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Foundation of Data Science (IT305B)

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Unit-V

HYPOTHESIS TESTING

Course Objectives : *To apply of sampling distributions and testing of Hypothesis,*

Course Outcome(CO5) : *Apply test of hypothesis for population parameter.*




Sampling Distribution

Sampling Distribution:

- A sampling distribution is a concept used in statistics. It is a probability distribution of a statistic obtained from a larger number of samples drawn from a specific population,
- The sampling distribution of a given population is the distribution of frequencies of a range of different outcomes that could possibly occur for a statistic of a population.
- A sampling distribution is a probability distribution of a statistic that is obtained through repeated sampling of a specific population.

Sampling Distribution,

Sampling distribution:



Sampling Distribution

['sam-plɪŋ di-strə-'byü-shən]

A probability distribution of a statistic obtained from a larger number of samples drawn from a specific population.



Sampling Distribution,

Sampling distribution:

- There are a few steps involved with sampling distribution. These include:
- 1) Choosing a random sample from the overall population
 - 2) Determine a certain statistic from that group, which could be the standard deviation, median, or mean
 - 3) Establishing a frequency distribution of each sample
 - 4) Mapping out the distribution on a graph



Sampling Distribution,

Sampling distribution:

- Sampling distributions are used in statistics and research. They highlight the chance or probability of an event that may take place.
- This is based on a set of data that is gathered from a small group within a larger population.
- Researchers aren't able to make conclusions about very large groups because of the number of subjects involved.
- That's why they use sampling. Sampling allows them to take a small group from a large population and analyze data.



Sampling Distribution,

Sampling distribution:

- Once that data is collected, researchers can plot out sampling distributions, which allow them to determine whether an event may take place within a certain population.
- This may include business growth or population trends, which can help businesses, governments, and other entities make better decisions for the future.



Hypothesis Testing

Hypothesis Testing:

- “A hypothesis is an idea that can be tested.”
- Hypothesis testing, sometimes called significance testing, is an act in statistics whereby an analyst tests an assumption regarding a population parameter.
- The methodology employed by the analyst depends on the nature of the data used and the reason for the analysis.
- Hypothesis testing is used to assess the plausibility of a hypothesis by using sample data. Such data may come from a larger population, or from a data-generating process.



Hypothesis Testing

- Hypothesis testing is used to assess the plausibility of a hypothesis by using sample data.
- The test provides evidence concerning the plausibility of the hypothesis, given the data.
- Statistical analysts test a hypothesis by measuring and examining a random sample of the population being analyzed.
- The four steps of hypothesis testing include stating the hypotheses, formulating an analysis plan, analyzing the sample data, and analyzing the result.



Hypothesis Testing

➤ *4 Steps of Hypothesis Testing:*

- 1) The first step is for the analyst to state the hypotheses.
- 2) The second step is to formulate an analysis plan, which outlines how the data will be evaluated.
- 3) The third step is to carry out the plan and analyze the sample data.
- 4) The final step is to analyze the results and either reject the null hypothesis, or state that the null hypothesis is plausible, given the data.



Hypothesis Testing

- Hypothesis testing helps assess the accuracy of new ideas or theories by testing them against data.
- This allows researchers to determine whether the evidence supports their hypothesis, helping to avoid false claims and conclusions.
- Hypothesis testing also provides a framework for decision-making based on data rather than personal opinions or biases.
- By relying on statistical analysis, hypothesis testing helps to reduce the effects of chance and confounding variables, providing a robust framework for making informed conclusions.



Hypothesis Testing

- ***Null Hypothesis:***
- *A null hypothesis is a type of statistical hypothesis that proposes that no statistical significance exists in a set of given observations*
- *Sometimes referred to simply as the "null," it is represented as H_0 .*
- *A null hypothesis is a type of conjecture in statistics that proposes that there is no difference between certain characteristics of a population or data-generating process.*
- *The alternative hypothesis proposes that there is a difference.*



Hypothesis Testing

➤ *Null Hypothesis:*

Null Hypothesis

[ˈnəl hī-ˈpä-thə-səs]

A hypothesis that proposes that no statistical significance exists in a set of given observations and is used to assess the credibility of a hypothesis by using sample data.



Hypothesis Testing

- ***Null Hypothesis:***
- *Hypothesis testing provides a method to reject a null hypothesis within a certain confidence level,*
- *If you can reject the null hypothesis, it provides support for the alternative hypothesis,*
- *The null hypothesis assumes that any kind of difference between the chosen characteristics that you see in a set of data is due to chance.*
- *Analysts look to reject the null hypothesis because doing so is a strong conclusion.*



Hypothesis Testing

➤ Alternate Hypothesis:

- *An important point to note is that we are testing the null hypothesis because there is an element of doubt about its validity.*
- *Whatever information that is against the stated null hypothesis is captured in the alternative (alternate) hypothesis (H_1),*
- *For the above examples, the alternative hypothesis would be:*
Students score an average that is not equal to seven.
The mean annual return of the mutual fund is not equal to 8% per year.
- *In other words, the alternative hypothesis is a direct contradiction of the null hypothesis.*



Hypothesis Testing

- **Alternate Hypothesis:**
- *The alternative hypothesis states that a population parameter is smaller, greater, or different from the assumed value.*
- *An alternative hypothesis is a direct contradiction of a null hypothesis. This means that if one of the two hypotheses is true, the other is false.*
- *Alternative and Null Hypotheses are complementary to each other.*
- *Both the hypotheses are also exhaustive and mutually exclusive, i.e., together, both will cover every possible outcome, but only one can be true at a time.*



Hypothesis Testing

➤ Alternate Hypothesis:

Null hypothesis	Alternative hypothesis
There is no relationship / association ship between two groups .	There is a relationship between two selected variables in a study.
It is denoted by H_0	It is denoted by H_1 or H_2
It is followed by 'equal to ' sign	It is followed by not equal to, 'less than 'or 'greater than' sign
The researcher tries to disprove in null hypothesis	The researcher tries to prove in alternative hypothesis



Hypothesis Testing

➤ Alternate Hypothesis:

Null hypothesis	Alternative hypothesis
The results are observed as a result of chance	The results are observed as a result of some real causes
The result of null hypothesis indicates no changes in opinions or actions	The results of an alternative hypothesis causes change in opinions and actions
If the null hypothesis is accepted the results of the study become insignificant	If an alternative hypothesis is accepted the results of the study become significant



Hypothesis Testing

➤ *Examples:*

- Problem Statement 1: Does eating an apple daily ensure weight loss?
State both Null and Alternative hypotheses.

Answer:

- ***Null Hypothesis (H_0):*** Eating apples daily does not affect weight loss.
- ***Alternative Hypothesis (H_1):*** Eating apples affects weight loss.



Hypothesis Testing

➤ *Examples:*

- Problem Statement 2: A researcher wants to know if the height of students at school differs from the national average of 5.5 feet. State null and alternative hypothesis.

Answer:

Here, researchers are interested in determining whether the height of students is either less than or greater than the national average height.

➤ *$H_0: \text{average} = 5.5 \text{ feet}$*

➤ *$H_1: \text{average} \neq 5.5 \text{ feet}$*



Hypothesis Testing

- In the Null Hypothesis, there is no relation between two variables, while in the Alternative Hypothesis, there is some statistical significance between the variables.
- The result of the null hypothesis indicates no change in opinion, while the result of the alternative hypothesis causes a change in opinion.
- In the null hypothesis, independent variables do not affect the dependent variable, while in the alternative hypothesis independent variable affects the dependent variable.
- Researchers try to disprove the null hypothesis and prove the alternative hypothesis.



Type-I and Type-II Error

- When conducting a hypothesis test there are two possible decisions: reject the null hypothesis or fail to reject the null hypothesis.
- You should remember though, hypothesis testing uses data from a sample to make an inference about a population.
- When conducting a hypothesis test we do not know the population parameters.
- In most cases, we don't know if our inference is correct or incorrect.



Type-I and Type-II Error

- When we reject the null hypothesis there are two possibilities:
- There could really be a difference in the population, in which case we made a correct decision. Or, it is possible that there is not a difference in the population (i.e. H_0 is true) but our sample was different from the hypothesized value due to random sampling variation. In that case we made an error. This is known as a Type I error.
- When we fail to reject the null hypothesis there are also two possibilities. If the null hypothesis is really true, and there is not a difference in the population, then we made the correct decision. If there is a difference in the population, and we failed to reject it, then we made a Type II error.



Type-I and Type-II Error

☰ Type I Error

Rejecting H_0 when H_0 is really true, denoted by α ("alpha") and commonly set at .05

$$\alpha = P(\text{Type I error})$$

☰ Type II Error

Failing to reject H_0 when H_0 is really false, denoted by β ("beta")

$$\beta = P(\text{Type II error})$$

Decision	Reality	
	H_0 is true	H_0 is false
Reject H_0 , (conclude H_a)	Type I error	Correct decision
Fail to reject H_0	Correct decision	Type II error



Type-I and Type-II Error

Example: Trial

A man goes to trial where he is being tried for the murder of his wife.

We can put it in a hypothesis testing framework. The hypotheses being tested are:

- H_0 : Not Guilty
- H_a : Guilty

Type I error is committed if we reject H_0 when it is true. In other words, did not kill his wife but was found guilty and is punished for a crime he did not really commit.


Type II error is committed if we fail to reject H_0 when it is false. In other words, if the man did kill his wife but was found not guilty and was not punished.



T-Test

- A t-test is an inferential statistic used to determine if there is a significant difference between the means of two groups and how they are related.
- T-tests are used when the data sets follow a normal distribution and have unknown variances, like the data set recorded from flipping a coin 100 times.
- Calculating a t-test requires three fundamental data values including the difference between the mean values from each data set, the standard deviation of each group, and the number of data values.

T-Test



T-Test
['tē-'test]

A statistical test used to compare the means of two groups of data.



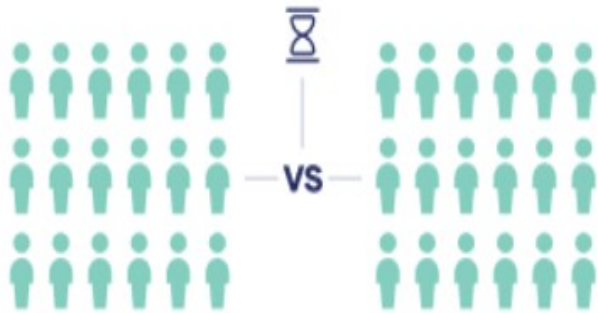
T-Test

- Mathematically, the t-test takes a sample from each of the two sets and establishes the problem statement. It assumes a null hypothesis that the two means are equal.
- A t-test can be used to determine if the results are correct and applicable to the entire population.
- The t test is a parametric test of difference, meaning that it makes the same assumptions about your data as other parametric tests. The t test assumes your data:
 - 1) are independent
 - 2) are (approximately) normally distributed
 - 3) have a similar amount of variance within each group being compared

T-Test

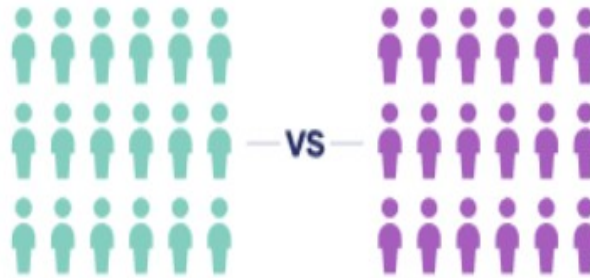
➤ What type of **t test** should use?

Paired-samples t test



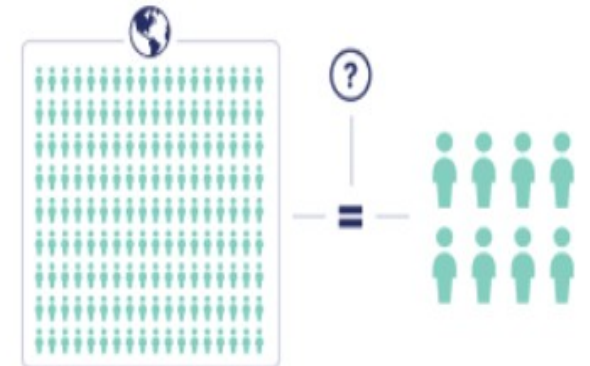
Investigate whether there's a difference within a group between two points in time (within-subjects).

Independent-samples t test



Investigate whether there's a difference between two groups (between-subjects).

One-sample t test



Investigate whether there's a difference between a group and a standard value or whether a subgroup belongs to a population.



F-Test

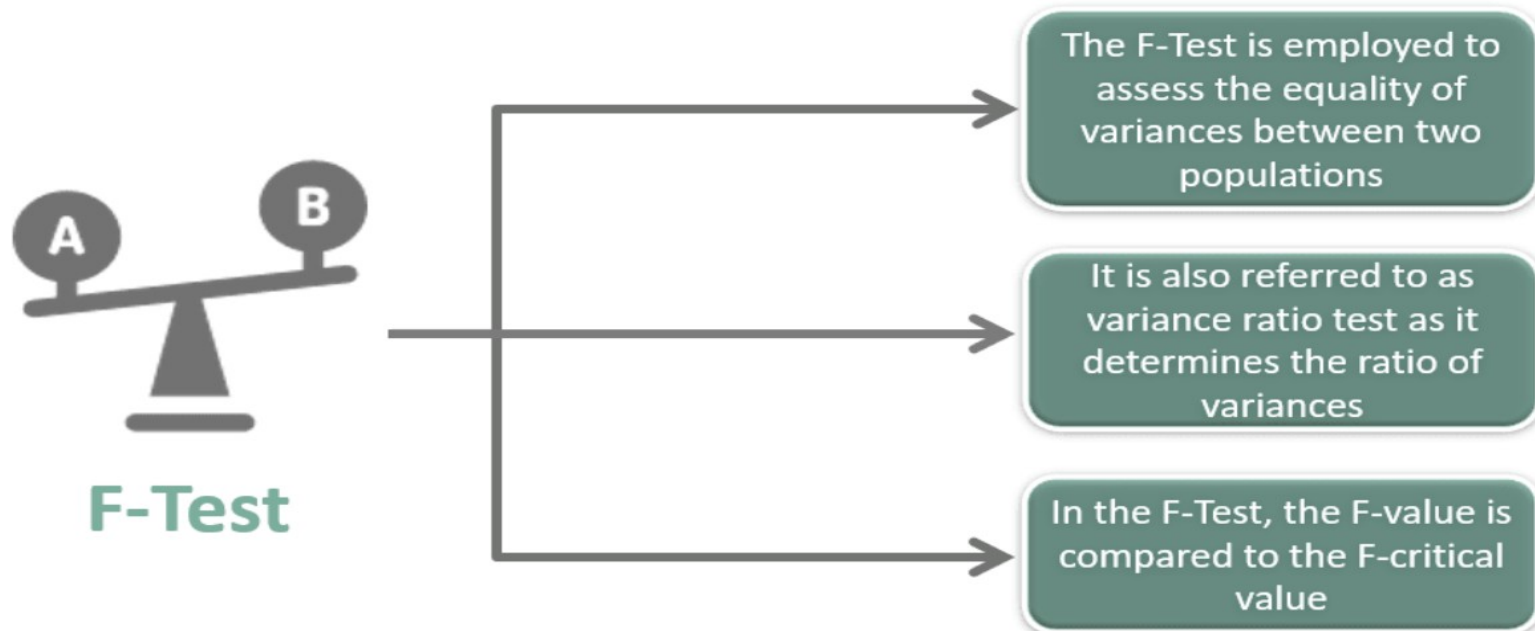
- F-Test in statistics is a hypothesis-testing procedure that considers two variances from two samples.
- The F-Test is used when the difference between two variances needs to be significantly assessed, i.e., when determining whether or not two samples can be taken as representative of the normal population with the same variance,
- The F-Test helps to determine the overall *significance of the regression*. It is useful in various situations, such as when a quality controller wants to determine whether the product's quality is deteriorating over time.



F-Test

- The t-test and the F-test are two separate tests. The T-test compares two populations' means, whereas the F-Test compares two populations' variances.

What is F-Test?





F-Test

- The following conditions are critical for using the F-test to compare the variances of two populations:
- 1) **Normality**: the populations must have a normal distribution.
 - 2) **Independent and random selection of sample items**: the selection of the samples' components should be independent and random.
 - 3) **More than unity**: The variance ratio must be one or larger than one; it cannot be less than one. When dividing variance estimates, smaller estimates divide the larger estimates of variances.
 - 4) The additive property states that the total of different variance components will equal the total variance, i.e., the total variance is the sum of the variance between samples and the variance within samples.

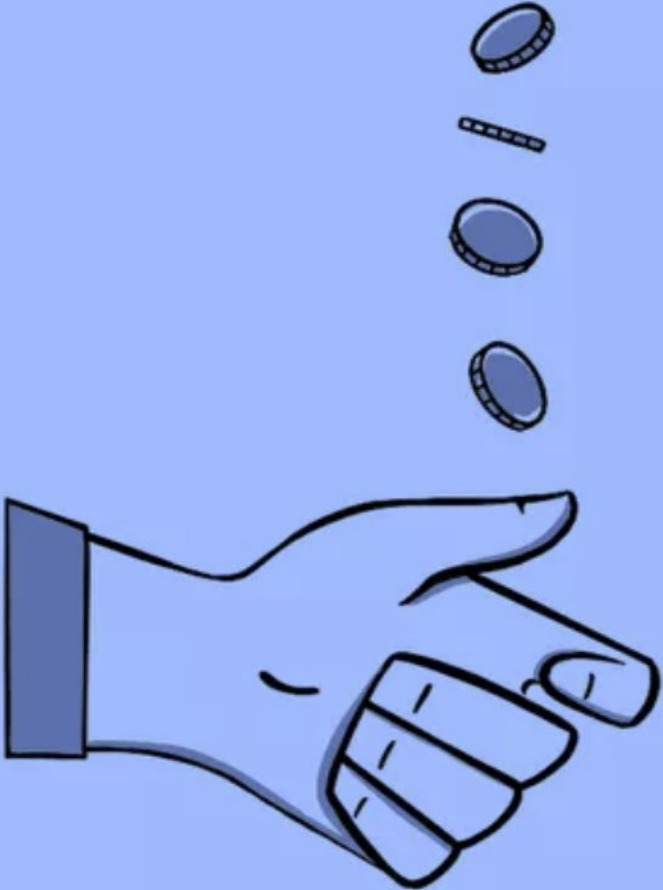


Chi-Square Test

- A chi-square (χ^2) statistic is a test that measures how a model compares to actual observed data.
- The data used in calculating a chi-square statistic must be *random, raw, mutually exclusive, drawn from independent variables*, and drawn from a large enough sample. For example, the results of tossing a fair coin meet these criteria.
- Chi-square is useful for analyzing such differences in categorical variables, especially those nominal in nature.



Chi-Square Test



Chi-Square (χ^2) Statistic

['kī-'skwer stə-'ti-stik]

A test that measures how a model compares to actual observed data.



Chi-Square Test

- Chi-square analysis is applied to categorical variables and is especially useful when those variables are nominal (where order doesn't matter, like marital status or gender)
- Chi-square is a statistical test used to examine the differences between categorical variables from a random sample in order to judge the goodness of fit between expected and observed results.
- Since chi-square applies to categorical variables, it is most used by researchers who are studying survey response data. This type of research can range from demography to consumer and marketing research to political science and economics.



Chi-Square Test

- *How to Perform a Chi-Square Test-*
- These are the basic steps whether you are performing a goodness of fit test or a test of independence:
 - 1) Create a table of the observed and expected frequencies;
 - 2) Use the formula to calculate the chi-square value;
 - 3) Find the critical chi-square value using a chi-square value table or statistical software;
 - 4) Determine whether the chi-square value or the critical value is the larger of the two;
 - 5) Reject or accept the null hypothesis.



Chi-Square Test

- *Limitations of the Chi-Square Test:*
- The chi-square test is sensitive to sample size. Relationships may appear to be significant when they aren't simply because a very large sample is used.
- In addition, the chi-square test cannot establish whether one variable has a causal relationship with another. It can only establish whether two variables are related.



Analysis of variance(ANOVA)

Analysis of variance(ANOVA):

- Analysis of variance (ANOVA) is an analysis tool used in statistics that splits an observed aggregate variability found inside a data set into two parts: systematic factors and random factors.
- The systematic factors have a statistical influence on the given data set, while the random factors do not.
- Analysts use the ANOVA test to determine the influence that independent variables have on the dependent variable in a regression study.



Analysis of variance(ANOVA)

Analysis of variance(ANOVA):

- The ANOVA test allows a comparison of more than two groups at the same time to determine whether a relationship exists between them.
- The result of the ANOVA formula, the F statistic (also called the F-ratio), allows for the analysis of multiple groups of data to determine the variability between samples and within samples.
- If no real difference exists between the tested groups, which is called the null hypothesis, the result of the ANOVA's F-ratio statistic will be close to 1.



Analysis of variance(ANOVA)

Example of How to Use ANOVA

- A researcher might, for example, test students from multiple colleges to see if students from one of the colleges consistently outperform students from the other colleges.
- In a business application, an R&D researcher might test two different processes of creating a product to see if one process is better than the other in terms of cost efficiency.
- The type of ANOVA test used depends on a number of factors. It is applied when data needs to be experimental,



Analysis of variance(ANOVA)

One-Way ANOVA Versus Two-Way ANOVA

- There are two main types of ANOVA: one-way (or unidirectional) and two-way.
- There also variations of ANOVA. For example, MANOVA (multivariate ANOVA) differs from ANOVA as the former tests for multiple dependent variables simultaneously while the latter assesses only one dependent variable at a time.
- One-way or two-way refers to the number of independent variables in your analysis of variance test.



Analysis of variance(ANOVA)

One-Way ANOVA Versus Two-Way ANOVA

- A one-way ANOVA evaluates the impact of a sole factor on a sole response variable. It determines whether all the samples are the same.
- The one-way ANOVA is used to determine whether there are any statistically significant differences between the means of three or more independent (unrelated) groups.
- A two-way ANOVA is an extension of the one-way ANOVA. With a one-way, you have one independent variable affecting a dependent variable.



Analysis of variance(ANOVA)

One-Way ANOVA Versus Two-Way ANOVA

- With a two-way ANOVA, there are two independents. For example, a two-way ANOVA allows a company to compare worker productivity based on two independent variables, such as salary and skill set.
- It is utilized to observe the interaction between the two factors and tests the effect of two factors at the same time.
- ANOVA differs from T tests in that ANOVA can compare three or more groups while T tests are only useful for comparing two groups at one time.



Analysis of variance(ANOVA)

Analysis of Variance in Finance

- Analysis of variance testing is used in finance in several different ways, such as to forecast the movements of security prices by first determining which factors influence stock fluctuations.
- This analysis can provide valuable insight into the behavior of a security or market index under various conditions.
- In addition to its applications in the finance industry, ANOVA is also used in a wide variety of contexts and applications to test hypotheses in reviewing clinical trial data.



THANK YOU