

# Project 1

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## Introduction

Within the `Project1.Rmd` file and this `Project1.pdf` file, the user can create a linear regression between two variables; also, the user can use a bootstrapping function. Within the function `myslr`, the user estimates the relationship between two variables, as well show the confidence in those estimates.

Within the bootstrapping function, the user can use a limited sample to infer information about a population.

## Data

Within the examples in this file, the `mtcars` data set provides meaningful information when estimating linear regressions and bootstrapping. This data set includes information from the 1974 *Motor Trends* US magazine, and “comprises fuel consumption,” as well as “10 aspects” of each of the thirty-two cars in the data set. These “aspects” resemble the variables within the data.

When considering the variables in the `mtcars` data set, it is useful to understand the types of data, which help best determine how to analyze the data. Please see the variables, their descriptions, and their data types below.

Variable Name	Variable Description	Data Type
mpg	Miles/(US) gallon	Ratio
cyl	Number of cylinders	Ratio
disp	Displacement (cu.in.)	Ratio
hp	Gross horsepower	Ratio
drat	Rear axle ratio	Ratio
wt	Weight (1000 lbs)	Ratio
qsec	1/4 mile time	Interval
vs	Engine (0 = V-shaped, 1 = straight)	Nominal
am	Transmission (0 = automatic, 1 = manual)	Nominal
gear	Number of forward gears	Ratio
carb	Number of carburetors	Ratio

## Theory Used

$$Y = \beta_0 + \beta_i * X_i + \epsilon_i \quad (1)$$

Y Represents the dependent, or explained, variable.

$$\beta_0 \quad (2)$$

represents the estimated intercept.

$$\beta_i \quad (3)$$

represents the slope of the estimated vector.

$$X_i \quad (4)$$

represents the independent, or control, variable.

$$\epsilon_i \quad (5)$$

represents some error term.

## Application of SLR to the mtcars data set

### Making the SLR function: myslr

```
myslr <- function(data,
                  y, yName,
                  x, xName,
                  sizeVar, sizeVarName,
                  colVar, colVarName,
                  titleVar)
{
  # Open Window to View Plot
  windows(title = "Linear Estimation Graph for Y on X")

  # Create Plot
  plot <- ggplot(
    # Data
    data,

    # Aesthetic Mapping
    aes(x, y,
        color = colVar,
        size = sizeVar)) +

    # Add Scatter Layer
    geom_point(alpha = 2/5) +

    # Add Linear Estimation
    geom_smooth(method = "lm",
                formula = y ~ x,
                color = "grey35") +

    # Titles
    labs(title = titleVar,
         subtitle = " ",
         x = xName,
         y = yName,
         col = colVarName,
         size = sizeVarName) +
```

```

        # Theme
        theme_get()

# show Plot
print(plot)

# Save plot
ggsave(filename = paste0(titleVar, ".png"),
        plot      = plot,
        height    = 6,
        width     = 8)

# Linear Estimation and Summary Output

## Linear Regression (returned)
y.lm <- lm(y ~ x)

## Linear Regression Output (void)
print(summary(y.lm))

## Confidence Interval at 95% (void)
CI <- ciReg(y.lm)
CI
write.csv(CI, file = "Confidence Intervals.csv")

## Check assumptions and save .png
png("Normal Interval Check.png", height = 150, width = 500)
normcheck(y.lm)
dev.off()

## Check residuals and save .png
png("Fitted vs. residuals Plot.png", height = 250, width = 500)
plot(y.lm, which = 1)
dev.off()

## Linear Estimation
return(y.lm)
}

```

## Invokemyslr function using the mtcars data set

```

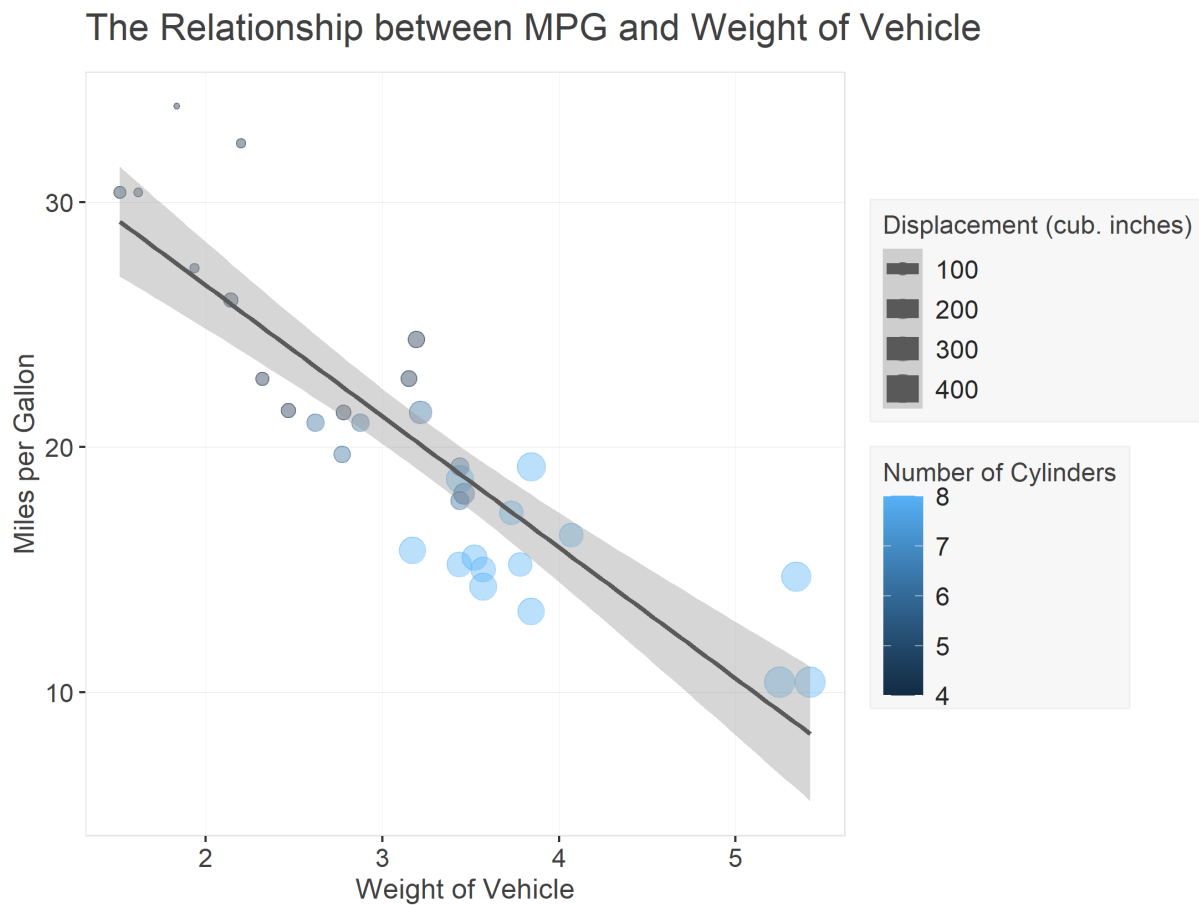
# Call Get Linear Estimation for y on x
y.lm <- myslr(data = mtcars,
              mtcars$mpg, "Miles per Gallon",
              mtcars$wt,  "Weight of Vehicle",
              mtcars$disp, "Displacement (cub. inches)",
              mtcars$cyl,  "Number of Cylinders",
              "The Relationship between MPG and Weight of Vehicle")

##
## Call:
## lm(formula = y ~ x)
##
## Residuals:
##      Min       1Q   Median       3Q      Max

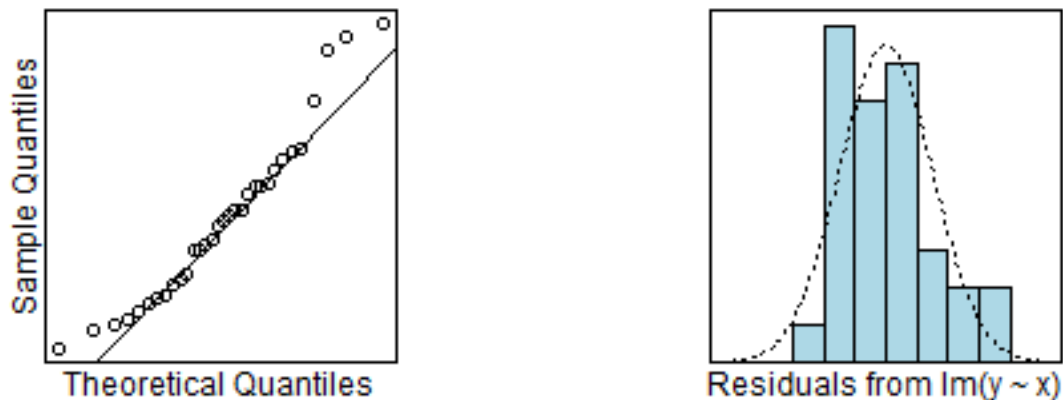
```

```
## -4.5432 -2.3647 -0.1252 1.4096 6.8727
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  37.2851     1.8776  19.858 < 2e-16 ***
## x           -5.3445     0.5591  -9.559 1.29e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.046 on 30 degrees of freedom
## Multiple R-squared:  0.7528, Adjusted R-squared:  0.7446
## F-statistic: 91.38 on 1 and 30 DF,  p-value: 1.294e-10
##
##             95 % C.I.lower    95 % C.I.upper
## (Intercept)   33.45050       41.11975
## x            -6.48631       -4.20263
# Coefficient list
coefsList <- y.lm$coefficients
```

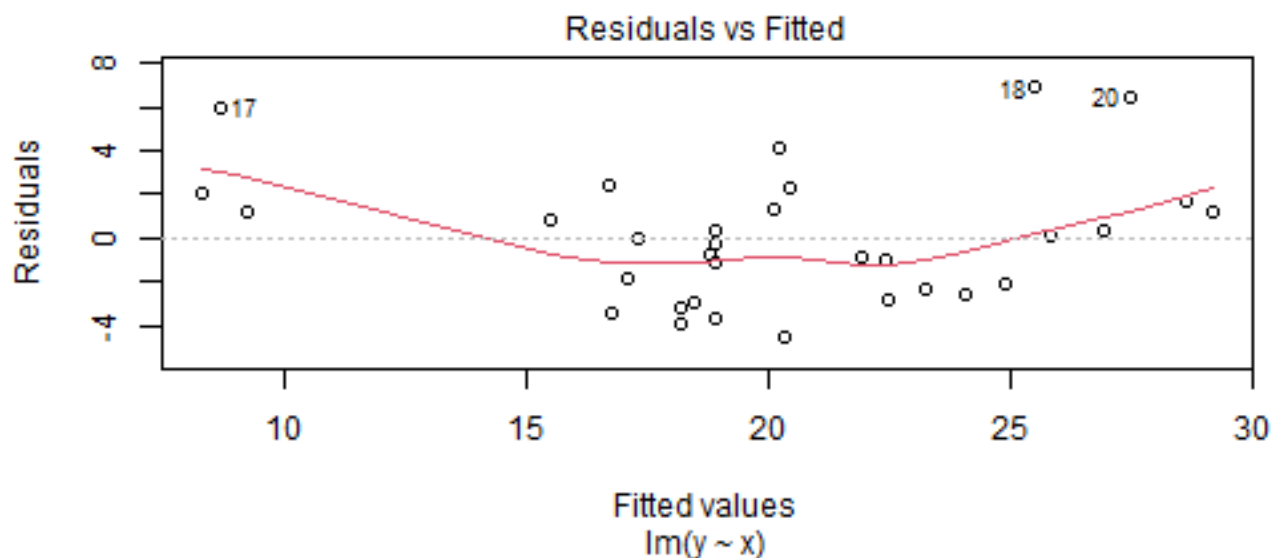
## Plot Output



## Normal Interval Check



## Fitted vs. Residuals



## Interpretation of Model

Within the model, it estimates that an increase of 1,000 pounds in weight of a given car decreases the miles per gallon of the vehicle by 5.34. Additionally, the model estimates that changes in weight account for 75.28% of the variation in the car's miles per gallon.

At a 95% level of confidence, the model estimates the lower bound to be a 6.49 decrease in miles per gallon when increasing the weight of a car by 1,000 pounds. Alternatively, the model estimates the upper bound to be a 4.20 decrease in miles per gallon when increasing the weight of a car by 1,000 pounds.

## Validity of the model

Although the model estimates a narrow confidence interval with a relatively high R-squared value, we may not assume that solely weight accounts for the full 76.28% variation in miles per gallon. This variable could easily be correlated with another relevant variable, thus confounding the simple linear regression.

# Bootstrap

## Make Bootstrap function

```
myboot <- function(iter = 10000, # num iterations
                  x,          # dataset
                  fun = "var", #
                  alpha = 0.05, # 95% confidence
                  cx = 1.5,
                  ...
                  )
{
  # Get Sample size
  n = length(x)

  # Create Sample
  y = sample(x,
            n * iter,
            replace = TRUE)

  # Form Matrix from sample
  rs.mat = matrix(y, # data from sampling
                nrow = n,
                ncol = iter,
                byrow = TRUE) # sort by row

  # Variance
  xstat = apply(rs.mat, 2, fun) # vector containing iter vals

  # Form confidence interval
  ci = quantile(xstat,
               c(alpha / 2,
                 1 - alpha / 2)
               )

  # Send summary Statistics to the console

  ## Confidence Interval Out
  print("-----")
  print(paste0("Confidence Interval at Alpha = ", alpha))
  print("-----")
  print(ci)

  ## Form matrix of sample stats
  statNames <- c("Mean:", "Median:", "Standard Deviation:")
  statVals <- c(comma(mean(xstat), digits = 2),
               comma(median(xstat), digits = 2),
               comma(sd(xstat), digits = 2)
               )
  summaryStats <- matrix(data = c(statNames,
                                   statVals),
                        nrow = 3,
                        ncol = 2)

  ## Sample Stats Out
```

```

print("-----")
print("Summary Statistics from Bootstrap Sampling:")
print("-----")
print(summaryStats)

# Create a histogram from Bootstrap sampling
para <- hist(
  xstat,
  freq = FALSE, # along numberline, not freq
  las = 1,
  main = paste0("Histogram of Bootstrap Sample Statistics",
    "\n",
    "Alpha = ", alpha, "; ",
    "Tiers = ", comma(iter, digits = 0)),
  col = alpha("skyblue3", 2/5),
  ...)

# Save Bootstrap plot
png("Bootstrap Estimate Plot.png", height = 150, width = 500)
para
dev.off()

# write a file to current directory with sample data
write.csv(xstat, "Bootstrap Estimations.csv")

return(xstat)
}

```

## Invoke myboot function

Get data from mtcars, while only containing 4 cylinder cars

```

# Get dataset from mtcars
df <- mtcars %>%

## filter to only 4-cylinder cars
filter(cyl == 4) %>%

## Only show vars of interest
select(mpg)

## Store as vector
df.vector <- df$mpg

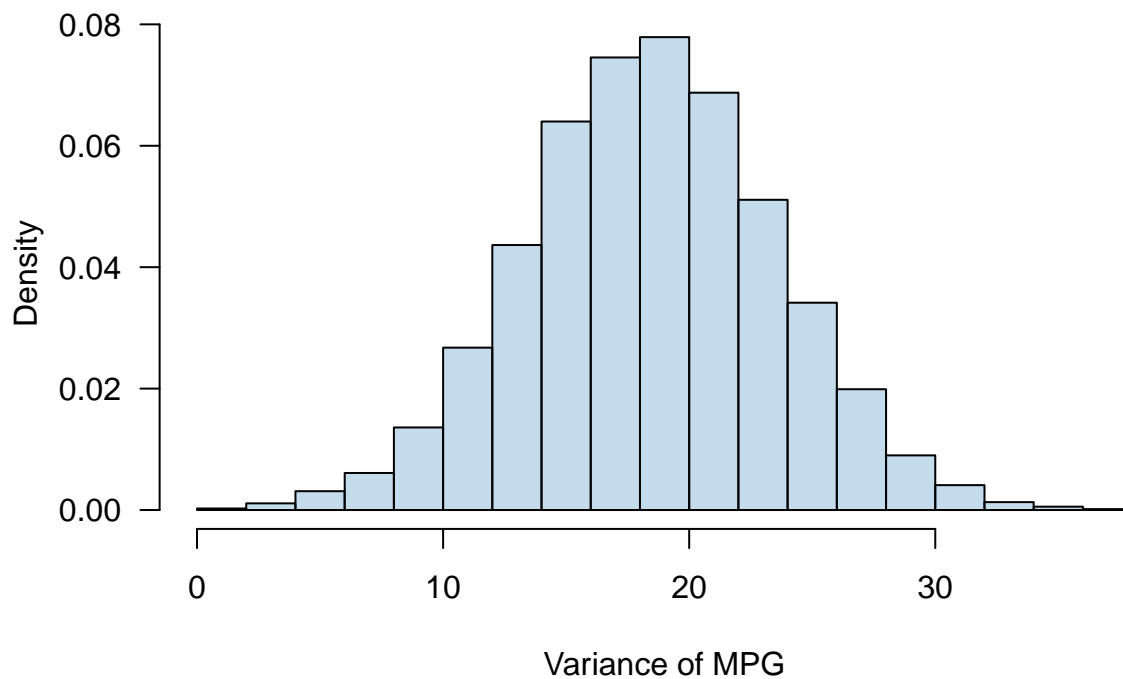
```

Call myboot function

```
varianceData <- myboot(iter = 10000,  
                        x     = df.vector,  
                        alpha = 0.05,  
                        cx    = 1.5,  
                        xlab  = "Variance of MPG")
```

```
## [1] "-----"  
## [1] "Confidence Interval at Alpha = 0.05"  
## [1] "-----"  
##      2.5%      97.5%  
## 8.318727 28.503005  
## [1] "-----"  
## [1] "Summary Statistics from Bootstrap Sampling:"  
## [1] "-----"  
##      [,1]      [,2]  
## [1,] "Mean:"      "18.4410419454545"  
## [2,] "Median:"     "18.4322727272727"  
## [3,] "Standard Deviation:" "5.10731380723669"
```

### Histogram of Bootstrap Sample Statistics Alpha = 0.05; Tiers = 10,000



Bootstrap Plots



Figure 1:  $h!$