R Lab I

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Roadmap

- R Markdown
- Seeing theory
- Exploring CEO salary dataset
- Problem set

R Markdown

This is an R R Markdown Notebook.

Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents.

- R R Markdown mainly consists of three parts: YAML header, texts, and `r` code chunck.
- RMarkdown usually begins with a YAML header (optional) surrounded by `---`s, the header specifies meta information.
- You can write your texts with features like using header `#`, *italic*, **bold** , etc.
- When you run code within R Markdown, the results show below the chunk of code.
- You can set chunk global options that apply to every chunk in your file. This is done by calling `knitr::opts_chunk$set` in this code chunk. However, these global defaults can be overwritten in individual chunk headers.
- To understand more chunck options like `echo = TRUE`, `message = FALSE`, and `warning = FALSE`, check RMarkdown tips and tricks.
- Insert a new chunk: click the *Insert Chunk* button & using *Cmd+Option+I*.
- Execute chunk: click the *Run* button within the chunk or using *Cmd+Shift+Enter*.
- Click the **Knit** button to generate a document that includes both contents as well as the output of any embedded R code chunks within the document.

Seeing Theory

"**Seeing Theory** is a project designed and created by Daniel Kunin with support from Brown University's Royce Fellowship Program. The goal of the project is to make statistics more accessible to a wider range of students through interactive visualizations."

Check this: https://seeing-theory.brown.edu/basic-probability/index.html

Importing dataset

Here are various ways of importing data:

```r
# load packages
library(readr)
library(tidyverse)
library(haven)

# set working directory (set your own directory)
setwd("./")

# RData (R)
load("UNpop.RData")

# csv
UNpop <- read_csv("./UNpop.csv") # readr package

# dta (Stata)
UNpop_stata_new <- read_dta("UNpop.dta") # haven package (new)
```

Read CEO data

```r
ceo = read_dta("./CEOSAL2.DTA") # read CEO dataset
```

View Data

Explore CEO data

```r
class(ceo) # type of object
```

```
## [1] "tbl_df"     "tbl"        "data.frame"
```

```r
names(ceo) # variable names (column)
```

```
##  [1] "salary"   "age"      "college"  "grad"     "comten"   "ceoten"  
##  [7] "sales"    "profits"  "mktval"   "lsalary"  "lsales"   "lmktval" 
## [13] "comtensq" "ceotensq" "profmarg"
```

```r
nrow(ceo) # number of rows
```

```
## [1] 177
```

```r
ncol(ceo) # number of columns
```

```
## [1] 15
```

```r
summary(ceo)  # summarize the dataset
```

```
##      salary            age           college            grad       
##  Min.   : 100.0   Min.   :33.00   Min.   :0.0000   Min.   :0.0000  
##  1st Qu.: 471.0   1st Qu.:52.00   1st Qu.:1.0000   1st Qu.:0.0000  
##  Median : 707.0   Median :57.00   Median :1.0000   Median :1.0000  
##  Mean   : 865.9   Mean   :56.43   Mean   :0.9718   Mean   :0.5311  
##  3rd Qu.:1119.0   3rd Qu.:62.00   3rd Qu.:1.0000   3rd Qu.:1.0000  
##  Max.   :5299.0   Max.   :86.00   Max.   :1.0000   Max.   :1.0000  
##      comten         ceoten           sales          profits      
##  Min.   : 2.0   Min.   : 0.000   Min.   :   29   Min.   :-463.0  
##  1st Qu.:12.0   1st Qu.: 3.000   1st Qu.:  561   1st Qu.:  34.0
##  Median :23.0   Median : 6.000   Median : 1400   Median :  63.0
##  Mean   :22.5   Mean   : 7.955   Mean   : 3529   Mean   : 207.8
##  3rd Qu.:33.0   3rd Qu.:11.000   3rd Qu.: 3500   3rd Qu.: 208.0
##  Max.   :58.0   Max.   :37.000   Max.   :51300   Max.   :2700.0
##      mktval          lsalary          lsales          lmktval
##  Min.   :  387   Min.   :4.605   Min.   : 3.367   Min.   : 5.958
##  1st Qu.:  644   1st Qu.:6.155   1st Qu.: 6.330   1st Qu.: 6.468
##  Median : 1200   Median :6.561   Median : 7.244   Median : 7.090
##  Mean   : 3600   Mean   :6.583   Mean   : 7.231   Mean   : 7.399
##  3rd Qu.: 3500   3rd Qu.:7.020   3rd Qu.: 8.161   3rd Qu.: 8.161
##  Max.   :45400   Max.   :8.575   Max.   :10.845   Max.   :10.723
##     comtensq         ceotensq         profmarg
##  Min.   :   4.0   Min.   :   0.0   Min.   :-203.077
##  1st Qu.: 144.0   1st Qu.:   9.0   1st Qu.:   4.231
##  Median : 529.0   Median :  36.0   Median :   6.834
##  Mean   : 656.7   Mean   : 114.1   Mean   :   6.420
##  3rd Qu.:1089.0   3rd Qu.: 121.0   3rd Qu.:  10.947
##  Max.   :3364.0   Max.   :1369.0   Max.   :  47.458
```

```
summary(ceo$salary)  # summarize the variable
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   100.0   471.0   707.0   865.9  1119.0  5299.0
```

```
length(ceo) # length of a dataset means # of variables
```

```
## [1] 15
```

```
length(ceo$salary)  # length of a variable means # of obs
```

```
## [1] 177
```

```
head(ceo) # show the first 5 rows of the dataset
```

```
## # A tibble: 6 x 15
##   salary   age college  grad comten ceoten sales profits mktval lsalary
##    <dbl> <dbl>   <dbl> <dbl>  <dbl>  <dbl> <dbl>   <dbl>  <dbl>   <dbl>
## 1   1161    49       1     1      9      2  6200     966  23200    7.06
## 2    600    43       1     1     10     10   283      48   1100    6.40
## 3    379    51       1     1      9      3   169      40   1100    5.94
## 4    651    55       1     0     22     22  1100     -54   1000    6.48
## 5    497    44       1     1      8      6   351      28    387    6.21
## 6   1067    64       1     1      7      7 19000     614   3900    6.97
## # ... with 5 more variables: lsales <dbl>, lmktval <dbl>, comtensq <dbl>,
## #   ceotensq <dbl>, profmarg <dbl>
```

```
table(ceo$grad) # show the frequency of a categorical variable
```

```
##
##  0  1
## 83 94
```

```
ceo_grate <- ceo[ceo$grad == 1,] # fiter by condition(s)

ceo_over_1kk <- ceo[ceo$salary > 1000,] # fiter by conditionn(s)

ceo_1to5 <- ceo[c(1:5), ] # filter by index
```

```r
ceo_1 <- ceo[,c("salary", "profmarg")] # select by variable name

ceo_var1to5 <- ceo[,c(1:5)] # select by index

# rename variable
names(ceo_1)
```

```
## [1] "salary"   "profmarg"
```

```r
names(ceo_1)[2] <- "profit_margin"
names(ceo_1)
```

```
## [1] "salary"        "profit_margin"
```

```r
rm(ceo_1) # remove dataset
```

Mean and Variance

population mean:

$$\mu = \frac{\sum_{i=1}^{n} x_i}{n}$$

sample mean:

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

```r
m_salary <- sum(ceo$salary)/length(ceo$salary)
m_salary
```

```
## [1] 865.8644
```

```r
mean(ceo$salary)
```

```
## [1] 865.8644
```

population variance:

$$\sigma^2 = \mathrm{E}[(X - \mathrm{E}[X])^2]$$

sample variance:

$$s^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}$$

```r
sum( (ceo$salary - m_salary)^2 ) / (length(ceo$salary)-1)
```

```
## [1] 345261.2
```

```r
var(ceo$salary) # R computes sample variance
```

```
## [1] 345261.2
```

Covariance & Correlation

population covariance:

$$Cov(X,Y) = E[(X - E(X)(Y - E(Y))]$$

sample covariance:

$$Cov(X,Y) = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{n-1}$$

We would like to look at the covariance and correlation between CEO's salary and firm performance measured by profit margins.

```
cov(ceo$salary,ceo$profmarg) # covariance
```

```
## [1] -303.6705
```

```
m_profmarg = sum(ceo$profmarg)/length(ceo$profmarg)
sum((ceo$salary - m_salary) * (ceo$profmarg - m_profmarg ))/(length(ceo$profmarg) - 1)
```

```
## [1] -303.6705
```

$$Corr(X,Y) = \frac{E[(X - E(X)E(Y - E(Y))]}{\sqrt{Var(X)Var(Y)}}$$

```
cor(ceo$salary,ceo$profmarg) # correlation
```

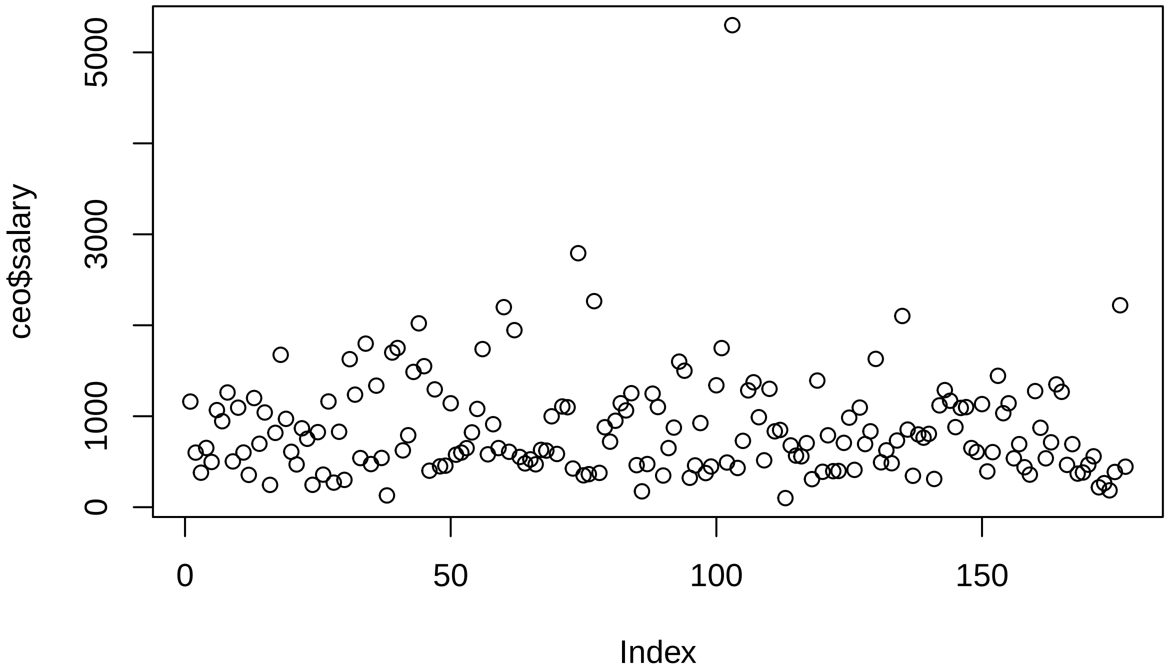
```
## [1] -0.02893538
```

```
# How to compute manually?
# Show it in the problem set, it should be the same as the result from cor()
```

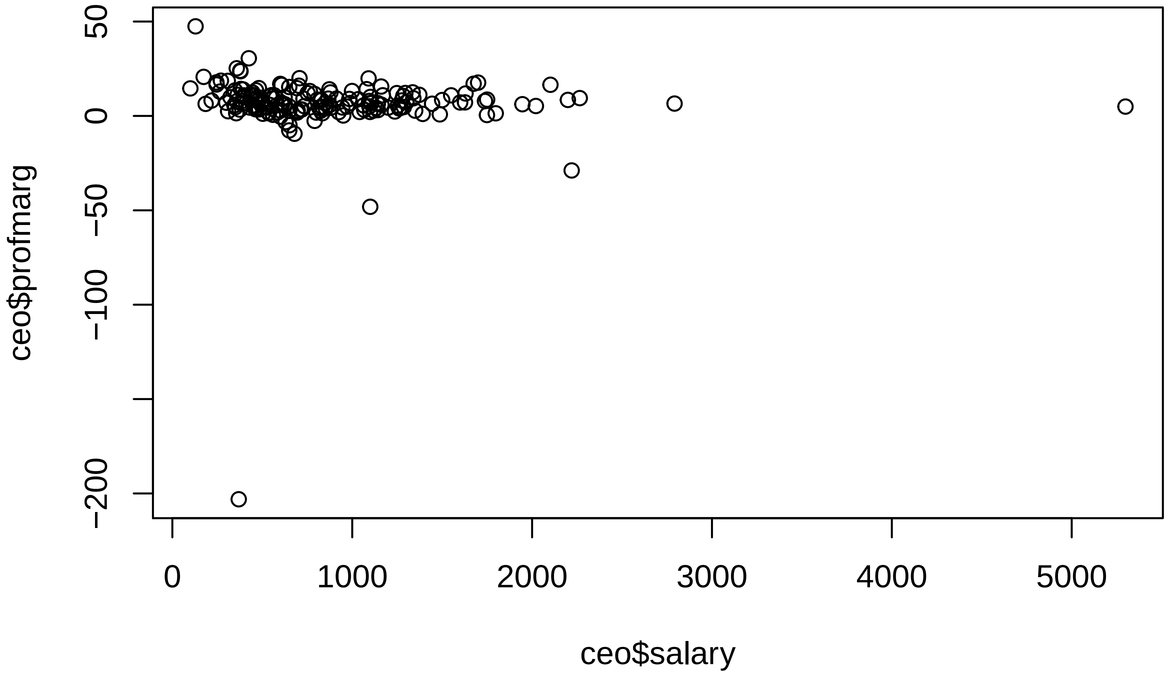
CDF and PDF of Normal Distribution

R basic graph

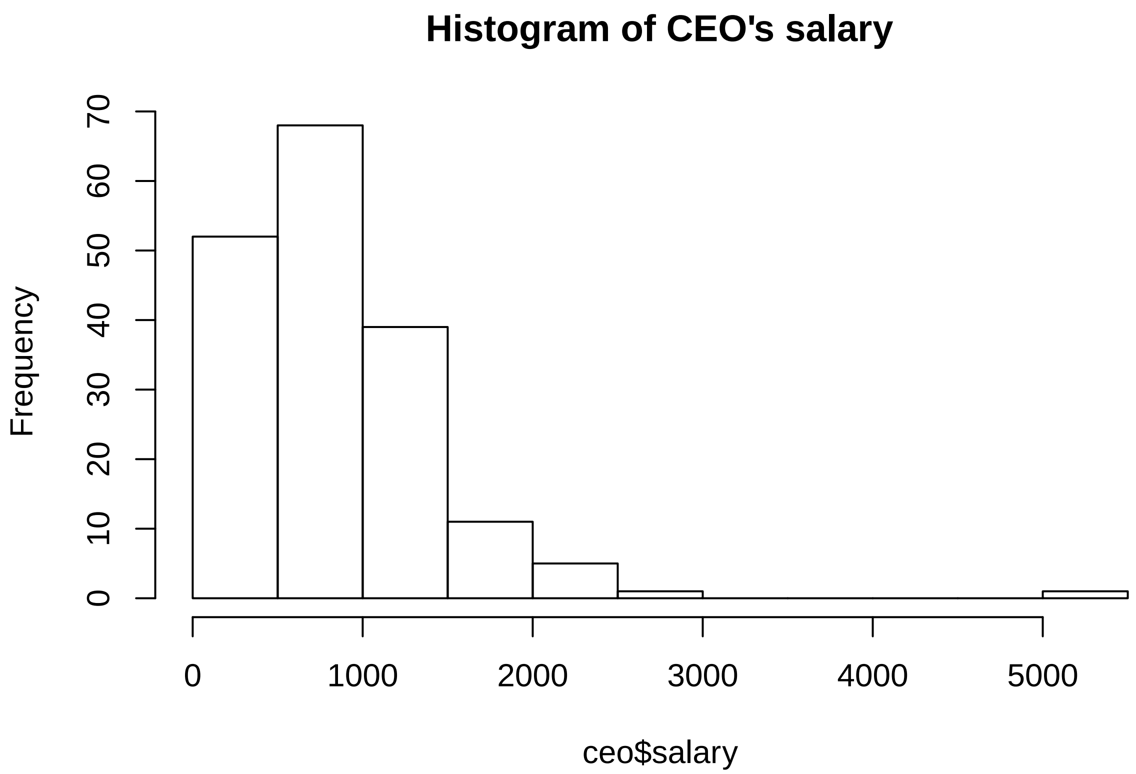
```
plot(ceo$salary) # one-way scatterplot
```



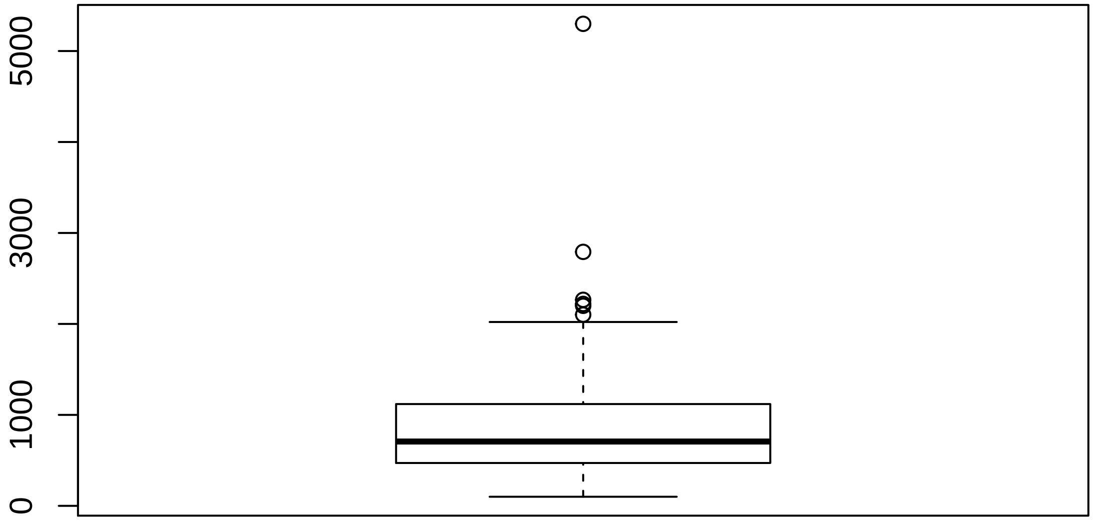
```r
plot(ceo$salary, ceo$profmarg) # two-way scatterplot
```



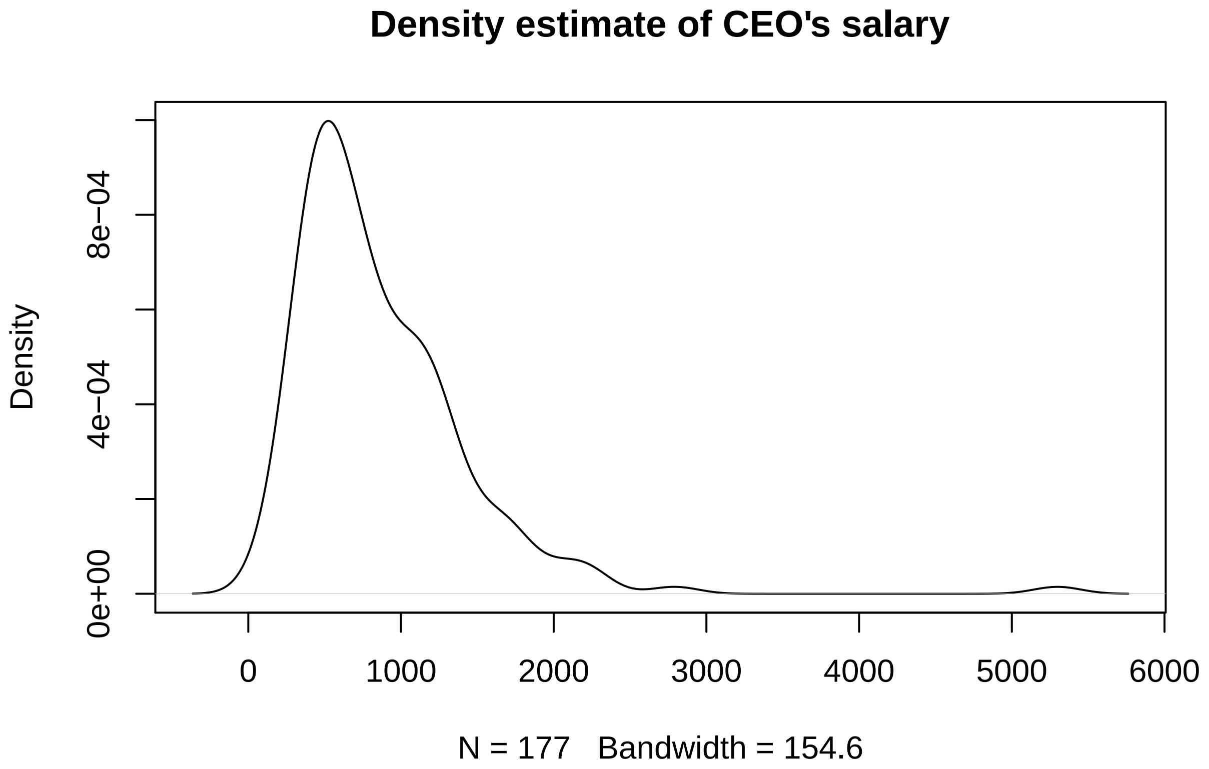
```r
hist(ceo$salary, main = "Histogram of CEO's salary") # histogram
```



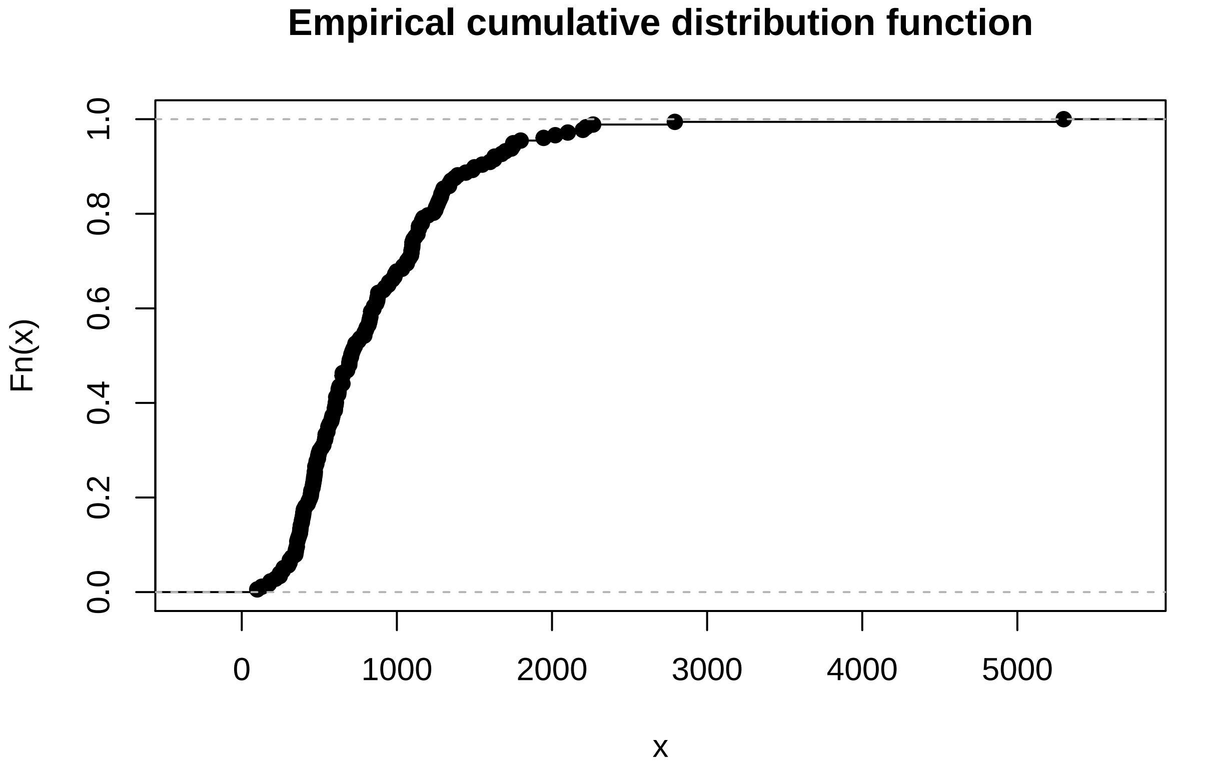
```
boxplot(ceo$salary) # boxplot
```



```
plot(density(ceo$salary), main = "Density estimate of CEO's salary") # pdf
```



```
plot(ecdf(ceo$salary),main = "Empirical cumulative distribution function") # cdf
```



Other resources

Installing RMarkdown: https://bookdown.org/yihui/rmarkdown/

Frequently asked questions: https://yihui.name/knitr/faq/

RMarkdown cheatsheet: https://www.rstudio.com/wp-content/uploads/2015/02/rmarkdown-cheatsheet.pdf

R Style: http://adv-r.had.co.nz/Style.html