R and its Applications

A PROJECT REPORT

Submitted in fulfillment of

the requirement for the course of

Data Science and Analytics

IN

TERM - II

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Table of Contents-

R-Codes Basic Intro and Hypothesis Testing

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Basic Operations and Shortcut in R

```
# Getting Working Directory
getwd()

## [1] "E:/term 2/Data Science and analytics/R studio/7-DSA"

help()

## starting httpd help server ... done

# Ctrl+ enter- to run the command
# Ctrl+(1,2,3,4)- to directly get into the command,console,environment and th
e files tabe in R Environment.
```

Assigning objects and values

```
x=5
y=10
```

Doing basic arithemetic operations in R

```
x*y   # Basic Multiplication

## [1] 50

x/y     # Basic Division

## [1] 0.5

x^y

## [1] 9765625

# Gives the value of x raised to the power y

sqrt(x)     # Gives the square root of x

## [1] 2.236068

exp(x)  # Provides the exponential of x

## [1] 148.4132
```

```r
log10(x)

## [1] 0.69897

x**y  # Gives the value of x raised to the power y

## [1] 9765625

# Assigning a different object
a=x*y
a

## [1] 50

z<-x-y
z

## [1] -5

class(a)

## [1] "numeric"

# The class function tells us about the Datatype.
a= "Hello" # Assigning Characters to the variables
a

## [1] "Hello"

class(a)

## [1] "character"
```

Baisc Functions in R

```r
# For Division we can also use the divider function
divider = function(x,y){
  result= x/y
  print(result)
}
divider(50,25)

## [1] 2

# For multiplication also we can use the below function
multiply= function(x,y){
  result=x*y
  print(result)
}
multiply(4,3)

## [1] 12
```

```
multiply(10,30)

## [1] 300
```

Various Data Types. (Nominal, Ordinal, Interval and Ratio)

```
# Self and System

# Data Types
x=5
class(x)

## [1] "numeric"

# Numeric- It gives whether the assigned variables is either Integer(Whole Nu
mber) or Decimal(Float-Decimal)
i= 10L  # L- Here the L symbol denotes the Integer
class(i)

## [1] "integer"

 # Is function is used to know whether the asked command is True or False for
the assigned variable.
is.integer(i)

## [1] TRUE

is.numeric(x)

## [1] TRUE

is.numeric(i)

## [1] TRUE

# Character -  Assigned the object as a Categorical Value
s= "RStudio"
class(s)

## [1] "character"

# Logical- TRUE has a value of (1) and FALSE has a value of (0) in R.

TRUE * 5 # same as 1 *5

## [1] 5

FALSE * 5 # same as 0*5

## [1] 0

K= TRUE
class(K)
```

```
## [1] "logical"

is.logical(K)

## [1] TRUE
```

Date -

```
# In R the Starting Date is 1st Jan 1970
# As function can be used to assigned value/operation to an object

date1= as.Date("2020-11-20")
date1

## [1] "2020-11-20"

class(date1)

## [1] "Date"

as.numeric(date1) # Gives the numeric vaue of the date asked for as each date
is assigned with a numeric value.

## [1] 18586

#POSIXct -  Gives Date and time together.
date2 = as.POSIXct("2020-11-20 10:10")
date2

## [1] "2020-11-20 10:10:00 IST"

as.numeric(date2)

## [1] 1605847200

class(date2)

## [1] "POSIXct" "POSIXt"
```

#Vector, Array and Matrices

```
#Vector. R is called as Vectorised Language.
#        A collection of elements, and all are of same types.
#        It cannot be of mixed type.
# Arrays- n-Dimension COllection of Similar elements in terms of R
#Matrices- Subset of Arrays. 2-d array is called matrix.
#          Will usually contain "numeric" value.

v= c(1,2,3,4,5) # the c function is used for the combination of same type of
elements together.

#we can also do basic arithmetic operations in vectors.
```

```r
s=v*2 # Each element is multiplied by same number.
s

## [1]  2  4  6  8 10

s1= v/10 # Each element gets divided by 10
s1

## [1] 0.1 0.2 0.3 0.4 0.5

s2= v^3 # each element gets cube of its number.
s2

## [1]   1   8  27  64 125

# we can also do in the following way

sqrt(v)

## [1] 1.000000 1.414214 1.732051 2.000000 2.236068

log10(v)

## [1] 0.0000000 0.3010300 0.4771213 0.6020600 0.6989700

#colon (:) used for operation-sequencing
# Creates sequence of numbers in either direction.
1:10 # shows number from 1-10

##  [1]  1  2  3  4  5  6  7  8  9 10

10:1

##  [1] 10  9  8  7  6  5  4  3  2  1

-2:7

##  [1] -2 -1  0  1  2  3  4  5  6  7

# Two Vectors
l=1:10
m=-5:4

# we can also do arithemetic operations in two vectors
l+m

##  [1] -4 -2  0  2  4  6  8 10 12 14

l-m

##  [1] 6 6 6 6 6 6 6 6 6 6
```

Baisc operations for getting LENGTH of vector

```
# We can also check the lenght of each vector by using the LENGTH function
length(l)

## [1] 10

length(m)

## [1] 10

# Unequal length vectors
l+c(1,2)

##  [1]  2  4  4  6  6  8  8 10 10 12

# when the other vector is of unequal length then the number start getting re
peated.
l+c(1,2,3)

## Warning in l + c(1, 2, 3): longer object length is not a multiple of short
er
## object length

##  [1]  2  4  6  5  7  9  8 10 12 11

# We can also do comparison on vectors
l<=5

##  [1]  TRUE  TRUE  TRUE  TRUE  TRUE FALSE FALSE FALSE FALSE FALSE

l<y

##  [1]  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE FALSE

# Vector comparison -"any" and "all"
l1= 10:1
m1= -4:5

any(l1<m1) # Any function help us in comparing whether any of the element of
the vector is satisfying the condition or not.

## [1] TRUE

any(l1>m1)

## [1] TRUE

anyDuplicated(l1)

## [1] 0

all(l1<m1) # All function help us in comparing whether all the element of the
vector is satisfying the condition or not.
```

```
## [1] FALSE
```

nchar function

```
# The "nchar" Gives the number of character in a wach word of the elements.
q=c("Hockey","Football","Baseball","Rugby","Tennis")
nchar(q)

## [1] 6 8 8 5 6
```

Subscripting function

```
# Subscripting: Assesing "Individual element" in vector
# Subscripting denoted by Square bracket or Square Bracket is used to target
the selected element in the vector.

x[1]

## [1] 5

x[7]

## [1] NA

q[3]

## [1] "Baseball"

q[1:3]

## [1] "Hockey"   "Football" "Baseball"

# Provides the value of of 1st,2nd,and 3rd element.
q[c(1,4)] # Provides the value of 1st and 4th element in the Q data sets.

## [1] "Hockey" "Rugby"
```

Naming Vectors

```
# We can also give name to a vector.
c(One="a", Two="b", Last="r")

##  One  Two Last
##  "a"  "b"  "r"

w=1:3
names(w)=c("a","b","c")
w

## a b c
## 1 2 3
```

```
# Factor Vectors- OrdinalData

q

## [1] "Hockey"   "Football" "Baseball" "Rugby"    "Tennis"

class(q)

## [1] "character"
```

Converting elements to factor data type

```
# converting "q" to factors
q_F= as.factor(q) # assigning Factor to q
q_F

## [1] Hockey   Football Baseball Rugby    Tennis
## Levels: Baseball Football Hockey Rugby Tennis

as.numeric(q_F) # Assigning Numeric function to q_F

## [1] 3 2 1 4 5

as.factor(q)

## [1] Hockey   Football Baseball Rugby    Tennis
## Levels: Baseball Football Hockey Rugby Tennis

as.numeric(q)

## Warning: NAs introduced by coercion

## [1] NA NA NA NA NA

class(q)

## [1] "character"

class(q_F)

## [1] "factor"

# R has two types of missing data- NA and NULL
# NA= Actual Missing Value
# NULL= Absence of anything.
z=c(1,2,NA,8,3,NA,3)# R treats NA as an empty element and hence, NA is shown
in the final output.
z

## [1]  1  2 NA  8  3 NA  3
```

```r
z=c(1,2,8,3,3) # R is a case sensitive platform and hence, na is treated diff
erently as NA.
z

## [1] 1 2 8 3 3

is.na(z)

## [1] FALSE FALSE FALSE FALSE FALSE

list(z)

## [[1]]
## [1] 1 2 8 3 3

z_char=c("Hockey",NA,"Cricket")
z_char

## [1] "Hockey"  NA        "Cricket"

is.na(z_char) # here na function checks whether there is any NA element in th
e vector.

## [1] FALSE  TRUE FALSE
```

NULL and NA

```r
# NULL
z1=c(1,NULL,3)
z1

## [1] 1 3

# R treats NULL as an empty cell and hence it doesn't consider it in the fina
l output.
x1=c(1,NA,3)
x1

## [1]  1 NA  3

length(z)

## [1] 5

length(z1)

## [1] 2

length(x1)

## [1] 3

# Assigning NULL and checking
```

```
d=NULL# Assigning D as a NULL element
is.null(d)

## [1] TRUE

is.null(z1)

## [1] FALSE

is.null(x1)

## [1] FALSE

is.na(z1) # here the NULL element is not counted.

## [1] FALSE FALSE

is.na(x1)

## [1] FALSE  TRUE FALSE
```

Matrices

```
# Creating Matrices in R.

A= matrix(1:10, nrow = 5) # Assigning A as a matrix with element ranging from
1-10 having 5 rows and 2 column.

B= matrix(21:30, nrow = 5)# Assigning B as a matrix with element ranging from
21-30 having 5 rows and 2 column.

C= matrix(21:40, nrow = 2)# Assigning C as a matrix with element ranging from
21-40 having 2 rows and 10 column.
A

##      [,1] [,2]
## [1,]    1    6
## [2,]    2    7
## [3,]    3    8
## [4,]    4    9
## [5,]    5   10

B

##      [,1] [,2]
## [1,]   21   26
## [2,]   22   27
## [3,]   23   28
## [4,]   24   29
## [5,]   25   30

C
```

```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
## [1,]   21   23   25   27   29   31   33   35   37    39
## [2,]   22   24   26   28   30   32   34   36   38    40
```

```
# We can do Arithmetic operations on matrices
A+B
```

```
##      [,1] [,2]
## [1,]   22   32
## [2,]   24   34
## [3,]   26   36
## [4,]   28   38
## [5,]   30   40
```

```
A*B
```

```
##      [,1] [,2]
## [1,]   21  156
## [2,]   44  189
## [3,]   69  224
## [4,]   96  261
## [5,]  125  300
```

```
A==B # Checking whether any of the element in Matrix A is equal to any elemen
t in Matrix B.
```

```
##       [,1]  [,2]
## [1,] FALSE FALSE
## [2,] FALSE FALSE
## [3,] FALSE FALSE
## [4,] FALSE FALSE
## [5,] FALSE FALSE
```

```
A %*% t(B)  # the %*% symbol is used for matrix multiplication in R and the t
(B) means the transpose of the matrix B.
```

```
##      [,1] [,2] [,3] [,4] [,5]
## [1,]  177  184  191  198  205
## [2,]  224  233  242  251  260
## [3,]  271  282  293  304  315
## [4,]  318  331  344  357  370
## [5,]  365  380  395  410  425
```

#Arrays

```
# Arrays  are a multidimensional vector having all the elements of the same t
ype.
# Creating an Array
theArray = array(1:20, dim=c(4,3,3))# The first 4in c represent the number of
row in an array, the second number (3) represents the number of column in an
array and the last number i.e., 3 denotes the number of outer dimensions that
```

```
will be created.
theArray

## , , 1
##
##      [,1] [,2] [,3]
## [1,]    1    5    9
## [2,]    2    6   10
## [3,]    3    7   11
## [4,]    4    8   12
##
## , , 2
##
##      [,1] [,2] [,3]
## [1,]   13   17    1
## [2,]   14   18    2
## [3,]   15   19    3
## [4,]   16   20    4
##
## , , 3
##
##      [,1] [,2] [,3]
## [1,]    5    9   13
## [2,]    6   10   14
## [3,]    7   11   15
## [4,]    8   12   16

# If there is nothing written in the bracket in the Array function then it me
ans that we are assessing the whole part of that array.
theArray [1, ,]#  Here we are accessing all the elements from Row 1, all the
columns and all outer dimensions because we have only specifies which row to
be considered and the other two components are not specified.

##      [,1] [,2] [,3]
## [1,]    1   13    5
## [2,]    5   17    9
## [3,]    9    1   13

theArray[1, ,1] # Here we are accessing all the elements from Row 1, all colu
mns, first outer dimension

## [1] 1 5 9

theArray[, ,1] #Here we are accessing all rows, all columns but only the firs
t outer dimension

##      [,1] [,2] [,3]
## [1,]    1    5    9
## [2,]    2    6   10
## [3,]    3    7   11
## [4,]    4    8   12
```

Data Frames

```
# Creating a Data frame

l1=10:1
m1=-4:5
q= c("Hockey","Football","Baseball","Tennis","Curling","Badminton","Rugby","S
occer","Carom","Ludo")

# We use the data.frame function to create a data frame or table combining va
rious data sets.
theDF= data.frame(l1,m1,q)
theDF

##    l1 m1         q
## 1  10 -4    Hockey
## 2   9 -3  Football
## 3   8 -2  Baseball
## 4   7 -1    Tennis
## 5   6  0   Curling
## 6   5  1 Badminton
## 7   4  2     Rugby
## 8   3  3    Soccer
## 9   2  4     Carom
## 10  1  5      Ludo

q= as.factor(q)
q

##  [1] Hockey    Football  Baseball  Tennis    Curling   Badminton Rugby
##  [8] Soccer    Carom     Ludo
## 10 Levels: Badminton Baseball Carom Curling Football Hockey Ludo ... Tenni
s

theDF=data.frame(First=l1, Second=m1, Sport=q) # Assigning names to the colum
ns in the data frame.
theDF

##    First Second     Sport
## 1     10     -4    Hockey
## 2      9     -3  Football
## 3      8     -2  Baseball
## 4      7     -1    Tennis
## 5      6      0   Curling
## 6      5      1 Badminton
## 7      4      2     Rugby
## 8      3      3    Soccer
## 9      2      4     Carom
## 10     1      5      Ludo
```

```r
# Str-Structure- Gives the whole structure of the data frame or table by expl
aining the total number of outcomes and also telling about the each columns s
eperately.

str(theDF)

## 'data.frame':    10 obs. of  3 variables:
##  $ First : int  10 9 8 7 6 5 4 3 2 1
##  $ Second: int  -4 -3 -2 -1 0 1 2 3 4 5
##  $ Sport : Factor w/ 10 levels "Badminton","Baseball",..: 6 5 2 10 4 1 8 9
3 7

# Checking the dimensions
nrow(theDF) # Provides the number of Row in the Data Frame

## [1] 10

ncol(theDF) # Provides the number of columns in the Data Frame

## [1] 3

dim(theDF)  # Provides the number of both rows and columns together in the Da
ta Frame.

## [1] 10  3

# Gives the Columns name starting from the First Column
names(theDF)

## [1] "First"  "Second" "Sport"

# Gives only the Colun Heading of the Third Column as square bracked is alway
s used to select a particular element.
names(theDF)[3]

## [1] "Sport"
```

HEAD and TAIL function

```r
# Square bracket is always used for accessing a particular data

# Head and Tail
head(theDF) # Gives the First 6 rows with all variables

##   First Second     Sport
## 1    10     -4    Hockey
## 2     9     -3  Football
## 3     8     -2  Baseball
## 4     7     -1    Tennis
## 5     6      0   Curling
## 6     5      1 Badminton
```

```r
tail(theDF) # Gives the Last 6 rows with all variables

##    First Second     Sport
## 5      6      0   Curling
## 6      5      1 Badminton
## 7      4      2     Rugby
## 8      3      3    Soccer
## 9      2      4     Carom
## 10     1      5      Ludo

tail(theDF, n=2) # It gives only the last 2 rows with all variables of the da
ta set.

##    First Second Sport
## 9      2      4 Carom
## 10     1      5  Ludo

class(theDF)

## [1] "data.frame"

# Accessing individual column
# For accessing individual column we use the ($) Dollar sign.
theDF$Sport  # Here we only want the data variables of only the Sport column
so we used the $ sign. Also, it provides the Levels and this level is organiz
ed in alphabetical order with only unique variables.

##  [1] Hockey    Football  Baseball  Tennis    Curling   Badminton Rugby
##  [8] Soccer    Carom     Ludo
## 10 Levels: Badminton Baseball Carom Curling Football Hockey Ludo ... Tenni
s
```

LIST Function

```r
# Lists - This function is used to store any number of items of any type and
can contain either numeric or characters.

# By using the "list" function we make each argument in "list" to become the
element of the list.

list(1,2,3)# Here we are creating a three element list

## [[1]]
## [1] 1
##
## [[2]]
## [1] 2
##
## [[3]]
## [1] 3
```

```r
list1=(c(1,2,3))# Here we are creating a single vector element which contains Three elements.
list1

## [1] 1 2 3

list2 = list(c(1,2,3), 3:7) # Creating a two element list with one element having 3 vector elements
list2

## [[1]]
## [1] 1 2 3
##
## [[2]]
## [1] 3 4 5 6 7

# We can also create a two element list combining a date frame and a vector.
list(theDF, 1:10) # Here theDF is a Data.frame that we have created above and the next is a vector with 10 elements.

## [[1]]
##    First Second     Sport
## 1     10     -4    Hockey
## 2      9     -3  Football
## 3      8     -2  Baseball
## 4      7     -1    Tennis
## 5      6      0   Curling
## 6      5      1 Badminton
## 7      4      2     Rugby
## 8      3      3    Soccer
## 9      2      4     Carom
## 10     1      5      Ludo
##
## [[2]]
##  [1]  1  2  3  4  5  6  7  8  9 10

# We can also create a list of elements by combining anotherr list in the data.
list3 = list(theDF, 1:10, list1)
list3

## [[1]]
##    First Second     Sport
## 1     10     -4    Hockey
## 2      9     -3  Football
## 3      8     -2  Baseball
## 4      7     -1    Tennis
## 5      6      0   Curling
## 6      5      1 Badminton
## 7      4      2     Rugby
## 8      3      3    Soccer
```

```
## 9       2       4      Carom
## 10      1       5       Ludo
##
## [[2]]
##  [1]  1  2  3  4  5  6  7  8  9 10
##
## [[3]]
## [1] 1 2 3
```

```r
#We can also name the list in R
names(list3)= c("data.frame", "vector","list")
names(list3)
```

```
## [1] "data.frame" "vector"     "list"
```

```r
list3
```

```
## $data.frame
##    First Second     Sport
## 1     10     -4    Hockey
## 2      9     -3  Football
## 3      8     -2  Baseball
## 4      7     -1    Tennis
## 5      6      0   Curling
## 6      5      1 Badminton
## 7      4      2     Rugby
## 8      3      3    Soccer
## 9      2      4     Carom
## 10     1      5      Ludo
##
## $vector
##  [1]  1  2  3  4  5  6  7  8  9 10
##
## $list
## [1] 1 2 3
```

```r
# Accessing individual element of a list
# We use Double Square Brackets[] to asses the individual elements in any lis
t by specifying the name or element type inside the square bracket.

list3[[1]] # Here we are assessing the first element i.e., the dataframe of t
he list 3 by specifying the position of the element.
```

```
##    First Second     Sport
## 1     10     -4    Hockey
## 2      9     -3  Football
## 3      8     -2  Baseball
## 4      7     -1    Tennis
## 5      6      0   Curling
## 6      5      1 Badminton
## 7      4      2     Rugby
```

```
## 8      3      3    Soccer
## 9      2      4     Carom
## 10     1      5      Ludo
```

```
list3[["data.frame"]] # We can also assess the element of a list by specifyin
g the element name in the list.
```

```
##    First Second     Sport
## 1     10     -4    Hockey
## 2      9     -3  Football
## 3      8     -2  Baseball
## 4      7     -1    Tennis
## 5      6      0   Curling
## 6      5      1 Badminton
## 7      4      2     Rugby
## 8      3      3    Soccer
## 9      2      4     Carom
## 10     1      5      Ludo
```

```
# Also we can assess any particular field of any specific field in a list by
using dollar sign inside a square brackets.
list3[[1]]$Sport
```

```
##  [1] Hockey    Football  Baseball  Tennis    Curling   Badminton Rugby
##  [8] Soccer    Carom     Ludo
## 10 Levels: Badminton Baseball Carom Curling Football Hockey Ludo ... Tenni
s
```

```
# We can find the Length of the list and the heading of the different element
s in the list  by using the length and names function respectively in R.
length(list3)
```

```
## [1] 3
```

```
names(list3)
```

```
## [1] "data.frame" "vector"     "list"
```

Reading data into R

```
# Reading Data into R

# we can directly read data from any website into R( The Common Source File o
r CSV File)

theUrl = "http://www.jaredlander.com/data/Tomato%20First.csv"
tomato = read.table(file=theUrl, header=TRUE, sep =",")
head(tomato)
```

```
##   Round             Tomato Price      Source Sweet Acid Color Texture Over
all
```

```
## 1     1         Simpson SM  3.99 Whole Foods   2.8  2.8   3.7     3.4
3.4
## 2     1  Tuttorosso (blue)  2.99     Pioneer   3.3  2.8   3.4     3.0
2.9
## 3     1 Tuttorosso (green)  0.99     Pioneer   2.8  2.6   3.3     2.8
2.9
## 4     1     La Fede SM DOP  3.99   Shop Rite   2.6  2.8   3.0     2.3
2.8
## 5     2       Cento SM DOP  5.49  D Agostino   3.3  3.1   2.9     2.8
3.1
## 6     2      Cento Organic  4.99  D Agostino   3.2  2.9   2.9     3.1
2.9
##   Avg.of.Totals Total.of.Avg
## 1          16.1         16.1
## 2          15.3         15.3
## 3          14.3         14.3
## 4          13.4         13.4
## 5          14.4         15.2
## 6          15.5         15.1

# It is good to use.csv file.
# We can't directly use excel files in R so, we have to first convert the exc
el file into a .csv file to bring that excel file into R.
```

we can also asess the buit in Data sets in R

```
data()  # Provides the list of all the Data sets installed in the R in my sys
tem.

data(mtcars) # Assessing the mtcars Data set from the R directory.

head(mtcars)

##                    mpg cyl disp  hp drat    wt  qsec vs am gear carb
## Mazda RX4         21.0   6  160 110 3.90 2.620 16.46  0  1    4    4
## Mazda RX4 Wag     21.0   6  160 110 3.90 2.875 17.02  0  1    4    4
## Datsun 710        22.8   4  108  93 3.85 2.320 18.61  1  1    4    1
## Hornet 4 Drive    21.4   6  258 110 3.08 3.215 19.44  1  0    3    1
## Hornet Sportabout 18.7   8  360 175 3.15 3.440 17.02  0  0    3    2
## Valiant           18.1   6  225 105 2.76 3.460 20.22  1  0    3    1

tail(mtcars)

##                 mpg cyl  disp  hp drat    wt qsec vs am gear carb
## Porsche 914-2  26.0   4 120.3  91 4.43 2.140 16.7  0  1    5    2
## Lotus Europa   30.4   4  95.1 113 3.77 1.513 16.9  1  1    5    2
## Ford Pantera L 15.8   8 351.0 264 4.22 3.170 14.5  0  1    5    4
## Ferrari Dino   19.7   6 145.0 175 3.62 2.770 15.5  0  1    5    6
## Maserati Bora  15.0   8 301.0 335 3.54 3.570 14.6  0  1    5    8
## Volvo 142E     21.4   4 121.0 109 4.11 2.780 18.6  1  1    4    2
```

#Statistics Basic

```
# The basic statistics consists of Mean, Variances,Correlations and T-tests

# Generating a random sample of 100 numbers between 1 and 50
x2 = sample(x =1:50, size = 20, replace = FALSE)
x2  # Here the xs will generate an output consisting of 20 elements which are
randomly selected from a data set of 50 numbers.

##  [1] 37 21  7 45 28 11 23  1 43 17 46 49  3  6 35 31 15 50 40 36

# Simple Arithmetic Mean
mean(x2)

## [1] 27.2

# Calculating means when there is a missing NA data in the data sets
y2= x2 # copy x to y
y2[sample(x=1:50, size = 20, replace = FALSE )] = NA # Null Values
y2   # The output will show NA in place of missing value.

##  [1] NA NA NA 45 NA 11 23 NA NA NA 46 NA  3  6 35 31 15 NA 40 36 NA NA NA
NA NA
## [26] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
NA NA

mean(y2) # In finding the mean of a missing value we will get NA as output be
cause we are unable to get the mean because of missing value in Data.

## [1] NA

# We can remove the missing value from the above data to get the mean.

mean(y2,na.rm=TRUE) # We will use the rm function to remove the missing value
. Hence, now there will be an output.

## [1] 26.45455

# We can also do a Weighted Mean in R
Grades = c(95,72,87,66)
Weights = c(1/2, 1/4, 1/8, 1/8)
mean(Grades)# Simple Arithmetic mean

## [1] 80

weighted.mean(x=Grades,w=Weights)# The Weighted Mean of Grades and Weights.

## [1] 84.625
```

#Variance

```
# we can also find out the variance of any data in R
var(x2)
```

```
## [1] 264.6947
```

Standard Deviation

```
# we can find the standard deviation by using either sqrt the variance method
or by directly using the standard deviation formula in R.
sqrt(var(x2))

## [1] 16.26944

sd(x2) # The standard deviation of x2

## [1] 16.26944

sd(y2)# The standard deviation of y2. It is showing NA because there is a mis
sing value in the y2 data.

## [1] NA

sd(y2, na.rm=TRUE) # We can remove the missing value from y2 to get an actual
dtandard deviation in output.

## [1] 15.63562

# Some of the other Commonly Used Functions in R
min(x2) # Used for generating the minimum value of the element in the data se
t.

## [1] 1

max(x2)# Used for generating the maximum value of the element in the data set
.

## [1] 50

median(x2) # To find the median of the data set.

## [1] 29.5

min(y2) # Here we are getting output as NA because there is a missing value.

## [1] NA

min(y2, na.rm=TRUE) # We remove the missing value to get the final output.

## [1] 3

#  The Summary Statistics Function is used for getting the overall summary of
the Data sets. This function gives the min, max, median, and the quantiles in
the Data set.
summary(x2)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    1.00   14.00   29.50   27.20   40.75   50.00
```

```
summary(y2)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##    3.00   13.00   31.00   26.45   38.00   46.00      39

# Quantile is a function used for generating the quantile in R
quantile(x2, probs = c(0.25, 0.45)) # Calculating 25th and 45th Quantile in t
he Data set.

##   25%   45%
## 14.00 25.75

quantile(x2, probs = c(0.1,0.25,0.5, 0.75,0.99)) # We can also find more than
2 quantiles together.

##   10%   25%   50%   75%   99%
##  5.70 14.00 29.50 40.75 49.81

quantile(x2, probs = c(0.25, 0.75)) # Calculate 25th and 45th Quantile. Here
we are getting NA because of the missing value.

##   25%   75%
## 14.00 40.75

quantile(y2, probs = c(0.25, 0.75), na.rm = TRUE) # Hence to get the actual o
utput we remove the missing values by using the rm function.

## 25% 75%
##  13  38
```

Correlation and Covariance

```
install.packages("ggplot2")

library(ggplot2)# require(ggplot2)

head(economics)# Generating the first 6 element of the "ggplot2 database that
we installed above.

## # A tibble: 6 x 6
##   date         pce    pop psavert uempmed unemploy
##   <date>     <dbl>  <dbl>   <dbl>   <dbl>    <dbl>
## 1 1967-07-01  507. 198712    12.6     4.5     2944
## 2 1967-08-01  510. 198911    12.6     4.7     2945
## 3 1967-09-01  516. 199113    11.9     4.6     2958
## 4 1967-10-01  512. 199311    12.9     4.9     3143
## 5 1967-11-01  517. 199498    12.8     4.7     3066
## 6 1967-12-01  525. 199657    11.8     4.8     3018

# To do correlation we use the cor function.
# HEre we are doing a correlation between the PCE and PSAVERT which are obtai
ned from the"ggplot2" package.
```

```r
cor(economics$pce, economics$psavert) #pce-Personal Consumption Expenditure;p
savert -Personal Savings Rate

## [1] -0.7928546
```

To compare correlation for Multiple variables

```r
# We can also do a correlation for multiple variables by specifying the colum
n numbers by using the combination function.
cor(economics[, c(2,4:6)])

##                 pce    psavert    uempmed   unemploy
## pce       1.0000000 -0.7928546  0.7269616  0.6145176
## psavert  -0.7928546  1.0000000 -0.3251377 -0.3093769
## uempmed   0.7269616 -0.3251377  1.0000000  0.8693097
## unemploy  0.6145176 -0.3093769  0.8693097  1.0000000

           pce    psavert    uempmed   unemploy
```

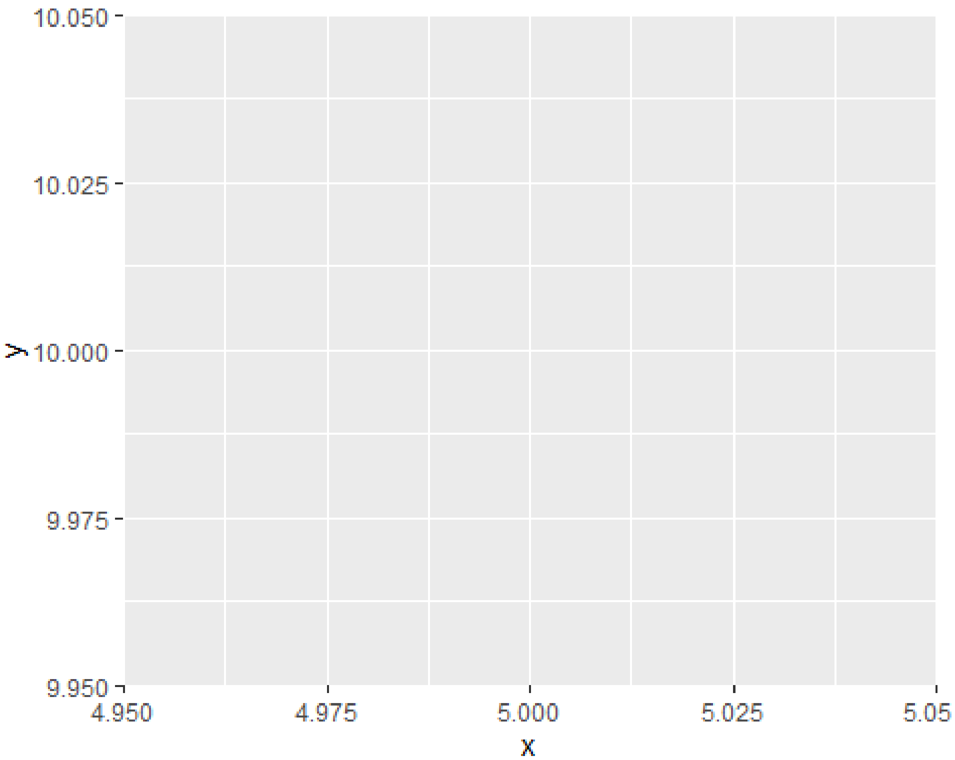
pce 1.0000000 -0.7928546 0.7269616 0.6145176 psavert -0.7928546 1.0000000 -0.3251377 -0.3093769 uempmed 0.7269616 -0.3251377 1.0000000 0.8693097 unemploy 0.6145176 -0.3093769 0.8693097 1.0000000

```r
# Display Correlation in Different Format!

# Lets install the required package and load them onto this R environment for
executing!!!

# Load the "reshape" package
require(reshape2)

## Loading required package: reshape2

# Also load the Scales package for some extra plotting features
# I havealready instally scales package in my system
library(scales)

econCor = cor(economics [ , c(2,4:6)])

econMelt = melt(econCor, varnames = c("x3" ,"y3"), value.name = "Correlation"
)
# Order it according to correlation

econMelt = econMelt[order(econMelt$Correlation),]
# Display the melted data
econMelt

##          x3       y3 Correlation
## 2   psavert      pce  -0.7928546
## 5       pce  psavert  -0.7928546
## 7   uempmed  psavert  -0.3251377
```

```
## 10  psavert  uempmed  -0.3251377
## 8  unemploy  psavert  -0.3093769
## 14  psavert unemploy  -0.3093769
## 4  unemploy      pce   0.6145176
## 13      pce unemploy   0.6145176
## 3   uempmed      pce   0.7269616
## 9       pce  uempmed   0.7269616
## 12 unemploy  uempmed   0.8693097
## 15  uempmed unemploy   0.8693097
## 1       pce      pce   1.0000000
## 6   psavert  psavert   1.0000000
## 11  uempmed  uempmed   1.0000000
## 16 unemploy unemploy   1.0000000

      x        y Correlation
```

2 psavert pce -0.7928546 5 pce psavert -0.7928546 7 uempmed psavert -0.3251377 10 psavert uempmed -0.3251377 8 unemploy psavert -0.3093769 14 psavert unemploy -0.3093769 4 unemploy pce 0.6145176 13 pce unemploy 0.6145176 3 uempmed pce 0.7269616 9 pce uempmed 0.7269616 12 unemploy uempmed 0.8693097 15 uempmed unemploy 0.8693097 1 pce pce 1.0000000 6 psavert psavert 1.0000000 11 uempmed uempmed 1.0000000 16 unemploy unemploy 1.0000000

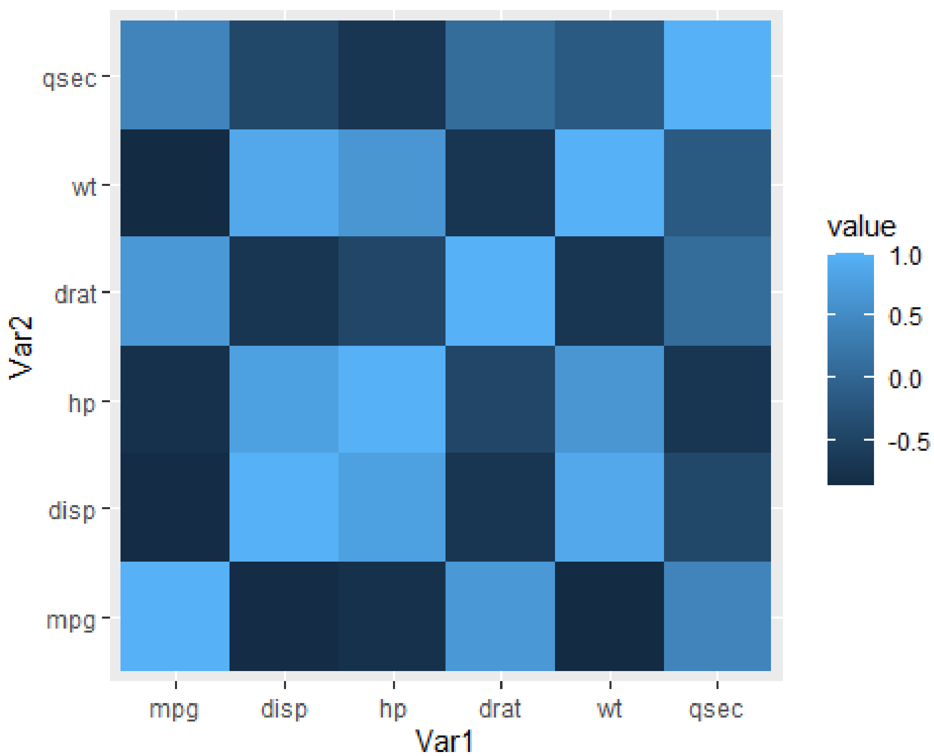
```
# Let's Visualize Correlation
## Plot it with ggplot
# Initialize the plot with x and y on the respective axes
ggplot(econMelt,aes (x=x, y=y),geom_tile(aes(fill = Correlation)),scale_fill_
gradient2(low = muted("red"), mid = "white", high = "steelblue",guide = guide
_colorbar(ticks=FALSE, barheight=10), limit=c(-1,1), theme_minimal(), labs(x=
NULL, y=NULL)))
```



Correlation

```
# Data Creation- The first step in correlation
mydata <- mtcars[, c(1,3,4,5,6,7)] # Getting data from the mtcars files packa
ge of R
head(mydata)

##                    mpg disp  hp drat    wt  qsec
## Mazda RX4         21.0  160 110 3.90 2.620 16.46
## Mazda RX4 Wag     21.0  160 110 3.90 2.875 17.02
## Datsun 710        22.8  108  93 3.85 2.320 18.61
## Hornet 4 Drive    21.4  258 110 3.08 3.215 19.44
## Hornet Sportabout 18.7  360 175 3.15 3.440 17.02
## Valiant           18.1  225 105 2.76 3.460 20.22

# Finding the Correlation- The Second Step.
cormat <- round(cor(mydata),2)
head(cormat)

##        mpg  disp    hp  drat    wt  qsec
## mpg   1.00 -0.85 -0.78  0.68 -0.87  0.42
## disp -0.85  1.00  0.79 -0.71  0.89 -0.43
## hp   -0.78  0.79  1.00 -0.45  0.66 -0.71
## drat  0.68 -0.71 -0.45  1.00 -0.71  0.09
## wt   -0.87  0.89  0.66 -0.71  1.00 -0.17
## qsec  0.42 -0.43 -0.71  0.09 -0.17  1.00
```

```
# Creating the correlation heatmap using the ggplot2
install.packages("reshape2")

library(reshape2)
melted_cormat <- melt(cormat)
head(melted_cormat)

##   Var1 Var2 value
## 1  mpg  mpg  1.00
## 2 disp  mpg -0.85
## 3   hp  mpg -0.78
## 4 drat  mpg  0.68
## 5   wt  mpg -0.87
## 6 qsec  mpg  0.42

# Creating the graph for the selected data
#The function geom_tile()[ggplot2 package] is used for correlation matrix.
library(ggplot2)
ggplot(data = melted_cormat, aes(x=Var1, y=Var2, fill=value)) +
  geom_tile()
```

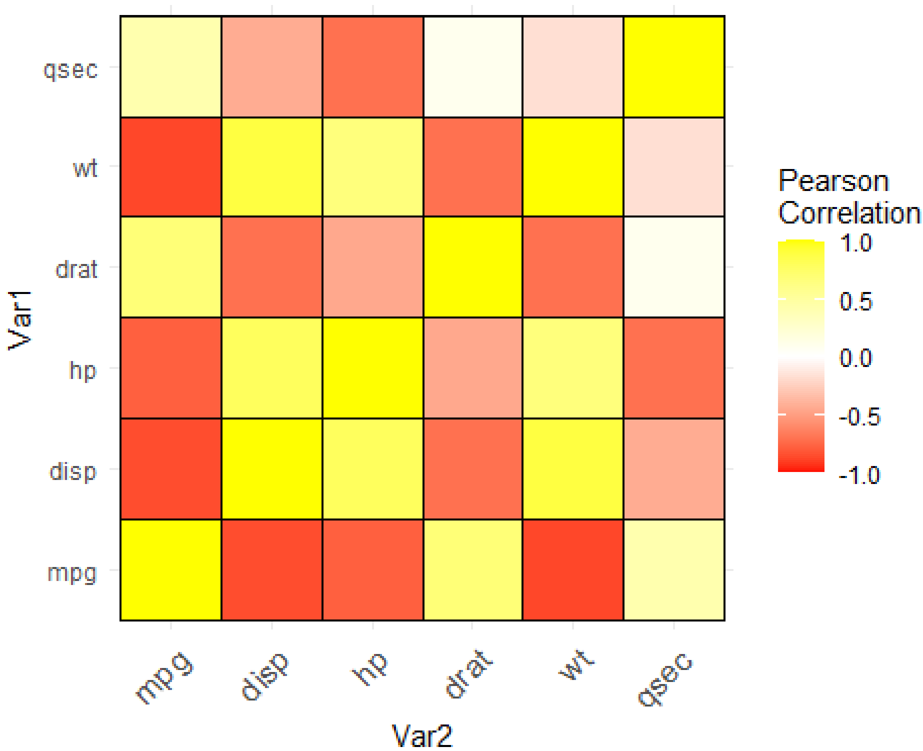



```
# The above graph has many redundant information. So we will use NA function
to set some of it to show NA.

# Getting the lower triangle of the correlation matrix
get_lower_tri<-function(cormat){
  cormat[upper.tri(cormat)] <- NA
```

```
  return(cormat)
}

# Getting  the upper triangle of the correlation matrix
get_upper_tri <- function(cormat){
  cormat[lower.tri(cormat)]<- NA
  return(cormat)
}
```

upper_tri <- get_upper_tri(cormat) upper_tri

```
# The last task of finishing the correlation matrix heatmap.
# We will remove the rows with the NA value and would show only those rows wh
ich contain some value.
# Melt the correlation matrix
library(reshape2)

# Now we will create the Heatmap for the above data.
library(ggplot2)
ggplot(data = melted_cormat, aes(Var2, Var1, fill = value))+
  geom_tile(color = "black")+
  scale_fill_gradient2(low = "red", high = "yellow", mid = "white",
                       midpoint = 0, limit = c(-1,1), space = "Lab",
                       name="Pearson\nCorrelation") +
  theme_minimal()+
  theme(axis.text.x = element_text(angle = 45, vjust = 1,
                                   size = 12, hjust = 1))+
  coord_fixed()
```

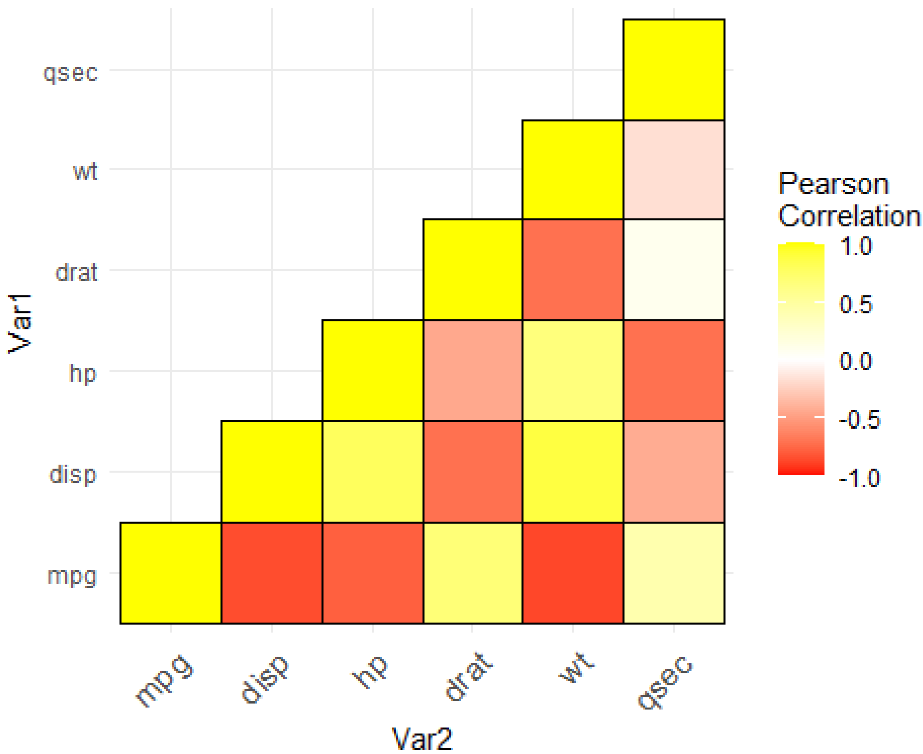



```
# In the output graph we can see that the negative correlation is shown by th
e red colour and the positive one are in yellow colour.

#We  use the coord_fixed() function to make one unit of x-axis equal to one u
nit of y axis
# Reordering  the correlation matrix
# We use the reorder_courmat function to reorder the correlation Matrix in R.
reorder_cormat <- function(cormat){
  dd <- as.dist((1-cormat)/2)
  hc <- hclust(dd)
  cormat <-cormat[hc$order, hc$order]
}

upper_tri <- get_upper_tri(cormat)
# Melt the correlation matrix
melted_cormat <- melt(upper_tri, na.rm = TRUE)
```

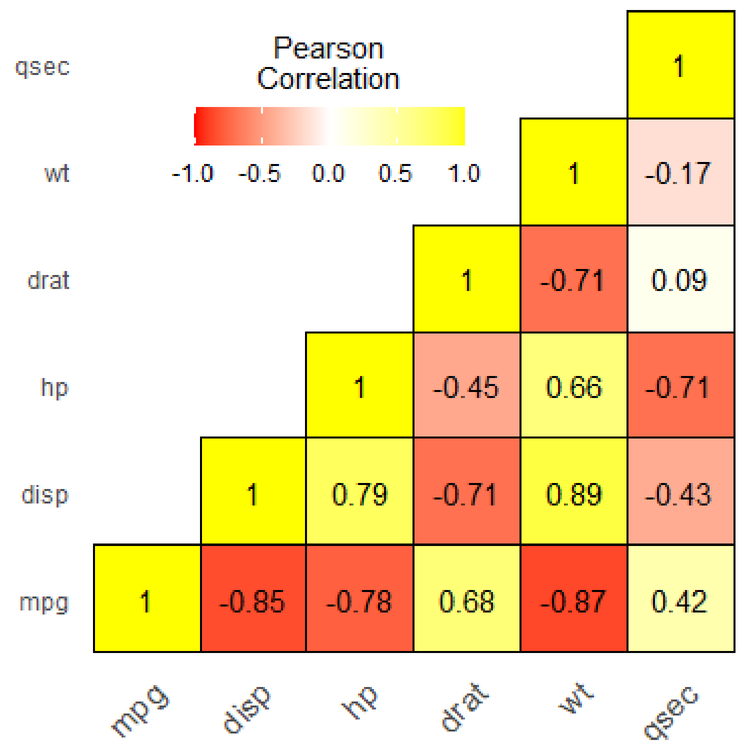
Creating a ggheatmap

```
# We use the ggheatmap function in R to create a heat map. We select the pack
age data and along with that we can also assign which which varaiables of the
data we want to select and we can also specify the colours of the correlation
in the graph.
ggheatmap <- ggplot(melted_cormat, aes(Var2, Var1, fill = value))+
  geom_tile(color = "black")+
  scale_fill_gradient2(low = "red", high = "yellow", mid = "white",
```

```
                         midpoint = 0, limit = c(-1,1), space = "Lab",
                         name="Pearson\nCorrelation") +
  theme_minimal()+ # minimal theme
  theme(axis.text.x = element_text(angle = 45, vjust = 1,
                                     size = 12, hjust = 1))+
  coord_fixed()

# Print the heatmap
print(ggheatmap)
```




```
#Add correlation coefficients on the heatmap
# We use geom_text() funtion to write coefficient on the heatmap.

ggheatmap +
  geom_text(aes(Var2, Var1, label = value), color = "black", size = 4) +
  theme(
    axis.title.x = element_blank(),
    axis.title.y = element_blank(),
    panel.grid.major = element_blank(),
    panel.border = element_blank(),
    panel.background = element_blank(),
    axis.ticks = element_blank(),
    legend.justification = c(1, 0),
    legend.position = c(0.6, 0.7),
    legend.direction = "horizontal")+
  guides(fill = guide_colorbar(barwidth = 7, barheight = 1,
                               title.position = "top", title.hjust = 0.5))
```




```
# Here we are creating a Heatmap showing a correlation between multiple varia
bles and alsong with that we are also highlighting the each block of the Data
on the graph.
```

T-Test

```
# We are selecting the tips dta of a restaurant from the reshape2 package of
the R. We have installed this package before using the install.package functi
on.
data(tips, package = "reshape2") # We are making a T-test to analyse about th
e tips offered in the restaurant.
head(tips) # We are asking for the first ^ data of the reshape2 package

##   total_bill  tip    sex smoker day   time size
## 1      16.99 1.01 Female     No Sun Dinner    2
## 2      10.34 1.66   Male     No Sun Dinner    3
## 3      21.01 3.50   Male     No Sun Dinner    3
## 4      23.68 3.31   Male     No Sun Dinner    2
## 5      24.59 3.61 Female     No Sun Dinner    4
## 6      25.29 4.71   Male     No Sun Dinner    4

str(tips) # To get the structure of the tip that whether the data is numeric
or factor etc. anf to know about a basic summary of the whole data.

## 'data.frame':    244 obs. of  7 variables:
##  $ total_bill: num  17 10.3 21 23.7 24.6 ...
##  $ tip       : num  1.01 1.66 3.5 3.31 3.61 4.71 2 3.12 1.96 3.23 ...
```

```
##  $ sex       : Factor w/ 2 levels "Female","Male": 1 2 2 2 1 2 2 2 2 2 ...
##  $ smoker    : Factor w/ 2 levels "No","Yes": 1 1 1 1 1 1 1 1 1 1 ...
##  $ day       : Factor w/ 4 levels "Fri","Sat","Sun",..: 3 3 3 3 3 3 3 3 3
3 ...
##  $ time      : Factor w/ 2 levels "Dinner","Lunch": 1 1 1 1 1 1 1 1 1 1 ..
.
##  $ size      : int  2 3 3 2 4 4 2 4 2 2 ...

# Gender # We are only asking for the gender from the data. This gives us the
total number of unique varaibles in the data.
unique(tips$sex)

## [1] Female Male
## Levels: Female Male

#One Sample t-test - Cosnsidering only a single group and performing a two ta
il test with a NULL hypothesis that the mean of the sample is equal to 2.5
t.test(tips$tip, alternative = "two.sided", mu=2.5)

##
##  One Sample t-test
##
## data:  tips$tip
## t = 5.6253, df = 243, p-value = 5.08e-08
## alternative hypothesis: true mean is not equal to 2.5
## 95 percent confidence interval:
##  2.823799 3.172758
## sample estimates:
## mean of x
##  2.998279

#One Sample t-test - Upper Tail. Ho:Mean LE 2.5. Considering that we are doin
g a upper tail test means that the alternate hypotheis will be either greater
than than mean.
t.test(tips$tip, alternative = "greater", mu=2.5)

##
##  One Sample t-test
##
## data:  tips$tip
## t = 5.6253, df = 243, p-value = 2.54e-08
## alternative hypothesis: true mean is greater than 2.5
## 95 percent confidence interval:
##  2.852023      Inf
## sample estimates:
## mean of x
##  2.998279

# Here the p value is very less than the

# Two Sample T-test with having Two groups.
t.test(tip ~ sex, data = tips, var.equal = TRUE)
```

```
##
##  Two Sample t-test
##
## data:  tip by sex
## t = -1.3879, df = 242, p-value = 0.1665
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.6197558  0.1074167
## sample estimates:
## mean in group Female   mean in group Male
##             2.833448             3.089618

# HEre in the below data we can find that the mean of both male and female se
parately and we can find that the p-value is greater than alpha value so we w
ill accept the null hypothesis.

#Paired Two-Sample T-Test
# here we are considering the 2 Data sets from the same package.

require(UsingR)

## Loading required package: UsingR

## Loading required package: MASS

## Loading required package: HistData

## Loading required package: Hmisc

## Loading required package: lattice

## Loading required package: survival

## Loading required package: Formula

##
## Attaching package: 'Hmisc'

## The following objects are masked from 'package:base':
##
##     format.pval, units

##
## Attaching package: 'UsingR'

## The following object is masked from 'package:survival':
##
##     cancer

head(father.son)

##    fheight  sheight
## 1 65.04851 59.77827
```

```
## 2 63.25094 63.21404
## 3 64.95532 63.34242
## 4 65.75250 62.79238
## 5 61.13723 64.28113
## 6 63.02254 64.24221
```

```
write.csv(father.son, "E:/term 2/Data Science and analytics/R studio/7-DSA/fa
ther_son.csv", row.names = FALSE) # we use wite.csv function to write the sel
ected data from the package in our drive in .csv file format.
```

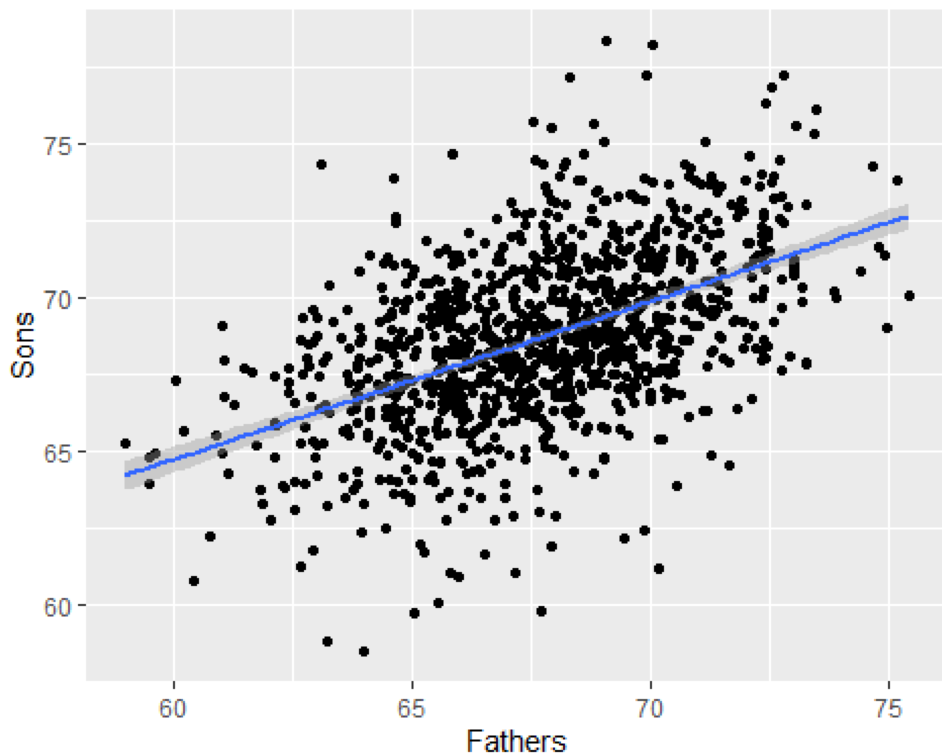
#ANOVA - Comparing Multiple Groups

```
# We can also do ANNOVA in R by using the aov() function.
# We are considering the same package and the same dta set from the above.
# We are finding the tip obtained in the day from different genders and their
variance around all days of the week.
str(tips)

## 'data.frame':    244 obs. of  7 variables:
##  $ total_bill: num  17 10.3 21 23.7 24.6 ...
##  $ tip       : num  1.01 1.66 3.5 3.31 3.61 4.71 2 3.12 1.96 3.23 ...
##  $ sex       : Factor w/ 2 levels "Female","Male": 1 2 2 2 1 2 2 2 2 2 ...
##  $ smoker    : Factor w/ 2 levels "No","Yes": 1 1 1 1 1 1 1 1 1 1 ...
##  $ day       : Factor w/ 4 levels "Fri","Sat","Sun",..: 3 3 3 3 3 3 3 3 3
3 ...
##  $ time      : Factor w/ 2 levels "Dinner","Lunch": 1 1 1 1 1 1 1 1 1 1 ..
.
##  $ size      : int  2 3 3 2 4 4 2 4 2 2 ...

tipAnova = aov(tip ~ day, tips)
summary(tipAnova)

##              Df Sum Sq Mean Sq F value Pr(>F)
## day           3    9.5   3.175   1.672  0.174
## Residuals   240  455.7   1.899

# Here, we get the ANNOVA results and this shows us the F value which we can
use to determine whether the hypothesis will be accpeted or not.
```

Simple Linear Regression

```
# HEre also we are considering the same data set from above i.e., the father
son height relation.
# We will use the simple linear regression to find our or do a prediction of
the son's height using the data of the father's height.
require(UsingR)
require(ggplot2) #COnsidering the ggplot2 package
head(father.son) # Selecting the father.son data

##    fheight  sheight
## 1 65.04851 59.77827
```

```
## 2 63.25094 63.21404
## 3 64.95532 63.34242
## 4 65.75250 62.79238
## 5 61.13723 64.28113
## 6 63.02254 64.24221

# We get the top 6 data of the height of the father and the son.

# Now we will plot the data of the height of the father and son on a graph to
get a basic understanding about the relation of the father and son height.
ggplot(father.son, aes(x=fheight, y=sheight))+geom_point()+
  geom_smooth(method="lm")+labs(x="Fathers", y="Sons")

## `geom_smooth()` using formula 'y ~ x'
```




```
# Now we will do a regression of the height data of the father and son to kno
w about the coefficient of the intercept and the father's height.
heightsLM = lm(sheight ~ fheight, data = father.son)
heightsLM

##
## Call:
## lm(formula = sheight ~ fheight, data = father.son)
##
## Coefficients:
## (Intercept)      fheight
##     33.8866       0.5141
```

```
summary(heightsLM)

##
## Call:
## lm(formula = sheight ~ fheight, data = father.son)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -8.8772 -1.5144 -0.0079  1.6285  8.9685
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 33.88660    1.83235   18.49   <2e-16 ***
## fheight      0.51409    0.02705   19.01   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.437 on 1076 degrees of freedom
## Multiple R-squared:  0.2513, Adjusted R-squared:  0.2506
## F-statistic: 361.2 on 1 and 1076 DF,  p-value: < 2.2e-16

# Now we can see that there is a big difference in the height of the father a
nd the son and hence, we will not be able to correctly predict the height of
the son using the data of father's height.
```

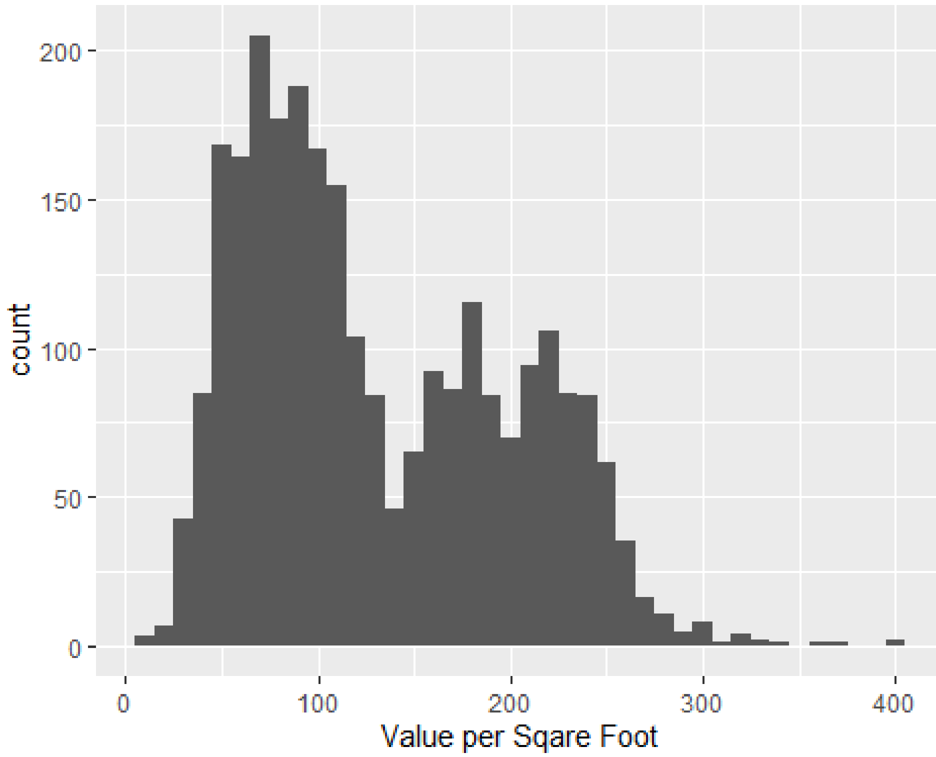
Multiple Linear Regression

```
# We will download the housing data by providing the URL of the data.
housing = read.table("http://www.jaredlander.com/data/housing.csv", sep =",",
header = TRUE, stringsAsFactors=FALSE)

write.table(housing, "Shousing.csv", col.names = TRUE,row.names = FALSE, quot
e = FALSE, sep =",")

str(housing)

## 'data.frame':    2626 obs. of  13 variables:
##  $ Neighborhood          : chr  "FINANCIAL" "FINANCIAL" "FINANCIAL" "FINA
NCIAL" ...
##  $ Building.Classification: chr  "R9-CONDOMINIUM" "R4-CONDOMINIUM" "RR-CON
DOMINIUM" "R4-CONDOMINIUM" ...
##  $ Total.Units           : int  42 78 500 282 239 133 109 107 247 121 ...
##  $ Year.Built            : int  1920 1985 NA 1930 1985 1986 1985 1986 198
7 1985 ...
##  $ Gross.SqFt            : int  36500 126420 554174 249076 219495 139719
105000 87479 255845 106129 ...
##  $ Estimated.Gross.Income : int  1332615 6633257 17310000 11776313 1000458
2 5127687 4365900 3637377 11246946 4115683 ...
##  $ Gross.Income.per.SqFt  : num  36.5 52.5 31.2 47.3 45.6 ...
##  $ Estimated.Expense      : int  342005 1762295 3543000 2784670 2783197 14
```

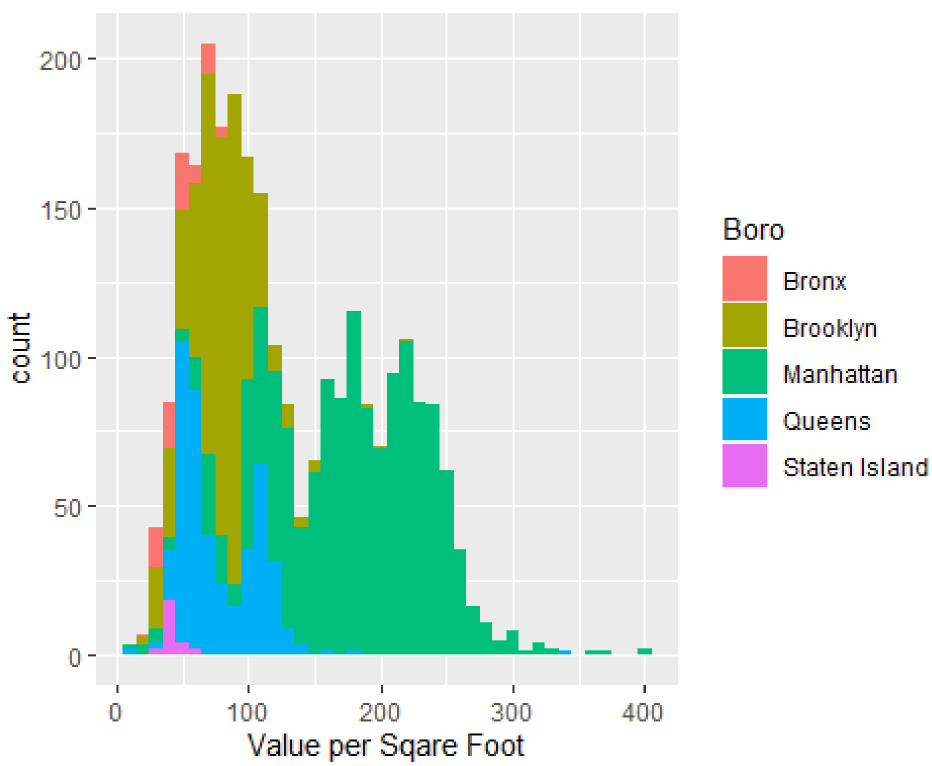
```
97788 1273650 1061120 2440761 1231096 ...
##  $ Expense.per.SqFt       : num  9.37 13.94 6.39 11.18 12.68 ...
##  $ Net.Operating.Income   : int  990610 4870962 13767000 8991643 7221385 3
629899 3092250 2576257 8806185 2884587 ...
##  $ Full.Market.Value      : int  7300000 30690000 90970000 67556006 543209
96 26737996 22210281 19449002 66316999 21821999 ...
##  $ Market.Value.per.SqFt  : num  200 243 164 271 247 ...
##  $ Boro                   : chr  "Manhattan" "Manhattan" "Manhattan" "Manh
attan" ...

# We are only selecting the Borough column in the entire data set and we conv
ert that convert as a factor in
housing$Boro= as.factor(housing$Boro)

str(housing)

## 'data.frame':    2626 obs. of  13 variables:
##  $ Neighborhood           : chr  "FINANCIAL" "FINANCIAL" "FINANCIAL" "FINA
NCIAL" ...
##  $ Building.Classification: chr  "R9-CONDOMINIUM" "R4-CONDOMINIUM" "RR-CON
DOMINIUM" "R4-CONDOMINIUM" ...
##  $ Total.Units            : int  42 78 500 282 239 133 109 107 247 121 ...
##  $ Year.Built             : int  1920 1985 NA 1930 1985 1986 1985 1986 198
7 1985 ...
##  $ Gross.SqFt             : int  36500 126420 554174 249076 219495 139719
105000 87479 255845 106129 ...
##  $ Estimated.Gross.Income : int  1332615 6633257 17310000 11776313 1000458
2 5127687 4365900 3637377 11246946 4115683 ...
##  $ Gross.Income.per.SqFt  : num  36.5 52.5 31.2 47.3 45.6 ...
##  $ Estimated.Expense      : int  342005 1762295 3543000 2784670 2783197 14
97788 1273650 1061120 2440761 1231096 ...
##  $ Expense.per.SqFt       : num  9.37 13.94 6.39 11.18 12.68 ...
##  $ Net.Operating.Income   : int  990610 4870962 13767000 8991643 7221385 3
629899 3092250 2576257 8806185 2884587 ...
##  $ Full.Market.Value      : int  7300000 30690000 90970000 67556006 543209
96 26737996 22210281 19449002 66316999 21821999 ...
##  $ Market.Value.per.SqFt  : num  200 243 164 271 247 ...
##  $ Boro                   : Factor w/ 5 levels "Bronx","Brooklyn",..: 3 3
3 3 3 3 3 3 3 3 ...

# Hence, we can now see that now the Boro row is showing as a factor Data typ
e instead of the Character Data type.

# Now we are only interested in the Boro Data set. So we will select only tha
t coloumn or data set using the $ symbol.
# ALso, we are only interested in the unique value in the Boro Data set so we
will use the unique function.
unique(housing$Boro)

## [1] Manhattan     Brooklyn      Queens        Bronx         Staten Island
## Levels: Bronx Brooklyn Manhattan Queens Staten Island
```

```r
head(housing)

##   Neighborhood Building.Classification Total.Units Year.Built Gross.SqFt
## 1    FINANCIAL          R9-CONDOMINIUM          42       1920      36500
## 2    FINANCIAL          R4-CONDOMINIUM          78       1985     126420
## 3    FINANCIAL          RR-CONDOMINIUM         500         NA     554174
## 4    FINANCIAL          R4-CONDOMINIUM         282       1930     249076
## 5      TRIBECA          R4-CONDOMINIUM         239       1985     219495
## 6      TRIBECA          R4-CONDOMINIUM         133       1986     139719
##   Estimated.Gross.Income Gross.Income.per.SqFt Estimated.Expense
## 1                1332615                 36.51            342005
## 2                6633257                 52.47           1762295
## 3               17310000                 31.24           3543000
## 4               11776313                 47.28           2784670
## 5               10004582                 45.58           2783197
## 6                5127687                 36.70           1497788
##   Expense.per.SqFt Net.Operating.Income Full.Market.Value Market.Value.per
.SqFt
## 1             9.37               990610           7300000                2
00.00
## 2            13.94              4870962          30690000                2
42.76
## 3             6.39             13767000          90970000                1
64.15
## 4            11.18              8991643          67556006                2
71.23
## 5            12.68              7221385          54320996                2
47.48
## 6            10.72              3629899          26737996                1
91.37
##        Boro
## 1 Manhattan
## 2 Manhattan
## 3 Manhattan
## 4 Manhattan
## 5 Manhattan
## 6 Manhattan

# We will now assign different names to the different columns by writing the
names in a sequential order as this will make the first nae that we write to
appear on the frst column.
names(housing)=c("Neighborhood","Class", "Units", "YearBuilt", "SqFt", "Incom
e", "IncomePerSqFt", "Expense", "ExpensePerSqFt", "NetIncome", "Value", "Valu
ePerSqFt", "Boro")


tail(housing)

##               Neighborhood          Class Units YearBuilt   SqFt  Income
## 2621      NEW SPRINGVILLE R4-CONDOMINIUM    37        NA  47880  673193
```

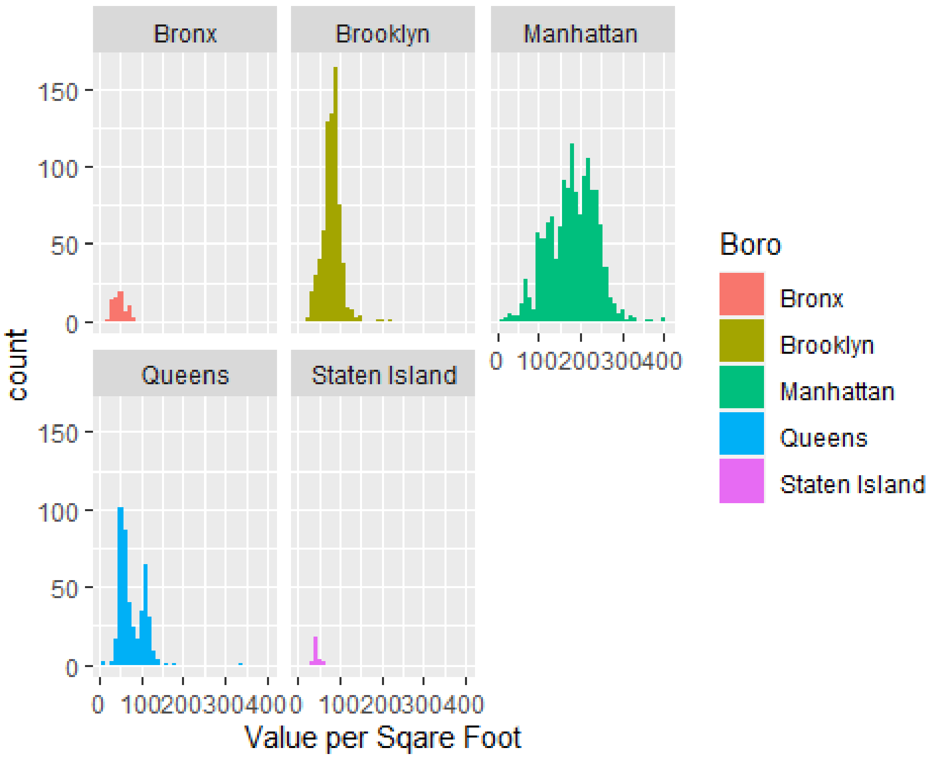
```
## 2622             ROSEBANK R4-CONDOMINIUM    52        NA  62391  831672
## 2623 ARROCHAR-SHORE ACRES R4-CONDOMINIUM   102      1987  90618 1274089
## 2624           GRANT CITY R4-CONDOMINIUM   100      1986  78903 1321625
## 2625           GRANT CITY R4-CONDOMINIUM   159      1961 166712 2343971
## 2626          GREAT KILLS R4-CONDOMINIUM    67      1965 108864 1298748
##      IncomePerSqFt Expense ExpensePerSqFt NetIncome   Value ValuePerSqFt
## 2621         14.06  336596           7.03    336597 2115260        44.18
## 2622         13.33  326305           5.23    505367 3354003        53.76
## 2623         14.06  637045           7.03    637044 5233000        57.75
## 2624         16.75  673832           8.54    647793 4687000        59.40
## 2625         14.06 1171985           7.03   1171986 5967531        35.80
## 2626         11.93  722857           6.64    575891 3673011        33.74
##               Boro
## 2621 Staten Island
## 2622 Staten Island
## 2623 Staten Island
## 2624 Staten Island
## 2625 Staten Island
## 2626 Staten Island

#Now we are considering Valuepersqft as our response variable.

# Visulaize the Data
require(ggplot2)
require(lattice)

# Drawing Histofgram for ValuePerSqFt
ggplot(housing, aes(x=ValuePerSqFt))+geom_histogram(binwidth=10)+labs(x="Valu
e per Sqare Foot")
```



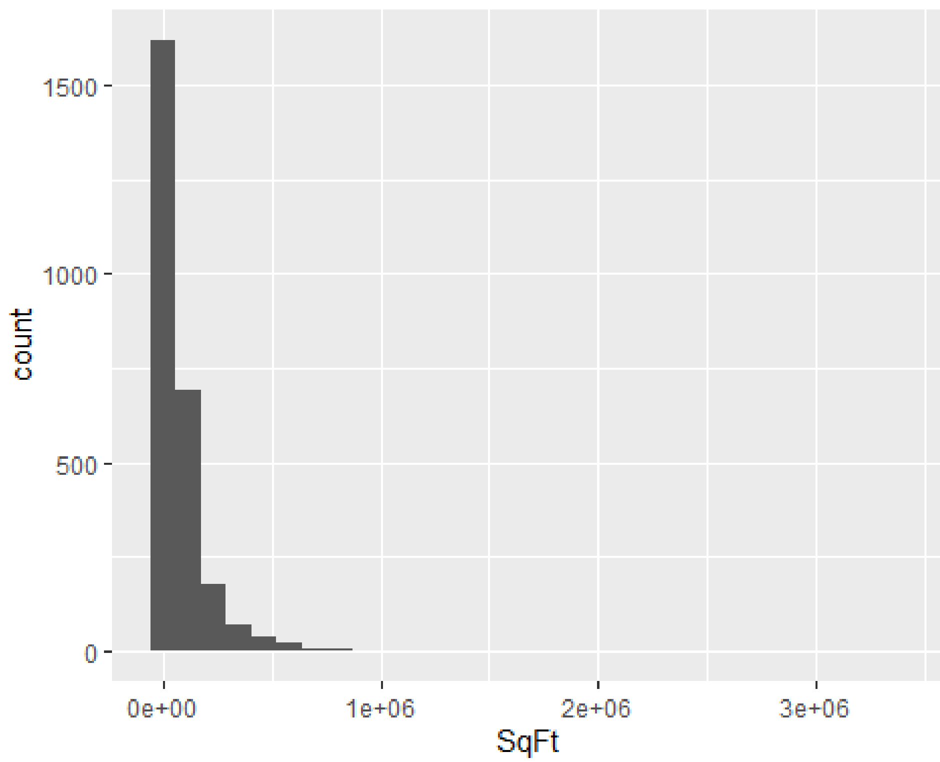

```
ggplot(housing, aes(x=ValuePerSqFt, fill=Boro))+geom_histogram(binwidth=10)+l
abs(x="Value per Sqare Foot")
```



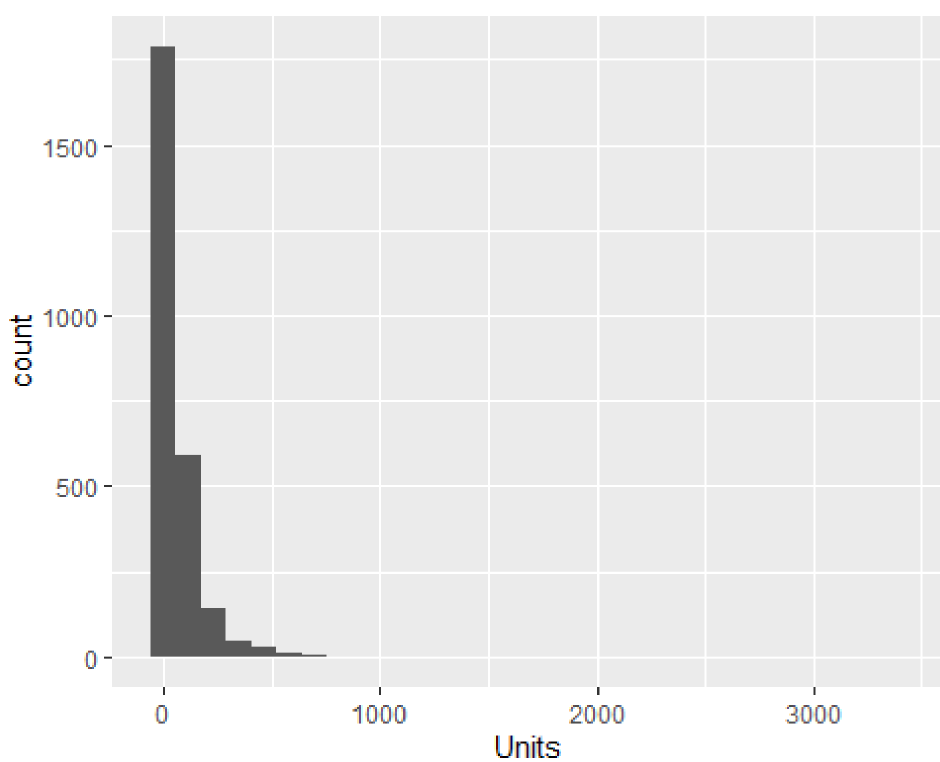
```r
ggplot(housing, aes(x=ValuePerSqFt, fill=Boro))+geom_histogram(binwidth=10)+l
abs(x="Value per Sqare Foot")+facet_wrap("Boro")
```



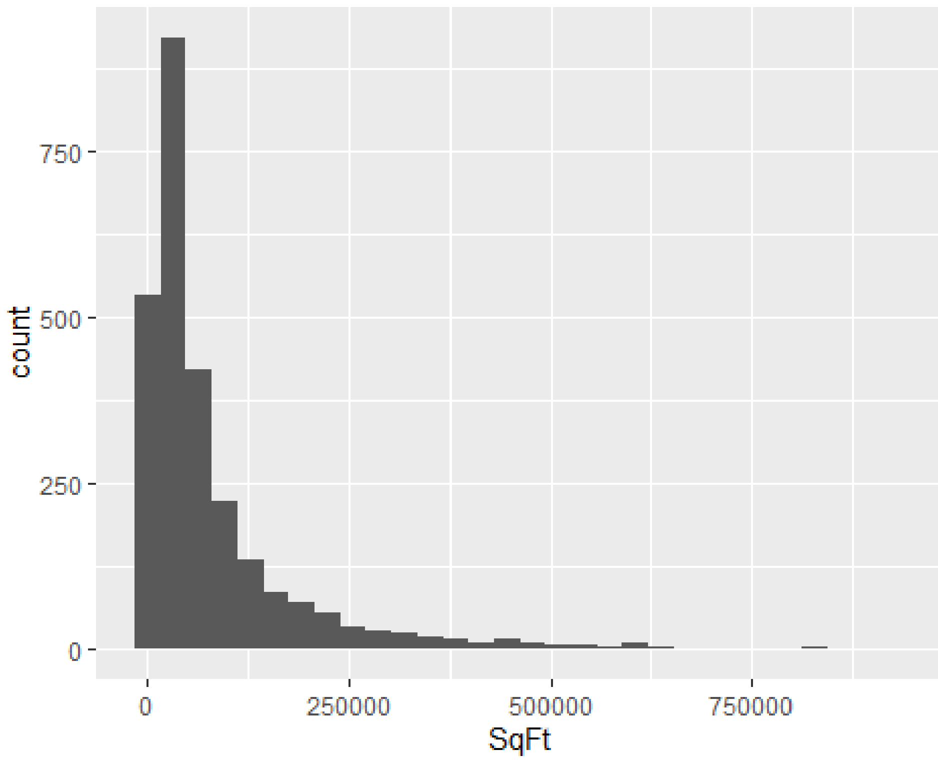

```r
# Creating Histogram
# For Square Footage and Units

ggplot(housing, aes(x=SqFt))+geom_histogram()

## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



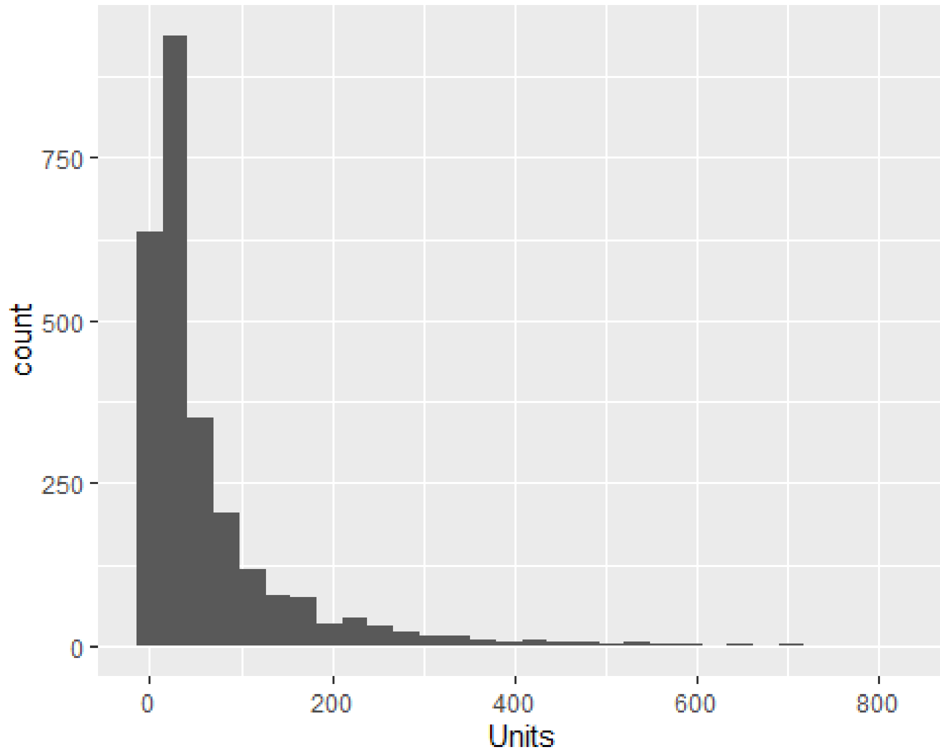

```
ggplot(housing, aes(x=Units))+geom_histogram()

## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



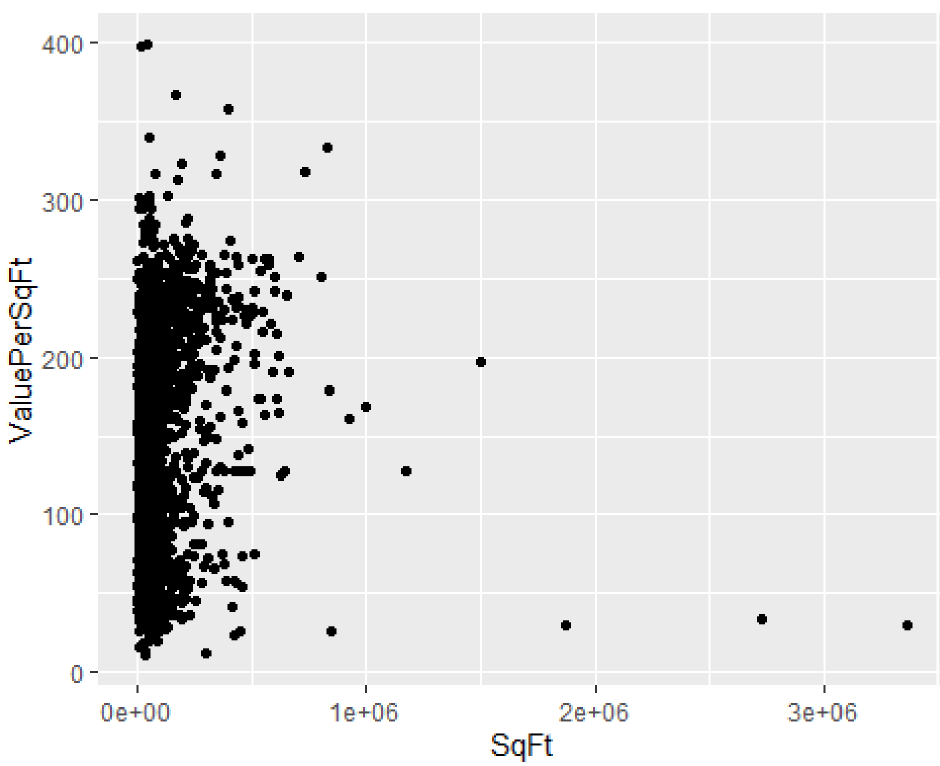
```r
ggplot(housing[housing$Units<1000,], aes(x=SqFt))+geom_histogram()
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



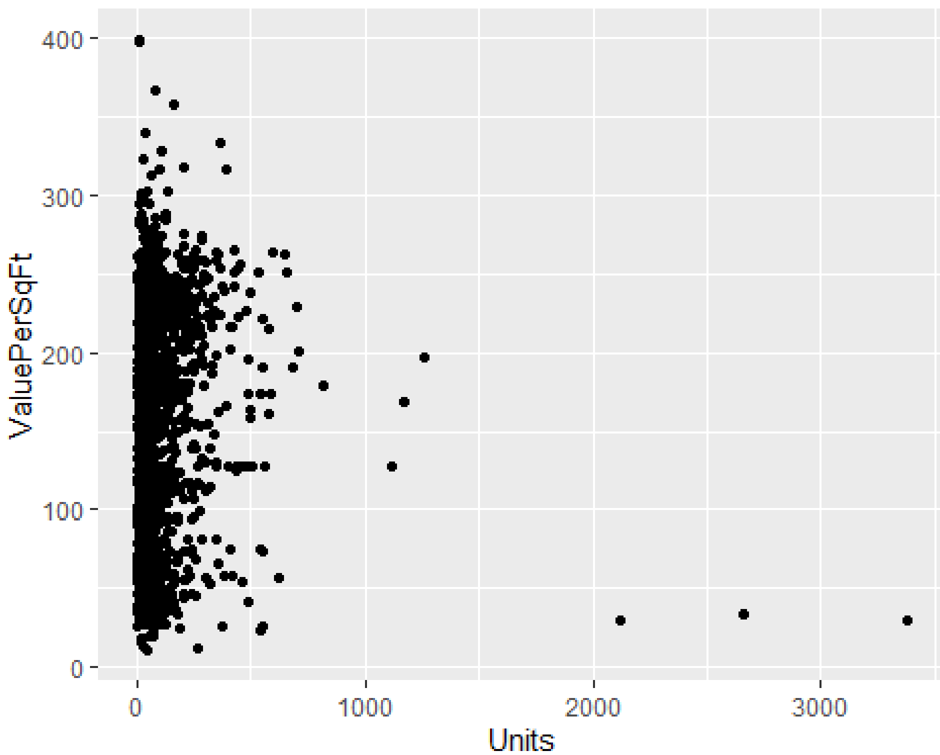

```r
ggplot(housing[housing$Units<1000,], aes(x=Units))+geom_histogram()
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



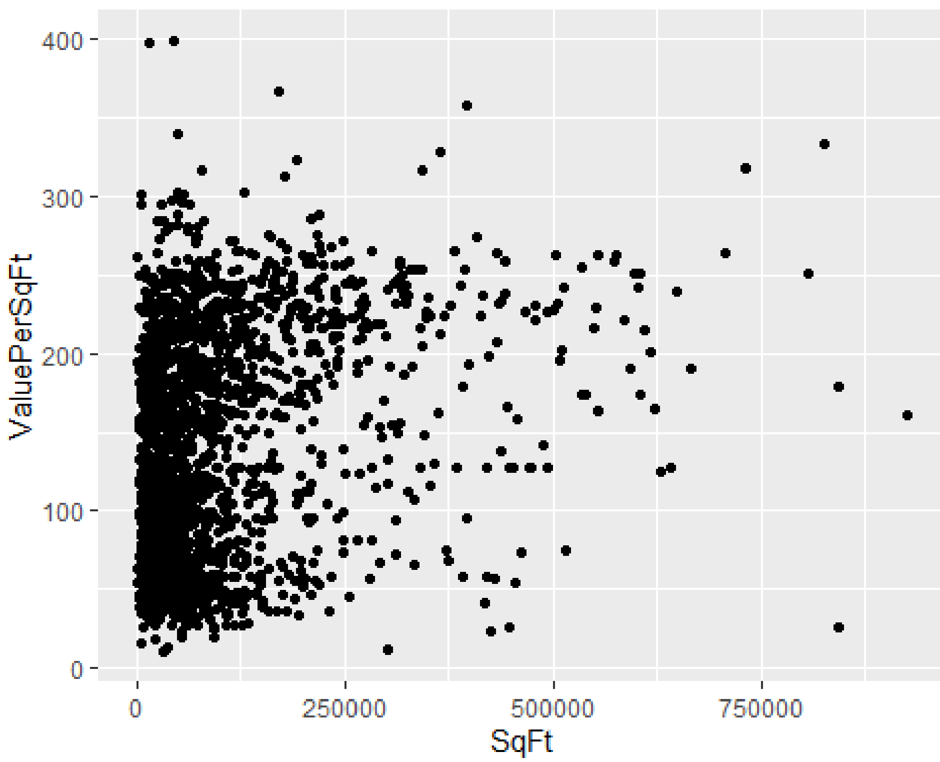

```
# We use point after the geom function to get the scatter graph.
ggplot(housing, aes(x=SqFt, y=ValuePerSqFt))+geom_point()
```



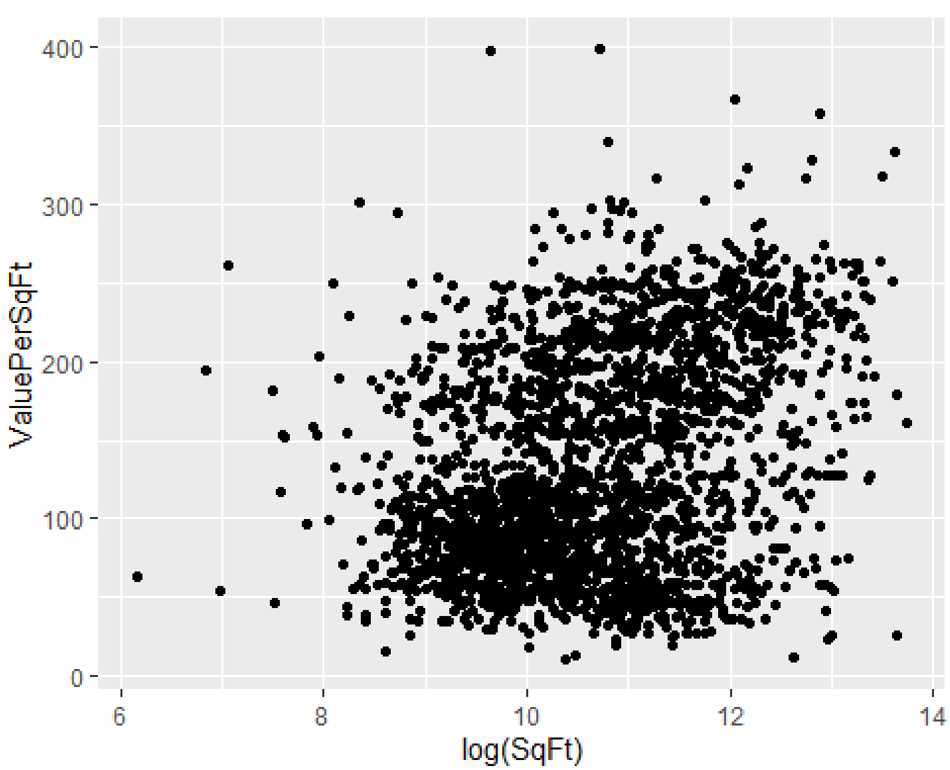
```
ggplot(housing, aes(x=Units, y=ValuePerSqFt))+geom_point()
```



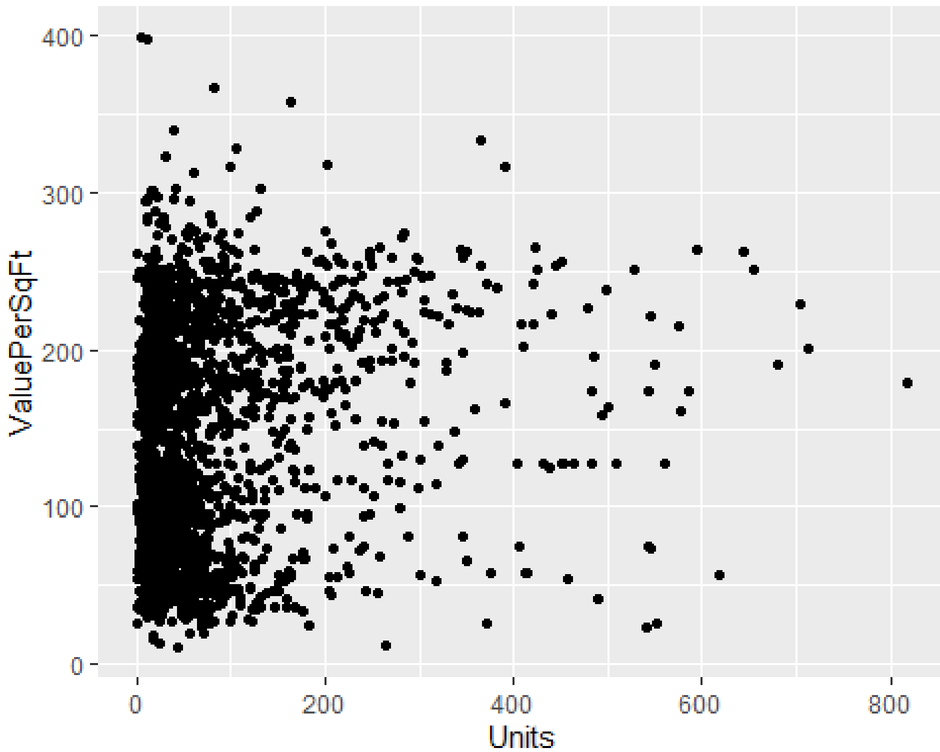

```
# How many Housing$Units greater than 1000
sum(housing$Units>=1000)

## [1] 6

# Remove Housing$Units greater than 1000
housing=housing[housing$Units<1000,]

# We would plot the value persqft value against the sqft value using the ggpl
ot function.
ggplot(housing, aes(x=SqFt, y=ValuePerSqFt))+geom_point()
```



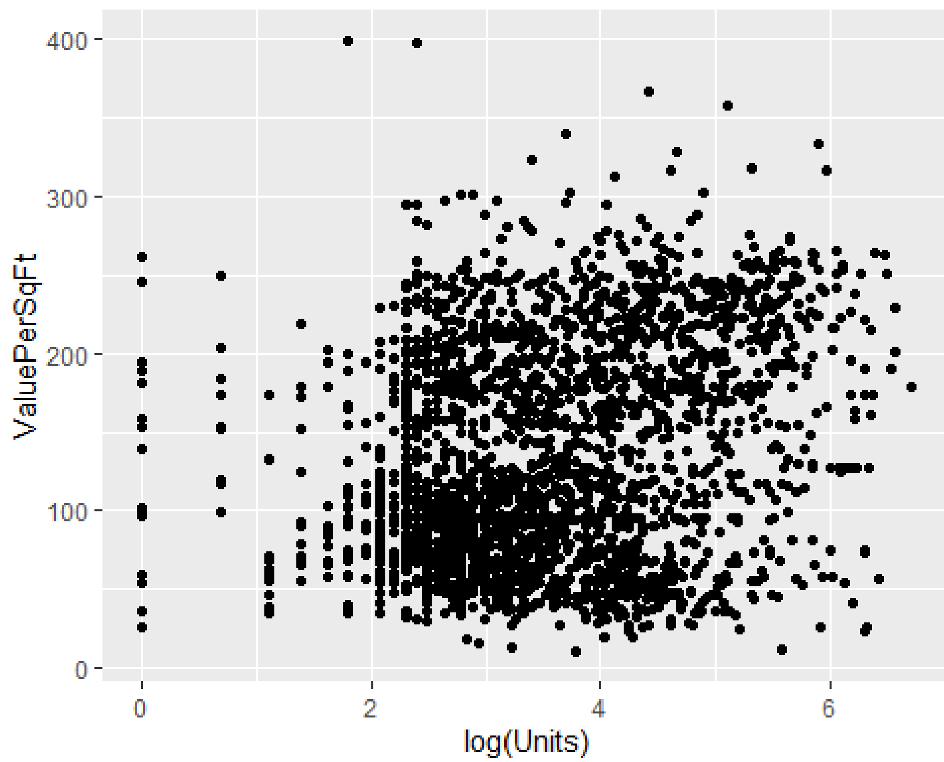

```
ggplot(housing, aes(x=log(SqFt), y=ValuePerSqFt))+geom_point()
```



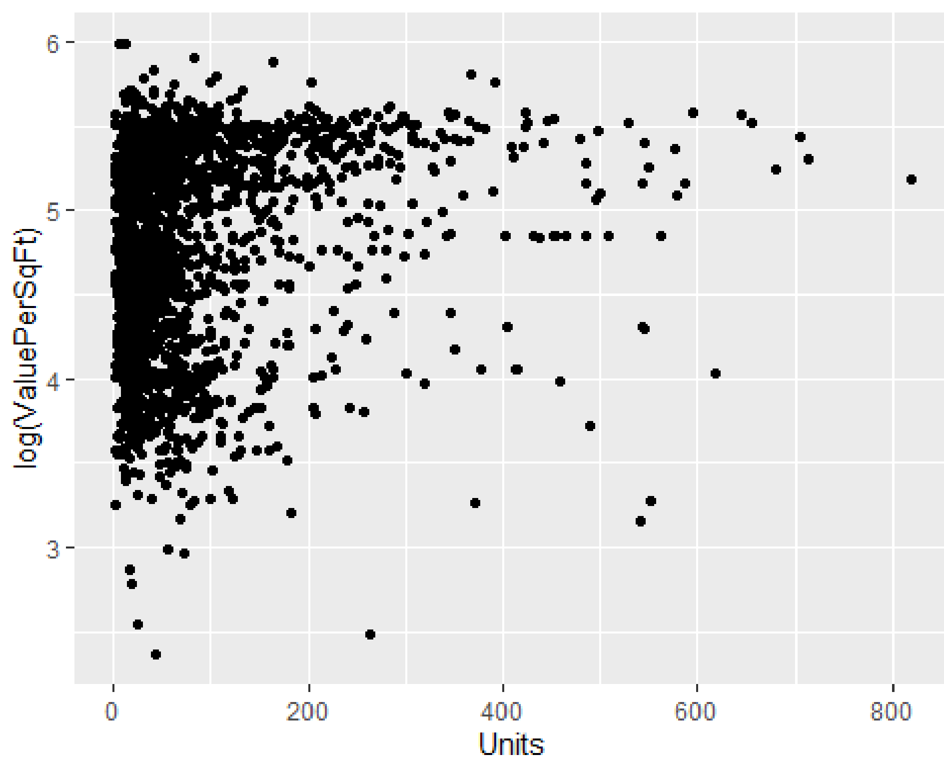
```
# Plot ValePerSqFt against Units
ggplot(housing, aes(x=Units, y=ValuePerSqFt))+geom_point()
```



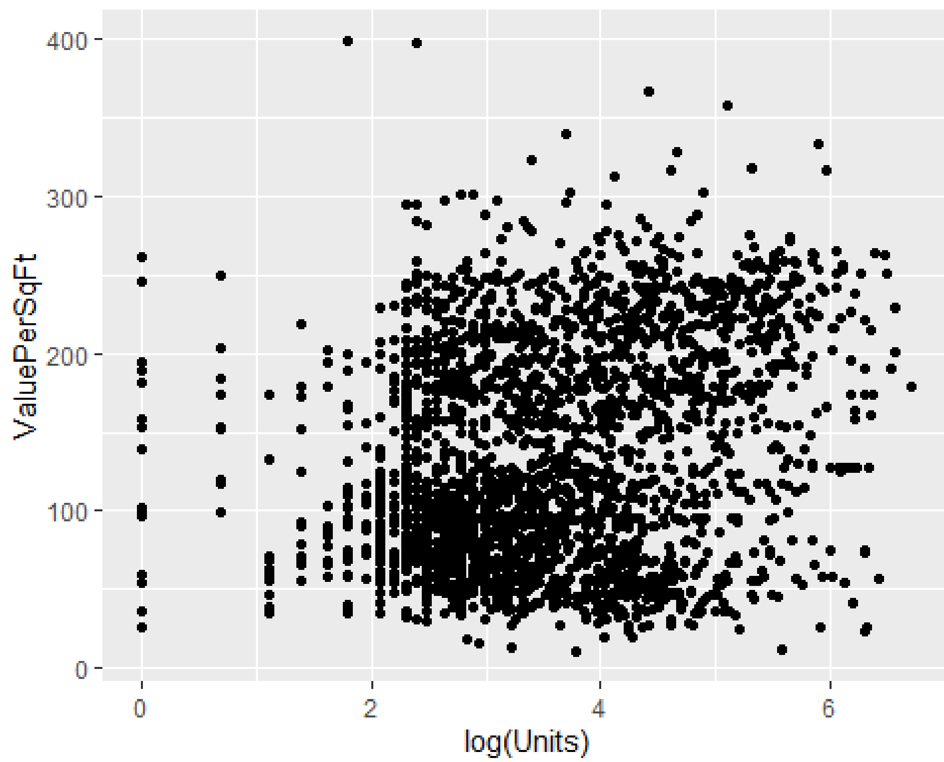

```
ggplot(housing, aes(x=log(Units), y=ValuePerSqFt))+geom_point()
```




```
ggplot(housing, aes(x=Units, y=log(ValuePerSqFt)))+geom_point()
```

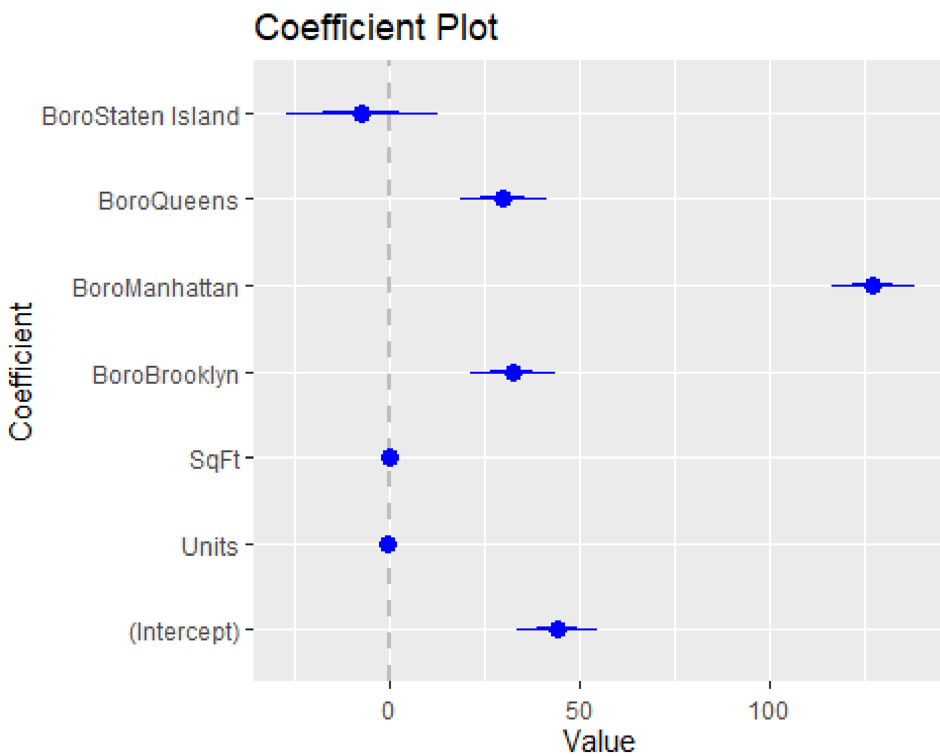



```
ggplot(housing, aes(x=log(Units), y=ValuePerSqFt))+geom_point()
```

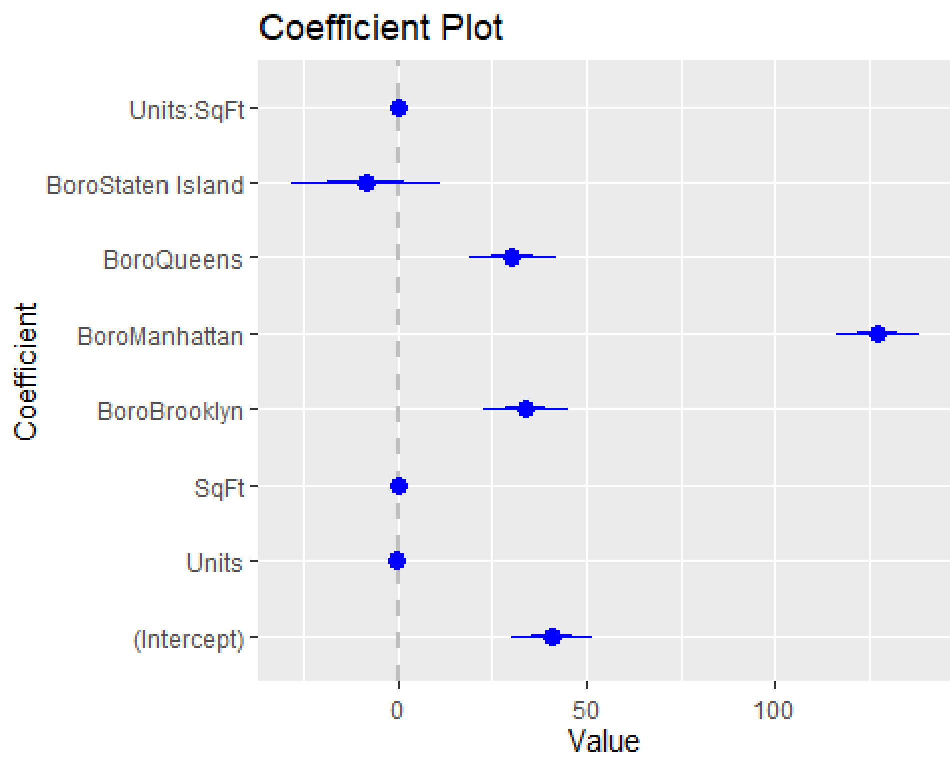



```
# Fit the Model
house1=lm(ValuePerSqFt~Units+SqFt+Boro, data=housing)
summary(house1)

##
## Call:
## lm(formula = ValuePerSqFt ~ Units + SqFt + Boro, data = housing)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -168.458  -22.680    1.493   26.290  261.761
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)          4.430e+01  5.342e+00   8.293  < 2e-16 ***
## Units               -1.532e-01  2.421e-02  -6.330 2.88e-10 ***
## SqFt                 2.070e-04  2.129e-05   9.723  < 2e-16 ***
## BoroBrooklyn         3.258e+01  5.561e+00   5.858 5.28e-09 ***
## BoroManhattan        1.274e+02  5.459e+00  23.343  < 2e-16 ***
## BoroQueens           3.011e+01  5.711e+00   5.272 1.46e-07 ***
## BoroStaten Island -7.114e+00  1.001e+01  -0.711    0.477
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 43.2 on 2613 degrees of freedom
## Multiple R-squared:  0.6034, Adjusted R-squared:  0.6025
## F-statistic: 662.6 on 6 and 2613 DF,  p-value: < 2.2e-16
```

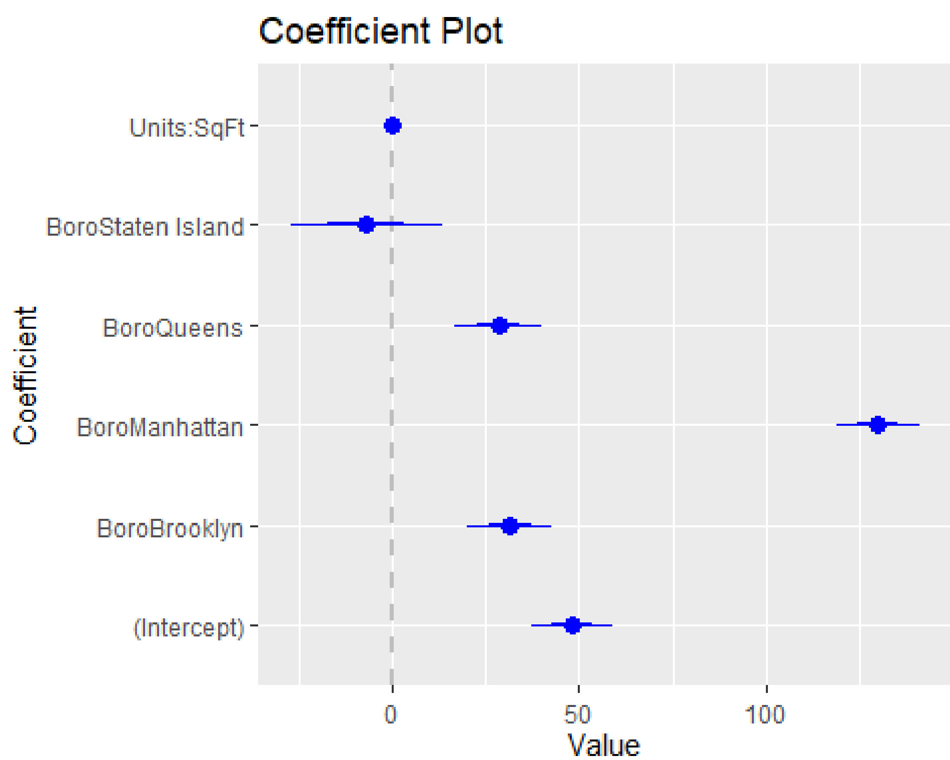
```r
# To get only Coefficients
house1$coefficients

##       (Intercept)             Units              SqFt      BoroBrooklyn
##      4.430325e+01     -1.532405e-01      2.069727e-04      3.257554e+01
##     BoroManhattan       BoroQueens BoroStaten Island
##      1.274259e+02      3.011000e+01     -7.113688e+00

coef(house1)

##       (Intercept)             Units              SqFt      BoroBrooklyn
##      4.430325e+01     -1.532405e-01      2.069727e-04      3.257554e+01
##     BoroManhattan       BoroQueens BoroStaten Island
##      1.274259e+02      3.011000e+01     -7.113688e+00

coefficients(house1)

##       (Intercept)             Units              SqFt      BoroBrooklyn
##      4.430325e+01     -1.532405e-01      2.069727e-04      3.257554e+01
##     BoroManhattan       BoroQueens BoroStaten Island
##      1.274259e+02      3.011000e+01     -7.113688e+00

# Draw coefficients Plot

require(coefplot)

## Loading required package: coefplot

coefplot(house1)
```




```
house2=lm(ValuePerSqFt~Units*SqFt+Boro, data = housing)
house3=lm(ValuePerSqFt~Units:SqFt+Boro, data = housing)
house2$coefficients

##       (Intercept)            Units             SqFt      BoroBrooklyn
##      4.093685e+01    -1.024579e-01     2.362293e-04      3.394544e+01
##     BoroManhattan       BoroQueens BoroStaten Island       Units:SqFt
##      1.272102e+02     3.040115e+01    -8.419682e+00     -1.809587e-07

house3$coefficients

##       (Intercept)     BoroBrooklyn    BoroManhattan        BoroQueens
##      4.804972e+01     3.141208e+01     1.302084e+02      2.841669e+01
## BoroStaten Island       Units:SqFt
##     -7.199902e+00     1.088059e-07

# Drawaing COeficcient Plot Graph in R
# We use the coefplot function to plot the coefficients in the Regression on
a Graph.
# Coefficient plot graph for House 2
coefplot(house2)
```




```r
# Coefficient plot graph for House 3
coefplot(house3)
```



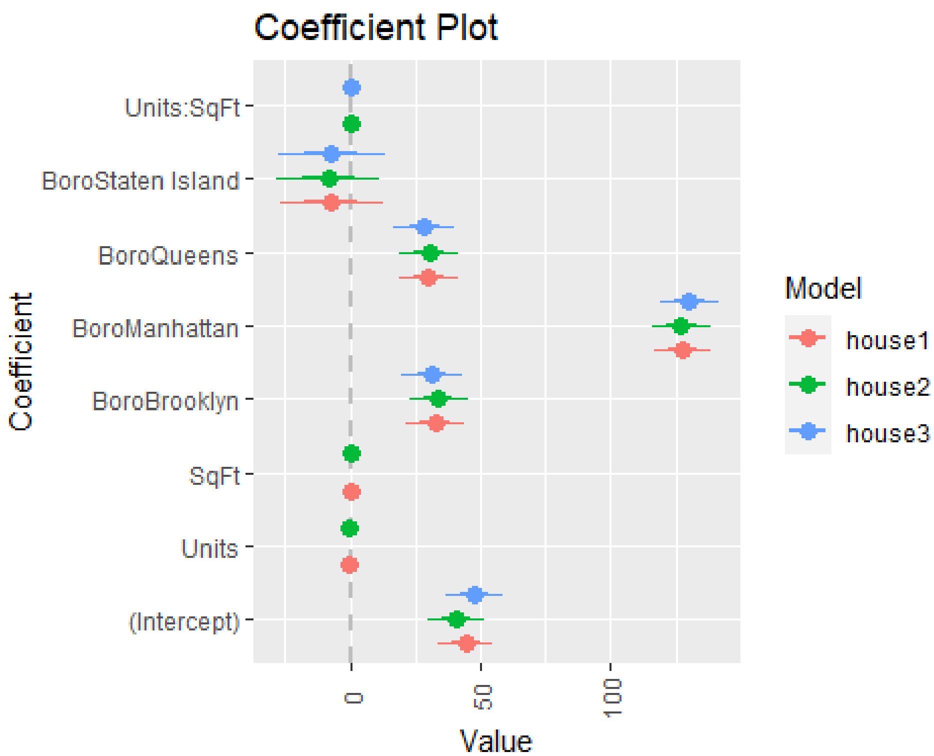
```r
# We are doing a regression of the value of value per sqft units and income.
house4=lm(ValuePerSqFt~ SqFt*Units*Income, data = housing)
house4$coefficients
```

```
##       (Intercept)              SqFt             Units            Income
##      1.116433e+02     -1.694688e-03      7.142611e-03      7.250830e-05
##        SqFt:Units       SqFt:Income      Units:Income SqFt:Units:Income
##      3.158094e-06     -5.129522e-11     -1.279236e-07      9.107312e-14
```

```r
# Interaction between TWO Categorical variables
house5=lm(ValuePerSqFt~Units:Class*Boro, data = housing)
house5$coefficients
```

```
##                                 (Intercept)
##                                5.494287e+01
##                                BoroBrooklyn
##                                2.653390e+01
##                               BoroManhattan
##                                1.191513e+02
##                                  BoroQueens
##                                2.671272e+01
##                           BoroStaten Island
##                               -1.297158e+01
##                     Units:ClassR2-CONDOMINIUM
##                               -3.041300e-01
##                     Units:ClassR4-CONDOMINIUM
##                               -1.062423e-01
##                     Units:ClassR9-CONDOMINIUM
##                               -4.872488e-02
##                     Units:ClassRR-CONDOMINIUM
##                                5.268445e-03
##        Units:ClassR2-CONDOMINIUM:BoroBrooklyn
##                               -2.656421e-05
##        Units:ClassR4-CONDOMINIUM:BoroBrooklyn
##                                1.255519e-01
##        Units:ClassR9-CONDOMINIUM:BoroBrooklyn
##                               -1.039370e-01
##        Units:ClassRR-CONDOMINIUM:BoroBrooklyn
##                               -6.328234e-01
##       Units:ClassR2-CONDOMINIUM:BoroManhattan
##                               -1.156371e+00
##       Units:ClassR4-CONDOMINIUM:BoroManhattan
##                                2.433943e-01
##       Units:ClassR9-CONDOMINIUM:BoroManhattan
##                                1.276151e-02
##       Units:ClassRR-CONDOMINIUM:BoroManhattan
##                                1.430965e-02
##          Units:ClassR2-CONDOMINIUM:BoroQueens
##                                9.655360e-02
##          Units:ClassR4-CONDOMINIUM:BoroQueens
```

```
##                                 6.848450e-02
##        Units:ClassR9-CONDOMINIUM:BoroQueens
##                                -5.456138e-02
##        Units:ClassRR-CONDOMINIUM:BoroQueens
##                                 6.057630e-01
## Units:ClassR2-CONDOMINIUM:BoroStaten Island
##                                           NA
## Units:ClassR4-CONDOMINIUM:BoroStaten Island
##                                 1.048513e-01
## Units:ClassR9-CONDOMINIUM:BoroStaten Island
##                                           NA
## Units:ClassRR-CONDOMINIUM:BoroStaten Island
##                                           NA

# We use I() function for getting the ratios in R
house6=lm(ValuePerSqFt~ I(SqFt/Units)+Boro, data = housing)
house6$coefficients

##       (Intercept)     I(SqFt/Units)      BoroBrooklyn     BoroManhattan
##      43.754838763       0.004017039      30.774343209     130.769502685
##        BoroQueens BoroStaten Island
##      29.767922792      -6.134446417

house7=lm(ValuePerSqFt~ (Units+SqFt)^2,housing)
house7$coefficients

##   (Intercept)         Units          SqFt    Units:SqFt
##  1.070301e+02 -1.125194e-01  4.964623e-04 -5.159669e-07

house8=lm(ValuePerSqFt~Units*SqFt, housing)
house8$coefficients

##   (Intercept)         Units          SqFt    Units:SqFt
##  1.070301e+02 -1.125194e-01  4.964623e-04 -5.159669e-07

identical(house7$coefficients, house8$coefficients)

## [1] TRUE

house9=lm(ValuePerSqFt~ I(Units+SqFt)^2,housing)
house9$coefficients

##     (Intercept) I(Units + SqFt)
##    1.147034e+02    2.107231e-04

# We can also plot multiple coefficient of data in R
# For this we use the multiplot() function.
multiplot(house1, house2, house3)
```




```
# We use the summary function to get the detailed summary about the regressio
n analysis.
summary(house1)

##
## Call:
## lm(formula = ValuePerSqFt ~ Units + SqFt + Boro, data = housing)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -168.458  -22.680    1.493   26.290  261.761
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)        4.430e+01  5.342e+00   8.293  < 2e-16 ***
## Units             -1.532e-01  2.421e-02  -6.330 2.88e-10 ***
## SqFt               2.070e-04  2.129e-05   9.723  < 2e-16 ***
## BoroBrooklyn       3.258e+01  5.561e+00   5.858 5.28e-09 ***
## BoroManhattan      1.274e+02  5.459e+00  23.343  < 2e-16 ***
## BoroQueens         3.011e+01  5.711e+00   5.272 1.46e-07 ***
## BoroStaten Island -7.114e+00  1.001e+01  -0.711    0.477
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 43.2 on 2613 degrees of freedom
## Multiple R-squared:  0.6034, Adjusted R-squared:  0.6025
## F-statistic: 662.6 on 6 and 2613 DF,  p-value: < 2.2e-16
```

```r
summary(house2)

##
## Call:
## lm(formula = ValuePerSqFt ~ Units * SqFt + Boro, data = housing)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -161.888  -22.867    1.802   26.431  261.733
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)          4.094e+01  5.393e+00   7.590 4.41e-14 ***
## Units               -1.025e-01  2.728e-02  -3.755 0.000177 ***
## SqFt                 2.362e-04  2.245e-05  10.521  < 2e-16 ***
## BoroBrooklyn         3.395e+01  5.556e+00   6.110 1.15e-09 ***
## BoroManhattan        1.272e+02  5.444e+00  23.369  < 2e-16 ***
## BoroQueens           3.040e+01  5.696e+00   5.338 1.02e-07 ***
## BoroStaten Island -8.420e+00  9.985e+00  -0.843 0.399160
## Units:SqFt          -1.810e-07  4.530e-08  -3.995 6.65e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 43.08 on 2612 degrees of freedom
## Multiple R-squared:  0.6058, Adjusted R-squared:  0.6047
## F-statistic: 573.4 on 7 and 2612 DF,  p-value: < 2.2e-16

summary(house3)

##
## Call:
## lm(formula = ValuePerSqFt ~ Units:SqFt + Boro, data = housing)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -165.666  -22.840    0.161   27.351  263.442
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)          4.805e+01  5.425e+00   8.857  < 2e-16 ***
## BoroBrooklyn         3.141e+01  5.668e+00   5.542 3.30e-08 ***
## BoroManhattan        1.302e+02  5.561e+00  23.414  < 2e-16 ***
## BoroQueens           2.842e+01  5.822e+00   4.881 1.12e-06 ***
## BoroStaten Island -7.200e+00  1.020e+01  -0.706     0.48
## Units:SqFt           1.088e-07  1.926e-08   5.649 1.79e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 44.07 on 2614 degrees of freedom
```

```
## Multiple R-squared:  0.5873, Adjusted R-squared:  0.5865
## F-statistic: 743.8 on 5 and 2614 DF,  p-value: < 2.2e-16
```

```
summary(house4)
```

```
##
## Call:
## lm(formula = ValuePerSqFt ~ SqFt * Units * Income, data = housing)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -226.020  -26.409   -7.011   20.752  274.520
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)          1.116e+02  1.382e+00  80.791   <2e-16 ***
## SqFt                -1.695e-03  5.324e-05 -31.834   <2e-16 ***
## Units                7.143e-03  3.886e-02   0.184    0.854
## Income               7.251e-05  1.320e-06  54.919   <2e-16 ***
## SqFt:Units           3.158e-06  1.328e-07  23.775   <2e-16 ***
## SqFt:Income         -5.130e-11  1.835e-12 -27.959   <2e-16 ***
## Units:Income        -1.279e-07  4.785e-09 -26.733   <2e-16 ***
## SqFt:Units:Income    9.107e-14  4.519e-15  20.152   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 40.47 on 2612 degrees of freedom
## Multiple R-squared:  0.6522, Adjusted R-squared:  0.6513
## F-statistic: 699.8 on 7 and 2612 DF,  p-value: < 2.2e-16
```

```
summary(house5)
```

```
##
## Call:
## lm(formula = ValuePerSqFt ~ Units:Class * Boro, data = housing)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -173.145  -22.686    0.031   26.007  259.975
##
## Coefficients: (3 not defined because of singularities)
##                                                 Estimate Std. Error t value
## (Intercept)                                    5.494e+01  9.267e+00   5.929
## BoroBrooklyn                                   2.653e+01  9.500e+00   2.793
## BoroManhattan                                  1.192e+02  9.389e+00  12.691
## BoroQueens                                     2.671e+01  9.636e+00   2.772
## BoroStaten Island                             -1.297e+01  1.706e+01  -0.760
## Units:ClassR2-CONDOMINIUM                     -3.041e-01  4.244e-01  -0.717
## Units:ClassR4-CONDOMINIUM                     -1.062e-01  1.430e-01  -0.743
## Units:ClassR9-CONDOMINIUM                     -4.872e-02  1.236e-01  -0.394
## Units:ClassRR-CONDOMINIUM                      5.268e-03  3.715e-01   0.014
```

```
## Units:ClassR2-CONDOMINIUM:BoroBrooklyn      -2.656e-05  4.524e-01   0.000
## Units:ClassR4-CONDOMINIUM:BoroBrooklyn       1.256e-01  1.466e-01   0.857
## Units:ClassR9-CONDOMINIUM:BoroBrooklyn      -1.039e-01  1.770e-01  -0.587
## Units:ClassRR-CONDOMINIUM:BoroBrooklyn      -6.328e-01  7.391e-01  -0.856
## Units:ClassR2-CONDOMINIUM:BoroManhattan     -1.156e+00  4.757e-01  -2.431
## Units:ClassR4-CONDOMINIUM:BoroManhattan      2.434e-01  1.435e-01   1.696
## Units:ClassR9-CONDOMINIUM:BoroManhattan      1.276e-02  1.250e-01   0.102
## Units:ClassRR-CONDOMINIUM:BoroManhattan      1.431e-02  3.725e-01   0.038
## Units:ClassR2-CONDOMINIUM:BoroQueens         9.655e-02  4.309e-01   0.224
## Units:ClassR4-CONDOMINIUM:BoroQueens         6.848e-02  1.465e-01   0.467
## Units:ClassR9-CONDOMINIUM:BoroQueens        -5.456e-02  1.300e-01  -0.420
## Units:ClassRR-CONDOMINIUM:BoroQueens         6.058e-01  9.633e-01   0.629
## Units:ClassR2-CONDOMINIUM:BoroStaten Island         NA         NA      NA
## Units:ClassR4-CONDOMINIUM:BoroStaten Island  1.049e-01  2.058e-01   0.510
## Units:ClassR9-CONDOMINIUM:BoroStaten Island         NA         NA      NA
## Units:ClassRR-CONDOMINIUM:BoroStaten Island         NA         NA      NA
##                                             Pr(>|t|)
## (Intercept)                                 3.45e-09 ***
## BoroBrooklyn                                 0.00526 **
## BoroManhattan                                < 2e-16 ***
## BoroQueens                                   0.00561 **
## BoroStaten Island                            0.44711
## Units:ClassR2-CONDOMINIUM                    0.47371
## Units:ClassR4-CONDOMINIUM                    0.45750
## Units:ClassR9-CONDOMINIUM                    0.69346
## Units:ClassRR-CONDOMINIUM                    0.98869
## Units:ClassR2-CONDOMINIUM:BoroBrooklyn       0.99995
## Units:ClassR4-CONDOMINIUM:BoroBrooklyn       0.39180
## Units:ClassR9-CONDOMINIUM:BoroBrooklyn       0.55715
## Units:ClassRR-CONDOMINIUM:BoroBrooklyn       0.39197
## Units:ClassR2-CONDOMINIUM:BoroManhattan      0.01513 *
## Units:ClassR4-CONDOMINIUM:BoroManhattan      0.08999 .
## Units:ClassR9-CONDOMINIUM:BoroManhattan      0.91868
## Units:ClassRR-CONDOMINIUM:BoroManhattan      0.96936
## Units:ClassR2-CONDOMINIUM:BoroQueens         0.82271
## Units:ClassR4-CONDOMINIUM:BoroQueens         0.64028
## Units:ClassR9-CONDOMINIUM:BoroQueens         0.67473
## Units:ClassRR-CONDOMINIUM:BoroQueens         0.52952
## Units:ClassR2-CONDOMINIUM:BoroStaten Island       NA
## Units:ClassR4-CONDOMINIUM:BoroStaten Island  0.61041
## Units:ClassR9-CONDOMINIUM:BoroStaten Island       NA
## Units:ClassRR-CONDOMINIUM:BoroStaten Island       NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 42.61 on 2598 degrees of freedom
## Multiple R-squared:  0.6165, Adjusted R-squared:  0.6134
## F-statistic: 198.8 on 21 and 2598 DF,  p-value: < 2.2e-16
```

```
summary(house6)
```

```
##
## Call:
## lm(formula = ValuePerSqFt ~ I(SqFt/Units) + Boro, data = housing)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -167.585  -23.001    0.282   27.558  261.709
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)          4.375e+01  5.560e+00   7.869 5.18e-15 ***
## I(SqFt/Units)        4.017e-03  9.438e-04   4.256 2.15e-05 ***
## BoroBrooklyn         3.077e+01  5.684e+00   5.414 6.72e-08 ***
## BoroManhattan        1.308e+02  5.574e+00  23.461  < 2e-16 ***
## BoroQueens           2.977e+01  5.842e+00   5.096 3.72e-07 ***
## BoroStaten Island -6.134e+00  1.023e+01  -0.600    0.549
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 44.18 on 2614 degrees of freedom
## Multiple R-squared:  0.5851, Adjusted R-squared:  0.5843
## F-statistic: 737.2 on 5 and 2614 DF,  p-value: < 2.2e-16
```

```r
summary(house7)
```

```
##
## Call:
## lm(formula = ValuePerSqFt ~ (Units + SqFt)^2, data = housing)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -296.38  -46.65  -12.21   48.52  284.15
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1.070e+02  1.874e+00  57.121  < 2e-16 ***
## Units       -1.125e-01  3.974e-02  -2.831  0.00467 **
## SqFt         4.965e-04  3.225e-05  15.393  < 2e-16 ***
## Units:SqFt  -5.160e-07  6.541e-08  -7.889 4.45e-15 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 63.42 on 2616 degrees of freedom
## Multiple R-squared:  0.1443, Adjusted R-squared:  0.1433
## F-statistic: 147.1 on 3 and 2616 DF,  p-value: < 2.2e-16
```

```r
summary(house9)
```

```
##
## Call:
## lm(formula = ValuePerSqFt ~ I(Units + SqFt)^2, data = housing)
```

```
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -266.37  -48.80  -14.04   52.70  279.58
##
## Coefficients:
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)     1.147e+02  1.575e+00   72.83   <2e-16 ***
## I(Units + SqFt) 2.107e-04  1.193e-05   17.67   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 64.79 on 2618 degrees of freedom
## Multiple R-squared:  0.1065, Adjusted R-squared:  0.1062
## F-statistic: 312.1 on 1 and 2618 DF,  p-value: < 2.2e-16
```

```
housingNew=read.table("http://www.jaredlander.com/data/housingNew.csv", sep =
",", header = TRUE, stringsAsFactors=FALSE)
# write.table(housingNew, "Testhousing.csv", col.names = NA,row.names = TRUE,
quote = FALSE, sep =",")
# To predict with 95 % confidence bounds
housePredict=predict(house1, newdata=housingNew, se.fit=TRUE, interval="predi
ction", level=0.95)
head(housePredict$fit)
```

```
##         fit        lwr      upr
## 1  74.00645 -10.813887 158.8268
## 2  82.04988  -2.728506 166.8283
## 3 166.65975  81.808078 251.5114
## 4 169.00970  84.222648 253.7968
## 5  80.00129  -4.777303 164.7799
## 6  47.87795 -37.480170 133.2361
```

```
View(housePredict$fit)
```

```
house4Predict=predict(house4, newdata=housingNew, se.fit=TRUE, interval="pred
iction", level=0.95)
head(house4Predict$fit)
```

```
##         fit       lwr      upr
## 1 110.87020 31.488812 190.2516
## 2  70.55054 -8.841812 149.9429
## 3 124.94771 45.360975 204.5344
## 4 150.81847 71.369611 230.2673
## 5 101.93912 22.563391 181.3149
## 6 100.59737 21.223953 179.9708
```

```
View(house4Predict$fit)
```

Key Learnings-

- R greatest advantage is that it is Open-source Software.
- It also gives flexibility in command line interface.
- By doing the assignment I get to learn more about the basic and complex features of R.
- It helps me in providing a platform where I can do various types of Hypothesis testing with ease.
- It also helped me in providing an another medium of creating graphs.
- I also get to learn about various features and functions.
- Also I got to learn that R gives us an option to directly import data from the internet.
- R also gives us the flexibility of doing various tasks like creating tables, doing arithmetic operations and making graphs in one platform only.