Hypothesis Testing

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Types of Hypothesis

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Null & Alternative Hypothesis

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- The alternative hypothesis is what you might believe to be true or hope to prove true.

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- As an example suppose flour packaged by a manufacturer want to test to determine whether their packaging process is out of control as to determine by weight of flour package is 40 ounce or not.
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$$H_o : \mu = 40, H_a : \mu \neq 40$$

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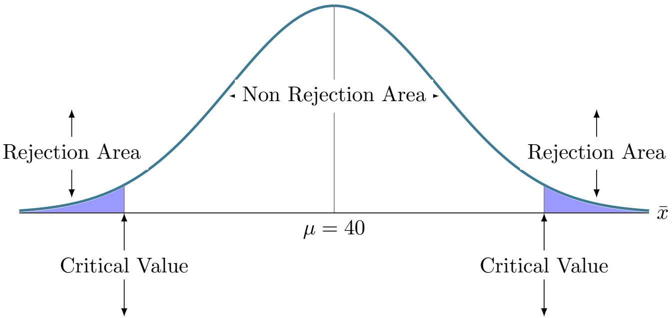
Non Rejection Area
Rejection Area
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- The decision is to reject null hypothesis even though the population mean is actually 40 ounce in that case the business researcher has committed Type-I error.

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	Accept Null	Reject Null

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Example: The life time of electric bulbs for a random sample of 10 from large consignment gave the following data:

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Example: The life time of electric bulbs for a random sample of 10 from large consignment gave the following data:

Item	1	2	3	4	5	6	7	8	9	1
Life ('000 hrs)	4.2	4.6	3.9	4.1	5.2	3.8	3.9	4.3	4.4	5

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Can you regard the mean life of light bulbs is atleast 4000 hrs?

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Life ('000 hrs)	4.2	4.6	3.9	4.1	5.2	3.8	3.9	4.3	4.4	5

Can you regard the mean life of light bulbs is atleast 4000 hrs? (Take $\alpha = 0.05$)

Method-III Testing a hypothesis for single proportion(z-test)

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Necessary Conditions

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1. $n.p \geq 5$

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1. $n.p \geq 5$
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$$z = \frac{\bar{p} - p}{\sqrt{\frac{p.(1-p)}{n}}}$$

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- p=Population proportion.
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Confidence Interval

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$$\bar{p} - z_{\alpha/2}\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} \leq p \leq \bar{p} + z_{\alpha/2}\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

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Example: A coin tossed 400 times and head turned up 216 times.

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Example: A coin tossed 400 times and head turned up 216 times. Test the hypothesis that the coin is unbiased.

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Example: In a hospital 480 female and 520 male babies were born in a week.

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Example: A factory is producing 50,000 pair of shoes daily.

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Method-IV Testing a hypothesis for double population mean(large samples)(z-test)

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1. Both sample sizes must be large($n_1 \geq 30, n_2 \geq 30$)
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Types of hypothesis

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Types of hypothesis

1. $H_o : \mu_1 - \mu_2 = 0$,$H_a : \mu_1 - \mu_2 \neq 0$

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z-formula

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$$z = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$$

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- σ_1=First population standard deviation.

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- n_1=First sample size.(≥ 30)

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Confidence Interval

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$$(\bar{x}_1 - \bar{x}_2) - z_{\alpha/2}\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}} \leq (\mu_1 - \mu_2) \leq (\bar{x}_1 - \bar{x}_2) + z_{\alpha/2}\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}$$

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Example:

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Example:A men buy 50 electric bulbs of Phillips and 50 electric bulbs of HMT.

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Example:A men buy 50 electric bulbs of Phillips and 50 electric bulbs of HMT.He finds that Phillips bulb give an average life of 1500 hrs with a population standard deviation of 60 hrs

Confidence Interval

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$$(\bar{x}_1 - \bar{x}_2) - z_{\alpha/2}\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}} \leq (\mu_1 - \mu_2) \leq (\bar{x}_1 - \bar{x}_2) + z_{\alpha/2}\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}$$

Example:A men buy 50 electric bulbs of Phillips and 50 electric bulbs of HMT.He finds that Phillips bulb give an average life of 1500 hrs with a population standard deviation of 60 hrs and HMT bulbs give an average life of 1512 hrs with a standard deviation of 80 hrs.

Confidence Interval

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Example:A men buy 50 electric bulbs of Phillips and 50 electric bulbs of HMT.He finds that Phillips bulb give an average life of 1500 hrs with a population standard deviation of 60 hrs and HMT bulbs give an average life of 1512 hrs with a standard deviation of 80 hrs.Is there any significant difference between the mean life of two types of bulbs.

Confidence Interval

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$$(\bar{x}_1 - \bar{x}_2) - z_{\alpha/2}\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}} \leq (\mu_1 - \mu_2) \leq (\bar{x}_1 - \bar{x}_2) + z_{\alpha/2}\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}$$

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Examples

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Example:A simple sample of height of 6,400 Englishmen has a mean of 67.85 inches

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Example:A simple sample of height of 6,400 Englishmen has a mean of 67.85 inches with a population standard deviation of 2.52 inches.

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Example:A simple sample of height of 6,400 Englishmen has a mean of 67.85 inches with a population standard deviation of 2.52 inches.While a simple sample of 1,600 Austrians has a mean height of 68.55 inches

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Example:A simple sample of height of 6,400 Englishmen has a mean of 67.85 inches with a population standard deviation of 2.52 inches.While a simple sample of 1,600 Austrians has a mean height of 68.55 inches with a population standard deviation of 2.52 inches.Do this data indicates that Austrians are on average taller than the Englishmen.(Take $\alpha = 0.01$)

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Example:A random sample of 100 mill workers at Kanpur showed their mean wage to be Rs 350 with a population standard deviation of Rs 28.

Examples

Example:A simple sample of height of 6,400 Englishmen has a mean of 67.85 inches with a population standard deviation of 2.52 inches.While a simple sample of 1,600 Austrians has a mean height of 68.55 inches with a population standard deviation of 2.52 inches.Do this data indicates that Austrians are on average taller than the Englishmen.(Take $\alpha = 0.01$)

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Method-V Testing a hypothesis for double population mean(small samples)(t-test)

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t-formula

t-formula

$$t = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{s_1^2(n_1-1)+s_2^2(n_2-1)}{n_1+n_2-2}}\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}}, d.f = n_1 + n_2 - 2$$

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Where

- $\bar{x}_1$=First sample mean.

t-formula

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Where

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- n_1=First sample size.

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Confidence Interval

Confidence Interval

Confidence Interval

Confidence Interval

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$$\leq (\mu_1 - \mu_2) \leq$$
$$(\bar{x}_1 - \bar{x}_2) + t_{\alpha/2}\sqrt{\frac{s_1^2(n_1-1)+s_2^2(n_2-1)}{n_1+n_2-2}}\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}$$

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	I division	II division
Sample size	12	10
Average Monthly Salary	12500	11200
Standard Deviation	320	480

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Batch No	1	2	3	4	5	6	7	8	9	10
Lab A	7	8	7	3	8	6	9	4	7	8
Lab B	9	8	8	4	7	7	9	6	6	6

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Batch No	1	2	3	4	5	6	7	8	9	10
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Is there any significant difference between the mean fate content obtained by two laboratories.

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Lab B	9	8	8	4	7	7	9	6	6	6

Is there any significant difference between the mean fate content obtained by two laboratories.(Take $\alpha = 0.01$)

Example

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Is there any significant difference between the mean fate content obtained by two laboratories.(Take $\alpha = 0.01$)Also establish 90% confidence limit.

Method-VI Testing a hypothesis for dependent population(Difference-test)(t-test)

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Condition

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Condition

- Small sample sizes.

Method-VI Testing a hypothesis for dependent population(Difference-test)(t-test)

Condition

- Small sample sizes.
- Data in pairs.

Method-VI Testing a hypothesis for dependent population(Difference-test)(t-test)

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Types of hypothesis

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- $H_o : D = 0, H_a : D \neq 0$

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- $H_o : D = 0, H_a : D \neq 0$
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Mid-Sem Mark(Statistical Methods) Before Assignment

Mid-Sem Mark(Statistical Methods)

Before Assignment

18

Mid-Sem Mark(Statistical Methods)

Before Assignment

18

7

Mid-Sem Mark(Statistical Methods)

Before Assignment

18

7

10

Mid-Sem Mark(Statistical Methods)

Before Assignment

18

7

10

22

Mid-Sem Mark(Statistical Methods)

Before Assignment

18

7

10

22

15

Mid-Sem Mark(Statistical Methods)

Before Assignment

18

7

10

22

15

0

Mid-Sem Mark(Statistical Methods)

Before Assignment

18
7
10
22
15
0
4

Mid-Sem Mark(Statistical Methods)

Before Assignment

18
7
10
22
15
0
4
25

Mid-Sem Mark(Statistical Methods)

Before Assignment

Before Assignment
18
7
10
22
15
0
4
25
17

Mid-Sem Mark(Statistical Methods)

Before Assignment

18
7
10
22
15
0
4
25
17
5

Mid-Sem Mark(Statistical Methods)

Before Assignment	After Assignments
18	
7	
10	
22	
15	
0	
4	
25	
17	
5	

Mid-Sem Mark(Statistical Methods)

Before Assignment	After Assignments
18	22
7	
10	
22	
15	
0	
4	
25	
17	
5	

Mid-Sem Mark(Statistical Methods)

Before Assignment	After Assignments
18	22
7	15
10	
22	
15	
0	
4	
25	
17	
5	

Mid-Sem Mark(Statistical Methods)

Before Assignment	After Assignments
18	22
7	15
10	12
22	
15	
0	
4	
25	
17	
5	

Mid-Sem Mark(Statistical Methods)

Before Assignment	After Assignments
18	22
7	15
10	12
22	28
15	
0	
4	
25	
17	
5	

Mid-Sem Mark(Statistical Methods)

Before Assignment	After Assignments
18	22
7	15
10	12
22	28
15	12
0	
4	
25	
17	
5	

Mid-Sem Mark(Statistical Methods)

Before Assignment	After Assignments
18	22
7	15
10	12
22	28
15	12
0	0
4	
25	
17	
5	

Mid-Sem Mark(Statistical Methods)

Before Assignment	After Assignments
18	22
7	15
10	12
22	28
15	12
0	0
4	2
25	
17	
5	

Mid-Sem Mark(Statistical Methods)

Before Assignment	After Assignments
18	22
7	15
10	12
22	28
15	12
0	0
4	2
25	14
17	
5	

Mid-Sem Mark(Statistical Methods)

Before Assignment	After Assignments
18	22
7	15
10	12
22	28
15	12
0	0
4	2
25	14
17	4
5	

Mid-Sem Mark(Statistical Methods)

Before Assignment	After Assignments
18	22
7	15
10	12
22	28
15	12
0	0
4	2
25	14
17	4
5	5

Mid-Sem Mark(Statistical Methods)

Before Assignment	After Assignments	d
18	22	
7	15	
10	12	
22	28	
15	12	
0	0	
4	2	
25	14	
17	4	
5	5	

Mid-Sem Mark(Statistical Methods)

Before Assignment	After Assignments	d
18	22	4
7	15	
10	12	
22	28	
15	12	
0	0	
4	2	
25	14	
17	4	
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Mid-Sem Mark(Statistical Methods)

Before Assignment	After Assignments	d
18	22	4
7	15	8
10	12	
22	28	
15	12	
0	0	
4	2	
25	14	
17	4	
5	5	

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Before Assignment	After Assignments	d
18	22	4
7	15	8
10	12	2
22	28	
15	12	
0	0	
4	2	
25	14	
17	4	
5	5	

Mid-Sem Mark(Statistical Methods)

Before Assignment	After Assignments	d
18	22	4
7	15	8
10	12	2
22	28	6
15	12	
0	0	
4	2	
25	14	
17	4	
5	5	

Mid-Sem Mark(Statistical Methods)

Before Assignment	After Assignments	d
18	22	4
7	15	8
10	12	2
22	28	6
15	12	-3
0	0	
4	2	
25	14	
17	4	
5	5	

Mid-Sem Mark(Statistical Methods)

Before Assignment	After Assignments	d
18	22	4
7	15	8
10	12	2
22	28	6
15	12	-3
0	0	0
4	2	
25	14	
17	4	
5	5	

Mid-Sem Mark(Statistical Methods)

Before Assignment	After Assignments	d
18	22	4
7	15	8
10	12	2
22	28	6
15	12	-3
0	0	0
4	2	-2
25	14	
17	4	
5	5	

Mid-Sem Mark(Statistical Methods)

Before Assignment	After Assignments	d
18	22	4
7	15	8
10	12	2
22	28	6
15	12	-3
0	0	0
4	2	-2
25	14	-11
17	4	
5	5	

Mid-Sem Mark(Statistical Methods)

Before Assignment	After Assignments	d
18	22	4
7	15	8
10	12	2
22	28	6
15	12	-3
0	0	0
4	2	-2
25	14	-11
17	4	-13
5	5	

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Before Assignment	After Assignments	d
18	22	4
7	15	8
10	12	2
22	28	6
15	12	-3
0	0	0
4	2	-2
25	14	-11
17	4	-13
5	5	0

t-formula

t-formula

$$t = \frac{\bar{d} - D}{\frac{s_d}{\sqrt{n}}}, d.f = n - 1$$

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- s_d=Sample standard deviation of difference.=$\sqrt{\frac{\sum(d-\bar{d})^2}{n-1}}$

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Confidence Interval

Confidence Interval

Confidence interval

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$$\bar{d} - t_{\alpha/2}\frac{s_d}{\sqrt{n}} \leq D \leq \bar{d} + t_{\alpha/2}\frac{s_d}{\sqrt{n}}$$

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Example:

Confidence Interval

Confidence interval

$$\bar{d} - t_{\alpha/2}\frac{s_d}{\sqrt{n}} \leq D \leq \bar{d} + t_{\alpha/2}\frac{s_d}{\sqrt{n}}$$

Example:To verify whether the course in accounting improved performance.

Confidence Interval

Confidence interval

$$\bar{d} - t_{\alpha/2}\frac{s_d}{\sqrt{n}} \leq D \leq \bar{d} + t_{\alpha/2}\frac{s_d}{\sqrt{n}}$$

Example:To verify whether the course in accounting improved performance. A similar test was given to 12 participants both before and after the course.

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Confidence interval

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Example:To verify whether the course in accounting improved performance. A similar test was given to 12 participants both before and after the course.The original mark recorded in alphabetical order of participants were 44,

Confidence Interval

Confidence interval

$$\bar{d} - t_{\alpha/2}\frac{s_d}{\sqrt{n}} \leq D \leq \bar{d} + t_{\alpha/2}\frac{s_d}{\sqrt{n}}$$

Example:To verify whether the course in accounting improved performance. A similar test was given to 12 participants both before and after the course.The original mark recorded in alphabetical order of participants were 44, 40,

Confidence Interval

Confidence interval

$$\bar{d} - t_{\alpha/2}\frac{s_d}{\sqrt{n}} \leq D \leq \bar{d} + t_{\alpha/2}\frac{s_d}{\sqrt{n}}$$

Example:To verify whether the course in accounting improved performance. A similar test was given to 12 participants both before and after the course.The original mark recorded in alphabetical order of participants were 44, 40, 61,

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Examples

Examples

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Example:A drug was given to 10 patient and increment in their blood pressure were recorded to be

Examples

Example:A drug was given to 10 patient and increment in their blood pressure were recorded to be 3,

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Examples

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Examples

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Examples

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Examples

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Examples

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Example:The sales of data of an item in six shops before and after a special promotional campaign are as under:

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Example:The sales of data of an item in six shops before and after a special promotional campaign are as under:

Shops	A	B	C	D	E	F
Before campaign	53	28	31	48	50	42
After campaign	58	29	30	55	56	45

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After campaign	58	29	30	55	56	45

Did the campaign make any significant difference in sale at 5% Significant level?

Method-VII Testing a hypothesis for double proportion(z-test)

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Necessary condition

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- $n_1.p_1 \geq 5$

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- $n_1.p_1 \geq 5$
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Method-VII Testing a hypothesis for double proportion(*z*-test)

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- $n_1.p_1 \geq 5$
- $n_1.(1 - p_1) \geq 5$
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Method-VII Testing a hypothesis for double proportion(z-test)

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- $n_1.p_1 \geq 5$
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z-formula

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$$z = \frac{(\bar{p}_1 - \bar{p}_2) - (p_1 - p_2)}{\sqrt{\bar{p}.\bar{q}(\frac{1}{n_1} + \frac{1}{n_2})}}$$

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$$z = \frac{(\bar{p}_1 - \bar{p}_2) - (p_1 - p_2)}{\sqrt{\bar{p}.\bar{q}(\frac{1}{n_1} + \frac{1}{n_2})}}$$

$\bar{p} = \frac{n_1.\bar{p}_1 + n_2.\bar{p}_2}{n_1 + n_2} = \frac{x_1 + x_2}{n_1 + n_2}$

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$$\bar{q} = 1 - \bar{p}$$

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Where

- $\bar{p}_1$=First sample proportion.

z-formula

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Where

- $\bar{p}_1$=First sample proportion.
- $\bar{p}_2$=Second sample proportion.

z-formula

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$\bar{q} = 1 - \bar{p}$

Where

- $\bar{p}_1$=First sample proportion.
- $\bar{p}_2$=Second sample proportion.
- p_1=First population proportion.

z-formula

$$z = \frac{(\bar{p}_1 - \bar{p}_2) - (p_1 - p_2)}{\sqrt{\bar{p}.\bar{q}(\frac{1}{n_1} + \frac{1}{n_2})}}$$

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Where

- $\bar{p}_1$=First sample proportion.
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- p_1=First population proportion.
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Confidence Interval

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$$(\bar{p}_1 - \bar{p}_2) - z_{\alpha/2}\sqrt{\frac{\bar{p}_1.(1-\bar{p}_1)}{n_1} + \frac{\bar{p}_2.(1-\bar{p}_2)}{n_2}}$$

$$\leq (p_1 - p_2) \leq$$

$$(\bar{p}_1 - \bar{p}_2) + z_{\alpha/2}\sqrt{\frac{\bar{p}_1.(1-\bar{p}_1)}{n_1} + \frac{\bar{p}_2.(1-\bar{p}_2)}{n_2}}$$

Confidence Interval

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Examples

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Example: In a village 'A' out of a random sample of 1000 persons 100 were found to be vegetarians.

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Example: In a village ‘A’ out of a random sample of 1000 persons 100 were found to be vegetarians.While in another village ‘B’ out of 1500 persons 180 were found to be vegetarians.

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Example: In a village 'A' out of a random sample of 1000 persons 100 were found to be vegetarians.While in another village 'B' out of 1500 persons 180 were found to be vegetarians. Do you find a significant difference in the food habits of the people of the two village?

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Method-VIII χ^2 Test(Contingency Table)

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Example: **GTU -May-2013**

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The table below gives beverage preferences for random samples of teens and adults.

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	Teens	Adults	Total
Coffee	50	200	250
Tea	100	150	250
Soft Drink	200	200	400
Other	50	50	100

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Test for independence between age (i.e., adult and teen) and drink preferences.(Take α = 0.05).

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Example: **GTU -Dec-2011**

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	Region				Total
	NE	NW	SE	SW	
Purchase the brand	40	55	45	50	190
Do not purchase	60	45	55	50	210
Total	100	100	100	100	400

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State the null and alternative hypotheses and test whether brand share is the same across the four regions at $\alpha = 0.05$

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	Brand A	Brand B	Brand C	Brand
No cavities	9	13	17	11
One to five cavities	63	70	85	82
More than five cavities	28	37	48	37
Total	100	120	150	130

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Define the chi-square test.

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Frequency	19	23	28	17	32	31

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The demand for a particular spare part in a factory was found to vary from day to day.In a sample study the following information was obtained:

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Demand	1124	1125	1110	1120	1126	1115

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Day	Mon	Tue	Wed	Thu	Fri	Sat
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Test the hypothesis that the number of part demanded does not depend on the day of the week at 5% of significance.

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A typist in a company commits the following number of mistakes per page in typing 432 pages. Does this information verify that the mistakes are distributed according to Poisson law?

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Example: **GTU -May-2012**

A typist in a company commits the following number of mistakes per page in typing 432 pages. Does this information verify that the mistakes are distributed according to Poisson law?

No. of mistakes per page	0	1	2	3	4	5
No. of pages	223	142	48	15	4	0

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No of account	35	40	19	2	0	2	2

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