HEALTH
UNIVERSITY OF UTAH

Analysis

Andrew Redd, PhD.

R Bootcamp 2020

Hypothesis Tests

T-test

Something Ridiculous

Test for the difference in GDP Per capita.

```
# using the restriocted data from the exercise
(gdp.test <- t.test(NY.GDP.PCAP.CD~in.Africa, data=data))
```

```
##
##  Welch Two Sample t-test
##
## data:  NY.GDP.PCAP.CD by in.Africa
## t = -7.0402, df = 3.022, p-value = 0.005749
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -58966.64 -22356.59
## sample estimates:
## mean in group Africa  mean in group Other
##             1201.708            41863.325
```

Terminology

Formulas, created with a `~`, represent relationships. They can

- be one sided `~x`
  - Lambda functions `~log(.+1)`
- or two sided `y ~ x + z`
  - specify relationships or models
- often include functions
  - `y ~ x + log(z)`
  - `y ~ x + poly(z,3)`, a polynomial fit of degree 3 on `z`
- have special syntax
  - interaction `y ~ x:z`
  - crossing `y ~ a*b` is equal to `y ~ a + b + a:b`
  - nesting `y ~ a + b %in% a` or equivalently `y~a/b`

Getting usable results from a model

The `gdp.test` object is a htest object, which prints nicely but what if we want to include this in our table 1?

Try these:

```
str(gdp.test) # get the underlying structure of the object.
glimpse(gdp.test) # alternative to str that handles some objects better.
gdp.test$p.value
getElement(gdp.test, 'p.value')
gdp.test[['p.value']]
```

Exercise: Proportion Test

Use `prop.test` to test for the difference in proportions of males for all countries.

5:00

Solution

```
suppressMessages(library(magrittr))
data %>%
    mutate(N.males = round(SP.POP.TOTL*SP.POP.TOTL.MA.ZS/100)) %$%
    prop.test(N.males, SP.POP.TOTL)
```

```
##
##  11-sample test for equality of proportions without
##  continuity correction
##
## data:  N.males out of SP.POP.TOTL
## X-squared = 135837, df = 10, p-value < 2.2e-16
## alternative hypothesis: two.sided
## sample estimates:
##    prop 1    prop 2    prop 3    prop 4    prop 5    prop 6
## 0.4781971 0.4848457 0.5014707 0.5014707 0.4999245 0.5062502
##    prop 7    prop 8    prop 9   prop 10   prop 11
## 0.4862119 0.4981671 0.4915102 0.4925855 0.4944933
```

Solution, what I did

```
suppressMessages(library(magrittr)) #< To ignore unimportant message.
data %>%
    mutate(N.males = round(SP.POP.TOTL*SP.POP.TOTL.MA.ZS/100)) %$%
    prop.test(N.males, SP.POP.TOTL)
```

1. Load magrittr to get the accessor pipe `%$%`.
2. `mutate(N.male = ...)`, get counts of males, because prop.test expects counts.
3. used `%$%` the Accessor pipe to make the variables directly accessible to the next command
4. used `prop.test` to perform the test.

Alternate Version

Passing in a matrix with ‘successes’ and ‘failures’:

```
data %>%
    # get our 'successes' and 'failures'
    transmute( males = round(SP.POP.TOTL*SP.POP.TOTL.MA.ZS/100)
             , females = SP.POP.TOTL-males
             ) %>%
    # convert to a matrix
    as.matrix() %>%
    prop.test()
```

```
## 
##  11-sample test for equality of proportions without
##  continuity correction
## 
## data:  .
## X-squared = 135837, df = 10, p-value < 2.2e-16
## alternative hypothesis: two.sided
## sample estimates:
##    prop 1    prop 2    prop 3    prop 4    prop 5    prop 6 
## 0.4781971 0.4848457 0.5014707 0.5014707 0.4999245 0.5062502 
##    prop 7    prop 8    prop 9   prop 10   prop 11 
## 0.4862119 0.4981671 0.4915102 0.4925855 0.4944933
```

Linear Models

Bordeaux Wine Data

```
wine <- read.csv("data/Bordeaux.csv")
```

Variables

- `Wine` - the name of the wine.
- `Price` - The price of the wine in pounds sterling(£)
- `ParkerPoints` - the rating out of 100 given by Robert Parker (https://www.robertparker.com/).
- `CoatesPoints` - the rating out of 20 given by Clive Coates (http://www.clive-coates.com/)
- `P95andAbove` - a dummy variable, 1 if `ParkerPoints>=95`
- `FirstGrowth` - inditcator of if the wine is a first growth (https://en.wikipedia.org/wiki/First_Growth)
- `CultWine` - indicator of if the wine is a cult wine (https://en.wikipedia.org/wiki/Cult_wine)
- `Pomerol` - indicator for if the wine is from Pomerol (https://en.wikipedia.org/wiki/Pomerol), France
- `VintageSuperstar` - indicator if the wine is a superstar

Wine Model

We will rely on the normal approximation for proportions.

```
model <- lm( Price ~ . - Wine - P95andAbove, data=wine)
model
```

```
## 
## Call:
## lm(formula = Price ~ . - Wine - P95andAbove, data = wine)
## 
## Coefficients:
##      (Intercept)      ParkerPoints      CoatesPoints  
##         -7390.78             61.94            116.27  
##      FirstGrowth          CultWine           Pomerol  
##          2001.41           4583.54            739.16  
## VintageSuperstar  
##          1424.58  
```

Not really useful.

Wine Model

We will rely on the normal approximation for proportions.

```
model <- lm( Price ~ . - Wine - P95andAbove, data=wine)
model
```

Concept

Fomula Subtraction

`Price ~ . - Wine - P95andAbove` should be read as

> *“Model Price by all variables* ***except*** *Wine and P95andAbove.”*

Summarizing Models

```
(model.summary <- summary(model))
```

```
## 
## Call:
## lm(formula = Price ~ . - Wine - P95andAbove, data = wine)
## 
## Residuals:
##     Min      1Q  Median      3Q     Max 
## -3251.2  -102.5    40.5   167.2  4463.7 
## 
## Coefficients:
##                  Estimate Std. Error t value Pr(>|t|)    
## (Intercept)      -7390.78    3766.82  -1.962   0.0540 .  
## ParkerPoints        61.94      44.84   1.381   0.1719    
## CoatesPoints       116.27     119.14   0.976   0.3327    
## FirstGrowth       2001.41     410.38   4.877 7.28e-06 ***
## CultWine          4583.54     470.80   9.736 2.56e-14 ***
## Pomerol            739.16     305.71   2.418   0.0184 *  
## VintageSuperstar  1424.58     715.89   1.990   0.0508 .  
## ---
## Signif. codes:  
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## Residual standard error: 941.3 on 65 degrees of freedom
## Multiple R-squared:  0.7716, Adjusted R-squared:  0.7506 
## F-statistic: 36.61 on 6 and 65 DF,  p-value: < 2.2e-16
```

Exercise: Try the following

Extracting Parts of the model

```
coef(model)
coef(summary(model))
deviance(model)
formula(model)
residuals(model)
```

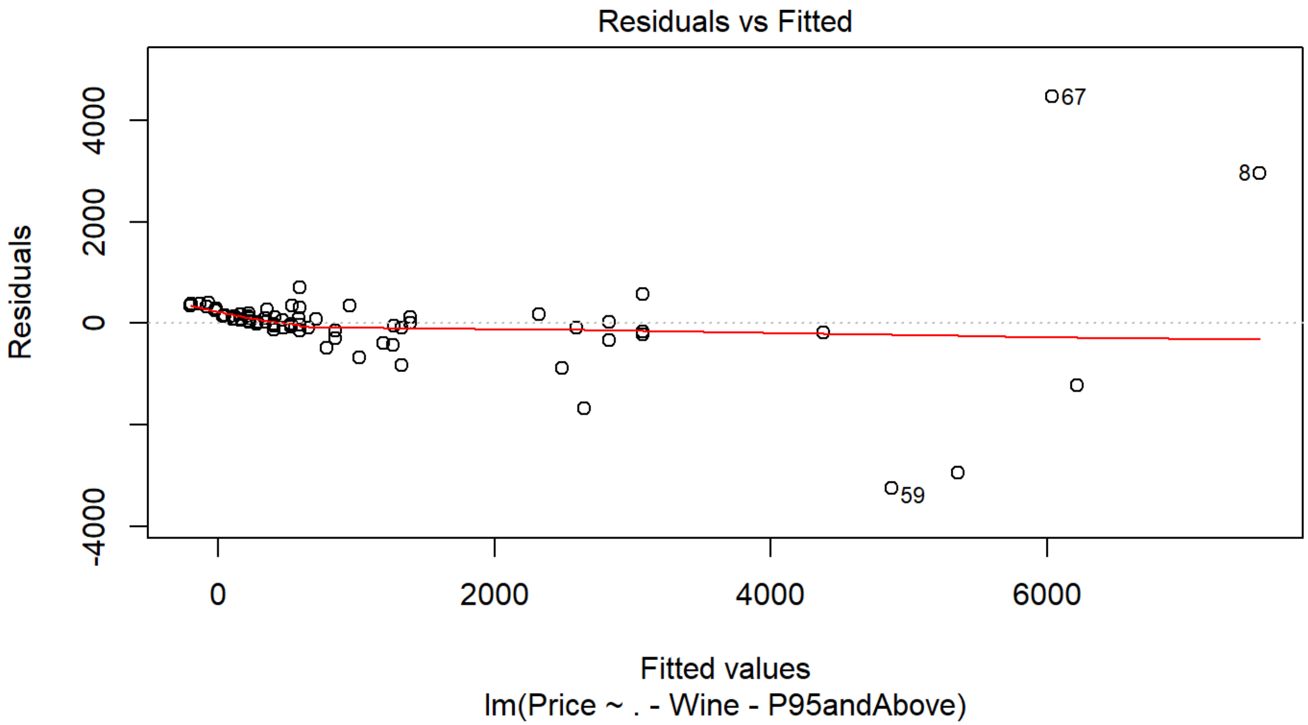
Operations on models

```
summary(model)
plot(model)
predict(model)
vcov(model)
anova(model)
aov(model)
```

5:00

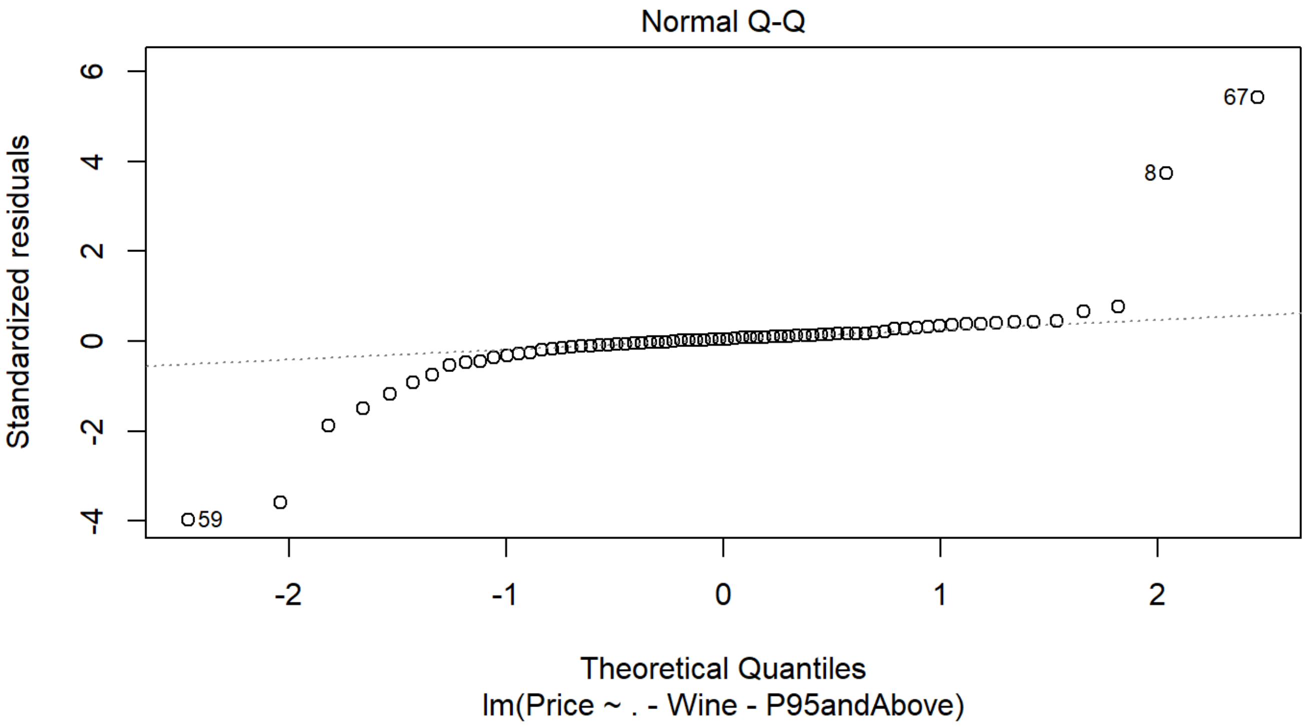
Residual plots

```
plot(model, 1) #< Residuals vs. Fitted  | Goodness of fit
```



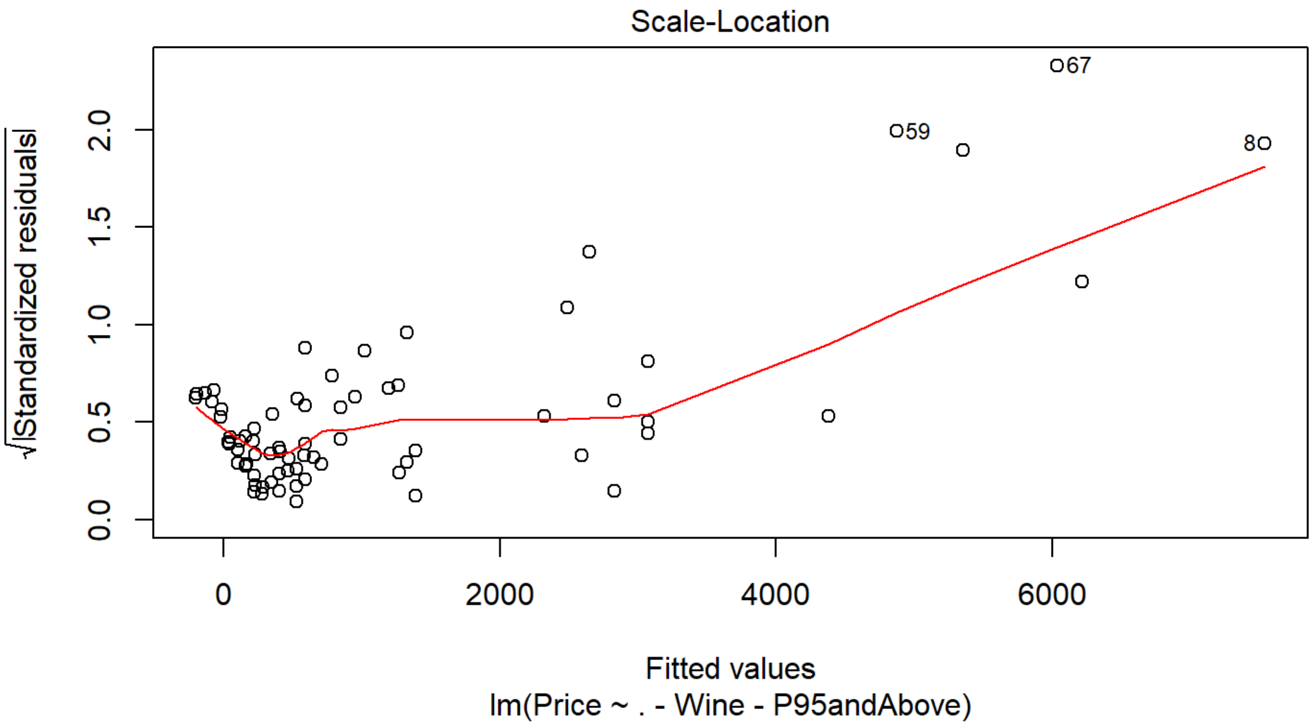
Residual plots

```
plot(model, 2) #< Normal Q-Q             | Appropriate error model
```



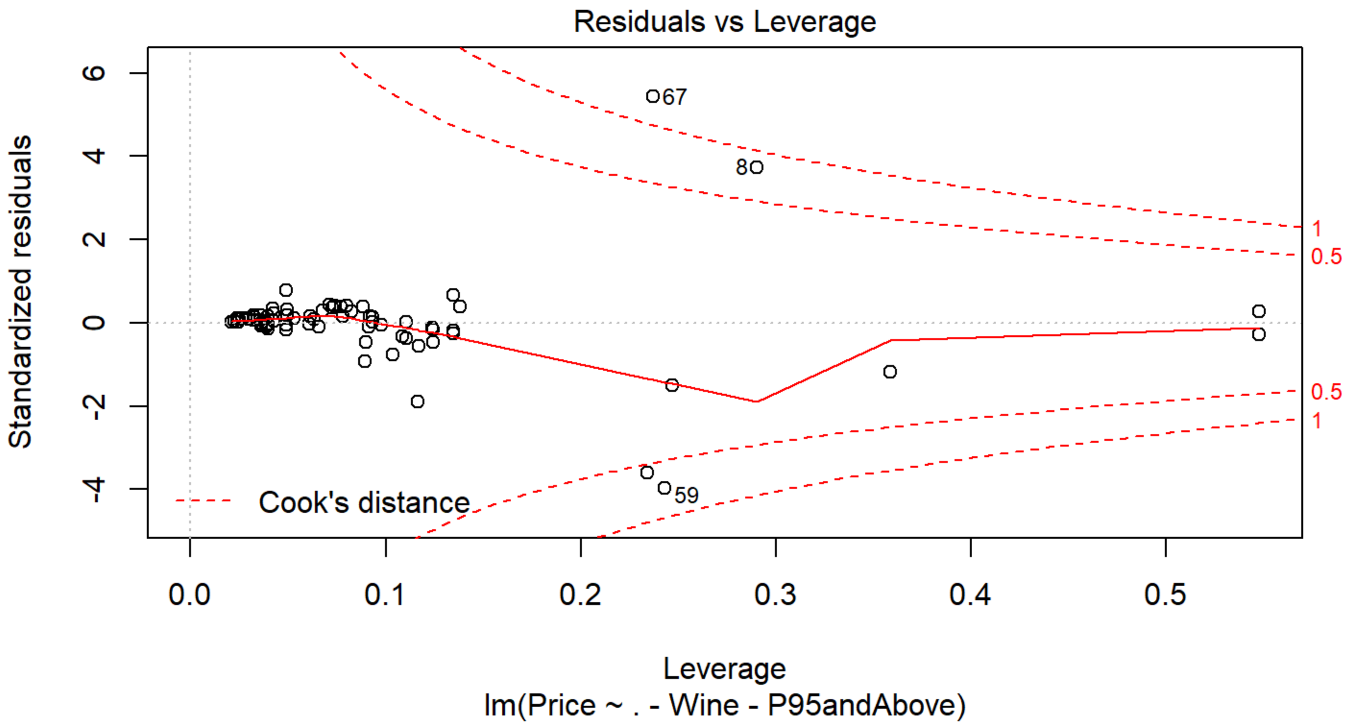
Residual plots

```
plot(model, 3) #< Scale-Location        | Homoscedasticity
```



Residual plots

```
plot(model, 5) #< Residual vs. Leverage | Influential points
```


Residuals vs Leverage
Standardized residuals
Leverage
lm(Price ~ . - Wine - P95andAbove)
Cook's distance