Statistical Inference Two- Way Analysis of Variance

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Two Way ANOVA

- Two Way Anova is used when there are 2 factors under study.
- Each factor can have 2 or more levels . Example: Gender and Age can be 2 factors. Gender with 2 levels as Male and Female Age with 3 levels as 18-30, 31-50 and >50
- Three hypothesis are tested.

Factor A H0: All group means are equal

H1: At least one mean is different from other means

Factor B H0: All group means are equal

H1: At least one mean is different from other means

Interaction H0: The interaction is not significant

H1: The interaction is significant



Two Way ANOVA

Total variation is partitioned as below:

Total SS= Between Groups SS due to factor A (SSA)

- + Between Groups SS due to factor B (SSB)
- + Interaction SS due to factor A and B (SSAB)
- + Error SS (SSE)

where, SS stands for sum of squares

Case Study

Background

A large company is assessing the difference in 'Satisfaction Index' of employees in Finance, Marketing and Client-Servicing departments. Experience level is also considered in the study.(<=5 years and >5 years)

Objective

To test the equality of the satisfaction index among employees of three departments (CS, Marketing, Finance) and among different experience bands.

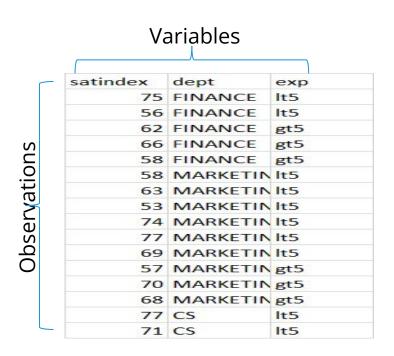
Sample Size

Sample size: 36

Variables: satindex, dept, exp

Data Snapshot

Two Way Anova



Columns	Description	Type	Measurement	Possible values
Satindex	Satisfaction Index	Numeric	-	Positive Values
Dept	Department	Character	MARKETING, CS, FINANCE	3
Exp	Years of Experience (grouped)	Character	It5 = less than 5, gt5 = greater than 5	2

Two Way ANOVA

Testing equality of means in two factors.

Objective

To compare employee satisfaction index in three departments (CS,

Marketing, Finance) and two experience level based groups.

Null Hypothesis

 (H_{01}) : Average satisfaction index is equal for 3 departments.

(H₀₂): Average satisfaction index is equal for 2 experience levels.

(H₀₃) Interaction effect(dept*exp) is not significant on satisfaction index.

The test statistic is computed for each of these null hypothesis.

Reject the null hypothesis if p-value < 0.05

Two Way ANOVA in R

Import data

data<-read.csv("Two Way Anova.csv", header=TRUE)

ANOVA Table

anovatable<-aov(formula=satindex~dept+exp+dept*exp, data=data)
summary(anovatable)

- 'aov' is the R function for ANOVA.
- formula specifies 'satindex' as analysis (dependent) variable and 'dept' and 'exp' as factor (independent) variables.
- dept*exp specifies the interaction effect.
- anovatable is user defined object name created to store output.

summary function displays the ANOVA table output.

Two Way ANOVA in R

Output:

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
dept	2	164.2	82.11	1.679	0.204
exp	1	78.0	78.03	1.595	0.216
dept:exp	2	20.2	10.11	0.207	0.814
Residuals	30	1467.2	48.91		

Interpretation:

- Since p-value is >0.05 for all three (dept, exp and dept*exp), do not reject H0 for all three tests. There is no significant difference in satisfaction index among 3 different departments and 2 experience levels.
- ☐ Also interaction effect is not significant.

Quick Recap

Two Way Anova

• two way ANOVA is an extension of one way ANOVA when we have 2 factors in the study instead of one.

Null Hypothesis
Drawing Inference

- Equality of means for levels in factor A
- Equality of means for levels in factor B
- No Interaction effect between 2 factors
- Total sum of squares is split into 4 parts and each hypothesis is tested.

Knowledge check question

- A large retailer is testing a marketing campaign on 24 stores. 8 stores are selected randomly from each of 3 zones.
- The variable of interest is 'sales increment(%) during campaign month'. Objective is to test whether the campaign is equally effective in 3 regions. Data is given below.

NORTH	WEST	SOUTH		
8	10.2	5.3		
12.5	9.3	5.8		
9.2	9.9	6		
6.7	8.7	7.1		
9.4	9.1	7		
5.9	10.2	6.1		
7.7	9.5	6.3		
6.9	10	7.3		

Is this One-way ANOVA problem or Two-way ANOVA problem?

ANSWER: One-way ANOVA

EXPLANATION: There is only one factor (zone) with 3 levels (North, West, South).