kernel

November 20, 2018

In [1]:
```
## Importing packages

# This R environment comes with all of CRAN and many other helpful packages preinstall
# You can see which packages are installed by checking out the kaggle/rstats docker im
# https://github.com/kaggle/docker-rstats

library(tidyverse) # metapackage with lots of helpful functions

## Running code

# In a notebook, you can run a single code cell by clicking in the cell and then hitti
# the blue arrow to the left, or by clicking in the cell and pressing Shift+Enter. In 
# you can run code by highlighting the code you want to run and then clicking the blue
# at the bottom of this window.

## Reading in files

# You can access files from datasets you've added to this kernel in the "../input/" di
# You can see the files added to this kernel by running the code below.

list.files(path = "../input")

## Saving data

# If you save any files or images, these will be put in the "output" directory. You
# can see the output directory by committing and running your kernel (using the
# Commit & Run button) and then checking out the compiled version of your kernel.
```

```
Attaching packages  tidyverse 1.2.1
ggplot2 3.0.0.9000      purrr   0.2.5
tibble  1.4.2           dplyr   0.7.6
tidyr   0.8.1           stringr 1.3.1
readr   1.2.0           forcats 0.3.0
Conflicts  tidyverse_conflicts()
dplyr::filter() masks stats::filter()
dplyr::lag()    masks stats::lag()
```

0.1 Functions to be used

```
In [2]: my.bootstrapci.ml <- function(vec0, nboot = 10000, alpha = 0.05){

            #extract sample size, mean and standard deviation from the original data
            n0 <- length(vec0)
            mean0 <- mean(vec0)
            sd0 <- sqrt(var(vec0))

            # create a vector to store the location of the bootstrap studentized deviation vec
            bootvec <- NULL
            bootbiasvec <- NULL

            #create the bootstrap distribution using a for loop
            for( i in 1:nboot){
                vecb <- sample(vec0, replace=T)

                #create mean and standard deviation to studentize
                meanb <- mean(vecb)
                sdb <- sqrt(var(vecb))

                #note since resampling full vector we can use n0 for sample size of vecb
                bootvec <- c(bootvec,(meanb-mean0)/(sdb/sqrt(n0)))

                #Calculation the vector that stores the bias of each bootstap sample
                bootbiasvec <- c(bootbiasvec, meanb-mean0)
              }


            bootbias <- mean(bootbiasvec)
            bootsd <- mean(bootvec)

            #Calculate lower and upper quantile of the bootstrap distribution
            lq <- quantile(bootvec,alpha/2)
            uq <- quantile(bootvec,1-alpha/2)

            #incorporate into the bootstrap confidence interval (what algebra supports this?)
            LB <- mean0-(sd0/sqrt(n0))*uq[[1]]
            UB <- mean0-(sd0/sqrt(n0))*lq[[1]]

            #since I have the mean and standard deviation calculate the normal confidence inte
            NLB <- mean0-(sd0/sqrt(n0))*qnorm(1-alpha/2)
            NUB <- mean0+(sd0/sqrt(n0))*qnorm(1-alpha/2)

            list(bootbias = bootbias, bootsd = bootsd, bootstrap.confidence.interval=c(LB,UB),
        }

In [3]: Jackknife <- function(v1, statfunc = sd, alpha = 0.05){
```

```
    # Calculate length of a vector v1
    n1 <- length(v1)

    # Initialize an empty vector
    jackvec <- NULL

    # Calculate standard deviation of v
    mu0 <- statfunc(v1)

    for(i in 1:n1){

        # Find out standard deviation/or any stat function of all values in the vector
        # eg. for a vector c(1,2,3,4), sd(v[-1]) will calculate the standard deviation
        # of c(2,3,4).
        mua <- statfunc(v1[-i])

        # Calculate n*sigma for the new vector, subtract this from the original vector
        jackvec <- c(jackvec, n1*(mu0) - (n1-1)*mua)
    }

    jackbias <- mean(jackvec) - mu0
    jacksd <- sd(jackvec)

    # Calculate the jacknife confidence intervals
    JLB <- mean(jackvec) - (jacksd/sqrt(n1))*qnorm(1-alpha/2)
    JUB <- mean(jackvec) + (jacksd/sqrt(n1))*qnorm(1-alpha/2)

    list(mu0=mu0,jackbias=jackbias,jacksd=jacksd, jackknife.confidence.interval = c(JLB
}
```

0.2 Question - 1

0.2.1 1.1 Confidence Interval Estimation using Bootstrap

```
In [4]: my.bootstrapci.ml(1:1000)
```

$bootbias -0.00954400000000003

$bootsd -0.000830443851709335

$bootstrap.confidence.interval 1. 482.35632314494 2. 518.359593382077

$normal.confidence.interval 1. 482.599114827485 2. 518.400885172515

0.2.2 1.2 Bias and Standar Deviation Estimation using Jacknife

```
In [5]: Jackknife(1:10000, statfunc = mean)
```

$mu0 5000.5

$jackbias 0

$jacksd 2886.89567990716

$jackknife.confidence.interval 1. 4943.91788440258 2. 5057.08211559742

0.3 Question - 2

0.3.1 2.1 Build a Simulator

```
In [6]: simulation <- function(mu.val = 3, n = 30, nsim = 1000){

            #create coverage indicator vectors for bootstrap and normal
            cvec.boot <- NULL
            cvec.norm <- NULL
            cvec.jack <- NULL


            #calculate real mean
            mulnorm <- (exp(mu.val+1/2))

            #run simulation
            for(i in 1:nsim){

                if((i/100)==floor(i/100)){
                  print(i)
                }

                #sample the simulation vector
                vec.sample <- rlnorm(n,mu.val)

                #bootstrap it
                boot.list <- my.bootstrapci.ml(vec.sample, nboot = 1000)

                #jackknife it
                jack.list <- Jackknife(vec.sample, statfunc = mean, alpha = 0.05)

                #fetch confidence intervals
                boot.conf <- boot.list$bootstrap.confidence.interval
                jack.conf <- jack.list$jackknife.confidence.interval
                norm.conf <- boot.list$normal.confidence.interval

                #calculate if confidence intervals include mu
                #count up the coverage by the bootstrap interval
                cvec.boot <- c(cvec.boot,(boot.conf[1]<mulnorm)*(boot.conf[2]>mulnorm))

                #count up the coverage by the jackknife interval
                cvec.jack <- c(cvec.jack,(jack.conf[1]<mulnorm)*(jack.conf[2]>mulnorm))

                #count up the coverage by the normal theory interval
                cvec.norm <- c(cvec.norm,(norm.conf[1]<mulnorm)*(norm.conf[2]>mulnorm))
```

```
    }

    #calculate and output coverage probability estimates
    list(boot.coverage = (sum(cvec.boot)/nsim), jack.coverage = (sum(cvec.jack)/nsim), no
}
```

0.4 Question - 3

Due to computational contraints, I am using nboot as only 1000

0.4.1 3.1 Using n = 10

```
In [8]: simulation(mu.val = 4, n = 10, nsim = 1000)
```

```
[1] 100
[1] 200
[1] 300
[1] 400
[1] 500
[1] 600
[1] 700
[1] 800
[1] 900
[1] 1000
```

$boot.coverage 0.891

$jack.coverage 0.778

$norm.coverage 0.778

0.4.2 3.2 Using n = 30

```
In [11]: simulation(mu.val = 4, n = 30, nsim = 1000)
```

```
[1] 100
[1] 200
[1] 300
[1] 400
[1] 500
[1] 600
[1] 700
[1] 800
[1] 900
[1] 1000
```

$boot.coverage 0.915

$jack.coverage 0.865

$norm.coverage 0.865

0.4.3 3.3 Using n = 100

```
In [12]: simulation(mu.val = 4, n = 100, nsim = 1000)
```

```
[1] 100
[1] 200
[1] 300
[1] 400
[1] 500
[1] 600
[1] 700
[1] 800
[1] 900
[1] 1000
```

$boot.coverage 0.937

$jack.coverage 0.908

$norm.coverage 0.908

0.5 Question - 4

```
In [13]: Jackknife_sd <- function(v1){
            n1 <- length(v1)
            jackvec <- NULL
            mu0 <- sd(v1)/n1

            for(i in 1:n1){
                mua <- sd(v1[-i])/(n1-1)
                jackvec <- c(jackvec, n1*(mu0)-(n1-1)*mua)
            }

            jackbias <- mean(jackvec) - mu0
            return (jackbias)
          }
```

```
In [14]: Bootstrap_sd <- function(vec0, nboot = 10000){

            #extract sample size, mean and standard deviation from the original data
            n <- length(vec0)
            mean0 <- sd(vec0)/n

            bootvec <- NULL
            bootbiasvec <- NULL

            #create the bootstrap distribution using a for loop
            for(i in 1:nboot){
```

```
            vecb <- sample(vec0, replace = T)

            #create mean and standard deviation to studentize
            meanb <- sd(vecb)/n

            #note since resampling full vector we can use n0 for sample size of vecb
            bootvec <- c(bootvec, meanb)

            #Calculation the vector that stores the bias of each bootstap sample
            bootbiasvec <- c(bootbiasvec, meanb-mean0)
        }

        return(mean(bootbiasvec))

    }
```

In [15]:
```
simulation_for_jackknife_and_bootstrap <- function(mu = 3, sd = 2, n = 30 , nsim = 4){

        #create coverage indicator vectors for bootstrap and normal
        bvec.boot <- NULL
        bvec.jack <- NULL

        #run simulation
        for(i in 1:nsim){

            if((i/100)==floor(i/100)){
              print(i)
            }

            #sample the simulation vector
            vec.sample <- rnorm(n, mean = mu, sd = sd)

            #bootstrap bias
            bvec.boot <- c(bvec.boot, Bootstrap_sd(vec.sample, nboot = 1000))

            #jackknife bias
            bvec.jack <- c(bvec.jack, Jackknife_sd(vec.sample))
        }

        list(boot_bias = bvec.boot, jack_bias = bvec.jack)

    }
```

In [16]:
```
Output_4 <- simulation_for_jackknife_and_bootstrap(mu = 3, sd = 2, n = 30 , nsim = 100
Output_4
```

```
[1] 100
[1] 200
```

```
[1] 300
[1] 400
[1] 500
[1] 600
[1] 700
[1] 800
[1] 900
[1] 1000
```

$boot_bias 1. -0.00189410008329643 2. -0.00205014182361615 3. -0.00180172970690065
4. -0.00122562488363328 5. -0.0014575365963745 6. -0.0016551564056354
7. -0.0011373430914509 8. -0.00136365110464378 9. -0.00152563673505289
10. -0.00176146057789976 11. -0.00181224618000808 12. -0.00150182148897575
13. -0.00146421178315812 14. -0.00164218296733404 15. -0.00179383111562126
16. -0.00192727885342959 17. -0.00153107052068764 18. -0.00122712035561777
19. -0.00188592539391316 20. -0.00162932659639909 21. -0.00125292157312532
22. -0.00109627721438469 23. -0.00121381347801202 24. -0.00184519370015272
25. -0.0014570790688 6869 26. -0.001061762613506 27. -0.00182421767159508
28. -0.00196570660712316 29. -0.00118605517914111 30. -0.00138452321402088
31. -0.00149132225900224 32. -0.00120602755710624 33. -0.00181376672246265
34. -0.00132924843073282 35. -0.00120852230090986 36. -0.00158446362259198
37. -0.0015824114154 2232 38. -0.0016036676281 3467 39. -0.0024494546565553
40. -0.00216018348368133 41. -0.00112117569781617 42. -0.00167490037826854
43. -0.00143505410427656 44. -0.00126099555363583 45. -0.00165141047550532
46. -0.000957518995442917 47. -0.00159994797023527 48. -0.0014737221134315
49. -0.00135055188240668 50. -0.00098340625813429 51. -0.00179649499355041
52. -0.000944092867042154 53. -0.00158533080761049 54. -0.00156114912788133
55. -0.00229653317104796 56. -0.00163121876684043 57. -0.00173069803088403
58. -0.00124485379840929 59. -0.00131142575903533 60. -0.00162002130610434
61. -0.00141353296814024 62. -0.00126890256212049 63. -0.00184771890845537
64. -0.00139061103508148 65. -0.00192296866487757 66. -0.00158872136678054
67. -0.00139947472143971 68. -0.00154349335914775 69. -0.00112652688109444
70. -0.00198500634614718 71. -0.00139421491552655 72. -0.00163781688338531
73. -0.00155731821468233 74. -0.00145925340416404 75. -0.00107312121365329
76. -0.00131845204687702 77. -0.00144086283371049 78. -0.0011457006669242
79. -0.001672260766535 80. -0.00122142566486725 81. -0.00130046014581117
82. -0.00208982849890677 83. -0.00147849599778929 84. -0.00199424013979211
85. -0.00251323468582946 86. -0.00143005379323135 87. -0.00162350160024727
88. -0.00168533905724495 89. -0.00105099787093727 90. -0.00153631047826489
91. -0.00126965837434046 92. -0.00148115979286074 93. -0.0021058533827187
94. -0.00136424820387158 95. -0.00100501376255327 96. -0.00126284839338881
97. -0.001842106580146 98. -0.0021204549146943 99. -0.00128502470455399
100. -0.00131984840373717 101. -0.00179531388862276 102. -0.00166756804321376
103. -0.00168027508214904 104. -0.0013846996839092 105. -0.00155272078936451
106. -0.00369618941086502 107. -0.00152939282770812 108. -0.00183558723079791
109. -0.00190247696043655 110. -0.00157539254745658 111. -0.00175875678020701
112. -0.0018252409948981 113. -0.00148751993934667 114. -0.00223970848485934

115.	-0.0013022549311443	116.	-0.0014356727525116	117.	-0.00122328093985717
118.	-0.00178810335360396	119.	-0.00206916904225268	120.	-0.00122450369854586
121.	-0.00144538622787567	122.	-0.00190690093043267	123.	-0.00124942321166812
124.	-0.00144855969609911	125.	-0.000992745893245611	126.	-0.00150579505348005
127.	-0.00140783395938596	128.	-0.00166332922623668	129.	-0.00148171922017624
130.	-0.00226151773889783	131.	-0.00262690240142304	132.	-0.00159781182144549
133.	-0.00149543626185504	134.	-0.00165676649328388	135.	-0.0017430621949729
136.	-0.00153243211314293	137.	-0.00117087788919259	138.	-0.00235738710699489
139.	-0.00100387698301883	140.	-0.00207735398120471	141.	-0.00119457421328965
142.	-0.0013733336058027	143.	-0.00131071995960453	144.	-0.00160943562890919
145.	-0.00213727742202255	146.	-0.00161166639380091	147.	-0.00199299138758221
148.	-0.00179415508856513	149.	-0.00169477238583187	150.	-0.00102461168588951
151.	-0.00127937853028061	152.	-0.00113686103130297	153.	-0.00187553927682945
154.	-0.00139286306237264	155.	-0.00192104875944717	156.	-0.00156099203235149
157.	-0.00151100846978593	158.	-0.0018473243753617	159.	-0.00165994204479988
160.	-0.000983850126714458	161.	-0.00157210379162315	162.	-0.00184967334332433
163.	-0.00221776786559011	164.	-0.0013859350356504	165.	-0.00117961819014831
166.	-0.00179715490610972	167.	-0.00176209809060787	168.	-0.00140309348852313
169.	-0.00117466388203312	170.	-0.00169893557209885	171.	-0.00153107642699741
172.	-0.00123600527731809	173.	-0.00222409073253757	174.	-0.00153226722585073
175.	-0.00157138452388667	176.	-0.00176353553752169	177.	-0.00156436448922888
178.	-0.00183887476987687	179.	-0.000863800806088415	180.	-0.00176958057498911
181.	-0.00192498634304071	182.	-0.00259928577192761	183.	-0.00188417402276446
184.	-0.00111756091957999	185.	-0.00105143539855897	186.	-0.00122859994127417
187.	-0.00181876471570389	188.	-0.00126985196134524	189.	-0.00211899211576965
190.	-0.00136218335159571	191.	-0.00158701843292909	192.	-0.00115281309859095
193.	-0.00146997170911832	194.	-0.00150354452137829	195.	-0.00132567786969623
196.	-0.00127347460198377	197.	-0.0018827115101374	198.	-0.00210558327588141
199.	-0.00148004144714767	200.	-0.00123196283911245	201.	-0.00128534254732251
202.	-0.00171151192696155	203.	-0.00141546677579936	204.	-0.00123253227391727
205.	-0.00154871371016835	206.	-0.00247583563669501	207.	-0.00184002808732374
208.	-0.00186049529169879	209.	-0.0023427907255861	210.	-0.00189715614166797
211.	-0.00185585982097628	212.	-0.00203536345246452	213.	-0.00122133909868742
214.	-0.00182727623245273	215.	-0.00129163567655455	216.	-0.00147465229286319
217.	-0.00120091562199317	218.	-0.0015168449489283	219.	-0.001044871881908
220.	-0.00282034211721166	221.	-0.00131152487765661	222.	-0.00136988046507539
223.	-0.00220614258642937	224.	-0.00195237532367457	225.	-0.00122309960931739
226.	-0.00238611738059248	227.	-0.00109444572148339	228.	-0.00162502825268804
229.	-0.00226752423507944	230.	-0.00150262706310454	231.	-0.0010904196060774
232.	-0.00176644284382503	233.	-0.00113080828133193	234.	-0.00153335641744311
235.	-0.00183003251248217	236.	-0.00176000315783096	237.	-0.00133396164850179
238.	-0.00219056768999967	239.	-0.00170789278296298	240.	-0.00189604183518145
241.	-0.00213998791343325	242.	-0.00133541095574456	243.	-0.00173624085462236
244.	-0.000729611571794895	245.	-0.00110552176547743	246.	-0.00151213412235078
247.	-0.00162218247505434	248.	-0.0022483979438598	249.	-0.00135025302826692
250.	-0.00144118065582208	251.	-0.0020718507986257	252.	-0.00261589513709205
253.	-0.00155129188165654	254.	-0.00169012162063519	255.	-0.0019831306007932
256.	-0.00152267250129399	257.	-0.0013120936077346	258.	-0.00179816935518731

259.	-0.00200895700493722	260.	-0.00196319790330983	261.	-0.00234836211333076
262.	-0.00229714096846028	263.	-0.00229390380084645	264.	-0.00210455735463516
265.	-0.00123445435920197	266.	-0.00149553898942631	267.	-0.00158345264803701
268.	-0.00129360689657396	269.	-0.00122372540270234	270.	-0.00137126232465888
271.	-0.00126438649247865	272.	-0.00227425567548823	273.	-0.0015218390599774
274.	-0.00125243491097204	275.	-0.00153074927302741	276.	-0.00142217363314912
277.	-0.0015285807268303	278.	-0.00152266175423661	279.	-0.00184126896351628
280.	-0.00219213988956917	281.	-0.00192597217517348	282.	-0.00220317008237971
283.	-0.00213693138898603	284.	-0.00155550083066319	285.	-0.00161402659933771
286.	-0.00185143888370364	287.	-0.00254182600525472	288.	-0.00137378810909422
289.	-0.00104461488761068	290.	-0.00219299615760402	291.	-0.00172085240501557
292.	-0.00146538691382595	293.	-0.00127231614844028	294.	-0.00104005008333711
295.	-0.00146715979721306	296.	-0.00161094555515437	297.	-0.00137944746962799
298.	-0.00127100203203546	299.	-0.00147239418792198	300.	-0.00204191687271746
301.	-0.00221152609639172	302.	-0.00332832114970606	303.	-0.00131287177287514
304.	-0.00163823277155301	305.	-0.00156288515918166	306.	-0.0016371458199195
307.	-0.00171839581060311	308.	-0.00161256972948887	309.	-0.00155674577147781
310.	-0.00152351197504556	311.	-0.00170959626739247	312.	-0.00140850290757773
313.	-0.00173501880431326	314.	-0.00160250092492798	315.	-0.000904365246538555
316.	-0.00205766628052142	317.	-0.00135485873716214	318.	-0.00126964544141258
319.	-0.00209900125858972	320.	-0.00217738193389133	321.	-0.00183252108056281
322.	-0.00180997902671264	323.	-0.00125515594595588	324.	-0.00174622699930798
325.	-0.00170604651330719	326.	-0.00222528111956328	327.	-0.000969017987838455
328.	-0.00233256545440004	329.	-0.00210704482804105	330.	-0.00106926709042882
331.	-0.00217369821471773	332.	-0.00129504903189788	333.	-0.00211003604711812
334.	-0.0020823714764011	335.	-0.00158805960260645	336.	-0.0015680082564694
337.	-0.00152498992880426	338.	-0.00172718736293879	339.	-0.00151255287234236
340.	-0.00128330286874902	341.	-0.00163488203343711	342.	-0.0017254288602498
343.	-0.00139467924749158	344.	-0.00116993076993345	345.	-0.00135884710033009
346.	-0.00160626607189306	347.	-0.00169619233684806	348.	-0.00201317099431447
349.	-0.00171786439891406	350.	-0.00154059416395234	351.	-0.00175214526593183
352.	-0.00160299581694596	353.	-0.00139396666052562	354.	-0.00132957311204761
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358.	-0.00156587659850459	359.	-0.000949973274458579	360.	-0.0014596928276848
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503.	-0.0664871133512934	504.	-0.0608704513508735	505.	-0.0656941480753111
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533.	-0.0649511513248389	534.	-0.0848880255084855	535.	-0.0559084068334848
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557.	-0.0661201137964923	558.	-0.0540860156255725	559.	-0.0628539566251739
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563.	-0.0703479060750243	564.	-0.0753800540340803	565.	-0.0712986620211831
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644.	-0.0643694458624914	645.	-0.0677571954293334	646.	-0.0685520817811208
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710.	-0.0655200029304222	711.	-0.0706184761575688	712.	-0.0726688608614748
713.	-0.0606578099308201	714.	-0.0566808137108086	715.	-0.060947481215675
716.	-0.0634905924385266	717.	-0.0491827163138421	718.	-0.0707335302728994
719.	-0.0712983842106945	720.	-0.0671123713376912	721.	-0.0591720040531327
722.	-0.0720835483918915	723.	-0.0762218338560167	724.	-0.0551287234883583
725.	-0.0655334531701156	726.	-0.0667123700252889	727.	-0.0410663607457324
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776.	-0.0518727098624705	777.	-0.0658469431532754	778.	-0.0700940666071782
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782.	-0.0697860105267596	783.	-0.080032444743079	784.	-0.0772645960692735
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797.	-0.0716215172035586	798.	-0.0574068650123481	799.	-0.0768265768907194
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830.	-0.0533876601665638	831.	-0.0730922701158237	832.	-0.0501956868066729
833.	-0.0709499422551698	834.	-0.0618460725258516	835.	-0.0620551231070204
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905.	-0.0654045870636449	906.	-0.068172518894675	907.	-0.0585327251302557
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911.	-0.0725873390573615	912.	-0.0668098747750283	913.	-0.0579391864219607
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941.	-0.0649125677632137	942.	-0.0762841338977941	943.	-0.0608330520028822
944.	-0.0813436088099526	945.	-0.0705615301806727	946.	-0.0658831206893826
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953.	-0.075921397176287	954.	-0.0662386291941458	955.	-0.0649544542555689
956.	-0.0800629960526842	957.	-0.0771198052441068	958.	-0.0587561480427501
959.	-0.0700597489519189	960.	-0.0521603031628889	961.	-0.0665578682210452
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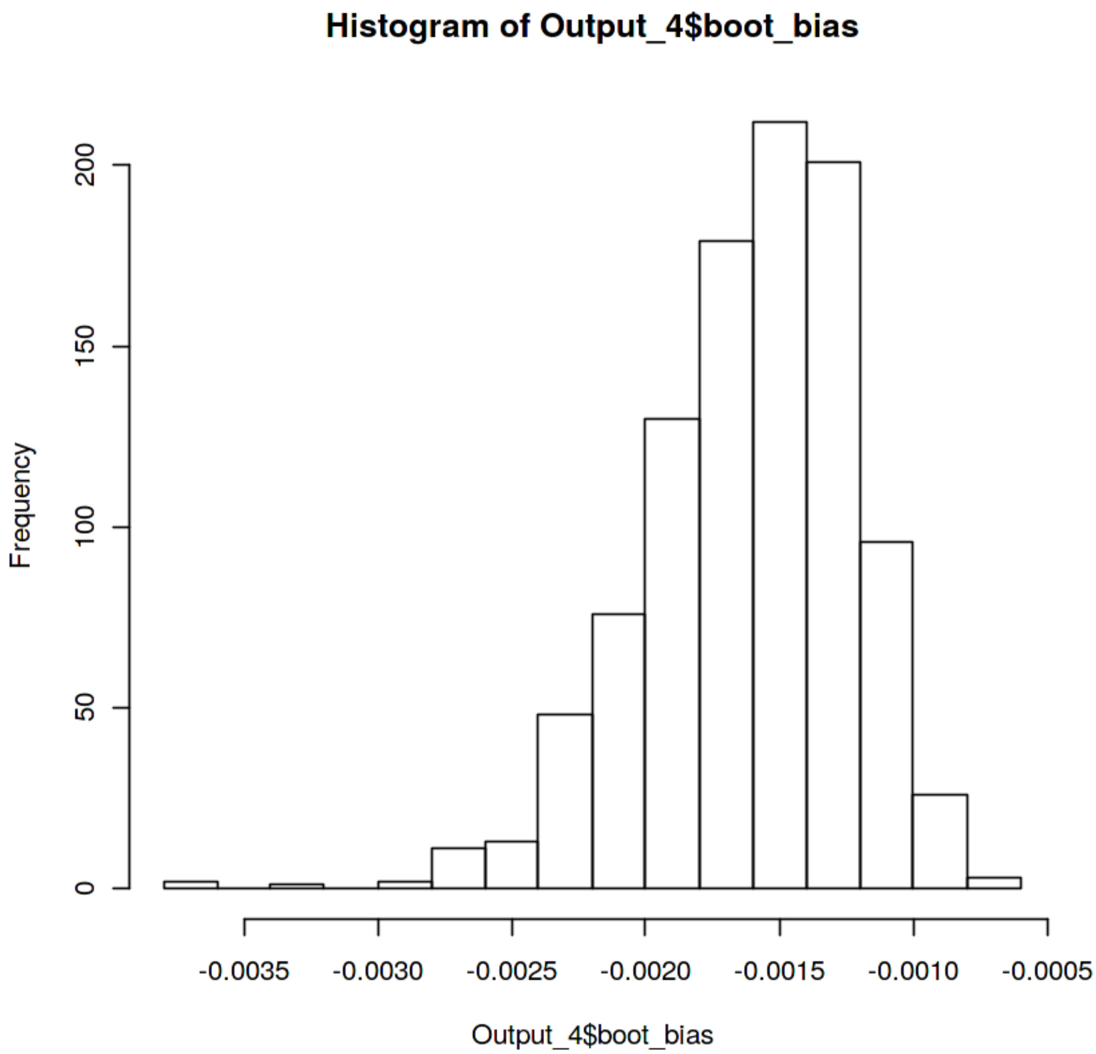
968.	-0.0687843524033101	969.	-0.0641349456085724	970.	-0.0631322594094442
971.	-0.0618244899940514	972.	-0.0682175124794748	973.	-0.0665673108070605
974.	-0.0789792201292431	975.	-0.0592014073825552	976.	-0.0572137735775255
977.	-0.0628550579329194	978.	-0.0624424919480192	979.	-0.0692018315321297
980.	-0.063314812617878	981.	-0.0601599483435101	982.	-0.0659357875847561

983.	-0.0736739457633728	984.	-0.078126023856574	985.	-0.0714580250710568
986.	-0.0706400608848279	987.	-0.0613820804167902	988.	-0.0739517055331607
989.	-0.0608627599630631	990.	-0.0783322871863022	991.	-0.0633822838318829
992.	-0.0735795034277836	993.	-0.0559828481899998	994.	-0.0522291564674887
995.	-0.0694708560997605	996.	-0.0713517463490305	997.	-0.0622191746403063

998. -0.0652109651780797 999. -0.0702554861109212 1000. -0.0660996906635884

In [17]:
```
hist(Output_4$boot_bias)
```



In [18]:
```
hist(Output_4$jack_bias)
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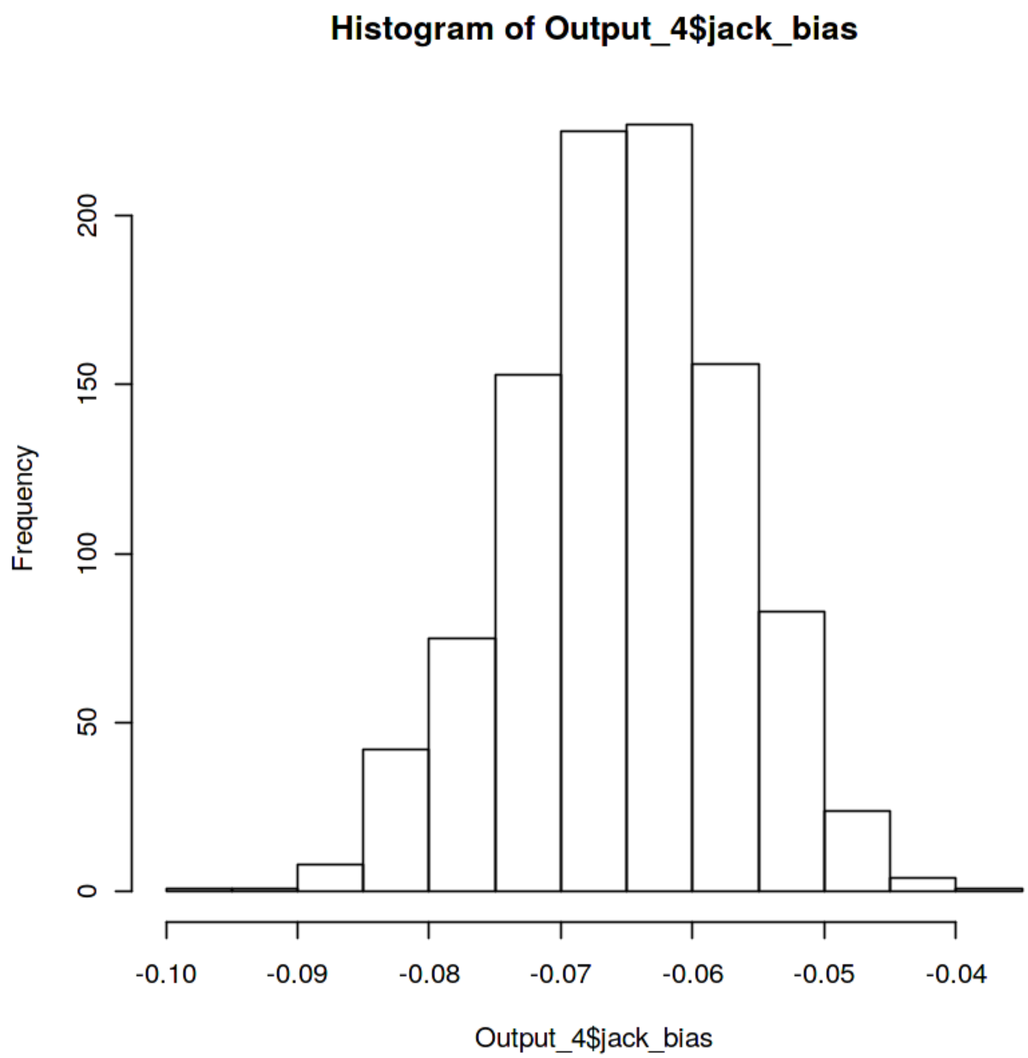

We observe that the Jackknife bias histogram is normal. The bootstrap bias histogram is also somewhat normal but is a little skewed.