VARIABLES AND HYPOTHESES

Unit Structure

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3.2 Meaning of variables
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3.10 Errors in testing of hypothesis
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3.0 OBJECTIVES:

After reading this unit you will be able to:

- Define variables
- Identify the different types of variables
- Show the relationship between the variables
- Explain the concept of hypotheses
- State the sources of hypotheses
- Explain different types of hypothesis
- Identify types of hypothesis
- Frame hypotheses skillfully
- Describe the characteristics of a good hypothesis
- Explain the significance level in hypothesis testing
- Identify the errors in testing of hypothesis
3.1 INTRODUCTION:

Each person/thing we collect data on is called an observation (in our research work these are usually people/subjects). Observation (participants) possess a variety of characteristics. If a characteristic of an observation (participant) is the same for every member of the group i.e. it does not vary, it is called a constant. If a characteristic of an observation (participant) differs for group members it is called a variable. In research we do not get excited about constants (since everyone is the same on that characteristic); we are more interested in variables.

3.2 MEANING OF VARIABLES

A variable is any entity that can take on different values. So what does that mean? Anything that can vary can be considered a variable. For instance, age can be considered a variable because age can take different values for different people or for the same person at different times. Similarly, country can be considered a variable because a person's country can be assigned a value.

* A variable is a concept or abstract idea that can be described in measurable terms. In research, this term refers to the measurable characteristics, qualities, traits, or attributes of a particular individual, object, or situation being studied.

Variables are properties or characteristics of some event, object, or person that can take on different values or amounts.

* Variables are things that we measure, control, or manipulate in research. They differ in many respects, most notably in the role they are given in our research and in the type of measures that can be applied to them.

By itself, the statement of the problem usually provides only general direction for the research study; it does not include all the specific information. There is some basic terminology that is extremely important in how we communicate specific information about research problems and about research in general.

Let us analyse an example; if a researcher is interested in the effects of two different teaching methods on the science achievement of fifth-grade students, the grade level is constant, because all
individuals involved are fifth-graders. This characteristic is the same for everyone; it is a ‘constant’ condition of the study. After the different teaching methods have been implemented, the fifth-graders involved would be measured with a science achievement test. It is very unlikely that all of the fifth-graders would receive the same score on this test, hence the score on the science achievement test becomes a variable, because different individuals will have different scores; at least, not all individuals will have the same scores. We would say that science achievement is a variable, but we would mean, specifically, that the score on the science achievement test is a variable.

There is another variable in the preceding example – the teaching method. In contrast to the science achievement test score, which undoubtedly would be measured on a scale with many possible values, teaching method is a categorical variable consisting of only two categories, the two methods. Thus, we have different kinds of variables and different names or classifications for them.

A concept which can take on different quantitative values is called a variable. As such the concepts like weight, height, income are all examples of variables. Qualitative phenomena (or the attributes) are also quantified on the basis of the presence or absence of the concerning attributes(s). Age is an example of continuous variable, but the number of male and female respondents is an example of discrete variable.

3.3 TYPES OF VARIABLES:

There are many classification systems given in the literature the names we use are descriptive; they describe the roles that variables play in a research study. The variables described below by no means exhaust the different systems and names that exist, but they are the most useful for communicating about educational research.

3.3.1 Independent variables:

Independent variables are variables which are manipulated or controlled or changed. In the example “a study of the effect of teacher praise on the reading achievement of second-graders”, the effect of praise, the researcher is trying to determine whether there is a cause-and-effect relationship, so the kind of praise is varied to see whether it produces different scores on the reading achievement test.
We call this a manipulated independent variable (treatment variable). The amount and kind of praise is manipulated by the researcher. The researcher could analyze the scores for boys and girls separately to see whether the results are the same for both genders. In this case gender is a classifying or attributes independent variable. The researcher cannot manipulate gender, but can classify the children according to gender.

3.3.2 Dependent variables:

Dependent variables are the outcome variables and are the variables for which we calculate statistics. The variable which changes on account of independent variable is known as dependent variable.

Let us take the example, a study of the effect of teacher praise on the reading achievement of second-graders; the dependent variable is reading achievement. We might compare the average reading achievement scores of second-graders in different praise conditions such as no praise, oral praise, written praise, and combined oral and written praise.

The following example further illustrates the use of variables and constants. In a study conducted to determine the effect of three different teaching methods on achievement in elementary algebra, each of three ninth-grade algebra sections in the same school, taught by the same teacher, is taught using one of the methods. Both boys and girls are included in the study. The constants in the study are grade level, school, and teacher. (This assumes that, except for method, the teacher can hold teaching effectiveness constant.) The independent variables in the study are teaching method and gender of the student. Teaching method has three levels that arbitrarily can be designated methods A, B, and C; gender of the student, of course, has two levels. Achievement in algebra, as measured at the end of the instructional period, is the dependent variable.

The terms dependent and independent variable apply mostly to experimental research where some variables are manipulated, and in this sense they are "independent" from the initial reaction patterns, features, intentions, etc. of the subjects. Some other variables are expected to be "dependent" on the manipulation or experimental conditions. That is to say, they depend on "what the subject will do" in response. Somewhat contrary to the nature of this distinction, these terms are also used in studies where we do not literally
manipulate independent variables, but only assign subjects to "experimental groups" based on some pre-existing properties of the subjects. Independent variables are those that are manipulated whereas dependent variables are only measured or registered.

Consider other examples of independent and dependent variables:

Example 1: A study of teacher-student classroom interaction at different levels of schooling.

Independent variable: Level of schooling, four categories – primary, upper primary, secondary and junior college.

Dependent variable: Score on a classroom observation inventory, which measures teacher – student interaction.


Independent variable: Gender of the teacher – male, female.

Dependent variable: Score on a professional attitude inventory.

3.3.3 Extraneous variable:

Independent variables that are not related to the purpose of the study, but may affect the dependent variable are termed as extraneous variables. Suppose the researcher wants to test the hypothesis that there is a relationship between children’s gains in social studies achievement and their self-concepts. In this case self-concept is an independent variable and social studies achievement is a dependent variable. Intelligence may as well affect the social studies achievement, but since it is not related to the purpose of the study undertaken by the researcher, it will be termed as an extraneous variable. Whatever effect is noticed on dependent variable as a result of extraneous variable(s) is technically described as an ‘experimental error’. A study must always be so designed that the effect upon the dependent variable is attributed entirely to the independent variable(s), and not to some extraneous variable or variables.

E.g. Effectiveness of different methods of teaching Social Science.
Here variables such as teacher’s competence, Teacher’s enthusiasm, age, socio economic status also contribute substantially to the teaching learning process. It cannot be controlled by the researcher. The conclusions lack incredibility because of extraneous variables.

3.3.4 Intervening variables:

They intervene between cause and effect. It is difficult to observe, as they are related with individuals feelings such as boredom, fatigue excitement At times some of these variables cannot be controlled or measured but have an important effect upon the result of the study as it intervenes between cause and effect. Though difficult, it has to be controlled through appropriate design. Eg. “Effect of immediate reinforcement on learning the parts of speech”.

Factors other than reinforcement such as anxiety, fatigue, and motivation may be intervening variables. They are difficult to define in operational, observable terms however they cannot be ignored and must be controlled using appropriate research design.

3.3.5 Moderator:

A third variable that when introduced into an analysis alters or has a contingent effect on the relationship between an independent and a dependent variable. A moderator variable is an independent variable that is not of primary interest that has levels, which when combined with the levels of the independent variable of interest produces different effects.

For example, suppose that the researcher designs a study to determine the impact of the lengths of reading passages on the comprehension of the reading passage. The design has three levels of passage length: 100 words, 200 words, and 300 words. The participants in the study are fourth-fifth- and sixth-graders. Suppose that the three grade levels all did very well on the 100-word passage, but only the sixth-graders did very well on the 300-word passage. This would mean that successfully comprehending reading passages of different lengths was moderated by grade level.
Check your progress:
1. What is a Variable?


2. Identify the variables in this example “Teaching effectiveness of secondary school teachers in relation to their presage characteristics”.


3.4 CONCEPT OF HYPOTHESIS

Hypothesis is usually considered as the principal instrument in research. The derivation of a suitable hypothesis goes hand in hand with the selection of a research problem. A hypothesis, as a tentative hunch, explains the situation under observation so as to design the study to prove or disprove it. What a researcher is looking for is a working or positive hypothesis. It is very difficult, laborious and time consuming to make adequate discriminations in the complex interplay of facts without hypothesis. It gives definite point and direction to the study, prevents blind search and indiscriminate gathering of data and helps to delimit the field of inquiry.

3.4.1 Meaning:

The word hypothesis (plural is hypotheses) is derived from the Greek word – ‘hypotithenai’ meaning ‘to put under’ or ‘to suppose’ for a hypothesis to be put forward as a scientific hypothesis, the scientific method requires that one can test it. Etymologically hypothesis is made up of two words, “hypo” (less than) and “thesis”, which mean less than or less certain than a thesis. It is the presumptive statement of a proposition or a reasonable guess, based upon the available evidence, which the researcher seeks to prove through his study.
According to Lundberg, “A hypothesis is a tentative generalisation, the validity of which remains to be tested. In its most elementary stage, the hypothesis may be any hunch, guess, imaginative idea, which becomes the basis for action or investigation.

Goode and Hatt have defined it as “a proposition which can be put to test to determine its validity”. A hypothesis is a statement temporarily accepted as true in the light of what is, at the time, known about a phenomenon, and it is employed as a basis for action in the search of new truth.

A hypothesis is a tentative assumption drawn from knowledge and theory which is used as a guide in the investigation of other facts and theories that are yet unknown.

It is a guess, supposition or tentative inference as to the existence of some fact, condition or relationship relative to some phenomenon which serves to explain such facts as already are known to exist in a given area of research and to guide the search for new truth.

Hypotheses reflect the research worker’s guess as to the probable outcome of the experiments.

A hypothesis is therefore a shrewd and intelligent guess, a supposition, inference, hunch, provisional statement or tentative generalization as to the existence of some fact, condition or relationship relative to some phenomenon which serves to explain already known facts in a given area of research and to guide the search for new truth on the basis of empirical evidence. The hypothesis is put to test for its tenability and for determining its validity.

In this connection Lundberg observes: Quite often a research hypothesis is a predictive statement, capable of being tested by scientific methods, that relates an independent variable to some dependent variable. For example, consider statements like the following ones: “Students who receive counselling will show a greater increase in creativity than students not receiving counseling” or “There is a positive relationship between academic aptitude scores and scores on a social adjustment inventory for high school students”
These are hypotheses capable of being objectively verified and tested. Thus, we may conclude that a hypothesis states what we are looking for and it is a proposition which can be put to a test to determine its validity.

3.4.2 Importance of the Hypotheses:

The importance of hypotheses is generally recognized more in the studies which aim to make predictions about some outcome. In experimental research, the researchers are interested in making predictions about the outcome of the experiment or what the results are expected to show and therefore the role of hypotheses is considered to be of utmost importance. In the historical or descriptive research, on the other hand, the researcher is investigating the history of a city or a nation, the life of a man, the happening of an event, or is seeking facts to determine the status quo of some situation and thus may not have a basis for making a prediction of results. A hypothesis, therefore, may not be required in such fact-finding studies. Hillway (1964) too is of the view that “when fact-finding alone is the aim of the study, a hypothesis may not be required.”

Most historical or descriptive studies, however, involve not only fact-finding but interpretation of facts to draw generalizations. If a researcher is tracing the history of an educational institution or making a study about the results of a coming assembly poll, the facts or data he gathers will prove useful only if he is able to draw generalizations from them. Whenever possible, a hypothesis is recommended for all major studies to explain observed facts, conditions or behaviour and to serve as a guide in the research process. The importance of hypotheses may be summarized as under.

1. Hypotheses facilitate the extension of knowledge in an area. They provide tentative explanations of facts and phenomena, and can be tested and validated. It sensitizes the investigator to certain aspects of situations which are relevant from the standpoint of the problem in hand.

2. Hypotheses provide the researcher with rational statements, consisting of elements expressed in a logical order of relationships which seek to describe or to explain conditions or events, that have not yet been confirmed by facts. The hypotheses enable the researcher to relate logically known facts
to intelligent guesses about unknown conditions. It is a guide to the thinking process and the process of discovery. It is the investigator’s eye – a sort of guiding light in the work of darkness.

3. Hypotheses provide direction to the research. It defines what is relevant and what is irrelevant. The hypotheses tell the researcher specifically what he needs to do and find out in his study. Thus it prevents the review of irrelevant literature and the collection of useless or excess data. Hypotheses provide a basis for selecting the sample and the research procedures to be used in the study. The statistical techniques needed in the analysis of data, and the relationships between the variables to be tested, are also implied by the hypotheses. Furthermore, the hypotheses help the researcher to delimit his study in scope so that it does not become broad or unwieldy.

4. Hypotheses provide the basis for reporting the conclusions of the study. It serves as a framework for drawing conclusions. The researcher will find it very convenient to test each hypothesis separately and state the conclusions that are relevant to each. On the basis of these conclusions, he can make the research report interesting and meaningful to the reader. It provides the outline for setting conclusions in a meaningful way.

Hypothesis has a very important place in research although it occupies a very small pace in the body of a thesis. It is almost impossible for a research worker not to have one or more hypotheses before proceeding with his work.

3.5 SOURCES OF HYPOTHESIS:

The derivation of a good hypothesis demands characteristic of experience and creativity. Though hypothesis should precede the gathering of data, a good hypothesis can come only from experience. Some degree of data gathering, the review of related literature, or a pilot study must precede the development and gradual refinement of the hypothesis. A good investigator must have not only an alert mind capable of deriving relevant hypothesis, but also a critical mind capable of rejecting faulty hypothesis.
What is the source of hypotheses? They may be derived directly from the statement of the problem; they may be based on the research literature, or in some cases, such as in ethnographic research, they may (at least in part) be generated from data collection and analysis. The various sources of hypotheses may be:

♦ Review of similar studies in the area or of the studies on similar problems;
♦ Examination of data and records, if available, concerning the problem for possible trends, peculiarities and other clues;
♦ Discussions with colleagues and experts about the problem, its origin and the objectives in seeking a solution.
♦ Exploratory personal investigation which involves original field interviews on a limited scale with interested parties and individuals with a view to secure greater insight into the practical aspects of the problem.
♦ Intuition is often considered a reasonable source of research hypotheses -- especially when it is the intuition of a well-known researcher or theoretician who “knows what is known”
♦ Rational Induction is often used to form “new hypotheses” by logically combining the empirical findings from separate areas of research
♦ Prior empirical research findings are perhaps the most common source of new research hypotheses, especially when carefully combined using rational induction
♦ Thus hypothesis are formulated as a result of prior thinking about the subject, examination of the available data and material including related studies and the council of experts.

Check your progress:

1. Define hypothesis.
2. Hypothesis is stated in researches concerned with

3. What are the sources of hypotheses?

3.6 TYPES OF HYPOTHESIS:

3.6.1 Research hypothesis: When a prediction or a hypothesized relationship is to be tested by scientific methods, it is termed as research hypothesis. The research hypothesis is a predictive statement that relates an independent variable to a dependent variable. Usually a research hypothesis must contain, at least, one independent and one dependent variable. A research hypothesis must be stated in a testable form for its proper evaluation. As already stressed, this form should indicate a relationship between the variables in clear, concise, and understandable language. Research hypotheses are classified as being directional or non-directional.

3.6.2 Directional hypothesis: The hypotheses which stipulate the direction of the expected differences or relationships are terms as directional hypotheses. For example, the research hypothesis: “There will be a positive relationship between individual’s attitude towards high caste Hindus and his socio-economic status,” is a directional research hypothesis. This hypothesis stipulates that individuals with favourable attitude towards high cast Hindus will generally come from higher socio-economic Hindu families and therefore it does stipulate the direction of the relationship. Similarly, the hypothesis: “Adolescent boys with high IQ will exhibit low anxiety than adolescent boys with low IQ” is a directional research hypothesis because it stipulates the direction of the difference between groups.
3.6.3 Non-directional hypothesis: A research hypothesis which does not specify the direction of expected differences or relationships is a non-directional research hypothesis. For example, the hypotheses: “There will be difference in the adaptability of fathers and mothers towards rearing of their children” or “There is a difference in the anxiety level of adolescent girls of high IQ and low IQ” are non-directional research hypotheses. Although these hypotheses stipulate there will be a difference, the direction of the difference is not specified. A research hypothesis can take either statistical form, declarative form, the null form, or the question form.

3.6.4 Statistical hypothesis: When it is time to test whether the data support or refute the research hypothesis, it needs to be translated into a statistical hypothesis. A statistical hypothesis is given in statistical terms. Technically, in the context of inferential statistics, it is a statement about one or more parameters that are measures of the populations under study. Statistical hypotheses often are given in quantitative terms, for example: “The mean reading achievement of the population of third-grade students taught by Method A equals the mean reading achievement of the population taught by Method B.” Therefore we can say that statistical hypotheses are, concerned with populations under study. We use inferential statistics, to draw conclusions about population values even though we have access to only a sample of participants. In order to use inferential statistics, we need to translate the research hypothesis into a testable form, which is called the null hypothesis. An alternative or declarative hypothesis indicates the situation corresponding to when the null hypothesis is not true. The stated hypothesis will differ depending on whether or not it is a directional research hypothesis.

3.6.5 Declarative hypothesis: When the researcher makes a positive statement about the outcome of the study, the hypothesis takes the declarative form. For example, the hypothesis: “The academic achievement of extroverts is significantly higher than that of the introverts,” is stated in the declarative form. In such a statement of hypothesis, the researcher makes a prediction based on his theoretical formulations of what should happen if the explanations of the behaviour he has given in his theory are correct.
3.6.6 **Null hypothesis:** In the null form, the researcher makes a statement that no relationship exists. The hypothesis, “There is no significant difference between the academic achievement of high school athletes and that of non-athletes,” is an example of null hypothesis. Since null hypotheses can be tested statistically, they are often termed as statistical hypotheses. They are also called the testing hypotheses when declarative hypotheses are tested statistically by converting them into null form. It states that even where it seems to hold good it is due to mere chance. It is for the researcher to reject the null hypothesis by showing that the outcome mentioned in the declarative hypothesis does occur and the quantum of it is such that it cannot be easily dismissed as having occurred by chance.

3.6.7 **Question form hypothesis:** In the question form hypothesis, a question is asked as to what the outcome will be instead of stating what outcome is expected. Suppose a researcher is interested in knowing whether programmed instruction has any relationship to test anxiety of children.

- The declarative form of the hypothesis might be: “Teaching children through the programmed instruction material will decrease their test anxiety”.

- The null form would be: “teaching children through programmed instruction material will have no effect on their test anxiety.” This statement shows that no relationship exists between programmed instruction and test anxiety.

- The question form puts the statement in the form: “Will teaching children through programmed instruction decrease their test anxiety?”

3.7 **FORMULATING HYPOTHESIS:**

Hypotheses are guesses or tentative generalizations, but these guesses are not merely accidents. Collection of factual information alone does not lead to successful formulation of hypotheses. Hypotheses are the products of considerable speculation and imaginative guess work. They are based partly on known facts and explanations, and partly conceptual. There are no precise rules for formulating hypotheses and deducing consequences from them that
can be empirically verified. However, there are certain necessary conditions that are conducive to their formulation. Some of them are:

- **Richness of background knowledge.** A researcher may deduce hypotheses inductively after making observations of behaviour, noticing trends or probable relationships. For example, a classroom teacher daily observes student behaviour. On the basis of his experience and his knowledge of behaviour in a school situation, the teacher may attempt to relate the behaviour of students to his own, to his teaching methods, to changes in the school environment, and so on. From these observed relationships, the teacher may inductively formulate a hypothesis that attempts to explain such relationships.

    Background knowledge, however, is essential for perceiving relationships among the variables and to determine what findings other researchers have reported on the problem under study. New knowledge, new discoveries, and new inventions should always form continuity with the already existing corpus of knowledge and, therefore, it becomes all the more essential to be well versed with the already existing knowledge.

    Hypotheses may be formulated correctly by persons who have rich experiences and academic background, but they can never be formulated by those who have poor background knowledge.

- **Versatility of intellect:** Hypotheses are also derived through deductive reasoning from a theory. Such hypotheses are called deductive hypotheses. A researcher may begin a study by selecting one of the theories in his own area of interest. After selecting the particular theory, the researcher proceeds to deduce a hypothesis from this theory through symbolic logic or mathematics. This is possible only when the researcher has a versatile intellect and can make use of it for restructuring his experiences. Creative imagination is the product of an adventure, sound attitude and agile intellect. In the hypotheses formulation, the researcher works on numerous paths. He has to take a consistent effort and develop certain habits and attitudes. Moreover, the researcher has to saturate himself with all possible information about the problem and then think liberally at it and proceed further in the conduct of the study.
• *Analogy and other practices.* Analogies also lead the researcher to clues that he might find useful in the formulation of hypotheses and for finding solutions to problems. For example, suppose a new situation resembles an old situation in regard to a factor X. If the researcher knows from previous experience that the old situation is related to other factors Y and Z as well as to X, he reasons that perhaps a new situation is also related to Y and Z. The researcher, however, should use analogies with caution as they are not fool proof tools for finding solutions to problems. At times, conversations and consultations with colleagues and expert from different fields are also helpful in formulating important and useful hypotheses.

### 3.8 CHARACTERISTICS OF A GOOD HYPOTHESIS

Hypothesis must possess the following characteristics:

i) Hypothesis should be clear and precise. If the hypothesis is not clear and precise, the inferences drawn on its basis cannot be taken as reliable.

ii) Hypothesis should be capable of being tested. Some prior study may be done by researcher in order to make hypothesis a testable one. A hypothesis “is testable if other deductions can be made from it which, in turn, can be confirmed or disproved by observation.”

iii) Hypothesis should state relationship between variables, if it happens to be a relational hypothesis.

iv) Hypothesis should be limited in scope and must be specific. A researcher must remember that narrower hypotheses are generally more testable and he should develop such hypotheses.

v) Hypothesis should be stated as far as possible in most simple terms so that the same is easily understandable by all concerned. But one must remember that simplicity of hypothesis has nothing to do with its significance.

vi) Hypothesis should be consistent with most known facts i.e. it must be consistent with a substantial body of established facts. In other words, it should be one which judges accept as being the most likely.

vii) *The hypotheses selected should be amenable to testing within a reasonable time.* The researcher should not select a problem which involves hypotheses that are not agreeable to
testing within a reasonable and specified time. He must know that there are problems that cannot be solved for a long time to come. These are problems of immense difficulty that cannot be profitably studied because of the lack of essential techniques or measures.

viii) Hypothesis must explain the facts that gave rise to the need for explanation. This means that by using the hypothesis plus other known and accepted generalizations, one should be able to deduce the original problem condition. Thus hypothesis must actually explain what it claims to explain, it should have empirical reference.

Check your progress:

1. What are the different types of hypothesis?

2. List the characteristics of hypothesis.

3.9 HYPOTHESIS TESTING AND THEORY

When the purpose of research is to test a research hypothesis, it is termed as hypothesis-testing research. It can be of the experimental design or of the non-experimental design. Research in which the independent variable is manipulated is termed ‘experimental hypothesis-testing research’ and a research in which an independent variable is not manipulated is called ‘non-experimental hypothesis-testing research’.

Let us get acquainted with relevant terminologies used in hypothesis testing.
Null hypothesis and alternative hypothesis:

In the context of statistical analysis, we often talk about null hypothesis and alternative hypothesis. If we are to compare method A with method B about its superiority and if we proceed on the assumption that both methods are equally good, then this assumption is termed as the null hypothesis. As against this, we may think that the method A is superior or the method B is inferior, we are then stating what is termed as alternative hypothesis. The null hypothesis is generally symbolized as $H_0$ and the alternative hypothesis as $H_a$. The null hypothesis and the alternative hypothesis are chosen before the sample is drawn. Generally, in hypothesis testing we proceed on the basis of null hypothesis, keeping the alternative hypothesis in view. Why so? The answer is that on the assumption that null hypothesis is true, one can assign the probabilities to different possible sample results, but this cannot be done if we proceed with the alternative hypothesis. Hence the use of null hypothesis (at times also known as statistical hypothesis) is quite frequent.

a) The level of significance: This is very important concept in the context of hypothesis testing. It is always some percentage (usually 5%) which should be chosen with great care, thought and reason. In case we take the significance level at 5 per cent, then this implies that $H_0$ will be rejected when the sampling result (i.e. observed evidence) has a less than 0.05 probability of occurring if $H_0$ is true. In other words, the 5 percent level of significance means that researcher is willing to take as much as a 5 percent risk of rejecting the null hypothesis when it ($H_0$) happens to be true. Thus the significance level is the maximum value of the probability of rejecting $H_0$ when it is true and is usually determined in advance before testing the hypothesis.

b) The criteria for rejecting the null hypothesis may differ. Sometimes the null hypothesis is rejected only when the quantity of the outcome is so large that the probability of its having occurred by mere chance is 1 time out of 100. We consider the probability of its having occurred by chance to be too little and we reject the chance theory of the null hypothesis and take the occurrence to be due to a genuine tendency. On other occasions, we may be bolder and reject the null hypothesis even when the quantity of the reported outcome is likely to occur by chance 5 times out of 100. Statistically the former is known as the rejection of the null hypothesis at 0.1 level of significance and the latter as the rejection at 0.5 level. It may be pointed out that if the
researcher is able to reject the null hypothesis, he cannot directly uphold the declarative hypothesis. If an outcome is not held to be due to chance, it does not mean that it is due to the very cause and effect relationship asserted in the particular declarative statement. It may be due to something else which the researcher may have failed to control.

c) **Decision rule or test of hypothesis:** Given a hypothesis $H_0$ and an alternative hypothesis $H_a$ we make a rule which is known as decision rule according to which we accept $H_0$ (i.e. reject $H_a$) or reject $H_0$ (i.e. accept $H_a$). For instance, if $H_0$ is that a certain lot is good (there are very few defective items in it) against $H_a$ that the lot is not good (there are too many defective items in it), then we must decide the number of items to be tested and the criterion for accepting or rejecting the hypothesis. We might test 10 times in the lot and plan our decision saying that if there are none or only 1 defective item among the 10, we will accept $H_0$ otherwise we will reject $H_0$ (or accept $H_a$). This sort of basis is known as decision rule.

d) **Two-tailed and One-tailed tests:** In the context of hypothesis testing, these two terms are quite important and must be clearly understood. A two-tailed test rejects the null hypothesis if, say, the sample mean is significantly higher or lower than the hypothesized value of the mean of the population. Such a test is appropriate when the null hypothesis is some specified value and the alternative hypothesis is a value not equal to the specified value of the null hypothesis. In a two-tailed test, there are two rejection regions, one on each tail of the curve which can be illustrated as under:

If the significance level is 5 per cent and the two-tailed test is to be applied, the probability of the rejection area will be 0.05 (equally divided on both tails of the curve as 0.025) and that of the acceptance region will be 0.95

But there are situations when only one-tailed test is considered appropriate. A one-tailed test would be used when we are to test, say, whether the population mean is either lower than or higher than some hypothesized value. We should always remember that accepting $H_0$, on the basis of sample information does not constitute the proof that $H_0$, is true. We only mean that there is no statistical evidence to reject it.
3.10 ERRORS IN TESTING OF HYPOTHESIS

Type I and Type II errors: in the context of testing of hypotheses, there are basically two types of errors we can make. We may reject $H_0$ when $H_0$ is true and we may accept $H_0$ when in fact $H_0$ is not true. The former is known as Type I error and the latter as Type II error. In other words, Type I error means rejection of hypothesis which should have been accepted and Type II error means accepting the hypothesis which should have been rejected. Type I error is denoted by $\alpha$ (alpha) known as $\alpha$ error, also called the level of significance of test; and Type II error is denoted by $\beta$ (beta) known as $\beta$ error. In a tabular form the said two errors can be presented as follows:

<table>
<thead>
<tr>
<th>Decision</th>
<th>Accept $H_0$</th>
<th>Reject $H_0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_0$ (true)</td>
<td>Correct decision</td>
<td>Type I error ($\alpha$ error)</td>
</tr>
<tr>
<td>$H_0$ (false)</td>
<td>Type II error ($\beta$ error)</td>
<td>Correct decision</td>
</tr>
</tbody>
</table>

The probability of Type I error is usually determined in advance and is understood as the level of significance of testing the hypothesis. If type I error is fixed at 5 per cent, it means that there are about 5 chances in 100 that we will reject $H_0$ when $H_0$ is true. We can control Type I error just by fixing it at a lower level. For instance, if we fix it at 1 per cent, we will say that the maximum probability of committing Type I error would only be 0.01.

But with a fixed sample size, $n$, when we try to reduce Type I error, the probability of committing Type II error increases. Both types of errors cannot be reduced simultaneously. There is a trade-off between two types of errors which means that the probability of making one type of error can only be reduced if we are willing to increase the probability of making the other type of error. To deal with this trade-off in business situations, decision-makers decide the appropriate level of Type I error by examining the costs or penalties attached to both types of errors. If Type I error involves the time and trouble of reworking a batch of chemicals that should have been accepted, whereas Type II error means taking a chance that an entire group of users of this chemical compound will be poisoned, then in such a situation one should prefer a Type I error to a Type II error. As a result one must set very high level for Type I error in one’s
testing technique of a given hypothesis. Hence, in the testing of hypothesis, one must make all possible effort to strike an adequate balance between Type I and Type II errors.

Check your progress:

1. Explain the term level of significance?

2. What are the two types of error in the testing of the hypothesis?

3.11 SUMMARY

It is important for the researcher to formulate hypotheses before data are gathered. This is necessary for an objective and unbiased study. It should be evident from what you have read so far that in order to carry out research; you need to start by identifying a question which demands an answer, or a need which requires a solution. The problem can be generated either by an initiating idea, or by a perceived problem area. We also studied that there are important qualities of hypotheses which distinguish them from other forms of statement. A good hypothesis is a very useful aid to organizing the research effort. It specifically limits the enquiry to the interaction of certain variables; it suggests the methods appropriated for collecting, analyzing and interpreting the data; and the resultant confirmation or rejection of the hypothesis through empirical or experimental testing gives a clear indication of the extent of knowledge gained. The hypothesis must be conceptually clear. The concepts utilized in the hypothesis should be clearly defined – not only formally but also if possible, operationally. Hypothesis testing is the often used strategy for deciding whether a sample data offer such support for a hypothesis that generalization can be made. Thus hypothesis testing enables us to make probability statements about population parameter(s).
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