***Basic Research***

***and***

***Statistics***

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**PART I**

**BASIC RESEARCH**

**1.1 MEANING OF RESEARCH**

The word “research” originated from the old French word “ recerchier ” meaning to search and search again. It literally implies repeating a search for something and implicitly assumes that the earlier search was not exhaustive and complete in the sense that there is still scope for improvement. Research in common parlance refers to a search for knowledge. It may be defined as a scientific and systematic search for pertinent information on a specific topic/area. In fact, research is an art of scientific investigation.

The Advanced Learner’s Dictionary of Current English lays down the meaning of research as “a careful investigation or inquiry especially through search for new facts in any branch of knowledge”. Redman and Mory define research as “a systematized effort to gain new knowledge”. Some people consider research as a movement, a movement from known to unknown. It is actually a voyage of discovery. Research is a scientific approach of answering a research question, solving a problem or generating new knowledge through a systematic and orderly collection, organization, and analysis of information with an ultimate goal of making the research useful in decision-making. Systematic research in any field of inquiry involves three basic operations-

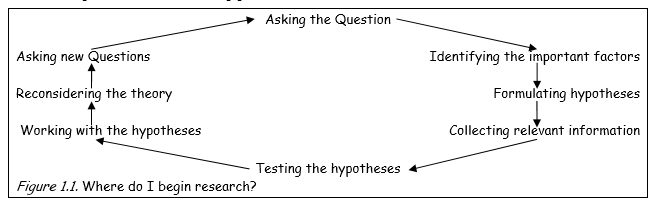
1. Data collection: It refers to observing, measuring, and recording information.

2. Data analysis : It refers to arranging and organizing the collected data so that we may be able to find out what their significance is and generalize about them.

3. Report writing: It is an inseparable part and a final outcome of a research study. Its purpose is to convey information contained in it to the readers or audience.

In this context, legal research is defined as ‘systematic’ finding law on a particular point and making advancement in the science of law. It involves a systematic search of legal materials, statutory, subsidiary and judicial pronouncements. For making advancement in the science of law, one needs to go into the ‘underlying principles or reasons of the law’. These activities warrant a systematic approach. An approach becomes systematic when a researcher follows scientific method. Research is systematic, because it follows certain steps that are logical in order. These steps are-

* Understanding the nature of problem to be studied and identifying the related area of knowledge.
* Reviewing literature to understand how others have approached or dealt with the problem.
* Collecting data in an organized and controlled manner so as to arrive at valid decisions.
* Analyzing data appropriate to the problem.
* Drawing conclusions and making generalizations.



Thus, legal research is the process of identifying and retrieving information necessary to support legal decision-making. It includes in it each step of a course of action that begins with an analysis of the facts of a problem and concludes with the application and communication of the results of the investigation.

***Characteristics of Research***

Research is a process through which we attempt to achieve systematically and with the support of data the answer to a question, the resolution of a problem, or a greater understanding of a phenomenon. This process has eight distinct characteristics. Research…

1. Originates with a question or problem.

2. Requires a clear articulation of a goal.

3. Follows a specific plan of procedure.

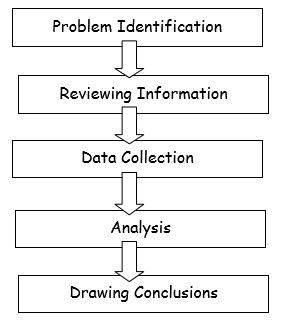
4. Usually divides the principal problem into more manageable sub-problems.

5. Is guided by the specific research problem, question, or hypothesis.

6. Accepts certain critical assumptions.

7. Requires the collection and interpretation of data in attempting to resolve the problem that initiated the research.

8. Is by its nature, cyclical; or more exactly, helical.



***Figure 1.2. Schematic Characteristics of Research***.

***1.2 OBJECTIVES/PURPOSES OF RESEARCH***

The principal objective or purpose of research in any field of inquiry is to add to what is known about the phenomenon under the investigation through the application of scientific methods. The purpose of research is the following-

1. Exploration

2. Description

3. Causal Explanation

4. Prediction.

***Exploration:***

Exploration is finding out about some previously unexamined phenomenon. It is particularly useful when researchers lack a clear idea of the problems they will meet during the course of the study. Through exploration, researchers

* Develop concepts more clearly
* Establish priorities
* Develop operational definitions
* Formulate research hypotheses, and
* Improve the final research design.

Explorative studies tend toward loose structures with the objective of discovering future research tasks. One might think, for example, of initiating an exploratory research in the following situations -  Crime is increasing in the city at an alarming rate, the reasons for which remain unknown. The problem is ambiguous and what is actually happening is to be cleared.  A new product is to be marketed, the manufacturer remains in worry if the product will be accepted by the people or not.

***Description:***

Description refers to the data based information-gathering activities. The situations and events which are described through studies are referred to as descriptive studie s . Descriptive studies try to discover answers to the questions who, what, when, where and sometimes how. A descriptive study may be feasible in the following cases

* What are the characteristics of the people who are involved in city crime? Are they young? Middle aged? Poor?
* Who are the potential buyers of the new product? Men or women? Urban people or rural people?

***Causal Exploration***:

An explanatory study goes beyond description and attempts to establish cause and-effect relationship between variables. It explains the reason for the phenomenon that describes study observed. Thus, if a researcher finds that communities having higher family size have higher child death, s/he is performing a descriptive study. If researcher is explaining why it is so and tries to establish cause-and-effect relationship, s/he is performing an explanatory study . Such studies are also called causal studies . Following examples fit to causal studies -

* Why people are involved in crime? Can we explain this as a consequence of present crisis in the job market? Or for lack of parental care?
* Will buyers be motivated to purchase the new product in a new container? Can attractive advertisement motivate them?

***Prediction:***

Prediction seeks to answer when and in what situations the event will occur, if it can be provided plausible explanation for the vent in question. In addition to being able to explain an event after it has occurred, it will be able to predict when the event will occur.

Hence, research objective of a given research study may fall under either of the following broad categories. To…

* Gain familiarity with a phenomenon or to achieve new insights into it.
* Portray accurately the characteristics of a particular individual, situation or a group.
* Determine the frequency with which something occurs or with which it is associated.
* Test causal relationship between two or more than two facts or situations.
* Know and understand a phenomenon with a view to formulating the problem precisely.

Describe accurately a given phenomenon and to test hypotheses about relationships among its different dimensions.

Some others objectives of research may be spell out as follows. To…

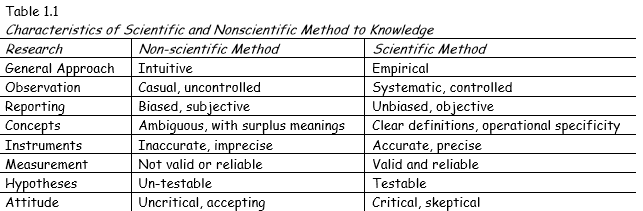
* Provide solutions to complex problems;
* Investigate laws of nature;
* Make new discoveries;
* Develop new products;
* Save costs;
* Improve our life, and
* Human desires.

***1.3 SCIENTIFIC BASED OF RESEARCH***

For clear perception about research one should know the meaning of scientific method. Scientific method is the pursuit of truth as determined by logical considerations. The ideal of science is to achieve a systematic interrelation of facts. Scientific method attempts to achieve this ideal by experimentation, observation, logical arguments from accepted postulates and a combination of these three in varying proportions. The scientific method is based on certain basic postulates which can be stated as follows. It…

* relies on empirical evidence,
* utilizes relevant concepts,
* is committed to only objective considerations,
* presupposes ethical neutrality,
* results into probabilistic predictions,
* is made known to all concerned through replication, and
* aims at formulating most general axioms.

Thus, scientific method implies an objective, logical and systematic method, i.e., a method free from personal bias or prejudice, a method to ascertain demonstrable qualities of a phenomenon capable of being verified, a method wherein the researcher is guided by the rules of logical reasoning, a method wherein the investigation proceeds in an orderly manner and a method that implies internal consistency.



***1.4 CRITERIA OF A GOOD RESEARCH***

Whatever the types of research works have been done, they all meet on the common ground of scientific method. Scientific research to satisfy the following criteria

* Purpose of the research should be clearly defined and common concepts be used.
* Research procedure used should be described in sufficient detail to permit another researcher to repeat the research for further advancement.
* Procedural design of the research should be carefully planned to yield results that are as objective as possible.
* Researcher should report with complete frankness, flaws in procedural design and estimate their effects upon the findings.
* Analysis of data should be sufficiently adequate to reveal its significance and the methods of analysis used should be appropriate. The validity and reliability of the data should be checked carefully.
* Conclusions should be confined to those justified by the data of the research.

A good research has also the following qualities –

1. It is systematic: Research is structured with specified steps to be taken in a specified sequence in accordance with the well defined set of rules. Systematic characteristic of the research does not rule out creative thinking but it certainly does reject the use of guessing and intuition in arriving at conclusions.

2. It is logical: Research is guided by the rules of logical reasoning and the logical process of induction and deduction are of great value in carrying out research. Induction is the process of reasoning from a part to the whole whereas deduction is the process of reasoning from some premise to a conclusion which follows from that very premise. In fact, logical reasoning makes research more meaningful in the context of decision making.

3. Good research is empirical: Research is related basically to one or more aspects of a real situation and deals with concrete data that provides a basis for external validity to research results.

4. Good research is replicable: Research results to be verified by replicating the study and thereby building a sound basis for decisions.

***1.5 CLASSIFICATION OF RESEARCH***

It is beneficial if you can classify a research study under a specific category because each category or type of research uses a specific set of procedures. There are two ways of classifying research –

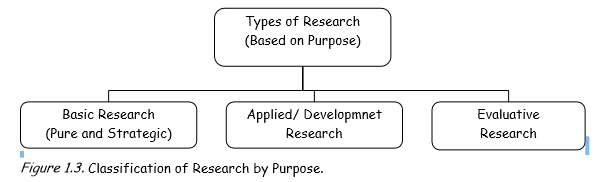
* One way is to classify research on the basis of its purpose , and
* The other is to classify research on the basis of the method employed in research.

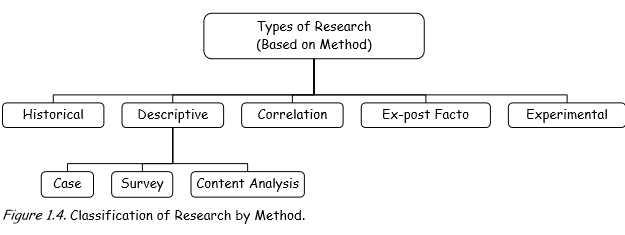
Taking purpose as the basis of classification, research is considered to be three types – Basic , Applied (including Developmental research) and Evaluative . The other basis for classifying research is by the method it employs. Research method is characterized by the techniques employed in collecting and analyzing data. On the basis of method, research can be classified as historical, descriptive, correlational, ex-post facto and experimental.

***Basic Research***:

When the solution to the research problem has no apparent applications to any existing practical problem but only of the scholarly interests of a community of a researcher, the research is called basic reach. Basic research attempts to generate and expand the fundamental knowledge about social world. It has no practical value or has little direct impact on action, performance or policy decision. Basic researchers are more detached and academic in their approach and tend to have their own motives. Example of pure research is - a social researcher in a developed country has investigated if there is any relationship between religion and occupation. If we attempt to see the relationship found in developed countries is also present in the developing country, we are doing a basic research. Pure basic research is experimental and theoretical work undertaken to acquire new knowledge without looking for long-term benefits other than the advancement of knowledge.

***Strategic basic research*** is experimental and theoretical work undertaken to acquire new knowledge directed into specified broad areas in the expectation of useful discoveries. It provides the broad base of knowledge necessary for the solution of recognized practical problems.





***Applied Research:***

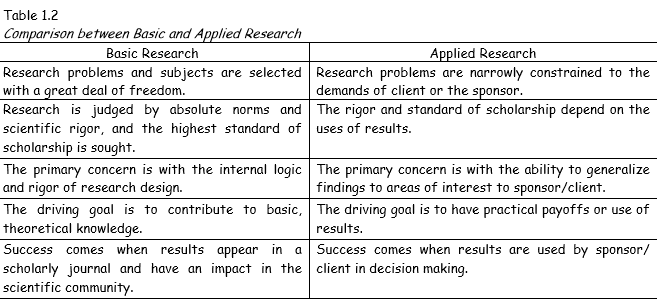
It variously known as action research, operations research, social research, decision-linked research, is a type of research that covers a wide range of social science areas. Applied research is inspired by the needs of social action and aims at finding a practical solution for an immediate problem of the sociality making optimal use of the available resources. The problems olving nature of the applied research means it is conducted to reveal answers to specific questions related to action, performance or policy needs. Example that demonstrates what the applied research is - it has been observed that in Bangladesh, the proportion of women who are delivered through Caesarian section is very high. It is suspected that small height is one of the risk factors to difficult deliveries. A study may therefore be conducted to verify if this is the case.

***Evaluative Research***:

It is concerned with the evaluation of such occurrences as social and organizational programs or intervention. Evaluative research attempts to-

* Assess implemented activities;
* Examine effects of activities;
* Assess short-term effects;
* Determine the impact of a program; and
* Evaluate success of intervention.

The use of the principles of experimental design is fairly entrenched in evaluation research, but other approaches have merged in recent years. An example is cited - Goiter is highly, prevalent in many parts of Bangladesh. UNICEF, Bangladesh initiated lipiodol injection campaign in some selected Thana in 1989. After a period of two years, the impact of this campaign was evaluated. The results were compared with another area where no such campaign was launched.



**Historical Research**: It is that which utilizes historical sources like documents, remains, etc. to study events or ideas of the past, including the philosophy of persons and groups at any remote point of time. The purpose of historical research is to arrive at conclusions concerning trends, causes or effects of past occurrences.

This may help in explaining present events and anticipating future events.

***Descriptive Research***: It includes case studies, surveys and fact-findings enquiries of different kinds. The major purpose of descriptive research is description of the state of affairs, as it exists at present. The main characteristic of this method is the researcher has no control over the variables; s/he can only reprot what has happened or what is happening. Descriptive research studies deal with collecting data and testing hypotheses or answering questions concerning the current status of the subject of study. It deals with the question ‘wh at is’ of a situation. It concerns with determining the current practices, status or features of situations. Another aspect of descriptive research is that data collection is either done through asking questions from individuals in the situation (through questionnaires or interviews) or by observation. Market study on peoples choice is mostly descriptive research.

***Correlational Research***: Descriptive and historical researches provide a picture of events that are currently happening or have occurred in the past. Researchers often want to go beyond mere description and begin discussing the relationship that certain events might have to one another. The most likely type of research to answer the relationship among variables or events is called correlational research. It aims at determining the degree of relationship between two or more quantifiable variables. Secondly, the relationship thus determined could be used for making predictions. A high value of relationship, however, does not signify a cause and effect relationship which must be verified through experimental study. This research is often conducted to test the reliability and predictive validity of instruments used for division making concerning selection of individuals for the likely success in a course of study or a specific job. Some authors consider this research as a type of descriptive research, since it describes the current conditions in a situation.

However, the difference lays in the nature of conditions studies. A correlational study describes in quantitative terms the degree to which the variables are related.

***Ex-post Facto Research***: There is some research where both the effect and the alleged cause have already occurred and are studied by the researcher in retrospect. Such research is referred to as Ex-post Facto (after the fact). Kerlinger (1973) defines Ex-post Facto research as: “Systematic empirical inquiry in which the scientist does not have direct control of independent variables because their manifestations have already occurred or because they are inherently not manipulable”. Thus, in ex-post facto research or causal-comparative research the researcher has no control on the variables or s/he cannot manipulate the variables (independent variables) which cause a certain effect (dependent variables) being measured. Since this type of study lacks manipulation of variables, the cause-effect relationship measured are only tentative. Some authors categorize Expost facto studies into the category of descriptive research. Though it too describes conditions that exist in a situation, it attempts to determine reasons or causes for the current status of the phenomena under study. The procedures involved in this study are quite different than those in descriptive research.

***Experimental Research***: We already know that correlational research can help establish the presence of a relationship among variables but not give us any reason to believe that variables are causally related to one another. How does one find out if the characteristics or behaviors or events are related in such a way that the relationship is a causal one? Two types of research can answer this:

(1) quasi-experimental research and

(2) experimental research.

Experimental research is where participants are assigned to groups based on some selected criterion often called treatment variable. Quasi - experimental research is where participants are pre-assigned to groups based on some characteristic or quality such as differences in sex, race, age, neighborhood, etc. These group assignments have already taken place before the experiment begins, and the researcher has no control as to what the people will belong to each group. The primary characteristic of experimental research is manipulation of at least one variables and control over the other relevant variables so as to measure its effect on one or more dependent variables. The variable (s) which is manipulated is also called an independent variable, a treatment, an experimental variables or the cause. Some of the examples of independent variables could be: temperature, pressure, chemical concentration, type of material and conductivity. Experimental research will always have two or more groups for comparison on the dependent variables. It is the only type of research which can establish truly the cause and effect relations.

***Some Other Types of Research Analytical Research***

In analytical research the researcher has to use facts or information already available, and analyze these to make a critical evaluation of the material.

***Quantitative Research***: It is based on the measurement of quantity or amount. It is applicable to phenomena that can be expressed in terms of quantity.

***Qualitative Research***: It is concerned with qualitative phenomenon, i.e., phenomena relating to or involving quality or kind. For instance, when we are interested in investigating the reasons for human behaviour (i.e., why people think or do certain things), we quite often talk of “Motivation Research”, an important type of qualitative research. This type of research aims at discovering the underlying motives and desires, using in depth interviews for the purpose. Attitude or opinion research i.e., research designed to find out how people feel or what they think about a particular subject or institution is also qualitative research. Qualitative research is specially important in the behavioural sciences where the aim is to discover the underlying motives of human behaviour.

***Conceptual Research***: It 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.

***Longitudinal Research:*** From the point of view of time, we can think of research either as one - time research or longitudinal research . In the former case the research is confined to a single timeperiod, whereas in the latter case the research is carried on over several time-periods. Historical research, case study, genetic comes under longitudinal approach of research.

***Cross Sectional Research:*** This type of studies are designed to look at a variable at a particular point in time. Longitudinal studies involve taking multiple measures over an extended period of time, while cross-sectional research is focused on looking at variables at a specific point in time. Experimental research, survey are the examples of cross sectional research.

***Clinical or Diagnostic Research :*** Clinical or diagnostic research follow case-study methods or indepth approaches to reach the basic causal relations. Such studies usually go deep into the causes of things or events that interest us, using very small samples and very deep probing data gathering devices.

***Baseline/Bench - mark Survey/Research:*** A baseline survey is a research in which data on pre-project socio-economic and business aspects are generated in order to facilitate the assessment of future impact of project intervention. A baseline survey is conducted in the absence of available published data on various socio-economic and business aspects.

***Impact Assessment***: The research, which is undertaken to measure the quantitative benefits derived out of project intervention and qualitative changes that occurred due to project intervention, is known as an impact assessment research. This type of research also provides information for identifying the negative impact of the project.

***Feasibility Studies:*** This type of research is undertaken prior to starting of any business enterprise or any business related project. This type of research is done to assess the technical, economic, market and financial viability of the project. The issue whether the project is socially desirable and environmentally acceptable is also taken into consideration.

Research can also be classified as conclusion - oriented and decision - oriented . While doing conclusion oriented research, a researcher is free to pick up a problem, redesign the enquiry as s/he proceeds and is prepared to conceptualize as s/he wishes. Decision-oriented research is always for the need of a decision maker and the researcher in this case is not free to embark upon research according to his/her own inclination. Operations research is an example of decision oriented research since it is a scientific method of providing executive departments with a quantitative basis for decisions regarding operations under their control.

***1.6 SIGNIFICANCE OF RESEARCH***

* Research is important for researchers in studying social relationship and in seeking answers to various social problems.
* Research provides the basis for nearly all government policies in our economic system.
* Research has its special significance in solving various operational and planning of business and industry.
* Research is needed to develop strategies and models in rural development.
* The role of research in several fields of applied economics, whether related to business or to the economy as a whole, has greatly increased in modern items.
* Research inculcates scientific and inductive thinking and it promotes the development of logical habits of thinking and organization.
* To students who are to write a master’s or PhD thesis, research may mean a way to attain a high position in the social structure.
* To professionals, research may mean a source of livelihood.
* To literary men and women, research may mean the development of new style and creative work.
* To analysts and intellectuals, research may mean the generalizations of new theories.

Thus, research is the foundation of knowledge for the sake of knowledge and an important source for providing guidelines for solving different business, government and social problems.

***1.7 SCOPE OF RESEARCH***

Research is the systematic investigation and study of materials and sources to establish facts and reach new conclusions, so it shapes people’s understanding of the world around them. Through research findings, researchers are able to explain individuals’ behaviors, including how people think and act in certain ways. This helps to determine disorders and their impact on the person and society, thus developing appropriate treatments to improve the individual’s quality of life. In business, market research helps companies to make projections and formulate appropriate strategies to ensure survival. Businesses conduct surveys to understand the needs of the community and consumption habits. Research has led to the introduction of new medical treatments and cures that have helped counter several diseases, thus increasing human life expectancy.

***SOCIAL RESEARCH***

Social research is connected with the social life. The two cannot be separated. Social research is in fact a part of the scientific study/approach. Social research investigates and verifies social phenomena and social realities, the facts about social life and formulates laws this regard. After the laws have been formulated, investigation is carried out and inter-relationships between various facts and laws are established. Through these steps we are able to collect data and knowledge about society. It provides scientific knowledge about social problems and helps the researcher to find out solutions to them. In brief, the goal of social research primarily is to explore and gain an understanding of human behavior. It tries to investigate the relationship that exists between various facts and phenomena of social life. A research aims to establish a scientific knowledge. Hence the purpose of social science research is to establish scientific, empirical knowledge about the human society. Thus, the scope of social research centers on the use of scientific method for the establishment of scientific knowledge of the society with the use of a scientific method. Scientific method is characterized by verifiability, ethical neutrality, accuracy, precision, objectivity, and it is systematic, its production based on probability. The scope and method of social research is both wide and complex because it involves the comprehension of social reality whose nature is very complex unlike the physical reality. Social research also covers the field of social planning as social research guides the social planning process. Adequate social planning depends for its success on the systematic knowledge of the social resources and liabilities.

Hence, the social science has a wide scope. The social sciences comprise academic disciplines concerned with the study of the social life of human groups, animals and individuals including anthropology, archeology, communication studies, cultural studies, demography, economics, human geography, history, linguistics, media studies, political science, psychology, social work and sociology. Mathematics and study of history, poetry or politics had no difference in the past. With the development of mathematical proof the people perceived the difference between scientific disciplines and others. Aristotle studied poetry and planetary motion at the same time with the same methods, and Plato mixed geometrical proofs with his demonstration on the state of intrinsic knowledge.

Following are the main branches of social sciences that deal with the modern problems of the modern world of 21st century.

* Economics is a social science that seeks to analyze and describe the production, distribution, and consumption of wealth.
* History is the continuous, systematic narrative and research of past events as relating to the human species; as well as the study of all events in time, in relation to humanity. History can be seen as the sum total of many things taken together and the spectrum of events occurring in action following in order leading from the past to the present and into the future. The historical method comprises the techniques and guidelines by which historians use primary sources and other evidence to research and then to write history.
* Linguistics investigates the cognitive and social aspects of human language. The field is divided into areas that focus on aspects of the linguistic signal, such as syntax (the study of the rules that govern the structure of sentences), semantics (the study of meaning), phonetics (the study of speech sounds) and phonology (the study of the abstract sound system of a particular language); however, work in areas like evolutionary linguistics (the study of the origins and evolution of language) and psycholinguistics (the study of psychological factors in human language) cut across these divisions.
* Political science is an academic and research disciplines that deals with the theory and practice of politics and the description and analysis of political systems and political behavior. Fields and subfields of political science include political economy, political theory and philosophy, civics and comparative politics, theory of direct democracy, apolitical governance, participatory direct democracy, national systems, cross- national political analysis, political development, international relations, foreign policy, international law, politics, public administration, administrative behavior, public law, judicial behavior, and public policy. Political science also studies power in international relations and the theory of Greatpowers and Superpowers.
* Sociology is the study of society and human social action. It generally concerns itself with the social rules and processes that bind and separate people not only as individuals, but as members of associations, groups communities and institutions and includes the examination of the organization and development of human social life. The sociological field of interest ranges from the analysis of short contacts between anonymous individuals on the street to the study of global social process.

There are so many other fields that enhance the scope of social sciences in the century of machines. Human life is enveloped by social sciences in one shape or other. The man of 21st century is surrounded by unlimited problems; social sciences are the solutions of these problems. Natural science talks about the facts of the universe; it is social sciences that deal with these facts.

**BUSINESS *RESEARCH***

Business research is described as the systematic and objective procedure for producing information for help in making business decisions. Business research should be objective, which means that the information found needs to be detached and impersonal instead of biased. Research facilitates the managerial decision process for all aspects of a business. By lowering the uncertainty of decisions, it cuts down on the risk of making incorrect decisions. Research should be an aid to managerial judgment but not a replacement for it. Scope of business research includes the following areas-

* Production Management: Research performs an important function in product development, diversification, introducing a new product, product improvement, process technologies, choosing a site, new investment etc.
* Personnel Management: Research works well for job redesign, organization restructuring, development of motivational strategies and organizational development.
* Marketing Management: Research performs an important part in choice and size of target market, the consumer behavior with regards to attitudes, life style, and influences of the target market. It is the primary tool in determining price policy, selection of channel of distribution and development of sales strategies, product mix, promotional strategies, etc.
* Financial Management: Research can be useful for portfolio management, distribution of dividend, capital raising, hedging and looking after fluctuations in foreign currency and product cycles.
* Materials Management: It is utilized in choosing the supplier, making the decisions relevant to make or buy as well as in selecting negotiation strategies.
* General Management: It contributes greatly in developing the standards, objectives, long-term goals, and growth strategies.

To perform well in a complex environment, you will have to be equipped with an understanding of scientific methods and a way of integrating them into decision making. You will have to understand what good research means and how to conduct it. Since the complexity of the business environment has amplified, there is a commensurate rise in the number and power of the instruments to carry out research.

***LEGAL RESEARCH***

Legal research becomes necessary -

* for ascertainment of law on a given topic or subject,
* to highlight ambiguities and inbuilt weaknesses of law,
* to critically examine legal provisions, principles or doctrines with a view to see consistency, coherence and stability of law and its underlying policy,
* to undertake social audit of law with a view to highlighting its pre-legislative ‘forces’ and post legislative ‘impacts’, and
* to make suggestions for improvements in, and development of law.

Legal research takes into its ambit -

**Doctrinal Research**: It is a research into legal rules, principles, concepts or doctrines. It involves a rigorous systematic exposition, analysis and critical evaluation of legal rules, principles or doctrines and their inter-relationship. It arranges the existing law in order and provides thematic parameters for such an order. It also concerns with critical review of legislations and of decisional processes and their underlying policy.

***Research in Theory:*** It involves an inquiry into conceptual bases of legal rules, principles or doctrines. It provides stimulus and intellectual infrastructure for empirical research as well as for advancements in law through legislative, judicial and administrative process.

***Empirical Investigations***: It assesses impact of law and reveals the gap between legal idealism and social reality. Perceiving the idea of law as a social phenomenon, a researcher explores social, political, economic and cultural dimensions or implications of law.

***Reform-oriented Research***: It, based on empirical study and critical examination of law, recommends changes in law and legal institutions.

Legal research, to sum up, needs to be carried out for the following reasons. To…

* Ascertain laws on a given topic or subject.
* Identify ‘gaps’ and ‘ambiguities’ in law.
* Critically examine consistency, coherence and stability of law and legal propositions.
* Undertake ‘social auditing of law’ [i.e. auditing pre-Legislative ‘forces’ and post-Legislative ‘impacts’ of law].
* Suggest reforms/developments in law by undertakings research intended. To…

a. investigate ‘gap’ between the ‘legal ideals’ and ‘actual practice’,

b. understand ‘effectiveness’ or ‘impact’ of law in a given social set-up at a given time,

c. find out as to whether law is serving the needs of the society and has a social value,

d. make suggestions for improvements in the law on concrete formulations and proposals, e. predict future trends of law.

***RESEARCH IN ARTS AND HUMANITIES***

The scope of research in arts and humanities are important because –

* Humanities help us understand others through their languages, histories and cultures.
* They foster social justice and equality.
* They reveal how people have tried to make moral, spiritual and intellectual sense of the world.
* Humanities teach empathy.
* They teach us to deal critically and logically with subjective, complex, imperfect information.
* They teach us to weigh evidence skeptically and consider more than one side of every question.
* Humanities students build skills in writing and critical reading.
* Humanities encourage us to think creatively. They teach us to reason about being human and to ask questions about our world.
* Humanities develop informed and critical citizens. Without the humanities, democracy could not flourish.

***1.8 STEPS IN CONDUCTING A RESEARCH***

Irrespective of the category of a research study, the steps followed in conducting it are the same. These steps are –

***Selecting and Defining Problem***: This marks the beginning of a research study and is the most difficult and important step. This involves –

(i) Identifying and stating the problem in specific terms;

(ii) Identifying the variables in the problem situation and defining them adequately;

(iii) Generating tentative guesses (hypotheses) about the relation of the variables or in other words the solution of the problem, or writing explicitly the questions (research questions) for which answers are sought; and

(iv) Evaluating the problem for its research ability.

To achieve this, you review the literature related to the problem to know what other researchers have done and discovered and to identify the possible methodology for conducting the research.

***Describing Methodology of*** ***Research***:

You need to state the purpose of the study and to define the problem clearly. This guides you in deciding the methodology of research which involves:

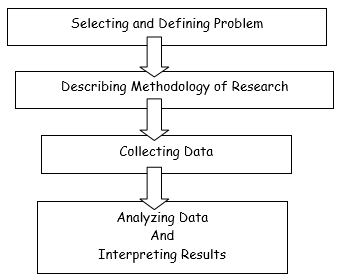
(a) identifying the method of research;

(b) specifying the subjects of study;

(c) selecting an adequate representative sample of subjects;

(d) selecting/constructing valid and reliable instruments for measuring the variables in the problem;

(e) selecting a research design and describing the procedure to be employed for conducting the research study.



***Figure 1.5. Steps in Conducting a Research***

***Collecting Data*** : This step involves conducting the study as per the designed procedure (manipulating the experimental variables in the case of an experimental method), administering instruments for measuring variables and/or gathering information through observation. It also involves tabulating the data thus collected for the purpose of analysis.

***Analyzing and*** ***Interpreting Results***: The results of the study are generated at this stage. The data are summarized, in other words analyzed to provide information for testing the hypotheses. Appropriate statistical methods of analysis are used to test the hypotheses. You can perform the analysis manually, by using a hand calculator or a computer as per the demands of the problem, and the available facilities. After completing the analysis results are tied together or summarized. The results are interpreted in the light of the hypotheses and/or the research problem. These are then discussed in relation to: the existing body of knowledge, consistencies and inconsistencies with the results of other research studies, and then the conclusions are drawn. This is followed by writing the research report.

***1.9 PHASES OF RESEARCH***

The work on the research can be divided up into three phases, the planning phase, the project phase and the documentation phase.

***Planning Phase***: One of the keys to developing a successful research is the careful planning of it from the outset. The mechanism for project planning is a proposal. The function of a proposal is to answer four questions:

(a) what will be done?

(b) why is it an important thing to do?

(c) what are the objectives and scope of the work? and

(d) how will it be done?

The following is a sample outline of a typical proposal

1. Introduction – including a statement of the problem to be studied – why is it an important thing to do?

2. Objectives of the work (a clear, concise statement).

3. Scope and limits of the project.

4. Preliminary survey of related work and literature.

5. Proposed procedure (may be a series of steps, task flow diagram, etc., including a schedule for when the tasks will be done).

6. Sources of data to be used.

7. Anticipated results (i.e., what questions will the project answer, or what problems will be solved; what benefits will result when the work is completed?).

8. Schedule of work by task.

9. Preliminary outline of the research report.

***Project Phase***: The actual work on the project is called the project phase. It is a good idea to keep a diary or project log during the phase. It is a point where look back at what has been done and a look forward at what remains to be done. It is also useful to write up rough statements of what has been done occasionally to help later in the documentation phase.

***Documentation Phase***: The documentation phase or the preparation of the research should occur continually during the project. The proposal and progress reports written during the project phase can form the basis for much of the final document. The following is a general outline for a research report. Of course, it is possible to deviate from this outline as the needs of the project dictate.

***Beginning Material:***

1. Title Page
2. Abstract (Final Manuscript)
3. Approval Sheet (Final Manuscript)
4. Dedication (Final Manuscript)
5. Acknowledgements (Final Manuscript)
6. Table of Contents,
7. List of Tables
8. List of Figures

***Chapter 1:* The Problem and Its Setting**

* 1. Background of the Study
  2. Statement of the Problem
  3. Hypotheses
  4. Objectives of the Study
  5. Theoretical and Conceptual Framework

1.5.1 Theoretical Framework

1.5.2 Conceptual Framework

* 1. *Review of Related Literature and Studies*
  2. Significance of the Study
  3. Scope and Delimitation of the Study
  4. Definition of Terms

***Chapter 2: Method***

2.1. Research Design

2.2. Research Local

2.3. Participants of the Study

2.4. Sampling Method

2.5. Data Gathering Procedure

2.6. Statistical Treatment

***Chapter 3: Results and Discussion***– indicate what happened and interpret what it means

***Chapter 4: Summary of findings, Conclusions and Recommendations*** – summarize conclusions and what they mean (i.e., answer the question, “So what?”). What changes and further work do you recommend?

***Appendices***

* Sample Questionnaires
* Letters to the Respondents
* Letters of Permission to Conduct the Study
* Documentation such as pictures and etc.

***References***

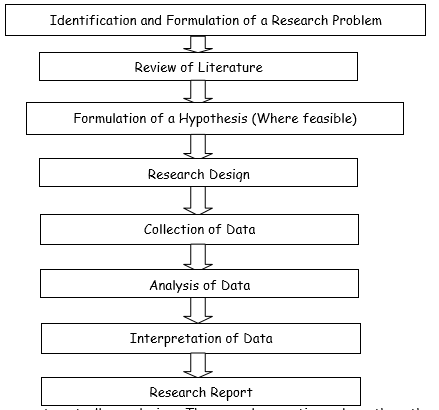
***Curriculum Vitae of the Researchers***

Invariably every research begins with a question or a problem of some sort. The aim of research is to know ‘something more’ about ‘something’ or to discover answers to meaningful questions through the application of scientific procedures. Legal research is not an exception to this general precept of research. However, undertaking and executing legal research, as a systematic inquiry, is a complex process. It involves a three-stage process. Each one of them warrants skill. The processes are research planning (Planning Phase), research implementation (Project Phase), and presenting of research findings (Documentation Phase).

Research planning requires the necessary sub-skills for: fact collection, legal analysis, legal knowledge, problem identification, legal analysis, fact analysis, further fact collection, identification of avenues of research, and generation of key (search) words.

Research implementation, as the second-stage processes, involves the skills pertaining to: identification of problems for resolution, identification of relevant research source materials, location of the source materials, effective use of the source materials, analysis of research findings, application of findings to the identified problem(s), and identification of further problem(s). While the third-stage process, i.e. presentation of research findings, requires the skills necessary for: identification of the (research) recipients’ needs, selection of appropriate format or framework, use of clear and succinct language, and use of appropriate language-style (informatory, advisory, recommendatory, or demanding).

A cumulative reading of these three-stage processes of research and of their components leads to the following major processes that, like any other research, involve in legal research. They may be presented in a flowchart as under –



These stages are not mutually exclusive. They overlap continuously rather than following the prescribed sequence strictly. The order sketched above is meant to provide a procedural guideline for research. A brief description of each one of the steps is necessary here to put the legal process in the right perspective and to highlight, in brief, their significance and role in legal research.

***Identification and Formulation of A Research Problem:***

Identification and formulation of a research problem constitutes the starting phase of research. It is the first and foremost step in any research undertaking. In fact, success of research depends upon the selection of an apt research problem and its proper formulation. An ill-identified and deficiently formulated research problem invariably makes the researcher subsequently to lose his/her ‘interest’ in the problem. It also lands researcher in a number of unanticipated difficulties at latter stages that may even compel to abdicate his/her research half a way. A research is goal-directed. If the goal itself is unknown or ill-defined, the research will lead the researcher nowhere. Thus, it becomes necessary to have a well-defined and precise research problem for meaningful research. It is an old and wise saying that ‘a problem well put is half solved’.

However, identification and formulation of a research problem is not an easy task. Before formulating a research problem, it is necessary for the researcher, in sequence, to identify an area of his/her general interest, an area or subject-matter of researcher special interest from the area of his/her general interest, and an aspect from the subject-matter of researcher special interest that s/he would like inquire into. Then s/he has to do a lot of reading on the aspect identified for further inquiry. For example, a scholar of law interested in undertaking research in public law that happens to be an area of researcher general interest. Researcher has then to identify an area of his/her special interest from public law, say Constitution. There may be an umpteen number of aspects of the Constitution that are of worth probing. Let us assume that researcher is interested in the Chapter Three of the Constitution dealing with Fundamental Rights and Freedoms. This is not enough for researcher to formulate a research problem. Researcher needs to select a Fundamental Right that interests him/her more and from this, s/he has to identify an aspect of the fundamental right that, according to researcher, deserves further probing. Researcher has to read a lot on, and about, the aspect before s/he ventures into formulating a statement of problem for his/her further inquiry. After reading about the aspect, researcher is required to put in a lot of thinking and intellectual input in phrasing the aspect in an intelligent and precise propositional form so that s/he can get something meaningful out of it. It needs to put in such a way that it signifies the focus of inquiry as well as its direction.

***Review of Literature***:

Once the research problem is formulated, the researcher needs to undertake an extensive survey of literature connected with, related to, and/or having bearing on, his/her research problem. This is the process whereby the researcher locates and selects the references that are relevant for his/her inquiry. A scholar of law, at this stage, is expected to carefully trace and lay his/her hands on standard textbooks, reference books dealing with or having bearing on the research problem, legal periodicals (to locate research articles written, or authoritative comments made, on the subject or its allied subjects), case reports (to get familiarize with the thitherto judicial exposition of the problem), conference/ symposium/ seminar proceedings, if any, (to acquaint with different dimensions highlighted in, delved into, or emerged from, the conference/ symposium/ seminars, Government or Committee Reports (to appreciate and understand perspectives of the experts in the field and of policy-makers), and general web pages (to know latest emerging perspectives and illustrative examples). The researcher has also to take special care to locate earlier studies done on the problem and to have a quick reading thereof.

However, in the recent past, the literature review process has changed dramatically with access to computers and especially World Wide Web (www).Though we may rely upon almost completely on the Web and search engines, let us remind ourselves of two caveats. First, searching the www is, by itself, insufficient for literature review. Although many leading journals and other published information from recognized sources are now available on the Web, it does not have all the available literature. Using the Web can be the basis of literature review but it needs to be balanced with material-very new-published in journals and periodicals that are not put on the Web and the publications that might not have been caught by search engines. Further, local country’s materials from marginalized groups may likely to be under-represented or un-represented on the Web. Secondly, it is not always evident that the information put on the Web is presented accurately.

Literature review makes the researcher conversant with the materials available on his/her research problem and their ‘place’, the thitherto explored (and unexplored) aspects/ dimensions of the problem, theoretical bases of the problem, and relevant theories in the field. Literature review, thus, helps the researcher to know and to have his/her preliminary impressions about –

1. The thitherto explored and unexplored aspects/dimensions of the problem and the explanations offered or issues raised without offering solutions there for.

2. The gaps, if any, in the thitherto-offered explanations of the problem/its dimensions and their inter-relationship and adequacy in explaining the problem/its dimensions.

3. Theoretical and conceptual issues raised, with or without suggesting solutions there for.

4. The operational framework and research techniques used in the previous research, and their propriety.

Literature review enables the researcher to know what kind of data has been used, what methods have been used to obtain the data, and what difficulties the earlier researchers in collecting and analyzing the data have faced. Main purposes of literature review, thus, are – To…

* Reveal what has been done and written on the topic in the past.
* ‘Map’ with their limitations, the thitherto used research techniques,
* Know the kind of material/data used and their sources.
* Appreciate adequacy (or otherwise) of the data used for drawing the conclusions.
* Know the central arguments advanced and the concepts revealed and discussed earlier.
* Acquaint with the patterns of presentation of these arguments and the concepts and the relationship established (or attempted to establish) between these arguments and the concepts.
* In the light of the earlier studies, findings, and the problems encountered, rephrase, with precision, his research problem/question, and to devise appropriate research techniques for smooth operation of his inquiry.

***Formulation of a Hypothesis***:

After extensive literature survey, researcher, in the light of the survey, has to re-phrase or reformulate his/her statement of problem, if necessary. A statement of problem, depending upon research goals and the nature of inquiry involved, may take form of either a mere statement or a proposition indicating possible relationship between two or more variables or concepts, the validity of which is unknown in the beginning. Such a proposition is known as hypothesis. Hypothesis, thus, is merely a tentative assumption made in order to draw and test its logical or empirical consequences. It is a tentative, testable statement. A statement to be a hypothesis must be capable of being tested. If its validity cannot be put to empirical confirmation, a proposition, howsoever attractive or interesting may be ceases to be a hypothesis.

The manner in which a hypothesis is formulated is very important as it gives significant clues about the kind of data required, the type of methods to be used for collecting data, and the methods of analysis to be used. It guides the researcher by delimiting the area of research and keeps researcher on the right track throughout his/her investigation. It sharpens researcher thinking and focuses attention on the more important facets of the problem under inquiry. Therefore, a hypothesis, to be worked with, needs to be precise, specific, and conceptually clear. It must have empirical referents. It must also be related to available research techniques. However, it is important to note that hypothesis is not required in all types of legal research. A researcher, for example, indulged in exploratory or descriptive legal research is not required to formulate hypothesis. Statement of problem in the form of hypothesis, invariably, is required in socio-legal research or empirical legal research, wherein the researcher is interested in finding ‘link’ between a ‘legal fact’ and a ‘social fact’ or is interested in assessing 'impact of law'.

***Research Design***:

After defining a research problem or formulating a hypothesis, as the case may be, the researcher has to work out a design for the study. Research design is the conceptual structure within which research is conducted. It is a logical systematic planning of research. The term research design refers to the entire process of planning and carrying out a research study. It is the process of visualization of the entire process of conducting empirical research before its commencement. Research design is a blue print of the proposed research. However, the blue print is tentative as the researcher may not be able to foresee all the contingencies before s/he starts his/her investigation. Researcher is allowed to meet these contingencies when s/he encounters them in his/her research journey. Research design helps the researcher to identify in advance the kind of data s/he requires, the means to collect them, the methods to be used for analysis and interpretation of the data, and presentation of researcher findings with more accuracy. Research design, thus, helps researcher in minimizing the uncertainties, confusion and practical hazards associated with the research problem. It helps in enhancing efficiency and reliability of researcher findings.

***Collection of Data:***

After formulating the research problem (or reformulating it in the light of literature review) and preparing a blue print of the research, the researcher has now to take a decision about the technique(s) to be employed to collect the requisite information. Researcher has to, from a wide range of methods of data collection, ranging from interviews to observations to document analysis, opt for the most appropriate method(s) for collecting data. However, it is not always easy to take the right decision. It is very crucial decision having far-reaching consequences on the outcome of research. The research method(s), which researcher chooses, will ultimately determine the quality and propriety of the data and in turn, of the consequential results. In a way, the selected methods of data collection determine the fate of his/her research. While selecting method(s) of data collection, the researcher has to take into account the objectives of his/her research and the nature and scope the inquiry. Data can be primary or secondary. Data collected by the researcher, by using primary sources, is primary. The data already collected by some other agency and available in some published form is secondary. In either case, the researcher has to select an appropriate method.

***Analysis of Data :***

After the data have been collected, the researcher needs to turn to the task of analyzing them. Data, in any form, are raw and neutral. Their direction and trend is generally highlighted and reflected with the help of analysis and interpretation. Analysis of data comes prior to interpretation. However, there is no clear-cut dividing line between analysis and interpretation. Analysis is not complete without interpretation and interpretation cannot proceed without analysis. They are inter-dependent. Analysis of data involves a number of closely related operations, such as classification or categorization, coding, and tabulation. Classification or categorization of data is the process of arranging data in groups or classes according to their resemblance or affinity. The researcher has to classify his/her data into required categories. The categorization has to be based on the problem under study or the hypothesis formulated. The category must be exhaustive and suitable for classifying all responses. They must be distinct, separate, and mutually exclusive. Coding involves the assigning of symbols or numerical to each of the category of responses so that raw data can be counted or tabulated. Tabulation is a means of recording classification in a compact form in such a way to facilitate comparisons and show the involved relations between two or more variables. It is a sort of arrangement of data in requisite rows and columns.

***Interpretation of Data*** :

Interpretation is considered as one of the basic components of research. It refers to the task of drawing inference from the collected data. The inference may be deductive or inductive. The former involves inferences from generally abstracts propositions to particular ones; while the latter is inference from particular propositions to general propositions.

Through interpretation, the researcher attempts to search for broader meaning of research findings. Researcher tries to establish link between the results of his/her inquiry with those of another and to establish some explanatory concepts. Researcher, through his/her interpretation, endeavors to find and understand the abstract principle that works beneath his/her findings. Interpretation opens up new avenues for intellectual adventures and stimulates the quest for more knowledge. Theprocess of interpretation may quite often trigger off new questions that in turn may lead to further researches. In fact, the usefulness and utility of a research lie in proper interpretation of the collected facts. One should, however, remember that even if data are properly collected and analyzed, wrong interpretation would lead to inaccurate and misleading conclusions. Interpretation, therefore, must be impartial and objective. A researcher should explain why his/her findings are so, in objective terms. Researcher should also try to bring out the principles involved behind his inferences. However, the task of interpretation is not an easy task. It requires a great skill. It is an art that one learns through practice and experience.

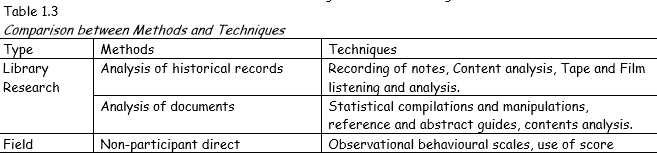
***Research Report:***

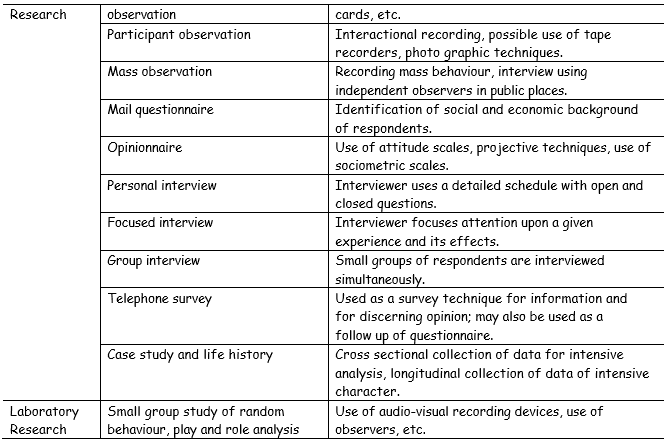
The last phase of the journey of research is the writing of research report. It is a major component of research. Research remains incomplete until report is written. Through research report, the researcher communicates with his/her audience. A research report generally needs to contain in it the requisite information about: (i) the problem undertaken for investigation and objectives thereof, (ii) methodology adopted in the inquiry, and (iii) analysis and inferences of investigation and their theoretical and practical implications, if any.

A general outlay of legal research report has three major components. They are: Preliminary Pages, the Main Text, and the End matter. In the first part, a legal researcher has to put Acknowledgement, Preface, Table of Contents, Table of Cases, Table of Statutes, Abbreviations, and List of Tables. While in the second part of the research report, researcher has to have different segments of his/her research in the form of chapters, with appropriate captions, starting from ‘Introduction’ to ‘Conclusions and Recommendations’. Each chapter has to have necessary headings and sub-heading with proper documentation in the form of footnotes. Chapters should be written in concise and simple language. While at the end of the report, researcher has to place Bibliography, different texts, like statutory provisions referred to in the main text, ‘interview’ or ‘questionnaire’, etc used by him/her for data collection, in the form of Annexure, and Index. Originality and clarity are the two vital components of research report. It is the ultimate test of one’s analytical ability and communication skills. It is an exercise involving the organization of ideas. Reporting the research, thus, requires skills somewhat different from those needed in the earlier phases of research.

***1.10 RESEARCH METHOD/ TECHNIQUE VERSUS METHODOLOGY***

All those methods which are used by the researcher during the course of studying his/her research problem are termed as research methods. Research techniques refer to the behaviour and instruments we use in performing research operations such as making observations, recording data, techniques of processing data and the like. Research methods refer to the behaviour and instruments used in selecting and constructing research technique. We can say that methods are more general. It is the methods that generate techniques. However, in practice, the two terms are taken as interchangeable and when we talk of research methods we do, by implication, include research techniques within their compass. For instance, difference between methods and techniques of data collection can better be understood from the details given in the following table -





Research methodology is a way to systematically solve the research problem. It may be understood as a science of studying how research is done scientifically. In it we study the various steps that are generally adopted by a researcher in studying his/her research problem along with the logic behind them. It is necessary for the researcher to know not only the research methods/techniques but also the methodology. Researchers not only need to know how to develop certain indices or tests, how to calculate the Mean, the Mode, the Median or the standard deviation or chi-square, how to apply particular research techniques, but they also need to know which of these methods or techniques, are relevant and which are not, and what would they mean and indicate and why. Researchers also need to understand the assumptions underlying various techniques and they need to know the criteria by which they can decide that certain techniques and procedures will be applicable to certain problems and others will not. All this means that it is necessary for the researcher to design his/her methodology for his problem as the same may differ from problem to problem. Research methodology has many dimensions and research methods do constitute a part of the research methodology. The scope of research methodology is wider than that of research methods. Thus, when we talk of research methodology we not only talk of the research methods but also consider the logic behind the methods we use in the context of our research study and explain why we are using a particular method or technique and why we are not using others so that research results are capable of being evaluated either by the researcher himself/herself or by others. Why a research study has been undertaken, how the research problem has been defined, in what way and why the hypothesis has been formulated, what data have been collected and what particular method has been adopted, why particular technique of analysing data has been used and a host of similar other questions are usually answered when we talk of research methodology.

**PART II - STATISTICS**

**INTRODUCTION**

**Statistics Overview**

Statistics is the study of the collection, organization, analysis, interpretation, and presentation of data. It deals with all aspects of data, including the planning of its collection in terms of the design of surveys and experiments. Some consider statistics a mathematical body of science that pertains to the collection, analysis, interpretation or explanation, and presentation of data, while others consider it a branch of mathematics concerned with collecting and interpreting data. Because of its empirical roots and its focus on applications, statistics is usually considered a distinct mathematical science rather than a branch of mathematics. As one would expect, statistics is largely grounded in mathematics, and the study of statistics has lent itself to many major concepts in mathematics, such as:probability, distributions, samples and populations, estimation, data analysis.

However, much of statistics is also non-mathematical. This includes:ensuring that data collection is undertaken in a way that produces valid conclusions, coding and archiving data so that information is retained and made useful for international comparisons of official statistics, reporting of results and summarized data (tables and graphs) in ways comprehensible to those who must use them, implementing procedures that ensure the privacy of census information

In short, statistics is the study of data. It includes descriptive statistics (the study of methods and tools for collecting data, and mathematical models to describe and interpret data) and inferential statistics (the systems and techniques for making probability-based decisions and accurate predictions based on incomplete data).

***Definition of Statistics***

**Statistics** is a branch of mathematics that deals with the scientific collection, organization, presentation, analysis and interpretation of numerical data in order to obtain useful and meaningful information.

* Collection of data refers to the process of obtaining information.
* Organization of data refers to the ascertaining manner of presenting the data into tables, graphs, or charts so that logical and statistical conclusions can be drawn from the collected measurements.
* Analysis of data refers to the process of extracting from the given data relevant information from which numerical description can be formulated.
* Interpretation of data refers to the task of drawing conclusions from the analyzed data.

The field of statistics is divided into two major divisions: descriptive and inferential. Each of these segments is important, offering different techniques that accomplish different objectives. Descriptive statistics describe what is going on in a [population](https://www.thoughtco.com/what-is-a-population-in-statistics-3126308) or [data set](https://www.thoughtco.com/what-is-the-range-in-statistics-3126248). Inferential statistics, by contrast, allow scientists to take findings from a sample group and generalize them to a larger population. The two types of statistics have some important differences.

**Descriptive Statistics** - try to describe the relationship between variables in a sample or population. In this branch of statistics, the goal is to describe. Numerical measures are used to tell about features of a set of data. There are a number of items that belong in this portion of statistics, such as:

**There are four major types of descriptive statistics:**

1. ***Measures of Frequency:***

\* Count, Percent, Frequency

\* Shows how often something occurs

\* Use this when you want to show how often a response is given

2. ***Measures of Central Tendency***

\* Mean, Median, and Mode

\* Locates the distribution by various *points*

*\**Use this when you want to show how an average or most commonly indicate

Response

3***. Measures of Dispersion or Variation***

\* Range, Variance, Standard Deviation

\* Identifies the spread of scores by stating intervals

\* Range = High/Low points

\* Variance or Standard Deviation = difference between observed score and mean

\* Use this when you want to show how "spread out" the data are. It is helpful to know when your data are so spread out that it affects the mean

4***.*** Measures of Location

\* Percentile, Decile, and Quartile

\* Describes how scores fall in relation to one another. Relies on standardized

scores

\* Use this when you need to compare scores to a normalized score (e.g., a

national norm)

These measures are important and useful because they allow scientists to see patterns among data, and thus to make sense of that data. Descriptive statistics can only be used to describe the population or data set under study: The results cannot be generalized to any other group or population.

In statistics, statistical inference is the process of drawing conclusions from data that is subject to random variation–for example, observational errors or sampling variation. More substantially, the terms statistical inference, statistical induction, and inferential statistics are used to describe systems of procedures that can be used to draw conclusions from data sets arising from systems affected by random variation, such as observational errors, random sampling, or random experimentation. Initial requirements of such a system of procedures for inference and induction are that the system should produce reasonable answers when applied to well-defined situations and that it should be general enough to be applied across a range of situations.

***Inferential statistics*** are produced through complex mathematical calculations that allow scientists to infer trends about a larger population based on a study of a sample taken from it. Scientists use inferential statistics to examine the relationships between variables within a sample and then make generalizations or predictions about how those variables will relate to a larger population.

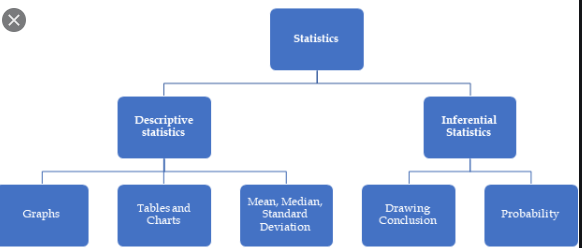
It is usually impossible to examine each member of the population individually. So scientists choose a representative subset of the population, called a statistical sample, and from this analysis, they are able to say something about the population from which the sample came. There are two major divisions of inferential statistics:

* A confidence interval gives a range of values for an unknown parameter of the population by measuring a statistical sample. This is expressed in terms of an interval and the degree of confidence that the parameter is within the interval.
* Tests of significance or [hypothesis testing](https://www.thoughtco.com/introduction-to-hypothesis-testing-3126336) where scientists make a claim about the population by analyzing a statistical sample. By design, there is some uncertainty in this process. This can be expressed in terms of a level of significance.

Techniques that social scientists use to examine the relationships between variables, and thereby to create inferential statistics, include [linear regression analyses](https://www.thoughtco.com/linear-regression-analysis-3026704), logistic regression analyses, [ANOVA](https://www.thoughtco.com/analysis-of-variance-anova-3026693), [correlation analyses](https://www.thoughtco.com/what-is-correlation-analysis-3026696), [structural equation modeling](https://www.thoughtco.com/structural-equation-modeling-3026709), and survival analysis. When conducting research using inferential statistics, scientists conduct a test of significance to determine whether they can generalize their results to a larger population. Common tests of significance include the [chi-square](https://www.thoughtco.com/chi-square-statistic-formula-and-usage-3126280) and [t-test](https://www.thoughtco.com/sample-t-test-confidence-interval-example-4022456). These tell scientists the probability that the results of their analysis of the sample are representative of the population as a whole.

Although descriptive statistics is helpful in learning things such as the spread and center of the data, nothing in descriptive statistics can be used to make any generalizations. In descriptive statistics, measurements such as the mean and standard deviation are stated as exact numbers.

Even though inferential statistics uses some similar calculations — such as the mean and standard deviation — the focus is different for inferential statistics. Inferential statistics start with a sample and then generalizes to a population. This information about a population is not stated as a number. Instead, scientists express these parameters as a range of potential numbers, along with a degree of confidence.



**VARIABLES**

Variable is a characteristic that varies from one individual member of population to another individual or a quantity whose value changes across the population and can be measured is called variable. For instance, consider a sample of employed individuals. The variables for this set of the population can be industry, location, gender, age, skills and job-type. The value of the variables will differ with each employee.

Variables such as height and weight are measured by some type of scale, convey quantitative information and are called as quantitative variables. Sex and eye color give qualitative information and are called as qualitative variables.

**Quantitative Variables**

Quantitative or numerical data are subdivided into discrete and continuous measurements. A discrete variable is a variable whose value is obtained by counting and this data are recorded as a whole number such as 0, 1, 2, 3,… (integer),.A continuous variable is a variable whose value is obtained by measuring. Continuous data can assume any value. Observations that can be counted constitute the discrete data and observations that can be measured constitute the continuous data. Examples of discrete data are number of episodes of respiratory arrests or the number of re-intubations in an intensive care unit. Similarly, examples of continuous data are the serial serum glucose levels, partial pressure of oxygen in arterial blood and the oesophageal temperature. A hierarchical scale of increasing precision can be used for observing and recording the data which is based on categorical, ordinal, interval and ratio scales.

**Qualitative Variables**

A qualitative variable, also known as categorical variables, qualitative variables are [variables](http://onlinestatbook.com/glossary/variable.html) with no natural sense of ordering. They are therefore measured on a [nominal scale](http://onlinestatbook.com/glossary/nominal_scales.html). Qualitative variables can be coded to appear numeric but their numbers are meaningless, as in male=1, female=2.. It describes data that fits into categories. For example:

* Eye colors (variables include: blue, green, brown, hazel).
* States (variables include: Florida, New Jersey, Washington).
* Dog breeds (variables include: Alaskan Malamute, German Shepherd, Siberian Husky, Shih tzu).

These are all qualitative variables as they have no natural order. On the other hand, [quantitative variables](https://www.statisticshowto.com/what-are-quantitative-variables-and-quantitative-data/) have a value and they can be added, subtracted, divided or multiplied.

**Levels of Measurement in Statistics**

To perform statistical analysis of data, it is important to first understand variables and what should be measured using these variables. There are different levels of measurement in statistics and data measured using them can be broadly classified into qualitative and quantitative data.

The level of measurement of a variable decides the statistical test type to be used. The mathematical nature of a variable or in other words, how a variable is measured is considered as the level of measurement.There are four main levels of measurement used in statistics: nominal, ordinal, interval, and ratio. Each of these have different degrees of usefulness in statistical research.

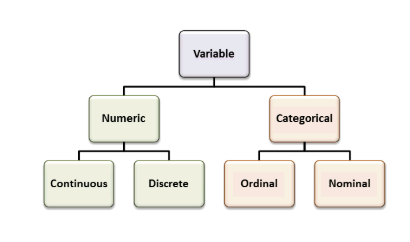
1. ***Nominal measurements*** have no meaningful rank order among values. Nominal data differentiates between items or subjects based only on qualitative classifications they belong to. Examples include gender, nationality, ethnicity, language, genre, style, biological species, visual pattern, etc.

2. ***Ordinal measurements*** have imprecise differences between consecutive values, but have a meaningful order to those values. Ordinal data allows for rank order (1st, 2nd, 3rd, etc) by which data can be sorted, but it still does not allow for relative degree of difference between them. Examples of ordinal data include dichotomous values such as “sick” versus “healthy” when measuring health, “guilty” versus “innocent” when making judgments in courts, “false” versus “true”, when measuring truth value. Examples also include non-dichotomous data consisting of a spectrum of values, such as “completely agree”, “mostly agree”, “mostly disagree”, or “completely disagree” when measuring opinion.

***3. Interval measurements*** have meaningful distances between measurements defined, but the zero value is arbitrary (as in the case with longitude and temperature measurements in Celsius or Fahrenheit). Interval data allows for the degree of difference between items, but not the ratio between them. Ratios are not allowed with interval data since 20°C cannot be said to be “twice as hot” as 10°C, nor can multiplication/division be carried out between any two dates directly. However, ratios of differences can be expressed; for example, one difference can be twice another. Interval type variables are sometimes also called “scaled variables”.

4. ***Ratio measurements*** have both a meaningful zero value and the distances between different measurements are defined; they provide the greatest flexibility in statistical methods that can be used for analyzing the data.

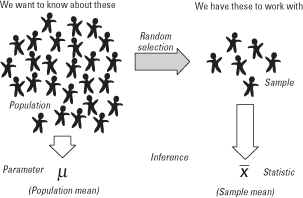
Because variables conforming only to nominal or ordinal measurements cannot be reasonably measured numerically, sometimes they are grouped together as categorical variables, whereas ratio and interval measurements are grouped together as quantitative variables, which can be either discrete or continuous, due to their numerical nature.



**Population and Sample**

A **population** is a group of phenomena that have something in common. Population includes all of the elements from a set of data. This can be the set of data on heights of students, age, gender, religion and etc. However, there are instances when the researcher cannot possibly handle a particular population due to some limitations such as time, cost, size and etc. to still study the characteristics of the population, the researcher may go into sampling. That is to select a portion of the population which is manageable is called as sample. **Sample** is the set of observation which is randomly selected from the population. The population size is denoted by N and the sample size is n.

A **parameter** is a characteristic of a population. A **statistic** is a characteristic of a sample. Inferential statistics enables you to make an educated guess about a population parameter based on a statistic computed from a sample randomly drawn from that population.



**Figure 1.Illustration of the relationship between samples and populations.**

**Comparison between sample statistic and population parameter**

|  |  |  |
| --- | --- | --- |
|  | Sample Statistic | Population Parameter |
| Mean | X | µ |
| Variance | S2 | δ2 |
| Standard Deviation | S | δ |

**Data** is measured, collected and reported, and analyzed, whereupon it can be visualized using graphs, images or other analysis tools. **Data** as a general concept refers to the fact that some existing information or knowledge is represented or coded in some form suitable for better usage or processing. Combination of multiple variables

One of the formulas to calculate the sample size is using the Slovin Formula:

**n =**

where: n is the sample size

N is the population size

e is the margin of error ( e= 0.05)

Example 1. Suppose sample is calculated out of 350 observations in a population. Use Slovin formula in calculating the number of samples.

n =

n =

n = 19

**Sampling Technique**

Sampling is concerned with the selection of a subset of individuals from within a statistical population to estimate characteristics of the whole population. Two advantages of sampling are that the cost is lower and data collection is faster than measuring the entire population. One of the formulas to calculate the sample size is using the Slovin

Sampling comes in two forms — probability sampling and non-probability sampling. Probability sampling uses random sampling techniques to create a sample. Non-probability sampling methods use non-random processes such as researcher judgement or convenience sampling.

Probability sampling is based on the fact that every member of a [population](https://www.statisticshowto.com/what-is-a-population/)has a known and equal chance of being selected.

Types of Probability Sampling

1. [Simple random sampling](https://www.statisticshowto.com/simple-random-sample/) is a completely random method of selecting subjects. These can include assigning numbers to all subjects and then using a random number generator to choose random numbers. Classic [ball and urn experiments](http://www.math.uah.edu/stat/urn/Introduction.html) are another example of this process (assuming the balls are sufficiently mixed). The members whose numbers are chosen are included in the sample.

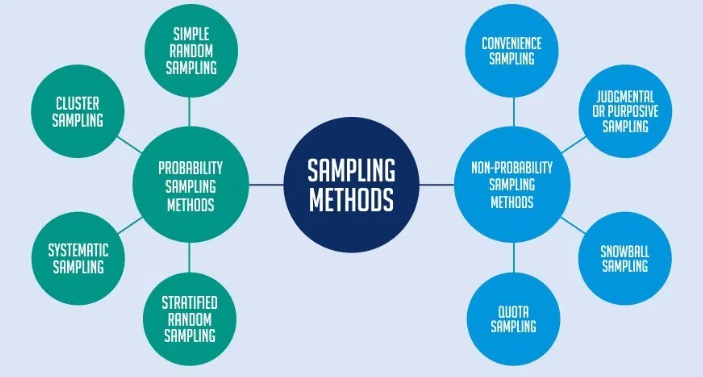
2. [Stratified Random Sampling](https://www.statisticshowto.com/stratified-random-sample/) involves splitting subjects into [mutually exclusive](https://www.statisticshowto.com/mutually-exclusive-event/) groups and then using simple random sampling to choose members from groups.

3. [Systematic Sampling](https://www.statisticshowto.com/systematic-sampling/) means that you choose every “nth” participant from a complete list. For example, you could choose every 10th person listed.

4. Cluster Random Sampling is a way to randomly select participants from a list that is too large for simple random sampling. For example, if you wanted to choose 1000 participants from the entire population of the U.S., it is likely impossible to get a complete list of everyone. Instead, the researcher randomly selects areas (i.e. cities or counties) and randomly selects from within those boundaries.

Types of Non-Probability Sampling

1. [Convenience Sampling:](https://www.statisticshowto.com/convenience-sampling/) as the name suggests, this involves collecting a sample from somewhere convenient to you: the mall, your local school, your church. Sometimes called accidental sampling, opportunity sampling or grab sampling.
2. [Purposive Sampling](https://www.statisticshowto.com/purposive-sampling/): where the researcher chooses a sample based on their knowledge about the population and the study itself. The study participants are chosen based on the study’s purpose.
3. [Quota Sampling](https://www.statisticshowto.com/quota-sampling/): where the groups (i.e. men and women) in the sample are proportional to the groups in the population.
4. [Snowball Sampling](https://www.statisticshowto.com/snowball-sampling/): where research participants recruit other members for the study. This method is particularly useful when participants might be hard to find. For example, a study on working prostitutes or current heroin users.

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***Testing Hypothesis***

Hypothesis is a conjecture, a proposition, assumption, or a supposition that is temporarily and provisionally accepted to describe a certain event which is still to be verified or proven by facts to be gathered. Hypothesis is a tentative insight that serves as the basis of investigation as guidance in proving or disproving certain characteristics of a population.

In statistics, hypothesis is either classified as null hypothesis denoted as Ho or alternative hypothesis denoted as H1. Etymologically, the term “null” comes from the latin word “nullus”, whichmeans none. Semantically , null means ‘nil” means no value or void.

A hypothesis (plural hypotheses) is a proposed explanation for a phenomenon. Hypothesis tests are thus procedures for making rational decisions about the reality of observed effects. In inferential statistics, the term ‘null hypothesis’ or Ho denotes that there is no relationship (difference) between the population variables in question. Alternative hypothesis (H1 and Ha ) denotes that a statement between the variables is expected to be true.

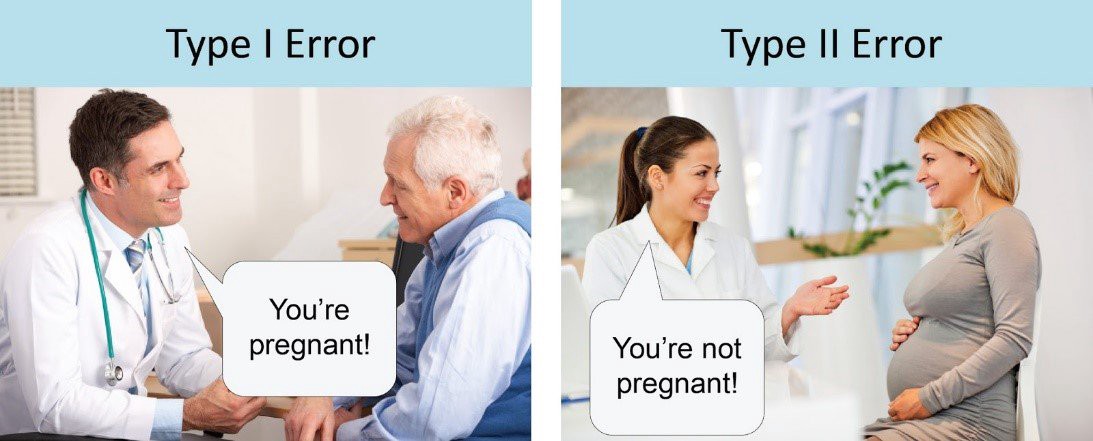
The null hypothesis is the hypothesis of no difference or relationship). This means that µ₁ - µ₂ = 0; µ₁ = µ₂; therefore Ho: µ₁ - µ₂ = 0; µ₁ = µ₂. Otherwise if µ₁ - µ₂ 0; µ₁ µ₂ therefore, µ₁ µ₂ or µ₁ µ₂ then reject the null hypothesis in favour of alternative hypothesis.

***Type I and Type II Error***

The probability of rejecting the null hypothesis Ho in favour of the alternative hypothesis H1, when it is in fact true which should have accepted is called Type I Error or False Positive. Type I Error is denoted by α the significance level of a test or it is the probability of committing Type I Error.

On the other hand, the probability of accepting the null hypothesis Ho when it is in fact false which should have rejected is called Type II Error. Refusing to believe a truth is considered as Type II Error and is denoted by .

For example, if Hostates that teacher’s teaching competency has no effect on the performance of the students. When Ho was tested and result showed to reject Ho in favour of H1 when in fact Ho is indeed true, Type I Error is committed. However, When Ho was tested and result showed to accept Ho when in fact it is false, Type II Error is committed.



***Level of Significance***

The probability of committing a type I error is also called level of significance of the test and denoted by α (alpha). The rejection or acceptance of the null hypothesis is not error free. It is possible that the conclusion could be wrong.

However, if the level of significance of the test α = 0.05 this means that the probability of committing a type I error is 5% or 95% level of confident that type I error will not be committed, if α = 0.01 level of significance this mean that the probability of committing a type I error is 1% or 99% confident that type I error will not be committed and if α = 0.10 level of significance this mean that the probability of committing a type I error is 10% or 90% confident that type I error will not be committed.

***One-Tailed and Two-Tailed Test***

A test of any statistical hypothesis, where the alternative is one-sided, such as

Ho: µ = µo

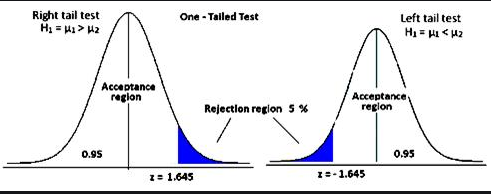
H1: µ > µo

Or perhaps

Ho: µ = µo

H1: µ < µo

is called one-tailed test. The critical region for the alternative hypothesis H1: µ > µo lies entirelyin the right tail of the distribution, while the critical region for the alternative hypothesis H1: µ < µo lies entirelyin the left tail of the distribution.

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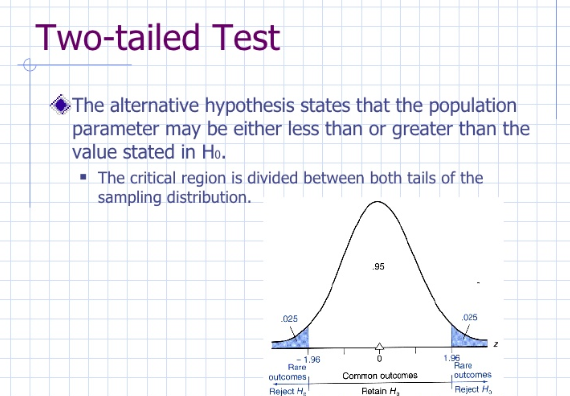
A test of any statistical hypothesis, where the alternative is two-sided, such as

Ho: µ = µo

H1: µ µo

is called two-tailed test, since the critical region is split into two equal parts in each tail of the distribution of the test statistic. The alternative hypothesis H1: µ µo states that either µ < µo or µ > µo two-tailed test used.

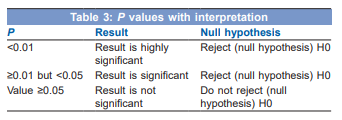
Testing of hypothesis is an investigation on some prevailing belief against what the researcher believes. If the researcher is investigating to check if what he believes is better than the prevailing belief , then the test is known as one-tailed test. On the other hand if the researcher is not interested in comparing the parameters, the best test is called two-tailed test.

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***Accepting and Rejecting the Null Hypothesis***

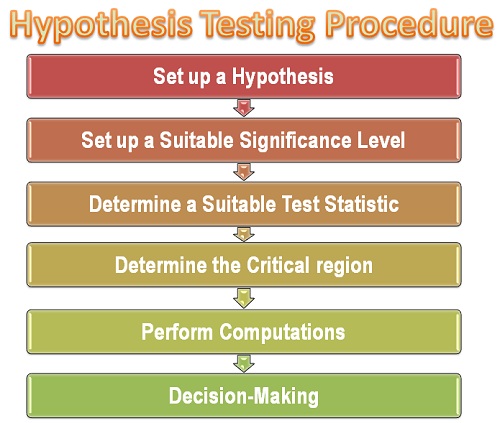
After the null hypothesis is being formulated, the tail of the test (if there is any), the level of significance, the critical value and the statistic test has been set, computation will follow. If the computed value of a test is less than the tabulated value or the critical value, Ho is Accepted but if the computed value of a test is greater than the tabulated value or the critical value, Ho is Rejected.

For results base on probability refer to table 3.



***Hypothesis Testing Procedure***

The following steps are followed in hypothesis testing:

[](https://businessjargons.com/wp-content/uploads/2016/04/Hypothesis-Testing-Procedure.jpg)

1. **Set up a Hypothesis:**The first step is to establish the hypothesis to be tested. The statistical hypothesis is an assumption about the value of some unknown parameter, and the hypothesis provides some numerical value or range of values for the parameter. Here two hypotheses about the population are constructed **Null Hypothesis**and **Alternative Hypothesis**.

The Null Hypothesis denoted by H0 asserts that there is no true difference between the sample of data and the population parameter and that the difference is accidental which is caused due to the fluctuations in sampling. Thus, a null hypothesis states that there is no difference between the assumed and actual value of the parameter.

The alternative hypothesis denoted by H1 is the other hypothesis about the population, which stands true if the null hypothesis is rejected. Thus, if we reject H0 then the alternative hypothesis H1 gets accepted.

1. **Set up a Suitable Significance Level:** Once the hypothesis about the population is constructed the researcher has to decide the level of significance, i.e. a confidence level with which the null hypothesis is accepted or rejected. The significance level is denoted by**‘α’** and is usually defined before the samples are drawn such that results obtained do not influence the choice. In practice, we either take 5%, 10% or 1% level of significance.

If the 5% level of significance is taken, it means that there are five chances out of 100 that we will reject the null hypothesis when it should have been accepted, i.e. we are about 95% confident that we have made the right decision. Similarly, if the 1% level of significance is taken, it means that there is only one chance out of 100 that we reject the hypothesis when it should have been accepted, and we are about 99% confident that the decision made is correct.

1. **Determining a Suitable Test Statistic:**After the hypothesis are constructed, and the significance level is decided upon, the next step is to determine a suitable test statistic and its distribution.
2. **Determining the Critical Region:**Before the samples are drawn it must be decided that which **values to the test statistic** will lead to the acceptance of H0 and which will lead to its rejection. The values that lead to rejection of H0is called the critical region.
3. **Performing Computations:**Once the critical region is identified, we compute several values for the random sample of size ‘n.’ Then we will apply the formula of the test statistic as shown in step (3) to check whether the sample results falls in the acceptance region or the rejection region.
4. **Decision-making:**Once all the steps are performed, the statistical conclusions can be drawn, and the management can take decisions. The decision involves either accepting the null hypothesis or rejecting it. The decision that the null hypothesis is accepted or rejected depends on whether the computed value falls in the acceptance region or the rejection region.

***T DISTRIBUTION***

**Student’s t‑test**

The t test is one type of inferential statistics. It is used to determine whether there is a significant difference between the means of two groups. With all inferential statistics, we assume the dependent variable fits a normal distribution. There are two applications: one for comparing the means of paired samples and the other is comparing the means of two non-paired samples. The later has two methods: a) samples with the same number of observation, and b. samples with different numbers of observations. Student’s t-test is used to test the null hypothesis that there is no difference between the means of the two groups. T-test is only applicable if the number of observation is less than 30 (n < 30). If the number of observation is 30 and above (n ≥ 30), Z test will be used.

1. ***COMPARING THE MEANS OF PAIRED SAMPLES***

Each x1 is paired in some way with that of x2. In other words, there is basis of pairing the observations. The formula is:

tc =

s² =

where: d͞ = mean difference

n = number of pairs

s²= estimated variance

d = difference between paired values

Example 1: Suppose we are going to compare the mean intelligence scores of husband (x1) and wives (x2). Evaluate that there is a significant difference between the intelligence scores of husbands and wives. Use α = 0.05 ; one-tailed test.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| x1 | 70 | 65 | 83 | 82 | 86 | 75 | 74 | 74 | 65 | 68 | 84 | 90 | 81 | 70 | 66 |
| x2 | 85 | 70 | 83 | 88 | 90 | 84 | 75 | 88 | 79 | 68 | 88 | 88 | 84 | 85 | 70 |

**SOLUTION:**

1. Problem: Is there a significant difference between the means ofhusbands and wives?

2. Hypotheses: Ho: µ1 - µ2 = 0 or there is no difference between the means of husbands and wives.

H1: µ1 - µ2 0 or there is a difference between the means of husbands and wives.

3. Level of significance: α = 0.05 ; one-tailed test

4. Statistics: t-test for paired sample

Critical Value @ α = 0.05 = 1.761

df = n - 1

= 15 -1

= 14

5. Computation:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | x1 | x2 | d | d2 |
| 1 | 70 | 85 | -15 | 225 |
| 2 | 65 | 70 | -5 | 25 |
| 3 | 83 | 83 | 0 | 0 |
| 4 | 82 | 88 | -6 | 36 |
| 5 | 86 | 90 | -4 | 16 |
| 6 | 75 | 84 | -9 | 81 |
| 7 | 74 | 75 | -1 | 1 |
| 8 | 74 | 88 | -14 | 196 |
| 9 | 65 | 79 | -14 | 196 |
| 10 | 68 | 68 | 0 | 0 |
| 11 | 84 | 88 | -4 | 16 |
| 12 | 90 | 88 | 2 | 4 |
| 13 | 81 | 84 | -3 | 9 |
| 14 | 70 | 85 | -15 | 225 |
| 15 | 66 | 70 | -4 | 16 |
|  |  |  | -92 | 1046 |

d͞ =

d͞ = -6.13

s2 =

s2 = 34.41

tc =

tc =│-4.05│

tc = 4.05

6. Decision: Since the computed t value of 4.05 is greater than the tabulated t value of 1.761 @ α = 0.05 and df = 14, thus the null hypothesis is rejected.

7. Conclusion: Therefore, there is a significant difference between the means of husbands and wives.

1. ***COMPARING THE MEANS OF TWO NON-PAIRED SAMPLES***

B.1 Samples with the same number of observations

tc = ; Degree 0f Freedom df= 2n - 2

s2 =

where: tc = computed t value

x͞₁ = sample mean of the first group

x͞₂ = sample mean of the second group

s² = pooled variance

s = standard deviation

Example 2: The following are the scores in spelling of 10 male and 10 female AB students. Test the null hypothesis that there is no significant difference between the performance of male and female AB students in spelling. Use α = 0.05 level of significance, two tailed test .

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Male | **X1** | **14** | **18** | **17** | **16** | **4** | **14** | **12** | **10** | **9** | **17** |
| Female | **X2** | **12** | **9** | **11** | **5** | **10** | **3** | **7** | **2** | **6** | **13** |

**SOLUTION**:

1. Problem: Is there a significant difference between the performance of male

and female AB students in spelling?

1. Hypotheses:

Ho: There is no significant difference between the performance of

male and female AB students in spelling.

H1: There is a significant difference between the performance of

male and female AB students in spelling.

1. Level of Significance:α = 0.05 ; two-tailed test
2. Statistics: t-test for two independent samples

Critical Value @ α = 0.05 = 2.101

df = n1 +n2 - 2

= 10 + 10 – 2

= 18

1. Computation:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | X1 | x₁² | X2 | x₂² |
| **1** | 14 | 196 | 12 | 144 |
| **2** | 18 | 324 | 9 | 81 |
| **3** | 17 | 289 | 11 | 121 |
| **4** | 16 | 256 | 5 | 25 |
| **5** | 4 | 16 | 10 | 100 |
| **6** | 14 | 196 | 3 | 9 |
| **7** | 12 | 144 | 7 | 49 |
| **8** | 10 | 100 | 2 | 4 |
| **9** | 9 | 81 | 6 | 36 |
| **10** | 17 | 289 | 13 | 169 |
| Total | ***131*** | ***1891*** | ***78*** | ***738*** |
| Mean | 13.1 |  | 7.8 |  |

x͞1

x͞1

x͞1

X͞2

X͞2

X͞2

s2 =

s2 =

s2  = 20.3

s = 4.51

tc =

tc = 2.63

6. Decision: Since the computed t value of 2.63 is greater than the tabulated t-value of 2.101, thus the null hypothesis is rejected at α = 0.05 with df = 18.

7. Conclusion: Therefore, there is a significant difference between the performance of male and female AB students in spelling.

B.2 Samples with different numbers of observations

tc =

s2 =

where: tc = computed t value

x͞₁ = sample mean of the first group

x͞₂ = sample mean of the second group

s² = pooled variance

s = standard deviation

n₁ = number of observation of the 1st sample

n₂ = number of observation of the 2nd sample

Example 4: Suppose that we are going to compare the yield per plot of two varieties of rice. Determine whether there is a significant difference in the yield of two varieties of rice. Use α = 0.01 level of significance, two tailed test.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Variety | A | 38 | 40 | 40 | 42 | 39 | 35 | 32 | 28 | 42 | 44 |
| B | 37 | 37 | 40 | 40 | 32 | 30 | 31 |  |  |  |

**SOLUTION**

1. Problem: Is there a significant difference in the yield of two varieties

of rice?

2. Hypotheses: Ho: There is no significant difference in the yield of two

Varieties of rice.

H1 : There is a significant difference in the yield of two

varieties of rice.

3. Statistics: t-test for samples with different numbers of observations

Critical Value @ α = 0.05 = 2.947

df = n1 +n2 - 2

= 10 + 7 – 2

= 15

4. Level of Significance: α = 0.01 ; two tailed test

5. Computation:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | x1 | x12 | x2 | x22 |
| 1 | 38 | 1444 | 37 | 1369 |
| 2 | 40 | 1600 | 37 | 1369 |
| 3 | 40 | 1600 | 40 | 1600 |
| 4 | 42 | 1764 | 40 | 1600 |
| 5 | 39 | 1521 | 32 | 1024 |
| 6 | 35 | 1225 | 30 | 900 |
| 7 | 32 | 1024 | 31 | 961 |
| 8 | 28 | 784 |  |  |
| 9 | 42 | 1764 |  |  |
| 10 | 44 | 1936 |  |  |
| Total | 380 | *14662* | *247* | *8823* |
| Mean | 38.0 |  | 35.29 |  |
|  | 14440 |  | 8716 |  |

s2 =

s2 =

s2 = 21.96

s = 4.69

tc =

tc =

tc = 1.18

6. Decision: Since the computed t value of 1.18 is lesser than the tabulated t value of 2.947, thus the null hypothesis is accepted.

7. Conclusion: Therefore, there is no significant difference in the yield of two varieties of rice.

**Z Test**

Z-tests are statistical calculations that can be used to compare population means to a sample’s. The z-score tells you how far, in standard deviation, a data point is from the mean or average of a data set. A z-test compares a sample to a defined population and is typical used for dealing problems relating to large samples (n > 30). Z-test can also be helpful when we want to test a hypothesis. Generally, they are most useful when the standard deviation is known.

A z-test is a statistical test used to determine whether two population means are different when the variances are known and the sample size is large. The test statistic is assumed to have a [normal distribution](https://www.investopedia.com/terms/n/normaldistribution.asp), and nuisance parameters such as standard deviation should be known in order for an accurate z-test to be performed.

A z-statistic, or z-score, is a number representing how many standard deviations above or below the mean population a score derived from a z-test is.

* *A z-test is a statistical test to determine whether two population means are different when the variances are known and the sample size is large.*
* *It can be used to test hypotheses in which the z-test follows a normal distribution.*
* *A z-statistic, or z-score, is a number representing the result from the z-test.*
* *Z-tests are closely related to t-tests, but t-tests are best performed when an experiment has a small sample size.*
* *Also, t-tests assume the standard deviation is unknown, while z-tests assume it is known.*

Several different types of tests are used in statistics (i.e. [f test](https://www.statisticshowto.com/probability-and-statistics/hypothesis-testing/f-test/), [chi square test](https://www.statisticshowto.com/probability-and-statistics/chi-square/), [t test](https://www.statisticshowto.com/probability-and-statistics/t-test/)). You would use a Z test if:

* Your [sample size](https://www.statisticshowto.com/probability-and-statistics/find-sample-size/) is greater than 30. Otherwise, use a [t test](https://www.statisticshowto.com/probability-and-statistics/t-test/).
* Data points should be [independent](https://www.statisticshowto.com/probability-and-statistics/dependent-events-independent/#or)from each other. In other words, one data point isn’t related or doesn’t affect another data point.
* Your data should be normally distributed. However, for large sample sizes (over 30) this doesn’t always matter.
* Your data should be randomly selected from a population, where each item has an equal chance of being selected.
* [Sample sizes](https://www.statisticshowto.com/probability-and-statistics/find-sample-size/) should be equal if at all possible.

There are different types of [Z-test](http://en.wikipedia.org/wiki/Z-test) each for different purpose. Some of the popular types are outlined below:

**1. One-Sample Z- Test**

A one sample z test is one of the most basic types of [hypothesis test](https://www.statisticshowto.com/probability-and-statistics/hypothesis-testing/). In order to run a one sample z test,

Z =

where: Ⴟ = sample mean;

µ = population mean;

σ = population standard deviation;

n = sample size.

**Example 1:A principal at a school claims that the students in his school are above average intelligence. A random sample of 35 students IQ scores, have a mean score of 115.5. The mean population IQ is 100 with standard deviation of 15. Is there sufficient evidence to support the principal’s claim?**

**SOLUTION**

**1. Problem: Is there sufficient evidence to support the principal’s claim?**

2. Hypotheses: Ho: The population mean is equal to 100 or µ =100.

H1: The mean scores of student is above average µ > 100.

3. Statistic: One sample z test

Critical Value = 1.645

4. Level of Significance: σ = 0.05

Two-tailed test

5. Computation:

Z =

Z =

Z = 0.3690

6. Decision: Since the computed z value of 0.369 is lesser than the tabulated z value of 1.645 at σ = 0.05, thus the null hypothesis is accepted.

7. Conclusion: Therefore, the mean scores of student is above average µ > 100. This implies that the principals’ claim is not right.

**2. Two Sample Z-Test**

Two sample z-test use to test the two normally distributed but independent populations.

Z =

where: x͞₁ = mean of the 1st sample

x͞₂ = mean of the 2nd sample

µ₁ - µ₂ = hypothesized difference between two populations

σ₁² =variance of the 1st population

σ₂² = variance of the 2nd population

n₁ = number of the 1st sample

n₂ = number of the 2nd sample

Example 2: The amount of a certain trace element in blood is known to vary with a standard deviation of 14.1 ppm (parts per million) for male blood donors and 9.5 ppm for female blood donors. A random sample of 75 male and 50 female that the population donors yield concentration means of 28 and 33 ppm, respectively. What is the likelihood that the population means of concentration of the element are the same for men and women?

SOLUTION

1. Problem: What is the likelihood that the population means of concentration of the element are the same for men and women?

2. Hypotheses: Ho: The population means of concentration of the element are the same for men and women.

H1: The population means of concentration of the element are not the same for men and women

3. Statistic: Two sample z test

Critical Value = 1.645

4. Level of Significance: σ = 0.05

5. Computation:

Z =

Z = -

Z = -2.37 finding the absolute value so

Z = 2.37

6. Decision: Since the computed z value of 2.37 is greater than the tabulated z

value of 1.645 at σ = 0.05, thus the null hypothesis is rejected.

7. Conclusion: Therefore, the population means of concentration of the element are not the same for men and women.

**3. One Sample Proportion Z Test**

The One Sample Proportion Test is used to estimate the proportion of a population. It compares the proportion to a target or reference value and also calculates a range of values that is likely to include the population proportion. This is also called hypothesis of inequality.

**Z =**

Where: n = Sample size

po = Null hypothesized value

= Observed proportion

Example: A survey claims that 9 out of 10 doctors recommend aspirin for their patients with headaches. To test this claim, a random sample of 100 doctors is obtained. Of these 100 doctors, 82 indicate that they recommend aspirin. Is this claim accurate? Use α = 0.05.

1. Problem**:** Is the claim that 9 out of 10 doctors recommend aspirin for their patients with headaches is accurate?

2. Hypotheses:

Ho: The claim that 9 out of 10 doctors recommend aspirin for their patients with headaches is accurate.

H1: The claim that 9 out of 10 doctors recommend aspirin for their patients with headaches is not accurate.

3. Statistic test: One Sample Proportion Z Test

Critical Value = 1.645

4. Level of Significance: α = 0.05 two-tailed test

5. Computation:

Z =

Z =

Z = -2.667 finding the absolute value so

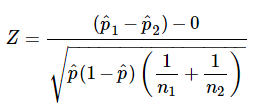
Z = 2.667

6. Decision: Since the computed Z value of 2.667 is greater than the tabulated Z value of 1.645, thus, the null hypothesis is rejected at 0.05 level of significance.

7. Conclusion: Therefore, the claim that 9 out of 10 doctors recommend aspirin for their patients with headaches is not accurate.

4. **Z Test For Difference Of Proportions**

Z test for difference of proportions is used to test the hypothesis that two populations have the same proportion. For example suppose one is interested to test if there is any significant difference in the habit of tea drinking between male and female citizens of a town. In such a situation, Z-test for difference of proportions can be applied.One would have to obtain two independent samples from the town- one from males and the other from females and determine the proportion of tea drinkers in each sample in order to perform this test.

[](https://www.statisticshowto.com/wp-content/uploads/2014/02/two-proprtion-z-test.png)

Where: ṕ =overall sample proportion

ṕ₁ = proportion of the 1st sample

ṕ₂ = proportion of the 2nd sample

**n₁ =1st sample**

**n₂ =2nd sample**

This test for a difference in proportions. A two proportion z-test allows you to compare two proportions to see if they are the same.

* The null hypothesis (H0) for the test is that the proportions are the same.
* The alternate hypothesis (H1) is that the proportions are not the same.

Example: Let’s say you’re testing two flu drugs A and B. Drug A works on 41 people out of a sample of 195. Drug B works on 351 people in a sample of 605. Are the two drugs comparable? Use a 5% [alpha level](https://www.statisticshowto.com/what-is-an-alpha-level/).

1. Problem: Are the two drugs comparable?

2. Hypotheses:

Ho : The two drugs are comparable.

H1: The two drugs are not comparable.

3. Test statistic: Two Proportion Z-Test

Critical value = 1.96

4. Level of Significance: α = 0.05 Two-tailed test

5. Computation:

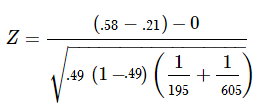
 Find the two proportions:

P1 = 41/195 = 0.21 (that’s 21%)

P2 = 351/605 = 0.58 (that’s 58%).

Find the overall sample proportion. The numerator will be the total number of “positive” results for the two samples and the denominator is the total number of people in the two samples.

p = (41 + 351) / (195 + 605) = 0.49.

[](https://www.statisticshowto.com/wp-content/uploads/2014/02/two-proprtion-z-test-2.png)  
Z = 8.99

6. Decision: Since the computed Z value of 8.99 is greater than the tabulated Z value of 1.96, thus the null hypothesis is rejected.

7. Conclusion: Therefore, the two drugs are not comparable at 0.05 level of significance.

**ANALYSIS OF VARIANCE**

Analysis of variance (**ANOVA**) is a collection of statistical models and their associated estimation procedures (such as the "variation" among and between groups) used to analyze the differences among group means in a sample. ANOVA is a hypothesis testing procedure that tests whether two or more means are significantly different from each other. A statistic, F, is calculated that measures the size of the effects by comparing a ratio of the differences between the means of the groups to the variability within groups.

The one-way ANOVA compares the means between the groups you are interested in and determines whether any of those means are statistically significantly different from each other. Specifically, it tests the null hypothesis:

One-way ANOVA Null Hypothesis

where *µ* = group mean and *k* = number of groups. If, however, the one-way ANOVA returns a statistically significant result, we accept the alternative hypothesis (HA), which is that there are at least two group means that are statistically significantly different from each other.

At this point, it is important to realize that the one-way ANOVA is an **omnibus** test statistic and cannot tell you which specific groups were statistically significantly different from each other, only that at least two groups were. To determine which specific groups differed from each other, you need to use a **post hoc test**. Post hoc tests are described later in this guide.

The purpose of ANOVA is to test if there is any significant difference between the means of two or more groups. In ANOVA, we study two variances –

(a) between-group variability and

(b) within-group variability.

The within-group variability (error variance) is the variation that cannot be accounted for in the study design. It is based on random differences present in our samples.

**Symbolic representation of data for One-Way ANOVA**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Categories | | | | |
| Scores | A1 | A2 | … | Ak | Total |
| x11 | x12 | .. | x1k |  |
| x21 | x22 | .. | x2k |  |
| x31 | x32 | … | x3k |  |
|  |  |  |  |  |
| xr1 | xr2 | .. | xrk |  |
| Sums |  |  | … |  |  |
| Means | x͞₁ | x͞₂ |  | x͞ₖ | x͞ |
| No. of Cases | R | r |  | R | N |

**Analysis of Variance for the One-Way Classification**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Source of Variation** | **Sum of Squares** | **Degrees of Freedom** | **Mean Square** | **Computed f** |
| **Column Means** | **SSC** | **k-1** |  |  |
| **Error** | **SSE** | **k(n-1)** |  |
| **Total** | **SST** | **nk-1** |  |  |

The computation in an analysis of variance problems are usually summarized in tabular form. It is customary to refer to the various estimates of σ² as the mean square.

**Sum-of-Squares Computational Formula**

**Total Sum of Squares SST =**

**Sum of Squares for Column Means SSC =**

**Error Sum of Squares SSE = SST – SSC**

**Example 1:** The following data represent the number of hours of pain relief provided by 5 different brands of headache tablets administered to 25 subjects. The 25 subjects were randomly divided into 5 groups and each group was treated with different brand.

Hours of Relief from Headache Tablets

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Tablets | | | | |
| A | B | C | D | E |
| 5 | 9 | 3 | 2 | 7 |
| 4 | 7 | 5 | 3 | 6 |
| 8 | 8 | 2 | 4 | 9 |
| 6 | 6 | 3 | 1 | 4 |
| 3 | 9 | 7 | 4 | 7 |

Perform the analysis of variance and test the hypothesis at the 0.05 level of significant that the mean number of hours of relief provided by the tablets is the same for all brands.

**SOLUTION**

1. Problem: Do the mean number of hours of relief provided by the tablets for all brands are not the same?

2. Hypotheses:

Ho: The mean number of hours of relief provided by the tablets is the same for all brands.

H1:The mean number of hours of relief provided by the tablets is not the same for all brands.

.

3. Level of Significance: α = 0.05

4. Critical Value: ft= 2.87

5. Computation:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Tablets | | | | | | | | | |  |
| A | A² | B | B² | C | C² | D | D² | E | E² |
|  | 5 | 25 | 9 | 81 | 3 | 9 | 2 | 4 | 7 | 49 |  |
| 4 | 16 | 7 | 49 | 5 | 25 | 3 | 9 | 6 | 36 |
| 8 | 64 | 8 | 64 | 2 | 4 | 4 | 16 | 9 | 81 |
| 6 | 36 | 6 | 36 | 3 | 9 | 1 | 1 | 4 | 16 |
| 3 | 9 | 9 | 81 | 7 | 49 | 4 | 16 | 7 | 49 |
| ***Total*** | ***26*** |  | ***39*** |  | ***20*** |  | ***14*** |  | ***33*** |  | ***132*** |
| ***Means*** | ***5*** |  | ***8*** |  | ***4*** |  | ***3*** |  | ***7*** |  | ***5.28*** |
| Total |  | 150 |  | 311 |  | 96 |  | 46 |  | 231 | 834 |

SST =

SST = 137. 040

SSC =

SSC = 79.44

SSE = 137.040 – 79.44

SSE =57.60

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Source of Variation** | **Sum of Squares** | **Degrees of Freedom** | **Mean Square** | **Computed f** |
| **Column Means** | **79.44** | **5 – 1 = 4** | **= 19.86** |  |
| **Error** | **57.60** | **5(5-1) = 20** |  |
| **Total** | **137.04** | **5(5)-1 =24** |  |  |

6. Decision: Since the computed f value of 6.90 is greater than the tabulated f value of 2.87 at α = 0.05 level of significance, thus the null hypothesis is rejected.

7. Conclusion: Therefore, the mean number of hours of relief provided by the tablets is not the same for all brands.

In experimental work one often loses some of the desired observations. For example, an experiment might be conducted to determine if college students obtain different grades on the average for classes meeting at different times of the day. Because of dropouts during the semester, it is entirely possible to conclude the experiment with unequal number of students in the various sections.

The previous analysis for equal samples size will still be valid by slightly modifying the sum of squares formulas. We now assume the k random samples to be the size n1, n2, …nk respectively, with N = . The computational formula for SST, SSC, and SSE are now given by:

**Computational Formulas for Unequal Sample Sizes**

**Total Sum of Squares SST =**

**Sum of Squares for Column Means SSC =**

**Error Sum of Squares SSE = SST – SSC**

The degrees of freedom are then partitioned in the same way; N – 1 for SST, k – 1 for SSC and N – k for SSE.

Example 2: It is suspected that the higher-priced automobiles are assembled with greater care than lower-priced automobiles. To investigate whether there is any basis for this feeling, a large luxury model A, a medium –size sedan B, and a subcompact hatchback C were compared for defects when they arrived at the dealer’s showroom. All cars were manufactured by the same company. The number of defects for several of the three models are recorded as follows:

|  |  |  |
| --- | --- | --- |
| Model | | |
| A | B | C |
| 4 | 5 | 8 |
| 7 | 1 | 6 |
| 6 | 3 | 8 |
| 6 | 5 | 9 |
|  | 3 | 5 |
|  | 4 |  |

Test the hypothesis at the 0.05 level of significance that the average number of defects is the same for the three models.

SOLUTION

1. Problem: Do the average number of defects is not the same for the three brands?

2. Hypotheses:

Ho: The average number of defects is the same for the three brands.

H1: The average number of defects is not the same for the three brands.

3. Level of Significance: α = 0.05

4. Critical Value: ft= 3.89

5. Computation:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Model | | | | | |  |
| A | A² | B | B² | C | C² |
|  | 4 | 16 | 5 | 25 | 8 | 64 |  |
| 7 | 49 | 1 | 1 | 6 | 36 |
| 6 | 36 | 3 | 9 | 8 | 64 |
| 6 | 36 | 5 | 25 | 9 | 81 |
|  |  | 3 | 9 | 5 | 25 |
|  |  |  | 4 | 16 |  |  |  |
| ***Total*** | ***23*** |  | ***21*** |  | ***36*** |  | ***80*** |
|  | ***137*** |  | ***85*** |  | ***270*** | ***492*** |
| **Means** | **5.75** |  | **3.5** |  | **7.2** |  |  |

SST = 137 + 85 + 270 -

SST =65.33

SSC =

SSC = 38.283

SSE = 65.33 – 38.283

SSE = 27.050

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Source of Variation** | **Sum of Squares** | **Degrees of Freedom** | **Mean Square** | **Computed f** |
| **Column Means** | **38.283** | **3 – 1 = 2** | **= 19.14** |  |
| **Error** | **27.050** | **(15 -1) – (3-1) = 12**  **14 -2 = 12** |  |
| **Total** | **65.33** | **15 -1 =14** |  |  |

6. Decision: Since the computed f value of 8.49 is greater than the tabulated f value of 3.89 at α = 0.05 level of significance, thus, the null hypothesis is rejected.

7. Conclusion: Therefore, the average number of defects is not the same for the

three brands.

**Tests after F Test**

If after using the analysis of variance and there is a need to reject the null hypothesis. It is imperative for us to test where the difference or the difference lie. There are several tests to determine this and one of them is Scheffe’s Test (1957). This is done by arranging the individual means and comparing each other.

The Scheffe Test (also called Scheffe’s procedure or Scheffe’s method) is a post-hoc test used in[Analysis of Variance](https://www.statisticshowto.com/probability-and-statistics/hypothesis-testing/anova/). It is named for the American statistician [Henry Scheffe](http://www-history.mcs.st-and.ac.uk/Biographies/Scheffe.html). After you have run ANOVA and got a significant [F-statistic](https://www.statisticshowto.com/probability-and-statistics/f-statistic-value-test/) (i.e. you have [rejected the null hypothesis](https://www.statisticshowto.com/support-or-reject-null-hypothesis/) that the means are the same), then you run Sheffe’s test to find out which pairs of means are significant. The Scheffe test corrects alpha for simple and complex mean comparisons. Complex mean comparisons involve comparing more than one pair of means simultaneously.

Note: Only run this test if you have rejected the null hypothesis in an ANOVA test, indicating that the means are not the same. Otherwise, the means are equal and so there is no point in running this test.

Then compute the F ratio of each group by:

F᾿ =

Where: x͞ᵢ is the mean of the ith sample

x͞ⱼ is the mean of the jth sample

ni is the number of measurement in the ith sample

nⱼ is the number of measurement in the jth sample

EMS is the error group variance

The critical value F᾿ for the Scheffe’s test is calculated from the critical value of the f test using:

**F᾿** = (k-1)(F test critical value)

Where: k is the number of groups

From Example 1:

**SOLUTION**

1. Problem: Which among the means differs significantly?

2. Hypotheses: Ho ; Means between A and B do not differ significantly.

H1: Means between A and B differs significantly.

Ho ; Means between A and C do not differ significantly.

H1: Means between A and C differs significantly.

Ho ; Means between A and D do not differ significantly.

H1: Means between A and D differs significantly.

Ho ; Means between A and E do not differ significantly.

H1: Means between A and E differs significantly.

Ho ; Means between Band C do not differ significantly.

H1: Means between B and C differs significantly.

Ho ; Means between B and D do not differ significantly.

H1: Means between B and D differs significantly.

Ho ; Means between B and E do not differ significantly.

H1: Means between B and E differs significantly.

Ho ; Means between C and D do not differ significantly.

H1: Means between C and D differs significantly.

Ho ; Means between C and E do not differ significantly.

H1: Means between CandE differs significantly.

Ho ; Means between D and E do not differ significantly.

H1: Means between D and E differs significantly.

3. Level of Significance: α = 0.05

4. Critical Value: F᾿>11.48

5. Computation: XA = 5 ;XB = 8; XC = 4; XD = 3; XE= 7

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Comparison | (x͞ᵢ - x͞ⱼ)² | EMS |  |  | Fs | F᾿ |
| AB | 9 | 2.88 | 0.4 | 1.152 | 7.813 | 11.48 |
| AC | 1 | 2.88 | 0.4 | 1.152 | 0.868 | 11.48 |
| AD | 4 | 2.88 | 0.4 | 1.152 | 3.472 | 11.48 |
| AE | 4 | 2.88 | 0.4 | 1.152 | 3.472 | 11.48 |
| BC | 16 | 2.88 | 0.4 | 1.152 | 13.89 | 11.48 |
| BD | 25 | 2.88 | 0.4 | 1.152 | 21.7 | 11.48 |
| BE | 1 | 2.88 | 0.4 | 1.152 | 0.868 | 11.48 |
| CD | 1 | 2.88 | 0.4 | 1.152 | 0.868 | 11.48 |
| CE | 9 | 2.88 | 0.4 | 1.152 | 7.813 | 11.48 |
| DE | 16 | 2.88 | 0.4 | 1.152 | 13.89 | 11.48 |

6. Decision: @ AB Fs F᾿ thus, Ho Accepted

@ ACFs F᾿ thus, Ho Accepted

@ AD Fs F᾿ thus, Ho Accepted

@ AE Fs F᾿ thus, Ho Accepted

@ BC Fs F᾿ thus, HoRejected

@ BD FsF᾿ thus, HoAccepted

@ BEFs F᾿ thus, Ho Accepted

@ CDFs F᾿ thus, Ho Accepted

@ CEFs F᾿ thus, HoAccepted

@ DE FsF᾿ thus, Ho Rejected

7. Conculsion: @ AB Therefore, means between A and do not differ significantly.

@ AC Therefore, means between A and C do not differ significantly.

@ AD Therefore, means between A and D do not differ significantly.

@ AE Therefore, means between A and E do not differ significantly.

@ BC Therefore, means between Band Cdiffers significantly.

@ BD Therefore, means between B and D do not differ significantly.

@ BE Therefore, means between B and Edo not differ significantly.

@ CD Therefore, means between C and Ddo not differ significantly.

@ CE Therefore, means between C and E do not differ significantly.

@ DE Therefore, means between D and Ediffers significantly.

From Example 2:

**SOLUTION**

1. Problem: Which among the means differs significantly?

2. Hypotheses: Ho ; Means between A and B do not differ significantly.

H1: Means between A and B differs significantly.

Ho ; Means between A and C do not differ significantly.

H1: Means between A and C differs significantly.

Ho ; Means between Band C do not differ significantly.

H1: Means between B and C differs significantly.

3. Level of Significance: α = 0.05

4. Critical Value: F᾿>7.78

5. Computation: XA = 5.75 ;XB = 3.50; XC = 7.2

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Comparison | (x͞ᵢ - x͞ⱼ)² | EMS |  |  | Fs | F᾿ |
| AB | 5.06 | 2.25 | 0.417 | 0.938 | 5.40 | 7.78 |
| AC | 2.10 | 2.25 | 0.45 | 1.013 | 2.08 | 7.78 |
| BC | 13.7 | 2.25 | 0.367 | 0.825 | 16.59 | 7.78 |

6. Decision: @ AB Fs F᾿ thus, Ho Accepted. Therefore, means between A and B

do not differ significantly.

@ ACFs F᾿ thus, Ho Accepted. Therefore, means between A and C

do not differ significantly.

@ BC Fs F᾿ thus, HoRejected. Therefore, means between Band C

differs significantly.

7. Conclusion: @ AB Therefore, means between A and Bdo not differ significantly.

@ AC Therefore, means between A and C do not differ significantly.

@ BC Therefore, means between B and Cdiffers significantly.

***CHI-SQUARE (X²) TEST***

**The Chi-Square (χ²) Tests**

The distribution of a categorical variable in a sample often needs to be compared with the distribution of a categorical variable in another sample. The **Chi-Square**statistic is commonly used for testing when the population is not assumed to be normally distributed. The statistic involved is known as non-parametric or distribution free statistics. Chi-square is used to test of significance when the data is expressed in frequencies. Data that are in terms of percentages or proportions that can be reduce to frequencies. The data must be independent – that is, no responses are related to any other responses.

The test of Independence assesses whether an association exists between the two variables by comparing the observed pattern of responses in the cells to the pattern that would be expected if the variables were truly independent of each other.  Calculating the Chi-Square statistic and comparing it against a critical value from the Chi-Square distribution allows the researcher to assess whether the observed cell counts are significantly different from the expected cell counts. The formula for Chi-Square (x²) test is:

***X² =***

where: O = observed frequency

E = expected or theoretical frequency

The X² is a general test used to determine whether there is a significant difference between observed frequencies and what is expected. It can be used to compare frequencies between two categories or to inter-related nominal categories with any number of categories.

There are two types of chi-square tests. Both use the chi-square statistic and distribution for different purposes:

1. A chi-square goodness of fit test determines if a sample data matches a population.

2. A chi-square test for independence compares two variables in a contingency table to see if they are related. In a more general sense, it tests to see whether distributions of [categorical variables](https://www.statisticshowto.com/what-is-a-categorical-variable/) differ from each another.

a. A very small chi square test statistic means that your observed data fits your expected data extremely well. In other words, there is a relationship.

b. A very large chi square test statistic means that the data does not fit very well. In other words, there isn’t a relationship.

**Chi-Square Goodness of Fit Test**

Chi-Square goodness of fit test is a non-parametric test that is used to find out how the observed value of a given phenomena is significantly different from the expected value.  In Chi-Square goodness of fit test, the term goodness of fit is used to compare the observed sample distribution with the expected probability distribution.  Chi-Square goodness of fit test determines how well theoretical distribution (such as normal, binomial, or Poisson) fits the empirical distribution. In Chi-Square goodness of fit test, sample data is divided into intervals. Then the numbers of points that fall into the interval are compared, with the expected numbers of points in each interval.

Procedure for Chi-Square Goodness of Fit Test:

* Set up the hypothesis for Chi-Square goodness of fit test:

A. Null hypothesis: In Chi-Square goodness of fit test, the null hypothesis assumes that there is no significant difference between the observed and the expected value.

B. Alternative hypothesis: In Chi-Square goodness of fit test, the alternative hypothesis assumes that there is a significant difference between the observed and the expected value.

* Degree of freedom: In Chi-Square goodness of fit test, the degree of freedom depends on the distribution of the sample.  The following table shows the distribution and an associated degree of freedom:

|  |  |  |
| --- | --- | --- |
| Type of distribution | No of constraints | Degree of freedom |
| Binominal distribution | 1 | n-1 |
| Poisson distribution | 2 | n-2 |
| Normal distribution | 3 | n-3 |

* Hypothesis testing: Hypothesis testing in Chi-Square goodness of fit test is the same as in other tests, like t-test, [ANOVA](http://www.statisticssolutions.com/academic-solutions/membership-resources/member-profile/data-analysis-plan-templates/data-analysis-plan-friedman-anova/), etc.  The calculated value of Chi-Square goodness of fit test is compared with the table value.  If the calculated value of Chi-Square goodness of fit test is greater than the table value, we will reject the null hypothesis and conclude that there is a significant difference between the observed and the expected frequency.  If the calculated value of Chi-Square goodness of fit test is less than the table value, we will accept the null hypothesis and conclude that there is no significant difference between the observed and expected value.

Example1: Acme Toy Company prints baseball cards. The company claims that 30% of the cards are rookies, 60% veterans but not All-Stars, and 10% are veteran All-Stars. Suppose a random sample of 100 cards has 50 rookies, 45 veterans, and 5 All-Stars. Is this consistent with Acme’s claim? Use a 0.05 level of significance.

**SOLUTION**

!. Problem: Do the proportion of rookies, veterans, and All-Stars is 30%, 60% and 10%, respectively?

2. Hypotheses: Ho: The proportion of rookies, veterans, and All-Stars is 30%, 60% and 10%, respectively.

H1: At least one of the proportions in the null hypothesis is false.

3. Test Statistic : Chi-square goodness of fit test

Critical Value = 5.991

Degree of Freedom df = k -1

= 3 – 1

= 2

4. Level of Significance: α = 0.05

5. Computation:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Baseball Cards | Observed Frequency | Expected Frequency | O - E | ( O - E )² |  |
| Rookies | 50 |  | 50 – 30 = 20 | 400 | 13.33 |
| Veterans | 45 | 100 x 0.60 = 60 | 45 – 60 = -15 | 225 | 3.75 |
| All Stars | 5 | 100 x 0.10 = 10 | 5 – 10 = -5 | 25 | 2.50 |
| X² |  | | | | 19.58 |

6. Decision: Since the computed x2 value of 19.58 is greater than the tabulated x2 value of 5.991 at α = 0.05 level of significance, thus the null hypothesis is rejected.

7. Conclusion: At least one of the proportions in the null hypothesis is false.

**Chi-Square Test of Independence**

The [Chi-Square test of independence](http://www.statisticssolutions.com/data-analysis-plan-chi-square-test-of-independence/) is used to determine if there is a significant relationship between two nominal (categorical) variables.  The frequency of each category for one nominal variable is compared across the categories of the second nominal variable.  The data can be displayed in a contingency table where each row represents a category for one variable and each column represents a category for the other variable.

Degree of freedom is calculated by using the following formula:

df = (r-1)(c-1)

Where: df = Degree of freedom  
r = number of rows  
c = number of columns

Expected frequency can be obtained by:

E = (Row Total x Column Total)/Grand Total

Example 2: A public opinion poll surveyed a simple random sample of 1000 voters. Respondents were classified by gender (male or female) and by voting preference (Republican, Democrat, or Independent). Results are shown in the [contingency table](https://stattrek.com/Help/Glossary.aspx?Target=Contingency%20table) below. Is there a gender gap? Do the men's voting preferences differ significantly from the women's preferences? Use a 0.05 level of significance.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Voting Preferences | | | Row total |
| Rep | Dem | Ind |
| Male | 200 | 150 | 50 | 400 |
| Female | 250 | 300 | 50 | 600 |
| Column total | 450 | 450 | 100 | 1000 |

**SOLUTION**

1. Problems: 1. Is there a gender gap?

2. Do the men's voting preferences differ significantly from the women's preferences?

2. Hypotheses. Ho: Gender and voting preferences are independent.

Ha: Gender and voting preferences are not independent.

3. Test Statistic: [Chi-Square test of independence](http://www.statisticssolutions.com/data-analysis-plan-chi-square-test-of-independence/)

Critical Value = 5.991

df= (2 - 1) \* (3 - 1) = 2

4. Level of Significance: α = 0.05

5.Computation:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Voting Preferences | | | | | | Row Total |
| Republican | | Democrat | | Independent | |
| O | E | O | E | O | E |
| Male | 200 | (450\*400)/1000 = 180 | 150 | (450\*400)/1000 = 180 | 50 | (100\*400)/1000 = 40 | 400 |
| Female | 250 | (452\*600)/1000 = 270 | 300 | (450\*600)/1000 = 270 | 50 | (100\*600)/1000 = 60 | 600 |
| Column Total | 450 |  | 450 |  | 100 |  | 1000 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | | O | E | O - E | **(O - E)²** |  |
| Republican | Male | 200 | 180 | 20 | 400 | 2.22 |
| Female | 250 | 270 | -20 | 400 | 1.48 |
| Democrat | Male | 150 | 180 | -30 | 900 | 5.00 |
| Female | 300 | 270 | 30 | 900 | 3.33 |
| Independent | Male | 50 | 40 | 10 | 100 | 2.50 |
| Female | 50 | 60 | -10 | 100 | 1.67 |
| X² |  | | | | | 16.20 |

6. Decision: Since the computed x2 value of 16.20 is greater than the tabulated x2 value of 5.991 at α = 0.05 level of significance, thus the null hypothesis is rejected.

7. Conclusion: Therefore, gender and voting preferences are not independent.

***CORRELATION AND REGRESSION***

The goal of statistical data analysis is to understand a complex, real-world phenomenon from partial and uncertain observations. It is important to make the distinction between the mathematical theory underlying statistical data analysis, and the decisions made after conducting an analysis. Where there is a subjective part in the way statistical analysis yields actual human decisions. Understanding the risk and the uncertainty behind statistical results is critical in the decision-making process. In this module, we will study the relation and association between phenomena through the correlation and regression statistical data analysis, covering in particular how to make appropriate decisions throughout applying statistical data analysis. These notions allow us to classify statistical techniques within multiple axes. Prediction consists of learning from data, and predicting the outcomes of a random process based on a limited number of observations, the term "predictor" can be misleading if it is interpreted as the ability to predict even beyond the limits of the data. Also, the term "explanatory variable" might give an impression of a causal effect in a situation in which inferences should be limited to identifying associations. The terms "independent" and "dependent" variable are less subject to these interpretations as they do not strongly imply cause and effect Observations are independent realizations of the same random process; each observation is made of one or several variables. Mainly variables are either numbers, or elements belonging to a finite set "finite number of values".

The first step in an analysis is to understand what your observations and variables are. Study is univariate if you have one variable. It is Bivariate if there are two variables and multivariate if at least two variables. Univariate methods are typically simpler. That being said, univariate methods may be used on multivariate data, using one dimension at a time. Although interactions between variables cannot be explored in that case, it is often an interesting first approach.

1.2. What Are correlation and regression

Correlation quantifies the degree and direction to which two variables are related. Correlation does not fit a line through the data points. But simply is computing a correlation coefficient that tells how much one variable tends to change when the other one does.

* When r is 0.0, there is no relationship.
* When r is positive, there is a trend that one variable goes up as the 2 other one goes up.
* When r is negative, there is a trend that one variable goes up as the other one goes down.

With correlation, it doesn't have to think about cause and effect. It doesn't matter which of the two variables is call dependent and which is call independent, if the two variables swapped the degree of correlation coefficient will be the same.

The sign (+, -) of the correlation coefficient indicates the direction of the association. The magnitude of the correlation coefficient indicates the strength of the association, e.g. A correlation of r = - 0.8 suggests a strong, negative association (reverse trend) between two variables, whereas a correlation of r = 0.4 suggest a weak, positive association. A correlation close to zero suggests no linear association between two continuous variables.

Linear regression finds the best line that predicts dependent variable from independent variable. The decision of which variable calls dependent and which calls independent is an important matter in regression, as it'll get a different best-fit line if you swap the two. The line that best predicts independent variable from dependent variable is not the same as the line that predicts dependent variable from independent variable in spite of both those lines have the same value for R2 . Linear regression quantifies goodness of fit with R2 , if the same data put into correlation matrix the square of r degree from correlation will equal R2 degree from regression. The sign (+, -) of the regression coefficient indicates the direction of the effect of independent variable(s) into dependent variable, where the degree of the regression coefficient indicates the effect of the each independent variable into dependent variable.

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