Regression Analysis

Analysis of Variance

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ANOVA R Example

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About This Lesson

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Cancer Survival

Reference:
Cameron, E. and Pauling, L. (1978) Supplemental ascorbate in the supportive treatment of cancer: re-evaluation of prolongation of survival times in terminal human cancer. Proceedings of the National Academy of Science USA, 75, 4538-4542.

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ANOVA Example Data

Response Variable:
Y_{ij} = The number of survival days for the j^{th} patient with i^{th} type of cancer

Categories:
Cancer type i for i = 1,2,3,4,5

Stomach	Bronchus	Colon	Ovary	Breast
124	81	248	1234	1235
42	461	377	89	24
25	20	189	201	1581
45	450	1843	356	1166
412	246	180	2970	40
51	166	537	456	727
1112	63	519		3808
46	64	455		791
103	155	406		1804
876	859	365		3460
146	151	942		719
340	166	776		
396	37	372		
	223	163		
	138	101		
	72	20		
	245	283		

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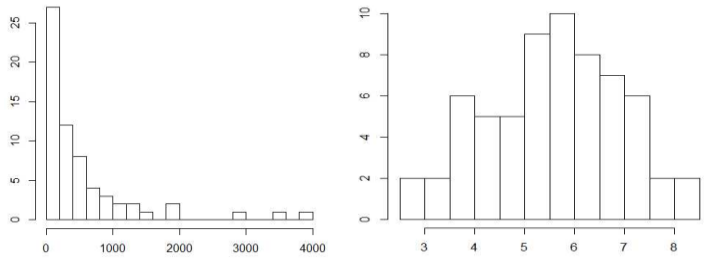
Exploratory Data Analysis in R

Read data with 'read.table' R command for reading ASCII files
cancer_data = read.table("CancerStudy.txt", header=T)
Response Variable
survival = cancer_data$Survival

Explore the shape of the distribution of the response variable
hist(survival, xlab="", ylab="Number of Survival Days", main="", nclass=15)

Transform due to skewness of the distribution
hist(log(survival), xlab="", ylab="Number of Survival Days", main="", nclass=15)



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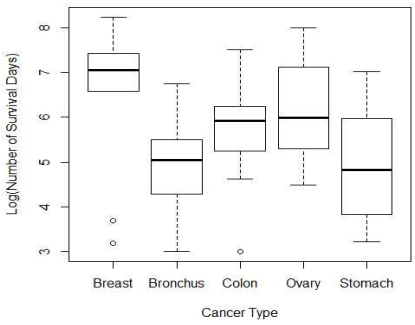
ANOVA in R

Need to specify Response & Categorical Variables
survival = log(survival)
cancertype = cancer_data$Organ
Convert into categorical variable in R
cancertype = as.factor(cancertype)
boxplot(survival~cancertype, xlab = "Cancer Type", ylab = "Log(Number of Survival Days)")….



- **Within-variability** – some groups have higher variability than others
- **Between-variability** – there is some variability between the means of the five groups
- *Is the between-variability significantly larger than the within-variability?*

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ANOVA in R (cont'd)

```
## ANOVA in R: Is the between-variability significantly larger than within-variability
model = aov(survival ~ cancertype)
summary(model)
             Df    Sum Sq   Mean Sq   F value    Pr(>F)
cancertype    4     24.49     6.122     4.286   0.00412 **
Residuals    59     84.27     1.428
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

## Obtain estimated means
model.tables(model, type="means")
Tables of means
Grand mean

5.555785

cancertype
        Breast   Bronchus   Colon   Ovary   Stomach
        6.559    4.953      5.749   6.151   4.968
rep     11.000   17.000     17.000  6.000   13.000
```

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Pairwise Comparison in R

```
## Which means are statistically significantly different? Pairwise Comparison
TukeyHSD(model)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = survival ~ cancertype)

$cancertype
                     diff        lwr         upr       p adj
Bronchus-Breast -1.60543320 -2.906741 -0.3041254  0.0083352
Colon-Breast    -0.80948110 -2.110789  0.4918267  0.4119156
Ovary-Breast    -0.40798703 -2.114754  1.2987803  0.9615409
Stomach-Breast  -1.59068365 -2.968399 -0.2129685  0.0158132
Colon-Bronchus   0.79595210 -0.357534  1.9494382  0.3072938
Ovary-Bronchus   1.19744617 -0.399483  2.7943753  0.2296079
Stomach-Bronchus 0.01474955 -1.224293  1.2537924  0.9999997
Ovary-Colon      0.40149407 -1.195435  1.9984232  0.9540004
Stomach-Colon   -0.78120255 -2.020245  0.4578403  0.3981146
Stomach-Ovary   -1.18269662 -2.842480  0.4770864  0.2763506
```

Statistically significant:

$\log(\hat{\mu}_{Bronchus}) - \log(\hat{\mu}_{Breast})$

$\log(\hat{\mu}_{Stomach}) - \log(\hat{\mu}_{Breast})$

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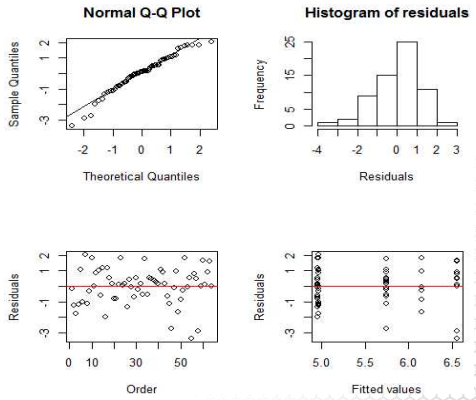
Residual Analysis in R

```
par(mfrow=c(2,2))
qqnorm(residuals(model))
qqline(residuals(model))
hist(residuals(model), main="Histogram of residuals",
xlab="Residuals")
plot(residuals(model), xlab="Order", ylab="Residuals")
abline(0, 0, lty=1, col="red")
plot(fitted(model), residuals(model), xlab="Fitted values",
ylab="Residuals")
abline(0, 0, lty=1, col="red")
```

- The quantiles align on the line and the histogram is approx. symmetric thus normality assumption holds
- Residuals are scattered around zero line with no pattern thus both the constant variance and uncorrelated errors hold



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Cancer Survival: Findings

- There is strong evidence for the difference in the survival time across the five different types of cancer;
- Survival time: Breast cancer vs. Bronchus or Stomach cancer.

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Summary

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