Portfolio-hw

In order to set up ETFs portfolios and analyze short-term tail risk, we choose three different portfolios with different industries. For the first portfolio which is pretty diverse, it is included ETFs from 3 industries: Agricultural commodity, Metals and Healthcare, and ETFs from 2 different supporters: government and corporate.

```
library(quantmod)
```

```
## Loading required package: xts
```

```
## Loading required package: zoo
```

```
##
## Attaching package: 'zoo'
```

```
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

```
## Registered S3 method overwritten by 'xts':
##   method     from
##   as.zoo.xts zoo
```

```
## Loading required package: TTR
```

```
## Registered S3 method overwritten by 'quantmod':
##   method            from
##   as.zoo.data.frame zoo
```

```
## Version 0.4-0 included new data defaults. See ?getSymbols.
```

```
library(mosaic)
```

```
## Loading required package: dplyr
```

```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:xts':
##
##     first, last
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union

## Loading required package: lattice

## Loading required package: ggformula

## Loading required package: ggplot2

## Loading required package: ggstance

##
## Attaching package: 'ggstance'

## The following objects are masked from 'package:ggplot2':
##
##     geom_errorbarh, GeomErrorbarh

##
## New to ggformula?  Try the tutorials:
##  learnr::run_tutorial("introduction", package = "ggformula")
##  learnr::run_tutorial("refining", package = "ggformula")

## Loading required package: mosaicData

## Loading required package: Matrix

## Registered S3 method overwritten by 'mosaic':
##   method                           from
##   fortify.SpatialPolygonsDataFrame ggplot2

##
## The 'mosaic' package masks several functions from core packages in order to add
## additional features.  The original behavior of these functions should not be affected by this.
##
## Note: If you use the Matrix package, be sure to load it BEFORE loading mosaic.

##
## Attaching package: 'mosaic'

## The following object is masked from 'package:Matrix':
##
##     mean

## The following object is masked from 'package:ggplot2':
##
##     stat
```

```
## The following objects are masked from 'package:dplyr':
##
##     count, do, tally

## The following objects are masked from 'package:stats':
##
##     binom.test, cor, cor.test, cov, fivenum, IQR, median,
##     prop.test, quantile, sd, t.test, var

## The following objects are masked from 'package:base':
##
##     max, mean, min, prod, range, sample, sum
```

```
library(foreach)
library(tidyverse)
```

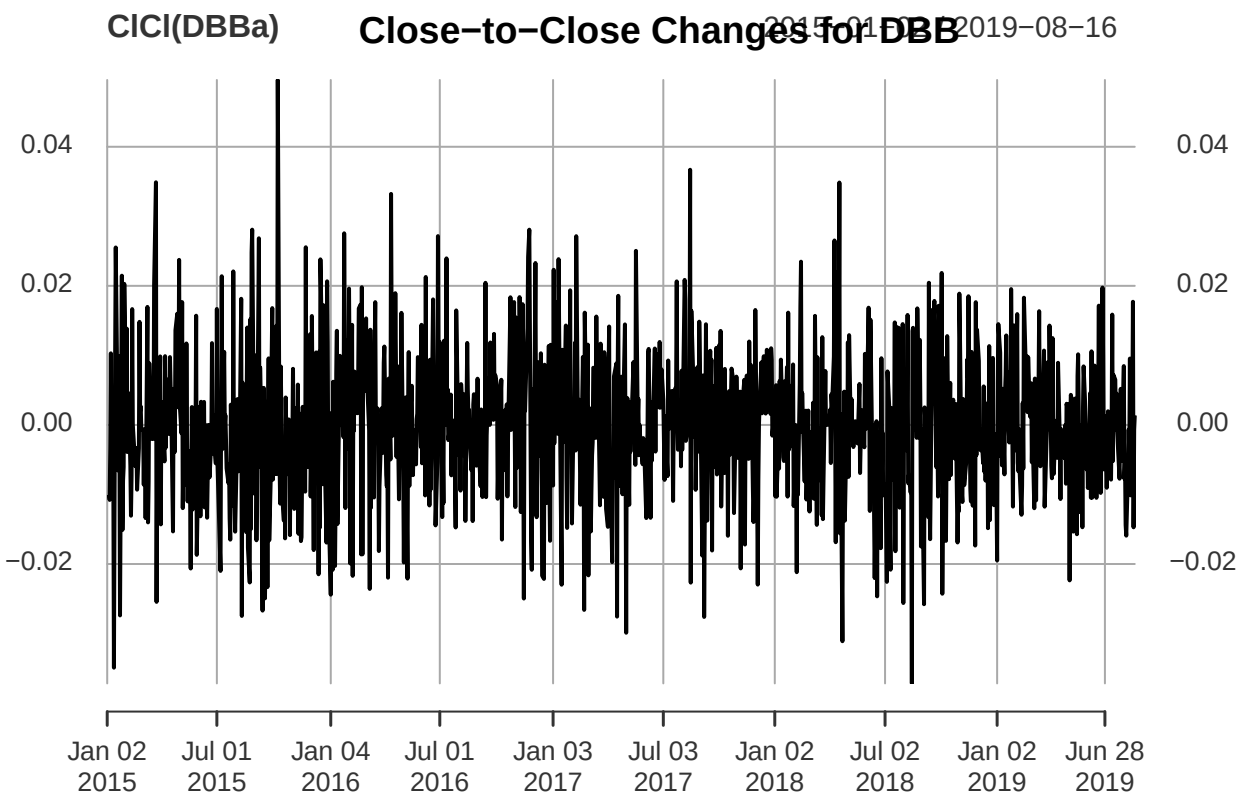
```
## -- Attaching packages --------------------------------------------------------- tidyverse 1.2.1 --

## v tibble  2.1.3     v purrr   0.3.2
## v tidyr   0.8.3     v stringr 1.4.0
## v readr   1.3.1     v forcats 0.4.0

## -- Conflicts ------------------------------------------------------------ tidyverse_conflicts() --
## x purrr::accumulate()        masks foreach::accumulate()
## x mosaic::count()            masks dplyr::count()
## x purrr::cross()             masks mosaic::cross()
## x mosaic::do()               masks dplyr::do()
## x tidyr::expand()            masks Matrix::expand()
## x dplyr::filter()            masks stats::filter()
## x dplyr::first()             masks xts::first()
## x ggstance::geom_errorbarh() masks ggplot2::geom_errorbarh()
## x dplyr::lag()               masks stats::lag()
## x dplyr::last()              masks xts::last()
## x mosaic::stat()             masks ggplot2::stat()
## x mosaic::tally()            masks dplyr::tally()
## x purrr::when()              masks foreach::when()
```

```
# Import ETF from different industries and different functions
# Agriculture, metal, healthcare, government, corporate
# pretty safe
set.seed(9)
portfolio_1 = c("LQD", "TAGS", "DBB","SHV","IHI")
getSymbols(portfolio_1, from = "2015-01-01")
```

```
## 'getSymbols' currently uses auto.assign=TRUE by default, but will
## use auto.assign=FALSE in 0.5-0. You will still be able to use
## 'loadSymbols' to automatically load data. getOption("getSymbols.env")
## and getOption("getSymbols.auto.assign") will still be checked for
## alternate defaults.
##
## This message is shown once per session and may be disabled by setting
## options("getSymbols.warning4.0"=FALSE). See ?getSymbols for details.
```

```
## [1] "LQD"  "TAGS" "DBB"  "SHV"  "IHI"
```

```
# Adjust for splits and dividends
LQDa = adjustOHLC(LQD)
TAGSa = adjustOHLC(TAGS)
DBBa = adjustOHLC(DBB)
SHVa = adjustOHLC(SHV)
IHIa = adjustOHLC(IHI)
# Look at close-to-close changes
plot(ClCl(DBBa))
title('Close-to-Close Changes for DBB')
```

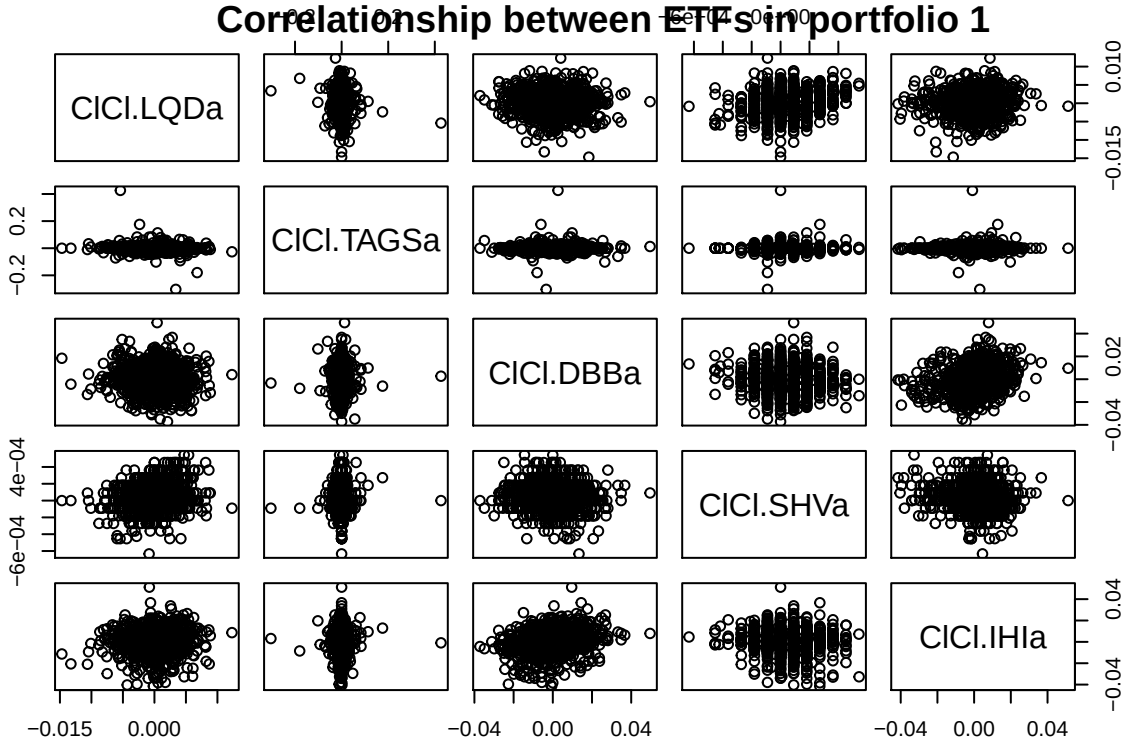



```
set.seed(9)
# Combine close to close changes in a single matrix
all_returns_1 = cbind(ClCl(LQDa),ClCl(TAGSa),ClCl(DBBa),ClCl(SHVa),ClCl(IHIa))
head(all_returns_1)
```

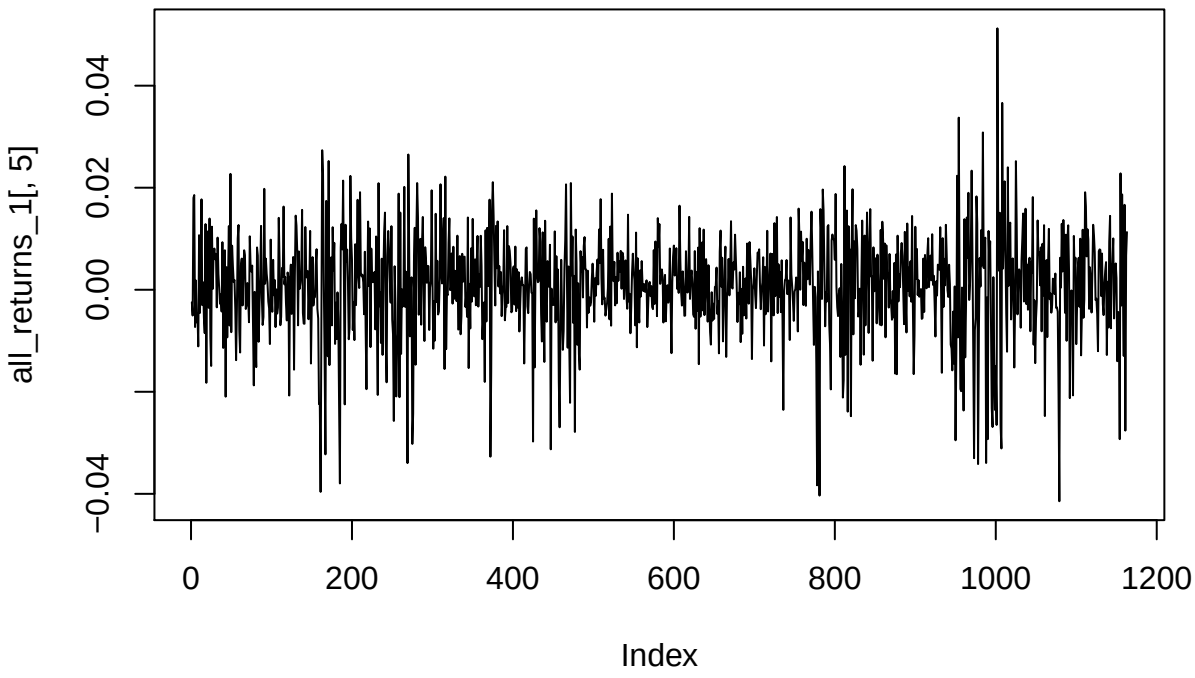
```
##               ClCl.LQDa   ClCl.TAGSa    ClCl.DBBa    ClCl.SHVa
## 2015-01-02           NA           NA           NA           NA
## 2015-01-05  0.004089110 -0.092284390 -0.010050251 0.000000e+00
## 2015-01-06  0.004072457 -0.068000033 -0.010786802 9.067404e-05
## 2015-01-07  0.001324419  0.002861302 -0.003207184 0.000000e+00
## 2015-01-08 -0.003223932  0.011055599  0.010296010 0.000000e+00
## 2015-01-09  0.002653840  0.000000000 -0.008280255 9.072932e-05
##               ClCl.IHIa
```

```
## 2015-01-02           NA
## 2015-01-05 -0.002477648
## 2015-01-06 -0.005056320
## 2015-01-07  0.018009949
## 2015-01-08  0.018567201
## 2015-01-09 -0.007308736
```

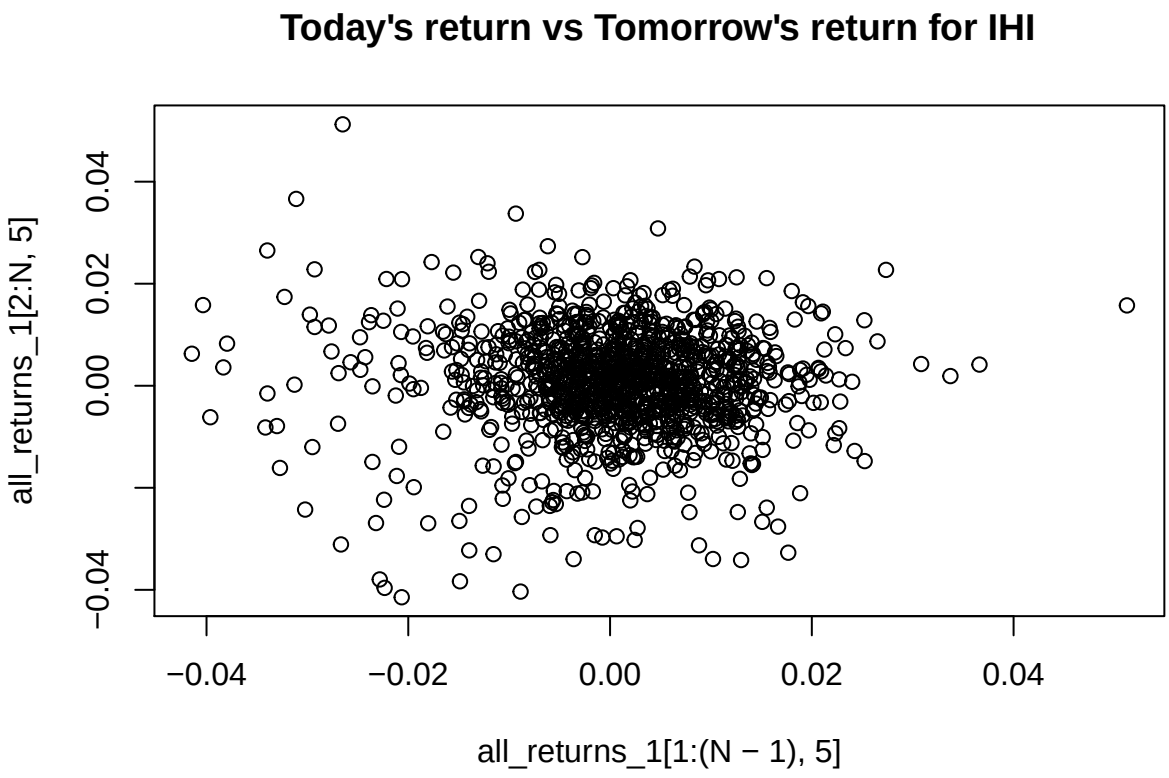
```
all_returns_1 = as.matrix(na.omit(all_returns_1))
N = nrow(all_returns_1)

pairs(all_returns_1)
title('Correlationship between ETFs in portfolio 1')
```




```
# Look at the portfolio_1 returns over time
plot(all_returns_1[,5], type='l')
```




```
# are today's returns correlated with tomorrow's?
# See today's return and tomorrow's for one ETFs
plot(all_returns_1[1:(N-1),5], all_returns_1[2:N,5])
title("Today's return vs Tomorrow's return for IHI")
```




```
for(ticker in portfolio_1) {
    expr = paste0(ticker, "a = adjustOHLC(", ticker, ")")
    eval(parse(text=expr))
}

head(LQDa)
```

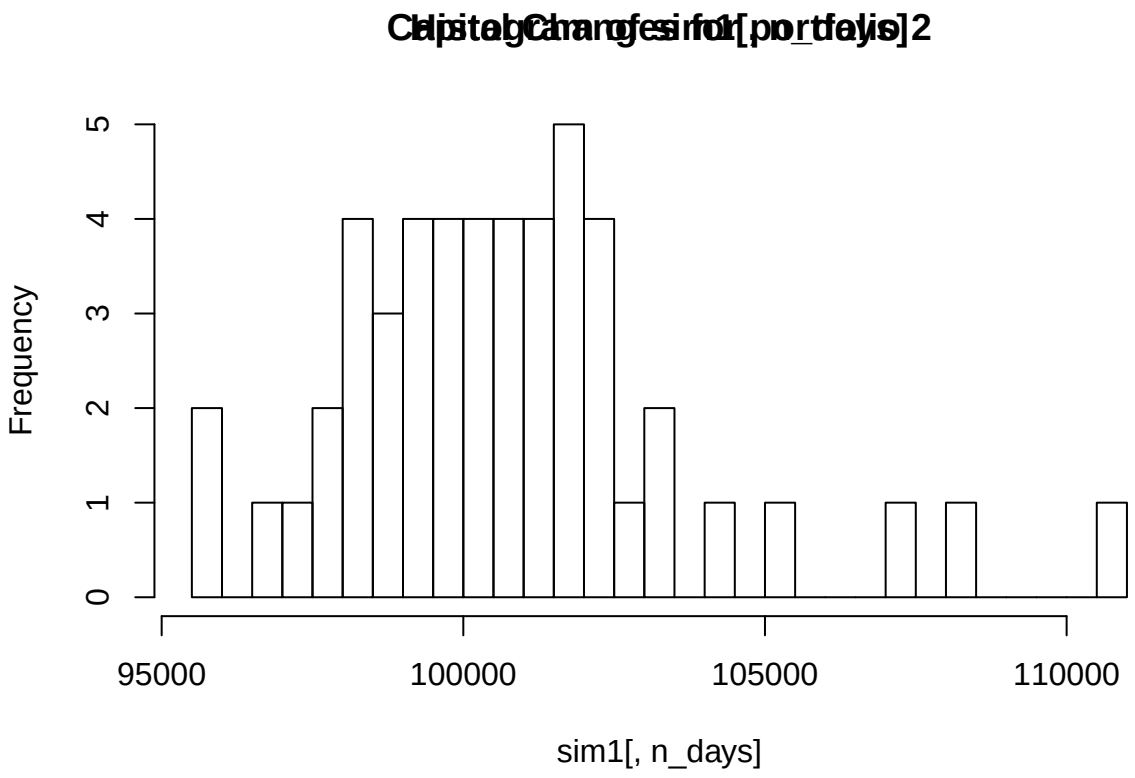
```
##            LQD.Open LQD.High  LQD.Low LQD.Close LQD.Volume LQD.Adjusted
## 2015-01-02 102.4555 103.0037 102.4126  102.6525    2523600     102.6525
## 2015-01-05 102.9609 103.3806 102.8752  103.0723    3218800     103.0723
## 2015-01-06 103.3550 103.8004 103.2008  103.4920    5313400     103.4920
## 2015-01-07 103.3464 103.6976 103.2350  103.6291    1636600     103.6291
## 2015-01-08 103.3550 103.3721 103.1151  103.2950    2156900     103.2950
## 2015-01-09 103.1579 103.6719 103.1322  103.5691    1530400     103.5691
```

```
# Sample a random return from the empirical joint distribution
# This simulates a random day
set.seed(9)
return.today = resample(all_returns_1, 1, orig.ids=FALSE)
initial_wealth = 100000
sim1 = foreach(i=1:50, .combine='rbind') %do% {
    total_wealth = initial_wealth
    weights = c(0.2, 0.2, 0.2, 0.2, 0.2)
    holdings = weights * total_wealth
    n_days = 20
```

```
    wealthtracker = rep(0, n_days)
    for(today in 1:n_days) {
        return.today = resample(all_returns_1, 1, orig.ids=FALSE)
        holdings = holdings + holdings*return.today
        total_wealth = sum(holdings)
        wealthtracker[today] = total_wealth
    }
    wealthtracker
}

head(sim1)
```

```
##               [,1]     [,2]      [,3]      [,4]      [,5]      [,6]
## result.1  99902.63 100311.3 100133.10  98921.72  98786.37  98714.47
## result.2  99788.48 100159.1 100348.34 100110.09 100092.80 100022.96
## result.3 100254.23 100407.3 100900.90  99894.20  99540.06  99011.49
## result.4  99814.16 100465.1 100777.90 100742.08 100780.74 100849.41
## result.5 100063.78  99843.6  99465.91  99087.11  98815.35  99141.67
## result.6  99665.95 100377.7 100331.83 100283.34 100072.55 100059.17
##               [,7]      [,8]      [,9]     [,10]     [,11]     [,12]
## result.1  98559.63  98209.03  97694.25  98044.22  98314.76  98384.98
## result.2  99920.10 100511.38 100122.65  99024.50  99405.58  99419.74
## result.3  99271.24  99110.31  99267.14  99101.51  99307.82  99686.17
## result.4 101159.67 100986.45 100820.44 100739.27 100493.53 100616.48
## result.5  98815.53  98676.61  99226.95  98358.86  98789.88  98380.28
## result.6 100137.02 100414.56 100657.99 100760.16 101667.73 101381.84
##              [,13]     [,14]     [,15]     [,16]     [,17]     [,18]
## result.1  98336.79  98718.32  99449.82  99377.22  99578.06  99439.88
## result.2  99576.65  99325.00  99513.04  98526.34  98301.89  98119.39
## result.3  99943.72  99766.88  99955.37  99953.66 100171.30 100414.92
## result.4  99982.76  99975.79  99935.12 100025.93 100519.21 100428.89
## result.5  98080.04  98122.63  99039.66  98905.05  99220.46  99151.72
## result.6 101446.61 101358.70 100273.26 100847.33 100837.71 101148.37
##              [,19]     [,20]
## result.1  98821.03  99052.93
## result.2  98308.76  98074.55
## result.3 100973.21 101690.31
## result.4 100493.80 100170.83
## result.5  99608.95  99577.45
## result.6 101125.60 100443.46
```

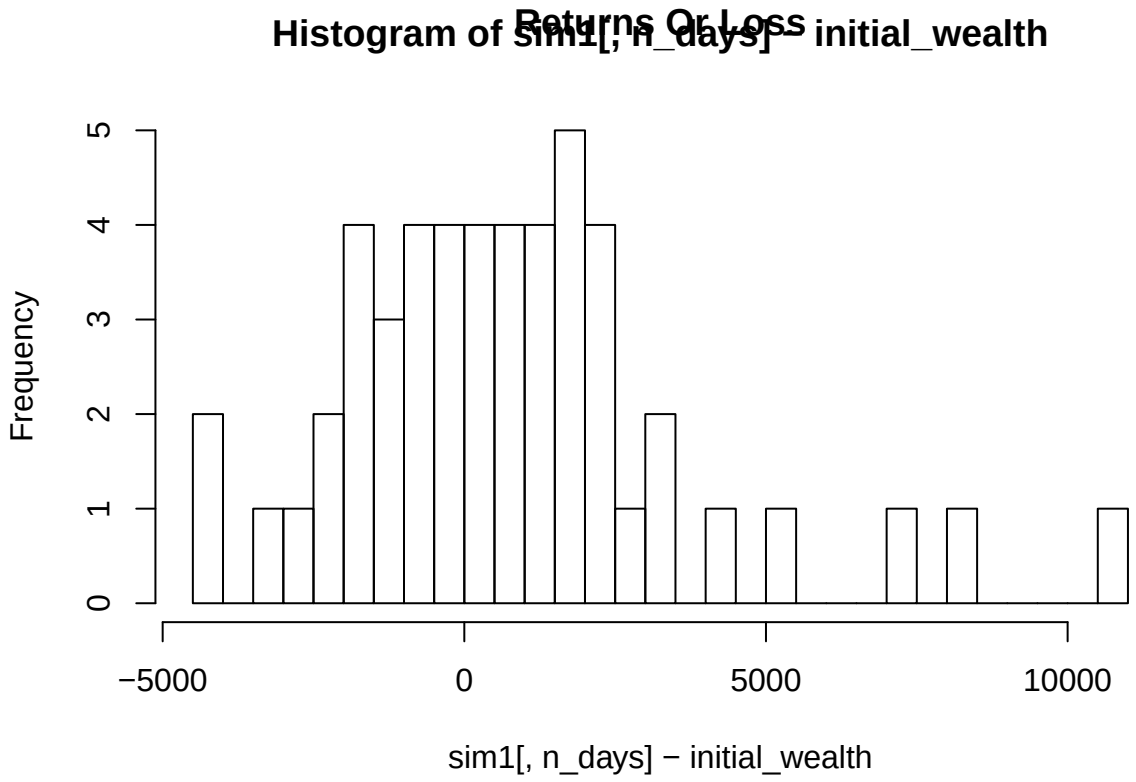
```
hist(sim1[,n_days], 25)
title("Capital Changes for portfolio 2")
```




```
# Profit/loss
mean(sim1[,n_days])
```

```
## [1] 100708.6
```

```
hist(sim1[,n_days]- initial_wealth, breaks=30)
title("Returns Or Loss",line=2)
```




```
mean(sim1[,n_days] > 100000)
```

```
## [1] 0.58
```

```
quantile(sim1[,n_days]- initial_wealth,.05)
```

```
##        5%
## -3127.665
```

```
quantile(sim1[,n_days]- initial_wealth,.01)
```

```
##        1%
## -4396.297
```

The mean of capital after 20 trading days is 100708.6 and we can earn an average rate of return of 0.7% for 20 trading days on our investment. In addition, we could earn returns at the 58% confidence. Considering the VaR, if the degree of risk preference and acceptance ability of our investors is 5%, portfolio 1 has a 5% VaR of 3128, which means that there is a 0.05 probability that the portfolio 1 will fall in value by more than 3128 in a 20 trading-day period. If the degree of risk preference and acceptance ability of our investors is 1%, portfolio 1 has a 1% VaR of 4396, which means that there is a 0.01 probability that the portfolio 1 will fall in value by more than 4396 in a 20 trading-day period.

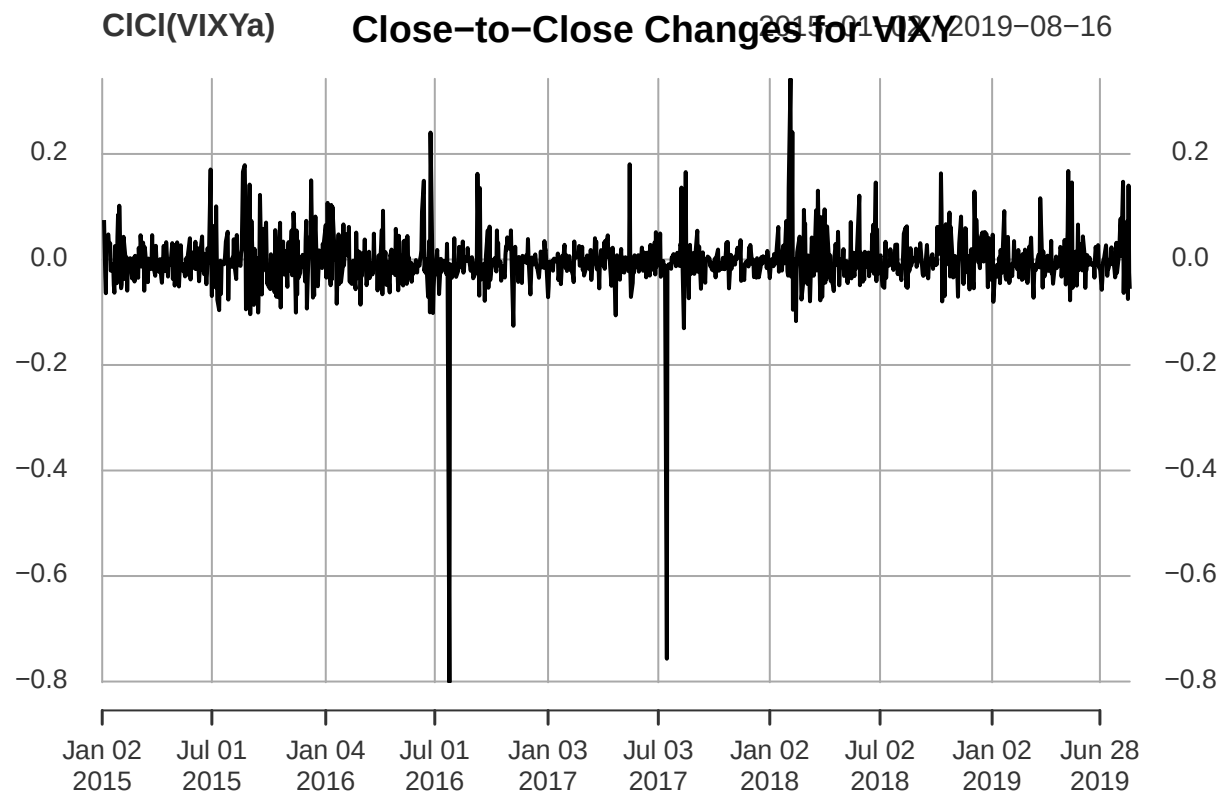
Portfolio 2 is more aggressive. It contains two kinds of bonds, which are volitality and leverage bonds. Leverage bonds provide magnified exposure to popular fixed income benchmarks. They can generage amplified

returns and also have higher risks. Volitality ETFs tend to move in the opposite direction of the broad market. Therefore, the portfolio 2 is supposed to win the market and win more when the market is down. However, it has to cover more risks as well whe nthe market is up.

```
portfolio_2 = c("VIXY", "VIXM", "VIIX","TBT","TMV")
getSymbols(portfolio_2, from = "2015-01-01")
```

```
## [1] "VIXY" "VIXM" "VIIX" "TBT"  "TMV"
```

```
set.seed(9)
# Adjust for splits and dividends
VIXYa = adjustOHLC(VIXY)
VIXMa = adjustOHLC(VIXM)
VIIXa = adjustOHLC(TBT)
TMVa = adjustOHLC(TMV)
TBTa = adjustOHLC(TBT)
# Look at close-to-close changes
plot(ClCl(VIXYa))
title('Close-to-Close Changes for VIXY')
```

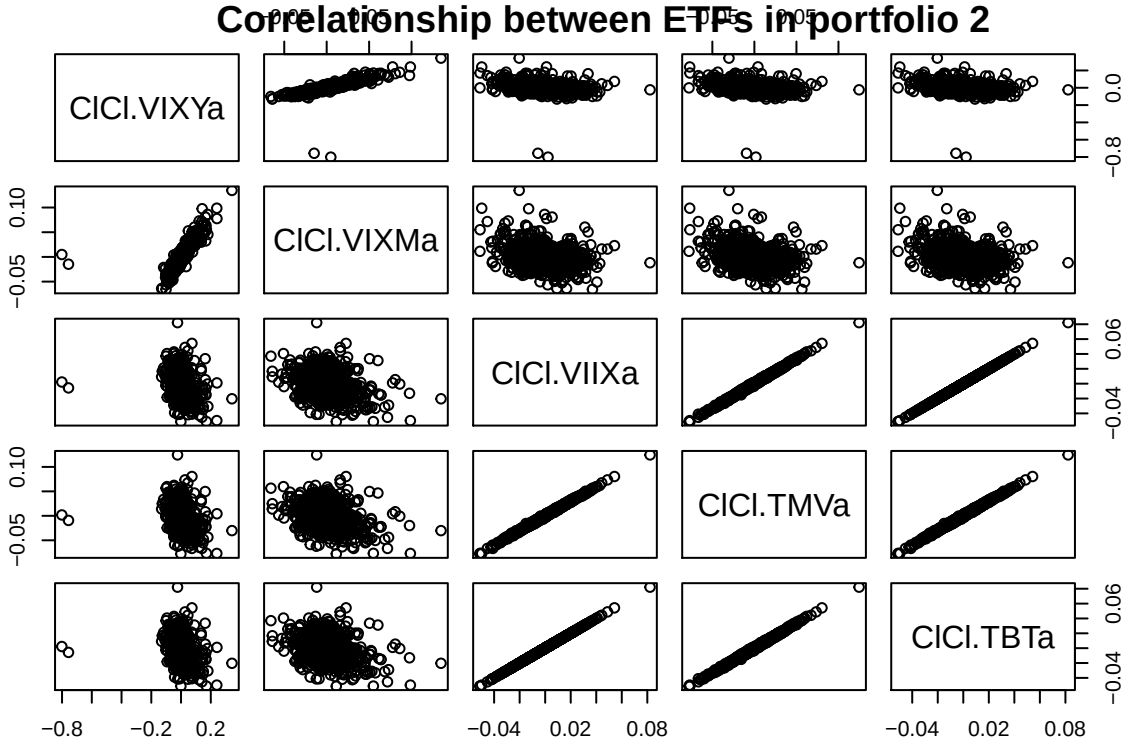



```
set.seed(9)
all_returns_2 = cbind(ClCl(VIXYa),ClCl(VIXMa),ClCl(VIIXa),ClCl(TMVa),ClCl(TBTa))
head(all_returns_2)
```

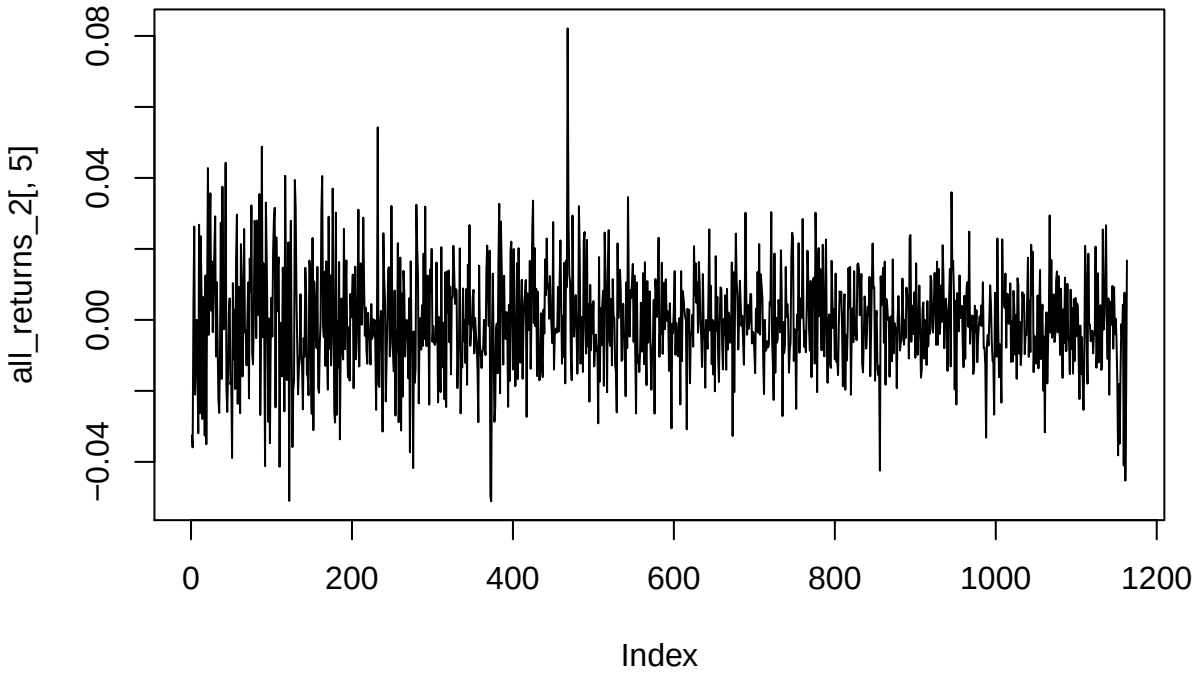
```
##             ClCl.VIXYa   ClCl.VIXMa   ClCl.VIIXa    ClCl.TMVa    ClCl.TBTa
```

```
## 2015-01-02          NA           NA           NA           NA           NA
## 2015-01-05  0.07472098  0.050970476 -0.032548911 -0.047526011 -0.032548911
## 2015-01-06  0.02167044  0.004504565 -0.035917298 -0.055023923 -0.035917298
## 2015-01-07 -0.03314185 -0.024663706  0.004008536  0.006148282  0.004008536
## 2015-01-08 -0.06398537 -0.041226038  0.026303404  0.039180446  0.026303404
## 2015-01-09  0.03906250  0.031809494 -0.021052677 -0.032514735 -0.021052677
```

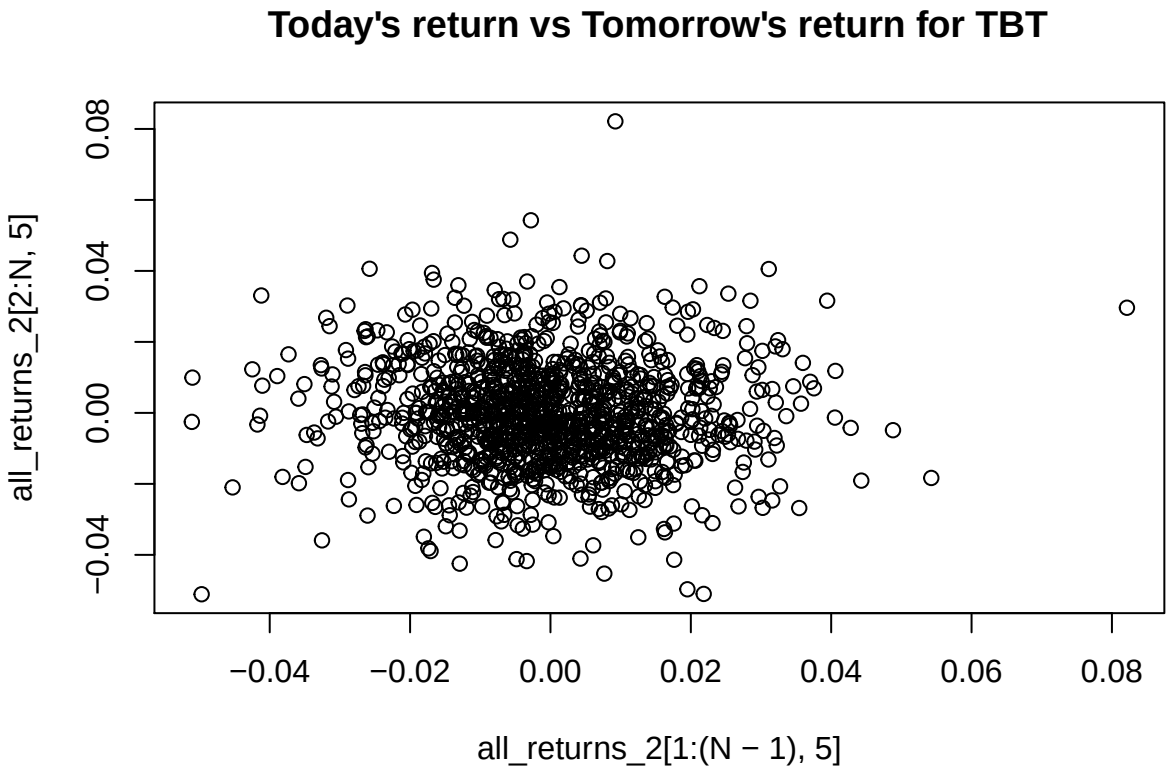
```r
all_returns_2 = as.matrix(na.omit(all_returns_2))
N = nrow(all_returns_2)

pairs(all_returns_2)
title('Correlationship between ETFs in portfolio 2')
```




```r
# Look at the portfolio_2 returns over time
plot(all_returns_2[,5], type='l')
```




```
# are today's returns correlated with tomorrow's?
plot(all_returns_2[1:(N-1),5], all_returns_2[2:N,5])
title("Today's return vs Tomorrow's return for TBT")
```




```
for(ticker in portfolio_2) {
    expr = paste0(ticker, "a = adjustOHLC(", ticker, ")")
    eval(parse(text=expr))
}

head(TBTa)
```

```
##            TBT.Open TBT.High  TBT.Low TBT.Close TBT.Volume TBT.Adjusted
## 2015-01-02 45.35767 45.48539 44.38509  44.66999    3824600     44.66999
## 2015-01-05 44.15914 44.19844 43.02937  43.21603    4346400     43.21603
## 2015-01-06 42.31222 42.62658 41.10386  41.66383    6139100     41.66383
## 2015-01-07 42.26310 42.61676 41.46735  41.83084    3984600     41.83084
## 2015-01-08 42.54799 43.08832 42.48905  42.93113    3146300     42.93113
## 2015-01-09 43.22585 43.35357 41.99785  42.02732    3673000     42.02732
```

```
set.seed(9)
# Sample a random return from the empirical joint distribution
# This simulates a random day
return.today = resample(all_returns_2, 1, orig.ids=FALSE)

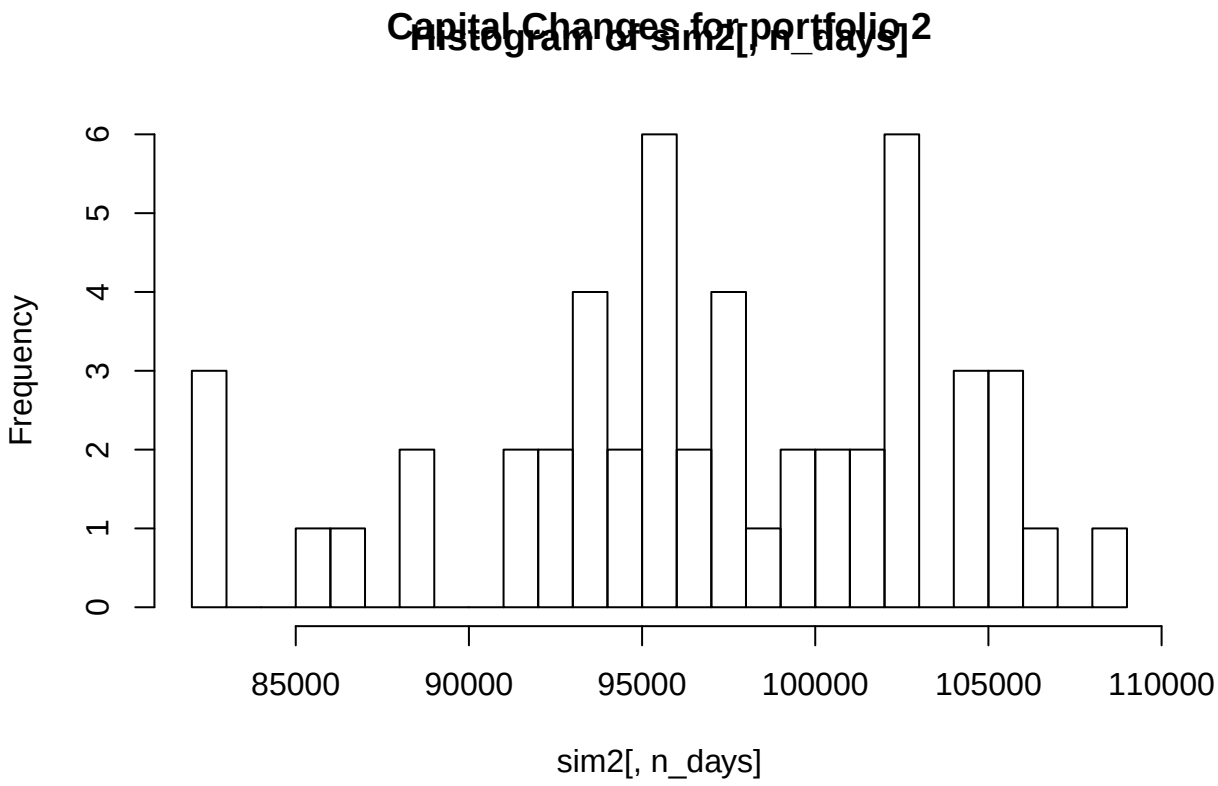
initial_wealth = 100000
sim2 = foreach(i=1:50, .combine='rbind') %do% {
    total_wealth = initial_wealth
    weights = c(0.2, 0.2, 0.2, 0.2, 0.2)
    holdings = weights * total_wealth
```

```
    n_days = 20
    wealthtracker = rep(0, n_days)
    for(today in 1:n_days) {
        return.today = resample(all_returns_2, 1, orig.ids=FALSE)
        holdings = holdings + holdings*return.today
        total_wealth = sum(holdings)
        wealthtracker[today] = total_wealth
    }
    wealthtracker
}

head(sim2)
```

```
##               [,1]      [,2]      [,3]      [,4]      [,5]      [,6]
## result.1 101346.49 101064.89 101515.88 103840.72 103049.64 103950.79
## result.2 101051.40 100698.27 100638.91 100492.91 100086.09 100991.75
## result.3 100155.12  99365.97  98422.67  98820.36 100975.79  98203.94
## result.4 100769.80  99417.54 100824.66  99455.89  98562.47  99602.15
## result.5 100114.60 100184.02 100675.24  99832.17  99864.46 100483.78
## result.6  98793.98  97600.61  94953.92  94791.00  95911.57  95969.94
##               [,7]      [,8]      [,9]     [,10]     [,11]     [,12]
## result.1 103782.20 104271.21 106156.89 109072.41 106133.54 107849.74
## result.2 102706.01 102332.45  99673.20 104034.04 103557.81 102233.35
## result.3  99420.34  99099.04  99810.12 100242.25  99473.00 100336.66
## result.4  98081.23  98289.65  98171.10  98783.31  97835.44  99291.71
## result.5  99216.91  99955.92  98508.15 101029.15 100606.80 102474.36
## result.6  95905.15  95443.67  95196.12  97556.02  95902.96  95144.46
##              [,13]     [,14]     [,15]     [,16]     [,17]     [,18]
## result.1 108557.19 108337.70 105566.99 105718.64 105669.87 107447.35
## result.2 102154.30 102929.67 102452.22 101942.69 102659.51 102506.94
## result.3  99359.86  99993.93  99904.45  99515.39  97753.72  97090.86
## result.4 100190.29 100864.43  99090.13 100534.27  97873.80  97034.29
## result.5 104052.27 103547.40 102012.44 102588.28 101384.47  97290.07
## result.6  95167.71  94976.97  94471.63  92384.05  91619.79  90181.49
##              [,19]     [,20]
## result.1 105843.19 104241.13
## result.2 101415.94 102116.54
## result.3  97883.10  96991.46
## result.4  96498.60  97123.58
## result.5  95781.53  95967.55
## result.6  90745.55  92052.45
```

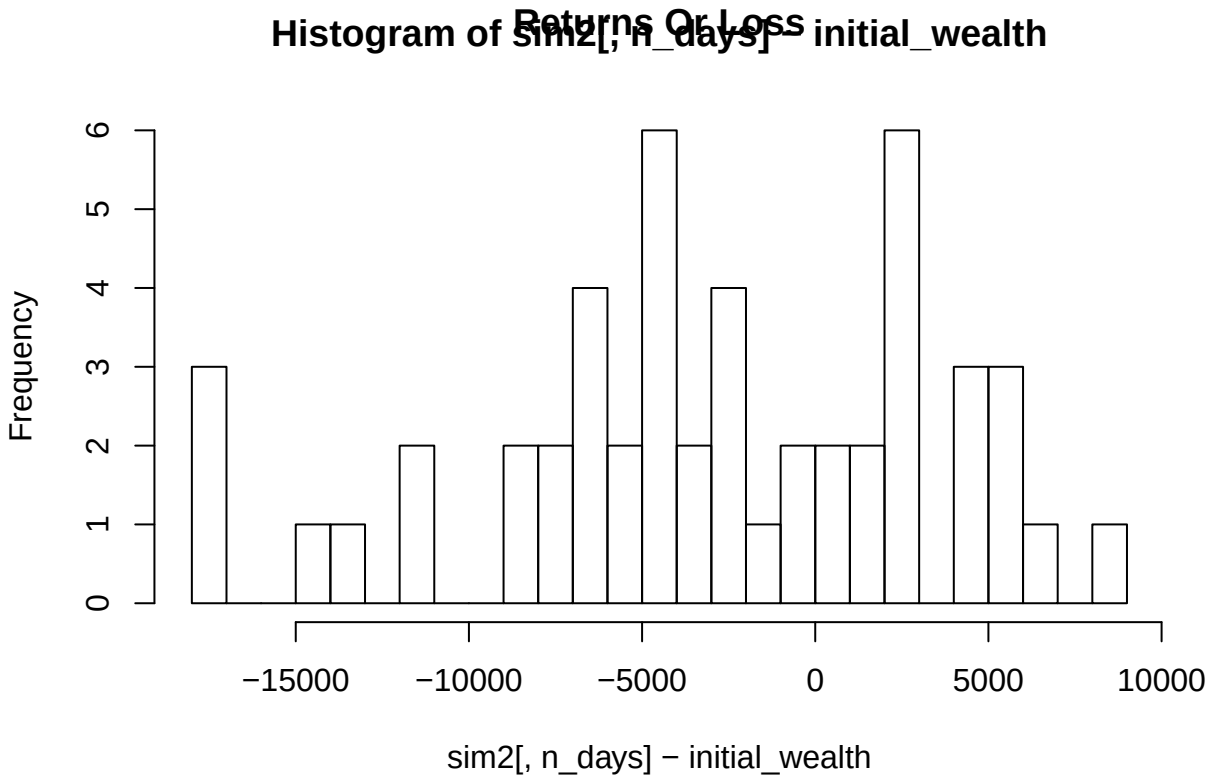
```
hist(sim2[,n_days], 25)
title("Capital Changes for portfolio 2",line=2)
```




```
# Profit/loss
mean(sim2[,n_days])
```

```
## [1] 96911.35
```

```
hist(sim2[,n_days]-initial_wealth, breaks=30)
title("Returns Or Loss",line=2)
```




```
mean(sim2[,n_days] > 100000)
```

```
## [1] 0.36
```

```
quantile(sim2[,n_days]-initial_wealth,.05)
```

```
##        5%
## -15993.69
```

```
quantile(sim2[,n_days]-initial_wealth,.01)
```

```
##        1%
## -17430.46
```

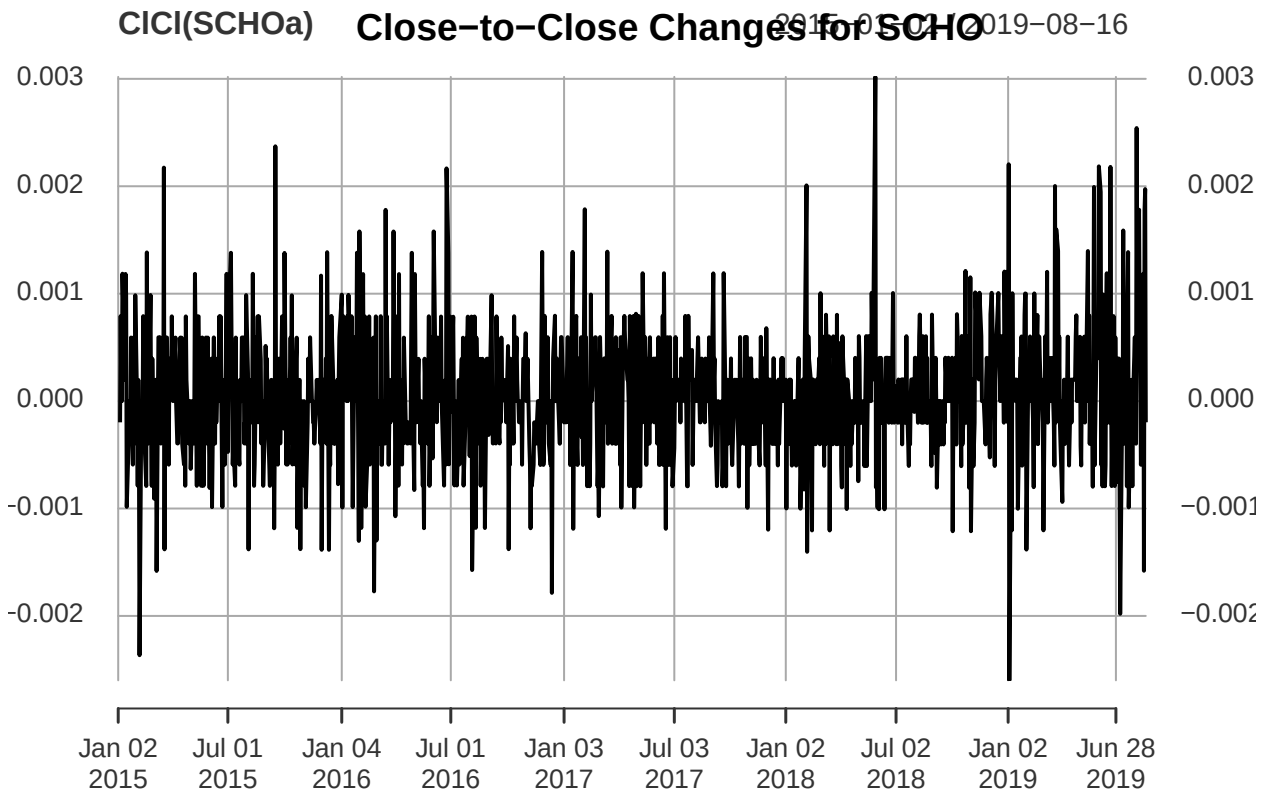
If we invest portfolio 2, the mean of capital is only 96862 for 20 trading days, which has the 3.1% loss. And there is only 34% probability to win. For investors at 5% of risk preference, the value in risk is more than 15539. For investors at 1% of risk preference, the value in risk is more than 17789. It only earns when the market is down, so we need to pay close attention to the broad market when investing this portfolio.

Finally, we choose a safer portfolio containing 5 government bonds. Government Bonds ETFs offer investors exposure to fixed income securities issued by government agencies, which have little risk and small returns as well. They are more preferred by risk averse individuals.

```
portfolio_3 = c("IEF", "SHY", "BIL","GOVT","SCHO")
getSymbols(portfolio_3, from = "2015-01-01")
```

```
## [1] "IEF"  "SHY"  "BIL"  "GOVT" "SCHO"
```

```
# Adjust for splits and dividends
IEFa = adjustOHLC(IEF)
SHYa = adjustOHLC(SHY)
BILa = adjustOHLC(BIL)
GOVTa = adjustOHLC(GOVT)
SCHOa = adjustOHLC(SCHO)
# Look at close-to-close changes
plot(ClCl(SCHOa))
title('Close-to-Close Changes for SCHO')
```




```
set.seed(99)

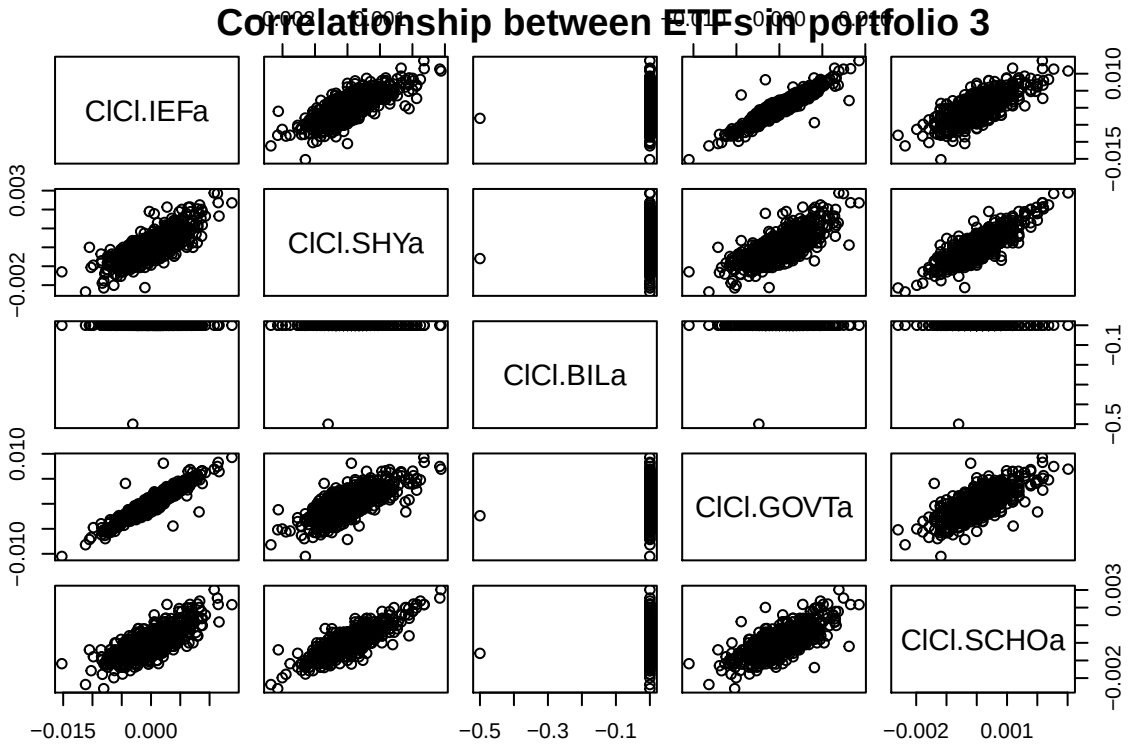
all_returns_3 = cbind(ClCl(IEFa),ClCl(SHYa),ClCl(BILa),ClCl(GOVTa),ClCl(SCHOa))
head(all_returns_3)
```

```
##               ClCl.IEFa     ClCl.SHYa     ClCl.BILa   ClCl.GOVTa
## 2015-01-02           NA            NA            NA           NA
## 2015-01-05  0.0061015771  0.0000000000  0.0002187186  0.001581613
## 2015-01-06  0.0067176899  0.0004731606 -0.0002186707  0.004737505
```

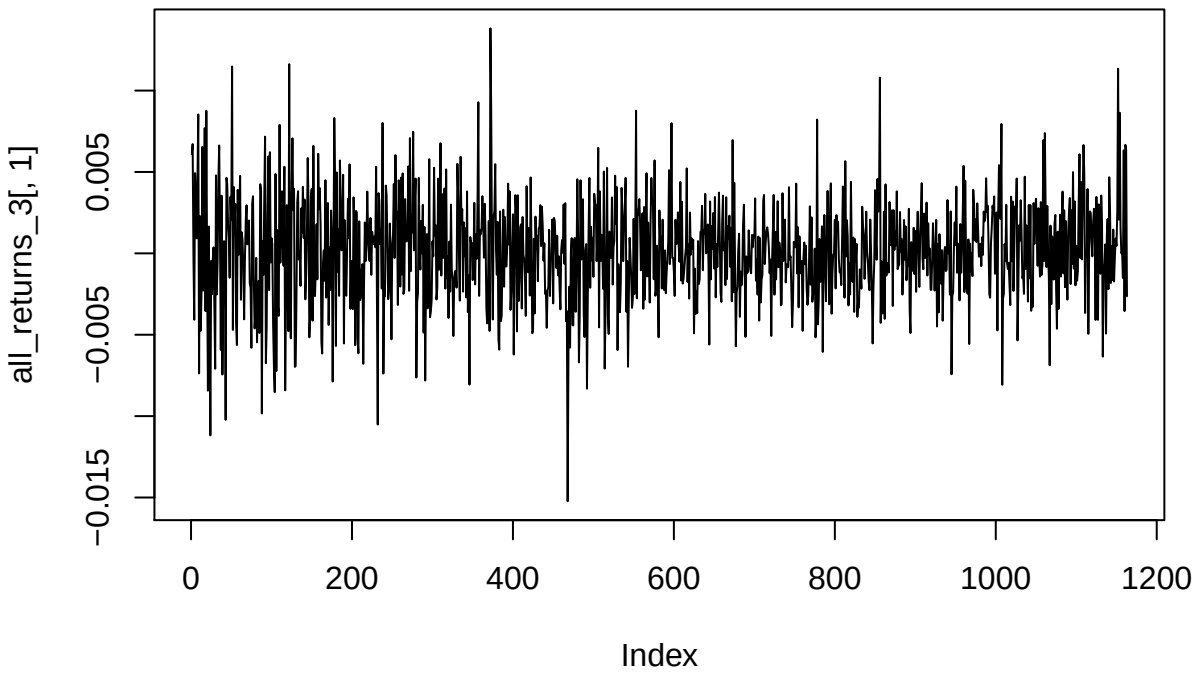
```
## 2015-01-07 -0.0001854031  0.0004729369  0.0000000000  0.000000000
## 2015-01-08 -0.0040785596 -0.0001181990  0.0000000000 -0.002357642
## 2015-01-09  0.0049329765  0.0008273135  0.0000000000  0.002756991
##               ClCl.SCHOa
## 2015-01-02            NA
## 2015-01-05 -0.0001977259
## 2015-01-06  0.0007910799
## 2015-01-07  0.0000000000
## 2015-01-08  0.0000000000
## 2015-01-09  0.0011858103
```

```
all_returns_3 = as.matrix(na.omit(all_returns_3))
N = nrow(all_returns_3)

pairs(all_returns_3)
title('Correlationship between ETFs in portfolio 3')
```




```
# all related. Because it is in the same industry
plot(all_returns_3[,1], type='l')
```




```
all_returns_3[,5]
```

```
##    2015-01-05    2015-01-06    2015-01-07    2015-01-08    2015-01-09
## -1.977259e-04  7.910799e-04  0.000000e+00  0.000000e+00  1.185810e-03
##    2015-01-12    2015-01-13    2015-01-14    2015-01-15    2015-01-16
##  3.947888e-04  1.972968e-04  1.183685e-03  9.852020e-04 -9.842323e-04
##    2015-01-20    2015-01-21    2015-01-22    2015-01-23    2015-01-26
## -1.970049e-04  0.000000e+00 -3.941860e-04  5.914629e-04 -5.911133e-04
##    2015-01-27    2015-01-28    2015-01-29    2015-01-30    2015-02-02
##  5.914629e-04  5.911133e-04 -3.938755e-04  9.850867e-04 -1.973179e-05
##    2015-02-03    2015-02-04    2015-02-05    2015-02-06    2015-02-09
## -7.876526e-04  1.970437e-04 -3.940887e-04 -2.365445e-03  0.000000e+00
##    2015-02-10    2015-02-11    2015-02-12    2015-02-13    2015-02-17
## -1.976487e-04 -1.975889e-04  7.906899e-04 -1.975509e-04 -7.901423e-04
##    2015-02-18    2015-02-19    2015-02-20    2015-02-23    2015-02-24
##  1.383946e-03 -3.948865e-04 -3.950227e-04  5.927287e-04  9.873618e-04
##    2015-02-25    2015-02-26    2015-02-27    2015-03-02    2015-03-03
## -1.972578e-04 -7.892857e-04  3.949645e-04 -9.084446e-04  0.000000e+00
##    2015-03-04    2015-03-05    2015-03-06    2015-03-09    2015-03-10
##  1.976280e-04  1.976878e-04 -1.580755e-03  5.937463e-04  5.933346e-04
##    2015-03-11    2015-03-12    2015-03-13    2015-03-16    2015-03-17
##  0.000000e+00  5.929828e-04 -3.951205e-04  3.952767e-04 -1.975109e-04
##    2015-03-18    2015-03-19    2015-03-20    2015-03-23    2015-03-24
##  2.173483e-03 -1.380106e-03  5.922606e-04  5.919298e-04  0.000000e+00
##    2015-03-25    2015-03-26    2015-03-27    2015-03-30    2015-03-31
```

```
##  0.000000e+00 -5.915796e-04  3.946527e-04  1.971992e-04  7.888188e-04
##    2015-04-01    2015-04-02    2015-04-06    2015-04-07    2015-04-08
##  3.351931e-04  0.000000e+00  5.912101e-04  0.000000e+00 -1.970061e-04
##    2015-04-09    2015-04-10    2015-04-13    2015-04-14    2015-04-15
## -3.939322e-04 -3.941860e-04  3.943415e-04  5.912101e-04  1.969470e-04
##    2015-04-16    2015-04-17    2015-04-20    2015-04-21    2015-04-22
##  5.908232e-04 -3.936233e-04 -5.907265e-04  1.970449e-04 -7.878669e-04
##    2015-04-23    2015-04-24    2015-04-27    2015-04-28    2015-04-29
##  7.884881e-04  1.969470e-04 -1.969082e-04 -3.939334e-04  0.000000e+00
##    2015-04-30    2015-05-01    2015-05-04    2015-05-05    2015-05-06
##  0.000000e+00 -6.309097e-04  0.000000e+00 -1.972578e-04 -3.946330e-04
##    2015-05-07    2015-05-08    2015-05-11    2015-05-12    2015-05-13
##  0.000000e+00  1.184386e-03 -7.886632e-04  0.000000e+00  7.892857e-04
##    2015-05-14    2015-05-15    2015-05-18    2015-05-19    2015-05-20
##  7.885844e-04  0.000000e+00 -7.879630e-04 -7.886632e-04  5.919298e-04
##    2015-05-21    2015-05-22    2015-05-26    2015-05-27    2015-05-28
##  3.944193e-04 -7.885078e-04  5.918722e-04 -3.943218e-04  3.944773e-04
##    2015-05-29    2015-06-01    2015-06-02    2015-06-03    2015-06-04
##  5.914629e-04 -8.083437e-04 -3.946330e-04 -3.948085e-04  3.949645e-04
##    2015-06-05    2015-06-08    2015-06-09    2015-06-10    2015-06-11
## -9.869522e-04  5.927287e-04 -3.949447e-04 -3.951205e-04  3.952767e-04
##    2015-06-12    2015-06-15    2015-06-16    2015-06-17    2015-06-18
## -1.975109e-04  3.951788e-04  3.950425e-04  7.896742e-04  0.000000e+00
##    2015-06-19    2015-06-22    2015-06-23    2015-06-24    2015-06-25
##  7.891300e-04 -9.856101e-04  0.000000e+00  1.972968e-04 -1.972578e-04
##    2015-06-26    2015-06-29    2015-06-30    2015-07-01    2015-07-02
## -5.919100e-04  1.184541e-03  0.000000e+00 -4.735025e-04  7.895973e-04
##    2015-07-06    2015-07-07    2015-07-08    2015-07-09    2015-07-10
##  1.380651e-03  5.908804e-04  0.000000e+00 -5.905315e-04 -3.939334e-04
##    2015-07-13    2015-07-14    2015-07-15    2015-07-16    2015-07-17
## -7.881970e-04  5.916585e-04 -3.941860e-04 -1.972003e-04 -3.943995e-04
##    2015-07-20    2015-07-21    2015-07-22    2015-07-23    2015-07-24
## -5.918130e-04  1.973549e-04  0.000000e+00  0.000000e+00  5.921255e-04
##    2015-07-27    2015-07-28    2015-07-29    2015-07-30    2015-07-31
##  5.916962e-04 -3.942637e-04 -1.971603e-04 -3.944970e-04  9.865825e-04
##    2015-08-03    2015-08-04    2015-08-05    2015-08-06    2015-08-07
##  2.564057e-04 -1.380398e-03  1.975316e-04  0.000000e+00 -1.974926e-04
##    2015-08-10    2015-08-11    2015-08-12    2015-08-13    2015-08-14
## -1.974329e-04  1.185029e-03  1.973170e-04 -7.889743e-04 -5.921634e-04
##    2015-08-17    2015-08-18    2015-08-19    2015-08-20    2015-08-21
##  5.925143e-04  0.000000e+00  7.895973e-04 -1.972781e-04  7.891300e-04
##    2015-08-24    2015-08-25    2015-08-26    2015-08-27    2015-08-28
##  3.942440e-04 -3.940887e-04  0.000000e+00 -1.971023e-04 -7.886632e-04
##    2015-08-31    2015-09-01    2015-09-02    2015-09-03    2015-09-04
## -1.973560e-04  5.133876e-04  1.973949e-04  3.946527e-04  0.000000e+00
##    2015-09-08    2015-09-09    2015-09-10    2015-09-11    2015-09-14
## -7.889743e-04  0.000000e+00  1.973549e-04  1.973949e-04  0.000000e+00
##    2015-09-15    2015-09-16    2015-09-17    2015-09-18    2015-09-21
## -1.183919e-03 -3.951205e-04  2.371601e-03  1.971412e-04 -5.913463e-04
##    2015-09-22    2015-09-23    2015-09-24    2015-09-25    2015-09-28
##  3.944773e-04  0.000000e+00  3.943415e-04 -3.941860e-04  7.885844e-04
##    2015-09-29    2015-09-30    2015-10-01    2015-10-02    2015-10-05
##  3.940307e-04  3.938559e-04 -2.560613e-04  1.379117e-03 -5.902616e-04
##    2015-10-06    2015-10-07    2015-10-08    2015-10-09    2015-10-12
```

```
##  1.968898e-04 -5.904743e-04  0.000000e+00 -3.938755e-04  5.910757e-04
##    2015-10-13    2015-10-14    2015-10-15    2015-10-16    2015-10-19
##  1.968498e-04  9.842323e-04 -5.899312e-04 -1.967532e-04  0.000000e+00
##    2015-10-20    2015-10-21    2015-10-22    2015-10-23    2015-10-26
## -5.904743e-04  3.938559e-04  5.906102e-04 -1.180445e-03  1.969470e-04
##    2015-10-27    2015-10-28    2015-10-29    2015-10-30    2015-11-02
##  1.969673e-04 -1.378224e-03 -3.943218e-04  0.000000e+00 -5.526565e-04
##    2015-11-03    2015-11-04    2015-11-05    2015-11-06    2015-11-09
##  0.000000e+00 -7.899092e-04 -1.975889e-04 -9.883178e-04 -1.979026e-04
##    2015-11-10    2015-11-11    2015-11-12    2015-11-13    2015-11-16
##  3.958045e-04  0.000000e+00  0.000000e+00  5.935312e-04  0.000000e+00
##    2015-11-17    2015-11-18    2015-11-19    2015-11-20    2015-11-23
##  0.000000e+00 -1.977461e-04 -1.977259e-04 -3.955696e-04  0.000000e+00
##    2015-11-24    2015-11-25    2015-11-27    2015-11-30    2015-12-01
##  1.978235e-04  0.000000e+00  1.978635e-04 -3.955696e-04  1.168043e-03
##    2015-12-02    2015-12-03    2015-12-04    2015-12-07    2015-12-08
## -1.384220e-03 -3.960396e-04  1.981379e-04  1.980194e-04  0.000000e+00
##    2015-12-09    2015-12-10    2015-12-11    2015-12-14    2015-12-15
##  3.960396e-04 -3.958828e-04  1.386139e-03 -1.384220e-03 -3.960396e-04
##    2015-12-16    2015-12-17    2015-12-18    2015-12-21    2015-12-22
## -5.942750e-04  1.981764e-04  7.927269e-04  1.979802e-04 -3.958820e-04
##    2015-12-23    2015-12-24    2015-12-28    2015-12-29    2015-12-30
## -1.980986e-04 -3.962163e-04  1.982164e-04 -7.731914e-04  1.983730e-04
##    2015-12-31    2016-01-04    2016-01-05    2016-01-06    2016-01-07
##  5.951002e-04  9.913363e-04 -9.903545e-04  7.930413e-04  5.942552e-04
##    2016-01-08    2016-01-11    2016-01-12    2016-01-13    2016-01-14
##  1.980202e-04  3.959026e-04  0.000000e+00  7.914721e-04  0.000000e+00
##    2016-01-15    2016-01-19    2016-01-20    2016-01-21    2016-01-22
##  9.885132e-04  1.974719e-04  7.899092e-04 -1.973560e-04 -9.867575e-04
##    2016-01-25    2016-01-26    2016-01-27    2016-01-28    2016-01-29
##  5.927104e-04  0.000000e+00  1.973939e-04  3.947888e-04  1.381215e-03
##    2016-02-01    2016-02-02    2016-02-03    2016-02-04    2016-02-05
## -1.301325e-03  1.579427e-03  7.884881e-04  5.908804e-04 -1.181043e-03
##    2016-02-08    2016-02-09    2016-02-10    2016-02-11    2016-02-12
##  1.182440e-03  0.000000e+00  0.000000e+00  7.874213e-04 -9.834579e-04
##    2016-02-16    2016-02-17    2016-02-18    2016-02-19    2016-02-22
## -3.937980e-04 -1.970061e-04  7.880418e-04 -5.905315e-04  0.000000e+00
##    2016-02-23    2016-02-24    2016-02-25    2016-02-26    2016-02-29
##  3.939531e-04 -1.969285e-04  5.908232e-04 -1.771305e-03  7.885844e-04
##    2016-03-01    2016-03-02    2016-03-03    2016-03-04    2016-03-07
## -1.297131e-03 -1.973549e-04  0.000000e+00 -3.948865e-04 -3.950227e-04
##    2016-03-08    2016-03-09    2016-03-10    2016-03-11    2016-03-14
##  7.903774e-04 -5.923593e-04 -5.926314e-04 -1.976280e-04  0.000000e+00
##    2016-03-15    2016-03-16    2016-03-17    2016-03-18    2016-03-21
## -3.954330e-04  1.780083e-03  1.973939e-04  7.895973e-04 -5.917751e-04
##    2016-03-22    2016-03-23    2016-03-24    2016-03-28    2016-03-29
## -1.973160e-04  1.973549e-04 -1.973160e-04  1.973549e-04  1.578883e-03
##    2016-03-30    2016-03-31    2016-04-01    2016-04-04    2016-04-05
##  5.911133e-04  3.938559e-04 -1.071617e-03  7.888188e-04  7.881970e-04
##    2016-04-06    2016-04-07    2016-04-08    2016-04-11    2016-04-12
## -7.875763e-04  1.182286e-03 -3.936233e-04  0.000000e+00 -5.907265e-04
##    2016-04-13    2016-04-14    2016-04-15    2016-04-18    2016-04-19
##  1.970449e-04 -3.939334e-04  5.911133e-04 -1.969082e-04 -1.970061e-04
##    2016-04-20    2016-04-21    2016-04-22    2016-04-25    2016-04-26
```

```
## -3.939322e-04 -1.971226e-04 -3.942637e-04 -1.971603e-04 -3.944970e-04
##    2016-04-27    2016-04-28    2016-04-29    2016-05-02    2016-05-03
##  5.919298e-04  1.380398e-03  1.969673e-04 -8.275930e-04  1.183218e-03
##    2016-05-04    2016-05-05    2016-05-06    2016-05-09    2016-05-10
##  3.939531e-04  1.968498e-04 -1.968110e-04  3.937783e-04 -1.968510e-04
##    2016-05-11    2016-05-12    2016-05-13    2016-05-16    2016-05-17
##  0.000000e+00 -3.937008e-04  0.000000e+00 -7.876526e-04 -5.913086e-04
##    2016-05-18    2016-05-19    2016-05-20    2016-05-23    2016-05-24
## -1.183139e-03  3.947877e-04  1.973949e-04 -1.973560e-04 -3.946319e-04
##    2016-05-25    2016-05-26    2016-05-27    2016-05-31    2016-06-01
##  1.973939e-04  7.895973e-04 -7.889743e-04  5.921634e-04 -5.329570e-04
##    2016-06-02    2016-06-03    2016-06-06    2016-06-07    2016-06-08
##  3.950425e-04  1.579427e-03  1.971614e-04  1.970437e-04 -1.970049e-04
##    2016-06-09    2016-06-10    2016-06-13    2016-06-14    2016-06-15
##  5.912101e-04  5.908804e-04  1.968898e-04  0.000000e+00  7.871875e-04
##    2016-06-16    2016-06-17    2016-06-20    2016-06-21    2016-06-22
##  0.000000e+00 -1.966175e-04 -7.868017e-04  0.000000e+00  1.968898e-04
##    2016-06-23    2016-06-24    2016-06-27    2016-06-28    2016-06-29
## -5.904743e-04  2.166207e-03  1.375516e-03 -5.886774e-04 -1.963872e-04
##    2016-06-30    2016-07-01    2016-07-05    2016-07-06    2016-07-07
##  7.855656e-04 -9.820324e-05  7.855656e-04  0.000000e+00 -7.849490e-04
##    2016-07-08    2016-07-11    2016-07-12    2016-07-13    2016-07-14
##  0.000000e+00 -7.854871e-04 -5.896816e-04 -1.966175e-04  1.966562e-04
##    2016-07-15    2016-07-18    2016-07-19    2016-07-20    2016-07-21
## -5.899312e-04  1.968123e-04  3.933897e-04 -3.932350e-04  5.901829e-04
##    2016-07-22    2016-07-25    2016-07-26    2016-07-27    2016-07-28
## -7.864923e-04 -1.967532e-04 -1.968510e-04  5.906102e-04  5.901829e-04
##    2016-07-29    2016-08-01    2016-08-02    2016-08-03    2016-08-04
##  7.864923e-04 -5.111862e-04  0.000000e+00 -1.966562e-04  7.868778e-04
##    2016-08-05    2016-08-08    2016-08-09    2016-08-10    2016-08-11
## -1.572597e-03 -1.969285e-04  7.877314e-04  5.902794e-04 -1.179882e-03
##    2016-08-12    2016-08-15    2016-08-16    2016-08-17    2016-08-18
##  5.906478e-04 -3.935655e-04 -1.968110e-04  1.968498e-04  3.937205e-04
##    2016-08-19    2016-08-22    2016-08-23    2016-08-24    2016-08-25
## -7.871114e-04  3.938559e-04 -1.968110e-04  0.000000e+00  0.000000e+00
##    2016-08-26    2016-08-29    2016-08-30    2016-08-31    2016-09-01
## -1.181355e-03  3.942440e-04  3.940887e-04  3.939531e-04 -3.152140e-04
##    2016-09-02    2016-09-06    2016-09-07    2016-09-08    2016-09-09
## -1.971226e-04  9.855904e-04  0.000000e+00 -3.938755e-04 -3.939322e-04
##    2016-09-12    2016-09-13    2016-09-14    2016-09-15    2016-09-16
##  0.000000e+00 -3.941860e-04  7.885844e-04  1.970449e-04 -1.970061e-04
##    2016-09-19    2016-09-20    2016-09-21    2016-09-22    2016-09-23
## -3.939322e-04  1.970437e-04 -1.970049e-04  5.912101e-04  1.969470e-04
##    2016-09-26    2016-09-27    2016-09-28    2016-09-29    2016-09-30
##  1.969673e-04  1.968498e-04  0.000000e+00  0.000000e+00 -1.968110e-04
##    2016-10-03    2016-10-04    2016-10-05    2016-10-06    2016-10-07
##  5.122355e-04 -1.378495e-03 -3.943995e-04 -5.918130e-04  3.947888e-04
##    2016-10-10    2016-10-11    2016-10-12    2016-10-13    2016-10-14
## -3.946330e-04  0.000000e+00 -3.948085e-04  7.899092e-04  0.000000e+00
##    2016-10-17    2016-10-18    2016-10-19    2016-10-20    2016-10-21
##  5.919298e-04  1.972392e-04  0.000000e+00  0.000000e+00 -1.972003e-04
##    2016-10-24    2016-10-25    2016-10-26    2016-10-27    2016-10-28
## -1.971603e-04  0.000000e+00 -5.917751e-04  0.000000e+00  3.947306e-04
##    2016-10-31    2016-11-01    2016-11-02    2016-11-03    2016-11-04
```

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##  3.945551e-04  6.314377e-04  0.000000e+00  1.972392e-04  3.943415e-04
##    2016-11-07    2016-11-08    2016-11-09    2016-11-10    2016-11-11
## -3.941860e-04 -5.915221e-04 -1.183626e-03 -5.925933e-04 -7.904546e-04
##    2016-11-14    2016-11-15    2016-11-16    2016-11-17    2016-11-18
## -5.933940e-04 -1.978824e-04 -1.979810e-04 -3.958820e-04 -3.961378e-04
##    2016-11-21    2016-11-22    2016-11-23    2016-11-25    2016-11-28
##  0.000000e+00  0.000000e+00 -3.962750e-04 -5.947076e-04  1.388417e-03
##    2016-11-29    2016-11-30    2016-12-01    2016-12-02    2016-12-05
##  1.980194e-04 -5.940396e-04 -5.155246e-04  7.935132e-04 -1.982557e-04
##    2016-12-06    2016-12-07    2016-12-08    2016-12-09    2016-12-12
##  0.000000e+00  5.948057e-04  0.000000e+00 -3.962750e-04 -5.947076e-04
##    2016-12-13    2016-12-14    2016-12-15    2016-12-16    2016-12-19
##  0.000000e+00 -1.784927e-03 -3.973972e-04  3.975552e-04  7.946950e-04
##    2016-12-20    2016-12-21    2016-12-22    2016-12-23    2016-12-27
##  0.000000e+00  0.000000e+00  3.970618e-04  1.985116e-04 -3.968452e-04
##    2016-12-28    2016-12-29    2016-12-30    2017-01-03    2017-01-04
##  2.383411e-04  5.956712e-04  5.953364e-04 -1.982943e-04  0.000000e+00
##    2017-01-05    2017-01-06    2017-01-09    2017-01-10    2017-01-11
##  0.000000e+00 -1.983337e-04  5.951984e-04  0.000000e+00 -1.983343e-04
##    2017-01-12    2017-01-13    2017-01-17    2017-01-18    2017-01-19
##  3.966878e-04 -5.947462e-04  1.388613e-03 -1.188629e-03 -1.982943e-04
##    2017-01-20    2017-01-23    2017-01-24    2017-01-25    2017-01-26
##  5.951002e-04  7.930413e-04 -3.962163e-04 -5.945105e-04  3.966092e-04
##    2017-01-27    2017-01-30    2017-01-31    2017-02-01    2017-02-02
##  1.981764e-04 -1.981371e-04  5.946283e-04 -3.370938e-04  1.983737e-04
##    2017-02-03    2017-02-06    2017-02-07    2017-02-08    2017-02-09
## -5.948443e-04  1.785714e-03 -3.961378e-04  5.943927e-04  0.000000e+00
##    2017-02-10    2017-02-13    2017-02-14    2017-02-15    2017-02-16
## -7.920990e-04  0.000000e+00 -7.927269e-04 -3.965887e-04  9.920436e-04
##    2017-02-17    2017-02-21    2017-02-22    2017-02-23    2017-02-24
##  0.000000e+00  3.964321e-04  1.981177e-04  5.942552e-04  5.940012e-04
##    2017-02-27    2017-02-28    2017-03-01    2017-03-02    2017-03-03
## -7.914721e-04 -5.940396e-04 -1.070706e-03 -5.955339e-04  5.958888e-04
##    2017-03-06    2017-03-07    2017-03-08    2017-03-09    2017-03-10
## -1.985312e-04 -5.955728e-04 -7.946166e-04  0.000000e+00  3.976342e-04
##    2017-03-13    2017-03-14    2017-03-15    2017-03-16    2017-03-17
## -1.987083e-04  1.987478e-04  1.391077e-03 -3.969042e-04  1.985706e-04
##    2017-03-20    2017-03-21    2017-03-22    2017-03-23    2017-03-24
##  3.970028e-04  5.951984e-04  7.931985e-04 -3.962750e-04 -1.982557e-04
##    2017-03-27    2017-03-28    2017-03-29    2017-03-30    2017-03-31
##  3.965107e-04 -3.963536e-04  5.948057e-04 -3.962750e-04  1.981764e-04
##    2017-04-03    2017-04-04    2017-04-05    2017-04-06    2017-04-07
##  4.760394e-04  1.982950e-04 -5.947076e-04  5.950615e-04 -9.910604e-04
##    2017-04-10    2017-04-11    2017-04-12    2017-04-13    2017-04-17
##  5.951984e-04  5.948642e-04  7.927269e-04  5.940396e-04  1.979418e-04
##    2017-04-18    2017-04-19    2017-04-20    2017-04-21    2017-04-24
##  1.978235e-04  0.000000e+00 -7.913155e-04  7.919422e-04 -3.956479e-04
##    2017-04-25    2017-04-26    2017-04-27    2017-04-28    2017-05-01
## -7.915496e-04  0.000000e+00  7.921766e-04 -9.894914e-04  8.128631e-04
##    2017-05-02    2017-05-03    2017-05-04    2017-05-05    2017-05-08
## -7.924128e-04 -1.982355e-04 -3.965893e-04  7.935132e-04 -7.928840e-04
##    2017-05-09    2017-05-10    2017-05-11    2017-05-12    2017-05-15
## -1.983337e-04 -1.984722e-04  1.985116e-04  1.190417e-03 -1.981371e-04
##    2017-05-16    2017-05-17    2017-05-18    2017-05-19    2017-05-22
```

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##  5.946283e-04  3.961965e-04 -5.940396e-04  0.000000e+00  3.962948e-04
##    2017-05-23    2017-05-24    2017-05-25    2017-05-26    2017-05-30
## -3.961378e-04  5.943927e-04 -1.979802e-04  0.000000e+00  3.960388e-04
##    2017-05-31    2017-06-01    2017-06-02    2017-06-05    2017-06-06
## -1.979410e-04 -5.944146e-05  3.964321e-04 -3.962750e-04  1.981764e-04
##    2017-06-07    2017-06-08    2017-06-09    2017-06-12    2017-06-13
##  5.945898e-04 -5.942365e-04 -5.945105e-04  0.000000e+00 -3.965893e-04
##    2017-06-14    2017-06-15    2017-06-16    2017-06-19    2017-06-20
##  7.935132e-04 -5.947076e-04  1.190044e-03 -1.188629e-03  1.983737e-04
##    2017-06-21    2017-06-22    2017-06-23    2017-06-26    2017-06-27
##  1.982748e-04  5.948057e-04 -5.944521e-04  5.948057e-04 -5.944521e-04
##    2017-06-28    2017-06-29    2017-06-30    2017-07-03    2017-07-05
##  1.982950e-04  1.981764e-04 -7.927269e-04 -4.367506e-04  5.958888e-04
##    2017-07-06    2017-07-07    2017-07-10    2017-07-11    2017-07-12
##  0.000000e+00  1.984518e-04  1.985116e-04  1.983730e-04  1.983337e-04
##    2017-07-13    2017-07-14    2017-07-17    2017-07-18    2017-07-19
## -1.982943e-04  3.967467e-04  1.982748e-04  1.982950e-04  0.000000e+00
##    2017-07-20    2017-07-21    2017-07-24    2017-07-25    2017-07-26
##  0.000000e+00  7.928840e-04 -7.922559e-04 -7.928840e-04  7.935132e-04
##    2017-07-27    2017-07-28    2017-07-31    2017-08-01    2017-08-02
##  1.981764e-04  3.963734e-04  1.981379e-04  4.757364e-04 -5.944521e-04
##    2017-08-03    2017-08-04    2017-08-07    2017-08-08    2017-08-09
## -1.982355e-04  1.982748e-04  1.982950e-04  0.000000e+00  1.981764e-04
##    2017-08-10    2017-08-11    2017-08-14    2017-08-15    2017-08-16
##  3.963734e-04  5.942552e-04 -1.979410e-04 -1.979802e-04  0.000000e+00
##    2017-08-17    2017-08-18    2017-08-21    2017-08-22    2017-08-23
##  3.960388e-04  0.000000e+00  0.000000e+00 -1.979410e-04  3.960396e-04
##    2017-08-24    2017-08-25    2017-08-28    2017-08-29    2017-08-30
##  0.000000e+00  0.000000e+00  0.000000e+00  5.938044e-04  0.000000e+00
##    2017-08-31    2017-09-01    2017-09-05    2017-09-06    2017-09-07
## -1.977844e-04 -4.159157e-04  1.188785e-03  1.979418e-04  3.957261e-04
##    2017-09-08    2017-09-11    2017-09-12    2017-09-13    2017-09-14
## -1.978244e-04 -7.913155e-04 -5.939022e-04  0.000000e+00 -1.980784e-04
##    2017-09-15    2017-09-18    2017-09-19    2017-09-20    2017-09-21
## -1.981771e-04 -1.981371e-04  0.000000e+00 -7.928840e-04 -5.951002e-04
##    2017-09-22    2017-09-25    2017-09-26    2017-09-27    2017-09-28
##  1.190909e-03  0.000000e+00 -7.929620e-04  1.983730e-04  1.983337e-04
##    2017-09-29    2017-10-02    2017-10-03    2017-10-04    2017-10-05
## -3.965887e-04 -1.994002e-05  0.000000e+00  3.972393e-04 -3.970816e-04
##    2017-10-06    2017-10-09    2017-10-10    2017-10-11    2017-10-12
## -5.957895e-04  0.000000e+00  1.987679e-04  1.986489e-04  0.000000e+00
##    2017-10-13    2017-10-16    2017-10-17    2017-10-18    2017-10-19
##  1.986095e-04 -3.971400e-04 -7.947745e-04  0.000000e+00  5.965202e-04
##    2017-10-20    2017-10-23    2017-10-24    2017-10-25    2017-10-26
## -3.974762e-04  1.988469e-04 -1.988074e-04 -1.987674e-04 -3.977133e-04
##    2017-10-27    2017-10-30    2017-10-31    2017-11-01    2017-11-02
##  5.967575e-04  5.964811e-04 -9.935028e-04  1.394104e-04  3.980095e-04
##    2017-11-03    2017-11-06    2017-11-07    2017-11-08    2017-11-09
## -5.968564e-04  3.981684e-04  0.000000e+00 -3.980100e-04  1.991240e-04
##    2017-11-10    2017-11-13    2017-11-14    2017-11-15    2017-11-16
## -3.981091e-04 -3.982477e-04  0.000000e+00  1.991633e-04 -1.991237e-04
##    2017-11-17    2017-11-20    2017-11-21    2017-11-22    2017-11-24
## -1.992430e-04 -5.977087e-04  0.000000e+00  5.980662e-04 -1.992230e-04
##    2017-11-27    2017-11-28    2017-11-29    2017-11-30    2017-12-01
```

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##  3.985851e-04 -1.992430e-04 -1.992230e-04 -5.978079e-04  6.786769e-04
##    2017-12-04    2017-12-05    2017-12-06    2017-12-07    2017-12-08
## -1.196908e-03  1.997603e-04  1.996406e-04  1.996007e-04  1.996607e-04
##    2017-12-11    2017-12-12    2017-12-13    2017-12-14    2017-12-15
## -3.991419e-04  0.000000e+00  3.993013e-04  0.000000e+00 -3.991419e-04
##    2017-12-18    2017-12-19    2017-12-20    2017-12-21    2017-12-22
##  0.000000e+00 -1.996007e-04 -5.991014e-04  1.998402e-04 -3.995206e-04
##    2017-12-26    2017-12-27    2017-12-28    2017-12-29    2018-01-02
##  3.996802e-04  1.199304e-04  3.999400e-04  0.000000e+00  1.999201e-04
##    2018-01-03    2018-01-04    2018-01-05    2018-01-08    2018-01-09
## -9.991806e-04  0.000000e+00  0.000000e+00  2.000000e-04 -4.000000e-04
##    2018-01-10    2018-01-11    2018-01-12    2018-01-16    2018-01-17
##  2.001200e-04 -2.000800e-04 -6.002201e-04  0.000000e+00 -2.002402e-04
##    2018-01-18    2018-01-19    2018-01-22    2018-01-23    2018-01-24
##  0.000000e+00 -6.007009e-04  2.003206e-04  4.006611e-04 -2.002203e-04
##    2018-01-25    2018-01-26    2018-01-29    2018-01-30    2018-01-31
##  0.000000e+00 -1.001382e-03  0.000000e+00  2.004411e-04 -2.004009e-04
##    2018-02-01    2018-02-02    2018-02-05    2018-02-06    2018-02-07
## -8.229863e-04  4.017678e-04  2.008092e-03 -1.402806e-03 -6.021071e-04
##    2018-02-08    2018-02-09    2018-02-12    2018-02-13    2018-02-14
##  6.024699e-04  4.012844e-04  2.006620e-04 -4.011432e-04 -1.203872e-03
##    2018-02-15    2018-02-16    2018-02-20    2018-02-21    2018-02-22
##  0.000000e+00  2.009241e-04 -4.017072e-04  0.000000e+00  2.009042e-04
##    2018-02-23    2018-02-26    2018-02-27    2018-02-28    2018-03-01
##  0.000000e+00  4.017678e-04 -4.016064e-04  1.004480e-03 -1.004922e-04
##    2018-03-02    2018-03-05    2018-03-06    2018-03-07    2018-03-08
##  0.000000e+00  0.000000e+00 -6.027326e-04  6.030961e-04 -4.018485e-04
##    2018-03-09    2018-03-12    2018-03-13    2018-03-14    2018-03-15
##  8.040402e-04 -2.008837e-04  2.009241e-04  6.025105e-04 -1.204376e-03
##    2018-03-16    2018-03-19    2018-03-20    2018-03-21    2018-03-22
##  0.000000e+00  2.010048e-04 -4.018485e-04  6.029950e-04  4.017678e-04
##    2018-03-23    2018-03-26    2018-03-27    2018-03-28    2018-03-29
##  4.016265e-04 -4.014653e-04  8.032329e-04 -4.012841e-04  4.014452e-04
##    2018-04-02    2018-04-03    2018-04-04    2018-04-05    2018-04-06
##  5.424427e-04 -6.023896e-04 -8.036970e-04  6.032174e-04  4.019494e-04
##    2018-04-09    2018-04-10    2018-04-11    2018-04-12    2018-04-13
##  0.000000e+00 -4.017879e-04  2.010048e-04 -1.004601e-03  2.011062e-04
##    2018-04-16    2018-04-17    2018-04-18    2018-04-19    2018-04-20
##  0.000000e+00 -2.010658e-04 -6.034191e-04  0.000000e+00 -4.025156e-04
##    2018-04-23    2018-04-24    2018-04-25    2018-04-26    2018-04-27
##  0.000000e+00 -2.012885e-04 -2.013290e-04  4.027392e-04  2.013690e-04
##    2018-04-30    2018-05-01    2018-05-02    2018-05-03    2018-05-04
##  2.012681e-04 -7.455418e-04  6.049405e-04  4.030633e-04 -2.014102e-04
##    2018-05-07    2018-05-08    2018-05-09    2018-05-10    2018-05-11
## -2.015313e-04 -2.014913e-04  0.000000e+00  0.000000e+00 -6.046966e-04
##    2018-05-14    2018-05-15    2018-05-16    2018-05-17    2018-05-18
##  6.050625e-04 -6.046966e-04 -2.017346e-04  2.017753e-04  6.050625e-04
##    2018-05-21    2018-05-22    2018-05-23    2018-05-24    2018-05-25
##  0.000000e+00  0.000000e+00  1.007841e-03  6.040878e-04  2.012880e-04
##    2018-05-29    2018-05-30    2018-05-31    2018-06-01    2018-06-04
##  3.018048e-03 -8.023471e-04 -2.008030e-04 -9.853205e-04 -1.006421e-03
##    2018-06-05    2018-06-06    2018-06-07    2018-06-08    2018-06-11
##  4.030022e-04 -2.014703e-04  4.029210e-04 -2.013290e-04  0.000000e+00
##    2018-06-12    2018-06-13    2018-06-14    2018-06-15    2018-06-18
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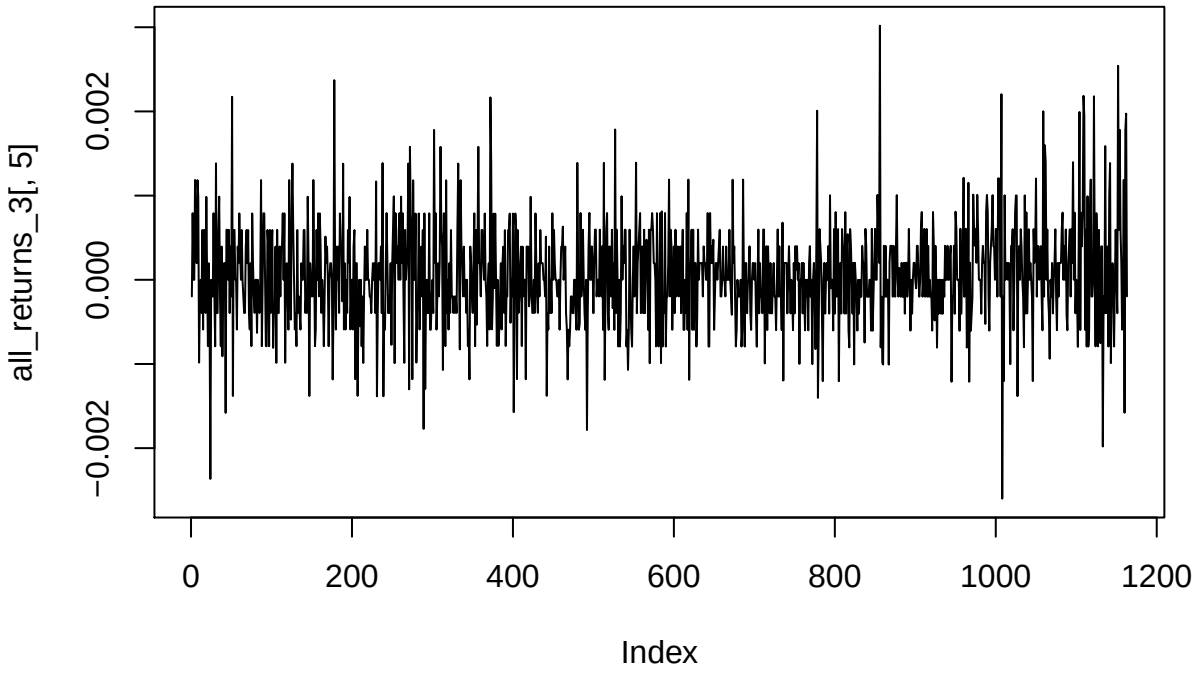
##  0.000000e+00 -1.007130e-03  2.016734e-04  4.031445e-04  4.030022e-04
##    2018-06-19    2018-06-20    2018-06-21    2018-06-22    2018-06-25
##  4.027392e-04 -2.012885e-04  4.027386e-04  2.012681e-04 -2.012276e-04
##    2018-06-26    2018-06-27    2018-06-28    2018-06-29    2018-07-02
##  4.025966e-04  1.006016e-03  0.000000e+00 -2.009648e-04  1.408695e-04
##    2018-07-03    2018-07-05    2018-07-06    2018-07-09    2018-07-10
##  0.000000e+00 -2.012885e-04  2.013290e-04 -2.012885e-04 -2.013290e-04
##    2018-07-11    2018-07-12    2018-07-13    2018-07-16    2018-07-17
##  2.013696e-04 -4.027588e-04  2.015109e-04  2.013696e-04 -2.013290e-04
##    2018-07-18    2018-07-19    2018-07-20    2018-07-23    2018-07-24
##  0.000000e+00  6.041893e-04  0.000000e+00 -6.038245e-04  0.000000e+00
##    2018-07-25    2018-07-26    2018-07-27    2018-07-30    2018-07-31
## -4.028399e-04  0.000000e+00  2.014507e-04  2.015109e-04  0.000000e+00
##    2018-08-01    2018-08-02    2018-08-03    2018-08-06    2018-08-07
## -1.008976e-04  4.034698e-04  4.033273e-04  0.000000e+00 -2.016327e-04
##    2018-08-08    2018-08-09    2018-08-10    2018-08-13    2018-08-14
##  0.000000e+00  6.048992e-04  8.059037e-04 -2.012885e-04  0.000000e+00
##    2018-08-15    2018-08-16    2018-08-17    2018-08-20    2018-08-21
##  6.040878e-04 -2.012276e-04  2.012681e-04  6.037835e-04 -2.011665e-04
##    2018-08-22    2018-08-23    2018-08-24    2018-08-27    2018-08-28
##  4.023537e-04 -2.010658e-04  0.000000e+00 -2.011665e-04 -2.011265e-04
##    2018-08-29    2018-08-30    2018-08-31    2018-09-04    2018-09-05
## -6.036821e-04  8.053352e-04  4.023537e-04 -4.834623e-04  4.030633e-04
##    2018-09-06    2018-09-07    2018-09-10    2018-09-11    2018-09-12
##  0.000000e+00 -8.058219e-04  0.000000e+00 -4.031452e-04  0.000000e+00
##    2018-09-13    2018-09-14    2018-09-17    2018-09-18    2018-09-19
##  0.000000e+00 -4.034086e-04  0.000000e+00 -4.035512e-04  0.000000e+00
##    2018-09-20    2018-09-21    2018-09-24    2018-09-25    2018-09-26
## -2.018975e-04  4.037957e-04  0.000000e+00  0.000000e+00  4.036529e-04
##    2018-09-27    2018-09-28    2018-10-01    2018-10-02    2018-10-03
##  0.000000e+00  0.000000e+00  2.828107e-04  4.039790e-04 -1.211347e-03
##    2018-10-04    2018-10-05    2018-10-08    2018-10-09    2018-10-10
## -2.021831e-04 -2.021432e-04  4.044489e-04 -4.042854e-04  8.089181e-04
##    2018-10-11    2018-10-12    2018-10-15    2018-10-16    2018-10-17
##  6.061426e-04  0.000000e+00  0.000000e+00  0.000000e+00 -6.057754e-04
##    2018-10-18    2018-10-19    2018-10-22    2018-10-23    2018-10-24
##  6.061426e-04 -4.038772e-04  0.000000e+00  4.040404e-04  1.211672e-03
##    2018-10-25    2018-10-26    2018-10-29    2018-10-30    2018-10-31
## -2.017346e-04  6.051644e-04  6.048992e-04 -8.059843e-04 -6.049405e-04
##    2018-11-01    2018-11-02    2018-11-05    2018-11-06    2018-11-07
##  1.152103e-03 -1.211347e-03  2.021225e-04 -6.062854e-04 -4.044692e-04
##    2018-11-08    2018-11-09    2018-11-12    2018-11-13    2018-11-14
## -2.023468e-04  1.011797e-03  6.064079e-04  4.040404e-04  6.057956e-04
##    2018-11-15    2018-11-16    2018-11-19    2018-11-20    2018-11-21
##  2.018567e-04  1.008878e-03  6.046765e-04  0.000000e+00  0.000000e+00
##    2018-11-23    2018-11-26    2018-11-27    2018-11-28    2018-11-29
##  0.000000e+00 -4.029009e-04  2.015720e-04  4.030022e-04  2.013696e-04
##    2018-11-30    2018-12-03    2018-12-04    2018-12-06    2018-12-07
##  2.013290e-04 -5.242811e-04  8.070420e-04  1.008145e-03  8.055790e-04
##    2018-12-10    2018-12-11    2018-12-12    2018-12-13    2018-12-14
## -2.012276e-04 -6.038245e-04  2.013696e-04  4.027386e-04  6.038446e-04
##    2018-12-17    2018-12-18    2018-12-19    2018-12-20    2018-12-21
##  1.005814e-03  4.019494e-04  3.823630e-04  0.000000e+00  6.035607e-04
##    2018-12-24    2018-12-26    2018-12-27    2018-12-28    2018-12-31
```

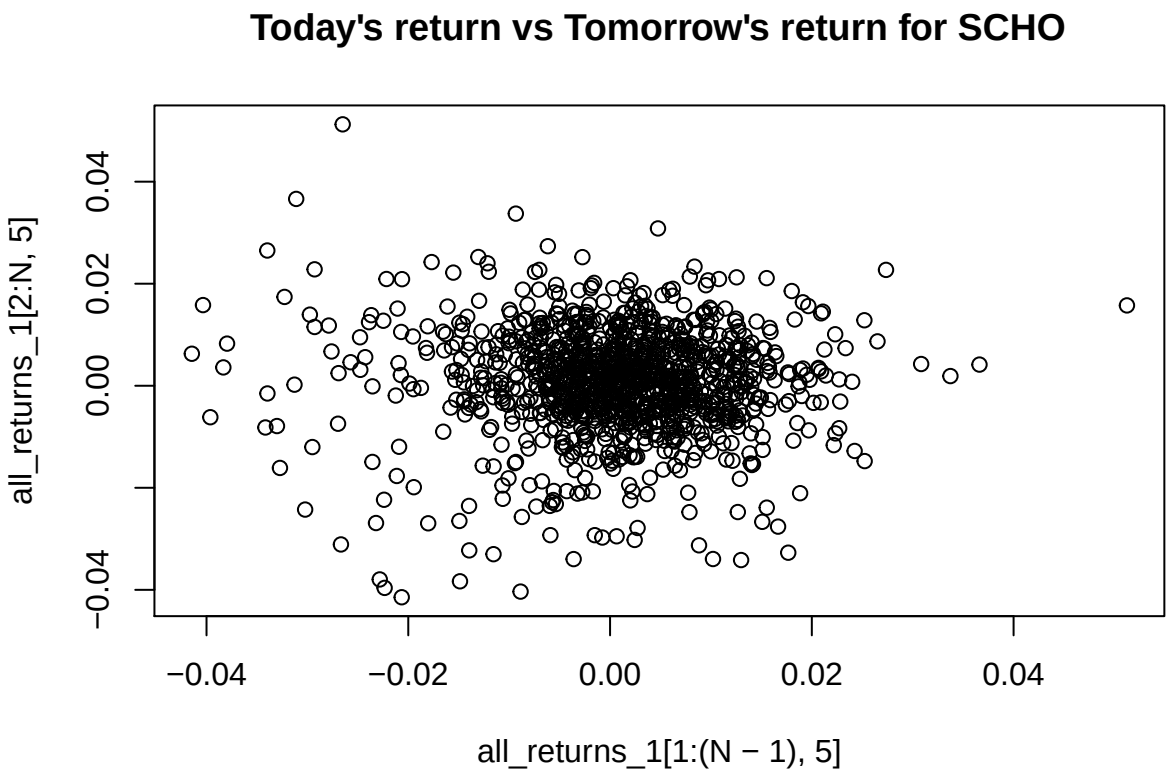
```
##  6.030961e-04 -2.009644e-04  1.205828e-03  6.021277e-04  1.203651e-03
##    2019-01-02    2019-01-03    2019-01-04    2019-01-07    2019-01-08
## -2.003206e-04  2.204329e-03 -2.599420e-03 -2.005212e-04 -1.203088e-03
##    2019-01-09    2019-01-10    2019-01-11    2019-01-14    2019-01-15
##  1.003814e-03  0.000000e+00  2.005215e-04  2.005615e-04  0.000000e+00
##    2019-01-16    2019-01-17    2019-01-18    2019-01-22    2019-01-23
##  2.004411e-04  0.000000e+00 -1.002185e-03  4.013042e-04  4.011231e-04
##    2019-01-24    2019-01-25    2019-01-28    2019-01-29    2019-01-30
##  6.014234e-04 -6.010619e-04  0.000000e+00  8.018645e-04  1.001663e-03
##    2019-01-31    2019-02-01    2019-02-04    2019-02-05    2019-02-06
##  1.000580e-03 -1.382279e-03  2.006620e-04  4.011231e-04  0.000000e+00
##    2019-02-07    2019-02-08    2019-02-11    2019-02-12    2019-02-13
##  6.014234e-04  4.007213e-04  0.000000e+00 -2.003204e-04 -8.012220e-04
##    2019-02-14    2019-02-15    2019-02-19    2019-02-20    2019-02-21
##  1.002386e-03 -4.005608e-04  8.014626e-04 -4.004204e-04  0.000000e+00
##    2019-02-22    2019-02-25    2019-02-26    2019-02-27    2019-02-28
##  6.008211e-04  0.000000e+00  2.002002e-04  0.000000e+00 -2.001601e-04
##    2019-03-01    2019-03-04    2019-03-05    2019-03-06    2019-03-07
## -1.203088e-03  6.022686e-04  2.006019e-04  4.012237e-04  1.203148e-03
##    2019-03-08    2019-03-11    2019-03-12    2019-03-13    2019-03-14
## -2.003204e-04  4.006611e-04  4.004806e-04  0.000000e+00  2.002002e-04
##    2019-03-15    2019-03-18    2019-03-19    2019-03-20    2019-03-21
##  4.002601e-04 -2.000800e-04 -6.002201e-04  2.001962e-03 -1.997602e-04
##    2019-03-22    2019-03-25    2019-03-26    2019-03-27    2019-03-28
##  1.598681e-03  1.396648e-03  0.000000e+00  5.977685e-04 -1.991637e-04
##    2019-03-29    2019-04-01    2019-04-02    2019-04-03    2019-04-04
## -3.983270e-04 -9.383273e-04  0.000000e+00 -1.998801e-04  1.999201e-04
##    2019-04-05    2019-04-08    2019-04-09    2019-04-10    2019-04-11
## -3.997002e-04  0.000000e+00  1.999000e-04  5.996802e-04 -1.998002e-04
##    2019-04-12    2019-04-15    2019-04-16    2019-04-17    2019-04-18
## -5.993806e-04  1.999000e-04 -1.998601e-04  1.999000e-04  1.999201e-04
##    2019-04-22    2019-04-23    2019-04-24    2019-04-25    2019-04-26
##  1.998002e-04  5.994606e-04  7.986621e-04  0.000000e+00  3.990423e-04
##    2019-04-29    2019-04-30    2019-05-01    2019-05-02    2019-05-03
##  0.000000e+00  5.983048e-04 -4.193845e-04 -5.993806e-04  1.999000e-04
##    2019-05-06    2019-05-07    2019-05-08    2019-05-09    2019-05-10
##  3.997602e-04  5.994606e-04 -1.997204e-04  5.991212e-04  1.996607e-04
##    2019-05-13    2019-05-14    2019-05-15    2019-05-16    2019-05-17
##  1.396907e-03  0.000000e+00  7.971503e-04 -3.982477e-04  0.000000e+00
##    2019-05-20    2019-05-21    2019-05-22    2019-05-23    2019-05-24
## -1.992430e-04 -7.969118e-04  3.987238e-04  1.993263e-03 -5.967376e-04
##    2019-05-28    2019-05-29    2019-05-30    2019-05-31    2019-06-03
##  7.961186e-04  3.977725e-04  7.952485e-04  2.185161e-03  1.946645e-03
##    2019-06-04    2019-06-05    2019-06-06    2019-06-07    2019-06-10
## -5.947462e-04  5.951002e-04 -7.929620e-04  9.920436e-04 -7.928840e-04
##    2019-06-11    2019-06-12    2019-06-13    2019-06-14    2019-06-17
## -5.951002e-04  7.939063e-04  1.190044e-03 -1.980784e-04 -1.981771e-04
##    2019-06-18    2019-06-19    2019-06-20    2019-06-21    2019-06-24
##  0.000000e+00  2.179964e-03  1.977852e-04 -7.908462e-04  7.914721e-04
##    2019-06-25    2019-06-26    2019-06-27    2019-06-28    2019-07-01
##  3.953341e-04 -7.904546e-04  5.933346e-04  0.000000e+00 -7.525249e-04
##    2019-07-02    2019-07-03    2019-07-05    2019-07-08    2019-07-09
##  3.963734e-04  3.961965e-04 -1.980158e-03 -1.984722e-04 -3.969042e-04
##    2019-07-10    2019-07-11    2019-07-12    2019-07-15    2019-07-16
```

```
##  1.588287e-03 -3.964519e-04  1.982748e-04  3.965107e-04 -7.927269e-04
##    2019-07-17    2019-07-18    2019-07-19    2019-07-22    2019-07-23
##  9.917295e-04  1.386963e-03 -9.892956e-04 -1.980986e-04  1.981379e-04
##    2019-07-24    2019-07-25    2019-07-26    2019-07-29    2019-07-30
##  0.000000e+00 -7.922559e-04  0.000000e+00  5.946283e-04  0.000000e+00
##    2019-07-31    2019-08-01    2019-08-02    2019-08-05    2019-08-06
## -3.962163e-04  2.541658e-03  5.941374e-04  1.781492e-03  5.927287e-04
##    2019-08-07    2019-08-08    2019-08-09    2019-08-12    2019-08-13
##  1.975316e-04 -5.923593e-04 -3.951205e-04  1.185810e-03 -1.579116e-03
##    2019-08-14    2019-08-15    2019-08-16
##  1.779280e-03  1.973594e-03 -1.970061e-04
```

```r
# Look at the portfolio_3 returns over time
plot(all_returns_3[,5], type='l')
```




```r
# are today's returns correlated with tomorrow's?
plot(all_returns_1[1:(N-1),5], all_returns_1[2:N,5])
title("Today's return vs Tomorrow's return for SCHO")
```

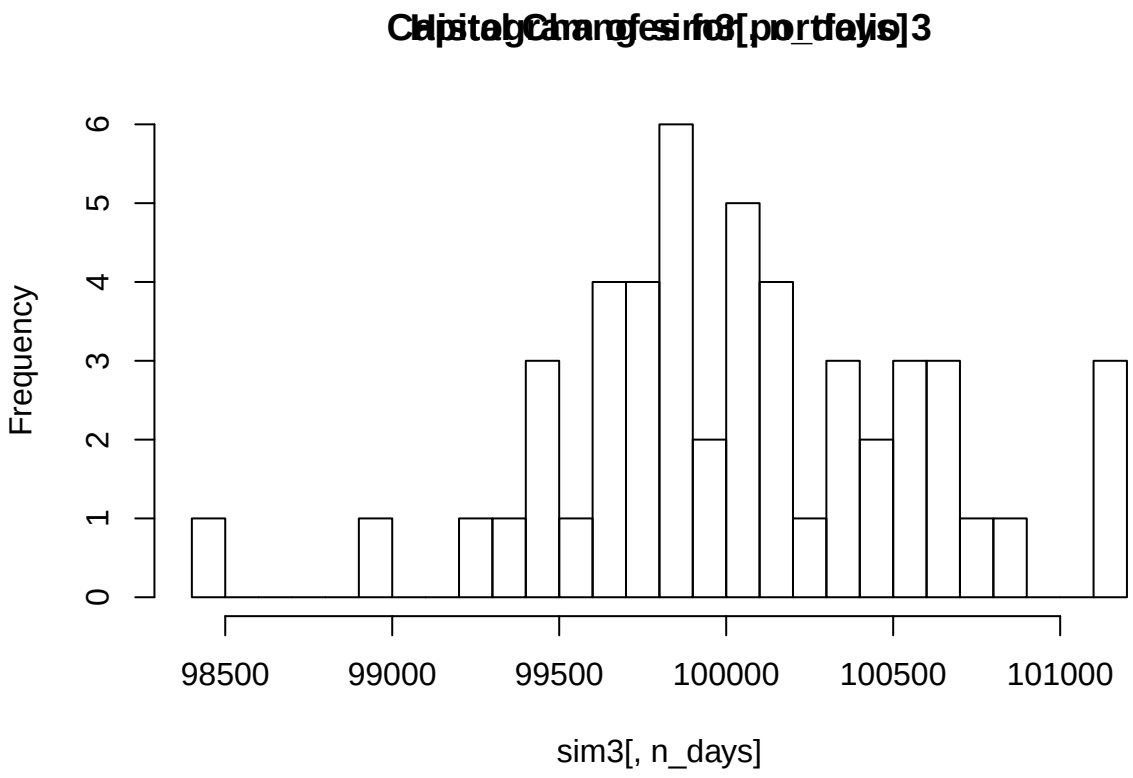



```
for(ticker in portfolio_3) {
    expr = paste0(ticker, "a = adjustOHLC(", ticker, ")")
    eval(parse(text=expr))
}


# Sample a random return from the empirical joint distribution
# This simulates a random day
set.seed(99)
return.today = resample(all_returns_3, 1, orig.ids=FALSE)

initial_wealth = 100000
sim3 = foreach(i=1:50, .combine='rbind') %do% {
    total_wealth = initial_wealth
    weights = c(0.2, 0.2, 0.2, 0.2, 0.2)
    holdings = weights * total_wealth
    n_days = 20
    wealthtracker = rep(0, n_days)
    for(today in 1:n_days) {
        return.today = resample(all_returns_3, 1, orig.ids=FALSE)
        holdings = holdings + holdings*return.today
        total_wealth = sum(holdings)
        wealthtracker[today] = total_wealth
    }
    wealthtracker
}
```

```r
head(sim3)
```

```
##               [,1]      [,2]      [,3]      [,4]      [,5]      [,6]
## result.1 100082.00 100102.71 100106.25 100596.28 100507.91 100341.38
## result.2  99972.25  99934.41  99792.18  99807.74  99643.05  99675.12
## result.3 100047.61  99771.94  99683.22  99649.53  99616.72  99620.04
## result.4 100147.83 100107.64  99923.48 100099.56 100015.13 100013.94
## result.5  99897.01  99929.10 100020.15 100026.59  99751.04  99634.21
## result.6  99996.63 100003.70  99963.90  99639.44  99615.89  99789.82
##               [,7]      [,8]      [,9]     [,10]     [,11]     [,12]
## result.1 100395.93 100316.50 100457.89 100268.13 100153.49 100049.76
## result.2  99662.71  99845.41  99699.67  99671.81  99611.81  99643.81
## result.3  99577.77  99513.76  99724.12  99716.57  99672.08  99855.58
## result.4 100124.59 100031.61 100071.24 100105.06 100096.21  99799.91
## result.5  99629.19  99586.82  99721.13  99696.57  99693.00  99596.19
## result.6  99824.25  99586.08  99692.94  99492.72  99827.85  99904.26
##              [,13]     [,14]     [,15]     [,16]     [,17]     [,18]
## result.1 100016.73  99981.88  99816.76  99728.35  99856.64  99815.76
## result.2  99615.88  99612.36  99670.01  99570.61  99749.59  99707.16
## result.3  99647.57  99607.26  99725.48  99674.10  99693.49  99832.20
## result.4 100018.79 100082.67 100060.58  99933.25 100050.56 100042.89
## result.5  99548.31  99676.25  99710.76  99652.61  99690.73  99702.48
## result.6  99942.58 100003.34 100118.72 100067.05 100204.92 100380.03
##              [,19]     [,20]
## result.1  99774.92  99808.99
## result.2  99894.22  99882.43
## result.3  99694.27  99652.79
## result.4  99946.53 100069.56
## result.5  99685.48  99533.70
## result.6 100332.14 100473.24
```

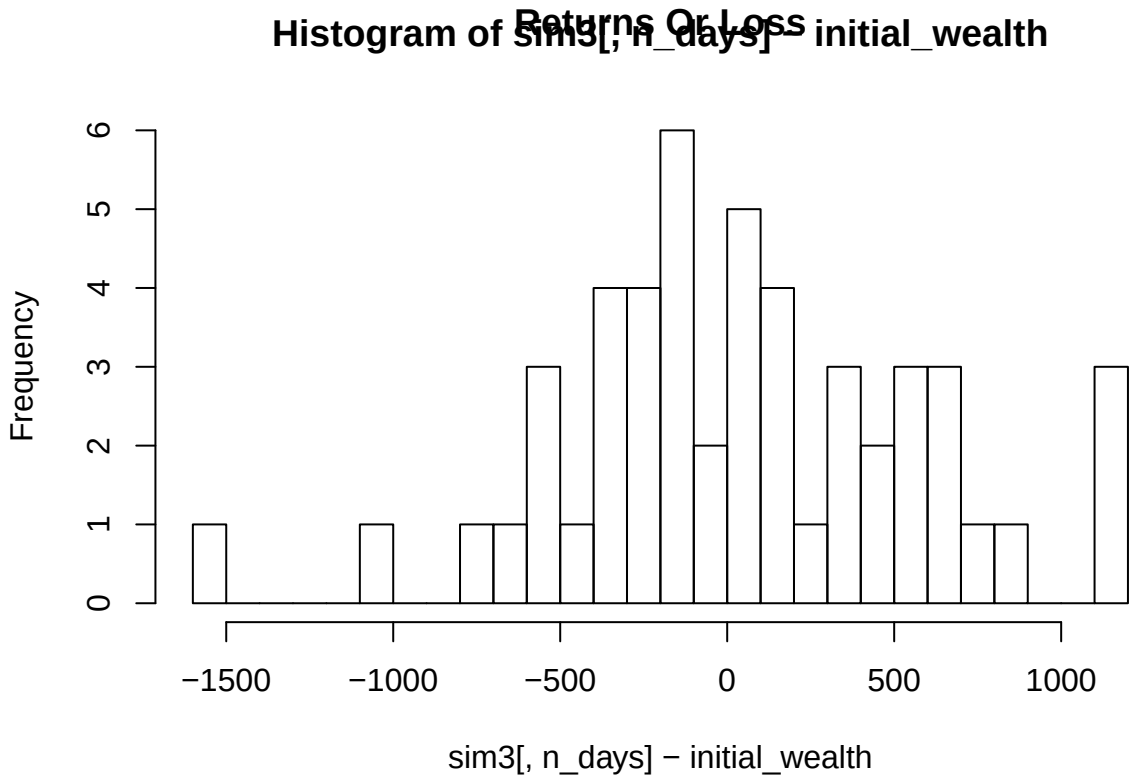
```r
hist(sim3[,n_days], 25)
title("Capital Changes for portfolio 3")
```




```
# Profit/loss
mean(sim3[,n_days])
```

```
## [1] 100039.1
```

```
hist(sim3[,n_days]- initial_wealth, breaks=30)
title("Returns Or Loss",line=2)
```




```
mean(sim3[,n_days] > 100000)
```

```
## [1] 0.52
```

```
quantile(sim3[,n_days]- initial_wealth,.05)
```

```
##        5%
## -690.1049
```

```
quantile(sim3[,n_days]- initial_wealth,.01)
```

```
##        1%
## -1301.901
```

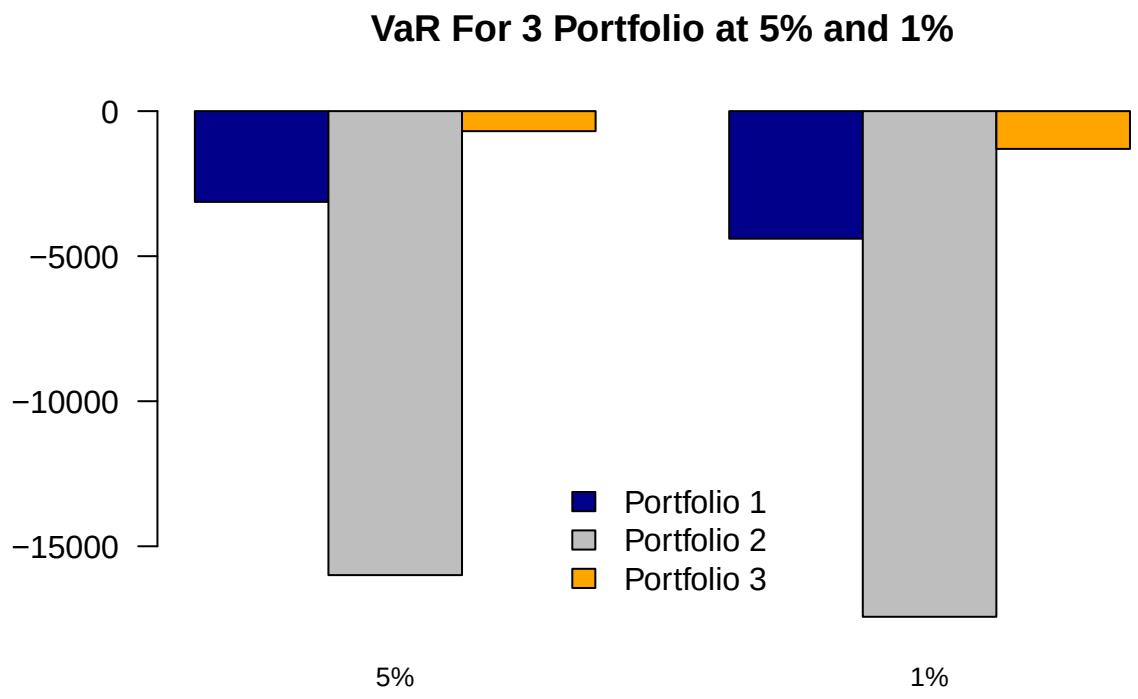
From the return and loss histogram, we know that the portfolio 3 is safer than portfolio 1 and 2, the most loss can only be 1500 and also the most earns can only less than 1200 approximately which follows the principle of low risk and low return. Also the correlationship between ETFs in porfolio 3, they have close relationship between each other since they are all issued by government agencies and varied simultaneously. For investors at 1% of risk preference, the value in risk is more than 1302.

Combine VaR for three portfolios

```r
# Combine VaR for three portfolios
Portfolio_3 <- c(quantile(sim3[,n_days]- initial_wealth,.05), quantile(sim3[,n_days]- initial_wealth,.0
Portfolio_2 <- c(quantile(sim2[,n_days]- initial_wealth,.05), quantile(sim2[,n_days]- initial_wealth,.0
Portfolio_1<- c(quantile(sim1[,n_days]- initial_wealth,.05), quantile(sim1[,n_days]- initial_wealth,.01
VaR <- rbind(Portfolio_1,Portfolio_2,Portfolio_3)
dimnames(VaR) = list( c("Portfolio 1","Portfolio 2","Portfolio 3"),c("5%","1%"))
VaR
```

```
##                       5%         1%
## Portfolio 1  -3127.6651  -4396.297
## Portfolio 2 -15993.6942 -17430.462
## Portfolio 3   -690.1049  -1301.901
```

```r
barplot(VaR, beside = TRUE,legend=TRUE,col=c("darkblue","grey","orange"),cex.names=0.8,las=1,bty ="n",a
title("VaR For 3 Portfolio at 5% and 1%")
```



From the VaR at 5% and 1% for these 3 portfolios, we can see that the porfolio 2 loses most and covers the most risks and the porfolio 1 is the safest compared with other porfolios. Also, the value at risk is also different by the lose probability. 1% lose probability will lose more compared with 5% lose probability. And the probability also represents the risk preference of investors. If the investors have low risk preference, it means that we need to consider high lose probability and the VaR turns out to be less. And we need to choose safer portfolio, like portfolio 1 or 2, in order to hedge risk as much as possible.