D.N.R.COLLEGE, (AUTONOMOUS): BHIMAVARAM
DEPARTMENT OF MANAGEMENT STUDIES

Quantitative Techniques in Management
I SEMESTER

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ONE - Way classification - ANOVA

129) Three samples each size of 5 were drawnfrom uncorrelated normal populations Test the hypothesis that the population means are equal to 5 percent level

Sample 1: 10 12 9 16 13

Sample 2: 9 7 12 11 11

Sample 3: 14 11 15 14 16

Sol: Ho: Population means are equal

Sample 1 x_1	x_1^2	Sample 2 x_2	x_2^2	Sample x_3	x_3^2
10	100	9	81	14	196
12	144	7	49	11	121
9	81	12	144	15	225
16	256	11	121	14	196
13	169	11	121	16	256
$\Sigma x_1 = 60$	$\Sigma x_1^2 = 750$	$\Sigma x_2 = 50$	$\Sigma x_2^2 = 516$	$\Sigma x_3 = 70$	$\Sigma x_3^2 = 994$

$T = \Sigma x_1 + \Sigma x_2 + \Sigma x_3$

$= 60 + 50 + 70$

$= 180$

Correction factor $= T^2/n$

$= \dfrac{(180)^2}{15}$

$= \dfrac{32400}{15}$

$= 2160$

Total sum of squares (SST) =

$\Sigma x_1^2 + \Sigma x_2^2 + \Sigma x_3^2 - \dfrac{T^2}{n}$

$= 750 + 516 + 994 - 2160$

$= 2260 - 2160$

$= 100$

Sum of squares between samples

$SSB = \dfrac{(\Sigma x_1)^2}{n} + \dfrac{(\Sigma x_2)^2}{n} + \dfrac{(\Sigma x_3)^2}{n} - \dfrac{T^2}{n}$

$$= \frac{(60)^2}{5} + \frac{(50)^2}{5} + \frac{(70)^2}{5} - 2160$$

$$= \frac{3600}{5} + \frac{2500}{5} + \frac{4900}{5} - 2160$$

$$= 720 + 500 + 980 - 2160$$

$$= 2200 - 2160$$

$$= 40$$

Sum of squares with samples

$SSW = SST - SSB$

$SSW = 100 - 40 = 60$

ANOVA Table

Source of variation	Sum of squares (SS)	difference of freedom	MS	F ratio
Between	40	$5-3=2$	$40/2=20$	
Within	60	$15-3=12$	$60/12=5$	$\frac{20}{5}=4$

Table for $v_1 = 2$ & $v_2 = 12$ at $0.05 = 3.89$

Conclusion:

Ho is rejected which means the population means of the three samples do not have the same

Two-way classification - ANOVA :

2) A large scale manufacturing company has appointed mangers with different educational qualification in its newly opened branches in three regions. Is there significant difference between & within the managers in terms of scale (Rs. '000)

Qualification	Regions A	B	C	Total
MBA	10	12	11	33
CA	8	7	9	24
B. Tech	6	8	9	23
Total	24	27	29	80

Sol:

Ho : Sales performance is equal between and within managers

Let denote A, B & C regions as x_1, x_2 & x_3 respectively

Managers	Regions						Total
	x_1	x_1^2	x_2	x_1^2	x_3	x_3^2	
MBA	10	100	12	144	11	121	33
CA	8	~~8~~ 64	7	49	9	81	24
B.Tech	6	36	8	64	9	81	23
	24	220	27	257	29	283	80

	MBA		CA		B.Tech	
	x_1	x_1^2	x_2	x_2^2	x_3	x_3^2
A	10	100	~~12~~ 8	64	~~11~~ 6	36
B	12	144	7	49	8	64
C	11	121	~~8~~ 9	81	9	81
	33		24		23	

$T = \Sigma x_1 + \Sigma x_2 + \Sigma x_3 = 24 + 27 + 29 = 80$

The correction factor

$$T^2/n = \frac{(80)^2}{9} = \frac{6400}{9} = 711.11$$

The total sum of squares

$$SST = \Sigma x_1^2 + \Sigma x_2^2 + \Sigma x_3^2 - \frac{T^2}{n}$$

$$= 220 + 257 + 283 - 711.11$$

$$= 48.89$$

The sum of squares between managers

$$SSB = \frac{(33)^2}{3} + \frac{(24)^2}{3} + \frac{(23)^2}{3} - 711.11$$

$$= 363 + 192 + 176.33 - 711.11$$

$$= 20.22$$

The sum of squares with in managers

$$= \frac{(24)^2}{3} + \frac{(27)^2}{3} + \frac{(29)^2}{3} - 711.11$$

$$= 192 + 243 + 280.33 - 711.11$$

$$= 4.22$$

The sum of squares of residenual

$= SST - (SSB + SSW)$

$= 48.89 - (20.22 + 4.22)$

$= 24.45$

ANOVA Table

Variation	SS	DF	MS	
Between managers	~~SS~~ 20.22	~~DF~~ 2	~~MS~~ 10.11	~~10.f~~ $10.11/6.11 = 1.65$
Within managers	~~20~~4.22	2	2.11	$2.11/6.11 = 0.34$
Residual	24.45	4	6.11	

~~For~~ $F(0.05)$ [for $v_1 = 2, v_2 = 4$) $= 6.94$

Since the calculated value of F is ratio. is lessthan the table value, difference is insignificant. Hence, Ho is accepted.

Test of goodness of fit - Chi square Test :

3) We can test if a worker is equally prone to producing defective components throughout an eight-hour shift (or) not. We break the shift into four 2-hour solts & count the

number of defective components produced in each of this slot. At the end of one-week found that the worker has produced 50 defective components with the following breakup

Time slot (hours)	Observed frequency
8.00 - 10.00	8
10.00 - 12.00	11
12.00 - 14.30	16
14.30 - 16.30	15
	50

Is it reasonable to assume that the probability to produce a defective component equal in each of the four 2-hour slots?

Sol:

Let denote probability of defective component came from the ith slot by pi

$H_0: P_1 = P_2 = P_3 = P_4 = 0.25$

$H_1:$ All of P_1, P_2, P_3 & P_4 are not equal

Calculate the expected frequency based on the assumption that the null hypothesis is true. It means the average expected frequency per slot become 12.5 (50/4).

Time slot	observed frequency (O)	Expected frequency (E)	$(O-E)^2/E$
8.00-10.00	8	12.50	$(8-12.50)^2/8 = 1.62$
10.00-12.00	11	12.50	$(11-12.50)^2/11 = 0.18$
12.00-14.30	16	12.50	$(16-12.50)^2/16 = 0.98$
14.30-16.30	15	12.50	$(15-12.50)^2/15 = 0.50$
	50	50.00	3.28

$$\chi^2 = \Sigma \frac{(O-E)^2}{E} = 3.28$$

$\chi^2 = \cancel{0.653}$ 3.28

d.f = 7.815

The calculated value of chi-square is less than the table value. It means the difference is insignificant. Hence Ho is accepted.

Test of Independence of Attributes:

(4) A survey of industrial sales persons included questions on the age of respondents and the degree of job pressure on the sales persons felt in connection with the job. Data is presented below. Using a significance level of 0.01, examine if there is any relationship between age & degree of job pressure.

Age (Years)	Degree of job pressure		
	Low	Medium	High
Less than 25	32	25	17
25-34	22	19	20
35-54	17	20	25
Above 55	15	24	26

Sol:

Age years	Degree of job pressure Low	Medium	High	Total
less 25 ~~(24.29)~~ (24.29)	32 ~~(24.85)~~ (24.85)	25 ~~(24.86)~~ (24.86)	17	74
25-34 ~~(20.02)~~ (20.02)	22 ~~(20.49)~~ (20.49)	19 ~~(20.49)~~ (20.49)	20	61
35-54 ~~(20.35)~~ (20.35)	17 ~~(20.82)~~ (20.82)	20 ~~(20.83)~~ (20.83)	25	62

~~Let us take the null hypothesis that there is no significant difference in the effectiveness of the two drugs. Applying χ^2 test age & degree of job relationship~~

~~Appling χ^2 test~~

Sol: Ho: There is relationship b/w age & degree of Job pressure

Age (years)	Degree of Job pressure Low	Medium	high	Total
less 25 (24.29)	32 (24.85)	25 (24.86)	17	74
25-34 (20.02)	22 (20.49)	19 (20.49)	20	61
35-54 (20.35)	17 (20.82)	20 (20.83)	25	62
Above 55 (21.34)	15 (21.84)	24 (21.82)	26	65
	86	88	88	262

By applying chi-square test ~~formula~~ formula

$$\chi^2 = \sum_{i=1}^{n} \frac{(O-E)^2}{E}$$

~~Arra~~. Arrange data in 4×3 contigency table

E values:

$\frac{86 \times 74}{262} = 24.29$, $\frac{86 \times 61}{262} = 20.02$, $\frac{86 \times 62}{262} = 20.35$,

$\frac{86 \times 65}{262} = 21.34$, $\frac{88 \times 74}{262} = 24.85$, $\frac{88 \times 61}{262} = 20.49$,

$\frac{88 \times 62}{262} = 20.82$, $\frac{88 \times 65}{262} = 21.84$, $\frac{88 \times 74}{262} = 24.86$,

$\frac{88 \times 61}{262} = 20.49$, $\frac{88 \times 62}{262} = 20.83$; $\frac{88 \times 65}{262} = 21.82$

O	E	$(O-E)^2$	$(O-E)^2/E$
32	24.29	59.44	$59.44/24.29 = 2.447$
22	20.02	3.92	0.196
17	20.35	11.22	0.551
15	21.34	40.19	1.883
25	24.85	0.0225	0.0009
19	20.49	2.22	0.108
20	20.82	0.67	0.032
24	21.84	4.66	0.214
17	24.86	61.77	2.485
20	20.49	~~0.69~~ 0.24	0.012
25	20.83	17.4	0.835
26	21.82	17.5	0.800
			$\Sigma\left[\frac{(O-E)^2}{E}\right] = 9.56$

Table value at 0·01 for 6 d.f

= 16·812

The calculated value of chi-square is lessthan table value. It implies difference not significant. Hence, Ho is accepted.