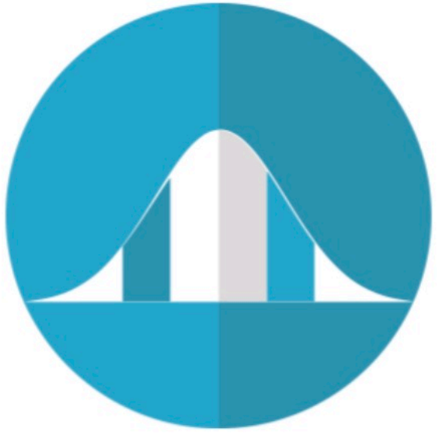
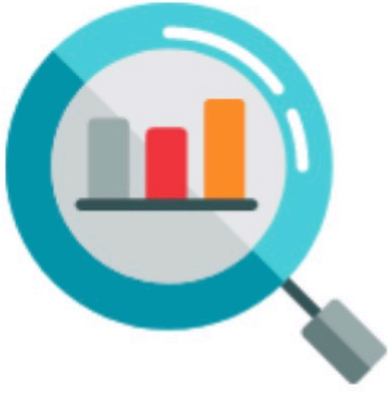


Statistics
Session-7



CLARUSWAY©
WAY TO REINVENT YOURSELF

Did you finish Statistics (Analysis of Categorical Data) pre-class activity?

Students choose an option

Pear Deck Interactive Slide
Do not remove this bar

No Multiple Choice Response
You didn't answer this question

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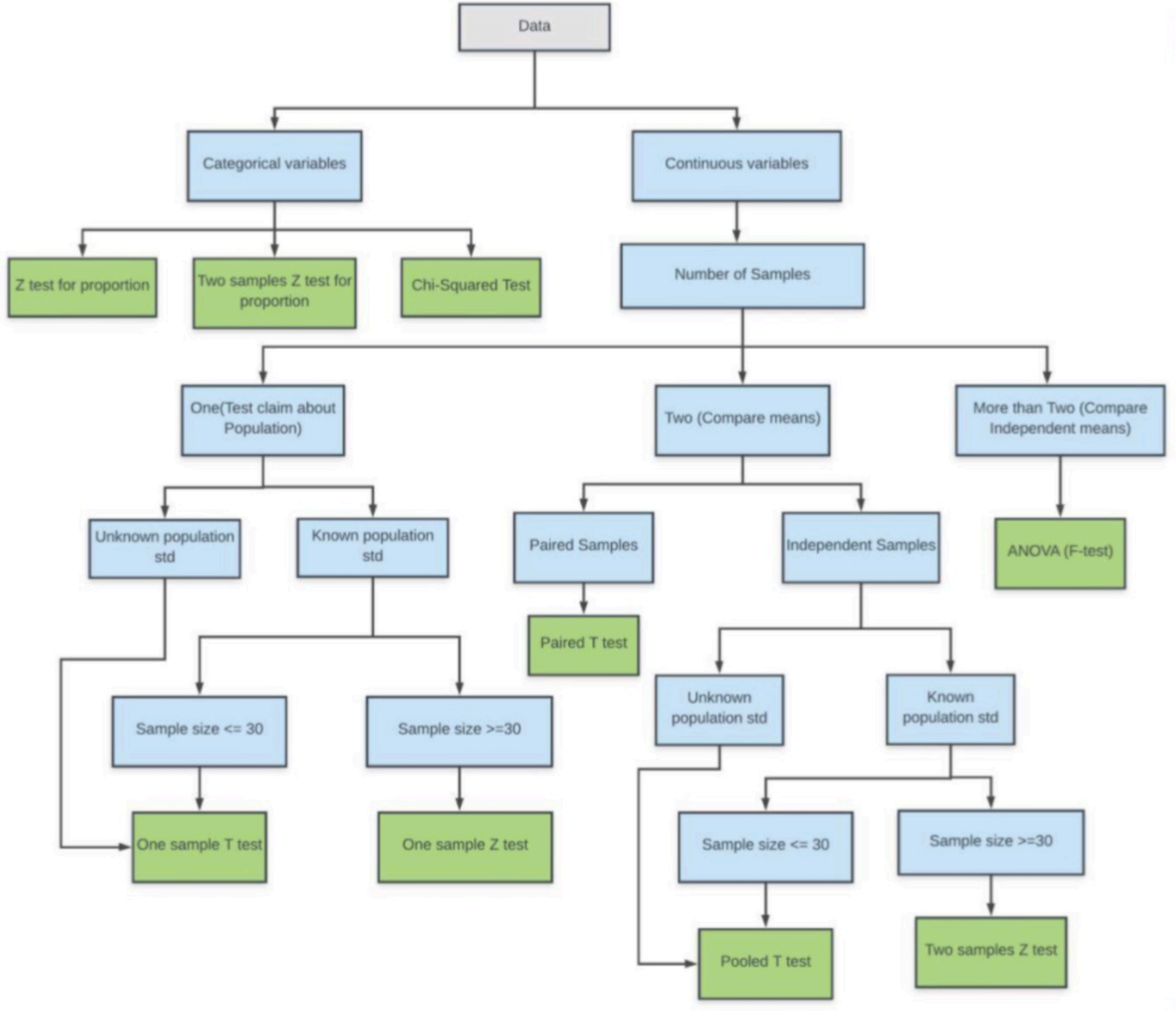
Test Types


Data
Categorical variables
Continuous variables
Z test for proportion
Two samples Z test for proportion
Chi-Squared Test
Number of Samples
One(Test claim about Population)
Two (Compare means)
More than Two (Compare Independent means)
Unknown population std
Known population std
Paired Samples
Independent Samples
ANOVA (F-test)
Paired T test
Sample size <= 30
Sample size >=30
Unknown population std
Known population std
One sample T test
One sample Z test
Sample size <= 30
Sample size >=30
Pooled T test
Two samples Z test

The Steps of a Significance Test

A significance test has five steps.

- **Step 1** : Assumptions
- **Step 2** : Hypotheses
- **Step 3** : Test Statistic
- **Step 4** : P-Value
- **Step 5** : Conclusion

Association

- Examining relationship between 2 categorical variables
- Some examples of association:
  - Smoking and lung cancer
  - Ethic group and coronary heart disease

- Questions of interest when testing for association between two categorical variables
  - Does the presence/absence of one factor (variable) influence the presence/absence of the other factor (variable)?
- Caution
  - Presence of an association does not necessarily imply causation

Contingency Tables

A contingency table (also called crosstab) is used to reveal the association between categorical variables.

Suppose that we wish to classify defects found on furniture produced in a manufacturing plant according to

(1) the type of defect
(2) the production shift

Contingency Tables

	Type of Defect				
Shift	A	B	C	D	*Total*
1	15	21	45	13	*94*
2	26	31	34	5	*96*
3	33	17	49	20	*119*
Total	*74*	*69*	*128*	*38*	*309*

- n=309 furniture defect was recorded
- The defects were classified as one of four types: A, B, C, or D
- The shifts were classified as one of three types: 1, 2, or 3

Association

	Type of Defect				
Shift	A	B	C	D	*Total*
1	15	21	45	13	*94*
2	26	31	34	5	*96*
3	33	17	49	20	*119*
Total	*74*	*69*	*128*	*38*	*309*

- Is there an association between type of defect and production shift?
- How can we see whether there is a relationship between those two variables?

Chi square

To analyze relationship between two categorical variables: Pearson's χ2 test.

$$\chi^2 = \sum \frac{(Observed - Expected)^2}{Expected}$$

Karl Pearson

Founder of Modern Statistics

Hypotheses

Null Hypothesis: The two categorical variables are independent.

- There **is no** association between type of defect and production shift in the population.

Alternative Hypothesis: The two categorical variables are dependent.

- There **is an** association between type of defect and production shift in the population.

Chi square test statistic

To test this, we **compare** the observed frequencies in each category to the frequencies we would expect in the categories if there would be no association

$$\chi^2 = \sum \frac{(f_o - f_e)^2}{f_e}$$

fo = observed frequencies
fe = expected frequencies (if there would be no association = expected under the null hypothesis)

Expected Frequencies

	Type of Defect				
Shift	A	B	C	D	*Total*
1					*94*
2					*96*
3					*119*
Total	*74*	*69*	*128*	*38*	*309*

- We can calculate the expected frequency of the marked cell via this formula:

$$f_e = \frac{n_r n_c}{n}$$

- n_r = total number in the row
- n_c = total number in the column
- n = total sample size

Expected Frequencies

	Type of Defect				
Shift	A	B	C	D	*Total*
1	22.51	20.99	38.94	11.56	*94*
2	22.99	21.44	39.77	11.81	*96*
3	28.50	26.57	49.29	14.63	*119*
Total	*74*	*69*	*128*	*38*	*309*

- We can calculate the expected frequency of the marked cell via this formula:

$$f_e = \frac{n_r n_c}{n}$$

- n_r = total number in the row
- n_c = total number in the column
- n = total sample size

Observed vs Expected Frequencies

	Type of Defect				
Shift	A	B	C	D	*Total*
1	15 (22.51)	21 (20.99)	45 (38.94)	13 (11.56)	*94*
2	26 (22.99)	31 (21.44)	34 (39.77)	5 (11.81)	*96*
3	33 (28.50)	17 (26.57)	49 (49.29)	20 (14.63)	*119*
Total	*74*	*69*	*128*	*38*	*309*

- Using this we can calculate our $\chi 2$ test statistic!

$$\chi^2 = \sum \frac{(f_o - f_e)^2}{f_e}$$

Do not forget the square!

Chi-square test for statistical association

- For the given problem:

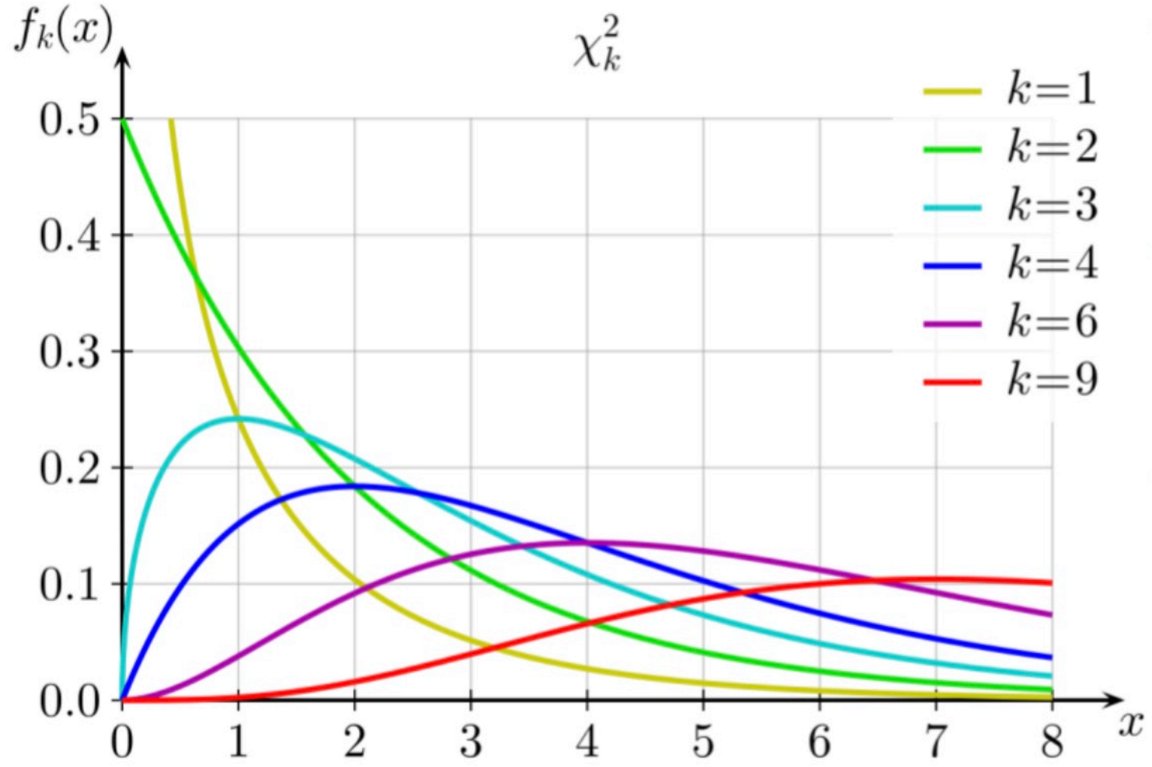
$$X^2 = \sum_{j=1}^{4}\sum_{i=1}^{3} \frac{[n_{ij} - \widehat{E(n_{ij})}]^2}{\widehat{E(n_{ij})}}$$

$$= \frac{(15 - 22.51)^2}{22.51} + \frac{(26 - 22.99)^2}{22.99} + \cdots + \frac{(20 - 14.63)^2}{14.63}$$

$$= 19.17.$$

- Chi-square degree of freedom is given by: (no. of rows-1)*(no. of cols-1) = (4-1)*(3-1) = 6

Chi-square Distribution



- Distribution depends on ***degrees of freedom*** (like the t-distribution)
- Chi-square is always≥ 0, because we used the squared differences.
- To determine the degrees of freedom:
  df (degrees of freedom) = (r-1)*(c-1)

p-value and Conclusion

```
[1]  from scipy import stats
```

```
[2]  1 - stats.chi2.cdf(19.17, 6)
```

```
0.003885957910757742 4
```

- P-value < α
- We reject the null hypothesis.

- Therefore, we can reject H_0 at 0.05 significance level and conclude that defect type and manufacturing shift are dependent.

p-value and Conclusion

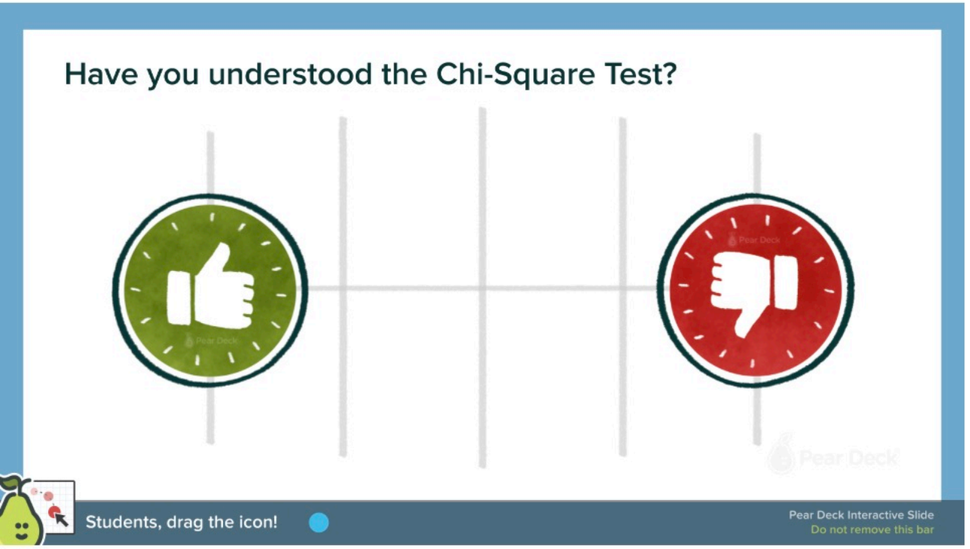
```
[5]  table = [[15, 21, 45, 13],[26, 31, 34, 5], [33, 17, 49, 20]]
```

```
[6]  stat, p, dof, expected = chi2_contingency(table)
```

```
stat=19.178, p=0.0039
```

- P-value < α
- We reject the null hypothesis.

- Therefore, we can reject H_0 at 0.05 significance level and conclude that defect type and manufacturing shift are dependent.



No Draggable™ Response

You didn't answer this question

THANKS!

Any questions?

You can find me at:

- jason@clarusway.com