HW5

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PROBLEM 1:

x-axis: list the different categories of household income, based on NES. NES divided the annual income of household voters (across all states) into five quantiles: 0-16, 17-33, 34-67, 68-95, and 96-100. In this study, each quantile is number as -2, -1, 0, 1, 2 respectively and correspondingly for the ease of interpreting regression (as they center around 0)

y-axis: is the probability of voting for Republican. If the value is >0.5, meaning that the in general, the households in that specific income category supports Republican.

Circles (or the points): each point corresponds to the probability an individual support Rep in relation to their income level. 'The open circles show the relative proportion (as compared to national averages) of households in each income category in each of the three states, and the solid circles show the average income level and estimated average support for Bush for each state.'

The line: each line represents the trend of households' voting in a state, based on voters' income category. The slope of the line tells us how strong the relation between voting preference vs. income. The steeper the slope, the stronger the relation. As a result, 'income is a very strong predictor of vote preference in Mississippi, a weaker predictor in Ohio, and only weakly predicts vote choice at all in Connecticut.'

Different slopes between right and left panels:
In Figure 3, the model only consider the relation between income vs. voting preference so that the lines representing each State only vary by income. In Figure 4, however, the calculated probability takes into the consideration of respondents' geography and income (2 vars). When taking into consideration of 2 vars, we don't require the plotted points to construct a specific linear relationship between voting preference vs. income or in other words, allows the model for varying slope. By allowing varying slope, the model reduces the deviance (as seen in 2000 vs. 2004 graph) and improved its estimation's accuracy.

Test: Below is only the method - or pseudocode - I think of.

Let x be the respondents' income, y is the probability voting for Republican, and z is the respondents' geography. n is the number of respondents where i is the n(th) respondent.

Without z, our calculation for y knowing x:
y <- a*x + b (linear relationship)

a, b: constants (is not provided)

See the regression without z:
summary(lm(y~x))

With z, our calculation for y:
y <- for (i in n){log(i)^(-1)*(alpha[z] + beta[z]*x)}

Formula from p.9
alpha, beta: constants (is not provided)

See the regression with z:
summary(lm(y~x+z))

The second regression should return a higher R-squared value.

PROBLEM 2:

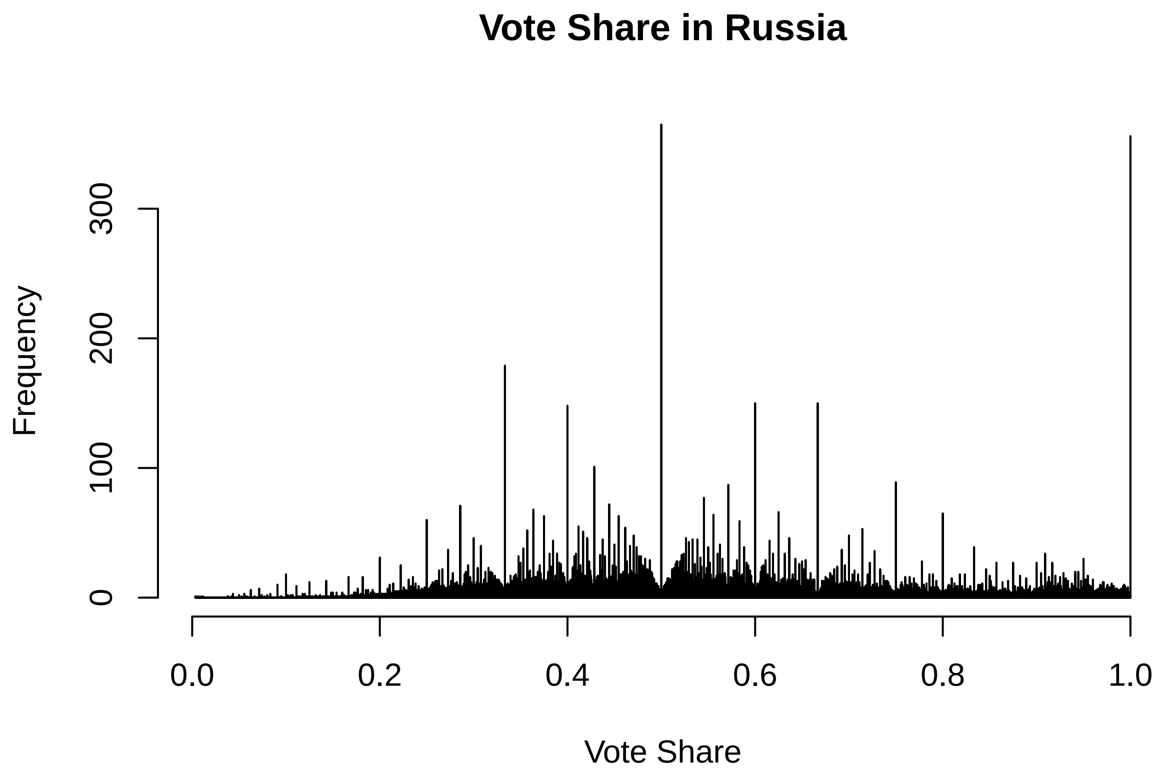
```
load('~/Desktop/Policy Research/HW5/fraud.RData')
```

a. To analyze the 2011 Russian election results, first compute United Russia's vote share as a proportion of the voters who turned out. Identify the 10 most frequently occurring fractions for the vote share. Create a histogram that sets the number of bins to the number of unique fractions, with one bar created for each uniquely observed fraction, to differentiate between similar fractions like 1/2 and 51/100. This can be done by using the breaks argument in the hist function. What does this histogram look like at fractions with low numerators and denominators such as 1/2 and 2/3? Ans:
Fractions with low numerators and denominators (i.e. 1/2, 2/3, 3/4) appear with the significant higher frequency than others.

```
#Calculate vote share
russia2011$vote_share <- russia2011$votes/russia2011$turnout

#Find frequency
vote_share_freq <- table(russia2011$vote_share)
#Find 10 most frequently occuring values
head(sort(vote_share_freq, decreasing=TRUE), n=10)
```

```
##
##               0.5                 1 0.333333333333333               0.6
##               365               356               179               150
## 0.666666666666667               0.4 0.428571428571429              0.75
##               150               148               101                89
## 0.571428571428571 0.545454545454545
##                87                77
```

```
#Create histogram
hist(russia2011$vote_share, breaks=length(vote_share_freq), xlab="Vote Share", main="Vote Share in Russi
```



b. The mere existence of high frequencies at low fractions may not imply election fraud. Indeed, more numbers are divisible by smaller integers like 2, 3, and 4 than by larger integers like 22, 23, and 24. To investigate the possibility that the low fractions arose by chance, assume the following probability model:

- **Turnout for a precinct is binomially distributed, with size equal to the number of voters in the precinct and success probability equal to its observed turnout rate.**

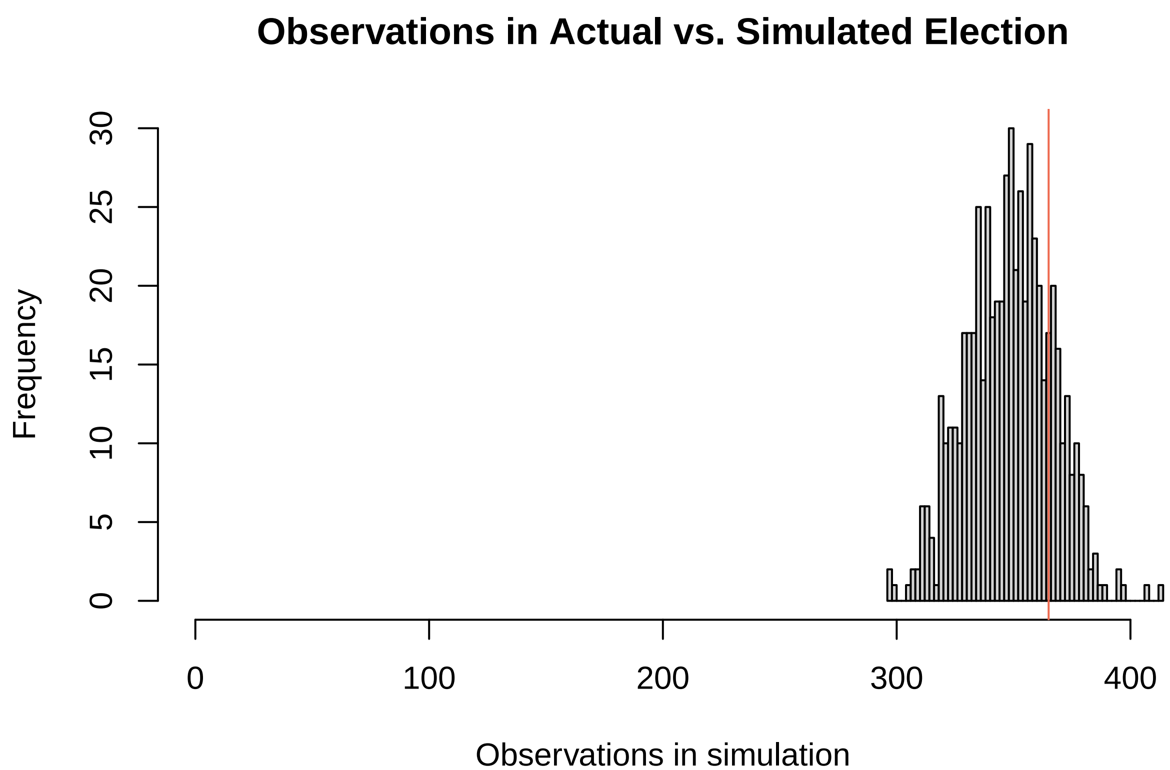
- **Conduct a Monte Carlo simulation under these assumptions. 1000 simulated elections should be sufficient. (Note that this may be computationally intensive code. Write your code for a small number of simulations to test before running all 1000 simulations.)** Ans: See below.

```
#Turnout rate
russia2011$turnout_rate <- russia2011$turnout/russia2011$N

#Initiate number of sims
sims <- 1000

#Function: Simulate an election
simulated_election <- function(dataset) {
  #Simulate a random sample of turn out
  turnout_sample <- rbinom(nrow(dataset), size=dataset$N, prob=dataset$turnout_rate)
  #Simulate a random sample of votes
```

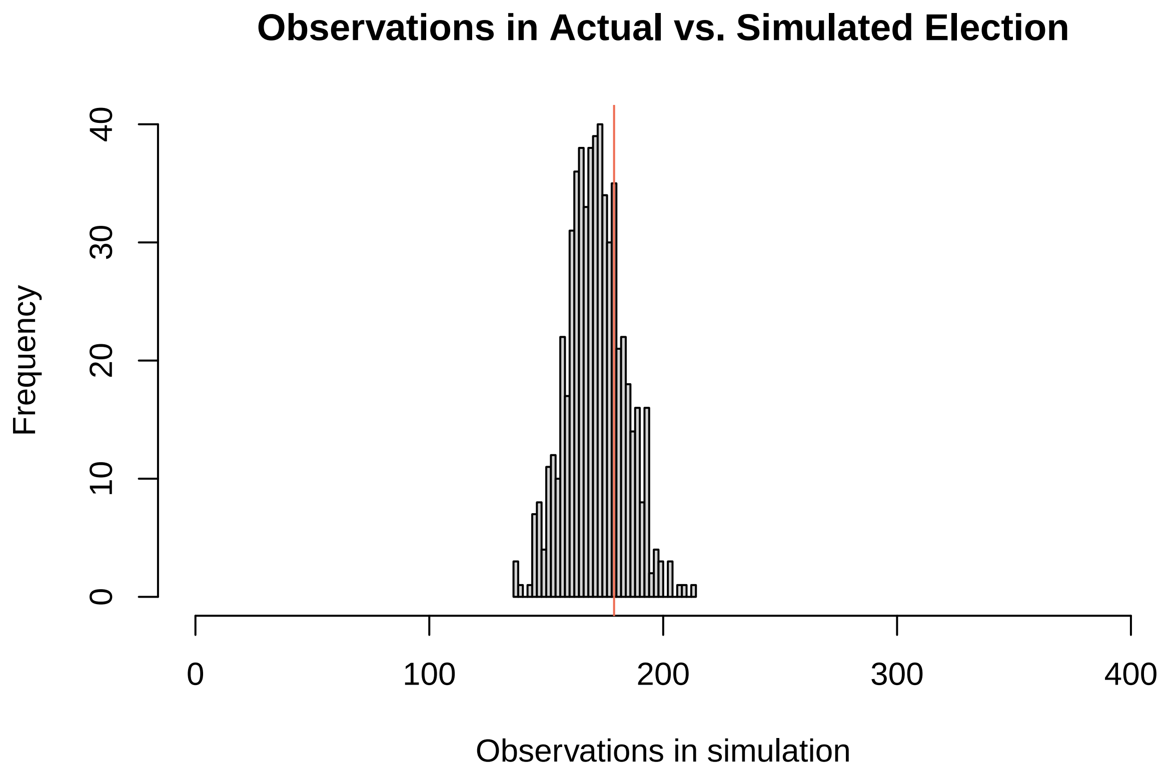
```r
  votes_sample <- rbinom(nrow(dataset), size=turnout_sample, prob=dataset$vote_share)
  #Calculate the vote shares
  return (vote_share_sample <- votes_sample/turnout_sample)
}

#NOTE: (This is where I got the issue)

#Initially, I used a for-loop for simulation
#When using loop (like the following below code), the vote_share_sim will only
#return the last, or the 1000th simulated election
  #for (i in 1:sims) {vote_share_sim = simulated_election(russia2011)}
#This affects our analysis in (d) and (e)

#I thought of two possible solutions for using a for-loop in large simulation:
#(1) Turn the vote_share_sim (which is the vote share of a simulated election)
#into a vector, then create a list and store all such vectors. This method, however,
#is really slow because the computer takes time to both convert and append values
#(2) Create a class for simulation with a function to generate vote share of a simulated
#election. Then each simulated election will be an instance of the class.
#We then can add the instances into the list. Working with instances in a list
#will be less error-prone than working with vectors in a list in (1)

#The book p297 shows one way to store values from large simulations. However, in the example,
#the range of values in Obama.ev is equal the number of sims since each of its
#value is the sum of votes in one election. We cannot apply, because in our case,
#we are calculating vote share, not the total number of votes which is aggregated data.

#Use a loop, regardless, will make our code for question (c) and above too complicated
#Use replicate: which instead returns a matrix (or 2-dimensional list),
#where each simulation is store in a column, and rows is vector of vote share of a simulation
vote_share_sim <- replicate(sims, simulated_election(russia2011))

#Visualization (for checking outcomes)
#Find frequency
#vote_share_freq_sim <- table(vote_share_sim)
#Create histogram
#hist(vote_share_sim, breaks=length(vote_share_freq_sim), xlab="Vote Share", main="Vote Share in Russia
```

c. To judge the Monte Carlo simulation results against the actual results of the 2011 Russian election, we compare the observed fraction of observations within a bin of certain size with its simulated counterpart. To do this, create histograms showing the distribution of part (b)'s four most frequently occurring fractions, i.e., 1/2, 1/3, 3/5, and 2/3, and compare them with the corresponding fractions' proportion in the actual election. Briefly interpret the results.
Ans:
The distribution of most of our observed fraction is close to the approximate value generated from Monte Carlo simulations, with the exception seen in the 3/5 fraction. Though this seems to be unusual and hints for voting manipulation, the difference observed in one fraction alone could hardly tell us anything about our analysis for whether or not fraud occur (there would be so many possible fractions that we can consider instead, not to mention the fact that the fraction of 1/2 - the one that looks to be most suspicious - turned out to have a 'natural' distribution so far).

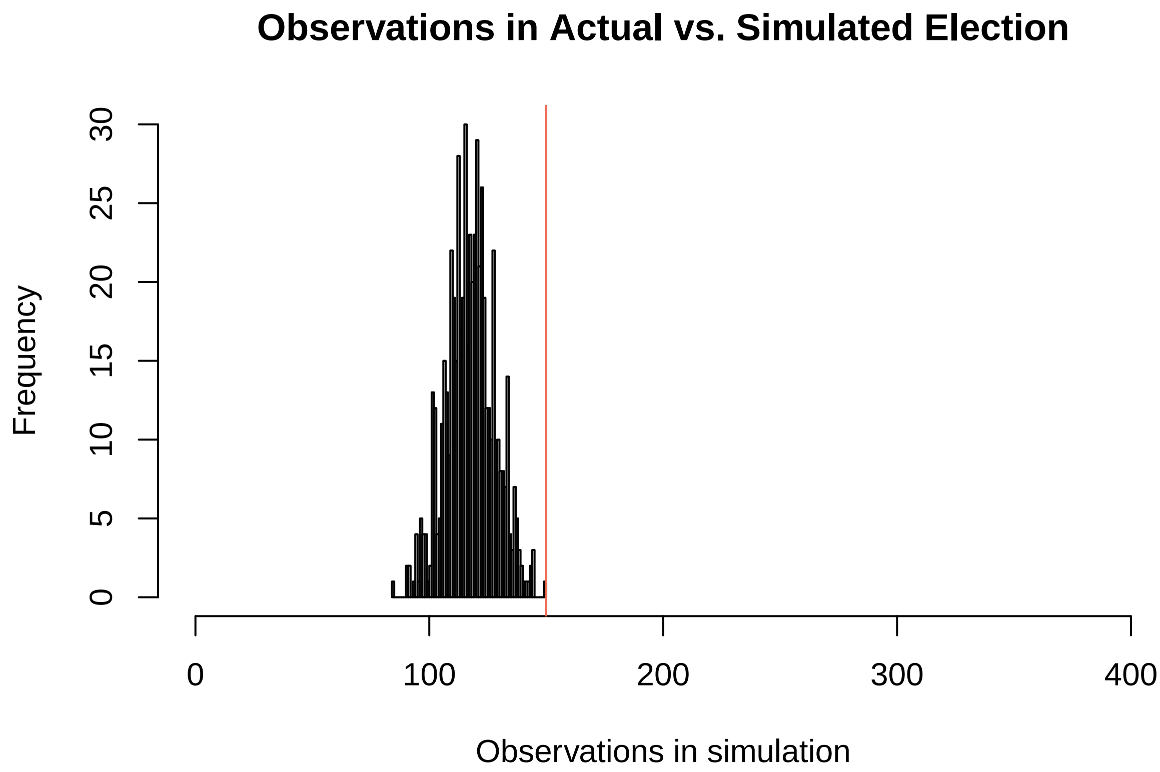
```
#Number of observations in each fraction
obs_1_2 = sum(russia2011$vote_share==1/2)
obs_1_3 = sum(russia2011$vote_share==1/3)
obs_3_5 = sum(russia2011$vote_share==3/5)
obs_2_3 = sum(russia2011$vote_share==2/3)

#Number of observations in each fraction from simulations
obs_1_2_sim = apply(vote_share_sim==1/2,2,sum)
obs_1_3_sim = apply(vote_share_sim==1/3,2,sum)
obs_3_5_sim = apply(vote_share_sim==3/5,2,sum)
obs_2_3_sim = apply(vote_share_sim==2/3,2,sum)

#Create histogram for distribution of obs of fraction in simulation and compare
#with that in the actual dataset
hist(obs_1_2_sim, xlim=c(0,400), breaks= 50, xlab='Observations in simulation', main='Observations in Ac
abline(v=obs_1_2, col = 'coral2')
```



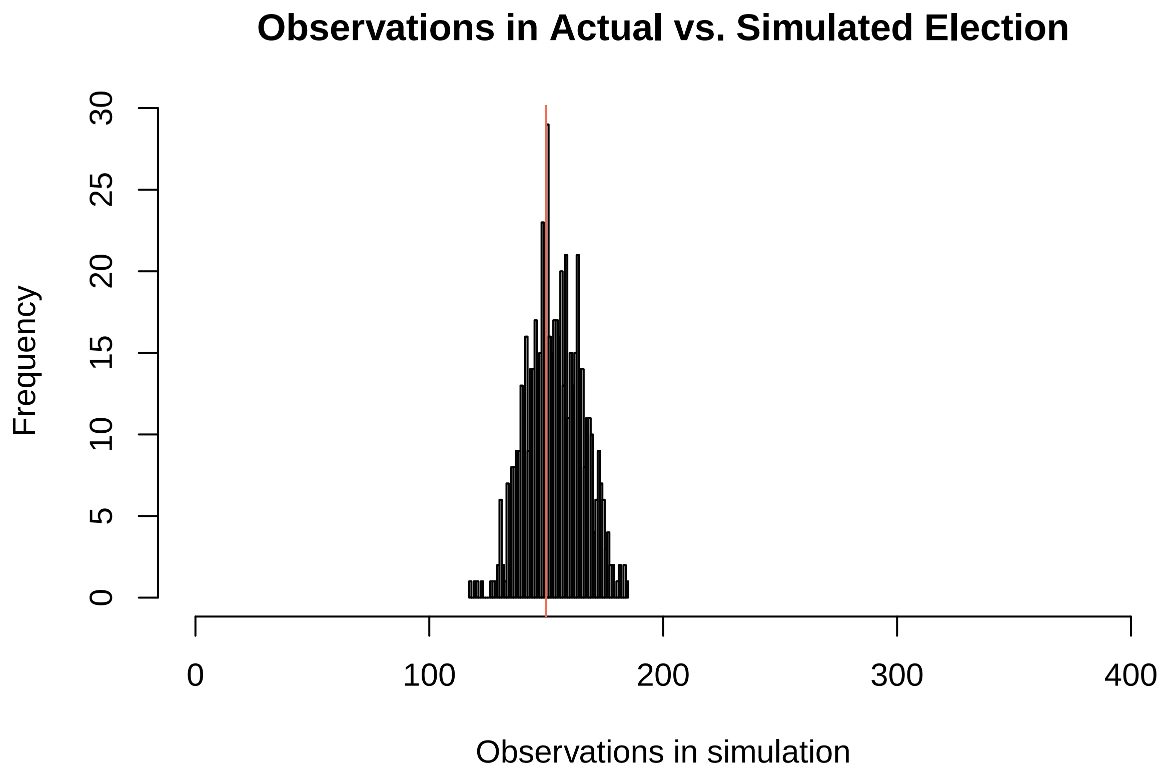

```
hist(obs_1_3_sim, xlim=c(0,400), breaks= 50, xlab='Observations in simulation', main='Observations in Ac
abline(v=obs_1_3, col = 'coral2')
```




```
hist(obs_3_5_sim, xlim=c(0,400), breaks= 50, xlab='Observations in simulation', main='Observations in Ac
abline(v=obs_3_5, col = 'coral2')
```




```
hist(obs_2_3_sim, xlim=c(0,400), breaks= 50, xlab='Observations in simulation', main='Observations in Ac
abline(v=obs_2_3, col = 'coral2')
```

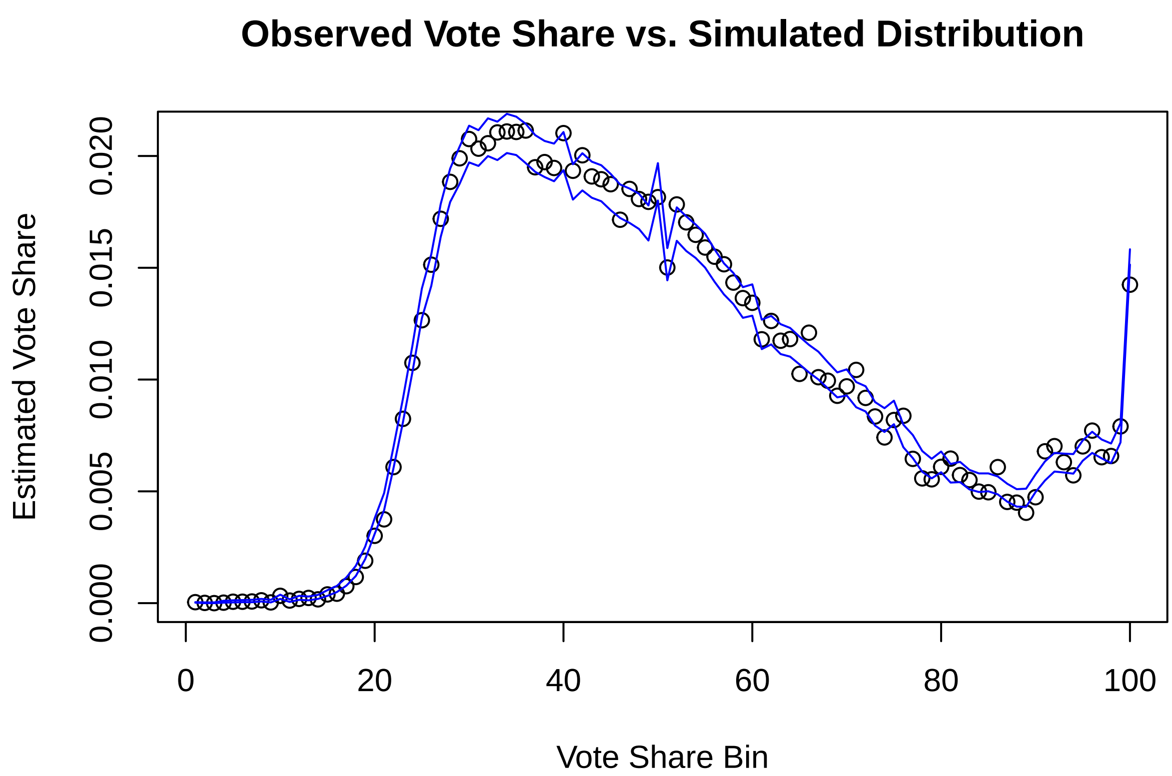


d. We now compare the relative frequency of observed fractions with the simulated ones beyond the four fractions examined in the previous question. To do this, we choose a bin size of 0.01 and compute the proportion of observations that fall into each bin. We then examine whether or not the observed proportion falls within the 2.5 and 97.5 percentiles of the corresponding simulated proportions. Plot the result with vote share bin on the horizontal axis and estimated vote share on the vertical axis. This plot attempts to reproduce the one held by protesters in the figure. Now count the number of times an observed precinct vote share falls outside its simulated interval. Interpret the results. Ans:

There are 31 observed precint vote share falls outside its simulated interval, meaning that almost 1/3 of the actual proportion of vote share falls out the range of 'natural' proportion of vote shares. This might be a implication of manipulation in the voting behavior. However, noted that since we only compared the actual observed vs. that of simulated elections in the range between 2.5 to 97.5 percentiles, there would possibly be chances that the 31 fall-out is within the range that we fall short to cover.

```
#Function: Get vote share and return proportion
bin_share = function(voteshare){
  seql=seq(0,1,length.out=101)[-101]
  seqh=seq(0,1,length.out=101)[-1]
  count=c()
  for (ii in 1:100){
    count[ii]=length(which(voteshare>seql[ii]&voteshare<=seqh[ii]))
  }
  prop=count/sum(count)
  return (prop)
}
```

```r
#Find observed proportion that fall into each bin
obs_bin = bin_share(russia2011$vote_share)

#Find the vote share prop at the 2.5 and 97.5 percentiles in the simulated elections
sim_obs_bin <- apply(vote_share_sim, 2, bin_share)
sim_2_5 <- apply(sim_obs_bin, 1, quantile, probs=0.025, na.rm=TRUE)
sim_97_5 <- apply(sim_obs_bin, 1, quantile, probs=0.975, na.rm=TRUE)


#Plot
plot(obs_bin, xlab="Vote Share Bin", ylab="Estimated Vote Share", main="Observed Vote Share vs. Simulat
lines(sim_2_5, col="blue")
lines(sim_97_5, col="blue")
```




```r
#Number of time an observed falls outside its simulated interval
sum(obs_bin < sim_2_5 | obs_bin > sim_97_5)
```

```
## [1] 32
```

e. To put the results of the previous question in perspective, apply the procedure developed in the previous question to the 2011 Canadian elections and the 2003 Russian election, where no major voting irregularities were reported. In addition, apply this procedure to the 2012 Russian presidential election, where election fraud allegations were reported. No plot needs to be produced. Briefly comment on the results you obtain. Ans:

The results are similar for all three: 21 fall-out observations for canada 2011, 23 for russia 2003, and 23 for russia 2012.
When a fraud reported election (russia 2012) generated such similar results to a non-fraud reported ones (russia 2003), it indicates that the result we found earlier for russia 2011 might not be sufficient for the conclusion whether fraud occurs or not.
Simultaneously, as noted earlier in (d), there are chances that the fall-outs are actually just a result of our lack of inclusion when using the 2.5 to 97.5 percentiles to compare. This fact further complicates our interpretation for whether or not fraud exists just by basing on the fall-out.

```
fraud_detection <- function(dataset){
  dataset$vote_share <- dataset$votes/dataset$turnout
  dataset$turnout_rate <- dataset$turnout/dataset$N
  VoteShareSim <- replicate(sims, simulated_election(dataset))
  ObsBin <- bin_share(dataset$vote_share)
  SimObsBin <- apply(VoteShareSim, 2, bin_share)
  Sim25 <- apply(SimObsBin, 1, quantile, probs=0.025, na.rm=TRUE)
  Sim975 <- apply(SimObsBin, 1, quantile, probs=0.975, na.rm=TRUE)
  return (sum(ObsBin < Sim25 | ObsBin > Sim975))
}

#No fraud: Canada and Russia 2003
fraud_detection(canada2011)
```

```
## [1] 20
```

```
fraud_detection(russia2003)
```

```
## [1] 21
```

```
#Fraud: Russia 2012
fraud_detection(russia2012)
```

```
## [1] 22
```

PROBLEM 3:

```
#Simulate and generate random var
sims<-1000
x <- runif(sims, min=1, max=1111)
y <- runif(sims, min=0, max=99999)
z <- runif(sims, min=0, max=100)

#Add var to a table
data <- list(x,y,z)
as.data.frame(data)
```

```
##      c.720.565746721346..867.464332207106..464.99430664489..273.09848694969..
## 1                                                                  720.565747
## 2                                                                  867.464332
## 3                                                                  464.994307
```

```
## 4                                                               273.098487
## 5                                                                 5.360726
## 6                                                              1028.156712
## 7                                                               610.012055
## 8                                                               191.028635
## 9                                                               604.410376
## 10                                                              354.499203
## 11                                                              658.693855
## 12                                                              821.927187
## 13                                                              377.363789
## 14                                                              625.700355
## 15                                                              609.790391
## 16                                                              966.912482
## 17                                                             1036.375354
## 18                                                              486.047684
## 19                                                             1025.565420
## 20                                                              212.157855
## 21                                                              172.958641
## 22                                                              564.583075
## 23                                                             1064.947192
## 24                                                              330.501349
## 25                                                              262.924867
## 26                                                             1060.300289
## 27                                                              754.563068
## 28                                                              358.319477
## 29                                                              797.395044
## 30                                                              142.332714
## 31                                                              197.121643
## 32                                                              307.010079
## 33                                                              616.509359
## 34                                                              925.738015
## 35                                                              332.677237
## 36                                                             1074.743973
## 37                                                              394.536376
## 38                                                              817.243571
## 39                                                              629.690642
## 40                                                              248.323355
## 41                                                              172.760544
## 42                                                              627.829748
## 43                                                              367.701945
## 44                                                              770.062556
## 45                                                                4.327793
## 46                                                              642.928834
## 47                                                               31.596925
## 48                                                              664.061351
## 49                                                              418.541696
## 50                                                              465.872401
## 51                                                               90.145264
## 52                                                              676.450286
## 53                                                              341.228156
## 54                                                              583.375507
## 55                                                              158.870271
## 56                                                              644.917514
## 57                                                              358.789177
```

```
## 58                                                          606.932637
## 59                                                          557.414081
## 60                                                          247.565925
## 61                                                          636.302414
## 62                                                          726.199767
## 63                                                          342.605119
## 64                                                          602.878004
## 65                                                         1082.494984
## 66                                                          525.946956
## 67                                                          660.458337
## 68                                                          751.548943
## 69                                                          702.020775
## 70                                                          425.368374
## 71                                                          732.962115
## 72                                                          920.287084
## 73                                                          121.929354
## 74                                                          748.439689
## 75                                                         1067.467468
## 76                                                          108.810502
## 77                                                          603.351186
## 78                                                          347.894259
## 79                                                          405.736124
## 80                                                          817.227052
## 81                                                         1093.752879
## 82                                                          485.348271
## 83                                                          939.468758
## 84                                                          962.304843
## 85                                                          933.641959
## 86                                                         1104.583250
## 87                                                          391.323031
## 88                                                         1058.869267
## 89                                                          313.923472
## 90                                                          543.615378
## 91                                                          440.854447
## 92                                                           38.109394
## 93                                                          994.476337
## 94                                                          446.138528
## 95                                                          427.478950
## 96                                                          139.111068
## 97                                                          196.325402
## 98                                                          445.886760
## 99                                                           69.898981
## 100                                                         763.587880
## 101                                                         461.598134
## 102                                                        1084.054775
## 103                                                         411.900849
## 104                                                         378.730190
## 105                                                         320.797990
## 106                                                         936.968945
## 107                                                        1062.232129
## 108                                                         765.574726
## 109                                                         506.376665
## 110                                                         525.324388
## 111                                                         696.524648
```

```
## 112                                                                         1049.322200
## 113                                                                          401.040352
## 114                                                                           87.300408
## 115                                                                          249.851402
## 116                                                                          752.128687
## 117                                                                          906.838336
## 118                                                                           56.482528
## 119                                                                         1072.949267
## 120                                                                         1029.746560
## 121                                                                          162.604255
## 122                                                                          247.346141
## 123                                                                          430.983111
## 124                                                                           46.051793
## 125                                                                          550.503205
## 126                                                                          299.101771
## 127                                                                          270.700936
## 128                                                                          401.177647
## 129                                                                          285.658281
## 130                                                                          994.740000
## 131                                                                         1012.163103
## 132                                                                          329.321141
## 133                                                                          340.404111
## 134                                                                          783.110557
## 135                                                                          775.145787
## 136                                                                          780.725608
## 137                                                                          138.240262
## 138                                                                          353.445210
## 139                                                                          946.853162
## 140                                                                            2.558061
## 141                                                                          253.808219
## 142                                                                          378.488772
## 143                                                                          318.725562
## 144                                                                         1019.808462
## 145                                                                          602.488739
## 146                                                                          138.010694
## 147                                                                          667.328476
## 148                                                                          528.571130
## 149                                                                           13.752183
## 150                                                                          398.014489
## 151                                                                          410.414059
## 152                                                                          992.323231
## 153                                                                          714.045827
## 154                                                                          782.289866
## 155                                                                          931.564171
## 156                                                                          890.244997
## 157                                                                          843.054292
## 158                                                                         1032.279027
## 159                                                                         1092.501492
## 160                                                                          614.734243
## 161                                                                          431.148527
## 162                                                                          675.734176
## 163                                                                          115.225126
## 164                                                                          605.209850
## 165                                                                          845.201616
```

```
## 166                                                        921.695254
## 167                                                         27.808512
## 168                                                        546.625783
## 169                                                        332.997518
## 170                                                        301.092514
## 171                                                         73.155245
## 172                                                        299.344218
## 173                                                        789.501014
## 174                                                         97.457171
## 175                                                        651.673786
## 176                                                        491.894569
## 177                                                       1055.603838
## 178                                                        713.904669
## 179                                                        626.991455
## 180                                                        346.863438
## 181                                                        650.359091
## 182                                                        920.684686
## 183                                                       1021.215222
## 184                                                        438.911841
## 185                                                        141.016531
## 186                                                        269.550999
## 187                                                       1074.361532
## 188                                                        846.628359
## 189                                                        485.204122
## 190                                                        987.298641
## 191                                                        384.880659
## 192                                                        542.556819
## 193                                                        384.580442
## 194                                                        621.515884
## 195                                                        338.662995
## 196                                                         17.472073
## 197                                                        535.649787
## 198                                                        607.831887
## 199                                                        782.332317
## 200                                                       1079.165197
## 201                                                        512.078460
## 202                                                        409.601126
## 203                                                        556.018006
## 204                                                        634.132878
## 205                                                        666.382275
## 206                                                        690.483951
## 207                                                        460.666018
## 208                                                        480.689461
## 209                                                        302.229142
## 210                                                        855.430614
## 211                                                         37.311523
## 212                                                        201.712157
## 213                                                        652.057664
## 214                                                       1020.626478
## 215                                                        819.262020
## 216                                                        940.249362
## 217                                                        761.772591
## 218                                                        715.661432
## 219                                                        766.713898
```

```
## 220                                                            1001.902943
## 221                                                             379.793481
## 222                                                             586.640051
## 223                                                             336.151291
## 224                                                             565.213725
## 225                                                             412.430270
## 226                                                             680.348836
## 227                                                             539.182707
## 228                                                             511.445391
## 229                                                             853.062496
## 230                                                             650.103544
## 231                                                             131.921609
## 232                                                             115.327062
## 233                                                              61.881055
## 234                                                             146.340833
## 235                                                             699.115799
## 236                                                             654.856160
## 237                                                             256.483893
## 238                                                             532.958302
## 239                                                             628.676232
## 240                                                             351.155010
## 241                                                             759.445851
## 242                                                             305.396382
## 243                                                              80.283750
## 244                                                             689.017692
## 245                                                             979.939238
## 246                                                             278.240113
## 247                                                            1056.177522
## 248                                                             192.454185
## 249                                                             289.691896
## 250                                                             665.317641
## 251                                                             955.548297
## 252                                                             498.161712
## 253                                                             332.821328
## 254                                                              79.341691
## 255                                                             259.976882
## 256                                                             142.869508
## 257                                                             590.473028
## 258                                                             460.595590
## 259                                                             144.730611
## 260                                                             594.977008
## 261                                                             182.980387
## 262                                                             331.195062
## 263                                                             699.275728
## 264                                                             685.777956
## 265                                                             267.781742
## 266                                                             446.877500
## 267                                                              55.033645
## 268                                                             606.578537
## 269                                                            1000.308394
## 270                                                             224.486687
## 271                                                              79.534810
## 272                                                             546.982634
## 273                                                             853.887484
```

```
## 274                                                        809.413759
## 275                                                        639.678938
## 276                                                       1058.089721
## 277                                                        670.876255
## 278                                                         77.685114
## 279                                                        443.729322
## 280                                                        491.096396
## 281                                                       1026.301996
## 282                                                        289.212422
## 283                                                        480.508681
## 284                                                        858.658708
## 285                                                        746.797399
## 286                                                        719.195059
## 287                                                         77.283539
## 288                                                        597.774079
## 289                                                         48.969177
## 290                                                        126.480819
## 291                                                        119.954834
## 292                                                        830.379482
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## 311                                                         37.377134
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## 323                                                        175.800916
## 324                                                         41.608060
## 325                                                        293.707011
## 326                                                          6.336859
## 327                                                        150.517882
```

```
## 328                                                    163.756406
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```

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```

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```

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```

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```

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## 651                                                          103.977584
```

```
## 652                                                                    960.900456
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## 705                                                                    250.181849
```

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## 706                                                          1108.010585
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```

```
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```

```
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```

```
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```

```
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## 621                                                              76985.25790
## 622                                                              90522.21611
```

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## 623                                                              23583.36220
## 624                                                               5403.94597
## 625                                                              35884.57700
## 626                                                              47307.92926
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## 676                                                              73786.78980
```

```
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```

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```

```
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```

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```

```
## 893                                                             47190.43441
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## 945                                                             85170.26222
## 946                                                             50056.79679
```

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## 885                                                                    0.98168945
## 886                                                                   34.40264391
## 887                                                                    6.30311042
## 888                                                                   16.10024052
## 889                                                                   96.84345517
## 890                                                                   79.99750874
## 891                                                                   65.51876129
## 892                                                                   89.06828589
## 893                                                                    4.12535283
## 894                                                                   38.46251380
## 895                                                                   46.51529475
## 896                                                                   12.07466195
## 897                                                                    2.58746569
## 898                                                                   42.80414756
## 899                                                                   47.99406205
## 900                                                                    9.80527825
## 901                                                                    0.80805237
## 902                                                                   22.16399487
## 903                                                                   98.03874984
## 904                                                                   20.14927894
## 905                                                                   17.31488144
## 906                                                                   56.02264453
## 907                                                                   31.48877285
## 908                                                                   11.31107113
## 909                                                                   87.03157345
## 910                                                                   51.02112878
## 911                                                                   64.46557511
## 912                                                                   97.19157685
## 913                                                                   13.53731004
## 914                                                                   73.71007006
## 915                                                                   60.86336293
## 916                                                                    6.79235610
## 917                                                                   80.97120738
```

```
## 918                                                                    51.95108980
## 919                                                                    65.65871073
## 920                                                                    79.51100059
## 921                                                                    59.27334675
## 922                                                                    28.50131486
## 923                                                                    40.67670139
## 924                                                                    28.07860989
## 925                                                                    13.42942421
## 926                                                                    61.54518591
## 927                                                                     3.97357855
## 928                                                                     1.22609911
## 929                                                                    37.98938473
## 930                                                                    68.54550827
## 931                                                                    56.41012301
## 932                                                                    84.17225906
## 933                                                                    39.44885153
## 934                                                                    90.10607989
## 935                                                                    56.95758034
## 936                                                                     1.13956505
## 937                                                                    94.77483339
## 938                                                                    41.86145382
## 939                                                                     6.68439032
## 940                                                                    91.92479867
## 941                                                                    16.87983971
## 942                                                                     0.08832628
## 943                                                                    53.25049537
## 944                                                                    47.22957008
## 945                                                                    80.65966682
## 946                                                                    16.67234369
## 947                                                                    33.55116039
## 948                                                                    60.97535247
## 949                                                                    50.90929032
## 950                                                                    43.93564560
## 951                                                                    76.90490331
## 952                                                                    22.10864327
## 953                                                                    24.54460885
## 954                                                                    30.92975526
## 955                                                                    91.46904026
## 956                                                                    64.57764765
## 957                                                                    55.30938257
## 958                                                                    59.90366172
## 959                                                                    98.07481887
## 960                                                                    38.06929972
## 961                                                                    53.70757261
## 962                                                                    95.99008774
## 963                                                                    70.36226906
## 964                                                                     8.57676708
## 965                                                                    67.67733663
## 966                                                                     3.68829344
## 967                                                                     0.16953128
## 968                                                                    87.50024545
## 969                                                                    21.61473497
## 970                                                                    83.16137532
## 971                                                                    82.40688720
```

```
## 972                                                                  6.21638463
## 973                                                                 31.67994933
## 974                                                                 65.85642418
## 975                                                                 19.32962257
## 976                                                                 11.76851594
## 977                                                                 76.31080158
## 978                                                                  0.26430166
## 979                                                                 45.28354905
## 980                                                                 21.27914003
## 981                                                                 11.80727158
## 982                                                                 80.36879345
## 983                                                                 96.02432605
## 984                                                                 38.59421879
## 985                                                                 27.20064069
## 986                                                                 53.59365414
## 987                                                                 88.30015883
## 988                                                                 51.32460648
## 989                                                                 18.19359534
## 990                                                                 30.89875565
## 991                                                                  9.84706129
## 992                                                                  7.31788056
## 993                                                                 20.21615829
## 994                                                                 37.36310415
## 995                                                                 60.91907928
## 996                                                                 95.53492877
## 997                                                                 28.13942449
## 998                                                                 94.76623395
## 999                                                                 37.14683352
## 1000                                                                86.58091426
```

```
#View regression relation
#between y and x
summary(lm(formula = y~x, data=data))
```

```
##
## Call:
## lm(formula = y ~ x, data = data)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -50635 -24754   -496  26076  49904
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) 50784.9414  1841.2508  27.582   <2e-16 ***
## x              -0.7168     2.9525  -0.243    0.808
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 29490 on 998 degrees of freedom
## Multiple R-squared:  5.906e-05,  Adjusted R-squared:  -0.0009429
## F-statistic: 0.05894 on 1 and 998 DF,  p-value: 0.8082
```

```r
#between y and x (adjusted for coufounding z)
summary(lm(formula = y~x+z, data=data))
```

```
##
## Call:
## lm(formula = y ~ x + z, data = data)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -50557 -24741   -538  26073  49856
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) 51008.9550  2385.4360  21.383   <2e-16 ***
## x              -0.6858     2.9614  -0.232    0.817
## z              -4.7823    32.3536  -0.148    0.883
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 29510 on 997 degrees of freedom
## Multiple R-squared:  8.097e-05,  Adjusted R-squared:  -0.001925
## F-statistic: 0.04037 on 2 and 997 DF,  p-value: 0.9604
```