30 Hours Online Certificate Course On *"Research & Data Analysis"*

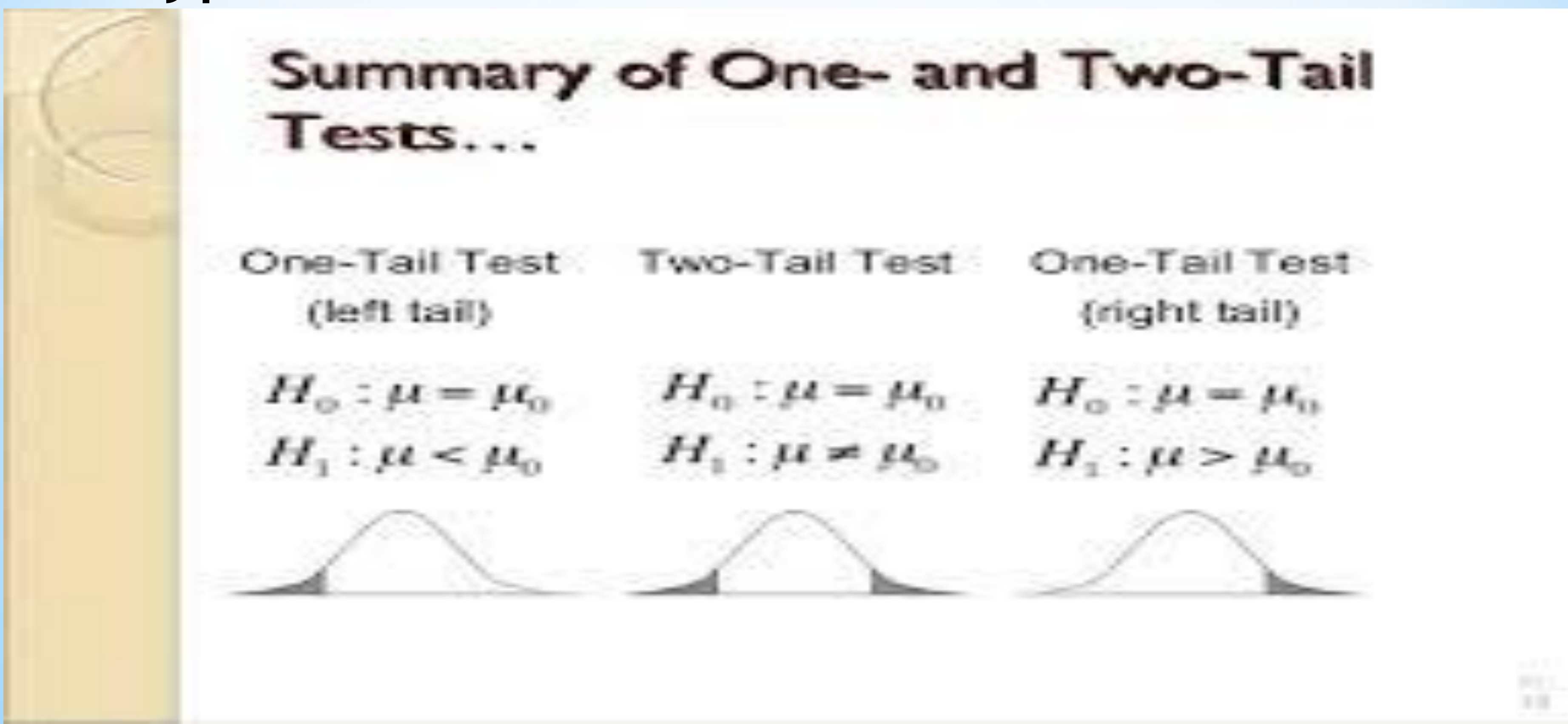
- Organised By: **Accounting and Finance Lab, Department of Commerce, Ramanujan College, University of Delhi**
- Resource Person: **Dr. Arnav Kumar**
- Designation: Assistant Professor, Department of Management Studies, Ramanujan College
- Email: arnavkumardse@gmail.com
- Day & Date: **June 19, 2020**.

Hypothesis Testing

- Hypothesis: Statements or Assumptions or Claims which can be Verified.
- Null Hypothesis (Ho): No Effect/Impact/ Relationship between Variables.
- Alternate or Research Hypothesis (Ha): It contains the prediction/hypothesis from our Theory. Presence of some Effect/ Impact/Relationship between Variables.
- We always test Null but want Alternate to be true & null to be not accepted.

One Tail and Two Tail Tests

- A statistical model that tests a directional hypothesis is called a one-tailed test, whereas one testing a non-directional hypothesis is known as a two-tailed test.



Test Statistics

- We look at a simple signal-to-noise ratio: we compare how good the model/hypothesis is against how bad it is (error).
- $$\text{Test statistic} = \frac{\text{signal}}{\text{noise}} = \frac{\text{variance explained by the model}}{\text{variance not explained by the model}} = \frac{\text{effect}}{\text{error}}$$
- t, F, and Chi Square (χ^2) are three very commonly used and popular test Statistics.
- The exact form of this equation changes depending on which test statistic you're calculating, but they all, broadly speaking, represent the same thing: signal-to-noise.

Hypothesis Testing Approaches

- To test null hypothesis, we use sample information to obtain the test statistic.
- Mostly, this test statistic turns out to be the point estimator of the unknown population parameter.
- Then, we try to find out the sampling, or probability, distribution of test statistic.
- Finally, we use one of the following two approaches to test the null hypothesis:
  - ✓ Confidence Interval Approach; or
  - ✓ Test of Significance (P Value) Approach.

Test of Significance Approach

- Instead of preselecting α at some arbitrary levels (like 1, 5, or 10%), we can obtain the p (probability) value, or the exact level of significance of a test statistic.
- P value is lowest significance level at which a Ho can be rejected. It is probability of finding observed, or more extreme value of a test statistic when (Ho) is true. If P-Value is less than given α, we have significant effect/relationship, Ho is rejected.
- Larger Test Statistic > Smaller P value.

Test of Significance Approach

- If the p-value is very small (usually < .05), we conclude that the model (Alternate Hypothesis) fits the data well, & we assume our initial prediction is true, i.e., we gain confidence in alternative hypothesis (Ha).

Situations	✓ Always Say	X Never Say	Real Meaning
If P-Value > 0.05 (5%), or 0.01 (1%), or 0.10 (10%)	Null Hypothesis (Ho) can not be rejected or We don't have enough evidence to reject Ho.	➢ Accept Ho ➢ Reject Ha ➢ Ho is True ➢ Ha is False	Little statistical evidence/support for our Alternate/ Research Hypothesis
If P-Value < 0.05 (5%), or 0.01 (1%), or 0.10 (10%)	Null Hypothesis (Ho) can be rejected or We have enough evidence to reject Ho.	➢ Accept Ha ➢ Ho is False ➢ Ha is True	Strong statistical evidence/support for our Alternate/ Research Hypothesis

Sample Size & Statistical Significance

- The significance of a test statistic is directly linked to the sample size.
- The same effect will have different p-values in different sized samples.
- Small differences can be deemed ‘Significant’ in Large Samples; and
- Large Effects might be deemed ‘Non Significant’ in Small Samples.
- This is also called Large Sample Bias.
- So for Significant results, get Large Samples.

Scales of Measurement - Permissible Statistics & Tests

Scale/Level of Measurement	Permissible Statistics	Permissible Tests
Binary	Frequencies, Percentages, Mode	Binomial, Chi-Square
Nominal	Frequencies, Percentages, Mode	Binomial, Chi-Square
Ordinal	Nominal + Median, Percentiles, Quartiles, Deciles, Rank Correlation	Binomial, Chi-Square, Non Parametric Tests
Interval	Ordinal + Mean, Range, Standard Deviation, Regression	Binomial, Chi-Square, t, Z, F
Ratio	All Under Sun	All Known to Mankind

Tests for Normality: K-S & Shapiro-Wilk Tests

- Both Kolmogorov–Smirnov (K-S) test and Shapiro–Wilk test compare scores in sample to a normally distributed set of scores with the same mean and standard deviation.
- If the test is non-significant ($p > .05$) it tells us that the distribution of the sample is not significantly different from a normal distribution (i.e., it is probably normal).
- If, the test is significant ($p < .05$) then the distribution is significantly different from a normal distribution (i.e., it is non-normal).

Tests for Normality: K-S & Shapiro-Wilk Tests

- Shapiro–Wilk test has more power to detect differences from normality (so it might be significant when the K-S test is not).
- In large samples, these tests can be significant even when the scores are only slightly different from a normal distribution.
- So, they are not particularly recommended and they should always be interpreted in conjunction with Histograms, P-P or Q-Q Plots, and values of Skewness & Kurtosis.

Tests for Normality:
K-S & Shapiro-Wilk Tests

- Performing **Kolmogorov-Smirnov (K-S) & Shapiro-Wilk Tests** in IBM SPSS Statistics to detect Non Normality:
- ✓ Analyze > Descriptive Stats. > Explore;
- ✓ Enter one or more Scale Variables (Percent);
- ✓ Select "Normality Plots with Tests" in Plots.
- ✓ Ho: Distribution of the Variable is not Significantly Different from a Normal Distribution;
- ✓ Interpret as per Significance/P-Values.

Analysis of Categorical Data - Cross Tabulation & Chi-Square Analysis

Crosstabs

- Type of table in matrix format that displays the (multivariate) frequency distribution of the variables.
- Heavily used in survey, social science and business research.

Event forecast	Event observed		
	Yes	No	Marginal total
Yes	a	b	a + b
No	c	d	c + d
Marginal total	a + c	b + d	a + b + c + d =n

Chi Square Test of Independence

- Used for 2 Categorical variables (Nominal or Ordinal Scale) with 2 or more sub categories.
- Basically, compares Observed and Expected Frequencies & computes Chi Square Statistic.
- In Crosstabs, it tests the Hypothesis that Row & Column Variables are Independent.
- Interpretation: If Asymptotic Significance (2-sided) of Pearson Chi Square & Likelihood Ratio is less than 0.05 (5%), we reject the null hypothesis that the two variables are independent. We gain evidence that the two variables are significantly related to each other.

SPSS: Crosstabs & Chi Square Test of Independence

- Crosstabs (*Gender – Ethnicity*)

Analyze > Descriptive Statistics > Crosstabs

- Steps:
- ✓ Select & Enter Row & Column Variables.
- ✓ In Statistics, Select Chi Square.
- ✓ In Cells, Select Percentages (Total).

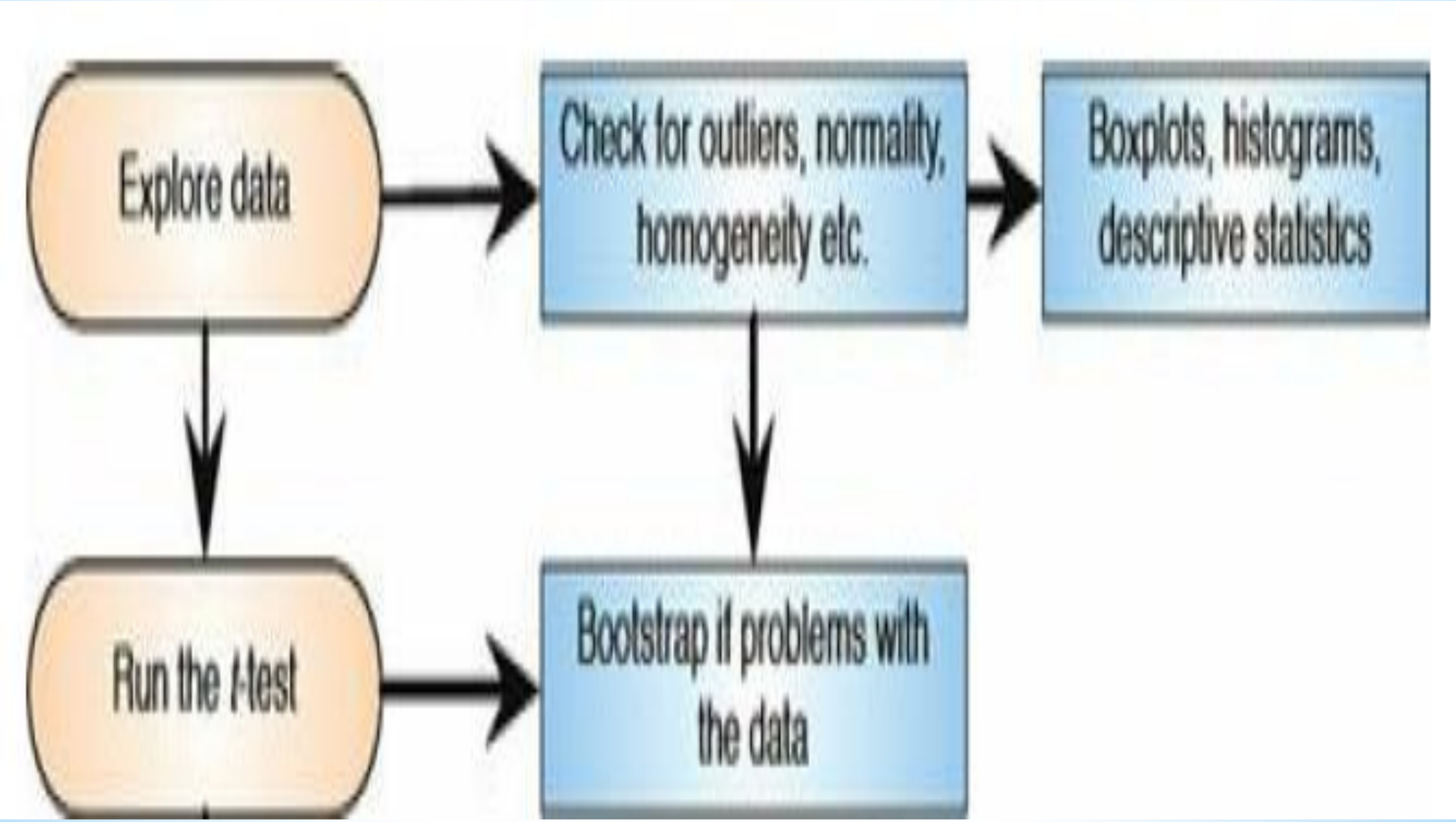
Parametric Tests - Comparing Means

Comparing Means – "t" Tests

- When to use "t" tests?
  - When Population Std. Dev. not known;
  - Sample size less than 30. For sample size more than 30 (it resembles Normal distribution).
- t tests:
  - One Sample t Test
  - Independent Samples t Test
  - Paired Samples t Test
- **Assumptions of All t Tests & ANOVA – Lack of Outliers, Normality of Data, Homogeneity of Variance. If there is any doubt in meeting any of these assumptions - use Bootstrap.**

Comparing Means – "t" Tests

- **The General Process of "t Tests"**



Comparing Means – One-Sample t Test

- Tests whether the mean of a single variable differs from a specified constant (e.g. 0 or 2.5 on a 5 point Likert Scale).
- SPSS:
  - ✓ Analyze > Compare Means > One-Sample T Test
  - ✓ Select one or more variables to be tested against same hypothesized value (Quiz 1-5).
  - ✓ Enter a numeric test value against which each sample mean is compared (5 & 7.5).
- Reject Ho (Null Hypothesis) of Mean Value = Constant Value if Significance of t Statistic < 0.05 (5%).

Comparing Means – Paired Sample t Test

- Compares means of two Quantitative (Interval or Ratio Scale) variables for a single sample.
- It computes the differences between values of the two variables for each case and tests whether the average differs from 0.
- **SPSS:**
- ✓ Analyze > Compare Means > Paired-Samples T Test.
- ✓ Then Select 1 or more pairs of Variables (*Quiz 1-2; 1-3; 1-4 & 1-5*).
- Reject Ho (Null Hypothesis) of No Difference in Mean Values if Significance of t Statistic < 0.05.

Comparing Means - Independent Sample t Test

- Compares means of a Quantitative Variable (Interval or Ratio Scale) for 2 categories/groups.
- Same as One Way ANOVA, but only for 2 Categories or Groups.
- The procedure uses a grouping variable with two values to separate the cases into two groups.
- The grouping variable can be numeric (values such as 1 and 2) or short string (yes and no).

Comparing Means – Independent Sample t Test

- **SPSS:**
  - Analyze > Compare Means > Independent-Samples T Test.
  - Select one or more quantitative test variables (*Percent and GPA*). A separate t test is computed for each variable.
  - Select a single grouping variable, and then click Define Groups to specify two codes for the groups that you want to compare. [*Variable: extcr - Did extra credit project?*; *Groups – 1 (No) & 2 (Yes)*].

Comparing Means - Independent Sample t Test

- **Interpretation:**
- First Check the result of Levene's test. If Sig. of F > 0.05; Null Hypothesis of Equal Variance is Accepted. So, Interpret t test results corresponding to that (the upper one).
- If Ho of equal variance is rejected, interpret the other t test (the lower one).
- If Sig. of t < 0.05, the Null Hypothesis of no difference in mean of Quantitative variable across the two groups is rejected.

Comparing Means – One Way ANOVA

- Calculates & compares subgroup means for dependent variables across categories of an independent variable.
- Dependent variable(s) must be quantitative (interval or ratio scale).
- Independent variable must be categorical having categorical values coded as integers (e.g. 1- Sec. A, 2- Sec. B & 3 – Sec. C).
- Categories can be two or more.
- Null Hypothesis: There is no Significant Difference between Mean Values of the Dependent Variable across the Categories of Independent variable.

One Way ANOVA – Post Hoc Tests

- After an ANOVA we need further analysis to find out which groups differ called Post Hoc Analysis.
- When you have no specific hypotheses before the experiment, use post hoc tests.
- When you have equal sample sizes and group variances are similar use REGWQ or Tukey.
- If sample sizes are slightly different then use Gabriel's procedure, but if sample sizes are very different use Hochberg's GT2.
- If there is any doubt that group variances are equal then use the Games-Howell procedure.

SPSS – One Way ANOVA

- From the menus choose:
- Analyze > Compare Means > One-Way ANOVA.
- Select one or more dependent variables (*Percent and GPA*).
- Select a single independent factor variable (*Section and Ethnicity*).
- In Options, Select Descriptives within Statistics.

- Reject Ho (Null Hypothesis) of Equal Means if Significance of F Statistic < 0.05 (5%).


The end!
Thank you for viewing and listening!


HAVE A NICE DAY!