GR5206 Midterm Exam

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The STAT GR5206 Fall 2018 Midterm is open notes, open book(s), open computer and online resources are allowed. Students are **not** allowed to communicate with any other people regarding the exam. This includes emailing fellow students, using WeChat and other similar forms of communication. Before the exam, the students should **turn off** their cellphone and pass it to the left side of each row. At the same time, please **close** the mailbox and **log out** WeChat and all the other apps for messaging and chatting. If there is any suspicion of one or more students cheating, further investigation will take place. If students do not follow the guidelines, they will receive a zero on the exam and potentially face more severe consequences. The exam will be posted on Canvas at **2:50PM**. Students are required to submit both the .pdf and .Rmd files on Canvas (or .html if you must) by **4:30PM**. Late exams will not be accepted.

Part 1 (Google Play Store Apps Data - Split/Apply/Combine and R plot, 11 + 2 pts)

We work on the `apps` dataset which contains approximately $7,700$ Google Play Store apps. There are 13 features that describe a given app. They are:

- **App** – Application name.
- **Category** – Category the app belongs to.
- **Rating** – Overall user rating of the app (between 0 and 5).
- **Reviews** – Number of user reviews for the app.
- **Size** – Size of the app.
- **Installs** – Number of user downloads/installs for the app.
- **Type** – Paid of Free
- **Price** – Price of the app
- **Content Rating** Age group the app is targeted at
- **Genres** An app can belong to multiple genres (apart from its main category). For example, a musical family game will belong to Music, Game, Family genres.
- **Last Updated** Date when the app was last updated on Play Store
- **Current Ver** Current version of the app available on Play Store
- **Android Ver** Minimum required Android version

Read in the dataset using the following code:

```
apps<-read.csv("apps.csv", header = T)
apps$Reviews<-as.numeric(apps$Reviews)
apps$Installs<-factor(apps$Installs, level= c("1+", "5+", "10+", "50+", "100+", "500+", "1,000+", "5,00
head(apps)
```

```
##                                                 App       Category Rating
## 1     Photo Editor & Candy Camera & Grid & ScrapBook ART_AND_DESIGN    4.1
## 2                               Coloring book moana ART_AND_DESIGN    3.9
```

```
## 3 U Launcher Lite - FREE Live Cool Themes, Hide Apps ART_AND_DESIGN    4.7
## 4                                Sketch - Draw & Paint ART_AND_DESIGN    4.5
## 5              Pixel Draw - Number Art Coloring Book ART_AND_DESIGN    4.3
## 6                         Paper flowers instructions ART_AND_DESIGN    4.4
##   Reviews Size    Installs Type Price Content.Rating
## 1     159 19.0     10,000+ Free     0       Everyone
## 2     967 14.0    500,000+ Free     0       Everyone
## 3   87510  8.7  5,000,000+ Free     0       Everyone
## 4  215644 25.0 50,000,000+ Free     0           Teen
## 5     967  2.8    100,000+ Free     0       Everyone
## 6     167  5.6     50,000+ Free     0       Everyone
##                      Genres Last.Updated        Current.Ver  Android.Ver
## 1              Art & Design     7-Jan-18              1.0.0 4.0.3 and up
## 2 Art & Design;Pretend Play    15-Jan-18              2.0.0 4.0.3 and up
## 3              Art & Design     1-Aug-18              1.2.4 4.0.3 and up
## 4              Art & Design     8-Jun-18 Varies with device   4.2 and up
## 5   Art & Design;Creativity    20-Jun-18                1.1   4.4 and up
## 6              Art & Design    26-Mar-17                  1   2.3 and up
```

Problem 1.0

Check the dimension of `apps`, make sure that there are $7,726$ lines and 13 variables (features). [1 pt]

```
# code goes here
dim(apps)
```

```
## [1] 7726   13
```

Prblem 1.1

In order to get an overview of the dataset, we want to check some summary statistics of each variable, and this can be done by calling the `R` function `summary()`. Compute the summary statistics of all 13 variables and display the results in a **list**. To receive full credit, you must use a vectorized function from the `apply` family or `plyr` family. [2 pts]

```
# code goes here
lapply(apps, summary)
```

```
## $App
##                                     ROBLOX
##                                          9
##                                8 Ball Pool
##                                          7
##                             Candy Crush Saga
##                                          7
##                               Bubble Shooter
##                                          6
##                                  Helix Jump
##                                          6
##                                       Nick
##                                          6
##                               Subway Surfers
##                                          6
##                                 Temple Run 2
```

```
##                                                 6
##                                  Zombie Catchers
##                                                 6
##                                Angry Birds Classic
##                                                 5
##     BeautyPlus - Easy Photo Editor & Selfie Camera
##                                                 5
##                                   Farm Heroes Saga
##                                                 5
##                                         Flow Free
##                                                 5
##                                            Granny
##                                                 5
##                     MeetMe: Chat & Meet New People
##                                                 5
##                           Plants vs. Zombies FREE
##                                                 5
##                                        Skyscanner
##                                                 5
## theScore: Live Sports Scores, News, Stats & Videos
##                                                 5
##                            Wish - Shopping Made Fun
##                                                 5
##              A&E - Watch Full Episodes of TV Shows
##                                                 4
##                                    Angry Birds Rio
##                                                 4
##                            Babbel - Learn Languages
##                                                 4
##                                      Block Puzzle
##                                                 4
##   busuu: Learn Languages - Spanish, English & More
##                                                 4
##                                    Clash of Clans
##                                                 4
##                                      Clash Royale
##                                                 4
##                                DC Super Hero Girls
##                                                 4
##                                 DRAGON BALL LEGENDS
##                                                 4
##                                 ESPN Fantasy Sports
##                                                 4
##  Expedia Hotels, Flights & Car Rental Travel Deals
##                                                 4
##                                   Garena Free Fire
##                                                 4
##                                        Google News
##                                                 4
##                                  Hill Climb Racing
##                                                 4
##                      imo free video calls and chat
##                                                 4
##                                             Meetup
```

```
##                                                4
##                                  My Talking Angela
##                                                4
##                                              Pou
##                                                4
##                                        PUBG MOBILE
##                                                4
## Rosetta Stone: Learn to Speak & Read New Languages
##                                                4
## Shutterfly: Free Prints, Photo Books, Cards, Gifts
##                                                4
##                                Talking Tom Gold Run
##                                                4
##                                              TED
##                                                4
##                                           The CW
##                                                4
##                                         WatchESPN
##                                                4
##                                        Wordscapes
##                                                4
##                                  Zombie Hunter King
##                                                4
##                                  Adult Dirty Emojis
##                                                3
##                                     Amazon Shopping
##                                                3
##                          BBW Dating & Plus Size Chat
##                                                3
##                                BET NOW - Watch Shows
##                                                3
##  Block Craft 3D: Building Simulator Games For Free
##                                                3
##                                  Camera for Android
##                                                3
##  Camera360: Selfie Photo Editor with Funny Sticker
##                                                3
##                               Candy Crush Soda Saga
##                                                3
##         Cardiac diagnosis (heart rate, arrhythmia)
##                                                3
##                                         Chick-fil-A
##                                                3
##                                          ClassDojo
##                                                3
##                          CNN Breaking US & World News
##                                                3
##                               Cut the Rope FULL FREE
##                                                3
##                     Daily Yoga - Yoga Fitness Plans
##                                                3
##                          Dog Run - Pet Dog Simulator
##                                                3
##                         Dr. Panda & Toto's Treehouse
```

```
##                                                3
##                           Dream League Soccer 2018
##                                                3
##                                           Dropbox
##                                                3
##                         Elmo Calls by Sesame Street
##                                                3
##                                     Equestria Girls
##                                                3
##                       ES File Explorer File Manager
##                                                3
##                                  Facetune - For Free
##                                                3
##                                              Fancy
##                                                3
##                                   Fashion in Vogue
##                                                3
##                  Firefox Focus: The privacy browser
##                                                3
##                                   Frozen Free Fall
##                                                3
##                                         Google Ads
##                                                3
##                      Gyft - Mobile Gift Card Wallet
##                                                3
##          Hily: Dating, Chat, Match, Meet & Hook up
##                                                3
##    HISTORY: Watch TV Show Full Episodes & Specials
##                                                3
##   Human Anatomy Atlas 2018: Complete 3D Human Body
##                                                3
##                               Hungry Shark Evolution
##                                                3
##                                    IMDb Movies & TV
##                                                3
##                         JackThreads: Men's Shopping
##                                                3
##                       Just She - Top Lesbian Dating
##                                                3
##                        KAYAK Flights, Hotels & Cars
##                                                3
##                                       Khan Academy
##                                                3
##   Lifetime - Watch Full Episodes & Original Movies
##                                                3
##                          LivingSocial - Local Deals
##                                                3
##                                  MARVEL Strike Force
##                                                3
##  Miraculous Ladybug & Cat Noir - The Official Game
##                                                3
##           Movies by Flixster, with Rotten Tomatoes
##                                                3
## muzmatch: Muslim & Arab Singles, Marriage & Dating
```

```
##                                                 3
##  mySugr: the blood sugar tracker made just for you
##                                                 3
##      Nike Training Club - Workouts & Fitness Plans
##                                                 3
##                               NYTimes - Latest News
##                                                 3
##                                            O-Star
##                                                 3
##                                     OkCupid Dating
##                                                 3
##                                       Open Camera
##                                                 3
##            Papumba Academy - Fun Learning For Kids
##                                                 3
##                                Periscope - Live Video
##                                                 3
##                     Pixel Art: Color by Number Game
##                                                 3
##                          PJ Masks: Moonlight Heroes
##                                                 3
##                                           (Other)
##                                              7350
##
## $Category
##      ART_AND_DESIGN   AUTO_AND_VEHICLES              BEAUTY
##                  59                   63                  37
## BOOKS_AND_REFERENCE            BUSINESS              COMICS
##                 144                  246                  48
##       COMMUNICATION              DATING           EDUCATION
##                 211                  173                 110
##       ENTERTAINMENT             EVENTS              FAMILY
##                  90                   38                1617
##             FINANCE      FOOD_AND_DRINK                GAME
##                 266                   84                 974
##  HEALTH_AND_FITNESS      HOUSE_AND_HOME  LIBRARIES_AND_DEMO
##                 223                   56                  62
##           LIFESTYLE MAPS_AND_NAVIGATION             MEDICAL
##                 280                   95                 324
##  NEWS_AND_MAGAZINES           PARENTING     PERSONALIZATION
##                 169                   44                 280
##         PHOTOGRAPHY        PRODUCTIVITY            SHOPPING
##                 236                  235                 179
##              SOCIAL              SPORTS               TOOLS
##                 177                  246                 633
##    TRAVEL_AND_LOCAL       VIDEO_PLAYERS             WEATHER
##                 160                  116                  51
##
## $Rating
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   1.000   4.000   4.300   4.174   4.500   5.000
##
## $Reviews
##     Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
```

```
##        1      107     2324   294777    38959 44893888
##
## $Size
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.008   5.300  14.000  22.959  33.000 100.000
##
## $Installs
##             1+             5+            10+            50+           100+
##              3              9             67             56            303
##           500+         1,000+         5,000+        10,000+        50,000+
##            197            690            420            969            436
##       100,000+       500,000+     1,000,000+     5,000,000+    10,000,000+
##           1037            490           1301            535            825
##    50,000,000+   100,000,000+   500,000,000+ 1,000,000,000+
##            147            201             30             10
##
## $Type
## Free Paid
## 7147  579
##
## $Price
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.000   0.000   0.000   1.128   0.000 400.000
##
## $Content.Rating
##     Everyone Everyone 10+   Mature 17+         Teen
##         6172          318          368          868
##
## $Genres
##                             Tools                     Entertainment
##                               633                               448
##                         Education                           Medical
##                               417                               324
##                            Action                    Personalization
##                               322                               280
##                         Lifestyle                           Finance
##                               279                               266
##                            Sports                          Business
##                               260                               246
##                       Photography                      Productivity
##                               236                               235
##                  Health & Fitness                     Communication
##                               223                               211
##                            Arcade                        Simulation
##                               186                               182
##                          Shopping                            Social
##                               179                               177
##                            Dating                  News & Magazines
##                               173                               169
##                            Casual                    Travel & Local
##                               160                               159
##                  Books & Reference           Video Players & Editors
##                               144                               115
##                            Puzzle                      Role Playing
```

```
##                            108                            103
##                       Strategy                Maps & Navigation
##                             96                             95
##                    Food & Drink                         Racing
##                             84                             83
##                      Adventure                Auto & Vehicles
##                             68                             63
##                Libraries & Demo                    House & Home
##                             62                             56
##                   Art & Design                        Weather
##                             53                             51
##                         Comics            Education;Education
##                             47                             41
##                           Card                          Board
##                             39                             38
##                         Events                         Beauty
##                             38                             37
##                      Parenting           Educational;Education
##                             35                             33
##                         Casino                    Educational
##                             32                             31
##              Casual;Pretend Play                         Trivia
##                             30                             27
##                           Word           Education;Pretend Play
##                             24                             22
##         Educational;Pretend Play              Puzzle;Brain Games
##                             18                             18
##       Action;Action & Adventure       Entertainment;Music & Video
##                             16                             16
##       Casual;Action & Adventure                          Music
##                             15                             15
##              Board;Brain Games         Racing;Action & Adventure
##                             14                             14
##     Adventure;Action & Adventure         Arcade;Action & Adventure
##                             13                             13
##              Casual;Brain Games     Simulation;Action & Adventure
##                             13                             11
##              Casual;Creativity          Art & Design;Creativity
##                              7                              6
##     Education;Action & Adventure          Educational;Brain Games
##                              6                              6
##        Entertainment;Brain Games             Education;Creativity
##                              6                              5
##           Educational;Creativity          Parenting;Music & Video
##                              5                              5
##        Puzzle;Action & Adventure   Role Playing;Action & Adventure
##                              5                              5
##        Role Playing;Pretend Play    Educational;Action & Adventure
##                              5                              4
##         Board;Action & Adventure                Casual;Education
##                              3                              3
##          Education;Music & Video  Entertainment;Action & Adventure
##                              3                              3
##              Music;Music & Video              Parenting;Education
```

```
##                                 3                                 3
##               Simulation;Education             Simulation;Pretend Play
##                                 3                                 3
##                Adventure;Education           Art & Design;Pretend Play
##                                 2                                 2
##         Books & Reference;Education             Card;Action & Adventure
##                                 2                                 2
##                Casual;Music & Video            Entertainment;Creativity
##                                 2                                 2
##          Entertainment;Pretend Play                  Puzzle;Creativity
##                                 2                                 2
##           Sports;Action & Adventure         Strategy;Action & Adventure
##                                 2                                 2
## Video Players & Editors;Creativity               Adventure;Brain Games
##                                 2                                 1
##                 Arcade;Pretend Play                 Board;Pretend Play
##                                 1                                 1
##                    Card;Brain Games                  Comics;Creativity
##                                 1                                 1
##                Education;Brain Games                           (Other)
##                                 1                                13
##
## $Last.Updated
##  3-Aug-18 31-Jul-18  1-Aug-18  2-Aug-18 30-Jul-18 25-Jul-18 26-Jul-18
##       205       189       178       173       130       124       114
## 27-Jul-18 24-Jul-18 16-Jul-18 18-Jul-18 23-Jul-18  6-Aug-18 11-Jul-18
##       101        98        93        84        84        81        80
## 17-Jul-18 12-Jul-18  3-Jul-18 19-Jul-18  5-Jul-18 20-Jul-18  4-Aug-18
##        73        71        71        68        66        63        63
## 24-May-18  9-Jul-18  6-Jul-18 13-Jul-18 27-Jun-18 25-May-18 26-Jun-18
##        58        58        56        55        48        46        46
## 13-Jun-18  6-Jun-18 19-Jun-18  2-Jul-18 29-Jun-18 25-Jun-18  5-Aug-18
##        41        41        38        37        37        36        36
## 20-Jun-18 28-Jul-18  4-Jul-18 10-Jul-18 21-Jun-18  5-Jun-18 12-Jun-18
##        35        35        34        33        33        33        32
## 29-Jul-18  7-Aug-18 23-May-18  8-Jun-18 15-Jun-18 21-May-18 31-May-18
##        30        30        29        29        28        28        27
## 18-Jun-18 28-Jun-18 30-May-18  7-Jun-18  1-Jun-18 22-May-18 29-May-18
##        26        26        26        26        25        25        25
## 11-Jun-18 15-Jul-18 18-May-18  8-Jul-18 26-Apr-18 14-Jun-18 28-May-18
##        24        24        24        24        23        22        22
##  5-Feb-17  1-Jul-18  6-Mar-18 22-Jun-18  4-May-18 15-May-18  7-Jul-18
##        22        21        20        19        19        18        18
## 10-May-18 16-Mar-18 17-May-18 20-Mar-18 23-Apr-18  3-Apr-18  4-Jun-18
##        17        17        17        17        17        17        17
##  5-Mar-18 11-Apr-18 21-Jul-18 22-Jul-18 28-Mar-18 29-Mar-18  3-May-18
##        17        16        16        16        15        15        15
##  5-Apr-18  9-Apr-18  9-May-18 13-Mar-18 15-Feb-18 17-Apr-18  2-May-18
##        15        15        15        14        14        14        14
## 27-Mar-18  9-Jun-18 12-Oct-17 13-Apr-18 15-Mar-17 18-Apr-18 19-Jan-18
##        14        14        13        13        13        13        13
##  2-Jan-18   (Other)
##        13      3533
##
```

```
## $Current.Ver
##                   1                 1.1                 1.2
##                 476                 206                 133
##                   2                 1.3                 1.4
##                 128                 119                  82
##               1.0.1                 1.5 Varies with device
##                  80                  75                  73
##               1.0.0                 1.6                 2.1
##                  67                  57                  56
##               1.0.2               1.0.4                 1.7
##                  51                  47                  46
##               1.0.3                   3               1.0.6
##                  44                  44                  43
##               1.2.1               2.0.0                 1.8
##                  43                  41                  39
##               1.0.5                   4               1.1.0
##                  38                  37                  36
##               1.2.0                 1.9               1.0.9
##                  36                  33                  32
##               2.3.2                 2.4               1.1.1
##                  32                  32                  31
##                 2.2                 3.1                   5
##                  31                  30                  29
##               1.4.0               2.0.1                 2.5
##                  27                  26                  26
##               1.0.7               1.0.8               1.1.3
##                  25                  25                  24
##               1.1.2               1.3.0               3.0.0
##                  23                  22                  22
##               1.2.2               1.2.3               2.1.1
##                  21                  21                  21
##                 3.3                 5.1                   6
##                  21                  21                  21
##                 2.3               3.1.0                 2.6
##                  20                  20                  19
##                 4.1               1.1.4                 8.2
##                  19                  18                  18
##               1.1.6               1.5.0               2.0.5
##                  17                  17                  17
##                   7               1.3.1               2.1.0
##                  17                  16                  16
##               2.1.2                 2.7                 2.9
##                  16                  16                  16
##                1.01               1.5.1               1.6.1
##                  15                  15                  15
##               2.4.0               2.5.1               3.0.1
##                  15                  15                  15
##               2.0.7               2.4.1               3.1.4
##                  14                  14                  14
##                1.03               1.1.5               1.2.7
##                  13                  13                  13
##                 2.8                 3.2                 5.2
##                  13                  13                  13
##               1.2.6               1.5.2               1.6.2
```

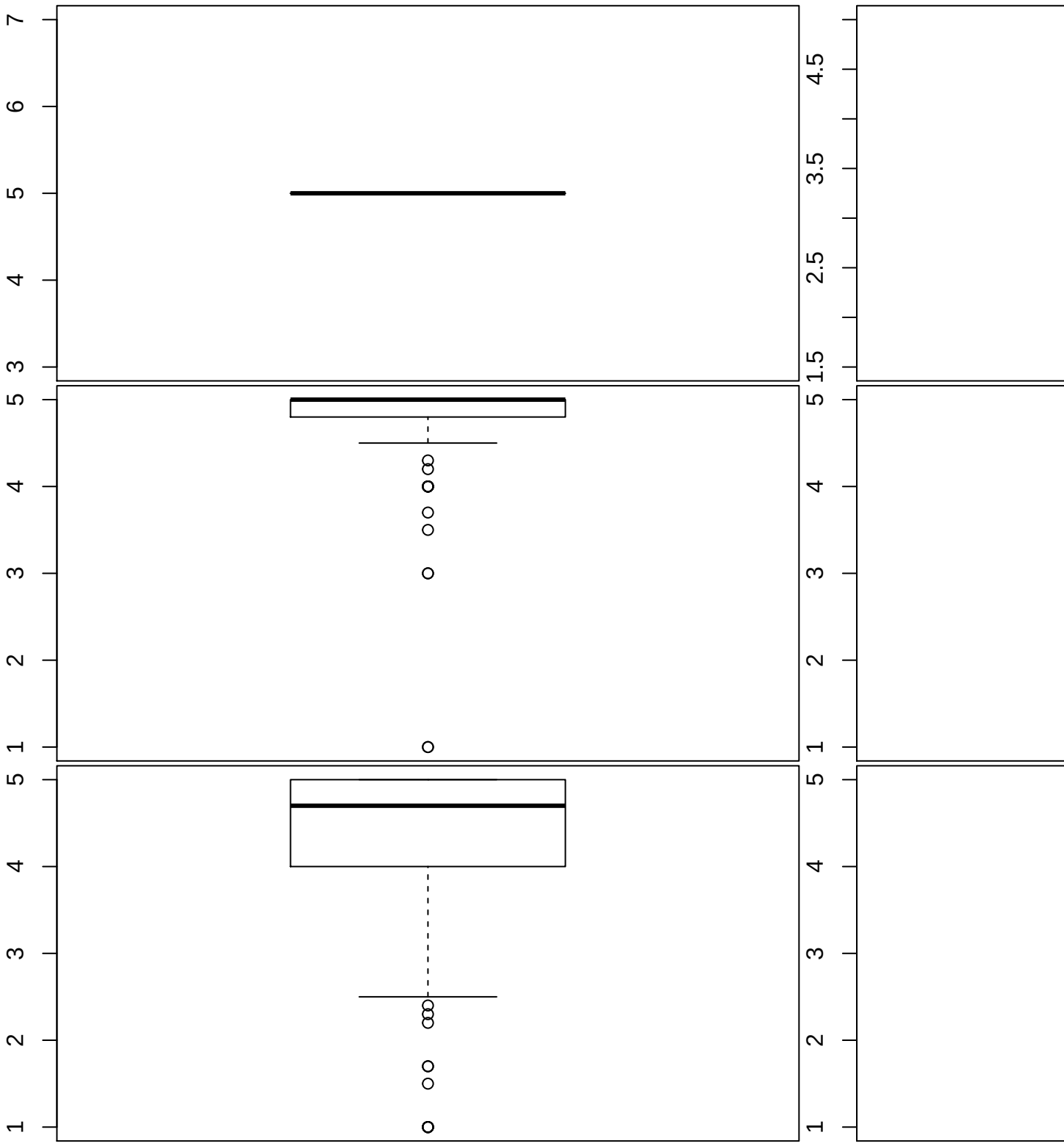
```
##                 12                 12                 12
##              3.0.5              3.6.1              3.8.0
##                 12                 12                 12
##                0.1             1.0.11              1.1.7
##                 11                 11                 11
##               1.11              1.3.3              2.0.3
##                 11                 11                 11
##              2.0.4              2.1.3              2.3.1
##                 11                 11                 11
##              4.1.0            5.9.1.0              1.2.5
##                 11                 11                 10
##              1.2.9              1.6.0              1.7.0
##                 10                 10                 10
##            (Other)
##               4328
##
## $Android.Ver
##         1.0 and up         1.5 and up         1.6 and up
##                  2                 15                 87
##         2.0 and up       2.0.1 and up         2.1 and up
##                 27                  7                113
##         2.2 and up         2.3 and up       2.3.3 and up
##                206                566                234
##         3.0 and up         3.1 and up         3.2 and up
##                211                  8                 31
##         4.0 and up      4.0.3 - 7.1.1       4.0.3 and up
##               1109                  2               1194
##        4.1 - 7.1.1         4.1 and up         4.2 and up
##                  1               1929                318
##         4.3 and up         4.4 and up        4.4W and up
##                195                805                  6
##          5.0 - 6.0          5.0 - 8.0         5.0 and up
##                  1                  2                490
##         5.1 and up         6.0 and up       7.0 - 7.1.1
##                 17                 45                  1
##         7.0 and up         7.1 and up         8.0 and up
##                 39                  2                  5
##                NaN Varies with device
##                  2                 56
```

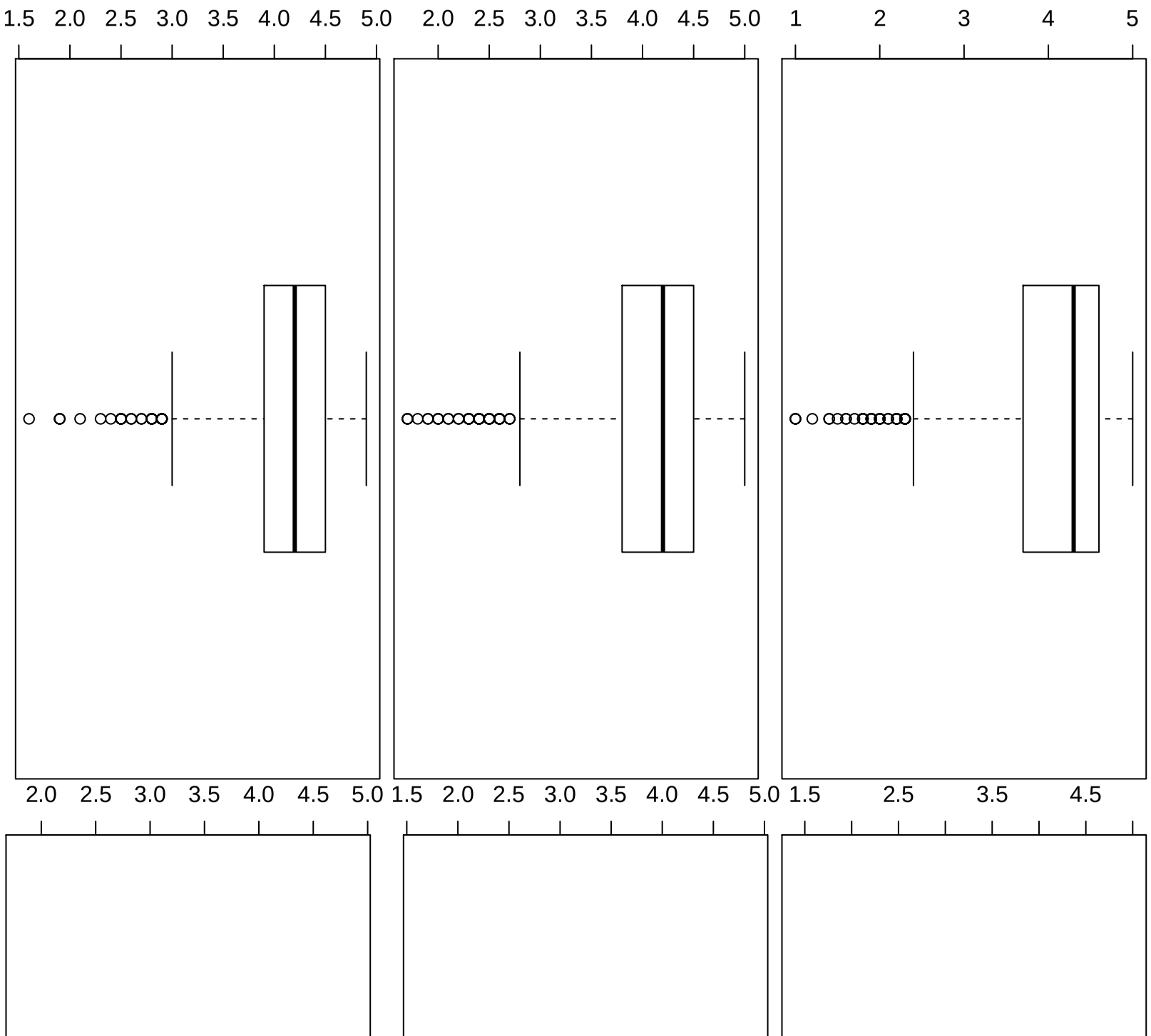
Problem 1.2

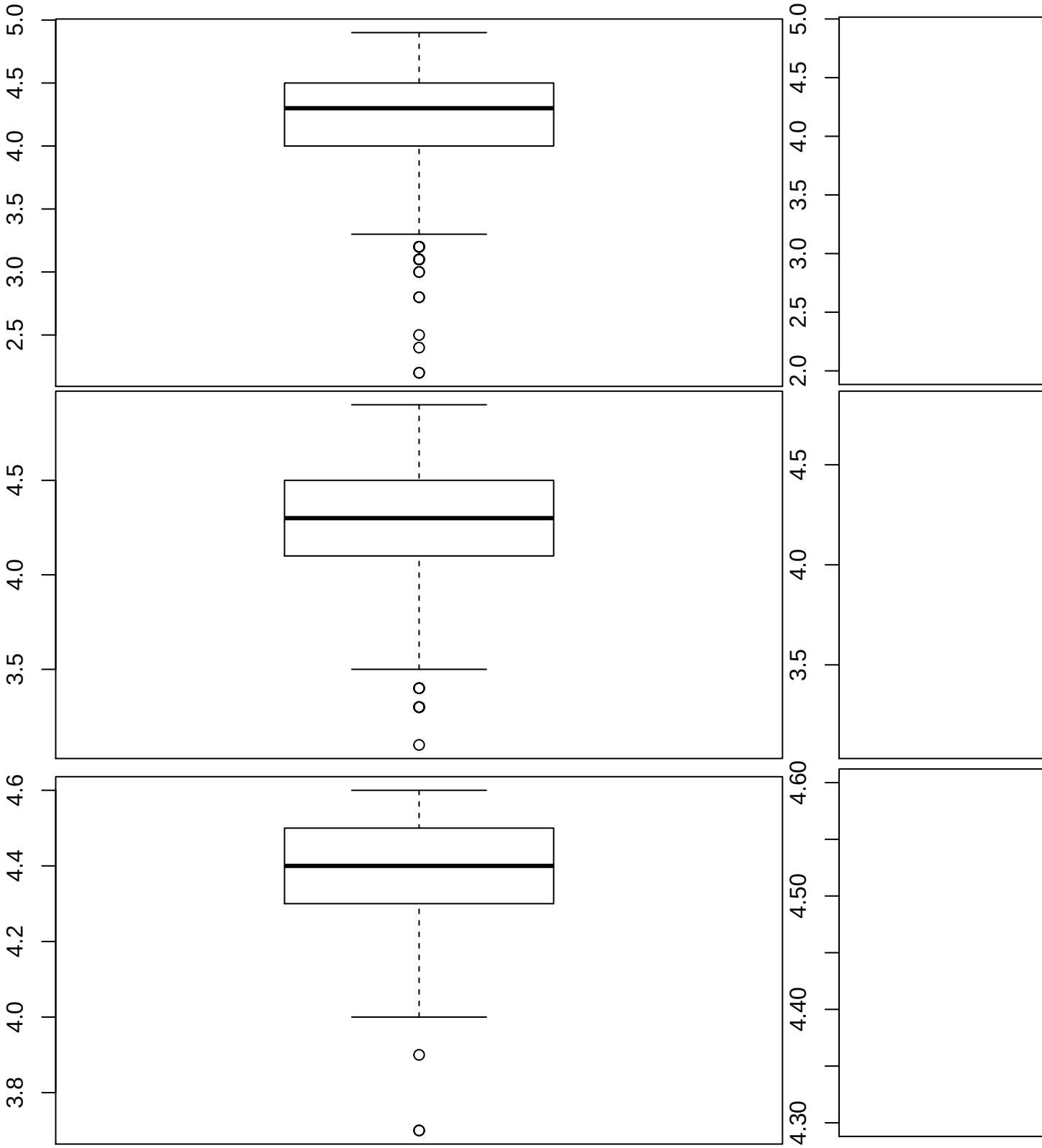
We want to investigate the association between the user's overall rating (`Rating`) of an app and the total number of installs (`Installs`). Use function `plot()` to construct a multiple boxplot of the overall rating of an app split by number of installs (`Installs`). Can you see any relationship in the plot? [3 pts]

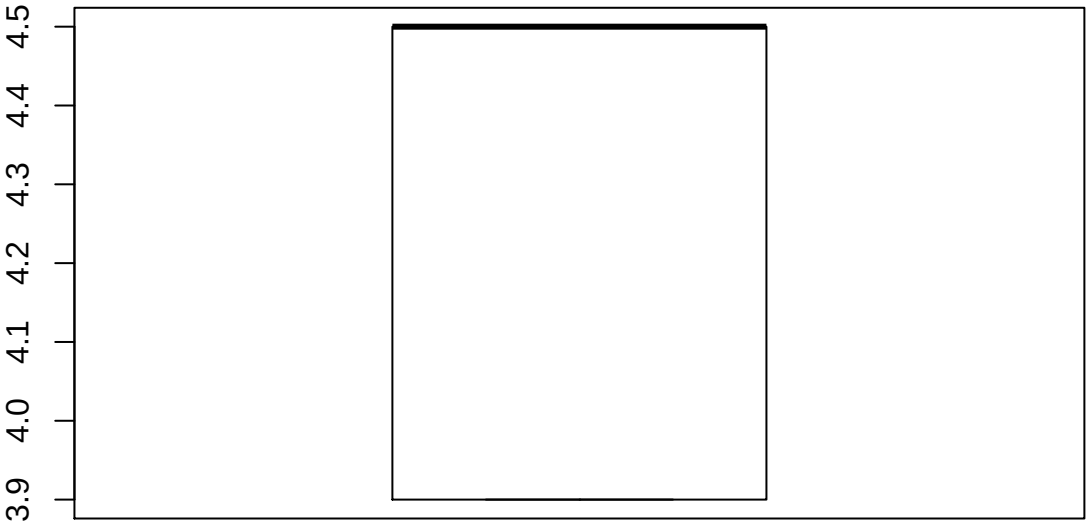
Adjust the labels of x-axis. Make sure that all levels of the variable `Installs` show in the plot. [2 extra pts]

```
# code goes here
inst_split <- split(apps, apps$Installs)
box_plt <- function(df) {
  boxplot(df$Rating)
}
sapply(inst_split, box_plt)
```


7
6
5
4
3
4.5
3.5
2.5
1.5
5
4
3
2
1
5
4
3
2
1


1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
2.0 2.5 3.0 3.5 4.0 4.5 5.0
1 2 3 4 5
2.0 2.5 3.0 3.5 4.0 4.5 5.0
1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
1.5 2.5 3.5 4.5


5.0
4.5
4.0
3.5
3.0
2.5
2.0
4.5
4.0
3.5
4.6
4.4
4.2
4.0
3.8
4.60
4.50
4.40
4.30

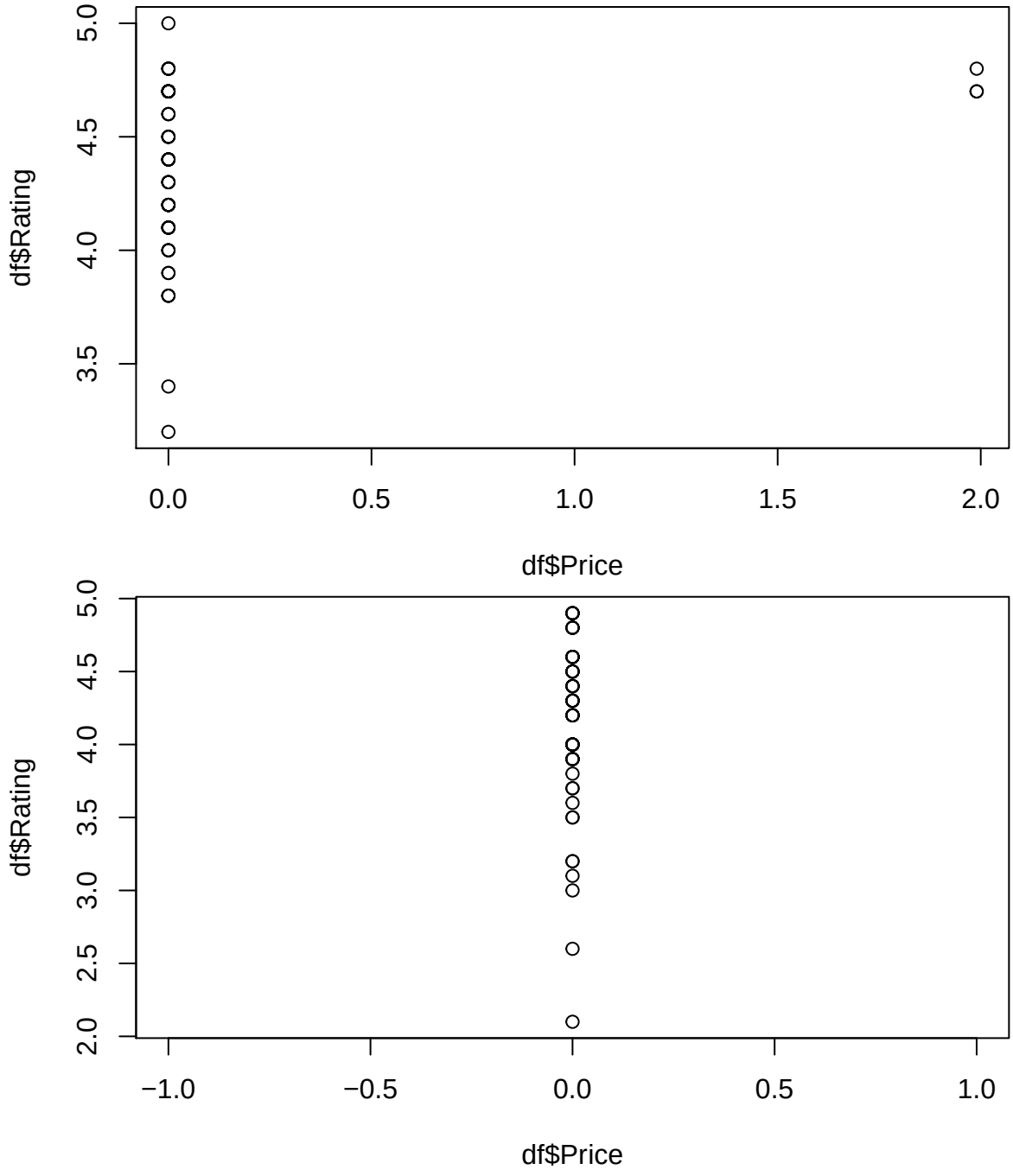


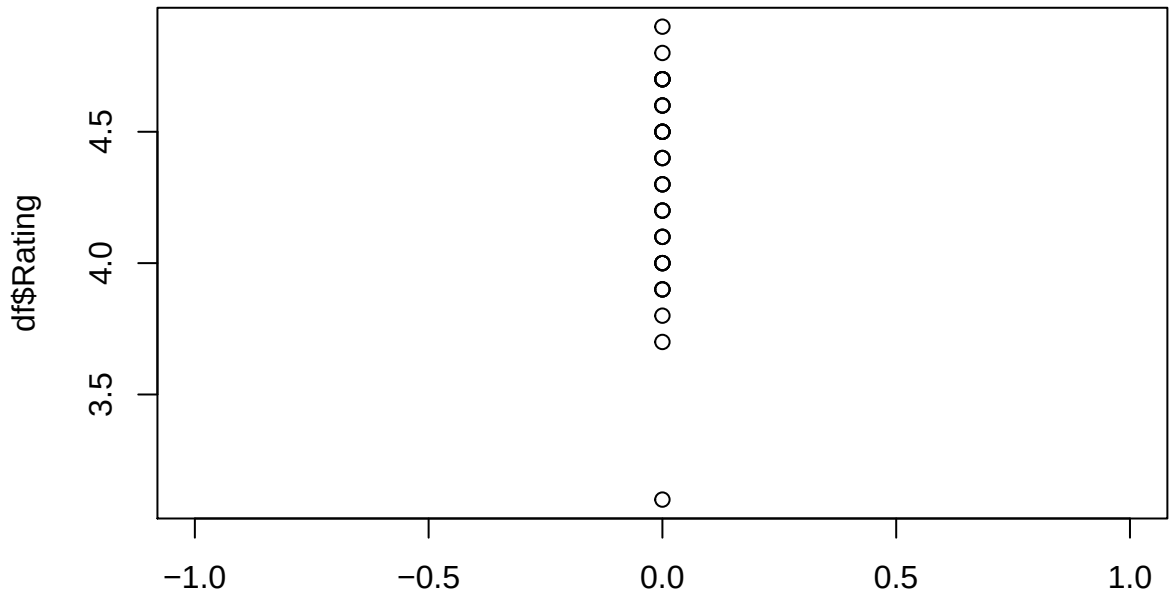

```
##       1+        5+        10+        50+       100+       500+
## stats Numeric,5 Numeric,5 Numeric,5  Numeric,5 Numeric,5  Numeric,5
## n     3         9         67         56        303        197
## conf  Numeric,2 Numeric,2 Numeric,2  Numeric,2 Numeric,2  Numeric,2
## out   Numeric,0 1.5       Numeric,14 Numeric,6 Numeric,11 Numeric,11
## group Numeric,0 1         Numeric,14 Numeric,6 Numeric,11 Numeric,11
## names "1"       "1"       "1"        "1"       "1"        "1"
##       1,000+     5,000+     10,000+    50,000+    100,000+   500,000+
## stats Numeric,5  Numeric,5  Numeric,5  Numeric,5  Numeric,5  Numeric,5
## n     690        420        969        436        1037       490
## conf  Numeric,2  Numeric,2  Numeric,2  Numeric,2  Numeric,2  Numeric,2
## out   Numeric,38 Numeric,15 Numeric,40 Numeric,17 Numeric,31 Numeric,11
## group Numeric,38 Numeric,15 Numeric,40 Numeric,17 Numeric,31 Numeric,11
## names "1"        "1"        "1"        "1"        "1"        "1"
##       1,000,000+ 5,000,000+ 10,000,000+ 50,000,000+ 100,000,000+
## stats Numeric,5  Numeric,5  Numeric,5   Numeric,5   Numeric,5
## n     1301       535        825         147         201
## conf  Numeric,2  Numeric,2  Numeric,2   Numeric,2   Numeric,2
## out   Numeric,18 Numeric,16 Numeric,9   Numeric,3   Numeric,3
## group Numeric,18 Numeric,16 Numeric,9   Numeric,3   Numeric,3
## names "1"        "1"        "1"         "1"         "1"
##       500,000,000+ 1,000,000,000+
## stats Numeric,5    Numeric,5
## n     30           10
## conf  Numeric,2    Numeric,2
## out   Numeric,2    Numeric,0
## group Numeric,2    Numeric,0
## names "1"          "1"
```

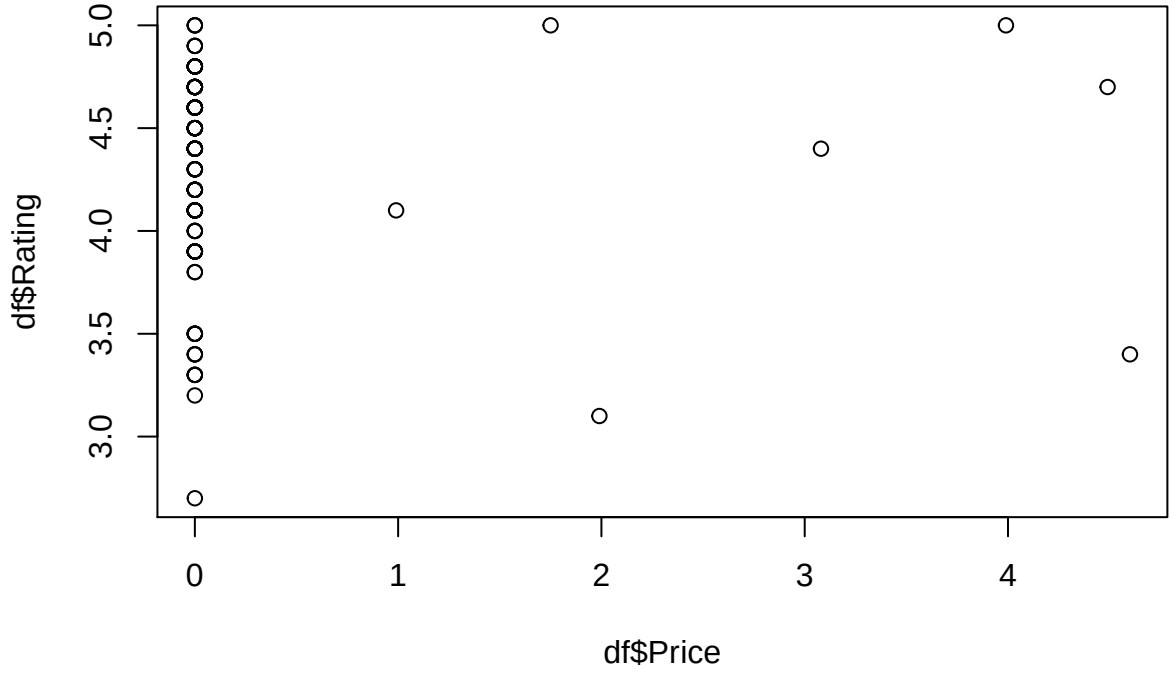
Problem 1.3

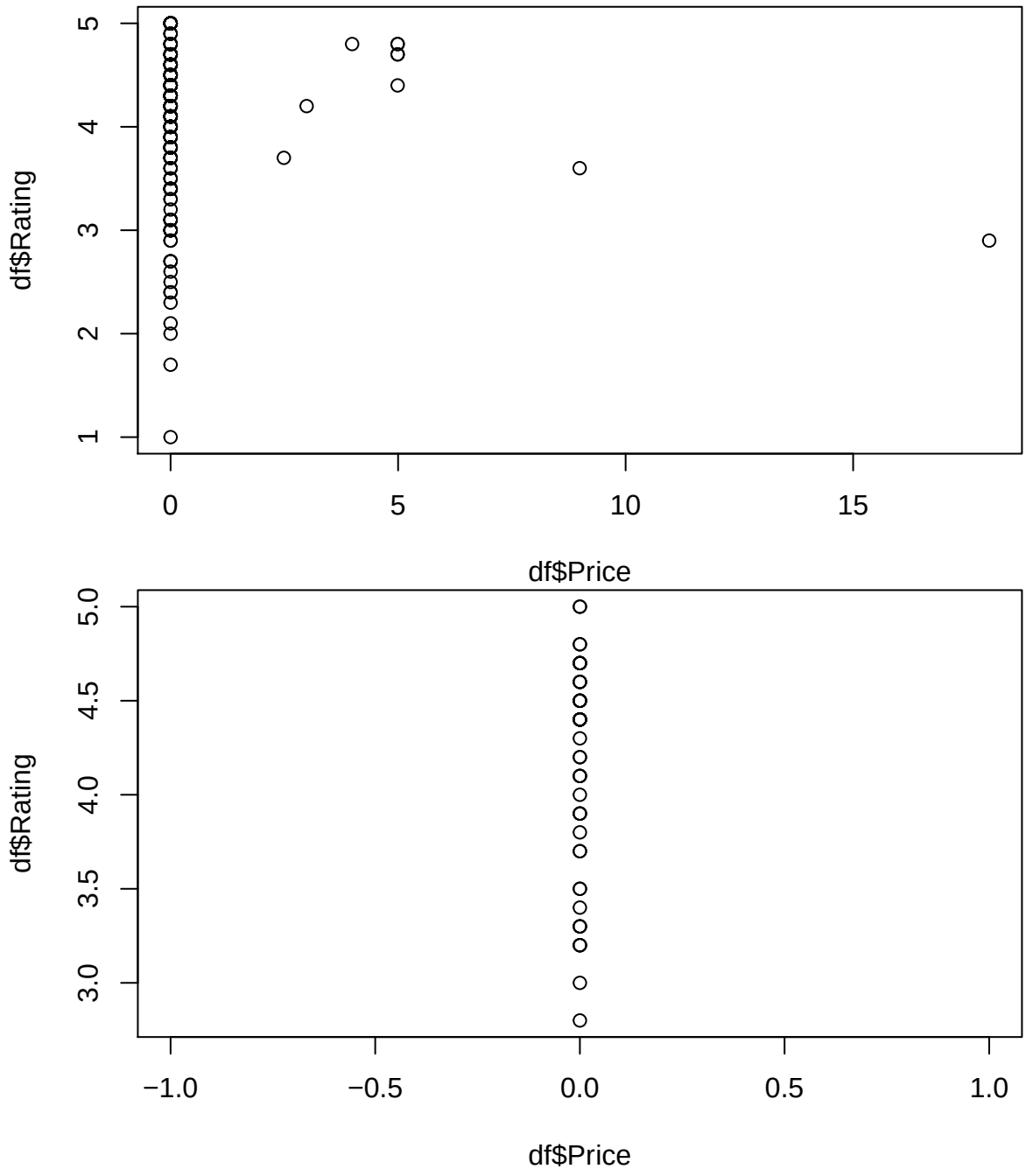
We now investigate how the overall rating (`Rating`) is associated with the category of the app (`Category`) and its price (`Price`). Use **Split/Apply/Combine** strategy to split the dataset by `Category`. For each category, generate a plot of user's rating (`Rating`) against the app's price (`Price`). Display all plots in one figure. To receive full credit, you must use a vectorized function from the `plyr` family. Make sure your figure contains **33** subplots, with each of them corresponding to one category. [5 pts]

```
# code goes here
library(plyr)
rat_plot <- function(df) {
  plot(df$Price, df$Rating)
}
#par(mfrow = c(3, 11))
d_ply(apps, .(Category), rat_plot)
```

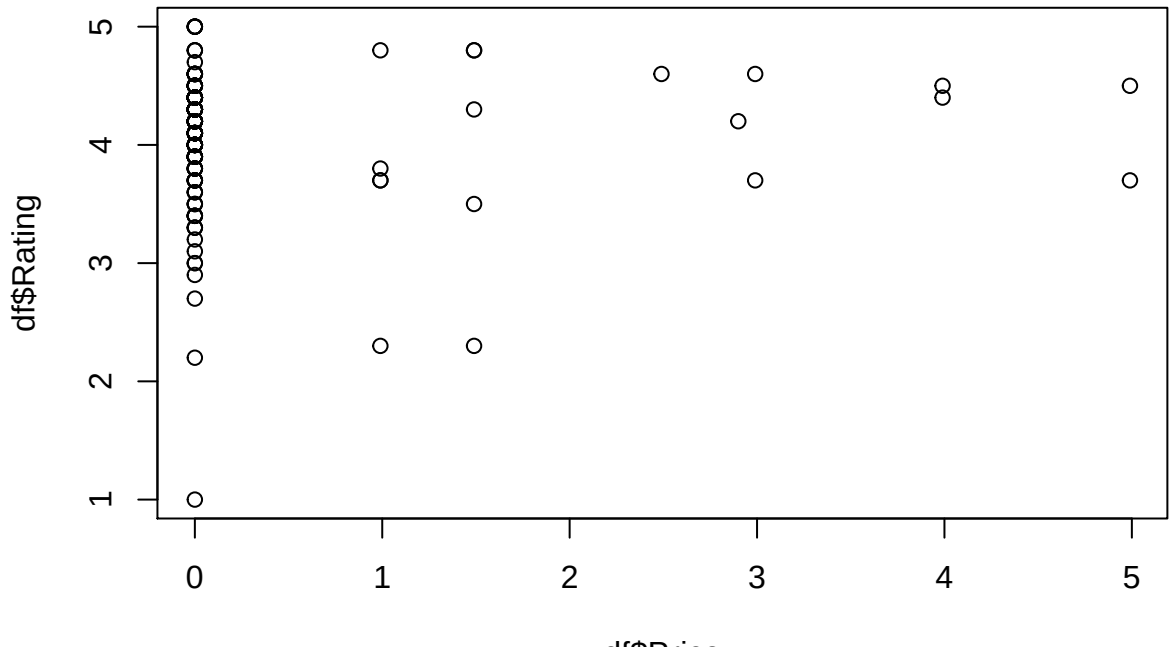


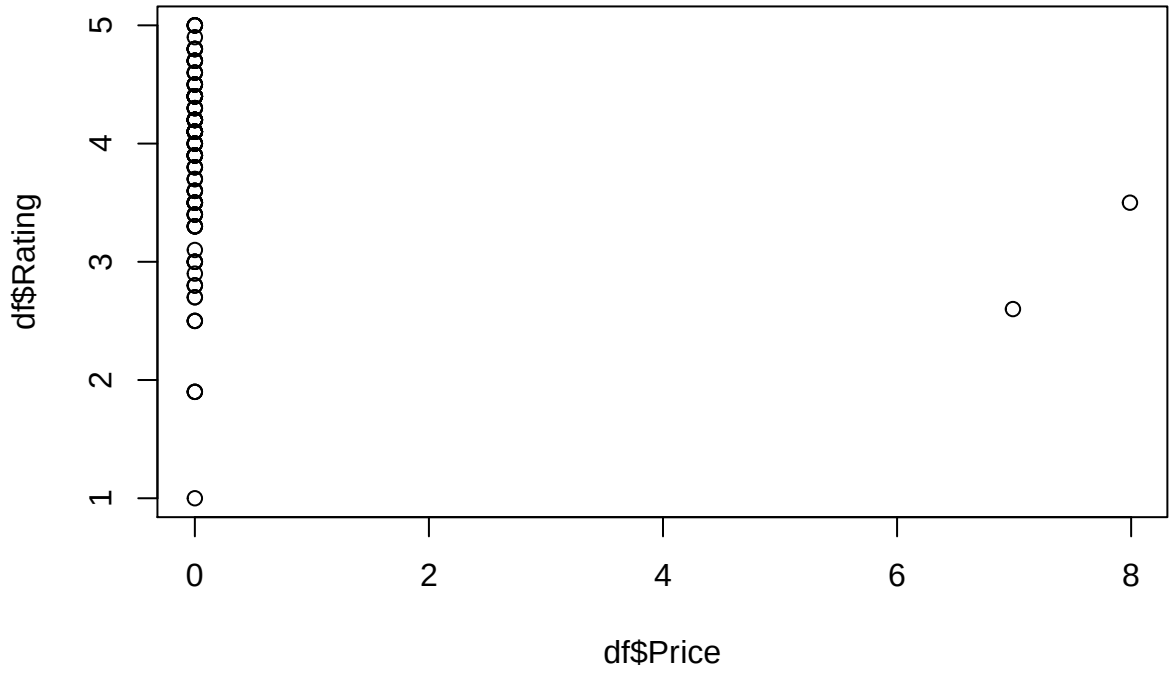

df$Rating
4.5
4.0
3.5
−1.0
−0.5
0.0
0.5
1.0
df$Price

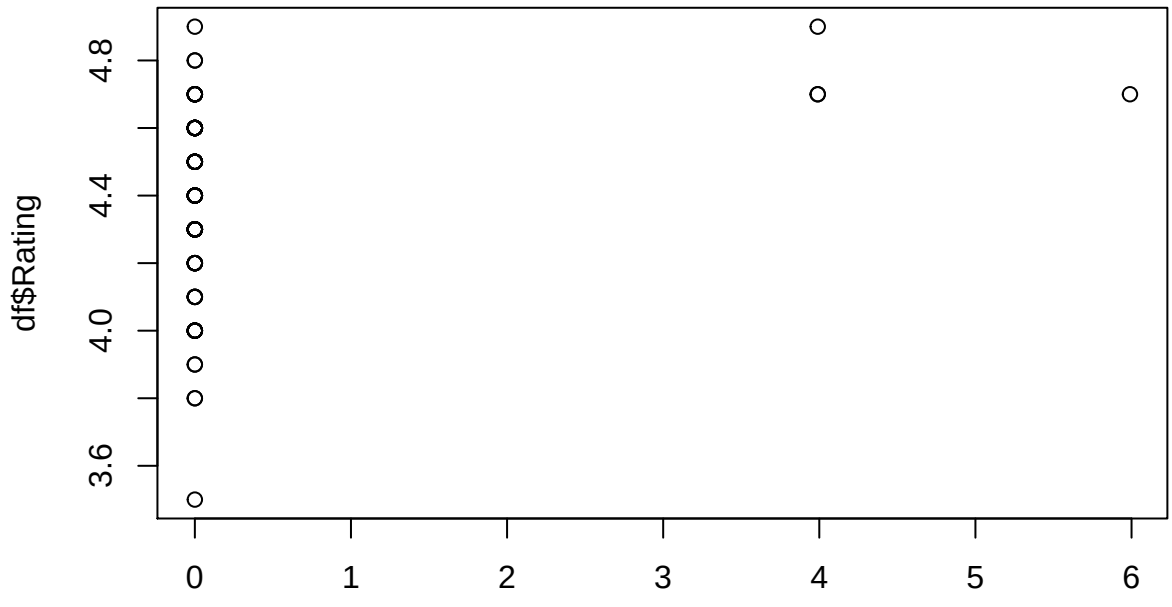

df$Rating
5.0
4.5
4.0
3.5
3.0
0
1
2
3
4
df$Price

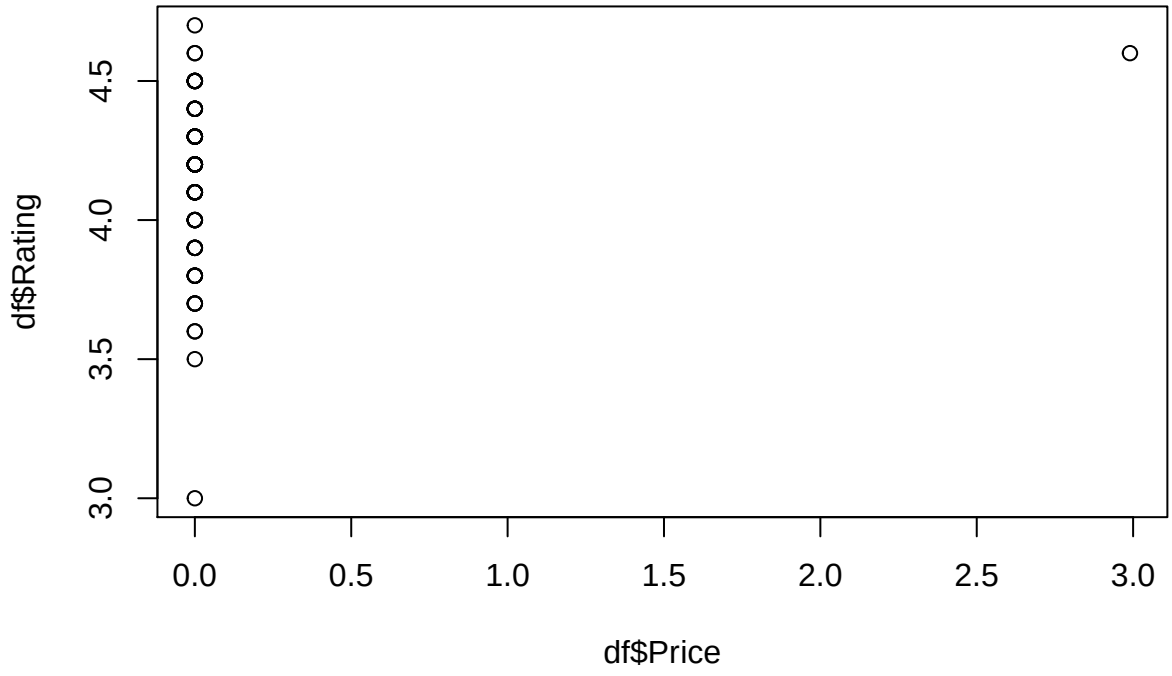

df$Rating
1
2
3
4
5
0
5
10
15
df$Price

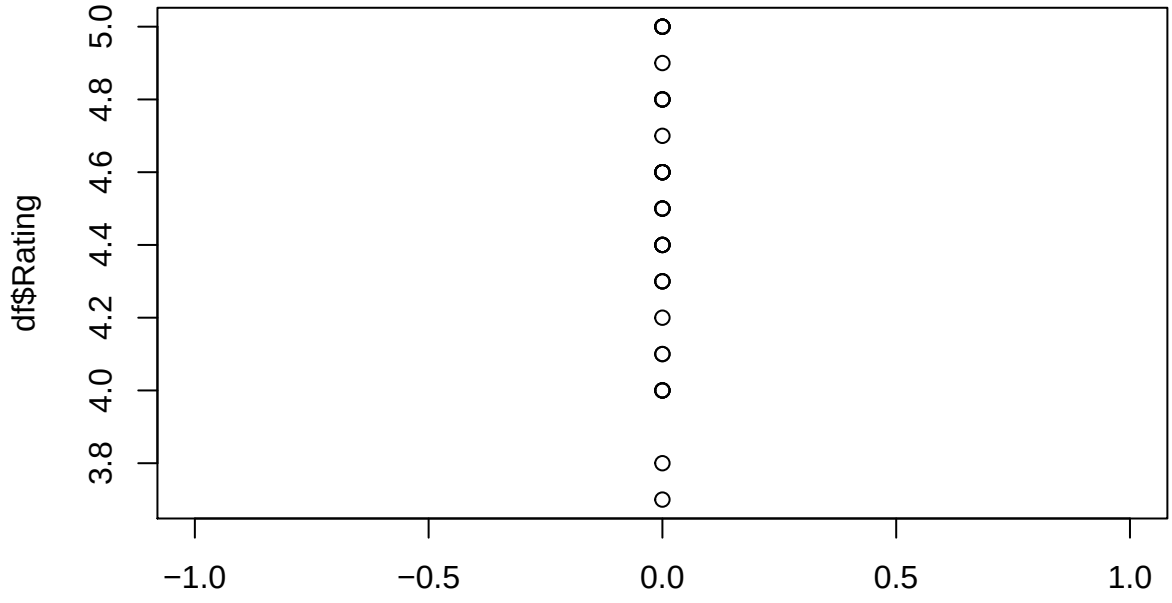
df$Rating
3.0
3.5
4.0
4.5
5.0
−1.0
−0.5
0.0
0.5
1.0
df$Price

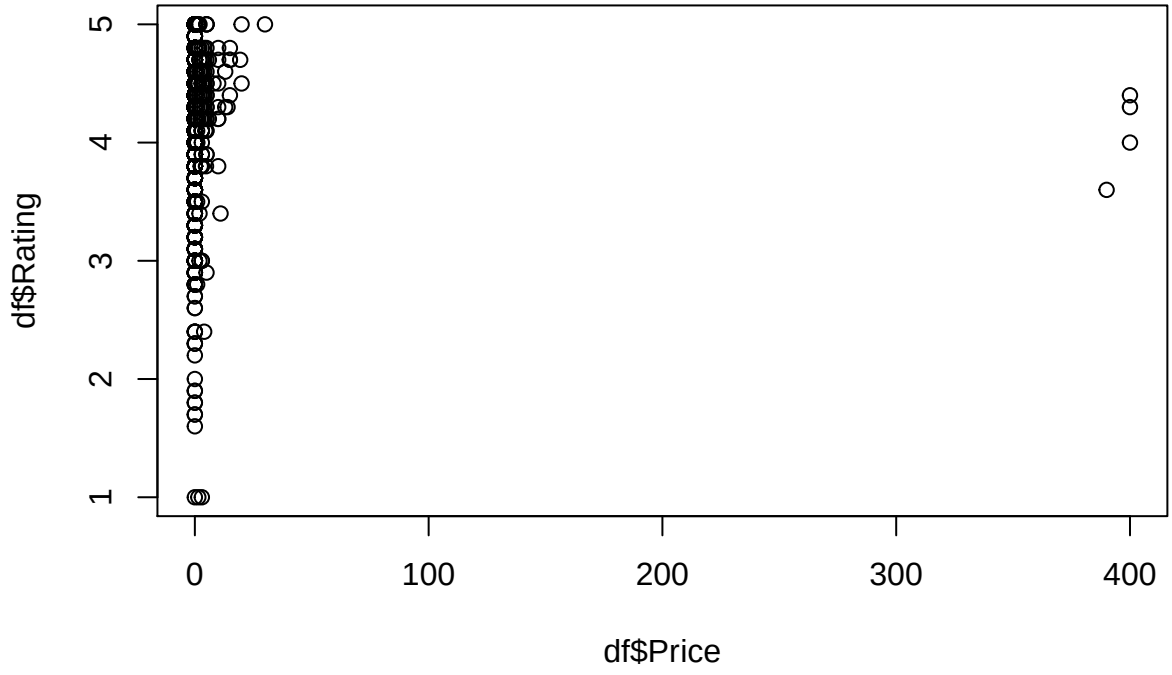

df$Rating
1
2
3
4
5
0
1
2
3
4
5
df$Price

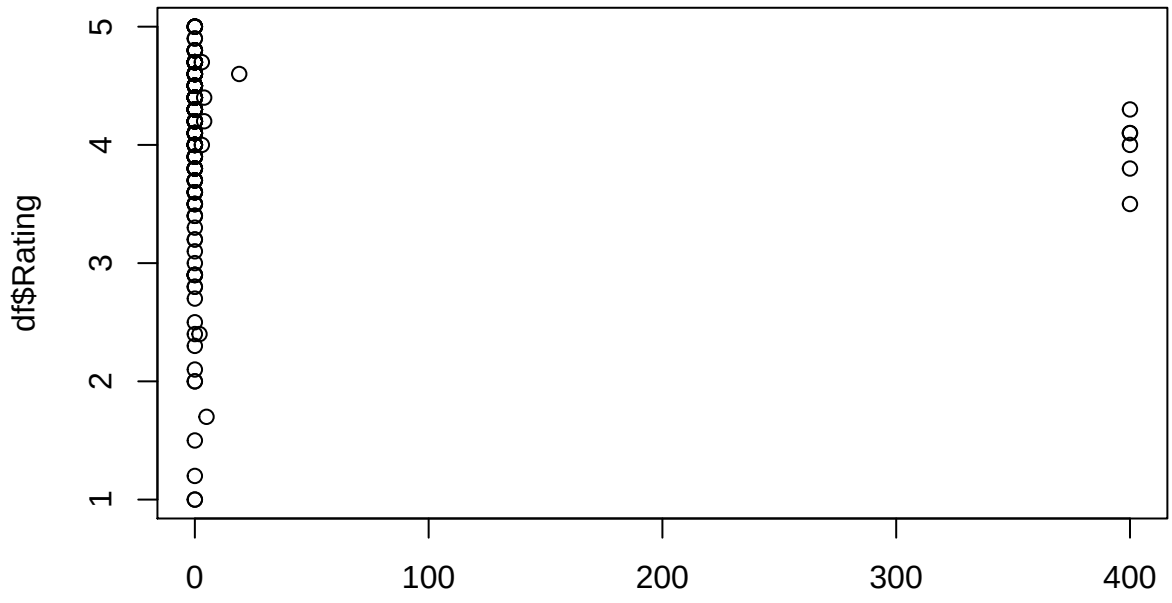

df$Rating
1
2
3
4
5
0
2
4
6
8
df$Price

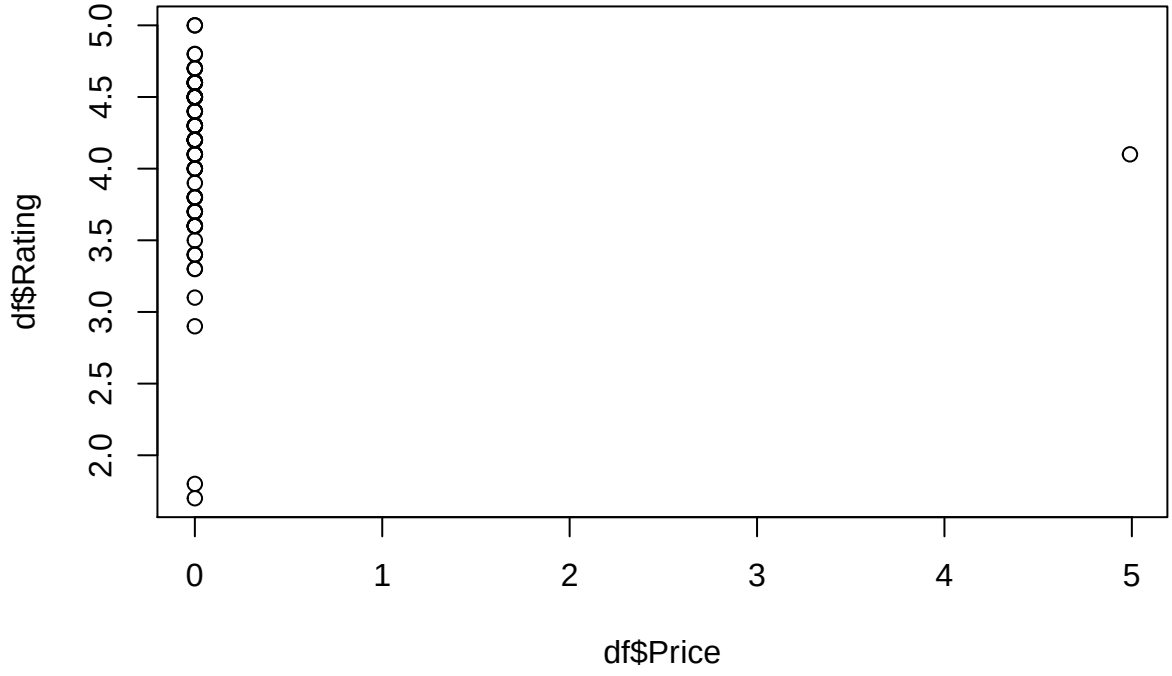

df$Rating
3.6
4.0
4.4
4.8
0
1
2
3
4
5
6
df$Price

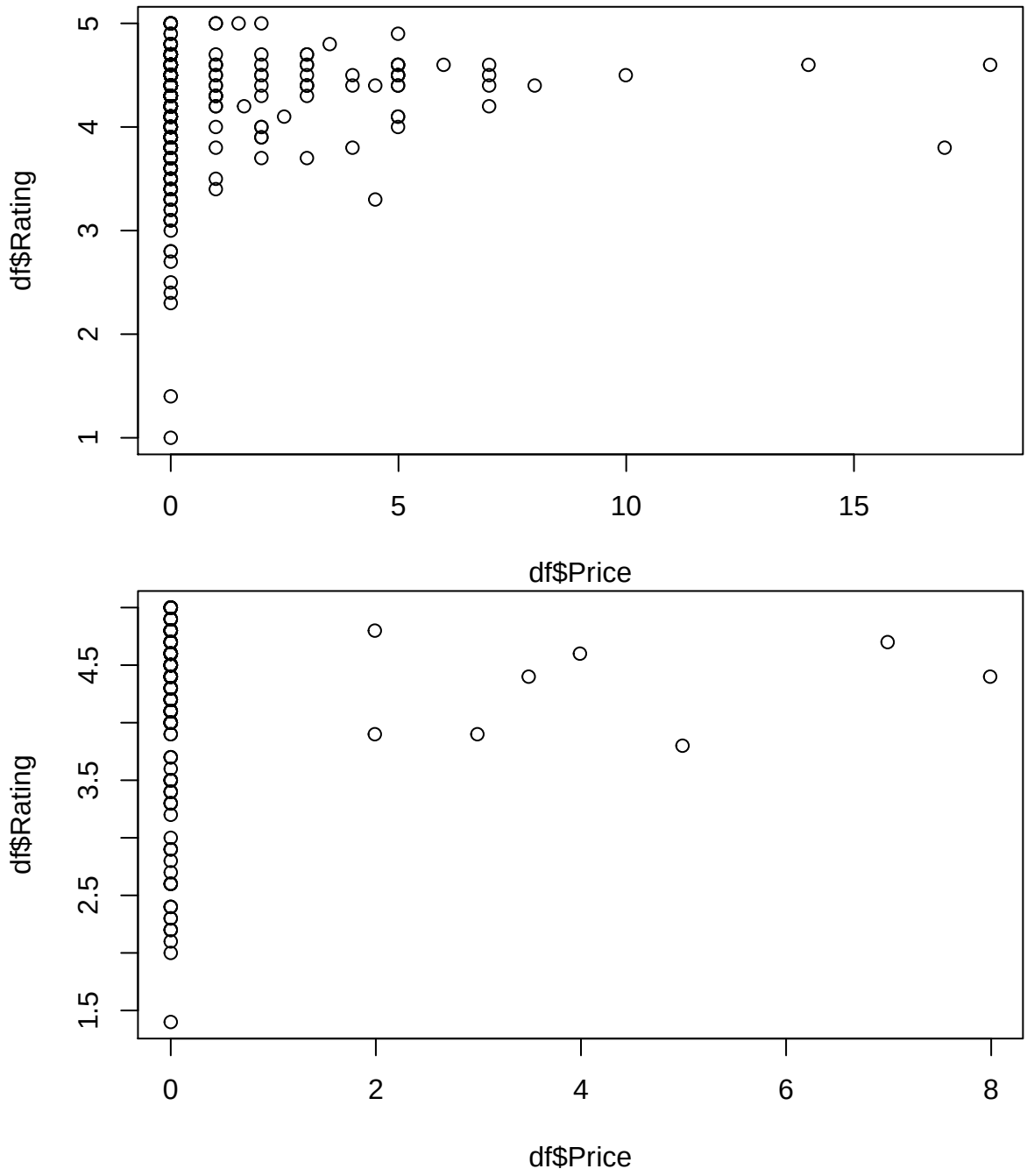

df$Rating
3.0
3.5
4.0
4.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
df$Price


df$Rating
5.0
4.8
4.6
4.4
4.2
4.0
3.8
−1.0
−0.5
0.0
0.5
1.0
df$Price

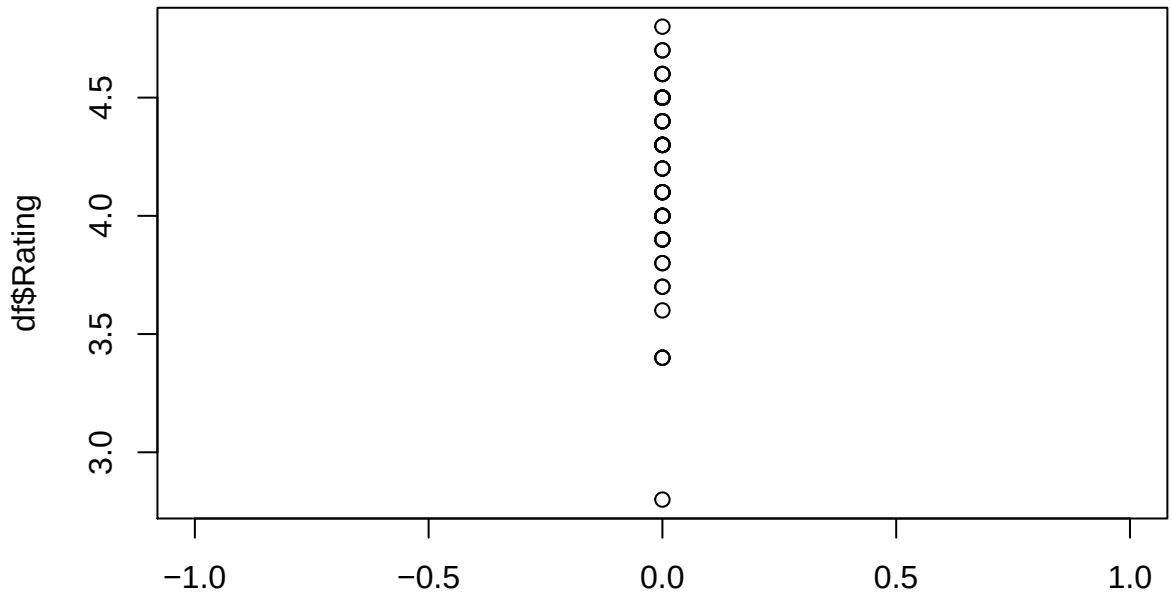

df$Rating
5
4
3
2
1
0
100
200
300
400
df$Price


df$Rating
1
2
3
4
5
0
100
200
300
400
df$Price


df$Rating
2.0
2.5
3.0
3.5
4.0
4.5
5.0
0
1
2
3
4
5
df$Price


df$Rating
1
2
3
4
5
0
5
10
15
df$Price

df$Rating
1.5
2.5
3.5
4.5
0
2
4
6
8
df$Price


df$Rating
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4.0
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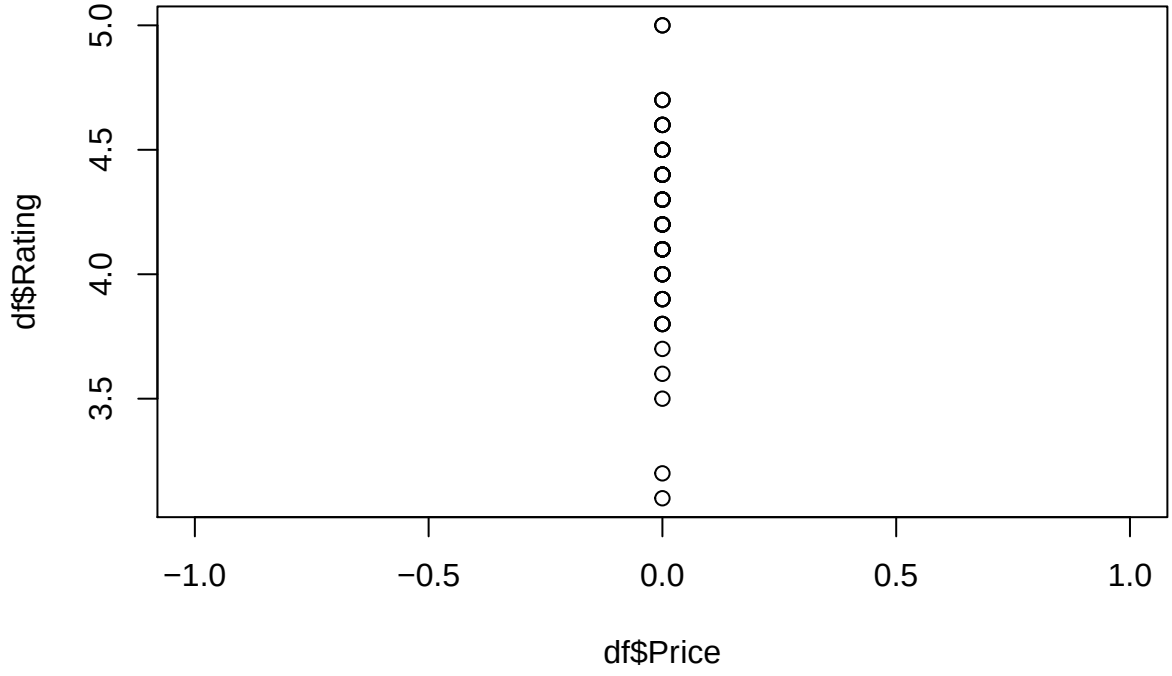
3.0
−1.0
−0.5
0.0
0.5
1.0
df$Price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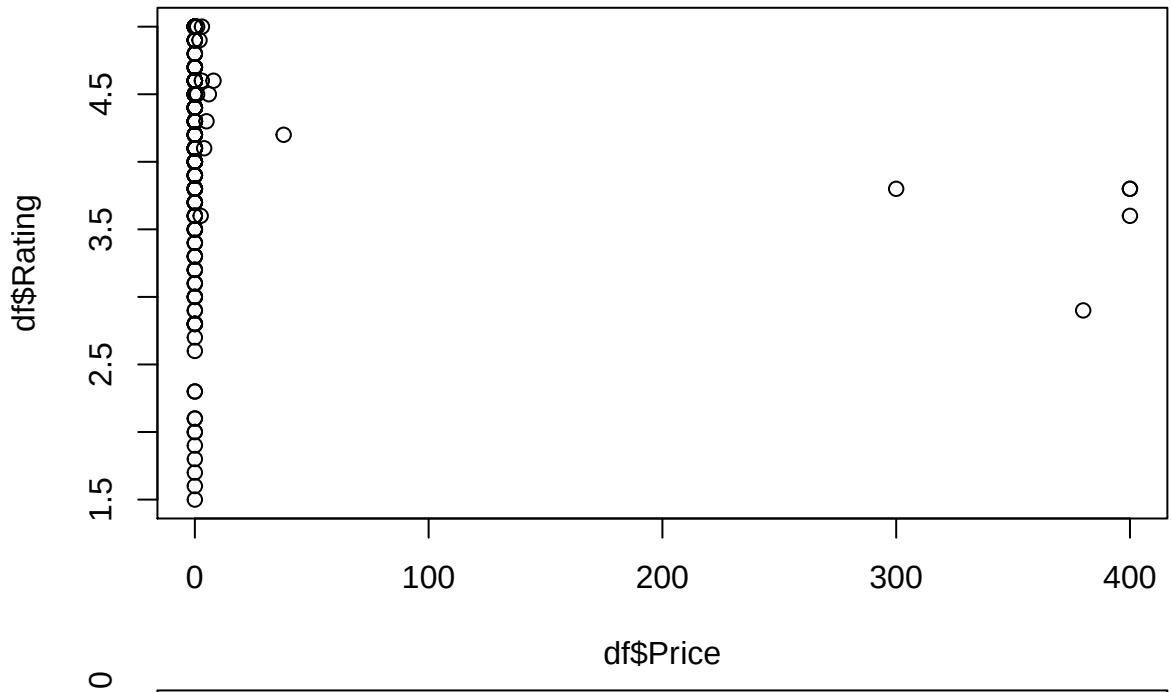
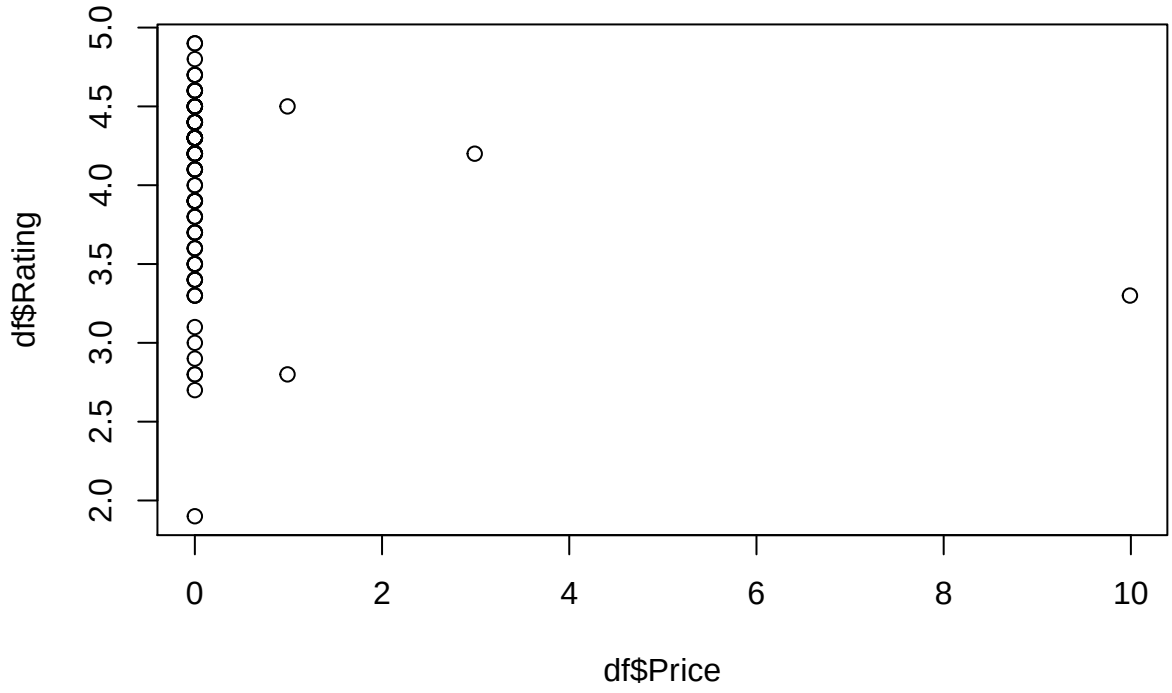
4.0
3.5
−1.0
−0.5
0.0
0.5
1.0
df$Price


df$Rating
1.5
2.5
3.5
4.5
0
100
200
300
400
df$Price


df$Rating
2.0
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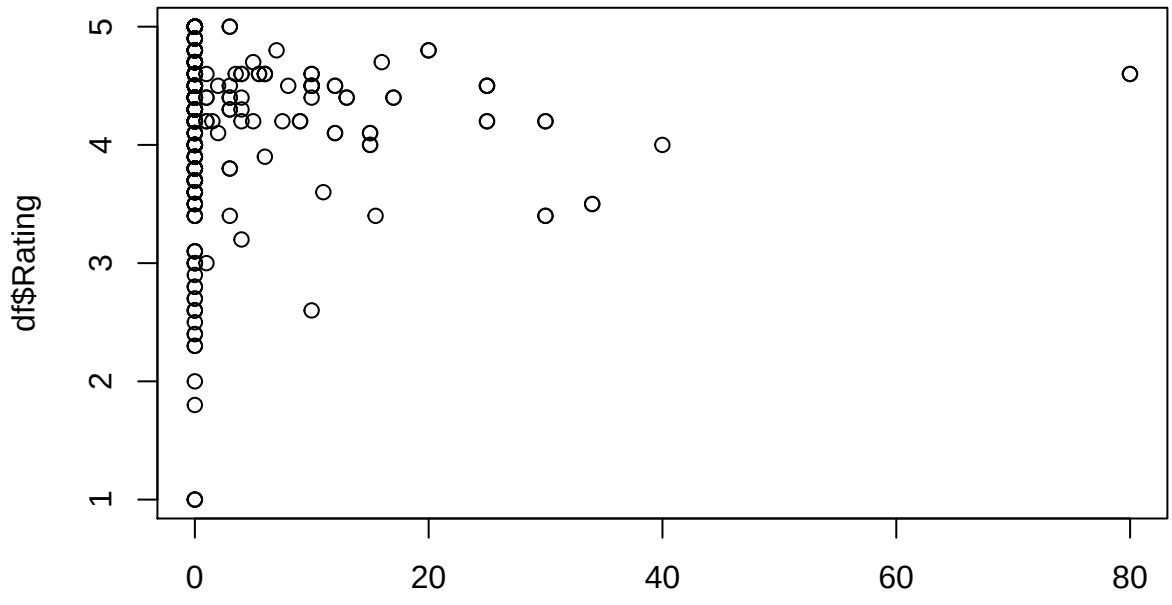
3.0
3.5
4.0
4.5
5.0
0
2
4
6
8
10
df$Price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2
3
4
5
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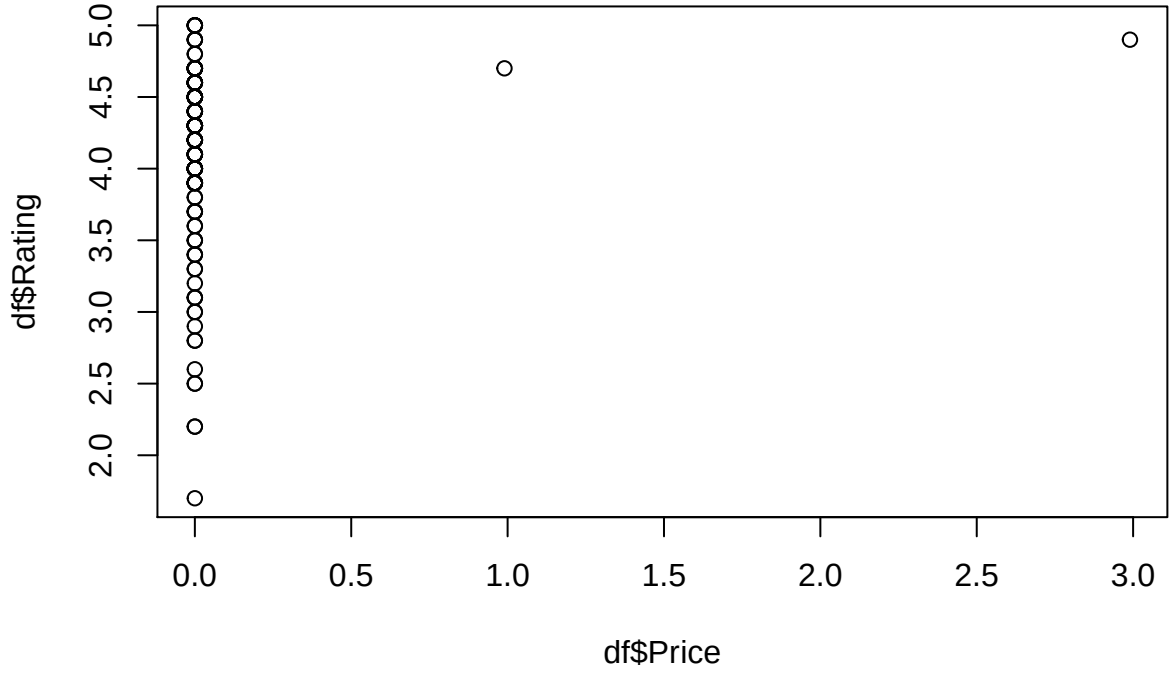
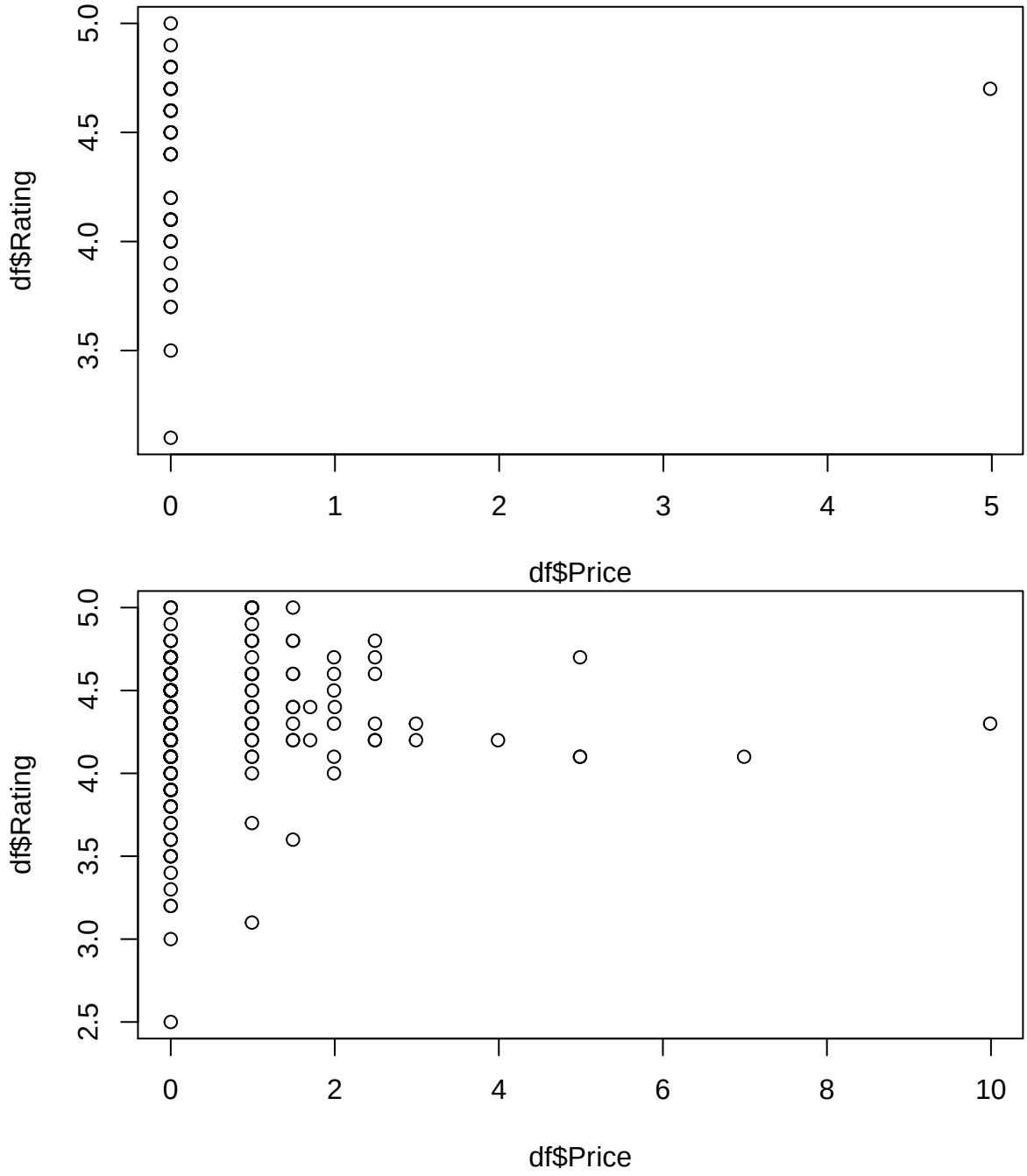
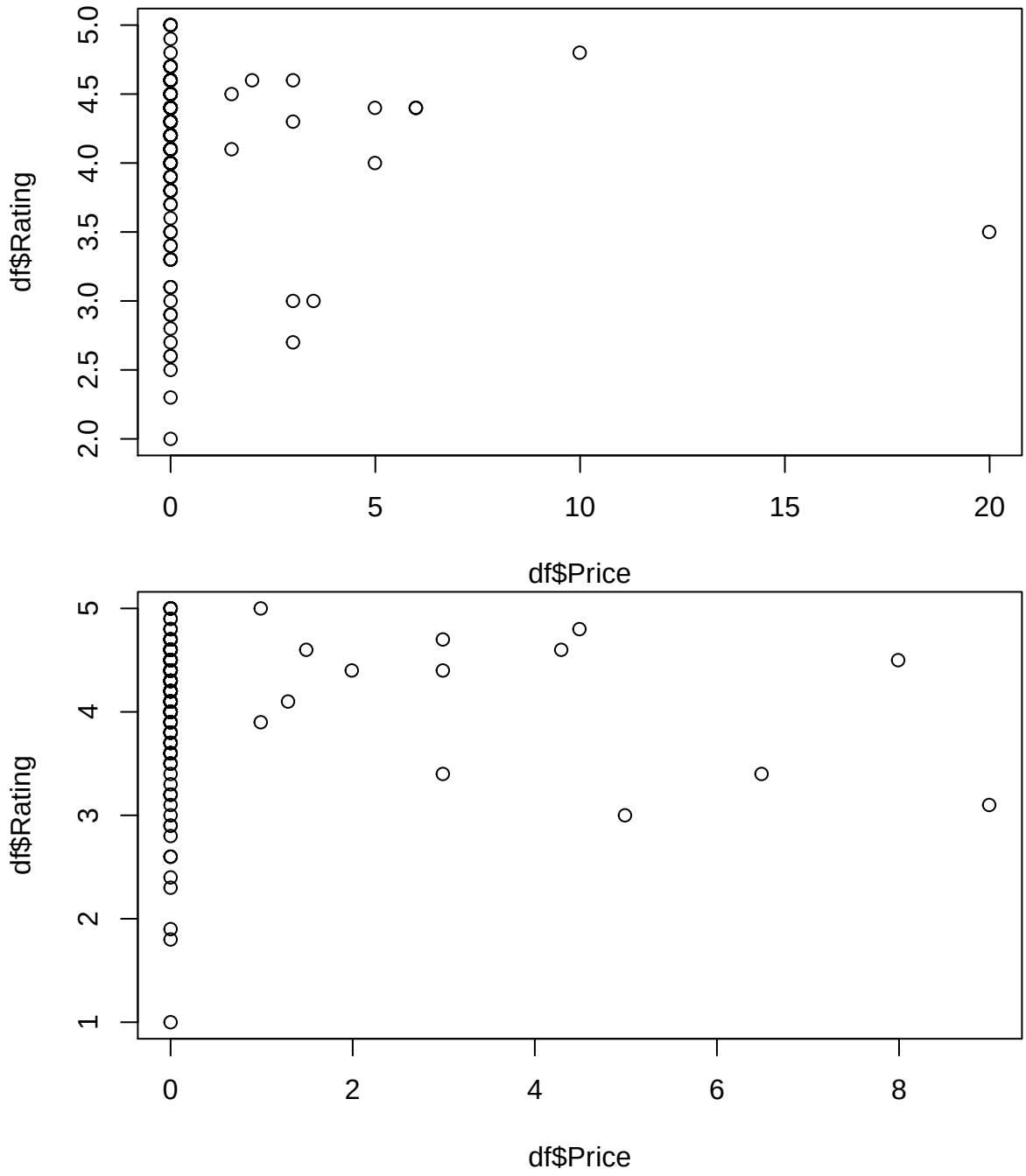
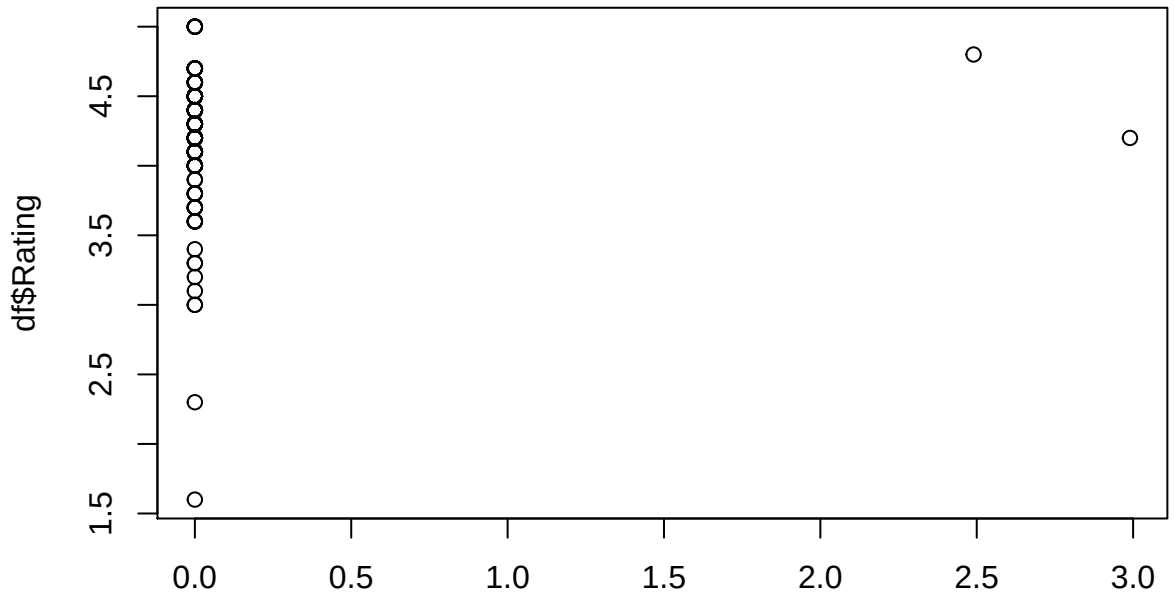
20
40
60
80
df$Price


df$Rating
2.0
2.5
3.0
3.5
4.0
4.5
5.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
df$Price


df$Rating
5.0
4.5
4.0
3.5
0
1
2
3
4
5
df$Price

df$Rating
5.0
4.5
4.0
3.5
3.0
2.5
0
2
4
6
8
10
df$Price


df$Rating
2.0
2.5
3.0
3.5
4.0
4.5
5.0
0
5
10
15
20
df$Price
df$Rating
1
2
3
4
5
0
2
4
6
8
df$Price


df$Rating
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3.5
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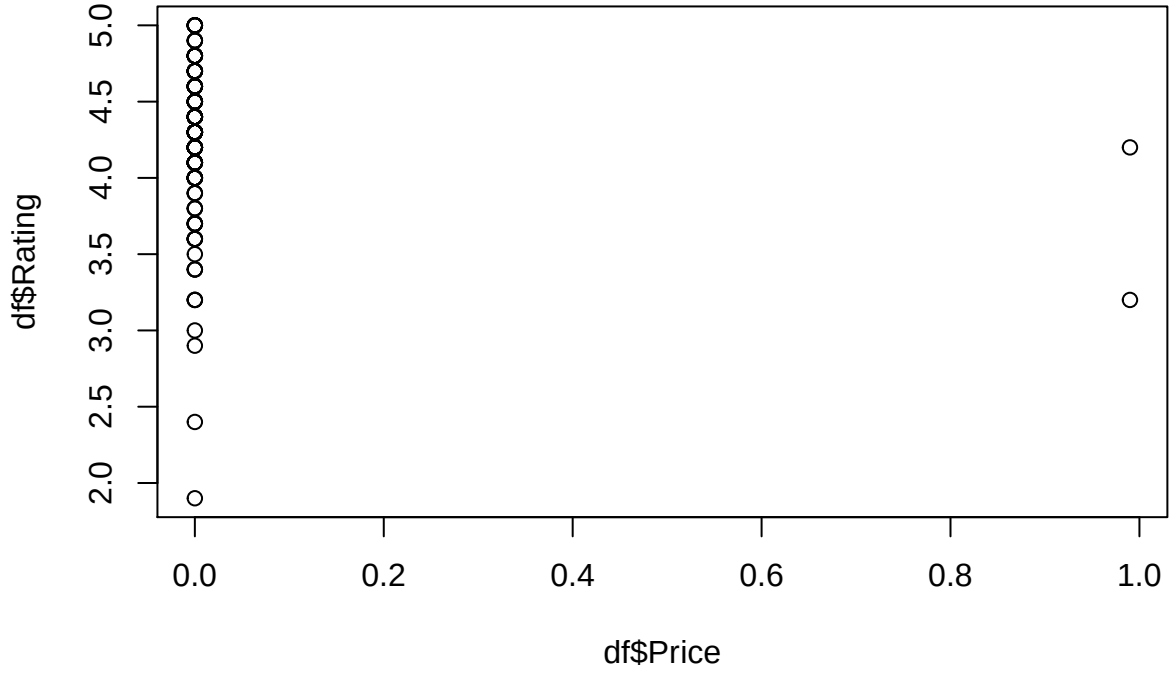
0.5
1.0
1.5
2.0
2.5
3.0
df$Price


df$Rating
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3.5
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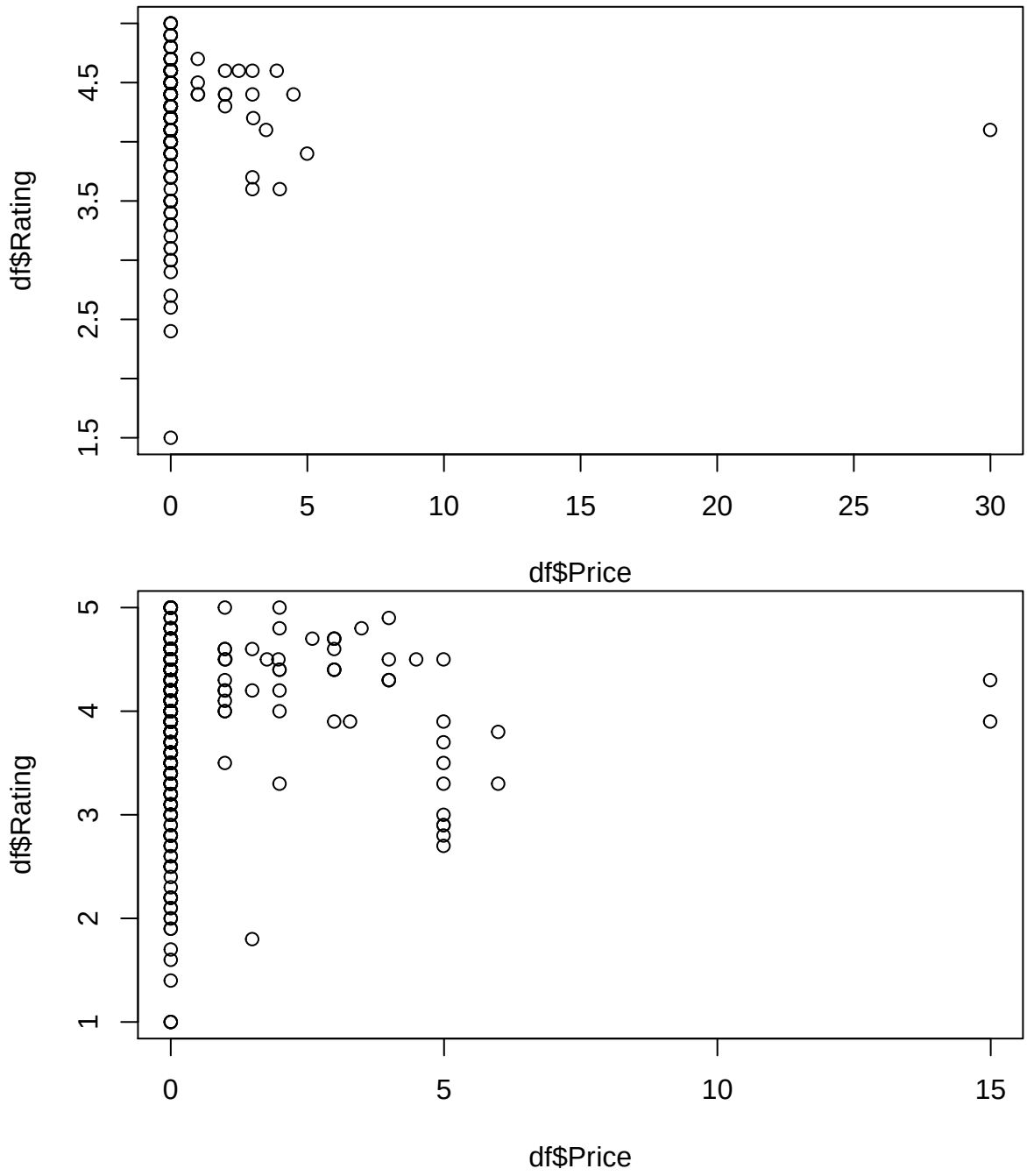
4.5
5.0
0.0
0.2
0.4
0.6
0.8
1.0
df$Price


df$Rating
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3.5
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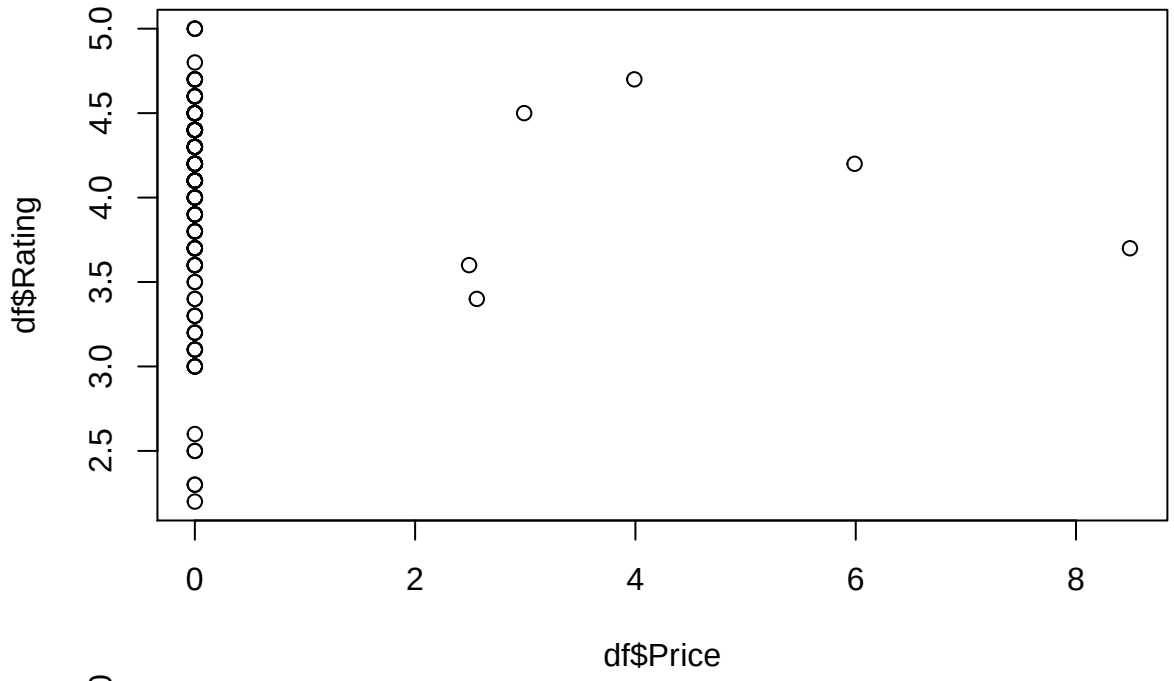
20
25
30
df$Price
df$Rating
1
2
3
4
5
0
5
10
15
df$Price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3.5
3.0
2.5
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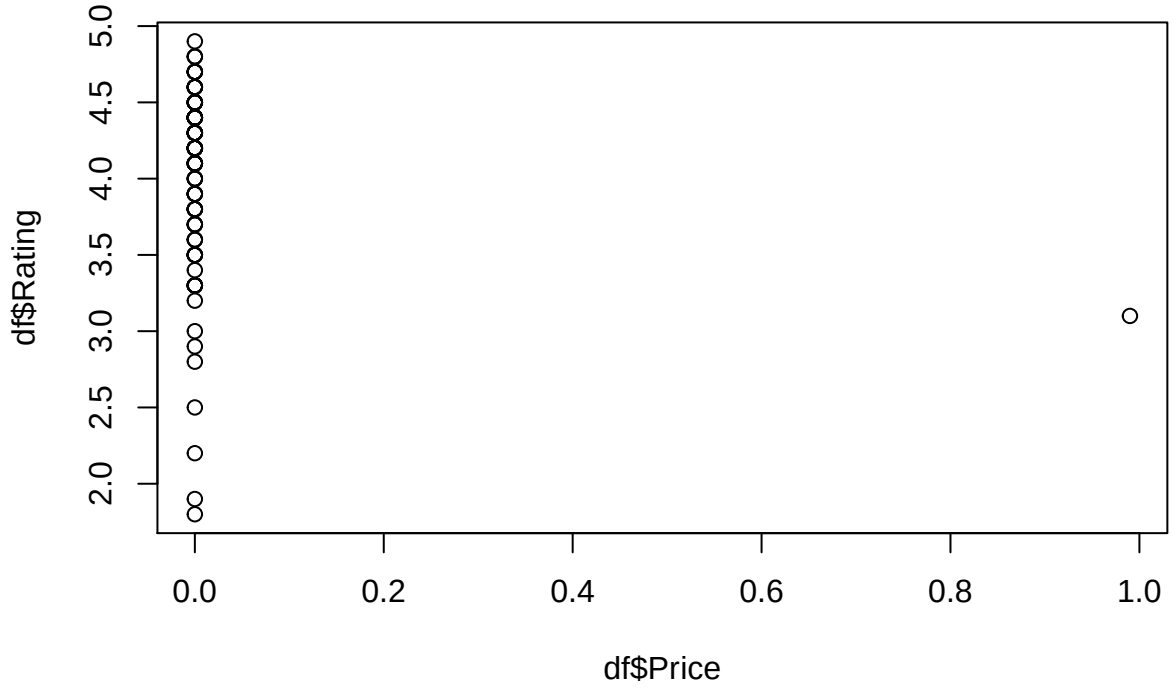
2
4
6
8
df$Price


df$Rating
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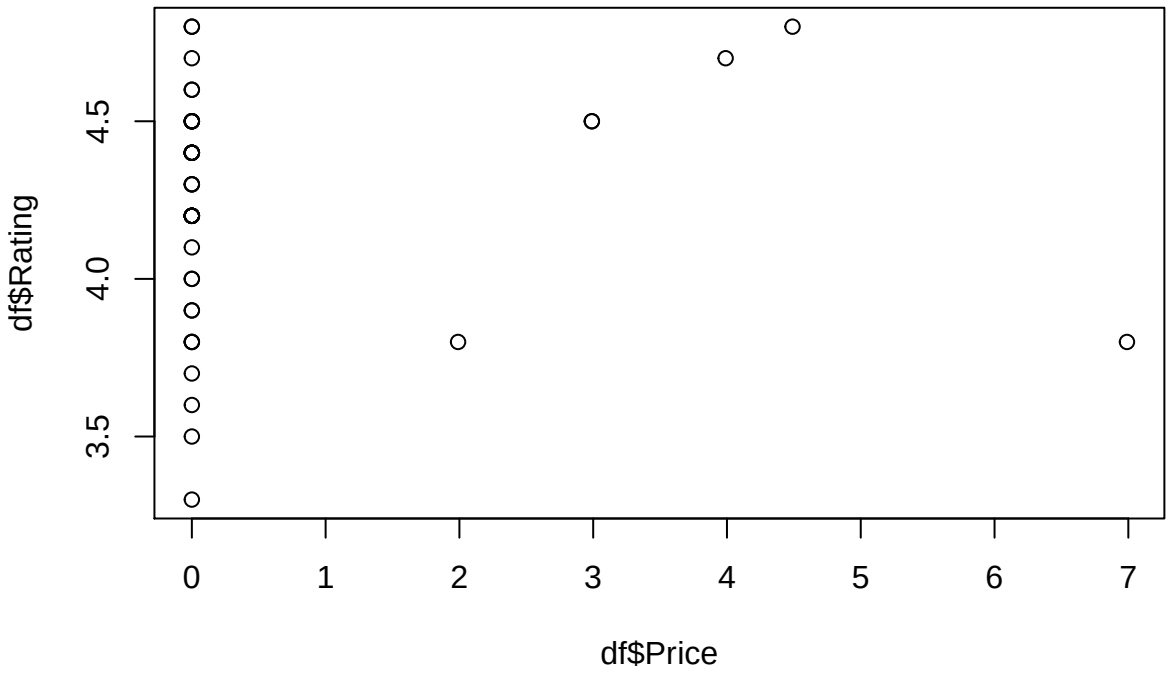
4.0
3.5
3.0
2.5
2.0
0.0
0.2
0.4
0.6
0.8
1.0
df$Price



Part 2 (Basic Web Scraping, 15 + 2 pts)

In this part, we look at the voting record of the 2018 US Congress for roll call 274. The votes were compiled from http://clerk.house.gov. The raw data have been saved in the file `Roll_Call_274.xml`. We want to extract the voting results for 427 members of the House of Representatives. First, we read in data.

```
rollCall274<-readLines("Roll_Call_274.xml")
```

Problem 2.0

Check the number of lines contained in the `Roll_call_274.xml` file. There should be 485 lines. [1 pt]

```
# code goes here
length(rollCall274)
```

```
## [1] 485
```

Problem 2.1

Use the `grep()` function to find the lines in the file that correspond to the votes. Make sure `grep()` finds 427 lines. Hint: such a line starts with `<recorded-vote>`. [2 pts]

```
# code goes here
pat <- '<recorded-vote>'
length(grep(pat, rollCall274))
```

```
## [1] 427
```

```
lines <- rollCall274[grep(pat, rollCall274)]
```

Problem 2.2

Write a regular expression that will capture the ID of a member. Using it extract the ID of each member. Hint: you can use the fact that `name-id=` appears before the ID. The ID is inside a pair of quotes, and it consists of one capital latter and six digits. [2 pts]

```
# code goes here
pat1 <- "name-id=\"[A-Z][0-9]{6}\""
id <- regmatches(lines, regexpr(pat1, lines))
id <- substring(id, 10, nchar(id)-1)
```

Problem 2.3

Using a regular expression extract the name of each member. Make sure that you can extract all names for 427 members. [2 extra pts]

```
# code goes here
pat2 <- "unaccented-name=\".+\" party"
name <- regmatches(lines, regexpr(pat2, lines))
name <- substring(name, 18, nchar(name)-7)
```

Problem 2.4

Extract the party of each member by using a regular expression. There should be 193 Democrats and 234 Republicans. [2 pts]

```
# code goes here
pat3 <- "party=\"[A-Z]\""
party <- regmatches(lines, regexpr(pat3, lines))
party <- substring(party, 8, nchar(party)-1)
```

Problem 2.5

Extract the state for each member by using a regular expression. [2 pts]

```
# code goes here
pat4 <- "state=\"[A-Z]+\""
state <- regmatches(lines, regexpr(pat4, lines))
state <- substring(state, 8, nchar(state)-1)
```

Problem 2.6

Last, use a regular expression to extract the vote. [2 pts]

```
# code goes here
pat5 <- "<vote>([A-z]+)</vote>"
vote <- regmatches(lines, regexpr(pat5, lines))
vote <- substring(vote, 7, nchar(vote)-7)
```

Problem 2.7

Make the extracted vote as a factor, and check its levels. Make a new variable called `numeric.vote`, which takes value 1 if the member voted "Yes (Aye)", 0 if the vote is "No", and -1 for "Not Voting". [2 pts]

```
# code goes here
# vote <- factor(vote)
# levels(vote)
# numeric.vote <- ifelse(vote == 'Aye', 0, 1, -1)
```

Problem 2.8

Create a dataframe `rollCall274`, which contains the following five variables: `name`, `state`, `party`, `vote`, `numeric.vote`. Use `id` to name the rows of this dataframe. [2 pts]

```
# code goes here
# rollCall274 <- data.frame(name, state, party, vote, numeric.vote)
# row.names(rollCall274) <- id
```

Part 3 (Bootstrap, 4 + 2 pts)

We consider the `strikes` data which we used in Lecture 6. The data set is about strikes in 18 countries over 35 years (compiled by Bruce Western, in the Sociology Department at Harvard University). The measured variables are:

- **country, year** – country and year of data collection
- **strike.volume** – days on strike per 1000 workers
- **unemployment** – unemployment rate
- **inflation** – inflation rate
- **left.parliament** – leftwing share of the government
- **centralization** – centralization of unions
- **density** – density of unions

In this problem, we *only* look at the strikes in Italy. On this subset, we run a simple linear regression using `strike.volume` as the response (Y) and `left.parliament` as the predictor (X). Our model is

$$Y = \beta_0 + \beta_1 X + \epsilon, \quad \epsilon \sim \mathcal{N}(0, \sigma^2).$$

```
strikes<-read.csv("strikes.csv", header = T)
italy.strikes<-strikes[strikes$country == "Italy", ]
dim(italy.strikes)
```

```
## [1] 35  8
```

```
lm.fit<- lm(strike.volume ~ left.parliament, data = italy.strikes)
round(lm.fit$coefficients,3)
```

```
##     (Intercept) left.parliament
##        -738.745          40.291
```

Problem 3.1

Denote our estimate of β_1 as $\hat{\beta}_1$, which is 40.291 according to the analysis above. Use the Bootstrap method to estimate the variance of $\hat{\beta}_1$. Here, you may draw 100 Bootstrap samples. [4 pts]

```
# code goes here
n <- nrow(italy.strikes)
B <- 100
resampled_values <- matrix(NA, nrow = B, ncol = n)
for (b in 1:B) {
  resampled_values[b, ] <- sample(1:n, n, replace = TRUE)
}

resampled_ests <- matrix(NA, nrow = B, ncol = 2)
colnames(resampled_ests) <- c("Intercept_Est", "Slope_Est")

for (b in 1:B) {
  resampled_ests[b, ] <- coef(lm(strike.volume ~ left.parliament, italy.strikes[resampled_values[b, ], ]
}

var(resampled_ests[, "Slope_Est"])
```

```
## [1] 563.8825
```

Problem 3.2

Construct a 95% confidence interval of β_1 based on the result in part 3.1. [2 extra pts]

```
# code goes here
Cl_1 <- quantile(resampled_ests[, "Slope_Est"], 0.025)
Cu_1 <- quantile(resampled_ests[, "Slope_Est"], 0.975)
int_1 <- c(Cl_1, Cu_1)
int_1
```

```
##      2.5%     97.5%
## -9.248921 73.009120
```