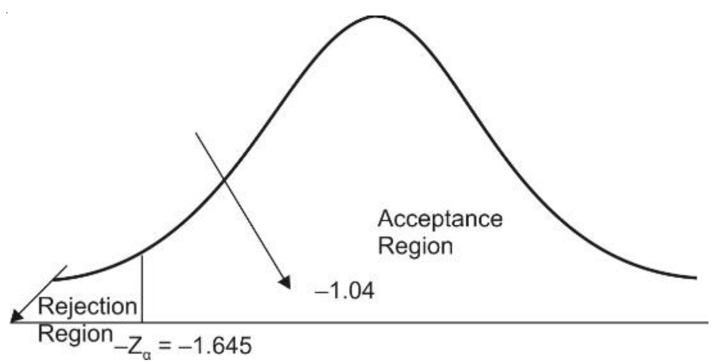
$\bar{X} = 73.6$, s = 8.10, $n = 36$ and $\alpha = 0.05$. As the sample size is large ($n > 30$), though population standard deviation σ is unknown, Z test is appropriate.

The test statistic is given by:

$$Z = \frac{\overline{X} - \mu_{H_0}}{\hat{\sigma}_{\bar{x}}} = \frac{73.6 - 75}{1.35} = \frac{-1.4}{1.35} = -1.04$$

$$\left(\hat{\sigma}_{\bar{x}} = \frac{s}{\sqrt{n}} = \frac{8.10}{\sqrt{36}} = \frac{8.10}{6} = 1.35 \right)$$

Since it is a one-tailed test and the interest is in the left hand tail of the distribution, the critical value of Z is given by $-Z_\alpha = -1.645$. Now, the computed value of Z lies in the acceptance region, and the null hypothesis is accepted as shown below:



Rejection Region for Example 6.2

Now, the same problem can be worked out using the *p* value approach.

$$\begin{aligned} p &= P(Z < -1.04) \\ &= 0.5 - 0.3508 \\ &= 0.1492 \text{ (From standard statistical table)} \end{aligned}$$

NOTES

Since the p value is greater than α, there is not enough evidence to reject the null hypothesis. Therefore, the average speed of the graduates of a secretarial school is not significantly different from 75.00 words per minute. Therefore, the claim of the employer is not valid.

Example 6.3: It is known from past studies that the monthly average household expenditure on the food items in a locality is ₹ 2700 with a standard deviation of ₹ 160. An economist took a random sample of 25 households from the locality and found their monthly household expenditure on food items to be ₹ 2790.0. At 0.01 level of significance, can we conclude that the average household expenditure on the food items is greater than ₹ 2700?

Solution:

$H_0 \; : \; \mu \; = \; 2700$

$H_1 \; : \; \mu \; > \; 2700$

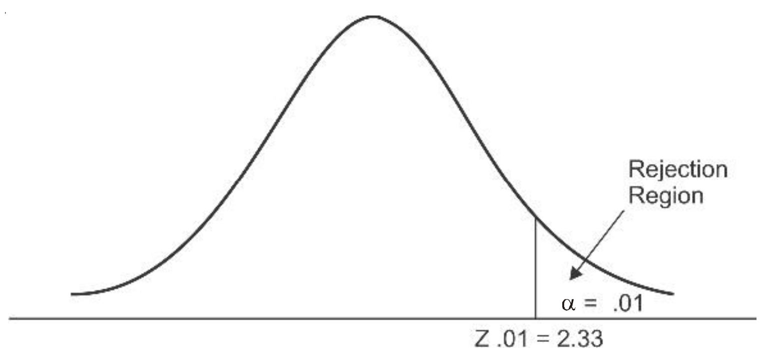
$\overline{X} = 2790, \sigma = 160, n = 25$, and $\alpha = 0.01$. It may be seen that although the sample size is small ($n < 30$), but since the population standard deviation is known, Z test could be applied.

The test statistic is given by,

$$Z = \frac{\overline{X} - \mu_{H_0}}{\sigma_x} = \frac{2790 - 2700}{32} = \frac{90}{32} = 2.81$$

$$\left(\sigma_x = \frac{\sigma}{\sqrt{n}} = \frac{160}{5} = 32 \right)$$

Since it is a one-tailed test and the interest is in the right hand tail of the distribution, the critical value of Z is given by $Z_\alpha = Z_{.01} = 2.33$. Now, the computed value of Z lies in the rejection region, the null hypothesis is rejected as shown below:



Rejection Region for Example 6.3

Therefore, it can be concluded that the monthly average household expenditure on food items is significantly greater than ₹ 2700.

Now using the p value approach, we compute it as:

$$\begin{aligned} p &= P(Z > 2.81) \\ &= 0.5 - 0.4975 \\ &= 0.0025 \text{ (From standard statistical table)} \end{aligned}$$

Since the p value of 0.0025 is less than 0.01, there is enough evidence to reject H_0.

Case of Small Sample

NOTES

In case the sample size is small ($n \leq 30$) and is drawn from a population having a normal population with unknown standard deviation σ, a *t* test is used to conduct the hypothesis for the test of mean. The *t* distribution is a symmetrical distribution just like the normal one. However, *t* distribution is higher at the tail and lower at the peak. The *t* distribution is flatter than the normal distribution. With an increase in the sample size (and hence degrees of freedom), *t* distribution loses its flatness and approaches the normal distribution whenever $n > 30$. A comparative shape of *t* and normal distribution is given in Figure 6.2.

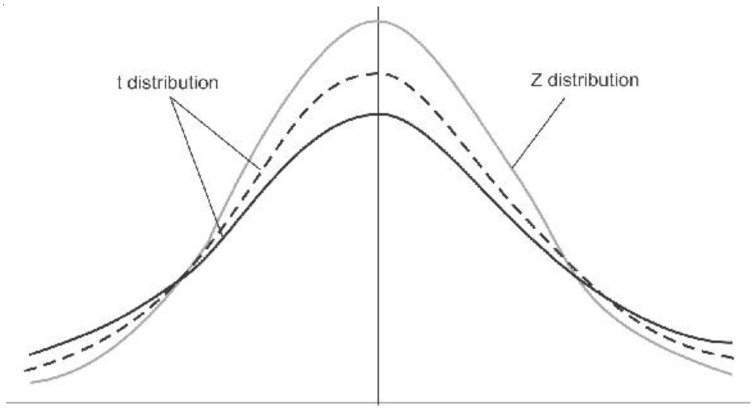


***Fig. 6.2** Shape of t and Normal Distribution*

The procedure for testing the hypothesis of a mean is similar to what is explained in the case of large sample. The test statistic used in this case is:

$$t_{n-1} = \frac{\overline{X} - \mu_{H_0}}{\hat{\sigma}_{\overline{x}}}$$

Where, $\hat{\sigma}_{\overline{x}} = \dfrac{S}{\sqrt{n}}$ (where s = Sample standard deviation)

n – 1 = degrees of freedom

A few examples pertaining to '*t*' test are worked out for testing the hypothesis of mean in case of a small sample.

Example 6.4: A sample of 16 graduating engineering students of a college was taken and the information was obtained on their starting salary. The mean monthly starting salary was found to be ₹ 30,200 with a standard deviation of ₹ 960. The past data on the starting salary has given a mean value of ₹ 30,000. Using a 5 per cent level of significance, can we conclude that the average starting salary is different from ₹ 30,000?

Solution:

$H_0 : \mu = 30{,}000$

$H_1 : \mu \neq 30{,}000$

$\overline{X} = 30{,}200$, $s = 960$, $n = 16$ and $\alpha = 0.05$. As the sample size is small ($n < 30$), and population standard σ is unknown, one may use a *t* test to examine the hypothesis in question.

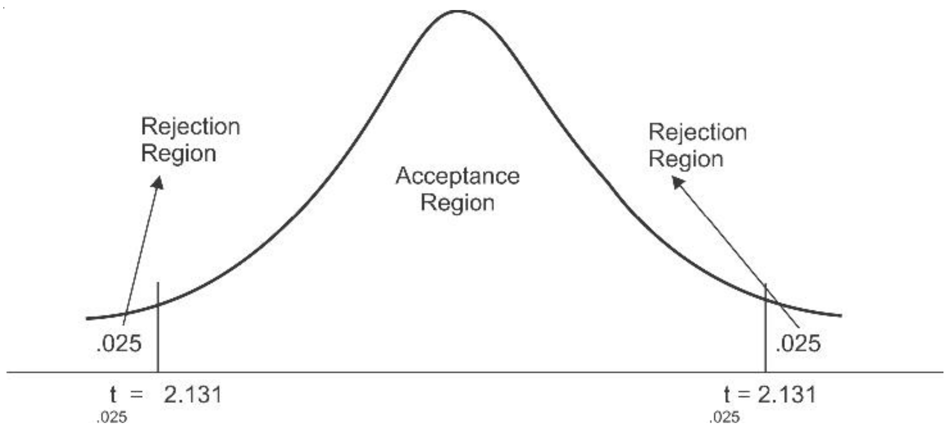
The test statistic is given by:

$$t_{n-1} = \frac{\overline{X} - \mu_{H_0}}{\hat{\sigma}_{\overline{x}}} = \frac{\overline{X} - \mu_{H_0}}{\frac{s}{\sqrt{n}}} = \frac{30,200 - 30,000}{\frac{960}{\sqrt{16}}}$$

$$= \frac{200 \times 4}{960} = \frac{800}{960} = 0.83$$

NOTES

Since it is a two-tailed test, the critical value of t with 15 degrees of freedom is given by $-t_{\alpha/2} = -2.131$ and $t_{\alpha/2} = 2.131$. These could be obtained from the t distribution table. It is seen from the curve given below that the computed value of t lies in the acceptance region.



Rejection Regions for Example 6.4

Therefore, there is not enough evidence to reject the null hypothesis. Hence, the average salary of graduating engineering students is not statistically different from ₹ 30,000 at 5 per cent level of significance.

For the p value approach, we examine the level of significance at which the computed value of $t = 0.83$ with 15 degrees of freedom falls. It is seen that the p value will be more than 10 per cent. This value of p is greater than the value of $\alpha = 0.05$. This means that the null hypothesis is accepted.

Example 6.5: Prices of share (in ₹) of a company on the different days in a month were found to be 66, 65, 69, 70, 69, 71, 70, 63, 64 and 68. Examine whether the mean price of shares in the month is different from 65. You may use 10 per cent level of significance.

Solution:

$H_0 : \mu = 65$

$H_1 : \mu \neq 65$

Since the sample size is $n = 10$, which is small, and the sample standard deviation is unknown, the appropriate test in this case would be t. First of all, we need to estimate the value of sample mean ($\overline{X}$) and the sample standard deviation (s). It is known that the sample mean and the standard deviation are given by the following formula.

$$\overline{X} = \frac{\sum X}{n} \qquad s = \sqrt{\frac{1}{n-1}\Sigma(X-\overline{X})^2}$$

NOTES

The computation of $\overline{X}$ and s is shown in Table 6.5.

$$\Sigma X = 675, \ \overline{X} = \frac{\sum X}{n} = \frac{675}{10} = 67.5$$

$$\Sigma(X-\overline{X})^2 = 70.5$$

$$s^2 = \frac{1}{n-1}\Sigma(X-\overline{X})^2 = \frac{70.5}{9} = 7.83$$

$$s = \sqrt{7.83} = 2.80$$

Table 6.3 *Computation of Sample Mean and Standard Deviation*

S. No.	X	$X - \overline{X}$	$(X - \overline{X})^2$
1	66	– 1.5	2.25
2	65	– 2.5	6.25
3	69	1.5	2.25
4	70	2.5	6.25
5	69	1.5	2.25
6	71	3.5	12.25
7	70	2.5	6.25
8	63	– 4.5	20.25
9	64	– 3.5	12.25
10	68	0.5	0.25
Total	675	0	70.5

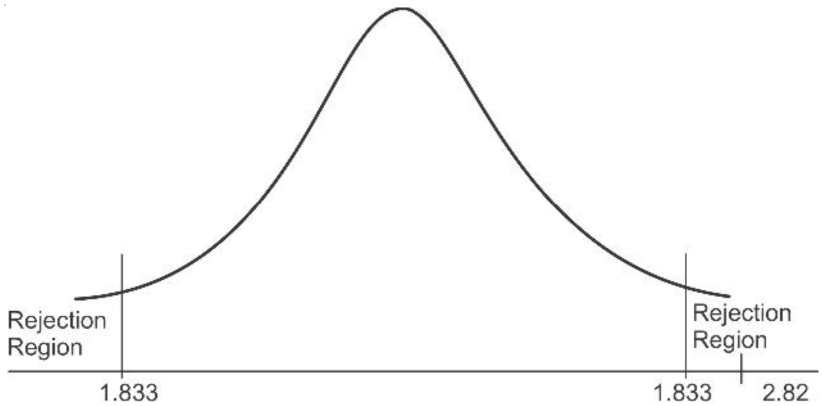
The test statistic is given by:

$$t_{n-1} = \frac{\overline{X} - \mu_{H_0}}{\hat{\sigma}_{\overline{x}}} = \frac{\overline{x} - \mu_{H_0}}{\frac{s}{\sqrt{n}}} = \frac{67.5 - 65}{\frac{2.8}{\sqrt{10}}} = \frac{2.5 \times \sqrt{10}}{2.8}$$

$= 2.5 \times 3.16/2.8 = 7.91/2.8 = 2.82$

The critical values of *t* with 9 degrees of freedom for a two-tailed test are given by –1.833 and 1.833. Since the computed value of t lies in the rejection region (see figure below), the null hypotheses is rejected.

NOTES



Rejection Region for Example 6.5

Therefore, the average price of the share of the company is different from 65.

This problem could also be solved using the *p* value approach as explained in the previous example. It is left to the readers to verify the conclusion using these two approaches.

Example 6.6: The results of a household survey indicated that a sample of 20 households bought an average of 75 litres of milk per month with a standard deviation of 13.0 litres. Test the hypothesis that the value of the population mean is 70 litres against the alternative that it is more than 70 litres. Use 0.05 level of significance.

Solution:

$H_0 : \mu = 70$

$H_1 : \mu > 70$

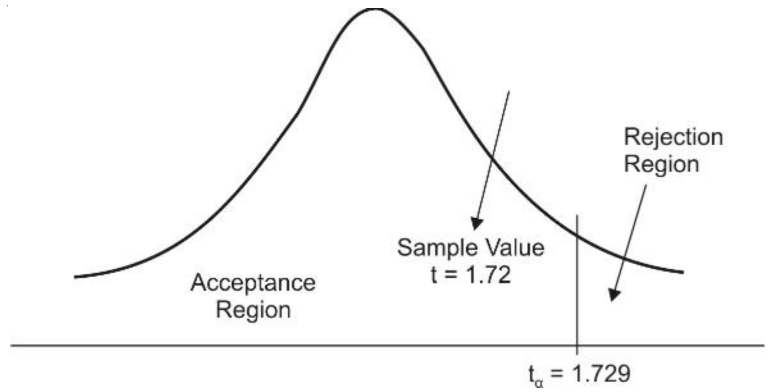
$\overline{X} = 75$, s = 13.0, $n = 20$, $\alpha = 0.05$. This is the problem of a one-tailed test. The population standard deviation is unknown and the sample size is small ($n < 30$). Therefore, a t test would be appropriate. The test statistic is given by:

$$t_{n-1} = \frac{\overline{X} - \mu_{H_0}}{\hat{\sigma}_{\bar{x}}} = \frac{\overline{X} - \mu_{H_0}}{s/\sqrt{n}} = \frac{75 - 70}{\frac{13}{\sqrt{20}}} = \frac{5}{2.91} 1.72$$

$$\left(\hat{\sigma}_{\bar{x}} = \frac{d}{\sqrt{n}} = \frac{13}{\sqrt{20}} = 2.91\right)$$

The critical value of *t* with 19 degrees of freedom for a one-tailed test is given by 1.729 (as per standard statistical table). As the computed value of *t* lies in the acceptance region, as shown in the figure below, the null hypothesis is accepted. Therefore, the average purchase of milk in a household per month is not significantly different from 70 litres.

NOTES



Rejection Region for Example 6.6

6.3 TEST INVOLVING ONE POPULATION AND TWO POPULATION MEANS

So far we have been concerned with the testing of means of a single population. We took up the cases of both large and small samples. It would be interesting to examine the difference between the two population means. Again, various cases would be examined as discussed below:

6.3.1 Z Test (Case of Large Sample)

In case both the sample sizes are greater than 30, a Z test is used. The hypothesis to be tested may be written as:

$H_0 \ : \ \mu_1 \ = \ \mu_2$

$H_1 \ : \ \mu_1 \ \neq \ \mu_2$

Where,

μ_1 = Mean of population 1

μ_2 = Mean of population 2

The above is a case of two-tailed test. The test statistic used is:

$$Z = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)H_0}{\sqrt{\dfrac{\sigma_1^2}{n_1} + \dfrac{\sigma_2^2}{n_2}}}$$

$\bar{X}_1$ = Mean of sample drawn from population 1

$\bar{X}_2$ = Mean of sample drawn from population 2

n_1 = Size of sample drawn from population 1

n_2 = Size of sample drawn from population 2

If $\pm_1$ and $\pm_2$ are unknown, their estimates given by $\pounds_1$ and $\pounds_2$ are used.

$$\pounds_1 = s_1 = \sqrt{\frac{1}{n_1 - 1}\sum_{i=1}^{n_1}(X_{1i} - \bar{X}_1)^2}$$

$$£_2 = s_2 = \sqrt{\frac{1}{n_{2-1}} \sum_{i=1}^{n_2} (X_{2i} - \overline{X}_2)^2}$$

NOTES

The Z value for the problem can be computed using the above formula and compared with the table value to either accept or reject the hypothesis. Let us consider the following problem:

City	Sample Mean Hourly Earnings	Standard Deviation of Sample	Sample Size
Ambala Cantt	₹ 8.95 ($\overline{X}_1$)	0.40 (s_1)	200 (n_1)
Lucknow	₹ 9.10 ($\overline{X}_2$)	0.60 (s_2)	175 (n_2)

Example 6.7: A study is carried out to examine whether the mean hourly wages of the unskilled workers in the two cities—Ambala Cantt and Lucknow are the same. The random sample of hourly earnings in both the cities is taken and the results are presented in the above Table.

Using a 5 per cent level of significance, test the hypothesis of no difference in the average wages of unskilled workers in the two cities.

Solution: We use subscripts 1 and 2 for Ambala Cantt and Lucknow respectively.

$H_0 \;:\; \mu_1 = \mu_2 \quad \rightarrow \; \mu_1 - \mu_2 = 0$

$H_1 \;:\; \mu_1 \neq \mu_2 \quad \rightarrow \; \mu_1 - \mu_2 \neq 0$

The following survey data is given:

$$\overline{X}_1 = 8.95,\ \overline{X}_2 = 9.10, s_1 = 0.40, s_2 = 0.60, n_1 = 200, n_2 = 175, \alpha = 0.05$$

Since both n_1, n_2 are greater than 30 and the sample standard deviations are given, a Z test would be appropriate.

The test statistic is given by:

$$Z = \frac{(\overline{X}_1 - \overline{X}_2) - (\mu_1 - \mu_2)H_0}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$$

As $£_1$, $£_2$ are unknown, their estimates would be used.

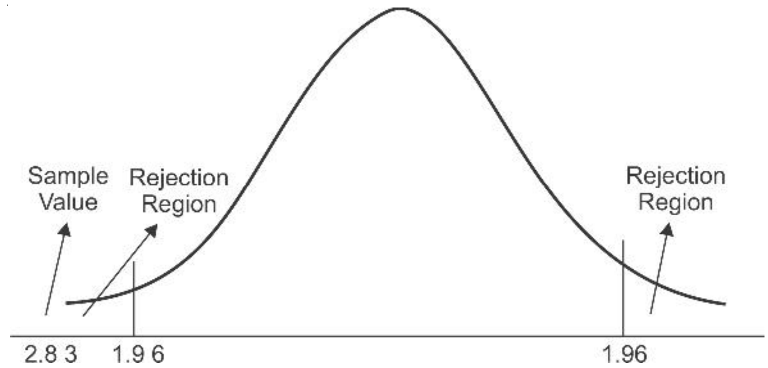
$S_1 = £_1$, $S_2 = £_2$

$$\sqrt{\frac{\hat{\sigma}_1^2}{n_1} + \frac{\hat{\sigma}_2^2}{n_2}} = \sqrt{\frac{(0.4)^2}{200} + \frac{(0.6)^2}{175}} = \sqrt{0.0028} = 0.0053$$

$$= \frac{(8.95 - 9.10) - 0}{0.053} = -2.83$$

As the problem is of a two-tailed test, the critical values of Z at 5 per cent level of significance are given by $-Z_{\alpha/2} = -1.96$ and $Z_{\alpha/2} = 1.96$. The sample value of Z = –2.83 lies in the rejection region as shown in the figure below:

NOTES



Rejection Regions for Example 6.7

Therefore, the null hypothesis is rejected and it may be concluded that there is a difference in the average wages of unskilled workers in the two cities. Let us rework the same problem using the p value approach. As it is known that the problem is of a two-tailed test, the p value is given by:

$$\begin{aligned} p &= P(Z < -2.83) + P(Z > 2.83) \\ &= 2P(Z > 2.83) \\ &= 2 \times (0.5 - 0.4977) \\ &= 2 \times 0.0023 \\ &= 0.0046 \end{aligned}$$

As the value of p is less than α (0.05), the null hypothesis is rejected. Similarly, the problems on one-tailed tests can be solved.

6.3.2 Case of Small Sample

If the size of both the samples is less than 30 and the population standard deviation is unknown, the procedure described above to discuss the equality of two population means is not applicable in the sense that a t test would be applicable under the assumptions:

(a) Two population variances are equal.

(b) Two population variances are not equal.

Population Variances are Equal (F-Test)

If the two population variances are equal, it implies that their respective unbiased estimates are also equal. In such a case, the expression becomes:

$$\sqrt{\frac{\hat{\sigma}_1^2}{n_1}+\frac{\hat{\sigma}_2^2}{n_2}} = \sqrt{\frac{\hat{\sigma}^2}{n_1}+\frac{\hat{\sigma}^2}{n_2}} = \hat{\sigma}\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}$$

$$(\text{Assuming } \hat{\sigma}_1^2 = \hat{\sigma}_2^2 = \hat{\sigma}^2)$$

To get an estimate of $\hat{\sigma}^2$, a weighted average of s_1^2 and s_2^2 is used, where the weights are the number of degrees of freedom of each sample. The weighted average is called a ‘pooled estimate’ of σ^2. This pooled estimate is given by the expression:

$$\hat{\sigma}^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}$$

NOTES

The testing procedure could be explained as under:

$H_0 \; : \; \mu_1 = \mu_2 \quad \Rightarrow \mu_1 - \mu_2 = 0$

$H_1 \; : \; \mu_1 \neq \mu_2 \quad \Rightarrow \mu_1 - \mu_2 \neq 0$

In this case, the test statistic t is given by the expression:

$$t_{n_1+n_2-2} = \frac{(\overline{X}_1 - \overline{X}_2) - (\mu_1 - \mu_2)H_0}{\hat{\sigma}\sqrt{\dfrac{1}{n_1} + \dfrac{1}{n_2}}}$$

Where $\hat{\sigma}\sqrt{\dfrac{(n_1 - 1)s_1^2 + (\mu_2 - 1)s_2^2}{n_1 + n_2 - 2}}$

Once the value of t statistic is computed from the sample data, it is compared with the tabulated value at a level of significance α to arrive at a decision regarding the acceptance or rejection of hypothesis. Let us work out a problem illustrating the concepts defined above.

Example 6.8: Two drugs meant to provide relief to arthritis sufferers were produced in two different laboratories. The first drug was administered to a group of 12 patients and produced an average of 8.5 hours of relief with a standard deviation of 1.8 hours. The second drug was tested on a sample of 8 patients and produced an average of 7.9 hours of relief with a standard deviation of 2.1 hours. Test the hypothesis that the first drug provides a significantly higher period of relief. You may use 5 per cent level of significance.

Solution: Let the subscripts 1 and 2 refer to drug 1 and drug 2, respectively.

$H_0 \; : \; \mu_1 = \mu_2 \quad \Rightarrow \mu_1 - \mu_2 = 0$

$H_1 \; : \; \mu_1 \neq \mu_2 \quad \Rightarrow \mu_1 - \mu_2 \neq 0$

The following survey data is given:

$$\overline{X}_1 = 8.5, \overline{X}_2 = 7.9, s_1 = 1.8, s_2 = 2.1, n_1 = 12, n_2 = 8,$$

As both n_1, n_2 are small and the sample standard deviations are unknown, one may use a t test with the degrees of freedom = $n_1 + n_2 - 2 = 12 + 8 - 2 = 18$ df

The test statistics is given by:

$$t_{n_1+n_2-2} = \frac{(\overline{X}1 - \overline{X}_2) - (\mu_1 - \mu_2)H_0}{\hat{\sigma}\sqrt{\dfrac{1}{n_1} + \dfrac{1}{n_2}}}$$

NOTES

$$\hat{\sigma} = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}}$$

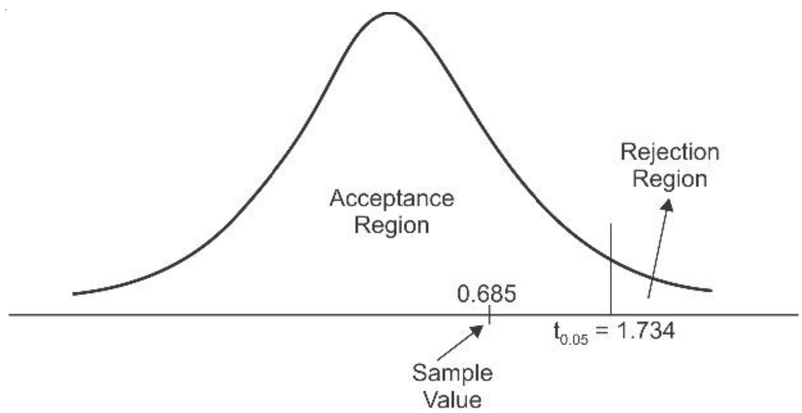
$$= \sqrt{\frac{(12-1)(1.8)^2 + (8-1)(2.1)^2}{12+8-2}} = \sqrt{\frac{11 \times 3.24 + 7 \times (4.41)}{18}}$$

$$= \sqrt{\frac{35.64 + 30.87}{18}} = \sqrt{\frac{66.61}{18}} = \sqrt{3.698} = 1.92$$

Where, $t_{18} = \dfrac{(8.5 - 7.9) - (0)}{1.92\sqrt{\dfrac{1}{12} + \dfrac{1}{8}}} = \dfrac{0.6}{1.92\sqrt{0.2083}}$

$$= \frac{0.6}{1.92 \times 0.456} = \frac{0.6}{0.8755} = 0.685$$

The critical value of t with 18 degrees of freedom at 5 per cent level of significance is given by 1.734. The sample value of t = 0.685 lies in the acceptance region as shown in figure below:



Rejection Region for Example 6.8

Therefore, the null hypothesis is accepted as there is not enough evidence to reject it. Therefore, one may conclude that the first drug is not significantly more effective than the second drug. The same answer could be obtained using a p value approach. It is left to the readers to verify the same.

When Population Variances are not Equal (Z-Test)

In case population variances are not equal, the test statistic for testing the equality of two population means when the size of samples are small is given by:

$$t = \frac{(\overline{X}_1 - \overline{X}_2) - (\mu_1 - \mu_2)H_0}{\sqrt{\dfrac{\hat{\sigma}_1^2}{n_1} + \dfrac{\hat{\sigma}_2^2}{n_2}}}$$

The degrees of freedom in such a case is given by the expression:

NOTES

$$d.f = \frac{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)^2}{\frac{1}{n_1 - 1}\left(\frac{s_1^2}{n_1}\right)^2 + \frac{1}{n_2 + 1}\left(\frac{s_2^2}{n_2}\right)^2}$$

The procedure for testing of hypothesis remains the same as was discussed when the variances of two populations were assumed to be same. Let us consider an example to illustrate the same.

Example 6.9: There were two types of drugs (1 and 2) that were tried on some patients for reducing weight. There were 8 adults who were subjected to drug 1 and seven adults who were administered drug 2. The decrease in weight (in pounds) is given below:

Drug 1	10	8	12	14	7	15	13	11
Drug 2	12	10	7	6	12	11	12	

Do the drugs differ significantly in their effect on decreasing weight? You may use 5 per cent level of significance. Assume that the variances of two populations are not same.

Solution:

$H_0 : \mu_1 = \mu_2$

$H_1 : \mu_1 \neq \mu_2$

Let us compute the sample means and standard deviations of the two samples as shown in Table 6.4.

Table 6.4 *Intermediate Computations for Sample Means and Standard Deviations*

S.No.	X_1	X_2	$(X_1 - \overline{X}_1)$	$(X_2 - \overline{X}_2)$	$(X_1 - \overline{X}_1)^2$	$(X_2 - \overline{X}_2)^2$
1	10	12	–1.25	2	1.5625	4
2	8	10	–3.25	0	10.5625	0
3	12	7	0.75	-3	0.5625	9
4	14	6	2.75	-4	7.5625	16
5	7	12	–4.25	2	18.0625	4
6	15	11	3.75	1	14.0625	1
7	13	12	1.75	2	3.0625	4
8	11		–0.25		0.0625	
Total	90	70	0	0	55.5	38
Mean	11.25	10				

$n_1 = 8,$ $\qquad$ $n_2 = 7,$

$$\overline{X}_1 = \frac{\Sigma X_1}{n_1} = \frac{90}{8} = 11.25 \qquad \overline{X}_2 = \frac{\Sigma \overline{X}_2}{n_2} = \frac{70}{7} = 10$$

NOTES

$$s_1^2 = \frac{\Sigma(X_1 - \overline{X}_1)^2}{n_1 - 1} = \frac{55.5}{7} = 7.93$$

$$s_2^2 = \frac{\Sigma(X_2 - \overline{X}_2)^2}{n_1 - 1} = \frac{38}{6} = 6.33$$

$$\hat{\sigma}_{\bar{x}_1 - \bar{x}_2} = \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}} = \sqrt{\frac{7.93}{8} + \frac{6.33}{7}} = \sqrt{0.99 + 0.90} = \sqrt{1.89} = 1.37$$

$$\text{d.f.} = \frac{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)^2}{\frac{1}{n_1 - 1}\left(\frac{s_1^2}{n_1}\right) + \frac{1}{n_2 - 1}\left(\frac{s_2^2}{n_2}\right)} = \frac{\left(\frac{7.33}{8} + \frac{6.33}{7}\right)^2}{\frac{1}{7}\left(\frac{7.33}{8}\right)^2 + \frac{1}{6}\left(\frac{6.33}{7}\right)^2}$$

$$= \frac{3.314}{0.12 + 0.136} = \frac{3.314}{0.12 + 0.136} = 12.996 = 13 \text{ (approx.)}$$

$$t = \frac{(\overline{X}_1 - \overline{X}_2) - (\mu_1 - \mu_2)H_0}{\sqrt{\frac{\hat{\sigma}_1^2}{n_1} + \frac{\hat{\sigma}_2^2}{n_2}}}$$

$$t = \frac{11.25 - 10}{1.37} = \frac{1.25}{1.37} = 0.912$$

The table value (critical value) of t with 13 degrees of freedom at 5 per cent level of significance is given by 2.16. As computed t is less than tabulated t, there is not enough evidence to reject H_0.

6.3.3 Case of Paired Sample (Dependent Sample)

Our discussion so far was concentrated upon two independent samples. At times, however, it makes sense to choose samples that are not independent of each other. In case of dependent samples (paired sample), two observations are taken from each respondent one prior to administering a treatment and the other after the treatment has been administered. For example, some customers may be questioned on their perception about a product and later on, a television commercial may be shown to them about the same product. After seeing the advertisement, they may again be questioned on their perception about the product. Such a sample is called dependent or paired sample because on the same respondent, two observations are taken—one prior to treatment and the other after being subjected to treatment. The objective of doing this could be to examine whether that perception has undergone a change after the subjects viewed the advertisement, and if so, in what direction?

The use of dependent sample enables us to perform a more precise analysis as it allows the controlling of extraneous variables. The difference is that we convert the problem from two samples to a one-sample problem. Suppose we are interested in comparing two teaching methods on the basis of average scores obtained by the management trainees divided randomly into two equal sizes, one taught by each method. After obtaining the scores by two methods, the null hypothesis of average scores being equal by two methods is written as:

NOTES

H_0 : $\mu_1 = \mu_2$

H_1 : $\mu_1 \neq \mu_2$

Let $\mu_d = \mu_1 - \mu_2$

Since the pair sample observations are taken, the hypothesis is converted to:

H_0 : $\mu_d = 0$

H_1 : $\mu_d \neq 0$

This means that we want to test that the average difference in score is zero against the alternative hypothesis that it is not so. Here, d denotes the difference in scores by two methods:

The test statistic in such a case,

$$t = \frac{\bar{d}}{\frac{s}{\sqrt{n}}}$$

which follows a t distribution with n – 1 degrees of freedom,

where, $\bar{d}$ = Mean of difference = $\frac{\sum di}{n}$

S = Standard deviation of differences = $\sqrt{\frac{\Sigma(d-\bar{d})^2}{n-1}}$

N = Number of paired observations in the sample

For a given level of significance α, the computed t statistic is compared with the tabulated (critical) t with n – 1 degrees of freedom to accept or reject the null hypothesis. Let us consider the following example.

Example 6.10: A company selects eight salesmen at random and their sales figures for the previous month are recorded. They then undergo a training course devised by a business consultant, and their sales figures for the following month are compared as shown in the table. Has the training course caused an improvement in the salesmen's ability? You may use a 0.05 level of significance.

Previous Month	75	90	94	95	100	90	70	64
Following Month	77	101	93	92	105	88	76	68

Solution: Let P and F stand for the previous and the following months:

H_0 : $\mu_d = 0$

H_1 : $\mu_d > 0$

d = F – P,

The required computations are given in Table 6.5.

NOTES

***Table 6.5** Intermediate Computations for Mean and Standard Deviation*

S.No.	P	F	d	$(d - \bar{d})$	$(d - \bar{d})^2$
1	75	77	2	–0.75	0.5625
2	90	101	11	8.25	68.0625
3	94	93	–1	–3.75	14.0625
4	95	92	–3	–5.75	33.0625
5	100	105	5	2.25	5.0625
6	90	88	–2	–4.75	22.5625
7	70	76	6	3.25	10.5625
8	64	68	4	1.25	1.5625
Total			22	0	155.5
Mean			2.75		

$$\sum d = 22, \qquad \bar{d} = \frac{\sum d}{8} = \frac{22}{8} = 2.75,$$

$$s_2 = \frac{\Sigma(d-\bar{d})^2}{n-1} = \frac{555.5}{7} = 22.214, \qquad s = 4.713$$

$$t_{n-1} = \frac{\bar{d} - \mu d}{\frac{s}{\sqrt{n}}} = \frac{(2.75-0)\sqrt{8}}{4.713} = \frac{(2.75 \times 2.828)}{4.713} = \frac{7.777}{4.713} = 1.650$$

tab t (5 per cent) = 1.895

As computed t is less than tabulated t, there is not enough evidence to reject H_0. Therefore, the training has not caused any improvement in the salesmen's ability.

6.3.4 Tests Concerning Population Proportion

We have already discussed the tests concerning population means. In the tests about proportion, one is interested in examining whether the respondents possess a particular attribute or not. For example, the interest could be in the proportion of students who are smokers or the proportion of consumers who use a particular brand of product or the percentage of skilled employees in a company who are not satisfied with their present job.

We note that in the examples cited above, the random variable in a question is a binary one in the sense it takes only two values—Yes or No. As we know that either a student is a smoker or not, a consumer either uses a particular brand of product or not and lastly, a skilled worker may be either satisfied or not with the present job. At this stage it may be recalled that the binomial distribution is a theoretically correct distribution to use while dealing with proportions. Further as the sample size increases, the binomial distribution approaches the normal distribution in characteristic. To be specific, whenever both np and nq (where n = number of trials, p = probability of success and q = probability of failure) are at least 5, one can use the normal distribution as a substitute for the binomial distribution. The test of hypotheses would be discussed in the case of single and two population proportions. We will take these cases one by one.

The case of single population proportion

Suppose we want to test the hypotheses,

$H_0 \ : \ p = p_0$

NOTES

$H_1 \ : \ p \neq p_0$

For large sample, the appropriate test statistic would be:

$$Z = \frac{\bar{p} - p_{H_0}}{q_{\bar{p}}}$$

Where, $\bar{p}$ = sample proportion

p_{H_0} = the value of p under the assumption that null hypothesis is true

$q_{\bar{p}}$ = Standard error of sample proportion

The value of $q_{\bar{p}}$ is computed by using the following formula:

$$q_{\bar{p}} = \frac{\bar{p} - p_{H_0}}{q_{\bar{p}}}$$

Where, $q_{H0} = 1 - p_{H0}$

= Sample size

For a given level of significance α, the computed value of Z is compared with the corresponding critical values, i.e. $Z_{\alpha/2}$ or $-Z_{\alpha/2}$ to accept or reject the null hypothesis. We will consider a few examples to explain the testing procedure for a single population proportion.

Example 6.11: An officer of the health department claims that 60 per cent of the male population of a village comprises smokers. A random sample of 50 males showed that 35 of them were smokers. Are these sample results consistent with the claim of the health officer? Use a level of significance of 0.05.

Solution:

Sample size (n) = 50

Sample proportion = $\bar{p} = \frac{x}{n} = \frac{35}{50} = 0.70$

$H_0 \ : \ p = 0.60$

$H_1 \ : \ p > 0.60$

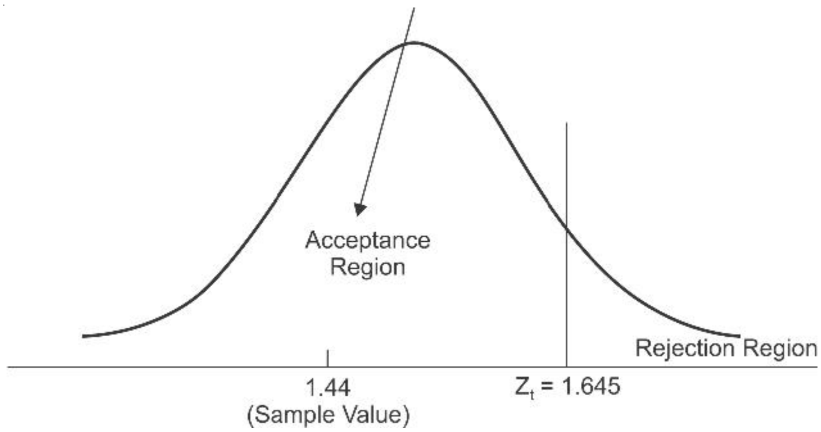
The test statistic is given by:

$$Z = \frac{\bar{p} - p_{H_0}}{\sigma_{\bar{p}}} = \frac{0.70 - 0.60}{0.069} = \frac{0.10}{0.069} = 1.44$$

$$\left(\sigma_{\bar{p}} = \sqrt{\frac{p_{H_0} q_{H_0}}{n}} = \sqrt{\frac{0.6 \times 0.4}{50}} = \sqrt{\frac{0.24}{50}} = 0.069 \right)$$

It is a one-tailed test. For a given level of significance $\alpha = 0.05$, the critical value of Z is given by $Z_\alpha = Z_{0.05} = 1.645$. It is seen that the sample value of Z = 1.44 lies in the acceptance region as shown below (see Figure below).

NOTES



Rejection Region for Example 6.11

Therefore, there is not enough evidence to reject the null hypothesis. So it can be concluded that the proportion of male smokers is not statistically different from 0.60.

Using the p value approach, the p value for this problem is given by:

$$\begin{aligned} p &= P(Z > 1.44) \\ &= 0.5 - P(0 < Z < 1.44) \\ &= 0.5 - 0.4251 \\ &= 0.0749 \end{aligned}$$

Since the p value is greater than $\alpha = 0.05$, the null hypothesis is accepted. Therefore, it is seen that same conclusion is arrived at by using the p value approach.

Example 6.12: A food processing company wants to know whether the proportion of customers who prefer the new packaging to the old one is 0.65. What can be concluded at the level of significance $\alpha = 0.05$ if 74 of the 100 randomly selected customers prefer the new kind of packaging and alternative hypothesis is $p \neq 0.65$.

Solution:

H_0 : $p = 0.65$

H_1 : $p \neq 0.65$

$$x = 74, \qquad n = 100, \qquad \bar{p} = \frac{x}{n} = \frac{74}{100} = 0.74, \qquad \alpha = 0.05$$

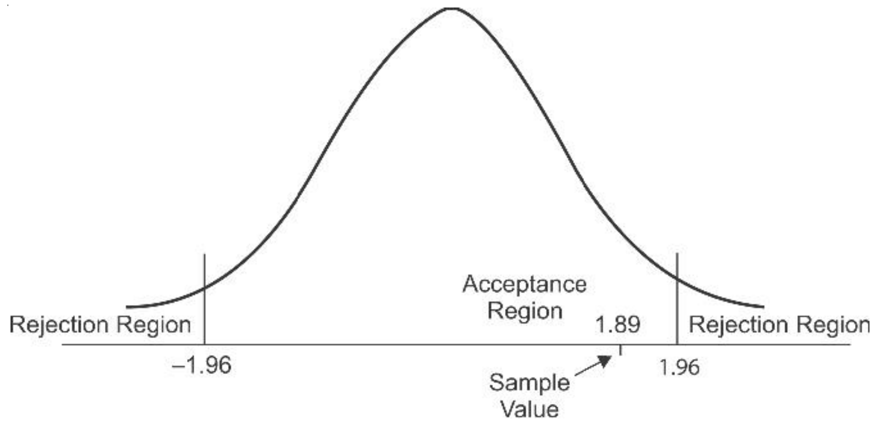
The problem is of a two-tailed test. The test statistic is given as:

$$Z = \frac{\bar{p} - p_{H_0}}{q_{\bar{p}}} = \frac{0.74 - 0.65}{0.0477} = 1.89$$

$$\left(q_{\bar{p}} = \sqrt{\frac{p_{H_0} q_{H_0}}{n}} = \sqrt{\frac{0.65 \times 0.34}{100}} = \sqrt{.002275} = 0.0477 \right)$$

For 5 per cent level of significance, the critical values are given by $-Z_{\alpha/2} = -Z_{.025} = -1.96$ and $Z_{\alpha/2} = Z_{0.025} = 1.96$. The computed value of Z lies in the acceptance region as shown in the figure below:

NOTES



Rejection Regions for Example 6.12

Therefore, there is not enough evidence to reject the null hypothesis. Accordingly, the proportion of customer preferring new kind of packaging to the old one is not significantly different from 0.65.

The same problem could be worked out using the p value approach. The p value for this problem could be computed as:

$$\begin{aligned} p &= P(Z > 1.89) + P(Z < -1.89) \text{ (It is a two-tailed test.)} \\ &= 2 \times P(Z > 1.89) \\ &= 2 \times (0.5 - P(0 < Z < 1.89)) \\ &= 2 \times (0.5 - 0.4706) \\ &= 0.0588 \end{aligned}$$

As p value is greater than 0.05, the level of significance, the null hypothesis is accepted. Therefore, we arrive at the same conclusion.

6.3.5 Two Population Proportions

Here, the interest is to test whether the two population proportions are equal or not. The hypothesis under investigation is:

$H_0 : p_1 = p_2 \Rightarrow p_1 - p_2 = 0$

$H_1 : p_1 \neq p_2 \Rightarrow p_1 - p_2 \neq 0$

The alternative hypothesis assumed is two sided. It could as well have been one sided. The test statistic is given by:

$$Z = \frac{\bar{p} - \bar{p}_2 - (p_1 - p_2)H_0}{\sigma_{\bar{p}_1 - \bar{p}_2}}$$

Where, $\bar{p}_1$ = Sample proportion possessing a particular attribute from population 1.

$\bar{p}_2$ = Sample proportion possessing a particular attribute from population 2.

$\sigma_{\bar{p}_1 - \bar{p}_2}$ = Standard error of difference between proportions.

$(p_1 - p_2)_{H0}$ = Value of difference between population proportion under the assumption that the null hypothesis is true.

NOTES

The formula for $\sigma_{P_1-P_2}$ is given by:

$$\sigma_{\bar{p}_1-\bar{p}_2} = \sqrt{\frac{p_1q_1}{n_1} + \frac{p_2q_2}{n_2}}$$

We do not know the value of p_1, p_2, etc., but under the null hypothesis $p_1 = p_2 = p$.

$$\sigma_{\bar{p}_1-\bar{p}_2} = \sqrt{\frac{pq}{n_1} + \frac{pq}{n_2}} = \sqrt{pq\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}$$

The best estimate of p is given by:

$$\hat{p} = \frac{x_1 + x_2}{n_1 + n_2}$$

Where, x_1 = Number of successes in sample 1
x_2 = Number of successes in sample 2
n_1 = Size of sample taken from population 1
n_2 = Size of sample taken from population 2

It is known that $\bar{p}_1 = \frac{x_1}{n_1}$ and $\frac{x_2}{n_2}$. Therefore $x_1 = n_1\bar{p}_1$, and $x_2 = n_2\bar{p}_2$.

Therefore, $$\hat{p} = \frac{n_1\bar{p}_1 + n_2\bar{p}_2}{n_1 + n_2}$$

Therefore, the estimate of standard error of difference between the two proportions is given by:

$$\hat{\sigma}_{\bar{p}_1-\bar{p}_2} = \sqrt{\hat{p}\hat{q}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}$$

Where $\hat{p}$ is as defined above and $\hat{q} = 1 - \hat{p}$. Now, the test statistic may be rewritten as:

$$Z = \frac{\hat{p}_1 - \hat{p}_2 - (p_1 - p_2)H_0}{\sqrt{\hat{p}\hat{q}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

Now, for a given level of significance α, the sample Z value is compared with the critical Z value to accept or reject the null hypothesis. We consider below a few examples to illustrate the testing procedure described above.

Example 6.13: A company is interested in considering two different television advertisements for the promotion of a new product. The management believes that advertisement A is more effective than advertisement B. Two test market areas with virtually identical consumer characteristics are selected. Advertisement A is used in one area and advertisement B in the other area. In a random sample of 60 consumers who saw advertisement A, 18 tried the product. In a random sample of 100 customers who saw advertisement B, 22 tried the product. Does this indicate that advertisement A is more effective than advertisement B, if a 5 per cent level of significance is used?

NOTES

Solution:

$$H_0 \quad : \quad p_a = p_b$$

$$H_1 \quad : \quad p_a > p_b$$

$$nA = 60, \quad x_A = 18, \quad n_B = 100, \quad x_B = 22$$

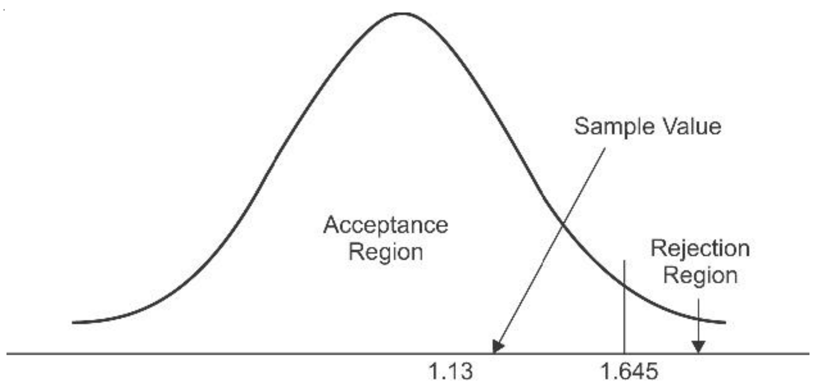
$$\left(\bar{p}_A = \frac{x_A}{n_A} = \frac{18}{60} = 0.3\right) \quad \left(\bar{p}_B = \frac{x_B}{n_B} = \frac{22}{100} = 0.22\right)$$

$$Z = \frac{\bar{P}_A - \bar{P}_B - (p_A - p_B)H_0}{\sigma_{\bar{P}_A - \bar{P}_B}} = \frac{0.3 - 0.22 - 0}{\sqrt{\hat{p}\hat{q}\left(\frac{1}{n_A} + \frac{1}{n_B}\right)}}$$

$$= \frac{0.08}{\sqrt{0.25 \times 0.75\left(\frac{1}{60} + \frac{1}{100}\right)}} = \frac{0.08}{\sqrt{0.25 \times 0.75(0.0267)} = \frac{0.08}{0.071}} = 1.3$$

$$\left(\hat{p} = \frac{x_A + x_B}{n_A + n_B} = \frac{18 + 22}{60 + 100} = \frac{40}{160} = 0.25\right)$$

The critical value of Z at 5 per cent level of significance is 1.645. The sample value of Z = 1.13 lies in the acceptance region as shown in the figure below:



Rejection Region for Example 6.13

Therefore, we accept the null hypothesis. It can be concluded that there is no difference in the effectiveness of two advertisements. We could work out the same problem using the p value approach. The p value may be calculated as:

$$\begin{aligned} p &= P(Z > 1.13) \\ &= 0.5 - P(0 < Z < 1.13) \\ &= 0.5 - 0.3708 \\ &= 0.1292 \end{aligned}$$

The p value of 0.1292 is greater than 0.05, therefore, we accept the null hypothesis as was done with the other approach.

Example 6.14: In a random sample of 100 persons taken from village A, 60 were found to be consuming tea. In another sample of 200 persons taken from village B, 100 persons were found to be consuming tea. Does the data reveal a significant difference between the two villages so far as the habit of taking tea is concerned? You may use a 5 per cent level of significance.

NOTES

Solution:

$H_0 \;:\; p_A = p_B$

$H_1 \;:\; p_A \neq p_B$

$n_A = 100, \quad x_A = 60, \quad \bar{p}_A = \frac{x_A}{n_A} = \frac{60}{100} = 0.6$

$n_B = 200, \quad x_B = 100, \quad \bar{p}_B = \frac{x_B}{n_B} = \frac{100}{200} = 0.5$

The test statistic to be used here is:

$$Z = \frac{\bar{p}_A - \bar{p}_B - (p_A - p_B)H_0}{\sigma_{\bar{p}_A - \bar{p}_B}} = \frac{\bar{p}_A - \bar{p}_B - 0}{\sqrt{\hat{p}\hat{q}\left(\frac{1}{n_A} + \frac{1}{n_B}\right)}}$$

$$= \frac{0.6 - 0.5 - 0}{\sqrt{.533 \times .467\left(\frac{1}{100} + \frac{1}{200}\right)}} = \frac{0.10}{\sqrt{.533 \times 467 \times 0.015}}$$

$$= \frac{0.10}{\sqrt{0.00373}} = \frac{0.10}{0.061} = 1.64$$

$$\left(\hat{p} = \frac{x_A + x_B}{n_A + n_B} = \frac{60 + 100}{100 + 200} = \frac{160}{300} = \frac{8}{15} = 0.533\right)$$

$$(\hat{p} = 1 - \hat{p} = 1 - 0.533 = 0.467$$

Tab Z = 1.96   Accept H_0

$$\begin{aligned} p &= P(Z > 1.64) + P(Z < -1.64) \\ &= 2P(Z > 1.64) \\ &= 2\,(0.5 - 0.4495) \\ &= 2 \times 0.0505 \\ &= 0.101 \end{aligned}$$

Since $p > \alpha = 0.05$, H_0 is accepted. Therefore, there is no difference in the proportions of persons consuming tea in the two villages.

In this chapter, we have discussed the test of significance for the mean and proportions of the single and two populations.

6.3.6 F Test

The major characteristics of the *F*-distribution are as follows:

(i) Unlike normal distribution, which is only one type of curve irrespective of the value of the mean and the standard deviation, the *F* distribution is a *family* of curves. A particular curve is determined by two parameters. These are the degrees of freedom in the numerator and the degrees of freedom in the denominator. The shape of the curve changes as the number of degrees of freedom changes.

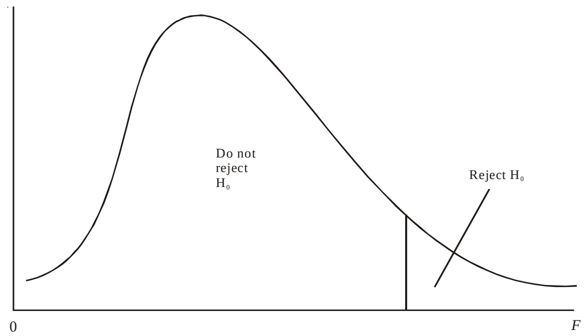
(ii) It is a continuous distribution and the value of *F* cannot be negative.

NOTES

(iii) The curve representing the *F* distribution is positively skewed.

(iv) The values of *F* theoretically range from zero to infinity.

A diagram of *F* distribution curve is shown below.



The rejection region is only in the right end tail of the curve because unlike *Z* distribution and *t* distribution which had negative values for areas below the mean, *F* distribution has only positive values by definition and only positive values of *F* that are larger than the critical values of *F*, will lead to a decision to reject the null hypothesis.

Computation of *F*

Since *F* ratio contains only two elements, which are the variance between the samples and the variance within the samples, the concepts of which have been discussed before, let us recapitulate the calculation of these variances.

If all the means of samples were exactly equal and all samples were exactly representative of their respective populations so that all the sample means, were exactly equal to each other and to the population mean, then there will be no variance. However, this can never be the case. We always have variation, both between samples and within samples, even if we take these samples randomly and from the same population. This variation is known as the *total variation.*

The total variation designated by $\sum (X - \bar{\bar{X}})^2$, where *X* represents individual observations for all samples and $\bar{\bar{X}}$ is the grand mean of all sample means and equals (μ), the population mean, is also known as the *total sum of squares* or *SST,* and is simply the sum of squared differences between each observation and the overall mean. This total variation represents the contribution of two elements. These elements are:

(A) *Variance between samples.* The variance between samples may be due to the effect of different *treatments*, meaning that the population means may be affected by the *factor* under consideration, thus, making the population means actually different, and some variance may be due to the inter-sample variability. This variance is also known as the *sum of squares* between samples. Let this *sum of squares* be designated as *SSB*.

Then, *SSB* is calculated by the following steps:

(i) Take *k* samples of size *n* each and calculate the mean of each sample, i.e., $\bar{X}_1, \bar{X}_2, \bar{X}_3, \ .... \ \bar{X}_k$.

(ii) Calculate the grand mean $\bar{\bar{X}}$ of the distribution of these sample means, so that,

$$\bar{\bar{X}} = \frac{\sum_{i=1}^{k} \bar{x}_i}{k}$$

NOTES

(iii) Take the difference between the means of the various samples and the grand mean, i.e.,

$$(\bar{X}_1 - \bar{\bar{X}}),\ (\bar{X}_2 - \bar{\bar{X}}),\ (\bar{X}_3 - \bar{\bar{X}}),\ ....,\ (\bar{X}_k - \bar{\bar{X}})$$

(iv) Square these deviations or differences individually, multiply each of these squared deviations by its respective sample size and sum up all these products, so that we get;

$$\sum_{i=1}^{k} n_i (\bar{X}_i - \bar{\bar{X}})^2,$$ where n_i = size of the ith sample.

This will be the value of the *SSB.*

However, if the individual observations of all samples are not available, and only the various means of these samples are available, where the samples are either of the same size n or different sizes, n_i, n_2, n_3, ..., n_k, then the value of SSB can be calculated as:

$$SSB = n_i (\bar{X}_i - \bar{\bar{X}})^2 + n_2 (\bar{X}_2 - \bar{\bar{X}})^2 +\ .....\ n_k (\bar{X}_k - \bar{\bar{X}})^2$$

where,

n_1 = Number of items in sample 1

n_2 = Number of items in sample 2

n_k = Number of items in sample k

$\bar{X}_1$ = Mean of sample 1

$\bar{X}_2$ = Mean of sample 2

$\bar{X}_k$ = Mean of sample k

$\bar{\bar{X}}$ = Grand mean or average of all items in all samples.

(v) Divide *SSB* by the degrees of freedom, which are $(k-1)$, where k is the number of samples and this would give us the value of $\sigma^2_{\text{between}}$, so that,

$$\sigma^2_{\text{between}} = \frac{SSB}{(k-1)}.$$

(This is also known as mean square between samples or *MSB).*

(B) *Variance within samples.* Even though each observation in a given sample comes from the same population and is subjected to the same treatment, some chance variation can still occur. This variance may be due to sampling errors or other natural causes. This variance or sum of squares is calculated through the following steps:

(i) Calculate the mean value of each sample, i.e., $\bar{X}_1, \bar{X}_2, \bar{X}_3,\ ....\ \bar{X}_k$.

(ii) Take one sample at a time and take the deviation of each item in the sample from its mean. Do this for all the samples, so that we would have a difference between each value in each sample and their respective means for all values in all samples.

(iii) Square these differences and take a total sum of all these squared differences (or deviations). This sum is also known as *SSW* or sum of squares within samples.

(iv) Divide this *SSW* by the corresponding degrees of freedom. The degrees of freedom are obtained by subtracting the total number of samples from the total number of items. Thus, if N is the total number of items or observations, and k is the number of samples, then,

$$df = (N - k)$$

These are the degrees of freedom within samples. (If all samples are of equal size n, then $df = k(n-1)$, since $(n-1)$ are the degrees of freedom for each sample and there are k samples).

(v) This figure *SSW*/*df*, is also known as σ^2_{within}, or MSW (mean of sum of squares within samples).

Now, the value of F can be computed as:

$$F = \frac{\sigma^2_{\text{between}}}{\sigma^2_{\text{within}}} = \frac{SSB/df}{SSW/df}$$

$$= \frac{SSB/(k-1)}{SSW/(N-k)} = \frac{MSB}{MSW}$$

This value of F is then compared with the critical value of F from the table and a decision is made about the validity of null hypothesis.

Example 6.15: To test whether all professors teach the same material in different sections of the introductory statistics class or not, four sections of the same course were selected and a common test was administered to five students selected at random from each section. The scores for each student from each section were noted and are given below. We want to test for any differences in learning, as reflected in the average scores for each section.

Student #	*Section 1 Scores* (X_1)	*Section 2 Scores* (X_2)	*Section 3 Scores* (X_3)	*Section 4 Scores* (X_4)
1	8	12	10	12
2	10	12	13	15
3	12	10	11	13
4	10	8	12	10
5	5	13	14	10
Totals	$\Sigma X_1 = 45$	$\Sigma X_2 = 55$	$\Sigma X_3 = 60$	$\Sigma X_4 = 60$
Means	$\overline{X}_1 = 9$	$\overline{X}_2 = 11$	$\overline{X}_3 = 12$	$\overline{X}_4 = 12$

Solution:

A. The Traditional Method

(i) State the null hypothesis. We are assuming that there is no significant difference among the average scores of students from these four sections and hence, all professors are teaching the same material with the same effectiveness, i.e.,

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

H_1: All means are not equal or at least two means differ from each other

(ii) Establish a level of significance. Let $a = 0.05$.

NOTES

(iii) Calculate the variance between the samples, as follows:

(a) The mean of each sample is:

$$\overline{X}_1 = 9,\ \overline{X}_2 = 11,\ \overline{X}_3 = 12, \overline{X}_4 = 12$$

(b) The grand mean or $\overline{\overline{X}}$ is:

$$\overline{\overline{X}} = \frac{\Sigma\overline{x}}{n} = \frac{9+11+12+12}{4}$$
$$= 11$$

(c) Calculate the value of *SSB*:

$$SSB = \Sigma n(\overline{X} - \overline{\overline{X}})^2$$
$$= 5\ (9-11)^2 + 5\ (11-11)^2 + 5\ (12-11)^2 + 5\ (12-11)^2$$
$$= 20 + 0 + 5 + 5$$
$$= 30$$

(d) The variance between samples $\sigma^2_{\text{between}}$ or *MSB* is given by:

$$MSB = \frac{SSB}{df} = \frac{(30)}{(k-1)} = \frac{(30)}{3} = 10$$

(iv) Calculate the variance within samples, as follows:

To find the Sum of Squares Within (SSW) samples, we square each deviation between the individual value of each sample and its mean, for all samples and then sum these squared deviations, as follows:

Sample 1: $\overline{X}_1 = 9$

$$\Sigma(X_1 - \overline{X}_1)^2 = (8-9)^2 + (10-9)^2 + (12-9)^2 + (10-9)^2 + (5-9)^2$$
$$= 1+1+9+1+16$$
$$= 28$$

Sample 2: $\overline{X}_2 = 11$

$$\Sigma(X_2 - \overline{X}_2)^2 = (12-11)^2 + (12-11)^2 + (10-11)^2 + (8-11)^2 + (13-11)^2$$
$$= 1+1+1+9+4$$
$$= 16$$

Sample 3: $\overline{X}_3 = 12$

$$\Sigma(X_3 - \overline{X}_3)^2 = (10-12)^2 + (13-12)^2 + (11-12)^2 + (12-12)^2 + (14-12)^2$$
$$= 4+1+1+0+4$$
$$= 10$$

Sample 4: $\overline{X}_4 = 12$

$$\Sigma(X_4 - \overline{X}_4)^2 = (12-12)^2 + (15-12)^2 + (13-12)^2 + (10-12)^2 + (10-12)^2$$
$$= 0+9+1+4+4$$
$$= 18$$

NOTES

Then, $SSW = 28 + 16 + 10 + 18$
$= 72$

Now, the variance within samples, σ^2_{within}, or *MSW* is given by:

$$MSW = \frac{SSW}{df} = \frac{SSW}{(N-k)} = \frac{72}{20\ -4} = \frac{72}{16} = 4.5$$

Then, the *F*-ratio = $\frac{MSB}{MSW} = \frac{10}{4.5} = 2.22.$

Now, we check for the critical value of *F* from the table for $\alpha = 0.05$ and degrees of freedom as follows:

df (numerator) = $(k - 1) = (4 - 1) = 3$

df (denominator) = $(N - k) = (20 - 4) = 16$

This value of *F* from the table is given as 3.24. Now, since our calculated value of $F = 2.22$ is less than the critical value of $F = 3.24$, we cannot reject the null hypothesis.

B. The Short-Cut Method

Following the procedure outlined before for using the short-cut method, we get:

(i) Total sum $(TS) = \Sigma X$
$= 220$

(ii) Correction before $CF = \frac{(TS)^2}{N} = \frac{(220)^2}{20} = 2420$

(iii) Total sum of squares:

$$SST = \Sigma(X^2) - CF$$
$$= 2522\ -\ 2420\ -102$$

(iv) Sum of squares betwen the samples *SSB* is obtained by:

$$SSB = \sum_{i=1}^{k} \frac{(X_i)^2}{n_i} - CF$$
$$= \frac{(X_1)^2}{n_1} + \frac{(X_2)^2}{n_2} + \ .... \ + \frac{(X_k)^2}{n_k} - CF$$
$$= \frac{(45)^2}{5} + \frac{(55)^2}{5} + \frac{(60)^2}{5} + \frac{(60)^2}{5} - (2420)$$
$$= 405 + 605 + 720 + 720 - 2420$$
$$= 30$$

(v) *SSW* can be calculated by:

$SST - SSB = 102 - 30 = 72$

Now the *F* value can be calculated as:

$$F = \frac{SSB/df}{SSW/df} = \frac{30/(k-1)}{72/(n-k)} = \frac{30/3}{72/16} = \frac{10}{4.5}$$
$$= 2.22$$

NOTES

As we see, we get the same value of F as obtained by the traditional method. So, we compare our value of F with the critical value of F from the table for $\alpha = 0.05$ and df (numerator = 3), and df (denominator = 16), and we get the critical value of F as 3.24. As before, we accept the null hypothesis.

6.4 ANOVA: ONE-WAY AND TWO-WAY ANOVA

The technique has found applications in the fields of economics, psychology, sociology, business and industry. It becomes handy in situations where we want to compare the means of more than two populations. Some examples could be to compare:

- the mean cholesterol content of various diet foods
- the average mileage of, say, five automobiles
- the average telephone bill of households belonging to four different income groups and so on.

As mentioned earlier, considering all combinations of two populations at a time would require not only a large number of tests but could also be very time consuming and waste a lot of money. Further, it may not possible to identify certain relationships, called the interaction effect, among the independent variables (factors). The technique of ANOVA becomes handy as it helps to compare the differences among the means of all the populations simultaneously.

R.A. Fisher developed the theory concerning ANOVA. The basic principle underlying the technique is that the total variation in the dependent variable is broken into two parts—one which can be attributed to some specific causes and the other that may be attributed to chance. The one which is attributed to the specific causes is called the variation between samples and the one which is attributed to chance is termed as the variation within samples. Therefore, in ANOVA, the total variance may be decomposed into various components corresponding to the sources of the variation. For example, the sales of chairs could differ because of the various styles and the sizes of the stores selling them. Similarly, one could study the differences among the various types of drugs for curing a specific disease or the differences in the cholesterol content of various diet foods or differences in the yield of crops due to varieties of seeds, fertilizers or soils.

In general, the ANOVA techniques investigate any number of factors which are supposed to influence the dependent variable of interest. It is also possible to investigate the differences in various categories within each of these factors. In ANOVA, the dependent variable in question is metric (interval or ratio scale), whereas the independent variables are categorical (nominal scale). If there is one independent variable (one factor) divided into various categories, we have one-way or one-factor analysis of variance. In the two-way or two-factor analysis of variance, two factors each divided into the various categories are involved. However, if the set of an independent variable consists of both the metric and the categorical variables, the technique is called Analysis Of Covariance (ANOCOVA). The discussion of ANOCOVA is beyond the scope of this text.

Check Your Progress

1. What is a hypothesis?
2. What is the basis of hypothesis testing?

NOTES

In ANOVA, it is assumed that each of the samples is drawn from a normal population and each of these populations has an equal variance. Another assumption that is made is that all the factors except the one being tested are controlled (kept constant). Basically, two estimates of the population variances are made. One estimate is based upon between the samples and the other one is based upon within the samples. The two estimates of variances can be compared for their equality using F statistic (for details on comparing the equality of variances of the two populations, refer to any textbook on statistics). Below, we discuss the concept of ANOVA in various experimental designs.

6.4.1 Basic Assumptions and Principles of ANOVA

The basic principle of ANOVA is to test for differences among the means of the populations by examining the amount of variation within each of these samples, relative to the amount of variation between the samples. In terms of variation within the given population it is assumed that the values of (x_{ij}) differ from the mean of this population only because of random effects, i.e., there are influences on (x_{ij}) which are unexplainable, whereas in examining differences between populations we assume that the difference between the mean of the *j*th population and the grand mean is attributable to what is called a 'specific factor' or what is technically described as treatment effect. Thus, while using ANOVA, we assume that each of the samples is drawn from a normal population and that each of these populations has the same variance. We also assume that all factors other than the one or more being tested are effectively controlled. This, in other words, means that we assume the absence of many factors that might affect our conclusions concerning the factor(s) to be studied.

Under the one-way ANOVA, we consider only one factor and then observe that the reason for the said factor to be important is that several possible types of samples can occur within that factor. We then determine if there are differences within that factor. The technique involves the following steps:

(i) Obtain the mean of each sample ie, obtain $\bar{x}_1, \bar{x}_2, \cdots, \bar{x}_K$, i.e., when there are K samples.

(ii) Work out the mean of the sample means as follows:

$$\bar{\bar{x}} = \left(\frac{\bar{x}_1 + \bar{x}_2 + \bar{x}_3 + \cdots + \bar{x}_K}{K} \right)$$

where K = No. of samples.

(iii) Take the deviations of the sample means from the mean of the sample means and calculate the square of such deviations which may be multiplied by the no. of items in the corresponding sample, and then obtain their total. This is known as the sum of squares for variance between the samples (or SS between).

Symbolically, this can be written as:

$$SS \text{ between} = \left[n_1 \left(\bar{x}_1 - \bar{\bar{x}}\right)^2 + n_2 \left(\bar{x}_2 - \bar{\bar{x}}\right)^2 + \cdots + n_k \left(\bar{x}_k - \bar{\bar{x}}\right)^2 \right]$$

(iv) Divide the result of the Step (iii) by the (no. of) degrees of freedom between the samples to obtain variance or Mean Square (MS) between samples.

Symbolically, this can be written as:

$$MS \text{ between} = \left[\frac{SS \text{ between}}{(k-1)}\right] \text{ where}$$

$(k-1)$ represents degrees of freedom (df) between samples.

NOTES

(v) Obtain the deviations of the values of the sample items for all the samples from corresponding means of the samples and calculate the squares of such deviations and then obtain their total. This total is known as the sum of squares for variance within samples (or *SS* within). Symbolically, this can be written as:

$$SS \text{ within} = \left[\Sigma\left(x_{1i}-\bar{x}_1\right)^2+\Sigma\left(x_{2i}-\bar{x}_2\right)^2+\cdots+\Sigma\left(x_{ki}-\bar{x}_k\right)^2\right]$$

where $i = 1, 2, 3, ...$

(vi) Divide the result of Step (v) by the degrees of freedom within samples to obtain the variance or Mean Square (*MS*) within samples. Symbolically, this can be written as:

$$MS \text{ within} = \left[\frac{SS \text{ within}}{(n-k)}\right] \text{ where}$$

$(n-k)$ represents the degrees of freedom within samples, (n = Total no. of items in all the samples, i.e., $(n_1 + n_2 + ... n_k)$ and k = No. of samples.

(vii) For a check, the sum of squares of deviations for total variance can also be worked out by adding the squares of deviations when the deviations for the individual items in all the samples have been taken from the mean of the sample means. Symbolically, this can be written as:

$$SS \text{ for total variance} = \Sigma\left(x_{ij}-\bar{\bar{x}}\right)^2$$

$$i = 1, 2, 3, \cdots$$

$$j = 1, 2, 3, \cdots$$

This should be equal to the total of the results of Step (iii) and Step (v) explained before i.e.,

SS for total variance = *SS* between + *SS* within

The degrees of freedom for total variance will be equal to the no. of items in all samples minus unity, i.e., $(n-1)$. The degrees of freedom for 'between' and 'within' must add up to the degrees of freedom for total variance, i.e.,

$(n-1) = [(k-1) + (n-k)]$

This fact explains the additive property of the ANOVA technique.

(viii) Finally, F-ratio may be worked out as under:

$$F\text{-ratio} = \frac{MS \text{ between}}{MS \text{ within}}$$

This ratio is used to judge whether the difference among several sample means is significant or is just a matter of sampling fluctuations. For this purpose we look into the table giving the values of F for given degrees of freedom at different levels of significance. If the worked out value of F, as stated above, is less than the table value of F, the difference is taken as insignificant, i.e., due to chance and the null hypothesis of no difference between sample means stands. In case the calculated value of F happens to be either equal or more than its table value, the difference is considered as significant (which means the samples could not have come from the same universe) and accordingly the conclusion may be drawn. The higher the calculated value of F is above the table value, the more definite and sure one can be about his conclusions/inferences.

NOTES

Two-way ANOVA technique is used when the data are classified on the basis of two factors. For example, the agricultural output may be classified on the basis of different varieties of seeds and also on the basis of different varieties of fertilizers used. A business firm may have its sales data classified on the basis of different salesmen and also on the basis of sales in different regions. In a factory, the various units of a product produced during a certain period may be classified on the basis of different varieties of machines used and also on the basis of different grades of labour. Such a two-way design may have repeated measurements of each factor or may not have repeated values. The ANOVA technique is little different in case of repeated measurements where we also compute the interaction variation. We shall now explain the two-way ANOVA technique in the context of both said designs with the help of examples.

As we do not have repeated values, we cannot directly compute the sum of squares within samples as we had done in the case of one-way ANOVA. Therefore, we have to calculate this residual or error variation by subtraction, once we have calculated (just on the same lines as we did in the case of one-way ANOVA) the sum of squares for total variance and for variance between varieties of one treatment as also for variance between varieties of the other treatment.

The various steps involved are as follows:

(i) Use the coding device, if the same simplifies the task.

(ii) Taking the total of the values of individual items (or their coded values as the case may be) in all the samples and call it T.

(iii) Work out the correction factor as under:

$$\text{Correction factor} = \frac{T^2}{n}.$$

(iv) Find out the squares of all the item values (or their coded values as the case may be) one by one and then take their total. Subtract the correction factor from this total to obtain the sum of squares of deviations for total variance. Symbolically, we can write it as:

$$\text{Sum of squares of deviations for total variance or } SS \text{ total} = \left[\Sigma x_{ij}^2 - \frac{T^2}{n}\right].$$

(v) Take the total of different columns and then obtain the square of each column total and divide such squared values of each column by the no. of items in the concerning column and take the total of the result thus obtained. Finally, subtract the correction factor from this total to obtain the sum of squares of deviations for variance between columns or (SS between columns)

(vi) Take the total of different rows and then obtain the square of each row total and divide such squared values of each row by the no. of items in the corresponding row and take the total of the result thus obtained. Finally, subtract the correction factor from this total to obtain the sum of squares of deviations for variance between rows (or SS between rows).

NOTES

(vii) Sum of squares of deviations for residual or error variance can be worked out by subtracting the result of the sum of Step (v) and Step (vi) from the result of Step (iv) stated above. In other words,

[*SS* total – (*SS* between columns + *SS* between rows)]

= *SS* for residual or error variance.

(viii) Degrees of freedom (*df*) can be worked out as under:

df for total variance = $(cr - 1)$

df for variance between columns = $(c - 1)$

df for variance between rows = $(r - 1)$

df for residual variance = $(c - 1)(r - 1)$

where c = No. of columns

and r = No. of rows.

(ix) ANOVA table can be set up in the usual fashion as shown below:

Analysis of Variance Table for Two-way ANOVA

Source of Variation	Sum of squares (SS)	Degrees of freedom (d.f)	Mean square (MS)	F-ratio of
Between columns treatment	$\left[\Sigma \frac{T_j^2}{nj} - \frac{T^2}{n}\right]$ (= *SSC*)	$(c - 1)$	$\left\{\frac{SS \text{ between rows}}{(r-1)}\right\}$ i.e, $MSC = \frac{SSC}{(c-1)}$	$\left\{\frac{MS \text{ between columns}}{MS \text{ residual}}\right\}$ i.e., $\frac{MSC}{MSE}$
Between rows treatment	$\left[\Sigma \frac{T_i^2}{n_i} - \frac{T^2}{n}\right]$ (= *SSR*)	$(r - 1)$	$\left\{\frac{SS \text{ between rows}}{(r-1)}\right\}$ i.e., $MSR = \frac{SSR}{(r-1)}$	$\left\{\frac{MS \text{ between rows}}{MS \text{ residual}}\right\}$ i.e., $\frac{MSR}{MSE}$
Residual or Error	[*SS* total — *SS* between columns – SSB between rows] (= SSE)	$(c - 1) \times (r - 1)$	$\frac{SS \text{ residual}}{(c-1)(r-1)}$ i.e., *MSE* $= \frac{SSE}{(c-1)(r-1)}$	
Total	$\left[\Sigma x_{ij}^2 - \frac{T^2}{n}\right]$ (= *SST*)	$(c \cdot r - 1)$		

In the table, c = No. of columns

r = No. of rows

SS residual = [*SS* total – (*SS* between columns + *SS* between rows)]

Thus, *MS* residual or the residual variance provides the basis for the *F*-ratios concerning variation between columns treatment and between rows treatment. *MS* residual is always due to the fluctuations of sampling, and hence serves as the basis for the significance test. Both the *F*-ratios are compared with their corresponding table values, for given degrees of freedom at a specified level of significance, as usual and if it is found that the calculated *F*-ratio concerning variation between columns is equal to or greater than its table value, then the difference among column means is considered significant. Similarly, the *F*-ratio concerning variation between rows can be interpreted.

NOTES

6.4.2 Completely Randomized Design in a One-Way ANOVA

Completely randomized design involves the testing of the equality of means of two or more groups. In this design, there is one dependent variable and one independent variable. The dependent variable is metric (interval/ratio scale) whereas the independent variable is categorical (nominal scale). A sample is drawn at random from each category of the independent variable. The size of the sample from each category could be equal or different. Let us consider a few examples to illustrate a one-way analysis of variance.

Numericals

Example 6.16: Suppose we want to compare the cholesterol contents of the four competing diet foods on the basis of the following data (in milligrams per package) which were obtained for three randomly taken 6-ounce packages of each of the diet foods:

Diet Food A	3.6	4.1	4.0
Diet Food B	3.1	3.2	3.9
Diet Food C	3.2	3.5	3.5
Diet Food D	3.5	3.8	3.8

We want to test whether the difference among the sample means can be attributed to chance at the 5 per cent level of significance.

Solution: As explained earlier, the total variation in the data set can be expressed as a sum of the variations that can be attributed to specific sources (in this example, the various diet foods) plus the one which is attributed due to chance. The total variation in the data set is called the Total Sum of Squares (TSS) and is computed as:

$$\text{TSS} = \sum_{i=1}^{k}\sum_{j=1}^{n} x_{ij}^2 - \frac{1}{kn} \bullet T^2{\bullet\bullet}$$

Where, (i = 1, ... k and j = 1, 2,....n)

x_{ij} = the jth observation of the ith sample (diet food)

T•• = Grand total of all the data

k = 4 (Number of diet foods)

n = 3 (Number of observations in each sample)

The term $\frac{1}{kn} \bullet T^2{\bullet\bullet}$ is referred to as the correction factor. The variation between the sample means which is attributed to specific sources or causes is referred to as the Treatment Sum of Squares (TrSS). This is computed using the following formula:

$$TrSS = \frac{1}{n}\sum_{i=1}^{k} T_{i\bullet}^2 - \frac{1}{kn} \bullet T^2_{\bullet\bullet}$$

NOTES

Where, $T_{i\bullet}$ = Total of observations for the ith treatment.

The variation within the sample, which is attributed to chance, is referred to as the error sum of squares (SSE). This could be computed by subtracting the treatment sum of squares from the total sum of squares. This is shown as:

SSE = TSS – TrSS

$$= \left[\sum_{i=1}^{k}\sum_{j=1}^{n} x_{ij}^2 - \frac{1}{kn} \bullet T_{\bullet\bullet}^2\right] - \left[\frac{1}{n}\sum_{i=1}^{k} T_{i\bullet}^2 - \frac{1}{kn} \bullet T_{\bullet\bullet}^2\right]$$

In order to test the null hypothesis,

H_0 : $\mu A = \mu B = \mu C = \mu D$

against the alternative hypothesis

H_1 : At least two means are not equal

(Treatment means are not equal)

We test the equality of TrSS with SSE. The necessary workings required for this are presented in Table 6.6, which is called one-way analysis of the variance table. The first column of the table indicates the sources of variation. The second column lists the degrees of freedom. There are k treatments; therefore the corresponding degrees of freedom are k – 1. Similarly, the total number of observations in the data set is kn and therefore, the corresponding degrees of freedom are kn – 1. The degrees of freedom for errors are obtained by subtracting from the total degrees of freedom, the degrees of freedom corresponding to the treatment, i.e., (kn – 1) – (k – 1) = k (n – 1). The third column lists the sum of squares due to the various sources of variation. The fourth column lists the mean square due to treatment $\left(MSTr = \frac{TrSS}{k-1}\right)$ and the mean square due to error $\left(MSE = \frac{SSE}{k(n-1)}\right)$ obtaining by dividing the corresponding sum of squares by their degrees of freedom. The last column indicates the F statistic given as the ratio of the two mean squares with k – 1 degrees of freedom for the numerator and k (n – 1) degrees of freedom for the denominator. For a given level of significance, , the computed F statistic is compared with the table value of F with k – 1 degrees of freedom in the numerator and k (n – 1) degrees of the freedom for the denominator. If the computed F value is greater than the tabulated F value, the null hypothesis is rejected.

Table 6.6 *One-Way ANOVA.*

Sources of Variation	**Degrees of Freedom**	**Sum of Squares**	**Mean Square**	$F^{k-1}_{k(n-1)}$
Treatments (Diet food)	k – 1	TrSS	$MSTr = \frac{TrSS}{k-1}$	$\frac{MSTr}{MSE}$
Error	k (n – 1)	SSE	$MSE = \frac{SSE}{k(n-1)}$	
Total	kn – 1	TSS		

NOTES

The required computations in case of Example 6.16 are given below:

$T_{..}$	=	3.6 + 4.1 + 4.0 + 3.1 + 3.2 + 3.9 + 3.2 + 3.5 + 3.5 + 3.5 + 3.8 + 3.8	=	43.2
$T_{1.}$	=	3.6 + 4.1 + 4.0	=	11.7
$T_{2.}$	=	3.1 + 3.2 + 3.9	=	10.2
$T_{3.}$	=	3.2 + 3.5 + 3.5	=	10.2
$T_{4.}$	=	3.5 + 3.8 + 3.8	=	11.1
$\sum_{i=j}^{4}\sum_{j=1}^{3} x_{ij}^2$	=	$(3.6)^2 + (4.1)^2 + (4.0)^2 + (3.1)^2 + (3.2)^2 + (3.9)^2 + (3.2)^2 + (3.5)^2 + (3.5)^2 + (3.5)^2 + (3.8)^2 + (3.8)^2$	=	156.70

$$\text{TSS} = \sum_{i=j}^{4}\sum_{j=1}^{3} x_{ij}^2 - \frac{1}{kn} \bullet T_{..}^2 = 156.70 - \frac{1}{12}(43.2)^2 = 1.18$$

$$\text{TrSS} = \frac{1}{n}\sum_{i=1}^{4} T_{1.}^2 - \frac{1}{kn} \bullet T_{..}^2$$

$$= \frac{1}{3}[11.72 + 10.22 + 10.22 + 11.12] - \frac{1}{12}(43.2)2 = 0.54$$

$$\text{SSE} = \text{TSS} - \text{TrSS}$$

$$= 1.18 - 0.54 = 0.64$$

The above results corresponding to Example 6.16 could be set up in the ANOVA Table 6.7.

Table 6.7 *ANOVA Table for Example 6.16*

Sources of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F_{8}^{3}
Treatments (Diet Food)	3	0.54	0.18	2.25
Error	8	0.64	0.08	
Total	11	1.18		

Assuming the level of significance to be 5 per cent, the table value of F with 3 degrees of freedom in the numerator and 8 degrees of freedom in a denominator equals 4.07 (as per standard statistical table). Since the computed F is less than the tabulated F, there is not enough evidence to reject the null hypothesis. Therefore, the difference in the cholesterol contents in the four diet foods could be attributed to chance.

A mentioned earlier, the size of the sample from each category (treatment) need not be same. If there are ni observations corresponding to ith treatment, the computing formula for the sum of squares would look like:

$$\text{TSS} = \sum_{i=j}^{k}\sum_{j=1}^{n_i} x_{ij}^2 - \frac{1}{N} \bullet T_{..}^2$$

$$\text{TrSS} = \sum_{i=1}^{k} \frac{T_{1.}^2}{n_i} - \frac{1}{N} T_{..}^2$$

$$\text{SSE} = \text{TSS} - \text{TrSS}$$

Where, $N = n_1 + n_2 + \ldots + n_k$

NOTES

The total number of degrees of freedom in the case is $N - 1$, and the degrees of freedom are $k - 1$ for the treatments and $N - k$ for the error. Let us consider a few more examples.

Example 6.17: The following are the number of words per minute which a secretary typed on several occasions on three different typewriters.

Typewriter 1	71	78	70	69	77	72	65	69
Typewriter 2	74	76	72	70	69	68	72	73
Typewriter 3	70	72	66	64	63	67	69	70

Test whether the differences among the mean of the three samples (typewriters) can be attributed to chance. You may use a 5 per cent level of significance.

Solution:

H_0 : $\mu_1 = \mu_2 = \mu_3$ (the mean difference in the typing speed between the three typewriters can be attributed to chance.)

H_1 : At least two means are not equal

$K = 3, n = 8$

$T_{..}$	=	71 + 78 + 70 + 69 + 77 + 72 + 65 + 69 + 74 + 76 + 72 + 70 + 69 + 68 + 72 + 73 + 70 + 72 + 66 + 64 + 63 + 67 + 69 + 70	=	1686
$T_{1\bullet}$	=	71 + 78 + 70 + 69 + 77 + 72 + 65 + 69	=	571
$T_{2\bullet}$	=	74 + 76 + 72 + 70 + 69 + 68 + 72 + 73	=	574
$T_{3\bullet}$	=	70 + 72 + 66 + 64 + 63 + 67 + 69 + 70	=	541
$\sum_{i=j}^{3}\sum_{j=1}^{8} x_{ij}^2$	=	$(71)^2 + (78)^2 + (70)^2 + (69)^2 + (77)^2 + (72)^2 + (65)^2 + (69)^2 + (74)^2 + (76)^2 + (72)^2 + (70)^2 + (69)^2 + (68)^2 + (72)^2 + (73)^2 + (70)^2 + (72)^2 + (66)^2 + (64)^2 + (63)^2 + (67)^2 + (69)^2 + (70)^2$	=	118774

$$\text{TSS} = \sum_{i=j}^{3}\sum_{j=1}^{8} x_{ij}^2 - \frac{1}{kn} \bullet T_{..}^2$$

$$= [712 + 782 + \ldots\ldots 692 + 702] - \frac{1}{3 \times 8}(1686)2$$

$$= 118774 - 118441.5$$

$$= 332.5$$

$$\text{TrSS} = \frac{1}{n}\sum_{i=1}^{3} T_{1\bullet}^2 - \frac{1}{kn} \bullet T_{..}^2$$

$$= \frac{1}{8}[5712 + 5742 + 5412] - \frac{1}{3 \times 8}(1686)2$$

$$= 118524.8 - 118441.5$$

$$= 83.25$$

$$\text{SSE} = \text{TSS} - \text{TrSS}$$

$$= 332.5 - 83.25$$

$$= 249.25$$

NOTES

The one-way ANOVA table in the case of Example 6.17 can be set up as shown in Table 6.8.

***Table 6.8** One-Way ANOVA for Example 6.17*

Sources of Variation	**Degrees of Freedom**	**Sum of Squares**	**Mean Square**	F^2_{21}
Typewriter (Between groups)	2	83.25	41.625	3.507
Error (with groups)	21	249.25	11.869	
Total	23	332.50		

The computed value of F^2_{21} = 3.507. The table value of F^2_{21} with 5 per cent level of significance equals 3.47. As the computed F statistic is greater than the corresponding tabulated value, we reject the null hypothesis. Therefore, the difference in the average number of the words typed on the three typewriters cannot be attributed to chance.

Once the null hypothesis is rejected, it will be interesting to examine in which typewriter the number of words typed per minute is significantly higher compared to the other typewriter(s). This issue would be taken up later. Let us now, consider another example where the size of the sample from each treatment is different.

Example 6.18: The following are the number of kilometres/litre which a test driver with three different types of cars has obtained randomly on different occasions.

Car 1	15	14.5	14.8	14.9		
Car 2	13	12.5	13.6	13.8	14	
Car 3	12.8	13.2	12.7	12.6	12.9	13

Using a 5 per cent level of significance, perform a one-way ANOVA to examine the hypothesis that the difference in the average mileage in the three types of cars can be attributed to chance.

Solution:

H_0 : $\mu_1 = \mu_2 = \mu_3$ (Average mileage in the three types of cars is the same.)

H_1 : At least two types of cars do not have the same mileage.

$K = 3, n_1 = 4, n_2 = 5, n_3 = 6$

$N = n_1 + n_2 + n_3 = 4 + 5 + 6 = 15$

$T_{..}$	=	15 + 14.5 + 14.8 + 14.9 + 13 + 12.5 + 13.6 + 13.8 + 14 + 12.8 + 13.2 + 12.7 + 12.6 + 12.9 + 13	=	203.3
$T_{1.}$	=	15 + 14.5 + 14.8 + 14.9	=	59.2
$T_{2.}$	=	13 + 12.5 + 13.6 + 13.8 + 14	=	66.9
$T_{3.}$	=	12.8 + 13.2 + 12.7 + 12.6 + 12.9 + 13	=	77.2
$\sum_{i=j}^{3}\sum_{j=1}^{8} x_{ij}^2$	=	$(15)^2 + (14.5)^2 + (14.8)^2 + (14.9)^2 + (13)^2 + (12.5)^2 + (13.6)^2 + (13.8)^2 + (14)^2 + (12.8)^2 + (13.2)^2 + (12.7)^2 + (12.6)^2 + (12.9)^2 + (13)^2$	=	2766.49

NOTES

$$\text{TSS} = \sum_{i=1}^{3}\sum_{j=1}^{ni} x_{ij}^2 - \frac{1}{N} \bullet T_{..}^2$$

$$= 2766.49 - \frac{1}{15}\ (203.3)2$$

$$= 2766.49 - 2755.393$$

$$= 11.097$$

$$\text{TrSS} = \sum_{i=1}^{3}\frac{T_{i\bullet}^2}{n_i} - \frac{1}{N}T_{..}^2$$

$$= \left[\frac{59.2^2}{4} + \frac{66.9^2}{5} + \frac{77.2^2}{6}\right] - \frac{1}{15}(203.3)^2$$

$$= 2764.5886 - 2755.3926$$

$$= 9.196$$

$$\text{SSE} = \text{TSS} - \text{TrSS}$$

$$= 11.097 - 9.196$$

$$= 1.901$$

The ANOVA table in the case of Example 6.18 can be set up as shown in Table 6.19.

Table 6.9 *One-Way ANOVA for Example 6.18*

Sources of Variation	**Degrees of Freedom**	**Sum of Squares**	**Mean Square**	F_{12}^2
Treatments (Between groups)	2	9.196	4.598	29.02
Error (within groups)	12	1.901	0.158	
Total	14	11.097		

The computed F statistics equals 29.02. The table value of F with 2 degrees of freedom in the numerator and 12 degrees of freedom in the denominator at a 5 per cent level of significance is given by 3.89. As the computed F statistic is greater than the table F value, the null hypothesis is rejected. Therefore, the average mileage in these types of cars is statistically different. It would, therefore, be interesting to examine which car significantly gives a higher mileage than the other. This will be taken up in the next section.

6.4.3 Randomized Block Design in Two-Way ANOVA

In Example 6.18, it could not be shown that there really is a significant difference in the average cholesterol content of the four diet foods. The results were not statistically different because there was a considerable difference in the values within each of the samples resulting in a large experimental error. However, if we have additional information that each of the value was randomly measured in the three different laboratories in such a way that the first value of each sample came from laboratory 1, the second value from laboratory 2, and the third value from laboratory 3. (the random assignment of test units to labs) In such a case, a two way Analysis of variance is

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suggested. We had earlier partitioned the total sum of squares into two components—one which is due to the differences between the sample (treatment sum of squares) and the other one due to the differences within the samples (error sum of squares). Now, this error sum of square includes the sum of squares due to laboratories (called blocks) as an extraneous factor. In two way Analysis of variance, we remove the effect of the extraneous factors (laboratories or blocks) from the error sum of squares. Therefore, the total sum of square is partitioned into three components—one due to treatment, second due to block and the third one due to chance (called the error sum of squares). It may be noted that the Total Sum of Squares (TSS) and the Treatment Sum of Squares (TrSS) would remain the same as computed earlier in Example 6.18. In addition, we will have another component called Block Sum of Squares (SSB) which is due to different laboratories and is computed as:

$$SSB = \frac{1}{k} \bullet \sum_{j=1}^{n} T_{\bullet j}^2 - \frac{1}{kn} \bullet T_{\bullet\bullet}^2$$

Where, $T_{\bullet j}$ = Total of the values in the jth block.

The error sum of squares would be computed as:

SSE = TSS – TrSS – SSB

There will be two hypotheses to be tested:

I (Diet Food)

H_0 : $\mu_A = \mu_B = \mu_C = \mu_D$

H_1 : At least the two means are not same.

II (Blocks or Labs)

H_0 : $\nu_1 = \nu_2 = \nu_3$

(Average cholesterol content in the three labs is same.)

H_1 : At least two means are not same.

Now, we would need to test the equality of TrSS with SSE and SSB with SSE. The necessary working required for this are presented in Table 6.10 called Two-way Analysis of variance table.

Table 6.10 *Two-Way ANOVA*

Sources of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Treatments	k – 1	TrSS	$MSTr = \frac{TrSS}{k-1}$	$F^{k-1}_{(k-1)(n-1)} = \frac{MSTr}{MSE}$
Blocks	n – 1	SSB	$MSB = \frac{SSB}{n-1}$	$F^{n-1}_{(k-1)(n-1)} = \frac{MSB}{MSE}$
Error	(k – 1) (n – 1)	SSE	$MSE = \frac{SSE}{(k-1)(n-1)}$	
Total	kn – 1	TSS		

The various columns of the above table are filled up in the same fashion as was done for Table 6.16. Example 6.16 can be rewritten as Example 6.19.

Example 6.19: Suppose in Example 6.16, the measurement of the cholesterol content was performed in three different laboratories. The first value of each sample came from

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one laboratory, the second value came from another laboratory, and the third value came from a third laboratory. The data is presented below:

Diet Food	Laboratory		
	One	Two	Three
Diet Food A	3.6	4.1	4.0
Diet Food B	3.1	3.2	3.9
Diet Food C	3.2	3.5	3.5
Diet Food D	3.5	3.8	3.8

Perform a two-way ANOVA using a 0.05 level of significance.

Solution: There will be two hypotheses to be tested in this case; one corresponding to the treatment (diet food) and the other corresponding to laboratories (blocks). These are listed below:

I (Diet Food)

H_0 : $\mu_A = \mu_B = \mu_C = \mu_D$ (Average cholesterol content of the four diet foods is same.)

H_1 : At least two means are not same.

II (Blocks or labs)

H_0 : $\nu_1 = \nu_2 = \nu_3$ (Average cholesterol content in the three labs is same.)

H_1 : At least two means are not same.

The TSS and TrSS here would be the same as computed in Example 6.16. As mentioned earlier, the block sum of square would be required in this problem using the formula:

$$SSB = \frac{1}{k} \bullet \sum_{j=1}^{n} T_{\bullet j}^2 - \frac{1}{kn} \bullet T_{\bullet\bullet}^2$$

Where, $T_{\bullet j}$ = Total of the values in the *j*th block.

The error sum of squares would be obtained as:

SSE = TSS – TrSS – SSB

The required computations for the two-way ANOVA are as under:

$T_{\bullet 1}$ = 3.6 + 3.1 + 3.2 + 3.5 = 13.4

$T_{\bullet 2}$ = 4.1 + 3.2 + 3.5 + 3.8 = 14.6

$T_{\bullet 3}$ = 4.0 + 3.9 + 3.5 + 3.8 = 15.2

$$SSB = \frac{1}{k} \bullet \sum_{j=1}^{n} T_{\bullet j}^2 - \frac{1}{kn} \bullet T_{\bullet\bullet}^2$$

$$= \frac{1}{4} [13.42 + 14.62 + + 15.22] - \frac{1}{12} (43.2)2$$

= 155.94 – 155.52

= 0.42

We have already computed in Example 6.18, the values of TSS & TrSS as under:

TSS = 1.18, TrSS = 0.54

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Therefore, SSE = TSS – TrSS – SSB

= 1.18 – 0.54 – 0.42

= 0.22

We note that the SSE in Example 6.16 was 0.64, whereas here it is 0.22. This is because the earlier SSE has been partitioned into two components, namely, the block Sum of Squares (SSB) having a value of 0.42 resulting in 0.22 as the new error Sum of Squares (SSE). The required results for the testing of the two hypotheses are presented in the ANOVA Table 6.11.

Table 6.11 *Two-Way ANOVA Table for Example 6.21*

Sources of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Treatments (Diet Food)	3	0.54	0.18	$F_6^3 = \frac{0.18}{0.0367} = 4.90$
Block (Laborataries)	2	0.42	0.21	$F_6^2 = \frac{0.21}{0.0367} = 5.72$
Error (Chance)	6	0.22	0.0367	
Total	11	1.18		

The table value of F_6^3 and F_6^2 at a 5 per cent level of significance is given by 4.76 and 5.14, respectively. The corresponding sample F values for both are 4.90 and 5.72. Since the computed F values are greater than the corresponding table values, the null hypothesis is rejected in both the cases. Therefore, it can be concluded that there is a difference in the average cholesterol content due to various diet foods and because of the laboratories where the measurements were taken. Let us consider one more example.

Example 6.20: The following table presents the number of the defective pieces produced by three workmen operating in turn on three different machines:

	Machine 1	Machine 2	Machine 3
Workman 1	27	34	23
Workman 2	29	32	25
Workman 3	22	30	22

Conduct a two-way ANOVA to test at 5 per cent level of significance, whether:

(i) The difference among the means obtained for the three workmen can be attributed to chance.

(ii) The differences among the means obtained for the three machines can be attributed to chance.

Solution: The following two hypotheses are to be tested:

I (Workman)

H_0 : $\mu_1 = \mu_2 = \mu_3$ (Average numbers of the defectives produced by the three workmen are the same.)

H1 : At least two means are different.

II (Machines)

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H_0 : $\nu_1 = \nu_2 = \nu_3$ (Average numbers of the defectives produced by the three machines are the same.)

H_1 : At least two means are different.

Using the notations explained in this chapter, we may compute:

$T_{\bullet\bullet} = 27 + 34 + 23 + 29 + 32 + 25 + 22 + 30 + 22 = 244$

$T_{1\bullet} = 27 + 34 + 23 = 84$

$T_{2\bullet} = 29 + 32 + 25 = 86$

$T_{3\bullet} = 22 + 30 + 22 = 74$

$T_{\bullet 1} = 27 + 29 + 22 = 78$

$T_{\bullet 2} = 34 + 32 + 30 = 96$

$T_{\bullet 3} = 23 + 25 + 22 = 70$

$$\sum_{n}^{k}\sum_{j=1}^{n} x_{ij}^2 = (27)^2 + (34)^2 + (23)^2 + (29)^2 + (32)^2 + (25)^2 + (22)^2 + (30)^2 + (22)^2 = 6772$$

$$\text{TSS} = \sum_{n}^{k}\sum_{j=1}^{n} x_{ij}^2 - \frac{1}{kn} \bullet T_{\bullet\bullet}^2$$

$$= 6772 - \frac{1}{9}(244)2$$

$$= 6772 - 6615.111$$

$$= 156.889$$

$$\text{TrSS} = \frac{1}{n}\sum_{i=1}^{k} T_{i\bullet}^2 - \frac{1}{kn} \bullet T_{\bullet\bullet}^2$$

$$= \frac{1}{3}[842 + 862 + 742] - \frac{1}{9}(244)2$$

$$= \frac{19928}{3} - 6615.111$$

$$= 27.556$$

$$\text{SSB} = \frac{1}{k}\sum_{j-1}^{n} T_{\bullet j}^2 - \frac{1}{kn} \bullet T_{\bullet\bullet}^2$$

$$= \frac{1}{3}[782 + 962 + 702] - \frac{1}{9}(244)2$$

$$= 6733.333 - 6615.111$$

$$= 118.222$$

$$\text{SSE} = \text{TSS} - \text{TrSS} - \text{SSB}$$

$$= 156.889 - 27.556 - 118.22$$

$$= 11.111$$

To test the two hypotheses, the results can be summarized in the form of a two-way ANOVA as shown in Table 6.12.

Table 6.12 *Results of Two-Way ANOVA*

Sources of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Treatments (Workmen)	2	27.556	13.778	$F^2_4 = 4.96$
Block (Machines)	2	118.222	59.111	$F^2_4 = 21.28$
Error	4	11.111	2.778	
Total	8	156.889		

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The table value of F with 2 degrees of freedom at the numerator and 4 in the denominator equals 6.94. The computed values of F^2_4 are 4.96 and 21.28 for the 1st and the 2nd hypothesis, respectively. Therefore, there is not enough evidence to reject the null hypothesis in the first case whereas it is rejected for the 2nd case. This means that there is no difference in the average number of the defectives produced by three workmen, whereas there is a significant difference in the average number of the defectives produced by the three machines. Thus, it can be concluded that the efficiency of the three machines to produce good items is different.

6.5 PARAMETRIC AND NON-PARAMETRIC TESTS

The population mean (μ), standard deviation (σ) and proportion (p) are called the parameters of a distribution. These tests were based on the assumption that the population(s) from where the sample is drawn is normally distributed. The test on the parameters like mean, standard deviation and proportion are called parametric tests.

However, there are situations where the populations under study are not normally distributed. The data collected from these populations is extremely skewed. In such a situation, an option could be used to increase the sample size. This is because the central limit theorem assumes that the distribution of sample estimates approximately has a normal distribution for large samples; whatever the shape of the population distribution. The other option is to use a Non-parametric test. These tests are called the distribution-free tests as they do not require any assumption regarding the shape of the population distribution from where the sample is drawn. However, some non-parametric tests do depend on a parameter such as median but they do not require a particular distribution for their application. These tests could also be used for the small sample sizes where the normality assumption does not hold true.

6.5.1 Advantages and Disadvantages of Non-Parametric Tests

There are many advantages of a non-parametric test. These are:

- They can be applied to many situations as they do not have the rigid requirements of their parametric counterparts, like the sample having been drawn from the population following a normal distribution. A researcher can encounter an application where a numeric observation is difficult to obtain but a rank value is not. For example, it is easy to obtain the rank data on the preference of consumer for the various brands of toothpaste rather than assigning a numerical value to them. By using ranks, it is possible to relax the assumptions regarding the underlying populations.

Check Your Progress

3. What does the ANOVA technique investigate?
4. What does completely randomized design involve?

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- Non-parametric tests can often be applied to the nominal and ordinal data that lack exact or comparable numerical values. For example, the respondents may be asked a question on their religion—Hindu, Sikh, Christian or Muslim. This is a nominal scale data and can only be analysed by non-parametric methods.
- Non-parametric tests involve very simple computations compared to the corresponding parametric tests.

However, the methods are not without their own drawbacks and there are certain disadvantages of non-parametric tests. These are:

- A lot of information is wasted because the exact numerical data is reduced to a qualitative form. For example, in one of the non-parametric tests like the sign test, the increase or the gain is denoted by a plus sign whereas a decrease or loss is denoted by a negative sign. No consideration is given to the quantity of the gain or loss. A gain of ₹ 1 or ₹ 1 lakh would both receive a plus sign.
- Non-parametric methods are less powerful than parametric tests when the basic assumptions of parametric tests are valid. Therefore, there is more risk of accepting a false hypothesis and thus committing a type II error.
- Null hypothesis in a non-parametric test is loosely defined as compared to the parametric tests. Therefore, whenever the null hypothesis is rejected, a non-parametric test yields a less precise conclusion as compared to the parametric test. For example, corresponding to the null hypothesis that the means of the two populations are equal in the parametric test, the null hypothesis in a non-parametric test is that the two populations have same probability distributions. In such a situation, rejecting a null hypothesis under the parametric test would imply that the means of the two populations are different whereas under a non- parametric test, it means that the two population distributions are different but the specific form of the difference between the two populations is not clearly defined.

In the following sections, we will discuss non-parametric tests such as chi-square, run test, sign test, the Mann-Whitney U test, the Wilcoxon matched-pair rank test and the Kruskal–Wallis test. The differences between parametric and non-parametric tests are summarized below.

	Parametric Tests	**Non-Parametric Tests**
Assumptions:	Normality assumption is required.	Normality assumption is not required.
	Uses the metric data.	Ordinal or interval scale data is used.
	Can be applied for both small and large samples.	Can be applied for small samples.
Applications:	One sample using Z or t statistics.	One sample using the sign test.
	Two independent samples using a t or z test.	Two independent samples using the Mann-Whitney U statistics.
	Two paired samples using a t or z test.	Two paired samples using the sign test and Wilcoxon matched pair rank test.
	Randomness – no test in parametric is available.	Randomness – using runs test.
	Several independent samples using F test in ANOVA.	Several independent samples using Kruskal–Wallis test.

6.5.2 Chi-Square Tests

For the use of a chi-square test, the data is required in the form of frequencies. The data expressed in percentages or proportion can also be used, provided it could be converted

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into frequencies. The majority of the applications of chi-square (χ^2) are with the discrete data. The test could also be applied to continuous data, provided it is reduced to certain categories and tabulated in such a way that the chi-square may be applied.

Some of the important properties of the chi-square distribution are:

- Unlike the normal and t distribution, the chi-square distribution is not symmetric (see Figure 6.3).

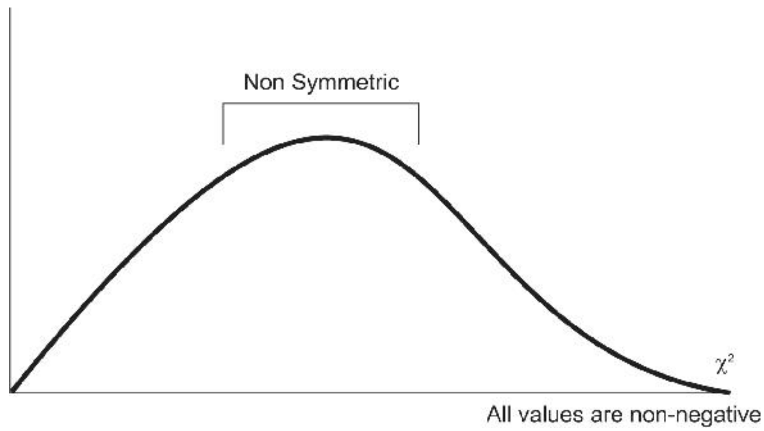


Fig. 6.3 *Shape of Chi-Square (¡^{2}) Distribution*

- The values of a chi-square are greater than or equal to zero.
- The shape of a chi-square distribution depends upon the degrees of freedom. With the increase in degrees of freedom, the distribution tends to normal (see Figure 6.4).

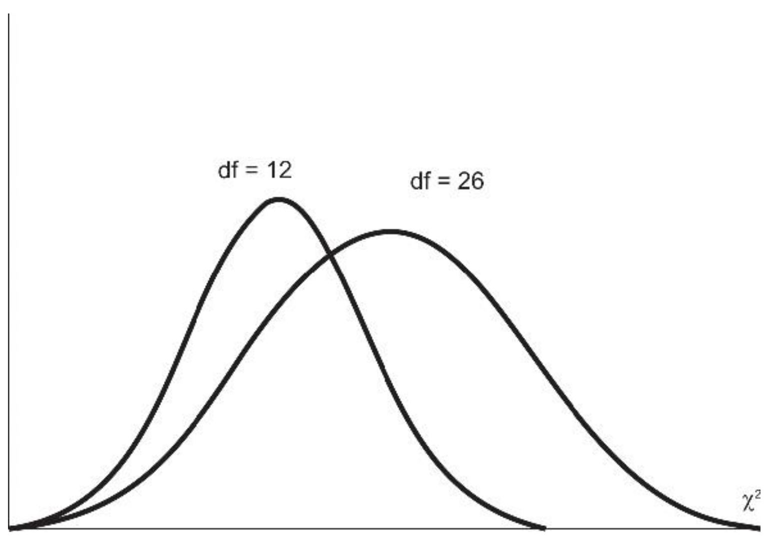


Fig. 6.4 *Shape of Chi-Square Distribution with Varying Degrees of Freedom*

Application of Chi-Square

There are many applications of a chi-square test. Some of them are explained below:

- A chi-square test for the goodness of fit.
- A chi-square test for the independence of variables.
- A chi-square test for the equality of more than two population proportions.

A Chi-Square Test for the Goodness of Fit

As discussed before, the data in chi-square tests is often in terms of counts or frequencies. The actual survey data may be on a nominal or higher scale of measurement. If it is on a higher scale of measurement, it can always be converted into categories. The real world situations in business allow for the collection of count data, e.g., gender, marital status, job classification, age and income. Therefore, a chi-square becomes a much sought after tool for analysis. The researcher has to decide what statistical test is implied by the chi-square statistic in a particular situation. Below are discussed common principles of all the chi-square tests. The principles are summarized in the following steps:

- State the null and the alternative hypothesis about a population.
- Specify a level of significance.
- Compute the expected frequencies of the occurrence of certain events under the assumption that the null hypothesis is true.
- Make a note of the observed counts of the data points falling in different cells
- Compute the chi-square value given by the formula.

$$\chi^2_{k-1} = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$$

Where,

O_i = Observed frequency of ith cell

E_i = Expected frequency of ith cell

k = Total number of cells

k–1 = degrees of freedom

- Compare the sample value of the statistic as obtained in previous step with the critical value at a given level of significance and make the decision.

A goodness of fit test is a statistical test of how well the observed data supports the assumption about the distribution of a population. The test also examines that how well an assumed distribution fits the data. Many a times, the researcher assumes that the sample is drawn from a normal or any other distribution of interest. A test of how normal or any other distribution fits a given data may be of some interest.

Consider for example the case of the multinomial experiment which is the extension of a binomial experiment. In the multinomial experiment, the number of the categories k is greater than 2. Further, a data point can fall into one of the k categories and the probability of the data point falling in the ith category is a constant and is denoted by p_i where i = 1, 2, 3, 4, ..., k. In summary, a multinomial experiment has the following features:

- There are fixed number of trials.
- The trials are statistically independent.
- All the possible outcomes of a trial get classified into one of the several categories.
- The probabilities for the different categories remain constant for each trial.

Consider as an example that a respondent can fall into any one of the four non-overlapping income categories. Let the probabilities that the respondent will fall into any of the four groups may be denoted by the four parameters p_1, p_2, p_3 and p_4. Given these, the multinomial distribution with these parameters, and n the number of people in a random sample, specifies the probabilities of any combination of the cell counts.

Given such a situation, we may use a multinomial distribution to test how well the data fits the assumption of k probability $p_1, p_2, ..., p_k$ of falling into the k cells. The hypothesis to be tested is:

H_0 : Probabilities of the occurrence of events $E_1, E_2, ..., E_k$ are given by the specified probabilities $p_1, p_2, ..., p_k$

H_1 : Probabilities of the k events are not the p_i stated in the null hypothesis.

Such hypothesis could be tested using the chi-square statistics. Below are given a set of illustrated examples.

Example 6.21: The manager of ABC ice-cream parlour has to take a decision regarding how much of each flavour of ice cream he should stock so that the demands of the customers are satisfied. The ice cream suppliers claim that among the four most popular flavors, 62 per cent customers prefer vanilla, 18 per cent chocolate, 12 per cent strawberry and 8 per cent mango. A random sample of 200 customers produces the results below. At the $\alpha = 0.05$ significance level, test the claim that the percentages given by the suppliers are correct.

Flavour	Vanilla	Chocolate	Strawberry	Mango
Number preferring	120	40	18	22

Solution:

Let

p_v : Proportion of customers preferring vanilla flavour.

p_c : Proportion of customers preferring chocolate flavour.

p_s : Proportion of customers preferring strawberry flavour.

p_m : Proportion of customers preferring mango flavour.

H_0 : $p_v = 0.62, p_c = 0.18, p_s = 0.12, p_m = 0.08$

H_1 : Proportions are not that specified in the null hypothesis.

The expected frequencies corresponding to the various flavors under the assumption that the null hypothesis is true are:

Vanilla = $200 \times 0.62 = 124$

Chocolate = $200 \times 0.18 = 36$

Strawberry = $200 \times 0.12 = 24$

Mango = $200 \times 0.08 = 16$

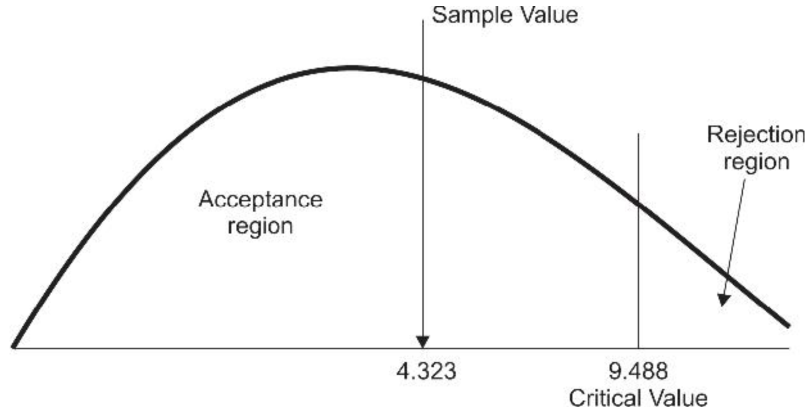
The computations for χ_3^2 are as under: $\sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$

Flavour	**O (Observed Frequencies)**	**E (Expected Frequencies)**	**O – E**	**$(O – E)^2$**	**$\frac{(O - E)^2}{E}$**
Vanilla	120	124	– 4	16	0.129
Chocolate	40	36	4	16	0.444
Strawberry	18	24	– 6	36	1.500
Mango	22	16	6	36	2.250
				Total	**4.323**

NOTES

The computed value of chi-square is 4.323.

Table χ^2_3 (5 per cent) = 9.488 (as per standard statistical table).



Rejection Region for Example 6.23

As sample χ^2 lies in the acceptance region, accept H_0. Therefore, the customer preference rates are as stated. Using the p value approach, we find that the sample χ^2 value lies as shown below:

χ^2 with 3 d.f.	11.345	7.815	6.251	↓
Level of significance	1 per cent	5 per cent	10 per cent	4.323 (sample χ^2)

It is seen that the sample χ^2 corresponds to a p value greater than 10 per cent. Therefore, there is not enough evidence to reject the null hypothesis. This means that the customer preference rates are as stated in the null hypothesis.

It may be worth pointing out that for the application of a chi-square test, the expected frequency in each cell should be at least 5.0. In case it is found that one or more cells have the expected frequency less than 5, one could still carry out the chi-square analysis by combining them into meaningful cells so that the expected number has a total of at least 5. Another point worth mentioning is that the degree of freedom, usually denoted by *df* in such cases, is given by k – 1, where k denotes the number of cells (categories).

It may be noted that in Example 6.23, the hypothesized probabilities were not equal. There are situations where the hypothesized probabilities in each category are equal or in other words, the interest is in investigating the uniformity of the distribution. The following example would illustrate it.

Example 6.22: An insurance company provides auto insurance and is analysing the data obtained from fatal crashes. A sample of the motor vehicle deaths is randomly selected for a two-year period. The number of fatalities is listed below for the different days of the week. At the 0.05 significance level, test the claim that accidents occur on different days with equal frequency.

Day	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Number of fatalities	31	20	20	22	22	29	36

NOTES

Solution:

Let

p_1 = Proportion of fatalities on Monday

p_2 = Proportion of fatalities on Tuesday

p_3 = Proportion of fatalities on Wednesday

p_4 = Proportion of fatalities on Thursday

p_5 = Proportion of fatalities on Friday

p_6 = Proportion of fatalities on Saturday

p_7 = Proportion of fatalities on Sunday

H_0 : $p_1 = p_2 = p_3 = p_4 = p_5 = p_6 = p_7 = \frac{1}{7}$

H_1 : At least one of these proportions is incorrect.

n = Total frequency = 31 + 20 + 20 + 22 + 22 + 29 + 36 = 180

The expected number of fatalities on each day of the week under the assumption that the null hypothesis is true is given as under:

Monday = 180 × = 25.714

Tuesday = 180 × = 25.714

Wednesday = 180 × = 25.714

Thursday = 180 × = 25.714

Friday = 180 × = 25.714

Saturday = 180 × = 25.714

Sunday = 180 × = 25.714

The computation of sample chi-square value is given in the following table:

Day	Observed Frequencies (O)	Expected Frequencies (E)	O – E	$(O - E)^2$	$\frac{(O-E)^2}{E}$
Monday	31	25.714	5.286	27.942	1.087
Tuesday	20	25.714	– 5.714	32.650	1.270
Wednesday	20	25.714	– 5.714	32.650	1.270
Thursday	22	25.714	– 3.714	13.794	0.536
Friday	22	25.714	– 3.714	13.794	0.536
Saturday	29	25.714	3.286	10.798	0.420
Sunday	36	25.714	10.286	105.802	4.114
				Total	**9.233**

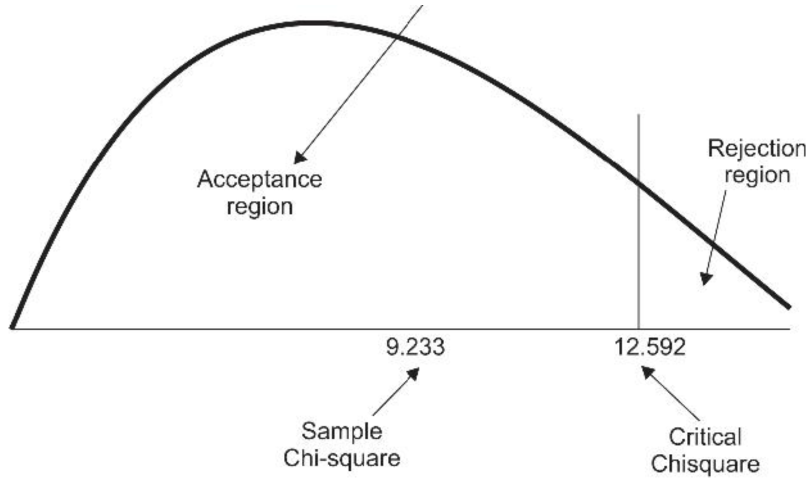
The value of sample $\chi^2 = \Sigma \frac{(O-E)^2}{E} = 9.233$

Degrees of freedom = 7 – 1 = 6

Critical (Table) $\chi_6^2 = 12.592$

NOTES

Since the sample chi-square value is less than the tabulated χ^2, there is not enough evidence to reject the null hypothesis as shown in the figure below.



Rejection Region for Example 6.24

The problem can also be worked out using the p-value approach. The sample value of $\chi^2 = 9.233$ with 6 df is less than the critical value 10.645, which corresponds to an area of 10 per cent. Therefore, the p value in this problem is greater than 10 per cent, which is higher than the level of significance $\alpha = 0.05$. Therefore, the null hypothesis is accepted. This means that the accidents occur on different days with equal frequencies.

A Chi-Square Test for Independence of Variables

The chi-square test can be used to test the independence of two variables each having at least two categories. The test makes a use of contingency tables also referred to as cross-tabs with the cells corresponding to a cross classification of attributes or events. Layout of contingency table given below.

Second Classification Category	**First Classification Category**				
	1	**2**	**3**	**4**	**Total**
1	O_{11}	O_{12}	O_{13}	O_{14}	R_1
2	O_{21}	O_{22}	O_{23}	O_{24}	R_2
3	O_{31}	O_{32}	O_{33}	O_{34}	R_3
Total	C_1	C_2	C_3	C_4	n

Assuming that there are r rows and c columns, the count in the cell corresponding to the ith row and the jth column is denoted by O_{ij}, where i = 1, 2, ..., r and j = 1, 2, ..., c. The total for row i is denoted by R_i whereas that corresponding to column j is denoted by C_j. The total sample size is given by n, which is also the sum of all the r row totals or the sum of all the c column totals.

The hypothesis test for independence is:

H_0 : Row and column variables are independent of each other.

H_1 : Row and column variables are not independent.

The hypothesis is tested using a chi-square test statistic for independence given by:

$$\chi^2 = \sum_{i=1}^{r}\sum_{j=1}^{c}\frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

The degrees of freedom for the chi-square statistic are given by (r – 1) (c – 1).

For a given level of significance α, the sample value of the chi-square is compared with the critical value for the degree of freedom (r – 1) (c – 1) to make a decision.

The expected frequency in the cell corresponding to the i^{th} row and the j^{th} column is given by:

$$E_{ij} = \frac{R_i \times C_j}{n}$$

Where, R_i = Total for the ith row

C_j = Total for the jth column

n = Total sample size.

Let us consider a few examples:

Example 6.23: A sample of 870 trainees was subjected to different types of training classified as intensive, good and average and their performance was noted as above average, average and poor. The resulting data is presented in the table below. Use a 5 per cent level of significance to examine whether there is any relationship between the type of training and performance.

Performance	Training			
	Intensive	**Good**	**Average**	**Total**
Above average	100	150	40	290
Average	100	100	100	300
Poor	50	80	150	280
Total	250	330	290	870

Solution:

H_0 : Attribute performance and the training are independent.

H_1 : Attribute performance and the training are not independent.

The expected frequencies corresponding the *i*th row and the *j*th column in the contingency table are denoted by E_{ij}, where i = 1, 2, 3 and j = 1, 2, 3.

$$E_{1,1} = \frac{290 \times 250}{870} = 83.33$$

$$E_{1,2} = \frac{290 \times 330}{870} = 110.00$$

$$E_{1,3} = \frac{290 \times 290}{870} = 96.67$$

$$E_{2,1} = \frac{300 \times 250}{870} = 86.21$$

$$E_{2,2} = \frac{300 \times 330}{870} = 113.79$$

$$E_{2,3} = \frac{300 \times 290}{870} = 100.00$$

NOTES

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$$E_{3,1} = \frac{280 \times 250}{870} = 80.46$$

$$E_{3,2} = \frac{280 \times 330}{870} = 106.21$$

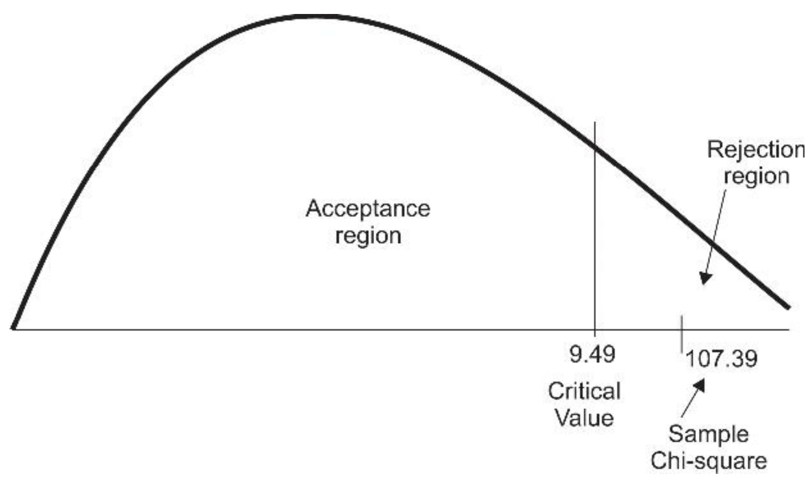
$$E_{3,3} = \frac{280 \times 290}{870} = 93.33$$

The table of the observed and expected frequencies corresponding to the *i*th row and the *j*th column and the computation of the chi-square is given in the table.

Row, Column	O_{ij}	E_{ij}	$(O_{ij} - E_{ij})^2$	$\frac{(O_{ij} - E_{ij})^2}{E_{ij}}$
1,1	100	83.33	277.89	3.335
1,2	150	110.00	1600.00	14.545
1,3	40	96.67	3211.49	33.221
2,1	100	86.21	190.16	2.21
2,2	100	113.79	190.16	1.671
2,3	100	100.00	0	0.000
3,1	50	80.46	927.81	11.53
3,2	80	106.21	686.96	6.468
3,3	150	93.33	3211.49	34.41
			Total	**107.39**

$$\text{Sample } \chi^2 = \sum_{i=1}^{r}\sum_{j=1}^{c}\frac{(O_{ij} - E_{ij})^2}{E_{ij}} = 107.39$$

The critical value of the chi-square at 5 per cent level of significance with 4 degrees of freedom is given by 9.49. The sample value of the chi-square falls in the rejection region as shown in the figure below.



Rejection Region for Example 6.23

Therefore, the null hypothesis is rejected and one can conclude that there is an association between the type of training and performance.

Using a p value approach, it can be seen that the computed value of chi-square (107.39) with 4 df is higher than the critical value (13.28) at 1 per cent level of significance. Therefore, the p value of this problem is less than 0.01 which is far below the level of significance. Therefore, the null hypothesis is rejected. This means that there is a relationship between the type of training and the performance.

Example 6.24: The following table gives the number of good and defective parts produced by each of the three shifts in a factory:

Shift	Good	Defective	Total
Day	900	130	1030
Evening	700	170	870
Night	400	200	600
Total	2000	500	2500

Is there any association between the shift and the equality of the parts produced? Use a 0.05 level of significance.

Solution:

H_0 : There is no association between the shift and the quality of parts produced.

H_1 : There is an association between the shift and quality of parts.

The computations of the expected frequencies corresponding to the *i*th row and the jth column of the contingency table are shown below: (i = 1, 2, 3) and (j = 1, 2).

$$E_{1,1} = \frac{1030 \times 2000}{2500} = 824$$

$$E_{1,2} = \frac{1030 \times 500}{2500} = 206$$

$$E_{2,1} = \frac{870 \times 2000}{2500} = 696$$

$$E_{2,2} = \frac{870 \times 500}{2500} = 174$$

$$E_{3,1} = \frac{600 \times 2000}{2500} = 480$$

$$E_{3,2} = \frac{600 \times 500}{2500} = 120$$

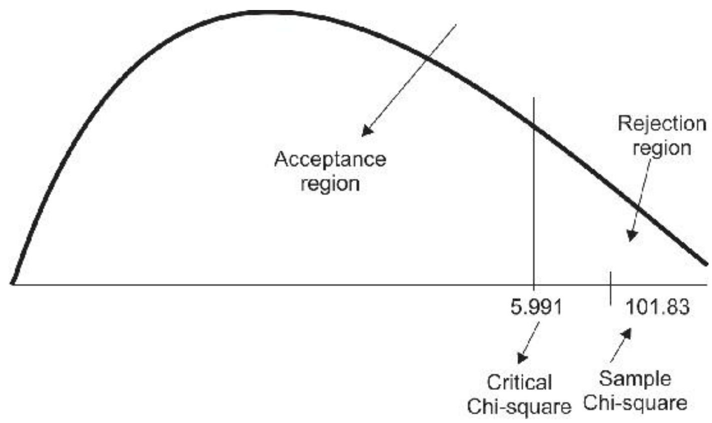
The table of the observed and expected frequencies corresponding to the *i*th row and the *j*th column and the computation of the chi-square is given below:

NOTES

Row, Column	O_{ij}	E_{ij}	$(O_{ij} - E_{ij})^2$	$\frac{(O_{ij} - E_{ij})^2}{E_{ij}}$
1,1	900	824	5776	7.010
1,2	130	206	5776	28.039
2,1	700	696	16	0.023
2,2	170	174	16	0.092
3,1	400	480	6400	13.333
3,2	200	120	6400	53.333
			Total	**101.83**

The sample chi-square is $\chi^2 = \sum_{i=1}^{3}\sum_{j=1}^{2}\frac{(O_{ij} - E_{ij})^2}{E_{ij}} = 101.83$

The critical value of the chi-square with 2 degrees of freedom at 5 per cent level of significance is given by 5.991. The null hypothesis is rejected as the sample chi-square lies in the rejection region as shown in the figure below. Therefore, the quality of parts produced is related to the shifts in which they were produced.



Rejection Region for Example 6.24

Using a p value approach, the same decision would be arrived at. It is left for the readers to show it.

It may be worth mentioning again that for the application of a chi-square test of independence, the sample should be selected at random and the expected frequency in each cell should be at least 5.

A chi-square test for the equality of more than two population proportions

In certain situations, the researchers may be interested to test whether the proportion of a particular characteristic is the same in several populations. The interest may lie in finding out whether the proportion of people liking a movie is the same for the three age groups, 25 and under, over 25 and under 50, and 50 and over. To take another example, the interest may be in determining whether in an organization, the proportion of the satisfied employees in four categories—Class I, Class II, Class III and Class IV employees—is the same. In a sense, the question of whether the proportions are equal is a question of whether the three age populations of different categories are homogeneous with respect to the characteristics being studied. Therefore, the tests for equality of proportions across several populations are also called tests of homogeneity.

NOTES

The analysis is carried out exactly in the same way as was done for the other two cases. The formula for a chi-square analysis remains the same. However, two important assumptions here are different.

(i) We identify our population (e.g., age groups or various class employees) and the sample directly from these populations.

(ii) As we identify the populations of interest and the sample from them directly, the sizes of the sample from different populations of interest are fixed. This is also called a chi-square analysis with fixed marginal totals. The hypothesis to be tested is as under:

H_0 : The proportion of people satisfying a particular characteristic is the same in population.

H_1 : The proportion of people satisfying a particular characteristic is not the same in all populations.

The expected frequency for each cell could also be obtained by using the formula as explained early. There is an alternative way of computing the same, which would give identical results. This is shown in the following example:

Example 6.25: An accountant wants to test the hypothesis that the proportion of incorrect transactions at four client accounts is about the same. A random sample of 80 transactions of one client reveals that 21 are incorrect; for the second client, the number is 25 out of 100; for the third client, the number is 30 out of 90 sampled and for the fourth, 40 are incorrect out of a sample of 110. Conduct the test at $\alpha = 0.05$.

Solution:

Let

p_1 = Proportion of incorrect transaction for 1st client

p_2 = Proportion of incorrect transaction for 2nd client

p_3 = Proportion of incorrect transaction for 3rd client

p_4 = Proportion of incorrect transaction for 4th client

Let

H_0 : $p_1 = p_2 = p_3 = p_4$

H_1 : All proportions are not the same.

The observed data in the problem can be rewritten as:

Transactions	**Client 1**	**Client 2**	**Client 3**	**Client 4**	**Total**
Incorrect transactions	21	25	30	40	116
Correct transactions	59	75	60	70	264
Total	80	100	90	110	380

An estimate of the combined proportion of the incorrect transactions under the assumption that the null hypothesis is true:

$$p = \frac{21+25+30+40}{80+100+90+110} = \frac{116}{380} = 0.305$$

q = Combined proportion of the correct transaction

$= 1 - p = 1 - 0.305 = 0.695$

NOTES

Using the above, the expected frequencies corresponding to the various cells are computed as shown below:

Transactions	Client 1	Client 2	Client 3	Client 4	Total
Incorrect transactions	80 × 0.305 = 24.4	100 × 0.305 = 30.5	90 × 0.305 = 27.45	110 × 0.305 = 33.55	115.9
Correct transactions	80 × 0.695 = 55.6	100 × 0.695 = 69.5	90 × 0.695 = 62.55	110 × 0.695 = 76.45	264.1
Total	80	100	90	110	380

In fact, the sum of each row/column in both the observed and expected frequency tables should be the same. Here, a bit of discrepancy is found because of the rounding of the error. It can be easily verified that the expected frequencies in each cell would be the same using the formula $E_{ij} = \frac{R_i \times C_j}{n}$ as already explained. Now the value of the chi-square statistic can be calculated as:

$$\chi^2 = \sum_{i=1}^{2}\sum_{j=1}^{4}\frac{(O_{ij}-E_{ij})^2}{E_{ij}} = \frac{(21-24.4)^2}{24.4} + \frac{(25-30.5)^2}{30.5} + \frac{(30-27.45)^2}{27.45} + \frac{(40-33.55)^2}{33.55}$$

$$+\frac{(59-55.6)^2}{55.6} + \frac{(75-69.5)^2}{69.5} + \frac{(60-62.55)^2}{62.55} + \frac{(70-76.45)^2}{76.45}$$

$$= 0.474 + 0.992 + 0.237 + 1.240 + 0.208 + 0.435 + 0.104 + 0.544$$

$$= 4.234$$

Degrees of freedom (df) = (2 – 1) × (4 – 1) = 3

The critical value of the chi-square with 3 degrees of freedom at 5 per cent level of significance equals 7.815. Since the sample value of χ^2 is less than the critical value, there is not enough evidence to reject the null hypothesis. Therefore, the null hypothesis is accepted. Therefore, there is no significant difference in the proportion of incorrect transaction for the four clients.

6.6 SUMMARY

- A hypothesis is an assumption or a statement that may or may not be true. The hypothesis is tested on the basis of information obtained from a sample. Hypothesis tests are widely used in business and industry for making decisions.
- First step is to establish the hypothesis to be tested. As it is known, these statistical hypotheses are generally assumptions about the value of the population parameter; the hypothesis specifies a single value or a range of values for two different hypotheses rather than constructing a single hypothesis.
- The null hypothesis is the hypothesis of the population parameter taking a specified value. In case of two populations, the null hypothesis is of no difference or the difference taking a specified value.
- The hypothesis that is different from the null hypothesis is the alternative hypothesis. If the null hypothesis H_0 is rejected based upon the sample information, the alternative hypothesis H_1 is accepted.
- The hypothesis may be rejected or accepted depending upon whether the value of the test statistic falls in the rejection or the acceptance region. Management

Check Your Progress

5. What are the parameters of distribution?
6. What are parametric tests?

NOTES

decisions are based upon the statistical decision of either rejecting or accepting the null hypothesis.

- The use of dependent sample enables us to perform a more precise analysis as it allows the controlling of extraneous variables. The difference is that we convert the problem from two samples to a one-sample problem.
- The technique of ANOVA becomes handy as it helps to compare the differences among the means of all the populations simultaneously.
- R.A. Fisher developed the theory concerning ANOVA. The basic principle underlying the technique is that the total variation in the dependent variable is broken into two parts—one which can be attributed to some specific causes and the other that may be attributed to chance.
- The one which is attributed to the specific causes is called the variation between samples and the one which is attributed to chance is termed as the variation within samples.
- In general, the ANOVA techniques investigate any number of factors which are supposed to influence the dependent variable of interest. It is also possible to investigate the differences in various categories within each of these factors.
- In ANOVA, the dependent variable in question is metric (interval or ratio scale), whereas the independent variables are categorical (nominal scale).
- In ANOVA, it is assumed that each of the samples is drawn from a normal population and each of these populations has an equal variance. Another assumption that is made is that all the factors except the one being tested are controlled (kept constant).
- Completely randomized design involves the testing of the equality of means of two or more groups. In this design, there is one dependent variable and one independent variable.
- The population means (μ), standard deviation (σ) and proportion (p) are called the parameters of a distribution. These tests were based on the assumption that the population(s) from where the sample is drawn is normally distributed. The test on the parameters like mean, standard deviation and proportion are called parametric tests.
- Non-parametric tests can often be applied to the nominal and ordinal data that lack exact or comparable numerical values.
- The majority of the applications of chi-square (χ^2) are with the discrete data. The test could also be applied to continuous data, provided it is reduced to certain categories and tabulated in such a way that the chi-square may be applied.

6.7 KEY TERMS

- **Null hypothesis:** The hypotheses that are proposed with the intent of receiving a rejection for them are called null hypotheses
- **Alternative hypotheses:** Rejection of null hypotheses leads to the acceptance of alternative hypotheses
- **One-tailed and two-tailed tests:** A test is called one-sided (or one-tailed) only if the null hypothesis gets rejected when a value of the test statistic falls in one specified tail of the distribution

6.8 ANSWERS TO 'CHECK YOUR PROGRESS'

NOTES

1. A hypothesis is an assumption or a statement that may or may not be true.
2. The basis of hypothesis testing is the information obtained from a sample.
3. The ANOVA technique investigates any number of factors which are supposed to influence the dependent variable of interest.
4. The completely randomized design involves the testing of the equality of means of two or more groups.
5. The population means (μ), standard deviation (σ) and proportion (p) are known as the parameters of distribution.
6. The tests on the parameters, like mean, standard deviation and proportion are called parametric tests.

6.9 QUESTIONS AND EXERCISES

Short-Answer Questions

1. What is null hypothesis?
2. What is probability approach?
3. Name the fields where ANOVA technique is used.

Long-Answer Questions

1. What is hypothesis? Describe the steps that are followed in testing of a hypothesis.
2. Explain the one-way and two-way ANOVA techniques.
3. Discuss the advantages and disadvantages of parametric and non-parametric tests.

6.10 FURTHER READING

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Saunders, Mark, Adrian Thornhill and Philip Lewis. 2009. *Research Methods for Business Students*, 5th edition. New Jersey: Pearson Education.

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UNIT 7 REPORT WRITING

NOTES

Structure

7.0 INTRODUCTION

In this unit, you will learn about the various methods of report writing. A research study is a tedious task and calls for exhaustive investigation on the part of the researcher. This quite often leads to accumulation of bulk data obtained from the research study. Even if the concerned study results in brilliant hypotheses or a generalized theory, it is the responsibility of the researcher to format this bulk study into an easy-to-understand pattern or format.

You will also learn about written and oral reports that are necessary for data representation. Writing a report is a creative activity that requires a lot of imagination, effort and patience in order to make it effective. It is impossible for an organization to progress without effective written reports, as most business activities require sending letters and reports. Effective oral reports involve communicating ideas verbally to the listener. An oral report saves time and builds a healthy atmosphere in an organization by bringing the employees closer to each other. Finally, you will learn the role of IT in research. Computers have a very important role to play in research activities. It has become an essential tool for research whether it is for academic purpose or for commercial purpose.

7.1 UNIT OBJECTIVES

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

- Discuss the importance of a research report
- Explain the precautions taken while writing research report
- Explain the various types of reports used in research

- Discuss the advantages and disadvantages of various types of reports
- Explain the significance of oral presentation

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7.2 RESEARCH REPORT: AN OVERVIEW

In simple terms, a research report describes the findings of some individual or a group of individuals. It gives an account of something seen, heard, done, etc. The findings may comprise information, such as data, surveys, resolutions or policies, on which the concerned individual or individuals have to submit their reports about the proceedings along with the relevant conclusions.

A report can be defined as a written document which presents the information in a specialized and concise manner. For example, a list of employees prepared by the human resource department for salary distribution can be termed as a report. In other words, a report is the information presented in a logical and concise manner.

The preparation and presentation of a research report is the most important part of the research process. No matter how well designed a research study is, it is of little value, unless communicated effectively to others in the form of a research report. Moreover, if the report were confusing or poorly written, then the time and effort spent on gathering and analysing the data would be wasted. It is, therefore, essential to summarize and communicate the result to the management of an organization with the help of an understandable and logical research report.

Research reports are helpful during the research study, in the sense that they facilitate the maintenance of vast data in a logical way. Thus, in case a researcher experiences any difficulty during the course of the study, it becomes easier to refer to the contents of the report to get the relevant data. Research report writing essentially involves the systematic arrangement of data. This helps in discovering flaws in reasoning, which may have been missed earlier while conducting the research.

7.2.1 Format of a Research Report

The layout of a research report is of utmost importance because the reader should be able to grasp logically, what has been said and not feel lost in the bulk findings mentioned in the research. This requires preparing a proper layout of the report. The report layout means allotting the research findings in a comprehensible format. The layout should contain the following points:

- **Preliminary Pages:** In the preliminary pages, the report should carry a ‘title’ and a ‘date,’ followed by the acknowledgements in the form of ‘Preface’ or ‘Foreword.’ The ‘Table of Contents’ should come next, followed by a ‘list of Tables and Illustrations.’ This entails readers to an easy reading and quick location of the required information.
- **Main Text:** The main text comprises the complete outline of the research report with all the details. The title of the research study is repeated at the top of the first page of the main text, and then follow the other details on the pages numbered consecutively, beginning with the second page. The main text can be classified into the following sections:
  - ***Introduction:*** The purpose of introduction is to introduce the research projects to the readers. It should clearly state the objectives of research, i.e., it should

make clear, why the problem was considered worth investigating. A brief summary of other relevant research can be included as well, to enable readers to see the present study in that context.

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- o ***Methodology Used for Performing the Study:*** The introduction should contain answers to questions like how the study was carried out, what was the basic design, what were the experimental directions, what questions were asked in the questionnaires used, etc. Besides this, the scope and limitations of the study must be marked out.
- o ***Statement of Findings and Recommendations:*** A research report should comprise a statement of findings and recommendations in a non-technical language so that it is easily comprehensible.
- o ***Results:*** A detailed presentation of the findings of the study, with supporting data in the tabular forms, along with the validation of results, should be given. This section should contain statistical summaries and deductions of the data rather than the raw data. There should be a logical sequence and sectional presentation of the results.
- o ***Implications of the Result:*** Researchers should write down their results clearly and precisely, again at the end of the main text. The implications derived from the results of the research study should be stated in research plan. The report should also mention the conclusion drawn from the study, which should be clearly related to the hypothesis stated in the introductory section.
- o ***Summary:*** The next step is to conclude the report with a short summary, mentioning in brief the research problem, the methodology, the major findings and the major conclusions drawn from the research results.
- o ***End Matter:*** The end of the research report should consist of appendices, enlisted in respect of all technical data, such as questionnaires, sample information, mathematical derivations, etc. The Bibliography of the referred sources and an index should also be given.

7.2.2 Steps in Writing Research Reports

Research reports are generated from a measured, thorough, accurate and inductive work. There is no such particular format suitable for report writing. The usual steps to be pursued while writing reports are as follows:

- **Logical Analysis of the Subject Matter:** This is the first step in report writing that concentrates on the development of a subject. A subject can be developed in two ways:
  - (i) ***Logical Development:*** This is based on the mental connections and associations between two things, such as the lunar eclipse and the shadow of the earth on the moon, and is performed by means of analysis. The logical treatment often consists of developing the material from the simplest possible to the most complex structures.
  - (ii) ***Chronological Development:*** This is based on a connection or a sequence in relation to time. Usually, directions concerned with doing or making something follow in the chronological order.
- **Preparation of the Final Outline:** According to S.M. Elliot, '*Outlines are the framework upon which long written works are constructed. They are an aid to the logical organization of the material and a reminder of the points to be*

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stressed in the report.' It is thus, the next step after logical analysis in writing reports, and facilitates the basic designing of a report.

- **Preparation of Rough Draft:** This is the most important step when the researcher starts to jot down all that he/she has done in the context of his/her research study. It comprises information about the procedure adopted in collecting data, the technique of analysis used, the findings and generalizations offered along with the several limitations encountered.
- **Rewriting and Polishing the Rough Draft:** This is the most difficult step of all formal writing. While rewriting and polishing, the researcher should check the report for linguistic and informative weaknesses from the point of view of logical development. He/She should also check if the material presented has unity and cohesion. The researcher should also concentrate on being consistent in the rough draft.
- **Preparation of the Final Bibliography:** The next task is to prepare the final bibliography. Bibliography is generally appended to the research report. It is a list of books relevant to the research, which has been referred and should include the names of all those works, which the researcher has referred. The bibliography should be in the alphabetical order and may be divided into two parts: the first part may contain the names of books and pamphlets and the second part may contain the names of magazine and newspaper articles. The entries in bibliography can be recorded in the following order:

  For books, the order should be:
  - o Name of author, last name first
  - o Title, underlined to indicate italics
  - o Place, publisher and date of publication
  - o Number of volumes

  For magazines and newspapers, the order is:
  - o Name of the author, the last name first
  - o Title of article in quotation marks
  - o Name of periodical underlined to indicate italics
  - o The volume or volume and number
  - o The date of the issue
  - o The pagination
- **Writing the Final Draft:** This constitutes the last step of the report writing. The final draft should have a concise and objective writing style and should use simple language. It should avoid using vague expressions, such as 'it seems', 'there may be' and 'like.' The researcher must also avoid abstract terminology and technical jargon. Illustrations and examples, based on common experience, must be incorporated in the final draft, as they can effectively communicate the research findings to others. A research should be interesting and motivating and should be original. A report is an attempt to solve some intellectual problem and must contribute to the solution of a problem. It should add to the knowledge of both the researcher and the reader.

7.2.3 Mechanics of Writing Research Reports

There are several methods of writing a research report, which are strictly followed for preparing reports. The following points should be considered for writing a research report:

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- **Size and Physical Design:** The manuscript, if handwritten, should be in black or blue ink and on unruled paper of 8½ × 11-inch size. A margin of at least 1½ inches is set at the left side and ½ inch at the right side of the paper. The top and bottom margins should be of 1 inch. If the manuscript is to be typed, then all typing should be double-spaced and on one side of the paper, except for the insertion of long quotations.
- **Layout:** According to the objective and nature of the research, the layout of the report should be decided and followed in a proper manner.
- **Quotations:** Quotations should be punctuated with quotation marks and double spaces, forming an immediate part of the text. However, if a quotation is too lengthy, then it should be single-spaced and indented at least ½ inch to the right of the normal text margin.
- **Footnotes:** Footnotes are meant for cross-references. They are placed at the bottom of the page, separated from the textual material by a space of ½ inch as a line that is around 1½-inch long. Footnotes are always typed in a single space, though they are divided from one another by double space.
- **Documentation Style:** The first footnote reference to any given work should be complete, giving all essential facts about the edition used. Such footnotes follow a general sequence and order as mentioned below:
  - o In case of the single volume reference:
    - Author's name in normal order
    - Title of work, underlined to indicate italics
    - Place and date of publication
    - Page number reference

    For example:

    John Gassner, *Masters of the Drama*, New York; Dover Publications, Inc.1954, p.315.
  - o In case of multi-volume reference:
    - Author's name in the normal order
    - Title of work, underlined to indicate italics
    - Place and date of publication
    - Number of volume
    - Page number reference

    For example:

    George Birkbeck Hill, *Life Of Johnson*, June 2004, Whitefish, Volume 2, p.124.
  - o In case of works arranged alphabetically:
    - For works arranged alphabetically such as encyclopaedias and dictionaries, no page reference is usually needed. In such cases, order is illustrated according to the names of the topics
    - Name of the encyclopaedia
    - Number of the edition

    For example:

    "Salamanca", *Encyclopaedia Britannica*, 14th Edition.
  - o In case of periodicals reference:

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- Name of the author in normal order
- Title of article, in quotation marks
- Name of periodical, underlined to indicate italics
- Volume number
- Date of issuance
- Pagination

For example:

P.V. Shahad, "Rajesh Jain's Ecosystem," in *Business Today*, Vol.14, December 18 2005, p.28.

o In case of multiple authorship:

If there are more than two authors or editors then in the documentation, the name of only the first is given and the multiple authorship is indicated by "*et al.*" or "and others".

- Author's name in normal order
- Title of work, underlined to indicate italics
- Place and date of publication
- Pagination references

For example:

Alexandra K. Wigdor, *Ability Testing: Uses, Consequences and Controversies*, 1981, p.23

Subsequent references to the same work need not be as detailed as above. If the work is cited again without any other work intervening, it may be indicated as ibid, followed by a comma and the page number.

- **Punctuations and Abbreviations in Footnotes:** Punctuations concerning the book and author names have already been discussed. They are general rules to be strictly adhered. Some English and Latin abbreviations are often used in bibliographies and footnotes to eliminate any repetition.

Table 7.1 shows the various English and Latin abbreviations used in bibliographies and footnotes.

Table 7.1 *English and Latin Abbreviations used in Bibliographies and Footnotes*

Abbreviations	Meaning
Anon.,	Anonymous
Ante.,	Before
Art.,	Article
Aug.,	Augmented
bk.,	Book
bull.,	Bulletin
cf.,	Compare
ch.,	Chapter
col.,	Column
diss.,	Dissertation
ed.,	editor, edition, edited
ed. cit.,	edition cited
e.g.	Exempli gratia: for example

Contd...

eng.,	Enlarged
et al.,	and others
et seq.,	et sequens: and the following
ex.,	Example
f.,ff.,	figure(s)
fn.,	Footnote
ibid., ibidem	in the same place
id., idem.,	the same
ill., illus., or illust(s)	illustrated, illustration(s)
Intro., intro.,	introduction
l., ll.,	line(s)
loc.cit.,	in the place cited; used as op.cit.,
MS., MSS.,	Manuscript(s)
N.B. nota bene	note well
n.d.,	no date
n.p.,	no place
no pub.,	no publisher
no(s) .,	number(s)
o.p.,	out of print
op.cit:	in the work cited
p.pp	page(s)
passim:	here and there
Post:	After
rev.,	Revised
tr., trans.,	translator, translated, translation
vid or vide:	see, refer to
viz.,	Namely
vol. or vol(s) .,	volume(s)
vs., versus.,	Against

- **Use of Statistics, Charts and Graphs:** Statistics contribute to clarity and simplicity in a report. They are usually presented in the form of tables, charts, bars, line-graphs and pictograms.
- **Final Draft:** It requires careful scrutiny with regard to grammar errors, logical sequence and coherence in the sentences of the report.
- **Index:** An index acts as a good guide to the reader. It can be prepared both as subject index and author index giving names of subjects and names of authors, respectively. The names are followed by the page numbers of the report, where they have appeared or been discussed.

7.2.4 Precautions for Writing Research Reports

A research report is a means of conveying the research study to a specific target audience. The following precautions should be taken while preparing a research report:

- It should be long enough to cover the subject and short enough to preserve interest.
- It should not be dull and complicated.
- It should be simple, without the usage of abstract terms and technical jargons.

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- It should offer ready availability of findings with the help of charts, tables and graphs, as readers prefer quick knowledge of main findings.
- The layout of the report should be in accordance with the objectives of the research study.
- There should be no grammatical errors and writing should adhere to the techniques of report writing in case of quotations, footnotes and documentations.
- It should be original, intellectual and contribute to the solution of a problem or add knowledge to the concerned field.
- Appendices should be enlisted with respect to all the technical data in the report.
- It should be attractive, neat and clean, whether handwritten or typed.
- The report writer should refrain from confusing the possessive form of the word 'it' is with 'it's.' The accurate possessive form of 'it is' is 'its.' The use of 'it's' is the contractive form of 'it is.'
- A report should not have contractions. Examples are 'didn't' or 'it's.' In report writing, it is best to use the non-contractive form. Therefore, the examples would be replaced by 'did not' and 'it is.' Using 'Figure' instead of 'Fig.' and 'Table' instead of 'Tab.' will spare the reader of having to translate the abbreviations, while reading. If abbreviations are used, use them consistently throughout the report. For example, do not switch among 'versus,' and 'vs'.
- It is advisable to avoid using the word 'very' and other such words that try to embellish a description. They do not add any extra meaning and, therefore, should be dropped.
- Repetition hampers lucidity. Report writers must avoid repeating the same word more than once within a sentence.
- When you use the word 'this' or 'these' make sure you indicate to what you are referring. This reduces the ambiguity in your writing and helps to tie sentences together.
- Do not use the word 'they' to refer to a singular person. You can either rewrite the sentence to avoid needing such a reference or use the singular 'he or she.'

7.3 TYPES OF RESEARCH REPORT

Research reports are designed in order to convey and record the information that will be of practical use to the reader. It is organized into distinct units of specific and highly visible information. The kind of audience addressed in the research report decides the type of report. Research reports can be categorized on the following basis:

- On the basis of information
- On the basis of representation

7.3.1 Classification on the Basis of Information

Following are the ways through which the results of the research report can be presented on the basis of information contained:

- **Technical Report:** A technical report is written for other researchers. In writing the technical reports, the importance is mainly given to the methods that have been used to collect the information and data, the presumptions that are made and finally, the various presentation techniques that are used to present the findings and data. Following are main features of a technical report:

- o ***Summary:*** It covers a brief analysis of the findings of the research in a very few pages.
- o ***Nature:*** It contains the reasons for which the research is undertaken, the analysis and the data that is required in order to prepare a report.
- o ***Methods employed:*** It contains a description of the methods that were employed in order to collect the data.
- o ***Data:*** It covers a brief analysis of the various sources from which the data has been collected with their features and drawbacks.
- o ***Analysis of data and presentation of the findings:*** It contains the various forms through which the data that has been analysed can be presented.
- o ***Conclusions:*** It contains a brief explanation of findings of the research.
- o ***Bibliography:*** It contains a detailed analysis of the various bibliographies that have been used in order to conduct a research.
- o ***Technical appendices:*** It contains the appendices for the technical matters and for questionnaires and mathematical derivations.
- o ***Index:*** The index of the technical report must be provided at the end of the report.

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- **Popular Report:** A popular report is formulated when there is a need to draw the conclusions of the findings of the research report. One of the main points of consideration that should be kept in mind while formulating a research report is that it must be simple and attractive. It must be written in a very simple manner that is understandable to all. It must also be made attractive by using large prints, various sub-headings and by giving cartoons occasionally. Following are the main points that must be kept in mind while preparing a popular report:
  - o ***Findings and their implications:*** While preparing a popular report, main importance is given to the findings of the information and the conclusions that can be drawn out of these findings.
  - o ***Recommendations for action:*** If there are any deviations in the report then recommendations are made for taking corrective action in order to rectify the errors.
  - o ***Objective of the study:*** In a popular report, the specific objective for which the research has been undertaken is presented.
  - o ***Methods employed:*** The report must contain the various methods that has been employed in order to conduct a research.
  - o ***Results:*** The results of the research findings must be presented in a suitable and appropriate manner by taking the help of charts and diagrams.
  - o ***Technical appendices:*** The report must contain an in-depth information used to collect the data in the form of appendices.

7.3.2 Classification on the Basis of Representation

Following are the ways through which the results of the research report can be presented on the basis of representation:

- Written report
- Oral report

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1. Written Report

A written report plays a vital role in every business operation. The manner in which an organization writes business letters and business reports creates an impression of its standard. Therefore, the organization should emphasize on the improvement of writing skills of the employees in order to maintain effective relations with their customers.

Writing effective written reports requires a lot of hard work. Therefore, before you begin writing, it is important to know the objective, i.e., the purpose of writing, collection and organization of required data.

Guidelines for Writing an Effective Written Report: Writing a report is the best way to communicate, and often the only way to convey one's ideas to others. Thus, it is necessary that the writing should be effective. To improve the effectiveness of writing a report, the following are the important points that should be kept in mind:

- Take breaks in between writing, as this gives you the time to incubate the ideas.
- Start writing a short manuscript first, and later a detailed one. Create an outline and organize the complete work.
- Make a checklist of the important points that are necessary to be covered in the manuscript.
- Focus on one objective at a time.
- Use dictionary and relevant reference materials as and when required.

Principles of Writing a Report: To write a useful report, it is necessary to follow certain principles. The following principles must be followed while writing a report:

- ***Principle of purpose:*** A report must have a clear and meaningful purpose that can be converted into an effective management. A clear statement of the purpose helps prepare a well-focussed report on which the management can work. Specification of the purpose is important because:
    - o Reports are the analysis of facts and proposals.
    - o Reports are the record of a particular business activity.
- ***Principle of organization:*** A report should be well designed and well ordered. The managerial plan of a report must include the following:
    - o Purpose of report.
    - o Information required to be included in the report.
    - o Method used to collect/report data.
    - o Summary of the report.
    - o Problems and solutions of the subject mentioned in the report.
    - o An appendix that describes and confirms the content and conclusion of the report.
- ***Principle of brevity:*** Reports should be concise. It is essential because:
    - o Long reports are costly.
    - o Long reports are difficult to examine.
    - o Long reports are prone to disapproval, as they seem insufficient.
    - o Long reports focus on the irrelevant minor details that may lead to the ignorance of major points.

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- ***Principle of clarity:*** Reports should be clear. Clarity can be maintained by using simple language for writing the report. New terms, if any, in the report, should be properly explained to avoid confusion.
- ***Principle of scheduling:*** Reports should be prepared at that time when there is no undue burden on the staff or when they have sufficient time to prepare it. However, the time period between the gathering of data and generating finished reports should not be long, as the report may become outdated and useless if it is not completed in time.
- ***Principle of cost:*** While preparing reports, it is necessary that the cost-benefit analysis of the report should be done. A report should be minimum at costs and maximum at the benefits. If the cost of preparation of the report is high but its benefit is low, then it is not advisable to prepare that report.

Different Formats of Written Report: A written report can be written in various formats, which are as follows:

- ***Straight-line format:*** This format is used when the information is to be presented in alphabetical, sequential or numerical orders. This format is used to generate descriptive reports.
- ***Building blocks format:*** This format is used when the information presented leads to some conclusion. The report in this format starts with a brief introduction, contains some logical facts and finally the conclusions and recommendations.
- ***Inverted pyramid format:*** The report in this format has the most important item at the top and the least important item at the bottom. That is, items are listed in the descending order with the most important item at the top. This style of writing or the format is also known as journalistic style or format.

2. Oral Report

At times, oral presentation of the results that are drawn out of a research is considered effective, particularly in cases where policy recommendations are to be made. This approach proves beneficial because it provides a medium of interaction between a listener and a speaker. This leads to a better understanding of the findings and their implications. However, the main drawback of oral presentation is lack of any permanent records related to the research. Oral presentation of the report is also effective when it is supported with various visual devices, such as slides, wall charts and white boards that help in better understanding of the research reports.

Advantages of Oral Reports: Oral reports help in direct communication without any delay. The following are some of the advantages of oral reports:

- It provides immediate feedback to the participants of the oral reports. Moreover, participants can also ask for further clarification, elaboration and justifications.
- It is time saving.
- It helps develop relationship among employees by building healthy atmosphere in an organization.
- It is an effective tool of persuasion in business.
- It is economical as it saves large amount of money spent on stationery.
- It provides speakers with an opportunity to correct themselves on the spot.

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It helps speakers to immediately understand the reaction of the group that they are addressing.

Disadvantages of Oral Reports: There are many disadvantages of the oral reports, which are as follows:

- Oral reports may not always be time saving. Sometimes, meeting between the speaker and the listener can continue for very long time without any satisfactory conclusion.
- A listener of the oral report cannot always retain the entire message.
- Messages in the oral reports do not have any legal validity, as they are not documented.
- Oral reports may sometimes be misleading, if the thoughts of speaker are not organized carefully.
- Lengthy oral messages may sometimes cause problems.

Principles of Oral Reports: Oral reports should follow some principles in order to make the communication between the speaker and the listener effective. The following are the basic principles of oral reports:

- It is the responsibility of a manager to inform his/her subordinates about the tasks that they have to perform.
- To obtain full commitment of employees for achieving their objectives, all-important information that directly or indirectly affects the objective should be communicated to the employees. Also, employees should be aware of the matters that are relevant to their circumstances.
- It is the duty of a manager to see the information in the report communicated to his/her subordinates is clear and complete.
- Proper planning for the information flow should be done.
- Information in the oral report should provide proper feedback that helps maintain effective industrial relations.

7.4 ORAL PRESENTATION AND PRECAUTIONS IN PREPARING ORAL PRESENTATIONS

Once the final draft of the research report is prepared and documented, the last stage is sharing the findings and research implications with the client or interested audience. This is usually done orally and with the support of visual aids. The presentation that the researcher might be making could be detailed for his team members or for an academic audience. However, in case the presentation is for the client or for a business audience, brevity and focus of the presentation is critical. A thumb rule for this is not to go beyond 20 minutes with more time for question and answers and interactive discussion on the findings.

Regardless of the audience for the presentation, the most critical aspect of the presentation is twofold:

(a) Who is the listener? What does he/she seek from the presentation?

(b) What is the core of the briefing—is it background, or methodology, key findings or decision directions that the findings are indicating?

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Once the researcher is clear on this, he needs to need to focus on three key aspects:

- **Study Background:** This should be essentially 10-15 per cent of the entire presentation. It should explain the impetus behind the study as briefly and with suitable emphasis as possible.
- **Study Findings:** The major conclusions of the study need to be shared in simple words and with appropriate supportive visuals or material. The researcher must be able to demonstrate clearly the link between the study objectives and the findings.
- **Study Implications:** In case this was agreed upon between the researcher and the client or was specified as a study objective by the researcher, this section would be the last section of the presentation. The link between what was found and what is suggested must be clear to the audience. The researcher may vary the discussion time between the earlier section and this as 45 per cent each or 30–70 or 70–30, depending on the study objective, i.e., more findings or more implication oriented.

As supportive material the researcher can make use of:

- **Handouts:** These could be in the form of the primary questionnaire designed for the study or company brochures and other related secondary material. They should be distributed to the audience when the presenter is referring to them.
- **Slides:** These are created today with the help of computer programmes. There are endless possibilities enhancing the material be presented and for engaging the listener. The designing and creation of the material requires considerable skill and care to ensure that the presentation style should be the supportive aid for an effective delivery and not a showcase of the computer graphics that the researcher is well versed with. Too much clutter and a random mix of text and graphics should be avoided. Animation of the data in synchronization with the vocal delivery makes the presentation more forceful.
- **Chalkboards and Flipcharts:** These are additional visual aids that could be kept as standby for the question-and-answer session when an idea might have to be highlighted or demonstrated in the response of some query raised by the listeners. However, use of these means during an active presentation should be avoided as they necessitate the presenter to be engaged with the medium at the cost of losing contact with the listener.
- **Video and Audio Tapes:** Again, these are supportive materials that can be used to emphasize a point.

The world has become smaller as a consequence of technological innovations that make dissemination of knowledge seem like child's play. Thus, the significance of communication and presentation of this learning cannot be overemphasized.

Through oral presentations, research findings can be communicated in an dynamic and interactive way. At times, oral presentations are to be made to those who wish to take decisions on the basis of the findings of a study. Policy makers are such audiences. They wish to see and hear the results of a study for quick understanding and easy decision-making. It is always necessary for a written report to be circulated, before the oral presentation is made.

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Key to effective oral presentations:

- Have liberal use of visual aids.
- Use colour generously to highlight features.
- Have pointed effective captions and titles with the slides.
- Illustrate with graphics wherever possible.
- Have bold fonts to show conclusions, implications, etc.

How to retain listener/viewer attention in an oral presentation:

(i) Begin with an anecdote, experience or an illustration.
(ii) Present the key aspects of the study.
(iii) Identify 3 to 5 major points to be made during the talk.
(iv) Connect ideas, logically and proceed.
(v) Give examples as you proceed.
(vi) Make eye contact with the audience, always.
(vii) Modulate your voice through the talk.
(viii) Use body language to good effect.
(ix) Be mindful of the time allotted.
(x) End on a strong note (leave the audience with a thought or an application of the results).
(xi) Always be available for taking questions.
(xii) Never forget to add a dash of humour in your presentation.
(xiii) Always have a speaking outline in front of you and the rest can be on the projection screen.

7.5 ROLE OF IT IN RESEARCH

Computers have a very important role to play in research activities. It has become an essential tool for research whether it is for academic purpose or for commercial purpose. You can find all kinds of information on the Internet and you can even discuss research problems with people around the world. Computers have led the way to a globalize information portal that is the World Wide Web. By using WWW we can conduct primary as well as secondary research on a massive scale. Various computer programs and applications have eased our way into compiling our research process. For example, MS office tools help us to organize data and handle quantitative as well as qualitative data. Inference and analysis is also easier to make by using a computer.

The purpose of any data analysis procedure is to condense information contained in a body of data into a form that can be easily comprehended and interpreted. In its most simple form, such analysis could appear as a chart or some other visual display of information. The more complex forms, however, require computers to help us complete analysis in a timely and accurate fashion. Computers are extremely useful for the processing of large quantities of data and reducing data to more manageable and easily understood forms. Thus the importance of computers in scientific research is exceptionally high and the use of a computer can help scientific research immensely. It is an almost invaluable and priceless tool. There are many reasons why computers are so important in scientific research. Following are some of the main reasons:

Speed: Although calculations can be done by a human being, but a computer can process numbers and information in a very short space of time. This means that computer computes the result more accurately and fast, thus saving the time of researchers so that they get more time to complete and conduct further researches.

Accuracy: Computers are incredibly accurate and a calculation or piece of research that is very difficult to calculate by a human can be processed easily by a computer, delivering flawless accuracy. Accuracy is of the utmost importance in scientific research as a wrong calculation could result in an entire project/research piece being filled with incorrect information.

Organization: When researching science, you can often be flooded with different pieces of information, calculations and notes, and with a computer, you are able to stock it all efficiently and safely. By using simple folders, word processors and computer programs, you can store millions of pages of information, which are stored safe within the computer. This is a method that is significantly more productive and safer than using a paper filing system in which anything can be easily misplaced, therefore disrupting research.

Consistency: As a computer is a machine, it cannot make mistakes through 'tiredness' or 'fatigue' or 'lack of concentration' which humans can sometimes suffer with when working. This trait alone makes the computer exceptionally important to the world of scientific research.

7.6 SUMMARY

- A research report should comprise a statement of findings and recommendations in a non-technical language so that it is easily comprehensible.
- A detailed presentation of the findings of the study, with supporting data in the tabular forms, along with the validation of results, should be given.
- Researchers should write down their results clearly and precisely, again at the end of the main text. The implications derived from the results of the research study should be stated in research plan.
- Research reports are generated from a measured, thorough, accurate and inductive work. There is no such particular format suitable for report writing.
- The manuscript, if handwritten, should be in black or blue ink and on unruled paper of 8½ × 11-inch size. A margin of at least 1½ inches is set at the left side and ½ inch at the right side of the paper.
- The first footnote reference to any given work should be complete, giving all essential facts about the edition used.
- Punctuations concerning the book and author names have already been discussed. They are general rules to be strictly adhered.
- Statistics contribute to clarity and simplicity in a report. They are usually presented in the form of tables, charts, bars, line-graphs and pictograms.
- In index acts as a good guide to the reader. It can be prepared both as subject index and author index giving names of subjects and names of authors, respectively.
- A research report is a means of conveying the research study to a specific target audience.
- Research reports are designed in order to convey and record the information that will be of practical use to the reader. It is organized into distinct units of specific and highly visible information.

NOTES

Check Your Progress

1. What is the significance of a research report?
2. Define the term report.
3. How are the research reports helpful?
4. Why is the layout of research report of utmost importance?
5. What does main text comprises of in a research report?
6. How is the research report generated?
7. State one precaution that should be taken while writing research reports.
8. What is the significance of a written report?

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- A technical report is written for other researchers. In writing the technical reports, the importance is mainly given to the methods that have been used to collect the information and data, the presumptions that are made and finally, the various presentation techniques that are used to present the findings and data.
- A popular report is formulated when there is a need to draw the conclusions of the findings of the research report. One of the main points of consideration that should be kept in mind while formulating a research report is that it must be simple and attractive.
- A written report plays a vital role in every business operation. The manner in which an organization writes business letters and business reports creates an impression of its standard.
- Writing effective written reports requires a lot of hard work. Therefore, before you begin writing, it is important to know the objective, i.e., the purpose of writing, collection and organization of required data.
- A report must have a clear and meaningful purpose that can be converted into an effective management. A clear statement of the purpose helps prepare a well-focussed report on which the management can work.
- Reports should be clear. Clarity can be maintained by using simple language for writing the report. New terms, if any, in the report, should be properly explained to avoid confusion.
- Reports should be prepared at that time when there is no undue burden on the staff or when they have sufficient time to prepare it. However, the time period between the gathering of data and generating finished reports should not be long, as the report may become outdated and useless if it is not completed in time.
- A report should be minimum at costs and maximum at the benefits. If the cost of preparation of the report is high but its benefit is low, then it is not advisable to prepare that report.
- Oral reports help in direct communication without any delay. It provides immediate feedback to the participants of the oral reports. Moreover, participants can also ask for further clarification, elaboration and justifications.
- Oral reports may not always be time saving. Sometimes, meeting between the speaker and the listener can continue for very long time without any satisfactory conclusion.
- Oral reports should follow some principles in order to make the communication between the speaker and the listener effective.
- The world has become smaller as a consequence of technological innovations that make dissemination of knowledge seem like child's play. Thus, the significance of communication and presentation of this learning cannot be overemphasized.
- Through oral presentations, research findings can be communicated in a dynamic and interactive way. At times, oral presentations are to be made to those who wish to take decisions on the basis of the findings of a study. Policy makers are such audiences.
- Computers have a very important role to play in research activities. It has become an essential tool for research whether it is for academic purpose or for commercial purpose. You can find all kinds of information on the Internet and you can even discuss research problems with people around the world.

- The purpose of any data analysis procedure is to condense information contained in a body of data into a form that can be easily comprehended and interpreted. In its most simple form, such analysis could appear as a chart or some other visual display of information.
- When researching science, you can often be flooded with different pieces of information, calculations and notes, and with a computer, you are able to stock it all efficiently and safely.
- As a computer is a machine, it cannot make mistakes through 'tiredness' or 'fatigue' or 'lack of concentration' which humans can sometimes suffer with when working. This trait alone makes the computer exceptionally important to the world of scientific research.

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7.7 KEY TERMS

- **Preliminary pages:** In the preliminary pages, the report should carry a 'title' and a 'date,' followed by the acknowledgements in the form of Preface or Foreword
- **Main text:** The main text comprises the complete outline of the research report with all the details
- **Logical development:** This is based on the mental connections and associations between two things, such as the lunar eclipse and the shadow of the earth on the moon, and is performed by means of analysis
- **Chronological development:** This is based on a connection or a sequence in relation to time
- **Nature:** It contains the reasons for which the research is undertaken, the analysis and the data that is required in order to prepare a report
- **Methods employed:** It contains a description of the methods that were employed in order to collect the data

7.8 ANSWERS TO 'CHECK YOUR PROGRESS'

1. A research report describes the findings of some individual or a group of individuals. It gives an account of something seen, heard, done, etc.
2. A report can be defined as a written document which presents the information in a specialized and concise manner.
3. Research reports are helpful during the research study, in the sense that they facilitate the maintenance of vast data in a logical way. Thus, in case a researcher experiences any difficulty during the course of the study, it becomes easier to refer to the contents of the report to get the relevant data.
4. The layout of a research report is of utmost importance because the reader should be able to grasp logically, what has been said and not feel lost in the bulk findings mentioned in the research.
5. The main text comprises the complete outline of the research report with all the details. The title of the research study is repeated at the top of the first page of the main text, and then follow the other details on the pages numbered consecutively, beginning with the second page.

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6. Research reports are generated from a measured, thorough, accurate and inductive work. There is no such particular format suitable for report writing.
7. Research report should be long enough to cover the subject and short enough to preserve interest.
8. A written report plays a vital role in every business operation. The manner in which an organization writes business letters and business reports creates an impression of its standard.

7.9 QUESTIONS AND EXERCISES

Short-Answer Questions

1. Define the term research report.
2. Write a format of a research report.
3. What are the steps to write a research report?
4. What are oral reports?
5. What is a written report?
6. State the disadvantages of oral report.

Long-Answer Questions

1. Describe the mechanism of writing research reports.
2. Discuss the precautions that must be taken while writing a research report.
3. Name the various types of research reports. Discuss each type in detail with the help of examples.
4. Classify the reports on the basis of representation.
5. How can you prepare oral and written reports? Discuss in brief.
6. Describe the role of IT in research.

7.10 FURTHER READING

Michael, V. P. 2012. *Research Methodology in Management*. New Delhi: Himalaya Publishing House.

Kothari, C R. 2014. *Research Methodology: Methods and Techniques,* 3rd edition. New Delhi: New Age International.

Saunders, Mark, Adrian Thornhill and Philip Lewis. 2009. *Research Methods for Business Students*, 5th edition. New Jersey: Pearson Education.

Levin, Richard I. 1984. *Statistics for Management,* 3rd edition. United States: Prentice-Hall.

APPENDIX

Guidelines for Consiructing/Questionnaire

Criteria for Questionnaire Designing

The first and foremost requirement is that the spelt-out research objectives must be converted into clear questions which will extract answers from the respondent. This is not as easy as it sounds, for example, if one wants to know something like what is the margin that a company gives to the retailer? This cannot be converted into a direct question as no one will give the correct figure. Thus, one will have to ask a disguised question like may be a range of percentage estimates—2–5 per cent, 6–10 per cent, 11–15 per cent, 16–20 per cent, etc., or the retailer might not go beyond a Yes, No or 'industry standard'.

The second requirement is, like the Toyota questionnaire, it should be designed to engage the respondent and encourage a meaningful response. For example, a questionnaire measuring stress cannot have a voluminous set of questions which fatigue the subject. The questions, thus, should be non-threatening, must encourage response and be clear to understand. One needs to remember that the essential usage of the instrument is to administer the same to a large base, thus there must be clarity and interest that should be part of the measure itself.

Lastly, the questions should be self-explanatory and not confusing as then the answers one gets might not be accurate or usable for analysis. This will be discussed in detail later, when we discuss the wording of the questions.

> The basic requirement for a questionnaire is that spelt-out research objectives must be converted into clear questions.

Types of Questionnaire

There are many different types of questionnaire available to the researcher. The categorization can be done on the basis of a variety of parameters. The two which are most frequently used for designing purposes are the degree of construction or structure and the degree of concealment, of the research objectives. Construction or formalization refers to the degree to which the response category has been defined. Concealed refers to the degree to which the purpose of the study is explained or is clear to the respondent.

Instead of considering them as individual types, most research studies use a mixed format. Thus, they will be discussed here as a two-by-two matrix (see Table 1).

Table 1 *Types of Questionnaire*

	FORMALIZED	NON-FORMALIZED
UNCONCEALED	Most research studies use standardized questionnaires like these	The response categories have more flexibility
CONCEALED	Used for assessing psychographic and subjective constructs	Questionnaires using projective techniques or sociometric analysis

Formalized and unconcealed questionnaire: This is the one that is indiscriminately and most frequently used by all management researchers. For example, if a new brokerage firm wants to understand the investment behaviour of the population under study, they would structure the questions and answers as follows:

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1. Do you carry out any investment(s)?

   Yes __________ No __________

   If yes, continue, else terminate.

2. Out of the following options, where do you invest (tick all that apply).

   Precious metals __________, real estate __________, stocks __________, government instruments __________, mutual funds __________, any other __________.

3. Who carries out your investments?

   Myself __________, agent __________, relative __________, friend __________,
   any other __________.

   In case the option ticked is self, please go to Q. 4, else skip.

4. What is your source of information for these decisions?

   Newspaper __________, investment magazines __________, company records, etc. __________, trading portals __________, agent __________.

This kind of structured questionnaire is easy to administer, as one can see that the questions are self-explanatory and, since the answer categories are defined as well, the respondent needs to read and tick the right answer. Another advantage with this form is that it can be administered effectively to a large number of people at the same time. Data tabulation and data analysis is also easier to compute than in other methods.

This format, as a consequence of its predefined composition, is able to produce relatively stable results and is reasonably high in its reliability. The validity, of course would be limited as the comprehensive meaning of the constructs and variables under study might not be holistic when it comes to structured and limited responses. In such cases, variables are made a part of the study and some open-ended questions as well as administration/additional instructions/probing by the field investigator could help in getting better results.

> Concealed questionnaire tries to reveal the latent causes of behaviour which cannot be determined by direct questions. It maps basic values, opinions and beliefs.

Formalized and concealed questionnaire: The research studies which are trying to unravel the latent causes of behaviour cannot rely on direct questions. Thus, the respondent has to be given a set of questions that can give an indication of what are his basic values, opinions and beliefs, as these would influence how he would react to certain products or issues. For example, a publication house that wants to launch a newspaper wants to ascertain what are the general perceptions and current attitudes about newspapers. Asking a direct question would only reveal apparent information, thus, some disguised attitudinal questions would need to be asked in order to infer this.

Please indicate your level of agreement with the following statements:

SA – Strongly Agree; A – Agree; N – Neutral; D – Disagree; SD – Strongly Disagree

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		SA	A	N	D	SD
1	The individual today is better informed about everything than before.					
2	I believe that one must live for the day and worry about tomorrow later.					
3	An individual must at all times keep abreast of what is happening in the world around him/her.					
4	Books are the best friends anyone can have.					
5	I generally read and then decide what to buy.					
6	My lifestyle is so hectic that I do not have time for reading the newspaper.					
7	The advent of radio, television and Internet have made the traditional information sources-like newspapers, redundant.					
8	A man/woman is known by what he/she reads.					

The logic behind these tests of attitude is that the questions do not seem to be in a particular direction and are apparently non-threatening, thus the respondent gives an answer which would be in the general direction of his/her attitudes.

The advantage of these questions is that since these are structured, one can ascertain their impact and quantify the same through statistical techniques. Secondly, it has been found that psychographic questions like these increase the subject coverage and improve the validity of the instrument as well. Most studies interested in quantifying the primary response data make use of questions that are designed both as formalized unconcealed and formalized concealed.

> Unconstructed questions allow a respondent to express his/her attitude in a liberated and uninhibited manner.

Non-formalized unconcealed: Some researchers argue that the respondent is not really cognizant of his/her attitude towards certain things. Also, this method asks him to give structured responses to attitudinal statements that essentially express attitudes in a manner that the researcher or experts think is the correct way. This however might not be the way the person thinks. Thus, rather than giving them pre-designed response categories, it is better to give them unstructured questions where he has the freedom of expressing himself the way he wants to. Some examples of these kinds of questions are given below:

1. What has been the reason for the success of the 'lean management drive' that the organization has undertaken? Please specify FIVE most significant reasons according to YOU.

    (a) ____________________
    (b) ____________________
    (c) ____________________
    (d) ____________________
    (e) ____________________

2. Why do you think Maggi noodles are liked by young children?

 ____

3. How do you generally decide on where you are going to invest your money?

 ____

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4. Give THREE reasons why you believe that the Commonwealth 2010 Games have helped the country?

The advantage of the method is that the respondent can respond in any way he/she believes is important. For example, for the last question, some people might respond by stating that it has boosted tourism in the country and contributed to the country's economy. Some might think it will encourage more international events to be held in the country. Some might also state that it is not a good idea and the government should instead be spending on improving the cause of the people who are below the poverty line.

Thus, one gets a comprehensive perspective on what the construct/product/policy means to the population at large; and at the micro level, what it means to people in different segments. The validity of these measures is higher than the previous two. However, quantification is a little tedious and one cannot go beyond frequency and percentages to represent the findings. The other problem is the researcher's bias which might lead to clubbing responses into categories which might not be homogenous in nature.

Non-formalized concealed: If the objective of the research study is to uncover socially unacceptable desires and latent or subconscious and unconscious motivations, the investigator makes use of questions of low structure and disguised purpose. The presumption behind this is that if the argument, the situation or question is ambiguous, it is most likely that the revelation it would result in would be more rich and meaningful. In Chapter 6, there was a discussion on projective techniques; these kinds of questionnaires are designed on the above-stated lines. The major weakness of these types of questionnaires is that being of a low structure, the interpretation required is highly skilled. Cost, time and effort are additional elements which might curtail the use of these techniques. A study conducted to measure to which segment should men's personal care toiletries (especially moisturizers and fairness creams) be targeted, the investigator designed two typical bachelors' shopping lists. One with a number of monthly grocery products as well as the normal male toiletries like shaving blades, gels, shampoos, etc., and the other list had the same grocery products and male toiletries but it had two additional items—Fair and Handsome fairness cream and sensitive skin moisturizer. The list was given to 20 young men to conceptualize/describe the person whose list this is. The answers obtained were as follows:

List with Cream and Moisturizer	**List without Cream and Moisturizer**
65 per cent said this person was good looking	10 per cent said this man was good looking
5 per cent said typical male	39 per cent said 30 plus in age
25 per cent said a 20-year-old	90 per cent said rugged and manly
48 per cent said has a girlfriend	38 per cent said has a girlfriend
46 per cent said has a boyfriend	No one spoke of boyfriend
26 per cent said spendthrift	21 per cent said thrifty
15 per cent said 'girly'	32 per cent said normal Indian male

Thus, as we can see, the normal Indian adult male is still going to take time to include beauty or cosmetic products into his normal personal care basket. Thus, it is wiser for the marketeers to target the younger metrosexual male who is a heavy spender.

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In a schedule, the interviewer reads out each question and makes a note of the respondent's answers.

Another useful way of categorizing questionnaires is on the method of administration. Thus, the questionnaire that has been prepared would necessitate a face-to-face interaction. In this case, the interviewer reads out each question and makes a note of the respondent's answers. This administration is called a *schedule*. It might have a mix of the questionnaire type as described in the section above and might have some structured and some unstructured questions. The investigator might also have a set of additional material like product prototypes or copy of advertisements. The investigator might also have a predetermined set of standardized questions or clarifications , which he can use to ask questions like 'why do you say that?' or 'can you explain this in detail' 'what I mean to ask is…….' The other kind is the *self-administered questionnaire*, where the respondent reads all the instructions and questions on his own and records his own statements or responses. Thus, all the questions and instructions need to be explicit and self-explanatory.

A self-administered qu- estionn- aire saves time, cost and manpower and, thus, it is advisable to use in case of a large sample.

The selection of one over the other depends on certain study prerequisites.

- **Population characteristics:** In case the population is illiterate or unable to write the responses, then one must as a rule use the schedule, as the questionnaire cannot be effectively answered by the subject himself.
- **Population spread:** In case the sample to be studied is large and dispersed, then one needs to use the questionnaire. Also when the resources available for the study, time, cost and manpower are limited, then schedules become expensive to use and it is advisable to use self-administered questionnaire.
- **Study area:** In case one is studying a sensitive topic, like organizational climate or quality of working life, where the presence of an investigator might skew the answers in a more positive direction, then it is better that one uses the questionnaire. However, in case the motives and feelings are not well-developed and structured, one might need to do additional probing and in that case a schedule is better. If the objective is to explore concepts or trace the reaction of the sample population to new ideas and concepts, a schedule is advisable.

There is another categorization that is based upon the mode of administration; this would be discussed in later sections of the chapter.

Questionnaire Design Procedure

In the earlier section, the researcher must have understood the great advantage he has in case he uses a questionnaire for his research purpose. However, one of the most difficult steps in the entire research process is designing a well-structured instrument. A number of scholars have attempted to create structured and sequential guidelines to be used by a researcher, no matter what his/her interest area. While not following any

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particular school of thought, presented below is a standardized process that a researcher can follow.

These, of course, might need to be modified depending upon the objectives of research. The steps are indicative of what one needs to accomplish, however, the final document that emerges and the effectiveness of the measure in extracting the study-related information, depends entirely upon the individual understanding of the researcher to be able to:

- Effectively and comprehensively list out the research information areas.
- Convert these into meaningful research questions.
- Understand and use the language of the respondent.

> The steps involved in the questionnaire design procedure are not independent. In the actual conduction, there might be a simultaneous involvement of some.

The steps involved in designing a questionnaire are as follows (see Figure 1): (1) Convert the research objectives into the information needed, (2) Method of administering the questionnaire, (3) Content of the questions, (4) Motivating the respondent to answer, (5) Determining the type of questions, (6) Question design criteria, (7) Determine the questionnaire structure, (8) Physical presentation of the questionnaire, (9) Pilot testing the questionnaire, (10) Standardizing the questionnaire.

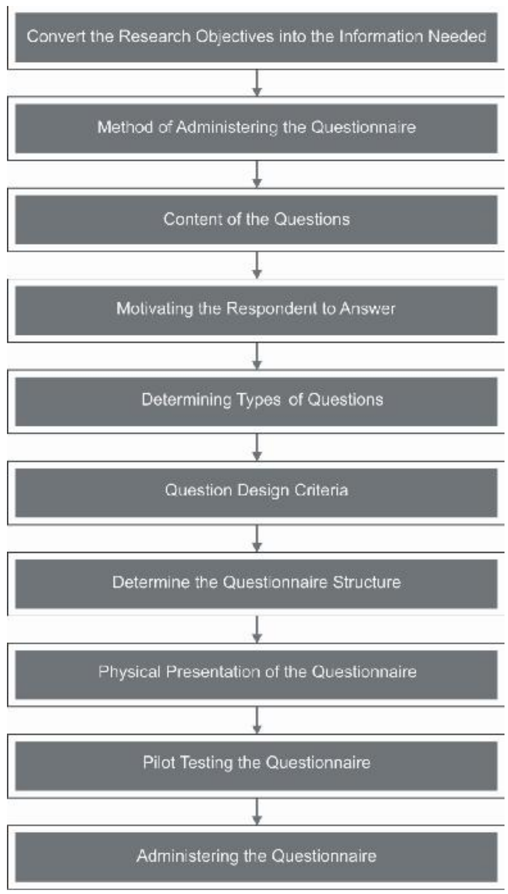

Fig. 1 *Questionaire Design Process*

Each of these would be discussed and illustrated in this section. The researcher needs to remember that these are not independent steps, where one needs to finish the first one to go on to the next one and so on. In the actual conduction, there might be a simultaneous conduction of some and one might not be able to draw clear cut boundaries between them. Also at times, the researcher might have to backtrack and modify an earlier task that he might have carried out.

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Convert the research objectives into information areas: This is the first step of the design process. As stated in the flowchart, this is the most critical stage and the researcher/investigator is assumed to have done considerable exploratory work to have crystallized objectives of the study. This is also the stage that requires formation of the research design of the study. Thus, by this stage one assumes that one has achieved the following tasks:

- Spelt out clearly the specific research questions that the study will address.
- Converted these questions into statements of objectives.
- Operationalized the variables to be studied, i.e., the variables under study should have been clearly defined.
- Identified the direction of the relation or any other assumption one makes about the variables under study in the form of a hypothesis.
- Specified the information needed for the study, in this case one will look at the information needed from the primary data source.

Once these tasks are accomplished, one can prepare a tabled framework so that the questions which need to be developed become clear.

By this time, the respondent would have also developed a clear idea about the group that he would need to study. Thus, the characteristics of the population which might impact the constructs under study would also need to be studied in order to frame appropriate questions on these. At this stage, it might emerge that one needs to design separate questionnaires for the populations whose inputs are important, or have separate set of questions for those with different stands on the stated criteria. This stepwise process is explained in Table 2.

Table 2 *Framework for Identifying Needs*

Research Questions	Research Objectives	Variables to be Studied	Information (Primary Required)	Population to be Studied
What is the nature of plastic bag usage amongst people in the NCR (National Capital Region)?	To identify the different uses of plastic bags. To find out the method of disposal of plastic bags. To find out who uses plastic bags. To find out what is the level of consciousness that people have about the environment.	Usage behaviour Demographic details	Uses of plastic bags Disposal of plastic bags	Consumers Retailers
What is the level of environment consciousness amongst them?	To find out whether they understand how plastic bags can be harmful to the environment. To identify strategies to discontinue plastic bag usage.	Environmental consciousness. Effect of plastic bag usage	Respondent attitudes and perceptions towards the environment Perception about the impact of plastic bags on the environment	Consumer Retailer
What measures can be taken to encourage people not to use plastic bags?		Corporation laws (if any) Attitudinal change strategies	Indicative measures for encouraging the general public to discontinue use of plastic bags	Policy maker Consumer Retailer

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Method of administration: Once the researcher has identified his information area; he needs to specify how the information should be collected. The researcher usually has available to him a variety of methods for administering the study. The main methods are personal schedule self-administered questionnaire through mail, fax, e-mail and web-based. There are different preconditions for using one method over the other. Also once the decision has been taken about the method, one also needs to design different ways of asking the required information. Table 3 gives a template the researcher can use to take his administration decision and the kind of questions he must ask. As can be seen, a larger population can be covered by mail or fax. In case the population to be studied is computer literate, it is possible to use e-mail or web-designed surveys.

For a smaller population and more complex or sensitive issues, personal schedule is advisable. In computer-assisted dissemination (CAPI and CATI), complex skip and branching options are possible and randomization of questions to eliminate the order bias can be carried out with considerable ease. When the researcher wants to have a higher control over the way the questions are answered, i.e., the sequence and response time for answering, he should be using the schedule. By sampling control we mean who answers the questions. When one is interested in the decision maker's thought process and purchase process, one would not like to go to those users who might not always be the buyers, for example the housewife buying toothpaste for a toothpaste evaluation study is the respondent and not her son who might be using the toothpaste but who is, definitely, not the buyer. Sampling control, as we can see, is highest in schedule and lowest in a Web-based survey.

Table 3 *Mode of Administration and Design Implications*

	Schedule	**Telephone**	**Mail/Fax**	**E-mail**	**Web-Based**
Administrative control	high	medium	Low	low	low
Sensitive issues	high	medium	Low	low	low
New concept	high	medium	Low	low	low
Large sample	low	low	High	high	high
Cost/time taken	high	medium	Medium	low	low
Question structure	unstructured	either	structured	structured	structured
Sampling control	high	high	Medium	low	low
Response rate	high	high	Low	medium	low
Interviewer bias	high	high	low	low	low

As the researcher proceeds from one administration mode to another, the question structure and instructions change. The major reason for this is the presence or absence of the investigator. This has been illustrated in the example below.

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Administration Mode and Question Structure

Schedule

Now I am going to give you a set of cards. Each card will have the name of one television serial (*Handover the cards to the respondent in a random order).* I want you to examine them carefully (*give her some time to read all the names)*. I would request you to hand over the card which has the name of the serial you like to watch the most. (*Record the serial and keep this card with you*). Now, of the remaining nine serials, name your next most favourite serial (*continue the same process till the person is left with the last card)*

	TV serial	Rank Order
1.	1	________________
2.	2	________________
3.	3	________________
4.	4	________________
5.	5	________________
6.	6	________________
7.	7	________________
8.	8	________________
9.	9	________________
10.	10	________________

Telephone Questionnaire

Please listen very carefully; I am going to slowly read the names of ten popular TV serials. I want to know how much you prefer watching them. You need to use a 1 to 10 scale, where 1 means—I do not like watching it—and 10 means—I really like watching it. For those in between you may choose any number between 1 to 10. However, please remember that the higher the number, the more you like watching it. Now, I am going to name the serials one by one. In case the name is not clear, I will repeat the list again. So, the serial's name is __________. Please use a number between 1 to 10 as I had told you. Ok thank you, the next name is __________. And so on till all the 10 names have been read out and evaluated.

	Serial										
1.	*Balika Badhu*	1	2	3	4	5	6	7	8	9	10
2.	*Sathiya*	1	2	3	4	5	6	7	8	9	10
3.	*Sasural Genda Phool*	1	2	3	4	5	6	7	8	9	10
4.	*Bidai*	1	2	3	4	5	6	7	8	9	10
5.	*Pathshala*	1	2	3	4	5	6	7	8	9	10
6.	*Bandini*	1	2	3	4	5	6	7	8	9	10
7.	*Lapataganj*	1	2	3	4	5	6	7	8	9	10
8.	*Sajan Ghar Jaana Hai*	1	2	3	4	5	6	7	8	9	10
9.	*Tere Liye*	1	2	3	4	5	6	7	8	9	10
10.	*Uttaran*	1	2	3	4	5	6	7	8	9	10

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Mail Questionnaire

In the next question you will find the names of ten popular Hindi serials that are being aired on television these days. You are requested to rank them in order of your preference. Start by identifying the serial which is your most favourite, to this you may give a rank of 1. Then from the rest of the nine, pick the second most preferred serial and give it a rank of 2. Please carry out this process till you have ranked all 10. The one you prefer the least should have a score of 10. You are also requested not to give two serials the same rank. The basis on which you decide to rank the serials is entirely dependent upon you. Once again, you are asked to rank all the 10 serials.

	Serial	**Rank Order**
1.	*Balika Badhu*	________________
2.	*Sathiya*	________________
3.	*Sasural Genda Phool*	________________
4.	*Bidai*	________________
5.	*Pathshala*	________________
6.	*Bandini*	________________
7.	*Lapataganj*	________________
8.	*Sajan Ghar Jaana Hai*	________________
9.	*Tere Liye*	________________
10.	*Uttaran*	________________

The pattern of instructions and the response structure for fax, e-mail and web surveys are similar. Thus, they have not been shown here separately.

Given the fact that the time of a respondent is precious, unless a question is adding to the data required for reaching an answer to the formulated problem it should not be included.

Content of the questionnaire: The next step, once the information needs and mode of administration has been decided, is to determine the matter to be included as questions in the measure. The decision to include or not include certain questions depends upon a certain criteria. Thus, the researcher needs to subject the questions designed by him to an objective quality check in order to ascertain what research objective/information need the question would be covering before using any of the framed questions.

How essential is it to ask the question? In the course of the research study, the researcher might formulate a number of questions which he thinks address the information needs of the study. Sometimes the researcher might find a particular question very intriguing or interesting and thus might decide to include it in the questionnaire. However, one needs to remember that the time of the respondent is precious and it should not be wasted. Unless a question is adding to the data required for reaching an answer to the formulated problem, it should not be included. For example, if one is studying the usage of plastic bags, then demographic questions on age group, occupation, education and

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gender might make sense but questions related to marital status, family size and the state to which the respondent belongs are not required as they have no direct relation with the usage or attitude towards plastic bags.

Sometimes, to gauge the information needs, the researcher might have to ask multiple questions, even though they might not seem to be related directly to the research objective. For example, instead of asking shopkeepers, who own a shop in a shopping centre, whether they would in the near future open an outlet in a mall, a set of questions were asked to understand the retailers' perception of shopping trends.

Please indicate your level of agreement with the following statements:

SA – Strongly Agree; A – Agree; N – Neutral; D – Disagree; SD – Strongly Disagree

	Compared to the Past (5-10 years)	**SA**	**A**	**N**	**D**	**SD**
1	The individual customer today shops more					
2	The consumer is well-informed about market offerings					
3	The consumer knows what he/she wants to buy before he enters the store					
4	The consumer today has more money to spend					
5	There are more shopping options available to the consumer today					

There are also times, especially in self-administered questionnaires, when one may ask some neutral questions at the beginning of the questionnaire to establish an involvement and rapport. For example, for a biofertilizer usage study, the following question was asked:

Farming for you is a:

Noble profession

Ancestral profession

Profession like any other

Profession that is not lucrative

Any other

Camouflaged or disguised questions are asked sometimes to keep the purpose or sponsorship of the project hidden. Here generally, what the researcher does is that rather than ask questions only with reference to the company/brand one is interested in, there might be questions related to a set of brand names in the product category. For example, in a survey done on power drinks carried out by Gatorade, one might also have questions related to Powerade and Red Bull. Similar questions might be kept at different points in the study to assess the consistency of the respondent in answering. Questions like these add to the reliability of the scale.

Do we need to ask several questions instead of a single one? After deciding on the significance of the question, one needs to ascertain whether a single question will serve the purpose or should more than one question be asked. For example, in the TV serial study, assume that the second question after the ranking/rating question is:

'Why do you like the serial __________ (the one you ranked No. 1/prefer watching most)?'

(Incorrect)

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Here, one lady might say, 'Everyone in my family watches it'. While another might say, 'It deals with the problems of living in a typical Indian joint family system' and yet another might say, 'My friend recommended it to me'. The first relates to joint decision-making by the family, the second relates to an attribute of the programme, while the third tells us what the information source was for her.

Thus, we need to ask her:

'What do you like about__________?'

'Who all in your household watch the serial?'

and

'How did you first hear about the serial?'

(Correct)

> The questionnaire should be so designed as to stimulate the respondent to give comprehensive information re- garding a particular topic under study.

Motivating the respondent to answer: The one thing the researcher must remember is that answering the questionnaire requires some effort on the part of the respondent. Thus, the questionnaire should be designed in a manner that it involves the respondent and motivates him/her to give comprehensive information. There might be two kinds of hindrances to active participation by the subject:

- The respondent might not be able to respond in the right manner.
- The respondent might be unwilling to part with the information.

We will discuss these situations and also understand how these need to be overcome, in order to be able to collect the data.

> Qualifying or filter questions measure the experience or knowledge of a respondent about the concerned research topic and, thus, save time.

Assisting the respondent to provide the required information: There are three kinds of situations which might lead to inability to answer in a correct manner. Each of these is examined separately here:

Does the person have the required information? It has been found that once the respondents get into the rhythm of answering the questions, they answer questions even when they do not understand or have information about the construct being investigated. This is not because they are inherently dishonest; it is simply the result of confusion. For example, a young man whose personal care products are bought by his mother will not have any knowledge about the purchase process and decision. Yet, if asked, he will answer them based on his general understanding of the process.

Another situation might be when the person has had no experience with the issue being investigated. Look at the following question:

How do you evaluate the negotiation skills module, viz., the communication and presentation skill module?

(Incorrect)

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In this case it might be that the person has not undergone one or even both the modules, so how can he compare? Thus, in situations where not all the respondents are likely to be informed about the research topic, certain qualifying or *filter questions* that measure the experience or knowledge must be asked before the questions about the topics themselves. Filter questions enable the researcher to filter out the respondents who are not adequately informed. Thus, the correct question would have been:

Have you been through the following training modules?

- Negotiation skills module Yes/no
- Communication and presentation skills Yes/no

In case the answer to both is yes, please answer the following question, or else move to the next question.

How do you evaluate the negotiation skills module, viz., the communication and presentation skill module?

(Correct)

Does the person remember? Many a times, the question addressed might be putting too much stress on an individual's memory. All of us know that human memory might be short and yet sometimes while designing the questionnaire, one overlooks this. For example, consider the following questions:

How much did you spend on eating out last month?

(Incorrect)

How many questions do you ask in a recruitment interview?

(Incorrect)

As one can see, such questions far surpass any normal individual's memory bank. There have been a number of studies to demonstrate that people are generally not very good at remembering quantities. Usually, people forget significant events like birthdays or anniversaries. However, generally this is more related to pleasant days rather than days like accident days or theft or even death anniversaries. Secondly, there is an element of the most recent to remembering, Thus, the employee will be able to better evaluate a training module that he attended last than those he attended in the whole year. A person remembers his recent big purchase details more than the last four major purchases.

Aided recall refers to the triggers which give a cue to the respondent so as to stimulate the memory and extract some forgotten material.

Forgotten material can be drawn out by giving cues to stimulate the memory. These triggers are termed as *aided recall*. For example, unaided recall of TV serials could be measured by questions such as follows, 'Which TV serials did you watch last week?' The aided recall approach on the other hand would assist in recall by giving a list of serials aired in the last week and then ask. 'Which of these serials did you watch last week?'

Thus, the questions listed above could have been rephrased as follows:

When you go out to eat, on an average your bill amount is:

Less than ₹ 100

₹ 101–250

₹ 251–500

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More than ₹ 500

How often do you eat out in a week?

1–2 times.

3–4 times

5–6 times

Everyday (Correct)

From the following, tick the areas on which you ask questions in a typical recruitment interview:

Educational background

Subject knowledge

Previous experience

General awareness

Individual information

Once the respondent ticks the relevant areas, then a number of questions from the indicated areas are asked. It is also possible to use the constant sum scale to indicate the percentage of questions asked from the area, so that the total adds up to 100 per cent.

Can the respondent articulate? The articulation does not refer to only enlisting the response. It also refers to not knowing what words to be used to articulate certain types of answers. For example, if you ask a respondent to:

- Describe a river rafting experience.
- The ambience of the new Levi's outlet. (Incorrect)

Most respondents would not know what phrases to use to give an answer. On the other hand, if the researcher uses a Semantic differential scale, the respondent can be provided adjectives to choose from. It must be remembered that if the person does not know what words to use or finds the task of description too tedious, the person will not fill in the answers. Thus, in the above case, one can provide answer categories to the person as follows:

Describe the river rafting experience. (Correct)

1	Unexciting		Exciting
2	Bad		Good
3	Boring		Interesting
4	Cheap		Expensive
5	Safe		Dangerous

Assisting the respondent to answer: This is the second reason for not answering a question. It might happen that the person understands the question and also knows the answer, yet he is not willing to part with the information. We will discuss the situations which might result in this scenario.

At times, the respondent is not ready to part with the information as the perspective is not clear. Hence, the questions asked should possess face validity.

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The perspective is not clear: The questions that are being asked must possess face validity, i.e., they must not appear to be out of context with the other questions in the survey. Thus, a questionnaire which is measuring a person's quality of working life and poses questions as below will not be appreciated as the questions will seem to be suspicious and might be perceived as having a hidden agenda.

How many credit cards do you own?

When did you last go on a holiday?

How many movies do you watch in a fortnight?

People are not willing to answer questions they think do not make sense. Respondents are also hesitant about sharing personal demographic data such as age, income, and profession. Thus, the purpose of asking such questions has to be made explicit in the instructional note.

Thus, in the previous example, the researcher can justify that a spillover of a healthy quality of working life is also reflected in a person's way of living. Thus, we would like to know how you live.

In the second case of demographic data details, stating that 'We would like to determine which TV serials are preferred by people of different ages, incomes and professions, we need information on ...', will put the respondent at ease when sharing the data.

Sensitive information: There might be instances when the question being asked might be embarrassing to the respondents and thus they would not be comfortable in disclosing the data required. Sometimes, this might diminish the respondent's willingness to respond to the other questions as well. These topics could be related to income, family life, politi- cal and religious beliefs, and socially undesirable habits and desires. A number of techniques are available to reduce the respondent's hesitation.

- Make a generic statement to soothe the anxieties and state that 'these days most women consume alcoholic drinks at social gatherings, followed by a question on alcohol consumption. This technique is called *counter biasing.*
- Place the sensitive question in between some seemingly neutral questions and then ask the questions at a rapid speed.
- The best way to get answers on sensitive issues is to use *the third-person technique* and ask the question as related to other people.

For example, questions, such as the following will not get any answers.

Have you ever used fake receipts to claim your medical allowance?

(Incorrect)

Have you ever spit tobacco on the road (to tobacco consumers)?

(Incorrect)

However, in case the socially undesirable habit is in the context of a third person, the chances of getting indicative correct responses are possible. Thus the questions should be rephrased as follows:

Do you associate with people who use fake receipts to claim their medical allowance?

(Correct)

Do you think tobacco consumers spit tobacco on the road? (Correct)

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- For certain demographic questions like income and age, instead of using the ratio scale one must use class intervals:

  'What is your household's annual income?'

  (Incorrect)

  'What is your household's annual income?'

  Under ₹ 25,000,

  ₹ 25,001–50,000,

  ₹ 50,001–75,000,

  Over ₹ 75,000. (Correct)

- For sensitive issues as stated earlier, it is much better to use unstructured questions and probe only after the respondent is comfortable with the investigator.

Determining the type of questions

After deciding on the necessity of questions and the mode of administration, the researcher comes to taking a decision on the response categories. The essential difference is whether the response options would be given to the respondent or will they be left open to be completed in the respondent's own words. In this section we will begin by first discussing the open and then the closed-ended questions. The closed-ended, as can be seen in Figure 2, can be further divided into different types. These will be discussed in the later section.

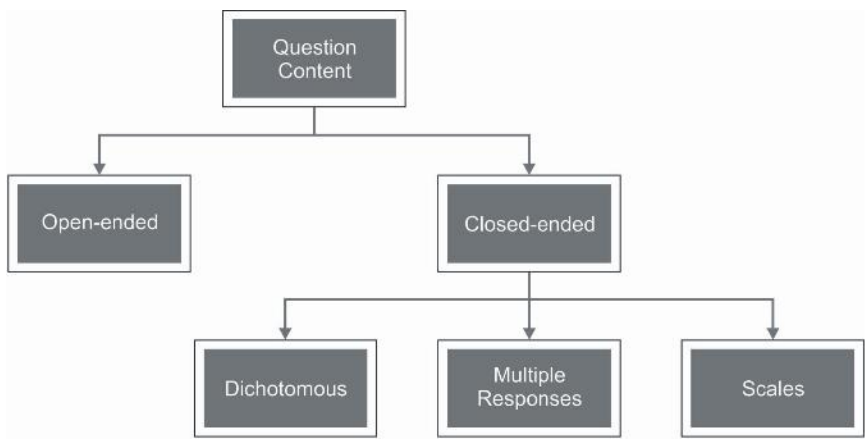

Fig. 2 *Types of Question Response Options*

Open-ended questions

These are termed as open-ended, but the openness refers to the option of responding in one's own words. They are also referred to as unstructured questions or free-response or free-answer questions. The researcher suggests no alternatives. Thus the words, logic and structure that a person would give while filling the answers is totally left to his discretion. Some illustrations of this type are listed below:

- What is your age?
- How would you evaluate the work done by the present government?
- How much orange juice does this bottle contain?
- What is your reaction to this new custard powder?
- Why do you smoke Gold Flakes cigarettes?

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- Which is your favourite TV serial?
- What training programme did you last attend?
- With whom in your work group do you interact with after office hours?
- How do you decide on the instrument in which you are going to invest?
- I like Nescafe because ________________________
- My career goal is to ________________________
- I think hybrid cars are ________________________

> **Open-ended Questions** are unstructured. Thus, the words, logic and structure are provided by a respondent and not the researcher.

The last three, as can be seen, are in a statement form while the first few are in question form. For the second and sixth question, the person would need to spend more time and the answer might have multiple components, while the others would be one word or one liner (last three).

Open-ended questions can typically be used for three reasons. First, they can be used in the beginning to start the questioning process. For example, a questionnaire on investment behaviour could begin with:

How do you think people manage their savings?

This puts the respondent into the frame of answering investment-related questions. Yet, as can be seen, the question is in third person and, thus, is non-threatening.

Open-ended questions can also be used as probing or clarifying questions to understand the reason behind certain responses.

For example:

Why do you feel that way?

Thirdly, they can be used in the end as suggestions or final opinion.

For example:

'Any suggestion you would like to give in terms of improving the quality of the working life in your organization __________.'

These questions have the inherent advantage of improving the validity of the construct being studied. Also, they are not restrictive and the respondents are free to express any views. The observations and justifications can provide the researcher with valuable interpretative material. However, the interpretation and evaluation of the answers are open to the investigator's bias. This is especially the case with schedules, where the researcher might not record the exact words but what he interprets as what the person wants to convey.

Coding or categorizing the written responses for open-ended question is expensive both in terms of time as well as finances.

Open-ended questions are also dependent upon the respondent's skill to articulate well. Secondly, they are more suited to face-to-face interactions rather than the self-administered type, where there are chances of misinterpretation or a complete non-response as well.

However, despite the problems listed above, they are still recognized as rich and versatile sources of data collection. Proponents of the format have created a number of ways that subjectivity on the part of the researcher and effort on the part of the respondent can be greatly reduced.

Closed-ended questions

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In these questions, both the question and response formats are structured and defined. The respondent only needs to select the option(s) that he feels are expressive of his opinion. There are three kinds of formats as we observed earlier—dichotomous questions, multiple–choice questions and those that have a scaled response.

> Dichotomous questions have restrictive alternatives and provide the respondents only with two options.

1. **Dichotomous questions:** These are restrictive alternatives and provide the respondents only with two answers. These could be 'yes' or 'no', like or dislike, similar or different, married or unmarried, etc.

Are you diabetic?	Yes/No
Have you read the new book by Dan Brown?	Yes/No
What kind of petrol do you use in your car?	Normal/Premium
What kind of cola do you drink?	Normal/Diet
Your working hours in the organization are?	Fixed/Flexible

   The first two questions are monotonic in nature in the sense they study only the presence and absence; while the others present two distinctly different alternatives. The problem with these situations is that these are forced choices and one needs to select one of them. Sometimes they might be complemented by a neutral alternative, such as 'no opinion,' 'do not know,' 'both' or 'none.' Thus, the dilemma is whether to include a neutral response alternative. If there are only two choices, he is forced to take a stand even when he has no opinion on either or he is uncertain about the two options. However, the problem with the neutral category is that most respondents want to avoid taking a stand and use it as an escape, thus the researcher does not get any meaningful number for or against the issue under study. It is advisable not to force the issue in case a substantial number of people might have an in-between stand. For example, for the cola question, there might be a large number of people who drink both, thus the option of 'both' should be provided. If the ratio of neutral respondents is expected to be small, then it should be avoided as in the following case:

   Who do you think will win the next Wimbledon men's single championship?

   Roger Federer ___________

   Rafael Nadal ___________

   Neither ___________

   Dichotomous questions are the easiest type of questions to code and analyse. They are constructed on the nominal level of measurement and are categorical or binary in nature. A disadvantage of the method is that the wording of the question might result in different answers. For example, the two questions asked at different places in a questionnaire were as follows:

Do you think management schools should permit laptops in class? Yes/No

Do you think management schools should forbid laptops in class? Yes/No

(Incorrect)

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For the first question, there were 56 per cent who said 'should not permit'. Essentially speaking, both the questions are identical and should give the same results. But it was found that 39 per cent of the same respondents said yes. To deal with this problem, it is suggested that the question should have both the options indicated in the question, for example:

Management schools should permit or forbid the use of laptops in class?

Permit/Forbid

Another disadvantage of the method is that the simple binary response might be reflective of the current stand, but need not reflect what the person intends to do at a later date or when given some other factors. For example, two people might say that they are not going to buy the Nano in the next six months. But one might change his stand in case he has the resources to do so, let's say when he gets a bonus , while the other might be waiting for the car to get good performance ratings before taking a decision. Thus, a simple yes /no would not capture the reply; rather a question with multiple choice responses would result in better answers.

2. **Multiple choice questions:** Unlike dichotomous questions, the person is given a number of response alternatives here. He might be asked to choose the one that is most applicable. For example, this question was given to a retailer who is currently not selling organic food products:

Will you consider selling organic food products in your store?

- Definitely not in the next one year
- Probably not in the next one year
- Undecided
- Probably in the next one year
- Definitely in the next one year

Sometimes, multiple choice questions do not have verbal but rather numerical options for the respondent to choose from, for example:

How much do you spend on grocery products (average in one month)?

Less than '2500/-

Between '2500–5000/-

More than '5000/-

Most multiple choice questions are based upon ordinal or interval level of measurement. However, in instances like the one discussed below, the answers are on a nominal level. This is because each alternative selected is evaluated as a categorical variable having a Yes or No answer.

> In certain instances, when multiple options are given to a respondent, he can select all those that apply in that case. This is called checklist.

There could also be instances when multiple options are given to the respondent and he can select all those that apply in the case. These kinds of multiple choice questions are called checklists. These are what has been earlier in the chapter termed as cues, as sometimes it is difficult to verbalize all the possible answers/

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reasons for the response given. For example, in the organic food study, the retailer who does not stock organic products was given multiple reasons as follows:

You do not currently sell organic food products because (Could be ≥ 1)

- You do not know about organic food products.
- You are not interested.
- You are interested but you do not know how to procure them.
- It is not profitable.
- The customer demand is too low.
- Organic products do not have attractive packaging.
- The product is too expensive for the typical customer who frequents your store.
- They have a poor shelf life.
- Organic food products are not supplied regularly.
- Any other ___________________________

Most of the issues discussed with reference to itemized rating scales. There are some additional concerns, with reference to multiple choice questions, which deserve a special mention here.

The response options given to the respondents should be exhaustive. Secondly, the answers should be mutually exclusive and should be constructed in a manner that there is no scope for any overlap between the categories. The general practice in a good research study is to draw out these alternatives through the exploratory study done preceding the questionnaire. Here, depth interviews or focus group discussions might provide a set of all the possible choices. However, as a practice, the researcher must still have an open-ended 'any other' to cover contingencies (as can be seen from the example above).

As we have seen in the above two examples, the response(s) to be made differs in the two situation. In one there is only one choice that is to be indicated, while the other can have the person choosing multiple options. Thus, the instructions must be separately mentioned, in bold or should be highlighted so that the respondent knows what is required. This caution is especially necessary in self-administered questionnaires.

As mentioned earlier, the list of alternatives should be exhaustive and not tedious. This is because in case there are too many options, the task of evaluating them becomes difficult. In case the researcher is getting the responses through a schedule, it is advisable to use response cards with alternatives separately printed on each (as was the case with the name of the ten TV serials mentioned in an earlier example). In case this is a self-administered instrument, then the investigator could consider splitting the question into two and dividing the options to be processed for a single question.

> Order of position or location bias can be managed in a schedule by shuffled response cards so that each respondent receives a differently numbered set.

A number of studies have been done on the impact of the position of alternatives on the selection process. This is termed as the *order of position or location*

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bias, i.e., a person's predisposition to select an option simply because it is placed in a particular place or order. The tendency is that when there are statements of intent or opinion, people usually pick up the first option (*primacy effect*) and sometimes the last (*recency effect*) as the one that applies. This can be managed in the schedule by shuffling and presenting the response cards so that for some respondents it comes first, for some in the end and for others, somewhere in between. This is not possible in mailed questionnaires unless multiple sets with shuffled response options are printed. This can be, however, managed in a web survey.

This order bias is somewhat different in case of numbers (quantities or prices) where there is a bias toward the central position on the list. This can also be managed in the same way as the statement options.

Multiple choice questions can effectively cancel the researcher's bias that was inherent in the open-ended questions. Secondly, since they have pre-designed response options that require the person to pick one or all that apply, the administration is much faster. Data processing for these questions is much easier, as is quantification and analysis of the information collected.

Administering them might be easier, but designing exhaustive multiple choice questions is a challenge. As stated earlier, the researcher will have to do an exploratory study to uncover possible alternatives or conduct an extensive secondary data analysis to identify the alternatives. The other problem is that though one includes an 'any other' option, most respondents play it safe and pick up one or few from the listed options only. Thus, the answers are restricted only to the predetermined set.

3. **Scales:** Scales refer to the attitudinal scales.

Since these questions have been discussed in detail in the earlier chapter, we will only illustrate this with an example. The following is a question which has five sub-questions designed on the Likert scale. These require simple agreement and disagreement on the part of the respondent. This scale is based on the interval level of measurement.

Given below are statements related to your organization. Please indicate your agreement/disagreement with each:

(1-Strongly Disagree ì = ì = ì = ì 5 Strongly Agree)	**1**	**2**	**3**	**4**	**5**
1. The people in my company know their roles very clearly.					
2. I want to complete my current task by hook or by crook.					
3. Existing systems are very effective.					
4. I feel the need for the organization to change.					
5. Top management is committed to long-term vision of creating value for organization.					

In the same questionnaire, depending upon the information need, one can use multiple questions that have been designed on different scales.

The advantage with these scaled questions is that they are easy to administer, no matter what be the mode. The other advantage is that coding and tabulating these questions is not difficult. Since the questions have been formulated by assigning

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numerical values to response categories, the quantification of subjective variables and attitudes becomes possible.

However, devising the questions so that they cover the construct under study, requires considerable effort, like the multiple choice questions. In case the respondent has an additional perspective, it is not possible to extract it.

Criteria for question designing

Step six of the questionnaire involves translating the questions identified into meaningful questions. Utmost care is needed to word the questioning, in a manner that the question is clear and easy to understand by the respondent. A confusing question or a poorly-worded question might result in either no response or a wrong response. Both of these arThere are certain designing criteria that a researcher should adhere to when writing the research questions. We will illustrate and discuss these individually.

> Quality check involves that the question formulated must clearly specify the issue concerned.

Clearly specify the issue: By reading the question, the person should be able to clearly understand the information need. To understand quality check, we can use the same template that the trainee newspaper journalists are advised to keep in mind while creating their first copy: namely, who, what, when, where, why, and how. The first four are applicable to all questions, the 'why' and 'how' might apply to some.

Which newspaper do you read? (Incorrect)

This might seem to be a well-defined and structured question. However, let us examine it carefully. The 'who' in this case could be the person filling in the questionnaire or it could be what he reads by virtue of the newspaper purchased by his family. The 'what' in this case is the newspaper being read. But what if the person reads more than one newspaper. Should he talk about the regular newspaper he reads, or the one he reads for business news, or the one he reads on weekends or the one he prefers to read most? The 'when' is not apparent as it could be stated as the one read on weekdays, weekends or the one he used to read earlier? The 'where' seems to be at home but is not apparent, as he could be reading the newspaper in the college library as well. A better way to word the ques- tion would be:

Which newspaper or newspapers did you personally read at home during the last month?

In case of more than one newspaper, please list all that you read. (Correct)

> Inclusion of technical words which are not used in everyday communication must be avoi- ded. The language should be understandable.

Use simple terminology: The researcher must take care to ask questions in a language that is understood by the population under study. Technical words or difficult words that are not used in everyday communication must be avoided. Most people do not understand them, thus it is advisable to stay simple. For example, instead of asking '*Do you think the distribution of Mother Dairy ice cream is adequate?'* ask: *'Do you think Mother Dairy ice cream is readily available when you want to buy it?*'

Do you think thermal wear provides immunity? (Incorrect)

Do you think that thermal wear provides you protection from the cold? (Correct)

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Sometimes words that are used might have a different meaning either in the local dialect or as a phrase. For example, a simple question like, '*When did you go to town?*' (incorrect)might get you the answer of the person's last visit to town or it may be taken as 'go to town' (go crazy or mad) and would be regarded as an insult. Thus the question can be rephrased as:

When did you last visit the town? (Correct)

Avoid ambiguity in questioning: The words used in the questionnaire should mean the same thing to all those answering the questionnaire. A lot of words are subjective and relative in meaning. Consider the following question:

How often do you visit Pizza Hut?

Never

Occasionally

Sometimes

Often

Regularly (Incorrect)

These are ambiguous measures, as *occasionally* in the above question, might be three to four times in a week for one person it, while for another it could be three times in a month. Three youngsters who visit Pizza Hut once a month may check three different categories: occasionally, sometimes, and often. A much better wording for this question would be the following:

In a typical month, how often do you visit Pizza Hut?

Less than once

1 or 2 times

3 or 4 times

More than 4 times (Correct)

These responses are giving definite numbers and thus there is no chance of the person misunderstanding the words. Some questions use ambiguous words in the question itself. For example,

Do you download music regularly from LimeWire? Yes/No (Incorrect)

Here, the word 'regularly' can mean different numbers to different people. Thus, rather than a dichotomous question, it is advisable to rephrase it as follows:

How often do you down load from LimeWire?

Once a week

2–3 times in a week

4–5 times in a week

Every day (Correct)

Followed by the question:

On an average, for how many hours do you download in a single sitting?

Less than an hour

1 to 3 hours

3 ½ to 5 hours

More than 5 hours (Correct)

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Leading questions provide a clue for the 'good' answer.

Avoid leading questions: Any question that provides a clue to the respondents in terms of the direction in which one wants them to answer is called a leading or biasing question. For example, '*Do you think that working mothers should buy ready-to-eat food when that might contain some chemical preservatives*?

Yes

No

Don't know (Incorrect)

The question would mostly generate a negative answer, as no working mother would like to buy something that is convenient but might be harmful. Thus, it is advisable to construct a neutral question as follows:

Do you think that working mothers should buy ready-to-eat food?

Yes

No

Don't know (Correct)

Even questions such as the following are suggestive in nature.

How long was the class session? Or how short was the class session? (Incorrect)

The individual, in this case, is reacting to short or long as the reference point. Thus, for the same class for the first question, the respondents said about 120 minutes and for the second, 90 minutes. Thus, we can use a measure in this kind of question and the question can be framed as follows:

For how many minutes did the class session run? (Correct)

A skewed response may also result if the name of the organization/brand is included in the question. Most respondents tend to be agreeable and would respond positively. For example, The question, '*Is Harvest Gold your favourite bread?*' is likely to bias the answers towards Harvest Gold. A better way to obtain the answers would be to ask, '*What is your favourite bread brand?*'

Similarly, quoting a reputed body or an expert like the Indian Medical Association certifies that…… can also bias the reply. In fact, even an ambiguous reference such as the one in the following example:

Industry experts think that flexible working hours positively affect work-life balance.' What is your opinion?

(Incorrect)

Here there are two leads—'industry experts' and 'positively affect'. A better way of questioning the respondent would be:

What is the relation between flexi working hours and work-life balance?

No relation

Positively related

Negatively related

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Avoid loaded questions: Questions that address sensitive issues are termed as loaded questions and the response to these questions might not always be honest, as the person might not wish to admit the answer, even when assured about his anonymity. For example, Questions such as follows will rarely get an affirmative answer:

Have you ever cheated on your spouse? (Incorrect)

Will you take dowry when you get married? (Incorrect)

Do you think your boss/supervisor is incompetent? (Incorrect)

Sensitive questions like this can be rephrased and camouflaged in a variety of ways as discussed earlier. For example, the first two questions could be constructed in the context of a third person as follows:

Do you think most people usually cheat on their spouses? (Correct)

Do you think most Indian men would take dowry when they get married?

(Correct)

For the third question, it could be interspersed between a numbers of other questions and the questions can be read out rapidly as follows:

Do you think your friend is incompetent?

Do you think the government is incompetent?

Do you think your juniors are incompetent?

Do you think your driver is incompetent?

Do you think your boss/supervisor is incompetent? (Correct)

Do you think your neighbour is incompetent?

Do you think your mechanic is incompetent?

Avoid implicit choices and assumptions: In case the option being queried is done in isolation and the other alternatives the person might have are hidden, this is referred to as an implicit assumption. Thus, in case other choices are not specified in the response categories, the assumption made about the option being evaluated might not be correct. Consider the following two questions:

Would you prefer to work fixed hours, in a five-day week? (Incorrect)

Would you prefer to work fixed hours, in a five-day week or would you like to have a flexi-time 40 hours week?

(Correct)

In the first question, the preference is being evaluated but the other alternatives against which he needs to do this are only implicit; while in the second question, it is explicit. Thus, the number of people who prefer a fixed schedule would be more realistic in the second case rather than in the first.

Thus, when there are multiple alternatives to the option being investigated, one must clearly spell them out. In case there are multiple alternatives and evaluation becomes difficult, as stated earlier, one may use response cards and ask the person to select from these.

NOTES

The researcher might sometimes frame questions that require the respondent to make some implicit assumptions in order to give an answer. The answer is, thus, a consequence of the assumption made. However, different respondents might make different assumptions, thus, the moderator variable might be different for different individuals, and the assumptions that the researcher wants the respondent to keep in mind while answering the questions should be explicity stated in the question (itself). Examine the following questions:

Are you in favour of the Commonwealth Games 2010 that were held in India?
(Incorrect)

Are you in favour of the Commonwealth Games 2010 that were held in India, if they resulted in increased revenue from tourism?
(Correct)

In the first question, one will make certain assumptions about the impact of the Commonwealth Games and give a positive or a negative answer. This might be an increase in revenue from tourism, it could lead to an improvement in the existing infrastructure, and the surplus generated could be used for the development of the country. On the other hand, the second question is a better way to word this question as here the researcher has included only the moderator variable or the assumption that he believes is most significant.

A double-barrelled question includes two separate options separated usually by 'or' and 'an'. These should be avoided.

Avoid double-barrelled questions: As specified earlier, questions that have two separate options separated by an 'or' or an 'and' are like the following:

Do you think Nokia and Samsung have a wide variety of touch phones?

Yes/No (Incorrect)

The problem is that the respondent might believe that Nokia has better phones or Samsung has better phones or both. These questions are referred to as *double-barrelled* and the researcher should always split them into two separate questions or the question should provide the two as response options. For example, a wide variety of touch phones is available for:

Nokia

Samsung

Both (Correct)

In the context of training needs analysis, consider the question:

Did the training you went through make you feel more motivated and effective in your job?
(Incorrect)

Here, when the answer is 'no', then we do not know whether he is not motivated or whether he is not effective at his job or both. Thus, to obtain the required information, we must split it into separate questions.

Did the training you went through make you feel motivated at your job? and
(Yes/No)

Did the training you went through make you more effective at your job?
(Yes/No) (Correct)

Questionnaire structure

NOTES

Once the researcher has formulated the questions and response options that he intends to use in the questionnaire, the next critical step is to put the questions together in a sequence that is reader/respondent-friendly and generates the required data in a short and effective manner. Thus, most questionnaires follow a standardized sequence of questions.

> Instructions explain the purpose of questionnaire administration and introduce the respondent to the researcher's objective.

Instructions: The questionnaires always, even the schedules, begin with standardized instructions. These begin by greeting the respondent and then introducing the researcher or investigator and the affiliating body. The note then goes on to explain the purpose of questionnaire administration. Sometimes, as in disguised questionnaire format, the sponsoring organization/brand might not be revealed, rather the investigator would talk about the generic brand. For example, in the study on organic food products, the following instructions were given at the beginning of the questionnaire:

'Hi. We __________ are carrying out a market research on the purchase behaviour of grocery products/organic food. We are conducting a survey of consumers, retailers and experts in the NCR for the same.

As you are involved in the purchase and/or consumption of food products, we seek your cooperation for providing the following relevant information for our research. We value your contribution to our research and to the organic community who has been facing the problem in acquiring organic food products. We do appreciate your support and encouragement provided through this information. Thank you very much.'

Even though the study was conducted on behalf of a particular marketer of organic food products , in the instructions the name was not revealed , as this then would be termed as 'leading instructions' that might bias the consumer/respondent in favour of the brand.

In case it is a study done on the employees of an organization for any human resource issue, the researcher must give the correct introduction about himself and in the instructions should reassure by saying 'Please be assured that the study is for an academic purpose and the responses and results would not be shared with any other organization.'

> Simple questions which do not require a lot of thinking or response time should be asked first as they build the tempo for answering the more difficult/sensitive questions later.

Opening questions: Then come the opening questions, these have to be non-threatening and yet lead the respondent to get into the right frame for answering the rest of the questions. For example, a questionnaire on understanding the consumer's buying behaviour in malls, can ask an opening question that is generic in nature, such as:

What is your opinion about shopping at a mall?

Most people like to share their perspective and this gets them into the responding mode and in the direction that the researcher wants. Thus, they serve the purpose of rapport formation even in a self-administered questionnaire.

NOTES

Sometimes, the questionnaire might need to be filled in by people fulfilling a certain criteria. Thus, the first question is a qualifying question and would determine whether the person is eligible to answer the questions and in case the answer is yes, he continues with the responding; else the interview terminates.

Study questions: After the opening questions, the bulk of the instrument needs to be devoted to the main questions that are related to the specific information needs of the study. Here also, as a general rule, one goes from the general questions to the specific ones, following a sequential mode.

Another aspect of the questionnaire is that the simpler questions, which do not require a lot of thinking or response time should be asked first as they build the tempo for answering the more difficult/sensitive questions later on . This method of going in a sequential manner from the general to the specific is called the funnel approach. Like a funnel, the initial set of questions are broad and as one goes along the questions, the answers required become more specific as well as restrictive. There are instances when one might reverse the funnel and start the questioning with the specific questions and leave the general and open-ended questions for the end. Given below is a funnel-shaped questionnaire to assess pizza purchase behaviour.

Illustration: Screening Question

Please indicate whether you have purchased pizzas from (Could be ≥ 1)

☐ Pizza Corner ☐ Nirula's
☐ Pizza Hut ☐ Domino's
☐ Local bakery ☐ any other ___________

(In case respondent has ticked BOTH Domino's and Pizza Hut, continue, else TERMINATE

1. How often do you order pizzas from outside? (Average)
   ☐ Once in 2–3 months ☐ Once a month
   ☐ Once a fortnight ☐ Once a week
   ☐ 2–3 times in a week ☐ Every day
2. How is it purchased? (Could be ≥ 1)
   ☐ Personal visit/take away ☐ Telephone (home delivery)
3. What are the preferred days for ordering the pizza?
   ☐ Week days ☐ Weekends
   Special occasions (Birthday party, guests, festivals)
4. What is generally the time for placing the order?
   ☐ Lunch time ☐ Dinner time
   ☐ Evening ☐ Any time
5. How much is your bill amount? (average)
   ☐ < ₹200 ☐ ₹200–350
   ☐ ₹351–500 ☐ > ₹500

Classification information: This is the information that is related to the basic socio-economic and demographic traits of the person. These might include name (kept optional in some cases), address, e-mail address and telephone number. Sometimes the socio-economic classification grid is presented to the respondent and he indicates by encircling the right choice.

There might be instances when the demographic questions might be asked right in the beginning as they could be the qualifying or screening questions. For example, if the study is to be done on young working mothers living in Delhi, then all these details might need to be taken right in the beginning.

Acknowledgement: The questionnaire ends by acknowledging the inputs of the respondent and thanking him for his cooperation and valuable contribution.

NOTES

Sequential order: The researcher must take care that there is a logical order maintained in the questions that are asked. A set of questions related to a particular area of investigation must be asked first before moving on to the next. In cases where one needs to go back to the earlier answers, then there must be triggers like 'In question _________ you had mentioned what is important for you when you buy a laptop; now I would request you to kindly evaluate the following brands on the features considered important by you _________.'

> Branching questions cover all the possibilities and they re- quire careful formulation and inclusion in the questionnaire format.

Sometimes, the set of questions that are to be asked are dependent on the answer that a particular person gives and there are different possibilities for each answer. In this case one needs to design a separate set of questions for each selected answer. These kinds of questions are called *branching questions*. These questions are designed so that all possibilities are covered. Thus, they require careful formulation and inclusion in the questionnaire format (see Figure 3).

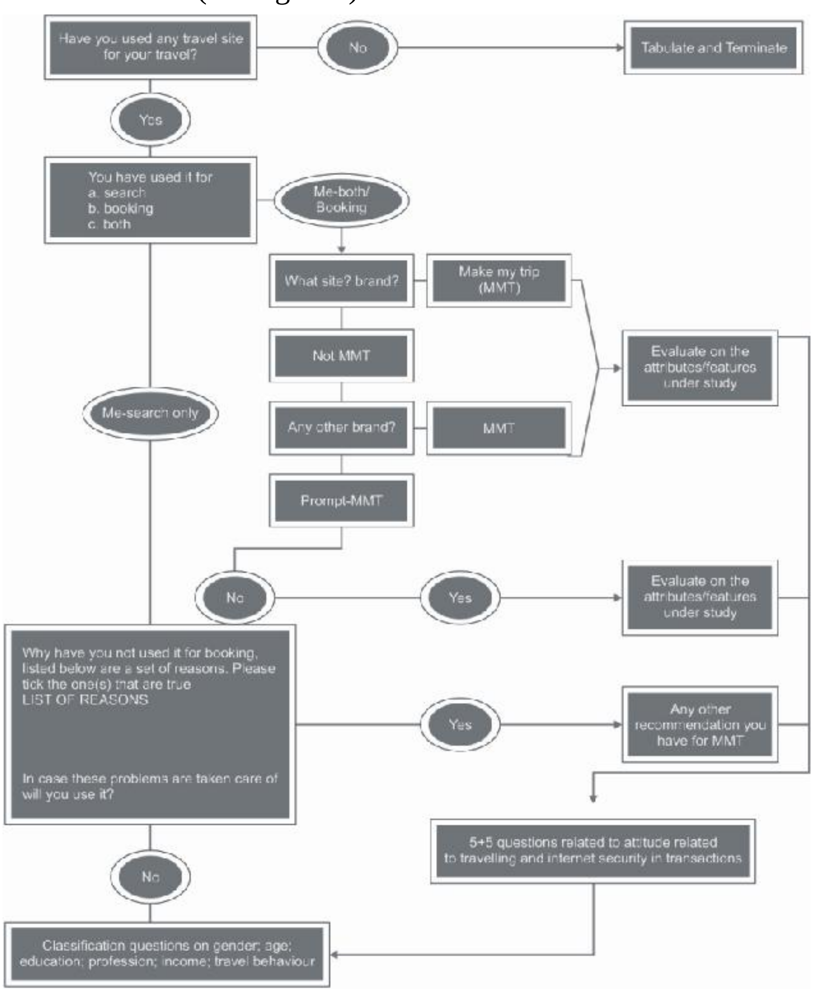

Fig. 3 *Sequence of Branching Questions for Determining usage of Travel Portals*

NOTES

Some researchers use the skip approach, for example 'in case answer _________ skip and go to question _________.' These are a little difficult to follow in a self-administered questionnaire. A simple way to handle this is to use a flow chart to enlist the valid and probable answers and then work on constructing the branching questions.

Using branching questions is considerably easy in Web-based surveys, where the person sees only the questions that follow the branching and there is no confusion.

Physical characteristics of the questionnaire

The questionnaire is a very important document that is the first interface between the respondent and the researcher. Thus, the appearance of the instrument is very important. The first thing is the quality of the paper on which the questionnaire is printed. In case the questionnaire is printed on a poor-quality paper or looks tattered and unprofessional, the respondents do not value the study and thus are not very sincere or careful in responding.

> Surveys for different groups could be on different coloured paper. This may assit while grouping the responses from different segments.

In case the number of questions is too many, instead of just stapling the papers together, it would be a good idea to put them together as a booklet. They are easy for the investigator and the subject to answer. Secondly, one can have a double-page format for the questions and the appearance, then, is more sombre and professional. The format, spacing and positioning of the questions can have a significant effect on the results, especially in the case of self-administered questionnaires.

The font style and spacing used in the entire document should be uniform. One must ensure that every question and its response options are printed on the same page. In fact, as far as possible, the response categories should be in the same row as the question. This saves space and at the same time, is more response friendly.

In case the questionnaire is long, or the researcher is economizing, one must not crowd questions together with no line spacing to make the questionnaire seem shorter. This format could result in error while recording as the person could fill the answer in the wrong row. Secondly, in case there are open-ended questions as well, the responses would be less revealing and shorter. The respondent might feel that this is going to be a really long and complex administration and may actually lose interest. Thus, though it is advisable to have short instruments that are not too taxing, but in case here is a research need for which the questions cannot be shortened, one must not clutter the appearance of the measuring instrument (questionnaire).

Although the use of colour does not really impact the quality of the response, sometimes it can be used to distinguish between the groups or for branching questions. Also, surveys for different groups could be on different coloured paper. This would be helpful when grouping the responses from different segments. For example, if Delhi is being studied as five zones, then the questionnaire used in each zone could be printed on a differently coloured paper.

As we saw in the last section, the questionnaire is segregated into different sections to address the various information needs. It is useful if the researcher divides the data needed into separate sections, such as Sections A, B, C and so on.

Then the questions in each part should be numbered, especially, when one is using branching questions. The other advantage of numbering the questions is that after the conduction coding, entering the data obtained becomes much easier. Precoded questionnaires are easier to administer and record.

NOTES

In case there is any response instruction for an individual question, it must accompany the question. In case it is a schedule and there are instructions for asking the question as well as instructions for responding, the response instruction should be placed very close to the question. However, instructions about how to record the answer and any probing question that needs to be asked should be placed after the question. To distinguish the instructions from questions, one should use a different font style. For example, overall how satisfied (are/were) you with your [Domino's] experience? Would you say you are (READ LIST)?

Very satisfied 5

Satisfied 4

Neither satisfied nor dissatisfied 3

Dissatisfied 2

Or, Very dissatisfied 1

IN CASE OF 2 or 1

(PROBE) What was the reason (s) for your experience? Kindly explain ______________

> Pilot testing involves the testing and administration of the designed instrument on a small group of people from the population under study.

Pilot testing of the questionnaire

Pilot testing refers to testing and administering the designed instrument on a small group of people from the population under study. This is to essentially cover any errors that might have still remained even after the earlier eight steps. Every aspect of the questionnaire has to be tested and one must record all the experiences of the conduction, including the time taken to administer it. If the respondent had a problem understanding a question or response category, the investigator should verbatim record the instruction he/she gave to clarify the point as this then would need to be incorporated in the final version of the questionnaire. In case a question got no answers, then it might be essential to rephrase the entire question.

Even when the mode of administration is mail or Internet or self-administered tests, the pilot tests should always be done in a face-to-face interaction. Here, the researcher is able to observe and record responses, both verbal and non-verbal. Sometimes, the researcher might also get the questionnaire vetted by academic or industry experts for their inputs.

Once the essential changes have been made, the researcher might carry out one short trial and then go ahead with the actual administration. As far as possible, the pilot should be a small scale replica of the actual survey that would be subsequently conducted.

It is advisable to use multiple investigators for the pilot study. The group of investigators should be a mix of experienced and seasoned field investigators and inexperienced investigators as well. The inexperienced ones would be able to reveal the problems encountered in administering the measure, while the experienced field workers would be able to report respondent difficulties in answering the questions.

NOTES

The respondent's experience of the pilot test can be recorded in two ways. One is protocol analysis where he is asked to speak out the reasoning in responding to the questions. This is recorded, as it helps to understand the underlying factors or mental processing involved in giving answers. The other method is called debriefing, where after the questionnaire has been completed, the person is asked to summarize his experience in terms of any problems experienced in answering or whether there was any confusion or fatigue while answering the questionnaire.

The researcher must then edit the questionnaire as required and carry out any further pilot tests. Once this is over, he enters the pilot data to explore and see whether the information that is being collected through the questionnaire would adequately furnish the information needs for which the instrument was designed.

> A questionnaire is a highly adaptable mechanism. It can be designed for every domain, branch and field of study.

Administering the questionnaire

Once all the nine steps have been completed, the final instrument is ready for conduction and the questionnaire needs to be administered according to the sampling plan. This will be discussed in detail in the next chapter on sampling.

Advantages and disadvantages of the questionnaire method: Thus, as we can see, designing a measuring instrument is an extremely structured, sequential and difficult task. However, once we have been able to give shape to the questionnaire, there are many advantages that it has over the other data collection methods discussed earlier.

Probably the greatest benefit of the method is its *adaptability*. There is, actually speaking, no domain and no branch for which a questionnaire cannot be designed. It can be shaped in a manner that can be easily understood by the population under study. The language, the content and the manner of questioning can be modified suitably. The instrument is particularly suitable for studies that are trying to establish the reasons for certain occurrences or behaviour. Here, methods like observations would not help as the motivations and intentions for the perspective have to be established. The second advantage is that it assures *anonymity* if it is self-administered by the respondent, as there is no pressure or embarrassment in revealing sensitive data. Secondly, a lot of questionnaires do not even require the person to fill in his/her name, which further offers a blanket of obscurity. Administering the questionnaire is much *faster* and *less expensive* as compared to other primary and a few secondary sources as well. The well-designed instrument can be *administered simultaneously* by a single researcher, thus it saves on both human and financial resources available for the study. There is considerable ease of quantitative coding and analysis of the obtained information as most response categories are closed-ended and based on the measurement levels. Most individuals have a previous experience of filling in a questionnaire and thus are not uncomfortable with the elicitation of answers. However, the questionnaires minimize and almost eliminate this. There is no pressure of immediate response, thus the subject can fill in the questionnaire whenever he or she wants. However, the method does not come without any disadvantages.

The major disadvantage is that the inexpensive standardized instrument has a *limited applicability* for only those who can read and write. Even though it is possible to get the responses by reading out aloud, but then the time and cost advantage would be lost.

The return ratio is the number of people who return the duly filled in questionnaires.

NOTES

The *return ratio*, i.e., the number of people who return the duly filled in questionnaires are sometimes not even 50 per cent of the number of forms distributed. This non-response could be because of various reasons. These reasons might range from lack of clarity of the purpose of the questionnaire to fact that the issue being questioned might be highly sensitive. However, one way to ensure that one gets the required sample for the study is to try and get a larger group of respondents, congregated at the same time to fill in the questionnaires.

Skewed sample response could be another problem. This can occur in two cases; one if the investigator distributes the same to his friends and acquaintances and second because of the self-selection of the subjects. This means that the ones who fill in the questionnaire and return it might not be the representatives of the population at large.

In case the person is not clear about a question, *clarification* with the researcher might not be possible. In case the person is filling in the questionnaire on his own, he might read the whole document first and the responses might be influenced by the way he is answering a previous or a subsequent question. Sometimes the person might genuinely be not able to respond, as either he does not remember ('how did you decide to buy your television ten years ago?') or he himself is not aware about how he took the decision ('why did you decide to buy this dress and not the other one?').

The spontaneity of the response gets faded if the respondent takes too much time in answering a particular question.

In most instances, the respondent is given sufficient time to respond, thus he thinks and gives his answers, in which case the *spontaneity* of response is lost and what the respondent reports is what he 'thinks is the right answer' and not 'what is the right answer.'

Questionnaire designing software/packages: With the advancement in computer programming, the task of the researcher is made much simpler and he/she is able to use different design packages available to compile the study questionnaire. Most of the sites and packages have developed area-specific methodologies, which help to customize the broadly- framed instrument to the research needs of the investigator. One can also help refine and modify a pre-designed questionnaire.

The package can also design questions based upon different levels of measurement, depending upon what is the nature of the data analysis required. The survey questionnaires can also be designed with branching questions and one has the provision of adding the company logo, different colours and graphics to make the instrument more user-friendly and attractive.

In some cases, the survey designing portals are also able to carry out the online survey and do preliminary data coding and entry as well. Some survey portals offering survey designing services are www.sawtoothsoftware.com and www.surveymethods.com, www.zoomerang.com. Most of these are user friendly and do not require special downloads and come with a free trial. The advantage of online surveys has been previously discussed; their advent has made questionnaire administration faster, cheaper and resulting in a higher response rate on the part of the respondent.

NOTES

Case 1
Malls for All

A research was undertaken to ascertain the attitude of Delhi shoppers towards mall shopping experience**.** For this purpose, it was felt that a mailed questionnaire could be used. Following is the questionnaire that was designed for the study. Please go over this and answer the following questions:

1. What do you think were the research objectives and the information areas that the investigator was interested in? Kindly enlist the same.
2. Has the questionnaire been effective in doing this?
3. How would you evaluate it as an instrument? Give reasons for your answer.
4. How would you modify the instrument? Specify the specific questions you would design by presenting adequate argument for doing so.

Instructions

1. The questionnaire deals with the analysis of consumers on their mall buying behaviour.
2. All the questions are quite general and simple but if there are any queries, then please feel free to clarify.
3. The questionnaire is solely an academic exercise, so please feel free to give us the information.

Name (Optional): Mr/Ms/Mrs

Mailing address (Area):

Age(in yrs):

☐ 10-20
☐ 21-30
☐ 31-40
☐ >40

Occupation:

☐ Student
☐ Housewife
☐ Professional/Service
☐ Self employed/Own Busines
☐ Others (Please specify________________)

1. Do you shop? Yes/No
   (a) How often do you shop ?
   ☐ Once a month
   ☐ Twice a month
   ☐ Thrice a month
   ☐ More than thrice a month
   (b) When do you prefer to shop ?
   ☐ Weekdays morning
   ☐ Weekend morning

- ☐ Weekdays afternoon
- ☐ Weekend afternoon
- ☐ Weekdays evening
- ☐ Weekend evening

NOTES

2. Where do you shop normally?
   - ☐ A local area market (Could you please specify the market _____________)
   - ☐ A shopping mall
   - ☐ Both of the above
3. Please tell us about your awareness and number of visits to the following malls?

	Awareness (Tick)	*Number of visit (No. of times in a month)*
Ansal Plaza		
Sahara Mall		
Waves Noida		
Metropolitan Mall		
Ansals Faridabad		
DT's Gurgaon		

4. Please give your views on malls for the following aspects.

	Strongly agree	*Agree*	*Neutral*	*Disagree*	*Strongly disagree*
Malls are convenient Malls offer more variety					
Malls are hygienic Malls offer value for money					
Malls are more expensive The atmosphere in malls is very congenial					
Malls are fashionable Malls are good for outing with family/friends					

5. Please specify your spending for the following with respect to a mall.

Spending / *Reasons*	*0-10 per cent*	*10-20 per cent*	*>20 per cent*
For eating or drinking			
For entertainment (movies, etc.)			
For shopping			

6. How would you classify your spending behaviour (Can have multiple options)?
   - ☐ On the spot mood
   - ☐ Planned purchases
   - ☐ Linked spending (e.g., eating out if you have come for shopping)

NOTES

7. Could you please give us your individual rating of the mall with respect to the following (Please rate from 1-5, good to bad)? (Please specify the name of the mall if you are taking a specific one______________)

V. Good __________ V.Bad

Availability of products	1	2	3	4	5
Eating joints	1	2	3	4	5
Multiplex/entertainment	1	2	3	4	5
Mall atmosphere	1	2	3	4	5
Facilities (AC, staff, parking)	1	2	3	4	5
Overall experience	1	2	3	4	5

Date: _______________

Place: _______________

NOTES

Case 2
Outlook of *Outlook*

The management of *Outlook* finds that despite the changes in the publication's frequency, *Outlook* magazine is still facing stiff competition from the rival *India Today*. Thus, they wanted to conduct a comparative survey for the two magazines and assess whether they had a distinct positioning. Who was the reader of the magazine *Outlook*? How did he rate the magazine and so on? For this they have developed a questionnaire as presented below. Go through the questionnaire and answer the following questions:

1. What were the research objectives and information needs of the study?
2. How would you evaluate this in terms of fulfilling those objectives?
3. What are the problems in the questionnaire? How would you suggest correcting them?

Questionnaire

This is a survey on readership habits. We would be highly obliged if you could take out some time from your busy schedule and give us your valuable comments/inputs. Please note that this is an academic exercise and all the information will be kept confidential.

Name	***Monthly Household Income***
Age:	₹ 3001 to ₹ 4000
Sex:	₹ 4001 to ₹ 5000
Highest educational qualification:	₹ 5001 to ₹ 6000
Occupation:	₹ 6001 to ₹ 8000
Type of occupation:	₹ 8001 to ₹ 10000
Self-employed	₹ 10001 to ₹ 12000
Service	₹ 12001 to ₹ 15000
Phone:	₹ 15001 to ₹ 20000
Mobile:	₹ 20001 to ₹ 30000
	₹ 30001 to ₹ 40000
	₹ 40001+

1. Which are the general interest magazines you are aware of?
2. Please tick the magazines that you are aware of from below:

The Week	
India Today	
Outlook	
Frontline	

NOTES

3. Do you read *Outlook* or *India Today*?

   ☐ Yes (Both) ☐ Yes (*Outlook*)

   ☐ Yes (*India Today*) ☐ No

   If Yes (Both) then continue else, please terminate.

4.
   (a) Do you subscribe to the two magazines listed below?

	Outlook	***India Today***
Yes		
No		

   (b) If no, please mention 'source of acquiring the magazine'

   ☐ Borrow ☐ Buy from retail shops

   ☐ Library ☐ Office/Workplace

   ☐ Others (Please specify_______________)

5. I know that you read these magazines __________ Who else in your family reads these magazines?

Occupation	***Reads Outlook***	***Reads India Today***
College student School student		
Housewife		
Professional		
Self-employed/entrepreneur		
Grandparents Others (Pls specify) _________		

6. On a scale of 1 to 5, please rate each of the magazines on the following attributes:

   1: Completely disagree

   2: Somewhat disagree

   3: Neither agree nor disagree

   4: Somewhat agree

   5: Completely agree

NOTES

Attribute	*Outlook*	*India Today*
This magazine gives me news first This magazine is very bold		
This magazines covers a variety of topics		
This magazine is truthful		
This magazine is read by elders		
This magazine is read by young people		
This magazine analyses information in-depth		
This magazine is for the highly inquisitive mind		
This magazine is very well researched		
This magazine gives attractive freebies This magazine gives me news which is spicy		
This magazine has very attractive issues		
This magazine is rich in content		
This magazine gives very predictable news		
This magazine gives relevant information only		
This magazine is intellectually stimulating		
This magazine provides me with an opinion		
This magazine is centered around politics		
This magazine gives me news as it is This magazine is for the practical people		
This magazine gives reliable news		

7. Can you recommend some changes in *Outlook* that you think it needs?
   (1) ____________________________________
   (2) ____________________________________
   (3) ____________________________________
8. In the table below, please tick the articles/commodities that you own in each category:

Brand	*Range 1*	*Range 2*	*Range 3*
Watches	Above ₹ 6000 Omega/Rolex/Cartier/Tissot/ Others ___________	₹ 1500-6000 Swatch/Tanishq/Tag Heur/Others ___________	Below ₹ 1500 Timex/HMT/Titan Others ___________
Mobiles	Above ₹ 15000 Brand and Model ___________	₹ 7000-15000 Brand and Model ___________	Below ₹ 7000 Brand and Model ___________
Car	Above ₹ 7 lakh Mercedes/Sonata/Skoda/Vectra Others ___________	₹ 4-7 Lacs Esteem/Accent/Bolero Others ___________	Below ₹ 4 Lacs Zen/Maruti 800/Alto/Santro/Palio Others___________

NOTES

9. How satisfied are you (overall) with:
   A. *Outlook*
   B. *India Today*

   Very satisfied/satisfied/neutral/dissatisfied/very dissatisfied

10. MARUTI Stands for Trust Stands for Taste
    (a) What do you think *Outlook* stands for?

    ____

    (b) What do you think *India Today* stands for?

    ____

NOTES

Case 3
What does an Employee Want?

An academic study was conducted across various IT companies to find out the percentage hike in the compensation (pay package) at which employees are ready to forgo better growth and development opportunities. For this, they have developed a questionnaire as presented below. Go through the questionnaire and answer the following questions:

1. What were the research objectives and information needs of the study?
2. How would you evaluate this in terms of fulfilling those objectives?
3. What are the problems in the questionnaire? How would you suggest correcting them?

Research Questionnaire

Name: ____

Working as: ___________________________________

Name of the organization: ______________________

E-mail ID: _____________________________________

Dated: ____

Please fill the following questionnaire:

1. Are you currently employed in the IT sector?
    - Yes
    - No

    If yes, then continue.
2. Are you a permanent employee?
    - Yes
    - No
3. Marital Status
    - Single
    - Married
4. Work experience till date
    - Less than 3 months
    - 3 months–1 year
    - 1–3 years
    - 3–5 years
    - More than 5 years
5. Work experience in this organization
    - Less than 3 months
    - 3 months–1 year
    - 1– years
    - 3–5 years
    - More than 5 years

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6. Mark your salary bracket (All figures are in INR)
   - Less than 20,000
   - 20,000–30,000
   - 30,001–40,000
   - 40,001–50,000
   - Above 50,000
7. Do you find sufficient growing opportunities in your current organization?
   - Yes
   - No
8. What is your priority?
   - Compensation hike
   - Current growth opportunity
9. Does your superior's view affect your decision of selecting pay hike or growth opportunities?
   - Yes
   - No
   - Can't say
10. Please rank the following growth opportunities as per your priority (Ranks: 1 to 7)
    - Promotion ________________________________
    - Onsite - (working abroad at Onsite) _____
    - Training __________________________________
    - Higher Education (MBA, MS, etc.) ______
    - Switching to a better company ________
    - Better working environment ____________
    - Better assignments ____________________
11. What is the minimum hike in package at which you will be satisfied even when you are not getting any of the above mentioned growing opportunity?
    - 0–5 per cent
    - 6–10 per cent
    - 11–15 per cent
    - 16–20 per cent
    - 21–25 per cent
    - More than 25 per cent
12. Is money the only factor to continue your current job?
    - Yes
    - No
13. At what percentage hike in package are you willing to forego?
    (a) The promotion opportunity
    - 0–5 per cent
    - 6–10 per cent
    - 11–15 per cent
    - 16–20 per cent

- 21–25 per cent
- 25–30 per cent
- More than 30 per cent
- Not willing to forego at any percentage hike

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(b) The training opportunity?
- 0–5 per cent
- 6–10 per cent
- 11–15 per cent
- 16–20 per cent
- 21–25 per cent
- 25–30 per cent
- More than 30 per cent
- Not willing to forego at any percentage hike

(c) The onsite opportunity (working at the site)
- 0–5 per cent
- 6–10 per cent
- 11–15 per cent
- 16–20 per cent
- 21–25 per cent
- 25–30 per cent
- More than 30 per cent
- Not willing to forego at any percentage hike

(d) Higher education opportunity?
- 0–5 per cent
- 6–10 per cent
- 11–15 per cent
- 16–20 per cent
- 21–25 per cent
- 25–30 per cent
- More than 30 per cent
- Not willing to forego at any percentage hike

(e) Company-switching opportunity?
- 0–5 per cent
- 6–10 per cent
- 11–15 per cent
- 16–20 per cent
- 21–25 per cent
- 25–30 per cent

- More than 30 per cent
- Not willing to forego at any percentage hike

(f) Better working-climate opportunity?

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- 0–5 per cent
- 6–10 per cent
- 11–15 per cent
- 16–20 per cent
- 21–25 per cent
- 25–30 per cent
- More than 30 per cent
- Not willing to forego at any percentage hike

(g) Better assignment opportunity?

- 0–5 per cent
- 6–10 per cent
- 11–15 per cent
- 16–20 per cent
- 21–25 per cent
- 25–30 per cent
- More than 30 per cent
- Not willing to forego at any percentage hike

(h) Working in the city of your choice?

- 0–5 per cent
- 6–10 per cent
- 11–15 per cent
- 16–20 per cent
- 21–25 per cent
- 25–30 per cent
- More than 30 per cent
- Not willing to forego at any percentage hike

14. What do you consider yourself, as per the following:
    - Underpaid
    - Overpaid
    - Paid as per the industry standards
15. Please mention any other growing opportunity which according to you is important but is not provided by your current organization.

    ____

    ____
16. Any other feedback you would like to share.

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