practisingTrading

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library(PortfolioAnalytics)

## Loading required package: zoo

##   
## Attaching package: 'zoo'

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

## Loading required package: xts

## Loading required package: foreach

## Loading required package: PerformanceAnalytics

##   
## Attaching package: 'PerformanceAnalytics'

## The following object is masked from 'package:graphics':  
##   
## legend

library(foreach)  
library(iterators)  
library(ROI)

## ROI: R Optimization Infrastructure

## Registered solver plugins: nlminb, glpk, quadprog.

## Default solver: auto.

##   
## Attaching package: 'ROI'

## The following objects are masked from 'package:PortfolioAnalytics':  
##   
## is.constraint, objective

library(ROI.plugin.quadprog)  
library(ROI.plugin.glpk)  
library(tidyverse)

## ── Attaching packages ────────────────────────────────────────────── tidyverse 1.3.0 ──

## ✓ ggplot2 3.3.2 ✓ purrr 0.3.4  
## ✓ tibble 3.0.1 ✓ dplyr 1.0.0  
## ✓ tidyr 1.1.0 ✓ stringr 1.4.0  
## ✓ readr 1.3.1 ✓ forcats 0.5.0

## ── Conflicts ───────────────────────────────────────────────── tidyverse\_conflicts() ──  
## x purrr::accumulate() masks foreach::accumulate()  
## x dplyr::filter() masks stats::filter()  
## x dplyr::first() masks xts::first()  
## x dplyr::lag() masks stats::lag()  
## x dplyr::last() masks xts::last()  
## x purrr::when() masks foreach::when()

library(tidyquant)

## Loading required package: lubridate

##   
## Attaching package: 'lubridate'

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

## Loading required package: quantmod

## Loading required package: TTR

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

## ══ Need to Learn tidyquant? ═══════════════════════════════════════════════════════════  
## Business Science offers a 1-hour course - Learning Lab #9: Performance Analysis & Portfolio Optimization with tidyquant!  
## </> Learn more at: https://university.business-science.io/p/learning-labs-pro </>

library(PerformanceAnalytics)  
library(PortfolioAnalytics)  
library(dplyr)  
library(xts)  
library(zoo)  
library(tibble)  
  
#Maximizing Mean Return  
#The objective to maximize mean return is a linear problem of the form:  
  
#maximize wµˆ(l)  
#w  
  
#Where µˆ is the estimated mean asset returns and w is the set of weights. Because this  
#is a linear problem, it is well suited to be solved using a linear programming solver. For  
#these types of problems, PortfolioAnalytics uses the ROI package with the glpk plugin  
  
  
  
  
  
data(edhec)  
data(edhec)  
returns <- edhec[, 1:4]  
colnames(returns) <- c("CA", "CTAG", "DS", "EM")  
print(head(returns, 5))

## CA CTAG DS EM  
## 1997-01-31 0.0119 0.0393 0.0178 0.0791  
## 1997-02-28 0.0123 0.0298 0.0122 0.0525  
## 1997-03-31 0.0078 -0.0021 -0.0012 -0.0120  
## 1997-04-30 0.0086 -0.0170 0.0030 0.0119  
## 1997-05-31 0.0156 -0.0015 0.0233 0.0315

tail(returns,5)

## CA CTAG DS EM  
## 2019-07-31 0.0032 0.0206 -0.0032 0.0044  
## 2019-08-31 0.0019 0.0300 -0.0089 -0.0348  
## 2019-09-30 0.0023 -0.0273 -0.0022 0.0076  
## 2019-10-31 0.0032 -0.0204 -0.0033 0.0204  
## 2019-11-30 0.0060 0.0058 -0.0043 -0.0008

#library(zoo)  
#z <- read.zoo(df)  
#returns <- as.data.frame(returns)  
#class(returns)   
  
#rownames\_to\_column()  
  
#returns <- rownames\_to\_column(returns, var="Fecha")  
  
  
  
  
#MyReturns <- returns %>%   
# filter(EM >= "0.0060" & EM <= "0.0065")  
  
  
# Get a character vector of the fund names  
funds <- colnames(returns)  
  
# Create portfolio object  
  
portf\_maxret <- portfolio.spec(assets=funds)  
  
# Add constraints to the portfolio object  
portf\_maxret <- add.constraint(portfolio=portf\_maxret, type="full\_investment")  
  
portf\_maxret <- add.constraint(portfolio=portf\_maxret, type="box",  
 min=c(0.02, 0.05, 0.03, 0.02),   
 max=c(0.55, 0.6, 0.65, 0.5))  
  
  
  
# Add objective to the portfolio object  
portf\_maxret <- add.objective(portfolio=portf\_maxret, type="return", name="mean")  
  
  
summary(portf\_maxret)

## $assets  
## CA CTAG DS EM   
## 0.25 0.25 0.25 0.25   
##   
## $enabled\_constraints  
## $enabled\_constraints[[1]]  
## An object containing 6 nonlinear constraints.  
##   
## $enabled\_constraints[[2]]  
## An object containing 5 nonlinear constraints.  
##   
##   
## $disabled\_constraints  
## list()  
##   
## $enabled\_objectives  
## $enabled\_objectives[[1]]  
## $name  
## [1] "mean"  
##   
## $target  
## NULL  
##   
## $arguments  
## list()  
##   
## $enabled  
## [1] TRUE  
##   
## $multiplier  
## [1] -1  
##   
## $call  
## add.objective(portfolio = portf\_maxret, type = "return", name = "mean")  
##   
## attr(,"class")  
## [1] "return\_objective" "objective"   
##   
##   
## $disabled\_objectives  
## list()  
##   
## attr(,"class")  
## [1] "summary.portfolio"

# Run the optimization  
  
opt\_maxret <- optimize.portfolio(R=returns, portfolio=portf\_maxret,  
 optimize\_method="ROI", trace=TRUE)  
  
  
print(opt\_maxret)

## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## PortfolioAnalytics Optimization  
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Call:  
## optimize.portfolio(R = returns, portfolio = portf\_maxret, optimize\_method = "ROI",   
## trace = TRUE)  
##   
## Optimal Weights:  
## CA CTAG DS EM   
## 0.02 0.05 0.65 0.28   
##   
## Objective Measure:  
## mean   
## 0.006371

opt\_maxret

## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## PortfolioAnalytics Optimization  
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Call:  
## optimize.portfolio(R = returns, portfolio = portf\_maxret, optimize\_method = "ROI",   
## trace = TRUE)  
##   
## Optimal Weights:  
## CA CTAG DS EM   
## 0.02 0.05 0.65 0.28   
##   
## Objective Measure:  
## mean   
## 0.006371

summary(opt\_maxret)

## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## PortfolioAnalytics Optimization Summary   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Call:  
## optimize.portfolio(R = returns, portfolio = portf\_maxret, optimize\_method = "ROI",   
## trace = TRUE)  
##   
## Optimal Weights:  
## CA CTAG DS EM   
## 0.02 0.05 0.65 0.28   
##   
## Objective Measures:  
## mean   
## 0.006371   
##   
##   
## Portfolio Assets and Initial Weights:  
## CA CTAG DS EM   
## 0.25 0.25 0.25 0.25   
##   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## PortfolioAnalytics Portfolio Specification   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Call:  
## portfolio.spec(assets = funds)  
##   
## Number of assets: 4   
## Asset Names  
## [1] "CA" "CTAG" "DS" "EM"   
##   
## Constraints  
## Enabled constraint types  
## - full\_investment   
## - box   
##   
## Objectives:  
## Enabled objective names  
## - mean   
##   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## Constraints  
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## Leverage Constraint:  
## min\_sum = 1  
## max\_sum = 1  
## actual\_leverage = 1  
##   
## Box Constraints:  
## min:  
## CA CTAG DS EM   
## 0.02 0.05 0.03 0.02   
## max:  
## CA CTAG DS EM   
## 0.55 0.60 0.65 0.50   
##   
## Position Limit Constraints:  
## Maximum number of non-zero weights, max\_pos:  
## [1] "Unconstrained"  
## Realized number of non-zero weights (i.e. positions):  
## [1] 4  
##   
## Maximum number of long positions, max\_pos\_long:  
## [1] "Unconstrained"  
## Realized number of long positions:  
## [1] 4  
##   
## Maximum number of short positions, max\_pos\_short:  
## [1] "Unconstrained"  
## Realized number of short positions:  
## [1] 0  
##   
##   
## Diversification Target Constraint:  
## [1] "Unconstrained"  
##   
## Realized diversification:  
## [1] 0.4962  
##   
## Turnover Target Constraint:  
## [1] "Unconstrained"  
##   
## Realized turnover from initial weights:  
## [1] 0.215  
##   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## Objectives  
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Objective: return\_objective   
## $name  
## [1] "mean"  
##   
## $target  
## NULL  
##   
## $arguments  
## list()  
##   
## $enabled  
## [1] TRUE  
##   
## $multiplier  
## [1] -1  
##   
## $call  
## add.objective(portfolio = portf\_maxret, type = "return", name = "mean")  
##   
## attr(,"class")  
## [1] "return\_objective" "objective"   
##   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Elapsed Time:  
## Time difference of 0.01152992 secs

names(opt\_maxret)

## [1] "weights" "objective\_measures" "opt\_values"   
## [4] "out" "call" "portfolio"   
## [7] "R" "data\_summary" "elapsed\_time"   
## [10] "end\_t"

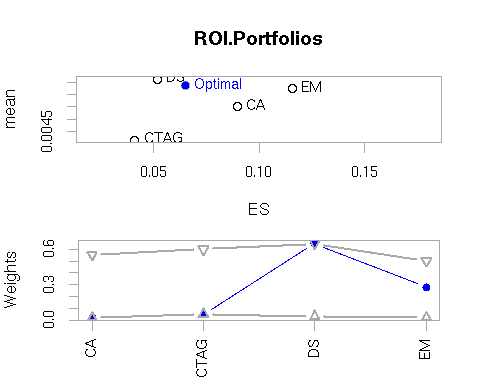
extractStats(opt\_maxret)

## mean out w.CA w.CTAG w.DS w.EM   
## 0.006370927 -0.006370927 0.020000000 0.050000000 0.650000000 0.280000000

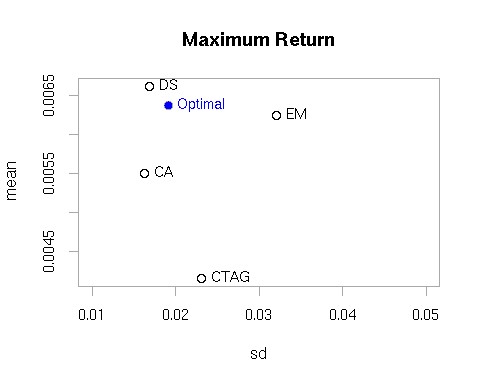
extractWeights(opt\_maxret)

## CA CTAG DS EM   
## 0.02 0.05 0.65 0.28

#The plot method charts of the optimal weights with the box constraints along with the  
#optimal portfolio in risk-return space. The blue dots are the optimal weights and the gray  
#triangles are the min and max of the box constraints.  
library(graphics)  
plot.new()  
plot(opt\_maxret, chart.assets=TRUE, xlim=c(0.02, 0.18))



#The optimal portfolio can be plotted in risk-return space along with other feasible  
#portfolios. The return metric is defined in the return.col argument and the risk metric  
#is defined in the risk.col argument. The scatter chart includes the optimal portfolio (blue  
#dot) and other feasible portfolios (gray circles) to show the overall feasible space given the  
#constraints. By default, if rp is not passed in, the feasible portfolios are generated with  
#random\_portfolios to satisfy the constraints of the portfolio object.  
#Volatility as the risk metric  
library(PerformanceAnalytics)  
library(PortfolioAnalytics)  
  
chart.RiskReward(opt\_maxret,return.col="mean", risk.col="sd",  
 chart.assets=TRUE, xlim=c(0.01, 0.05), main="Maximum Return")



#Backtesting  
#An out of sample backtest is run with optimize.portfolio.rebalancing. In this example, an initial training period of 36 months is used and the portfolio is rebalanced  
#quarterly  
  
  
bt\_maxret <- optimize.portfolio.rebalancing(R=returns, portfolio=portf\_maxret,  
 optimize\_method="ROI",  
 rebalance\_on="quarters",  
 training\_period=36)

## Warning: executing %dopar% sequentially: no parallel backend registered

bt\_maxret

## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## PortfolioAnalytics Optimization with Rebalancing  
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Call:  
## optimize.portfolio.rebalancing(R = returns, portfolio = portf\_maxret,   
## optimize\_method = "ROI", rebalance\_on = "quarters", training\_period = 36)  
##   
## Number of rebalancing dates: 81   
## First rebalance date:  
## [1] "1999-12-31"  
## Last rebalance date:  
## [1] "2019-11-30"  
##   
## Annualized Portfolio Rebalancing Return:  
## [1] 0.06755494  
##   
## Annualized Portfolio Standard Deviation:  
## [1] 0.06116238

summary(bt\_maxret)

## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## PortfolioAnalytics Optimization with Rebalancing  
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Call:  
## optimize.portfolio.rebalancing(R = returns, portfolio = portf\_maxret,   
## optimize\_method = "ROI", rebalance\_on = "quarters", training\_period = 36)  
##   
## First rebalance date:  
## [1] "1999-12-31"  
##   
## Last rebalance date:  
## [1] "2019-11-30"  
##   
## Annualized Portfolio Rebalancing Return:  
## [1] 0.06755494  
##   
## Annualized Portfolio Standard Deviation:  
## [1] 0.06116238  
##   
## Downside Risk Measures:  
## portfolio.returns  
## Semi Deviation 0.0140  
## Gain Deviation 0.0099  
## Loss Deviation 0.0162  
## Downside Deviation (MAR=10%) 0.0152  
## Downside Deviation (Rf=0%) 0.0117  
## Downside Deviation (0%) 0.0117  
## Maximum Drawdown 0.2773  
## Historical VaR (95%) -0.0212  
## Historical ES (95%) -0.0410  
## Modified VaR (95%) -0.0274  
## Modified ES (95%) -0.0622

names(bt\_maxret)

## [1] "portfolio" "R" "call" "elapsed\_time"   
## [5] "opt\_rebalancing"

extractStats(bt\_maxret)

## $`1999-12-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.008867083 -0.008867083 0.550000000 0.050000000 0.380000000 0.020000000   
##   
## $`2000-03-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.0101719 -0.0101719 0.4200000 0.0500000 0.0300000 0.5000000   
##   
## $`2000-06-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009793381 -0.009793381 0.550000000 0.050000000 0.380000000 0.020000000   
##   
## $`2000-09-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009760978 -0.009760978 0.550000000 0.050000000 0.380000000 0.020000000   
##   
## $`2000-12-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.008994188 -0.008994188 0.550000000 0.050000000 0.380000000 0.020000000   
##   
## $`2001-03-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009534784 -0.009534784 0.550000000 0.050000000 0.380000000 0.020000000   
##   
## $`2001-06-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009650593 -0.009650593 0.550000000 0.050000000 0.380000000 0.020000000   
##   
## $`2001-09-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009560351 -0.009560351 0.550000000 0.050000000 0.380000000 0.020000000   
##   
## $`2001-12-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009340433 -0.009340433 0.550000000 0.050000000 0.380000000 0.020000000   
##   
## $`2002-03-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009155889 -0.009155889 0.550000000 0.050000000 0.380000000 0.020000000   
##   
## $`2002-06-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.008973348 -0.008973348 0.550000000 0.050000000 0.380000000 0.020000000   
##   
## $`2002-09-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.008659029 -0.008659029 0.550000000 0.400000000 0.030000000 0.020000000   
##   
## $`2002-12-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.008841972 -0.008841972 0.550000000 0.050000000 0.380000000 0.020000000   
##   
## $`2003-03-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009115213 -0.009115213 0.550000000 0.050000000 0.380000000 0.020000000   
##   
## $`2003-06-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009407872 -0.009407872 0.550000000 0.050000000 0.380000000 0.020000000   
##   
## $`2003-09-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009311679 -0.009311679 0.550000000 0.050000000 0.380000000 0.020000000   
##   
## $`2003-12-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009517286 -0.009517286 0.280000000 0.050000000 0.650000000 0.020000000   
##   
## $`2004-03-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009622241 -0.009622241 0.280000000 0.050000000 0.650000000 0.020000000   
##   
## $`2004-06-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009377911 -0.009377911 0.280000000 0.050000000 0.650000000 0.020000000   
##   
## $`2004-09-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009258581 -0.009258581 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2004-12-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009727927 -0.009727927 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2005-03-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009620899 -0.009620899 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2005-06-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009443667 -0.009443667 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2005-09-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009658295 -0.009658295 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2005-12-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009598398 -0.009598398 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2006-03-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009873559 -0.009873559 0.020000000 0.050000000 0.430000000 0.500000000   
##   
## $`2006-06-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009719614 -0.009719614 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2006-09-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009592889 -0.009592889 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2006-12-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.0098964 -0.0098964 0.0200000 0.0500000 0.4300000 0.5000000   
##   
## $`2007-03-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009941878 -0.009941878 0.020000000 0.050000000 0.430000000 0.500000000   
##   
## $`2007-06-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.01016387 -0.01016387 0.02000000 0.05000000 0.43000000 0.50000000   
##   
## $`2007-09-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.01006947 -0.01006947 0.02000000 0.05000000 0.43000000 0.50000000   
##   
## $`2007-12-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.01000037 -0.01000037 0.02000000 0.05000000 0.43000000 0.50000000   
##   
## $`2008-03-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009469563 -0.009469563 0.020000000 0.050000000 0.430000000 0.500000000   
##   
## $`2008-06-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.009369254 -0.009369254 0.020000000 0.050000000 0.430000000 0.500000000   
##   
## $`2008-09-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.008316411 -0.008316411 0.020000000 0.050000000 0.430000000 0.500000000   
##   
## $`2008-12-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.007159569 -0.007159569 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2009-03-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.007029884 -0.007029884 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2009-06-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.00772368 -0.00772368 0.02000000 0.05000000 0.43000000 0.50000000   
##   
## $`2009-09-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.008243464 -0.008243464 0.020000000 0.050000000 0.430000000 0.500000000   
##   
## $`2009-12-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.008427776 -0.008427776 0.020000000 0.050000000 0.430000000 0.500000000   
##   
## $`2010-03-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.008527208 -0.008527208 0.020000000 0.050000000 0.430000000 0.500000000   
##   
## $`2010-06-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.008234006 -0.008234006 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2010-09-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.008399364 -0.008399364 0.020000000 0.050000000 0.430000000 0.500000000   
##   
## $`2010-12-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.008539762 -0.008539762 0.020000000 0.050000000 0.430000000 0.500000000   
##   
## $`2011-03-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.008526725 -0.008526725 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2011-06-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.008365897 -0.008365897 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2011-09-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.007776785 -0.007776785 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2011-12-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.007691361 -0.007691361 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2012-03-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.00788053 -0.00788053 0.02000000 0.05000000 0.65000000 0.28000000   
##   
## $`2012-06-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.007600333 -0.007600333 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2012-09-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.007693063 -0.007693063 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2012-12-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.007794495 -0.007794495 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2013-03-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.007873144 -0.007873144 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2013-06-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.007810646 -0.007810646 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2013-09-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.007802289 -0.007802289 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2013-12-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.007875696 -0.007875696 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2014-03-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.007871391 -0.007871391 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2014-06-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.00789241 -0.00789241 0.02000000 0.05000000 0.65000000 0.28000000   
##   
## $`2014-09-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.007701629 -0.007701629 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2014-12-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.007478778 -0.007478778 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2015-03-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.007426973 -0.007426973 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2015-06-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.007323072 -0.007323072 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2015-09-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.007017498 -0.007017498 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2015-12-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.006870886 -0.006870886 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2016-03-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.006736377 -0.006736377 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2016-06-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.00680644 -0.00680644 0.02000000 0.05000000 0.65000000 0.28000000   
##   
## $`2016-09-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.006913844 -0.006913844 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2016-12-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.006956275 -0.006956275 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2017-03-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.006978091 -0.006978091 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2017-06-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.006918744 -0.006918744 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2017-09-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.006935631 -0.006935631 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2017-12-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.006950647 -0.006950647 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2018-03-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.006899435 -0.006899435 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2018-06-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.006824446 -0.006824446 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2018-09-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.006746529 -0.006746529 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2018-12-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.006481466 -0.006481466 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2019-03-31`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.006560869 -0.006560869 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2019-06-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.006542107 -0.006542107 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2019-09-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.006417593 -0.006417593 0.020000000 0.050000000 0.650000000 0.280000000   
##   
## $`2019-11-30`  
## mean out w.CA w.CTAG w.DS w.EM   
## 0.006370927 -0.006370927 0.020000000 0.050000000 0.650000000 0.280000000

extractWeights(bt\_maxret)

## CA CTAG DS EM  
## 1999-12-31 0.55 0.05 0.38 0.02  
## 2000-03-31 0.42 0.05 0.03 0.50  
## 2000-06-30 0.55 0.05 0.38 0.02  
## 2000-09-30 0.55 0.05 0.38 0.02  
## 2000-12-31 0.55 0.05 0.38 0.02  
## 2001-03-31 0.55 0.05 0.38 0.02  
## 2001-06-30 0.55 0.05 0.38 0.02  
## 2001-09-30 0.55 0.05 0.38 0.02  
## 2001-12-31 0.55 0.05 0.38 0.02  
## 2002-03-31 0.55 0.05 0.38 0.02  
## 2002-06-30 0.55 0.05 0.38 0.02  
## 2002-09-30 0.55 0.40 0.03 0.02  
## 2002-12-31 0.55 0.05 0.38 0.02  
## 2003-03-31 0.55 0.05 0.38 0.02  
## 2003-06-30 0.55 0.05 0.38 0.02  
## 2003-09-30 0.55 0.05 0.38 0.02  
## 2003-12-31 0.28 0.05 0.65 0.02  
## 2004-03-31 0.28 0.05 0.65 0.02  
## 2004-06-30 0.28 0.05 0.65 0.02  
## 2004-09-30 0.02 0.05 0.65 0.28  
## 2004-12-31 0.02 0.05 0.65 0.28  
## 2005-03-31 0.02 0.05 0.65 0.28  
## 2005-06-30 0.02 0.05 0.65 0.28  
## 2005-09-30 0.02 0.05 0.65 0.28  
## 2005-12-31 0.02 0.05 0.65 0.28  
## 2006-03-31 0.02 0.05 0.43 0.50  
## 2006-06-30 0.02 0.05 0.65 0.28  
## 2006-09-30 0.02 0.05 0.65 0.28  
## 2006-12-31 0.02 0.05 0.43 0.50  
## 2007-03-31 0.02 0.05 0.43 0.50  
## 2007-06-30 0.02 0.05 0.43 0.50  
## 2007-09-30 0.02 0.05 0.43 0.50  
## 2007-12-31 0.02 0.05 0.43 0.50  
## 2008-03-31 0.02 0.05 0.43 0.50  
## 2008-06-30 0.02 0.05 0.43 0.50  
## 2008-09-30 0.02 0.05 0.43 0.50  
## 2008-12-31 0.02 0.05 0.65 0.28  
## 2009-03-31 0.02 0.05 0.65 0.28  
## 2009-06-30 0.02 0.05 0.43 0.50  
## 2009-09-30 0.02 0.05 0.43 0.50  
## 2009-12-31 0.02 0.05 0.43 0.50  
## 2010-03-31 0.02 0.05 0.43 0.50  
## 2010-06-30 0.02 0.05 0.65 0.28  
## 2010-09-30 0.02 0.05 0.43 0.50  
## 2010-12-31 0.02 0.05 0.43 0.50  
## 2011-03-31 0.02 0.05 0.65 0.28  
## 2011-06-30 0.02 0.05 0.65 0.28  
## 2011-09-30 0.02 0.05 0.65 0.28  
## 2011-12-31 0.02 0.05 0.65 0.28  
## 2012-03-31 0.02 0.05 0.65 0.28  
## 2012-06-30 0.02 0.05 0.65 0.28  
## 2012-09-30 0.02 0.05 0.65 0.28  
## 2012-12-31 0.02 0.05 0.65 0.28  
## 2013-03-31 0.02 0.05 0.65 0.28  
## 2013-06-30 0.02 0.05 0.65 0.28  
## 2013-09-30 0.02 0.05 0.65 0.28  
## 2013-12-31 0.02 0.05 0.65 0.28  
## 2014-03-31 0.02 0.05 0.65 0.28  
## 2014-06-30 0.02 0.05 0.65 0.28  
## 2014-09-30 0.02 0.05 0.65 0.28  
## 2014-12-31 0.02 0.05 0.65 0.28  
## 2015-03-31 0.02 0.05 0.65 0.28  
## 2015-06-30 0.02 0.05 0.65 0.28  
## 2015-09-30 0.02 0.05 0.65 0.28  
## 2015-12-31 0.02 0.05 0.65 0.28  
## 2016-03-31 0.02 0.05 0.65 0.28  
## 2016-06-30 0.02 0.05 0.65 0.28  
## 2016-09-30 0.02 0.05 0.65 0.28  
## 2016-12-31 0.02 0.05 0.65 0.28  
## 2017-03-31 0.02 0.05 0.65 0.28  
## 2017-06-30 0.02 0.05 0.65 0.28  
## 2017-09-30 0.02 0.05 0.65 0.28  
## 2017-12-31 0.02 0.05 0.65 0.28  
## 2018-03-31 0.02 0.05 0.65 0.28  
## 2018-06-30 0.02 0.05 0.65 0.28  
## 2018-09-30 0.02 0.05 0.65 0.28  
## 2018-12-31 0.02 0.05 0.65 0.28  
## 2019-03-31 0.02 0.05 0.65 0.28  
## 2019-06-30 0.02 0.05 0.65 0.28  
## 2019-09-30 0.02 0.05 0.65 0.28  
## 2019-11-30 0.02 0.05 0.65 0.28

#Maximizing Mean Return  
#The objective to maximize mean return is a linear problem of the form:  
  
#maximize wµˆ(l)  
#w  
  
#Where µˆ is the estimated mean asset returns and w is the set of weights. Because this  
#is a linear problem, it is well suited to be solved using a linear programming solver. For  
#these types of problems, PortfolioAnalytics uses the ROI package with the glpk plugin  
  
  
#Minimizing Portfolio Variance  
#The objective to minimize portfolio variance is a quadratic problem of the form:  
  
#minimize w^(0) \*Σw  
#w  
  
#Where Σ is the estimated covariance matrix of asset returns and w is the set of weights.  
#Because this is a quadratic problem, it is well suited to be solved using a quadratic programming solver. For these #types of problems, PortfolioAnalytics uses the ROI package  
#with the quadprog plugin  
  
  
  
# Create portfolio object  
portf\_minvar <- portfolio.spec(assets=funds)  
  
# Add full investment constraint to the portfolio object  
portf\_minvar <- add.constraint(portfolio=portf\_minvar, type="full\_investment")  
  
# Add objective to minimize variance  
#The only constraint specified is the full investment constraint, therefore the #optimization problem is solving for the global minimum variance portfolio.  
  
  
portf\_minvar <- add.objective(portfolio=portf\_minvar, type="risk", name="var")  
  
 # Run the optimization  
  
opt\_gmv <- optimize.portfolio(R=returns, portfolio=portf\_minvar,  
 optimize\_method="ROI", trace=TRUE)  
  
opt\_gmv

## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## PortfolioAnalytics Optimization  
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Call:  
## optimize.portfolio(R = returns, portfolio = portf\_minvar, optimize\_method = "ROI",   
## trace = TRUE)  
##   
## Optimal Weights:  
## CA CTAG DS EM   
## 0.3637 0.2887 0.5581 -0.2105   
##   
## Objective Measure:  
## StdDev   
## 0.01187

summary(opt\_gmv)

## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## PortfolioAnalytics Optimization Summary   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Call:  
## optimize.portfolio(R = returns, portfolio = portf\_minvar, optimize\_method = "ROI",   
## trace = TRUE)  
##   
## Optimal Weights:  
## CA CTAG DS EM   
## 0.3637 0.2887 0.5581 -0.2105   
##   
## Objective Measures:  
## StdDev   
## 0.01187   
##   
##   
## Portfolio Assets and Initial Weights:  
## CA CTAG DS EM   
## 0.25 0.25 0.25 0.25   
##   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## PortfolioAnalytics Portfolio Specification   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Call:  
## portfolio.spec(assets = funds)  
##   
## Number of assets: 4   
## Asset Names  
## [1] "CA" "CTAG" "DS" "EM"   
##   
## Constraints  
## Enabled constraint types  
## - full\_investment   
##   
## Objectives:  
## Enabled objective names  
## - var   
##   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## Constraints  
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## Leverage Constraint:  
## min\_sum = 1  
## max\_sum = 1  
## actual\_leverage = 1  
##   
## Box Constraints:  
## min:  
## [1] -Inf -Inf -Inf -Inf  
## max:  
## [1] Inf Inf Inf Inf  
##   
## Position Limit Constraints:  
## Maximum number of non-zero weights, max\_pos:  
## [1] "Unconstrained"  
## Realized number of non-zero weights (i.e. positions):  
## [1] 4  
##   
## Maximum number of long positions, max\_pos\_long:  
## [1] "Unconstrained"  
## Realized number of long positions:  
## [1] 3  
##   
## Maximum number of short positions, max\_pos\_short:  
## [1] "Unconstrained"  
## Realized number of short positions:  
## [1] 1  
##   
##   
## Diversification Target Constraint:  
## [1] "Unconstrained"  
##   
## Realized diversification:  
## [1] 0.4285863  
##   
## Turnover Target Constraint:  
## [1] "Unconstrained"  
##   
## Realized turnover from initial weights:  
## [1] 0.2302493  
##   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## Objectives  
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Objective: portfolio\_risk\_objective   
## $name  
## [1] "var"  
##   
## $target  
## NULL  
##   
## $arguments  
## $arguments$portfolio\_method  
## [1] "single"  
##   
##   
## $enabled  
## [1] TRUE  
##   
## $multiplier  
## [1] 1  
##   
## $call  
## add.objective(portfolio = portf\_minvar, type = "risk", name = "var")  
##   
## attr(,"class")  
## [1] "portfolio\_risk\_objective" "objective"   
##   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Elapsed Time:  
## Time difference of 0.01120782 secs

names(opt\_gmv)

## [1] "weights" "objective\_measures" "opt\_values"   
## [4] "out" "call" "portfolio"   
## [7] "R" "data\_summary" "elapsed\_time"   
## [10] "end\_t"

extractStats(opt\_gmv)

## StdDev out w.CA w.CTAG w.DS   
## 0.0118713641 0.0001409293 0.3637452496 0.2886587657 0.5580945505   
## w.EM   
## -0.2104985658

extractWeights(opt\_gmv)

## CA CTAG DS EM   
## 0.3637452 0.2886588 0.5580946 -0.2104986

#Constrained Minimum Variance Portfolio  
  
  
# Add long only constraints  
portf\_minvar <- add.constraint(portfolio=portf\_minvar, type="box",  
 min=0, max=1)  
  
 # Add group constraints  
portf\_minvar <- add.constraint(portfolio=portf\_minvar,  
 type="group",  
 groups=list(groupA=1,  
 groupB=c(2, 3),  
 groupC=4),  
 group\_min=c(0, 0.25, 0.10),  
 group\_max=c(0.45, 0.6, 0.5))  
  
  
  
# Run the optimization  
opt\_minvar <- optimize.portfolio(R=returns, portfolio=portf\_minvar,  
 optimize\_method="ROI", trace=TRUE)  
  
opt\_minvar

## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## PortfolioAnalytics Optimization  
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Call:  
## optimize.portfolio(R = returns, portfolio = portf\_minvar, optimize\_method = "ROI",   
## trace = TRUE)  
##   
## Optimal Weights:  
## CA CTAG DS EM   
## 0.4008 0.3217 0.1774 0.1000   
##   
## Objective Measure:  
## StdDev   
## 0.0136

summary(opt\_minvar)

## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## PortfolioAnalytics Optimization Summary   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Call:  
## optimize.portfolio(R = returns, portfolio = portf\_minvar, optimize\_method = "ROI",   
## trace = TRUE)  
##   
## Optimal Weights:  
## CA CTAG DS EM   
## 0.4008 0.3217 0.1774 0.1000   
##   
## Objective Measures:  
## StdDev   
## 0.0136   
##   
##   
## Portfolio Assets and Initial Weights:  
## CA CTAG DS EM   
## 0.25 0.25 0.25 0.25   
##   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## PortfolioAnalytics Portfolio Specification   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Call:  
## portfolio.spec(assets = funds)  
##   
## Number of assets: 4   
## Asset Names  
## [1] "CA" "CTAG" "DS" "EM"   
##   
## Constraints  
## Enabled constraint types  
## - full\_investment   
## - box (long only)   
## - group   
##   
## Objectives:  
## Enabled objective names  
## - var   
##   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## Constraints  
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## Leverage Constraint:  
## min\_sum = 1  
## max\_sum = 1  
## actual\_leverage = 1  
##   
## Box Constraints:  
## min:  
## CA CTAG DS EM   
## 0 0 0 0   
## max:  
## CA CTAG DS EM   
## 1 1 1 1   
##   
## Group Constraints:  
## Groups:  
## $groupA  
## [1] "CA"  
##   
## $groupB  
## [1] "CTAG" "DS"   
##   
## $groupC  
## [1] "EM"  
##   
##   
## Lower bound on group weights, group\_min:  
## [1] 0.00 0.25 0.10  
##   
## Upper bound on group weights, group\_max:  
## [1] 0.45 0.60 0.50  
##   
## Group Weights:  
## groupA groupB groupC   
## 0.4008296 0.4991704 0.1000000   
##   
## Position Limit Constraints:  
## Maximum number of non-zero weights, max\_pos:  
## [1] "Unconstrained"  
## Realized number of non-zero weights (i.e. positions):  
## [1] 4  
##   
## Maximum number of long positions, max\_pos\_long:  
## [1] "Unconstrained"  
## Realized number of long positions:  
## [1] 4  
##   
## Maximum number of short positions, max\_pos\_short:  
## [1] "Unconstrained"  
## Realized number of short positions:  
## [1] 0  
##   
##   
## Diversification Target Constraint:  
## [1] "Unconstrained"  
##   
## Realized diversification:  
## [1] 0.6943398  
##   
## Turnover Target Constraint:  
## [1] "Unconstrained"  
##   
## Realized turnover from initial weights:  
## [1] 0.1112807  
##   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## Objectives  
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Objective: portfolio\_risk\_objective   
## $name  
## [1] "var"  
##   
## $target  
## NULL  
##   
## $arguments  
## $arguments$portfolio\_method  
## [1] "single"  
##   
##   
## $enabled  
## [1] TRUE  
##   
## $multiplier  
## [1] 1  
##   
## $call  
## add.objective(portfolio = portf\_minvar, type = "risk", name = "var")  
##   
## attr(,"class")  
## [1] "portfolio\_risk\_objective" "objective"   
##   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Elapsed Time:  
## Time difference of 0.008224726 secs

names(opt\_minvar)

## [1] "weights" "objective\_measures" "opt\_values"   
## [4] "out" "call" "portfolio"   
## [7] "R" "data\_summary" "elapsed\_time"   
## [10] "end\_t"

extractStats(opt\_minvar)

## StdDev out w.CA w.CTAG w.DS w.EM   
## 0.0136033595 0.0001850514 0.4008295616 0.3217317910 0.1774386474 0.1000000000

extractWeights(opt\_minvar)

## CA CTAG DS EM   
## 0.4008296 0.3217318 0.1774386 0.1000000

# Backtesting  
  
bt\_gmv <- optimize.portfolio.rebalancing(R=returns, portfolio=portf\_minvar,  
 optimize\_method="ROI",  
 rebalance\_on="quarters",  
 training\_period=36)  
  
bt\_gmv

## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## PortfolioAnalytics Optimization with Rebalancing  
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Call:  
## optimize.portfolio.rebalancing(R = returns, portfolio = portf\_minvar,   
## optimize\_method = "ROI", rebalance\_on = "quarters", training\_period = 36)  
##   
## Number of rebalancing dates: 81   
## First rebalance date:  
## [1] "1999-12-31"  
## Last rebalance date:  
## [1] "2019-11-30"  
##   
## Annualized Portfolio Rebalancing Return:  
## [1] 0.05608581  
##   
## Annualized Portfolio Standard Deviation:  
## [1] 0.04840955

summary(bt\_gmv)

## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## PortfolioAnalytics Optimization with Rebalancing  
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Call:  
## optimize.portfolio.rebalancing(R = returns, portfolio = portf\_minvar,   
## optimize\_method = "ROI", rebalance\_on = "quarters", training\_period = 36)  
##   
## First rebalance date:  
## [1] "1999-12-31"  
##   
## Last rebalance date:  
## [1] "2019-11-30"  
##   
## Annualized Portfolio Rebalancing Return:  
## [1] 0.05608581  
##   
## Annualized Portfolio Standard Deviation:  
## [1] 0.04840955  
##   
## Downside Risk Measures:  
## portfolio.returns  
## Semi Deviation 0.0108  
## Gain Deviation 0.0082  
## Loss Deviation 0.0123  
## Downside Deviation (MAR=10%) 0.0127  
## Downside Deviation (Rf=0%) 0.0089  
## Downside Deviation (0%) 0.0089  
## Maximum Drawdown 0.1899  
## Historical VaR (95%) -0.0182  
## Historical ES (95%) -0.0302  
## Modified VaR (95%) -0.0213  
## Modified ES (95%) -0.0496

names(bt\_gmv)

## [1] "portfolio" "R" "call" "elapsed\_time"   
## [5] "opt\_rebalancing"

tail(extractStats(bt\_gmv))

## $`2018-09-30`  
## StdDev out w.CA w.CTAG w.DS w.EM   
## 0.0137260884 0.0001884055 0.3836741205 0.3252923385 0.1910335409 0.1000000000   
##   
## $`2018-12-31`  
## StdDev out w.CA w.CTAG w.DS w.EM   
## 0.0137812383 0.0001899225 0.3987372221 0.3252963000 0.1759664779 0.1000000000   
##   
## $`2019-03-31`  
## StdDev out w.CA w.CTAG w.DS w.EM   
## 0.013727601 0.000188447 0.394917980 0.325538799 0.179543221 0.100000000   
##   
## $`2019-06-30`  
## StdDev out w.CA w.CTAG w.DS w.EM   
## 0.0136936813 0.0001875169 0.3957064089 0.3242861094 0.1800074817 0.1000000000   
##   
## $`2019-09-30`  
## StdDev out w.CA w.CTAG w.DS w.EM   
## 0.0136413590 0.0001860867 0.3981167198 0.3224871099 0.1793961703 0.1000000000   
##   
## $`2019-11-30`  
## StdDev out w.CA w.CTAG w.DS w.EM   
## 0.0136033595 0.0001850514 0.4008295616 0.3217317910 0.1774386474 0.1000000000

tail(extractWeights(bt\_gmv))

## CA CTAG DS EM  
## 2018-09-30 0.3836741 0.3252923 0.1910335 0.1  
## 2018-12-31 0.3987372 0.3252963 0.1759665 0.1  
## 2019-03-31 0.3949180 0.3255388 0.1795432 0.1  
## 2019-06-30 0.3957064 0.3242861 0.1800075 0.1  
## 2019-09-30 0.3981167 0.3224871 0.1793962 0.1  
## 2019-11-30 0.4008296 0.3217318 0.1774386 0.1

chart.Weights(opt\_minvar)

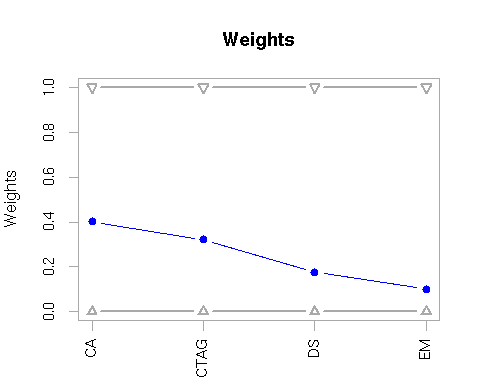
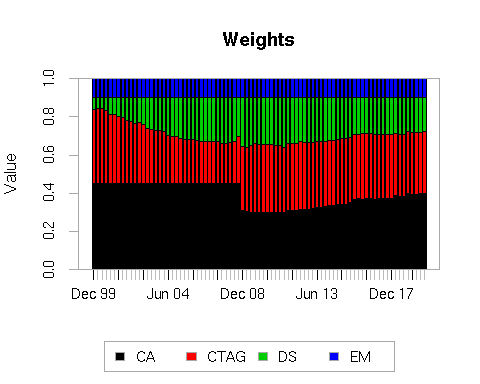


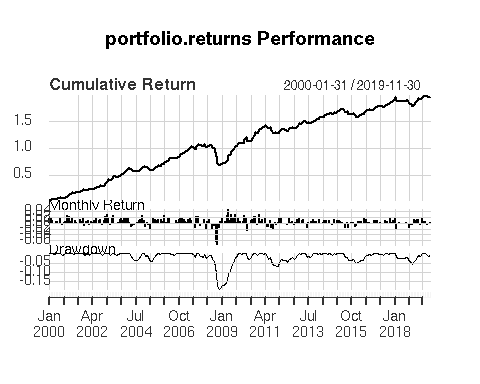
chart.Weights(bt\_gmv)



extractObjectiveMeasures(bt\_gmv)

## StdDev  
## 1999-12-31 0.01237827  
## 2000-03-31 0.01206091  
## 2000-06-30 0.01182820  
## 2000-09-30 0.01182062  
## 2000-12-31 0.01177995  
## 2001-03-31 0.01178284  
## 2001-06-30 0.01161512  
## 2001-09-30 0.01136747  
## 2001-12-31 0.01142580  
## 2002-03-31 0.01132767  
## 2002-06-30 0.01113168  
## 2002-09-30 0.01093345  
## 2002-12-31 0.01103885  
## 2003-03-31 0.01132628  
## 2003-06-30 0.01144957  
## 2003-09-30 0.01136533  
## 2003-12-31 0.01126266  
## 2004-03-31 0.01118000  
## 2004-06-30 0.01160160  
## 2004-09-30 0.01148188  
## 2004-12-31 0.01143848  
## 2005-03-31 0.01158838  
## 2005-06-30 0.01190338  
## 2005-09-30 0.01176193  
## 2005-12-31 0.01168768  
## 2006-03-31 0.01168751  
## 2006-06-30 0.01167024  
## 2006-09-30 0.01155538  
## 2006-12-31 0.01146036  
## 2007-03-31 0.01133322  
## 2007-06-30 0.01123049  
## 2007-09-30 0.01146900  
## 2007-12-31 0.01157293  
## 2008-03-31 0.01179729  
## 2008-06-30 0.01169594  
## 2008-09-30 0.01349727  
## 2008-12-31 0.01488515  
## 2009-03-31 0.01476215  
## 2009-06-30 0.01506476  
## 2009-09-30 0.01519816  
## 2009-12-31 0.01509369  
## 2010-03-31 0.01508059  
## 2010-06-30 0.01521782  
## 2010-09-30 0.01515158  
## 2010-12-31 0.01521594  
## 2011-03-31 0.01510879  
## 2011-06-30 0.01517437  
## 2011-09-30 0.01535731  
## 2011-12-31 0.01527571  
## 2012-03-31 0.01522972  
## 2012-06-30 0.01516837  
## 2012-09-30 0.01506692  
## 2012-12-31 0.01499358  
## 2013-03-31 0.01492127  
## 2013-06-30 0.01492090  
## 2013-09-30 0.01483380  
## 2013-12-31 0.01473384  
## 2014-03-31 0.01465801  
## 2014-06-30 0.01455811  
## 2014-09-30 0.01448512  
## 2014-12-31 0.01443381  
## 2015-03-31 0.01433813  
## 2015-06-30 0.01435485  
## 2015-09-30 0.01435663  
## 2015-12-31 0.01432939  
## 2016-03-31 0.01427183  
## 2016-06-30 0.01420150  
## 2016-09-30 0.01412442  
## 2016-12-31 0.01405362  
## 2017-03-31 0.01398880  
## 2017-06-30 0.01392534  
## 2017-09-30 0.01385365  
## 2017-12-31 0.01379087  
## 2018-03-31 0.01386201  
## 2018-06-30 0.01379728  
## 2018-09-30 0.01372609  
## 2018-12-31 0.01378124  
## 2019-03-31 0.01372760  
## 2019-06-30 0.01369368  
## 2019-09-30 0.01364136  
## 2019-11-30 0.01360336

rr <- Return.portfolio(returns, weights = extractWeights(bt\_gmv))   
charts.PerformanceSummary(rr)



#Constrained Minimum Variance Portfolio  
  
# Add long only constraints  
portf\_minvar <- add.constraint(portfolio=portf\_minvar, type="box",  
 min=0, max=1)  
 # Add group constraints  
 portf\_minvar <- add.constraint(portfolio=portf\_minvar,  
 type="group",  
 groups=list(groupA=1,  
 groupB=c(2, 3),  
 groupC=4),  
 group\_min=c(0, 0.25, 0.10),  
 group\_max=c(0.45, 0.6, 0.5))  
  
# Run the optimization  
 opt\_minvar <- optimize.portfolio(R=returns, portfolio=portf\_minvar,  
 optimize\_method="ROI", trace=TRUE)  
   
   
# Backtesting  
 bt\_minvar <- optimize.portfolio.rebalancing(R=returns, portfolio=portf\_minvar,  
 optimize\_method="ROI",  
 rebalance\_on="quarters",  
 training\_period=36)  
   
 opt\_minvar

## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## PortfolioAnalytics Optimization  
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Call:  
## optimize.portfolio(R = returns, portfolio = portf\_minvar, optimize\_method = "ROI",   
## trace = TRUE)  
##   
## Optimal Weights:  
## CA CTAG DS EM   
## 0.4008 0.3217 0.1774 0.1000   
##   
## Objective Measure:  
## StdDev   
## 0.0136

summary(opt\_minvar)

## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## PortfolioAnalytics Optimization Summary   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Call:  
## optimize.portfolio(R = returns, portfolio = portf\_minvar, optimize\_method = "ROI",   
## trace = TRUE)  
##   
## Optimal Weights:  
## CA CTAG DS EM   
## 0.4008 0.3217 0.1774 0.1000   
##   
## Objective Measures:  
## StdDev   
## 0.0136   
##   
##   
## Portfolio Assets and Initial Weights:  
## CA CTAG DS EM   
## 0.25 0.25 0.25 0.25   
##   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## PortfolioAnalytics Portfolio Specification   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Call:  
## portfolio.spec(assets = funds)  
##   
## Number of assets: 4   
## Asset Names  
## [1] "CA" "CTAG" "DS" "EM"   
##   
## Constraints  
## Enabled constraint types  
## - full\_investment   
## - box (long only)   
## - group   
## - box (long only)   
## - group   
##   
## Objectives:  
## Enabled objective names  
## - var   
##   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## Constraints  
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## Leverage Constraint:  
## min\_sum = 1  
## max\_sum = 1  
## actual\_leverage = 1  
##   
## Box Constraints:  
## min:  
## CA CTAG DS EM   
## 0 0 0 0   
## max:  
## CA CTAG DS EM   
## 1 1 1 1   
##   
## Group Constraints:  
## Groups:  
## $groupA  
## [1] "CA"  
##   
## $groupB  
## [1] "CTAG" "DS"   
##   
## $groupC  
## [1] "EM"  
##   
##   
## Lower bound on group weights, group\_min:  
## [1] 0.00 0.25 0.10  
##   
## Upper bound on group weights, group\_max:  
## [1] 0.45 0.60 0.50  
##   
## Group Weights:  
## groupA groupB groupC   
## 0.4008296 0.4991704 0.1000000   
##   
## Position Limit Constraints:  
## Maximum number of non-zero weights, max\_pos:  
## [1] "Unconstrained"  
## Realized number of non-zero weights (i.e. positions):  
## [1] 4  
##   
## Maximum number of long positions, max\_pos\_long:  
## [1] "Unconstrained"  
## Realized number of long positions:  
## [1] 4  
##   
## Maximum number of short positions, max\_pos\_short:  
## [1] "Unconstrained"  
## Realized number of short positions:  
## [1] 0  
##   
##   
## Diversification Target Constraint:  
## [1] "Unconstrained"  
##   
## Realized diversification:  
## [1] 0.6943398  
##   
## Turnover Target Constraint:  
## [1] "Unconstrained"  
##   
## Realized turnover from initial weights:  
## [1] 0.1112807  
##   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## Objectives  
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Objective: portfolio\_risk\_objective   
## $name  
## [1] "var"  
##   
## $target  
## NULL  
##   
## $arguments  
## $arguments$portfolio\_method  
## [1] "single"  
##   
##   
## $enabled  
## [1] TRUE  
##   
## $multiplier  
## [1] 1  
##   
## $call  
## add.objective(portfolio = portf\_minvar, type = "risk", name = "var")  
##   
## attr(,"class")  
## [1] "portfolio\_risk\_objective" "objective"   
##   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Elapsed Time:  
## Time difference of 0.009123564 secs

names(opt\_minvar)

## [1] "weights" "objective\_measures" "opt\_values"   
## [4] "out" "call" "portfolio"   
## [7] "R" "data\_summary" "elapsed\_time"   
## [10] "end\_t"

extractStats(opt\_minvar)

## StdDev out w.CA w.CTAG w.DS w.EM   
## 0.0136033595 0.0001850514 0.4008295616 0.3217317910 0.1774386474 0.1000000000

extractWeights(opt\_minvar)

## CA CTAG DS EM   
## 0.4008296 0.3217318 0.1774386 0.1000000

extractWeights(opt\_minvar)

## CA CTAG DS EM   
## 0.4008296 0.3217318 0.1774386 0.1000000

chart.Weights(opt\_minvar)

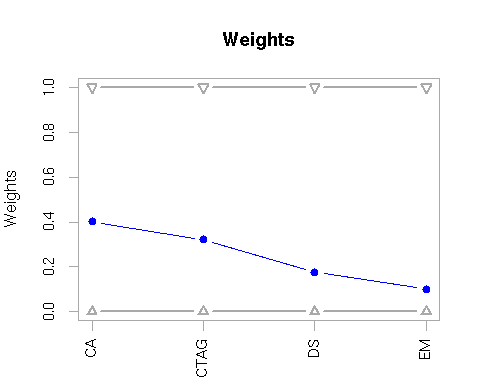
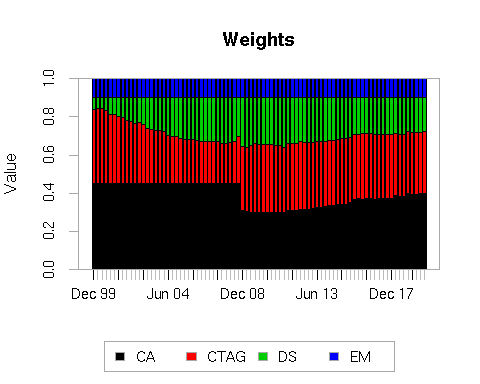


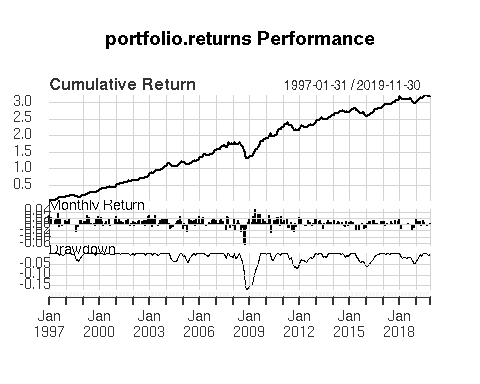
chart.Weights(bt\_minvar)



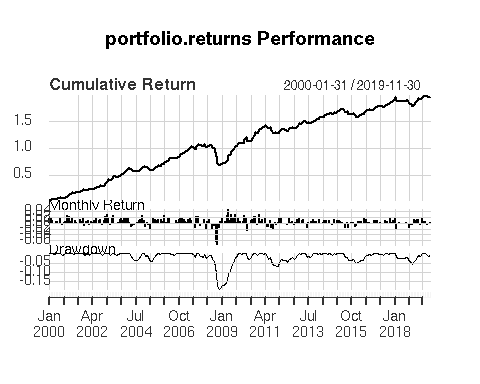
extractObjectiveMeasures(opt\_minvar)

## $StdDev  
## StdDev   
## 0.01360336

rr <- Return.portfolio(returns, weights = extractWeights(opt\_minvar))   
charts.PerformanceSummary(rr)



rr <- Return.portfolio(returns, weights = extractWeights(bt\_minvar))   
charts.PerformanceSummary(rr)



# Maximizing Quadratic Utility  
  
  
# The objective to maximize quadratic utility is a quadratic problem of the form:  
#maximize w^(0)\*µ − λ/2 \* w^(0) \*Σw  
#w  
  
#Where µ is the estimated mean asset returns, λ is the risk aversion parameter, Σ is  
#the estimated covariance matrix of asset returns and w is the set of weights. Quadratic  
#utility maximizes return while penalizing variance. The λ risk aversion parameter controls  
#how much portfolio variance is penalized. Because this is a quadratic problem, it is well  
#suited to be solved using a quadratic programming solver. For these types of problems,  
#PortfolioAnalytics uses the ROI package with the quadprog plugin   
  
  
  
 #Portfolio Object  
# Create initial portfolio object  
init\_portf <- portfolio.spec(assets=funds)  
  
# Create full investment constraint  
  
fi\_constr <- weight\_sum\_constraint(type="full\_investment")  
  
 # Create long only constraint  
  
lo\_constr <- box\_constraint(type="long\_only", assets=init\_portf$assets)  
  
# Combine the constraints in a list  
qu\_constr <- list(fi\_constr, lo\_constr)  
  
  
# Create return objective  
ret\_obj <- return\_objective(name="mean")  
  
  
# Create variance objective specifying a risk\_aversion parameter which controls  
#how much the variance is penalized  
var\_obj <- portfolio\_risk\_objective(name="var", risk\_aversion=0.25)  
  
 # Combine the objectives into a list  
  
qu\_obj <- list(ret\_obj, var\_obj)  
  
# Run the optimization  
opt\_qu <- optimize.portfolio(R=returns, portfolio=init\_portf,  
 constraints=qu\_constr,  
 objectives=qu\_obj,  
 optimize\_method="ROI",  
 trace=TRUE)  
  
 opt\_qu

## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## PortfolioAnalytics Optimization  
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Call:  
## optimize.portfolio(R = returns, portfolio = init\_portf, constraints = qu\_constr,   
## objectives = qu\_obj, optimize\_method = "ROI", trace = TRUE)  
##   
## Optimal Weights:  
## CA CTAG DS EM   
## 0 0 1 0   
##   
## Objective Measure:  
## mean   
## 0.006622   
##   
##   
## StdDev   
## 0.01689

summary(opt\_qu)

## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## PortfolioAnalytics Optimization Summary   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Call:  
## optimize.portfolio(R = returns, portfolio = init\_portf, constraints = qu\_constr,   
## objectives = qu\_obj, optimize\_method = "ROI", trace = TRUE)  
##   
## Optimal Weights:  
## CA CTAG DS EM   
## 0 0 1 0   
##   
## Objective Measures:  
## mean   
## 0.006622   
##   
##   
## StdDev   
## 0.01689   
##   
##   
## Portfolio Assets and Initial Weights:  
## CA CTAG DS EM   
## 0.25 0.25 0.25 0.25   
##   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## PortfolioAnalytics Portfolio Specification   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Call:  
## portfolio.spec(assets = funds)  
##   
## Number of assets: 4   
## Asset Names  
## [1] "CA" "CTAG" "DS" "EM"   
##   
## Constraints  
## Enabled constraint types  
## - full\_investment   
## - long\_only   
##   
## Objectives:  
## Enabled objective names  
## - mean   
## - var   
##   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## Constraints  
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## Leverage Constraint:  
## min\_sum = 1  
## max\_sum = 1  
## actual\_leverage = 1  
##   
## Box Constraints:  
## min:  
## CA CTAG DS EM   
## 0 0 0 0   
## max:  
## CA CTAG DS EM   
## 1 1 1 1   
##   
## Position Limit Constraints:  
## Maximum number of non-zero weights, max\_pos:  
## [1] "Unconstrained"  
## Realized number of non-zero weights (i.e. positions):  
## [1] 1  
##   
## Maximum number of long positions, max\_pos\_long:  
## [1] "Unconstrained"  
## Realized number of long positions:  
## [1] 1  
##   
## Maximum number of short positions, max\_pos\_short:  
## [1] "Unconstrained"  
## Realized number of short positions:  
## [1] 0  
##   
##   
## Diversification Target Constraint:  
## [1] "Unconstrained"  
##   
## Realized diversification:  
## [1] 1.110223e-15  
##   
## Turnover Target Constraint:  
## [1] "Unconstrained"  
##   
## Realized turnover from initial weights:  
## [1] 0.375  
##   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## Objectives  
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Objective: return\_objective   
## $name  
## [1] "mean"  
##   
## $target  
## NULL  
##   
## $arguments  
## list()  
##   
## $enabled  
## [1] TRUE  
##   
## $multiplier  
## [1] -1  
##   
## attr(,"class")  
## [1] "return\_objective" "objective"   
##   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## Objective: portfolio\_risk\_objective   
## $name  
## [1] "var"  
##   
## $target  
## NULL  
##   
## $arguments  
## $arguments$portfolio\_method  
## [1] "single"  
##   
##   
## $enabled  
## [1] TRUE  
##   
## $multiplier  
## [1] 1  
##   
## $risk\_aversion  
## [1] 0.25  
##   
## attr(,"class")  
## [1] "portfolio\_risk\_objective" "objective"   
##   
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Elapsed Time:  
## Time difference of 0.008010864 secs

# Backtesting  
  
bt\_qu <- optimize.portfolio.rebalancing(R=returns, portfolio=init\_portf,  
 constraints=qu\_constr,  
 objectives=qu\_obj,  
 optimize\_method="ROI",  
 rebalance\_on="quarters",  
 training\_period=36)  
  
  
  
  
 bt\_qu

## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## PortfolioAnalytics Optimization with Rebalancing  
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Call:  
## optimize.portfolio.rebalancing(R = returns, portfolio = init\_portf,   
## constraints = qu\_constr, objectives = qu\_obj, optimize\_method = "ROI",   
## rebalance\_on = "quarters", training\_period = 36)

## Warning in Return.portfolio.geometric(R = R, weights = weights, wealth.index =  
## wealth.index, : The weights for one or more periods do not sum up to 1: assuming  
## a return of 0 for the residual weights

## Number of rebalancing dates: 81   
## First rebalance date:  
## [1] "1999-12-31"  
## Last rebalance date:  
## [1] "2019-11-30"  
##   
## Annualized Portfolio Rebalancing Return:  
## [1] 0.1261984  
##   
## Annualized Portfolio Standard Deviation:  
## [1] 0.03543838

summary(bt\_qu)

## Warning in Return.portfolio.geometric(R = R, weights = weights, wealth.index =  
## wealth.index, : The weights for one or more periods do not sum up to 1: assuming  
## a return of 0 for the residual weights

## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
## PortfolioAnalytics Optimization with Rebalancing  
## \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
##   
## Call:  
## optimize.portfolio.rebalancing(R = returns, portfolio = init\_portf,   
## constraints = qu\_constr, objectives = qu\_obj, optimize\_method = "ROI",   
## rebalance\_on = "quarters", training\_period = 36)  
##   
## First rebalance date:  
## [1] "1999-12-31"  
##   
## Last rebalance date:  
## [1] "2019-11-30"  
##   
## Annualized Portfolio Rebalancing Return:  
## [1] 0.1261984  
##   
## Annualized Portfolio Standard Deviation:  
## [1] 0.03543838  
##   
## Downside Risk Measures:  
## portfolio.returns  
## Semi Deviation 0.0072  
## Gain Deviation 0.0081  
## Loss Deviation 0.0044  
## Downside Deviation (MAR=10%) 0.0063  
## Downside Deviation (Rf=0%) 0.0028  
## Downside Deviation (0%) 0.0028  
## Maximum Drawdown 0.0215  
## Historical VaR (95%) -0.0073  
## Historical ES (95%) -0.0105  
## Modified VaR (95%) -0.0067  
## Modified ES (95%) -0.0107

names(bt\_qu)

## [1] "portfolio" "R" "call" "elapsed\_time"   
## [5] "opt\_rebalancing"

extractStats(bt\_qu)

## $`1999-12-31`  
## mean StdDev out w.CA w.CTAG   
## 8.936111e-03 1.189271e-02 -8.900752e-03 1.000000e+00 2.182070e-17   
## w.DS w.EM   
## 2.287059e-14 0.000000e+00   
##   
## $`2000-03-31`  
## mean StdDev out w.CA w.CTAG   
## 1.023495e-02 2.009404e-02 -1.013401e-02 7.556488e-01 -5.504568e-17   
## w.DS w.EM   
## 0.000000e+00 2.443512e-01   
##   
## $`2000-06-30`  
## mean StdDev out w.CA w.CTAG   
## 1.072619e-02 1.194628e-02 -1.069051e-02 1.000000e+00 0.000000e+00   
## w.DS w.EM   
## 2.153833e-14 0.000000e+00   
##   
## $`2000-09-30`  
## mean StdDev out w.CA w.CTAG   
## 1.089111e-02 1.157330e-02 -1.085763e-02 1.000000e+00 -9.369392e-17   
## w.DS w.EM   
## 0.000000e+00 0.000000e+00   
##   
## $`2000-12-31`  
## mean StdDev out w.CA w.CTAG   
## 1.014583e-02 1.165353e-02 -1.011188e-02 1.000000e+00 0.000000e+00   
## w.DS w.EM   
## -2.220446e-16 -5.286908e-17   
##   
## $`2001-03-31`  
## mean StdDev out w.CA w.CTAG   
## 1.089804e-02 1.186908e-02 -1.086282e-02 1.000000e+00 0.000000e+00   
## w.DS w.EM   
## 1.325329e-14 0.000000e+00   
##   
## $`2001-06-30`  
## mean StdDev out w.CA w.CTAG   
## 1.066667e-02 1.166813e-02 -1.063263e-02 1.000000e+00 1.203510e-30   
## w.DS w.EM   
## 0.000000e+00 1.784556e-16   
##   
## $`2001-09-30`  
## mean StdDev out w.CA w.CTAG   
## 1.065088e-02 1.136948e-02 -1.061856e-02 1.000000e+00 0.000000e+00   
## w.DS w.EM   
## 2.198242e-14 1.747802e-16   
##   
## $`2001-12-31`  
## mean StdDev out w.CA w.CTAG   
## 1.029000e-02 1.138032e-02 -1.025762e-02 1.000000e+00 -8.709944e-17   
## w.DS w.EM   
## 1.398881e-14 0.000000e+00   
##   
## $`2002-03-31`  
## mean StdDev out w.CA w.CTAG   
## 1.004127e-02 1.129750e-02 -1.000936e-02 1.000000e+00 -5.693326e-31   
## w.DS w.EM   
## 2.220446e-16 0.000000e+00   
##   
## $`2002-06-30`  
## mean StdDev out w.CA w.CTAG   
## 9.786364e-03 1.112694e-02 -9.755411e-03 1.000000e+00 8.402358e-17   
## w.DS w.EM   
## 2.220446e-15 0.000000e+00   
##   
## $`2002-09-30`  
## mean StdDev out w.CA w.CTAG   
## 9.414493e-03 1.133961e-02 -9.382346e-03 1.000000e+00 0.000000e+00   
## w.DS w.EM   
## 4.163779e-30 5.162658e-17   
##   
## $`2002-12-31`  
## mean StdDev out w.CA w.CTAG   
## 9.733333e-03 1.127324e-02 -9.701562e-03 1.000000e+00 -3.041291e-31   
## w.DS w.EM   
## 6.661338e-16 -4.508381e-17   
##   
## $`2003-03-31`  
## mean StdDev out w.CA w.CTAG   
## 1.001733e-02 1.125574e-02 -9.985660e-03 1.000000e+00 0.000000e+00   
## w.DS w.EM   
## 1.765255e-14 -5.308605e-17   
##   
## $`2003-06-30`  
## mean StdDev out w.CA w.CTAG   
## 9.924359e-03 1.120202e-02 -9.892988e-03 1.000000e+00 -1.433757e-30   
## w.DS w.EM   
## 3.330669e-16 8.879249e-17   
##   
## $`2003-09-30`  
## mean StdDev out w.CA w.CTAG   
## 9.571605e-03 1.137095e-02 -9.539280e-03 1.000000e+00 -1.273131e-30   
## w.DS w.EM   
## 6.661338e-16 0.000000e+00   
##   
## $`2003-12-31`  
## mean StdDev out w.CA w.CTAG   
## 9.633544e-03 1.526133e-02 -9.575317e-03 2.003848e-01 9.461819e-18   
## w.DS w.EM   
## 7.996152e-01 0.000000e+00   
##   
## $`2004-03-31`  
## mean StdDev out w.CA w.CTAG   
## 9.800000e-03 1.707024e-02 -9.727152e-03 5.551115e-17 4.290624e-17   
## w.DS w.EM   
## 1.000000e+00 -5.551115e-17   
##   
## $`2004-06-30`  
## mean StdDev out w.CA w.CTAG   
## 9.790000e-03 1.685525e-02 -9.718975e-03 5.551115e-16 0.000000e+00   
## w.DS w.EM   
## 1.000000e+00 0.000000e+00   
##   
## $`2004-09-30`  
## mean StdDev out w.CA w.CTAG   
## 9.701075e-03 1.659875e-02 -9.632196e-03 5.551115e-16 1.932332e-17   
## w.DS w.EM   
## 1.000000e+00 0.000000e+00   
##   
## $`2004-12-31`  
## mean StdDev out w.CA w.CTAG   
## 1.017500e-02 1.660971e-02 -1.010603e-02 -1.110223e-16 -1.383496e-16   
## w.DS w.EM   
## 1.000000e+00 3.330669e-16   
##   
## $`2005-03-31`  
## mean StdDev out w.CA w.CTAG   
## 1.007172e-02 1.638464e-02 -1.000460e-02 2.551128e-31 1.826609e-16   
## w.DS w.EM   
## 1.000000e+00 0.000000e+00   
##   
## $`2005-06-30`  
## mean StdDev out w.CA w.CTAG   
## 9.860784e-03 1.624002e-02 -9.794850e-03 0.000000e+00 1.806270e-16   
## w.DS w.EM   
## 1.000000e+00 0.000000e+00   
##   
## $`2005-09-30`  
## mean StdDev out w.CA w.CTAG   
## 9.968571e-03 1.602280e-02 -9.904389e-03 0.000000e+00 1.784641e-16   
## w.DS w.EM   
## 1.000000e+00 -2.220446e-16   
##   
## $`2005-12-31`  
## mean StdDev out w.CA w.CTAG   
## 9.867593e-03 1.584894e-02 -9.804795e-03 1.110223e-16 0.000000e+00   
## w.DS w.EM   
## 1.000000e+00 1.332268e-15   
##   
## $`2006-03-31`  
## mean StdDev out w.CA w.CTAG   
## 1.004235e-02 1.571924e-02 -9.980576e-03 0.000000e+00 1.749255e-16   
## w.DS w.EM   
## 9.999277e-01 7.232907e-05   
##   
## $`2006-06-30`  
## mean StdDev out w.CA w.CTAG w.DS w.EM   
## NA NA NA NA NA NA NA   
##   
## $`2006-09-30`  
## mean StdDev out w.CA w.CTAG   
## 9.873504e-03 1.540371e-02 -9.814186e-03 0.000000e+00 -1.726289e-16   
## w.DS w.EM   
## 1.000000e+00 0.000000e+00   
##   
## $`2006-12-31`  
## mean StdDev out w.CA w.CTAG   
## 1.007894e-02 1.574027e-02 -1.001700e-02 -3.469447e-18 1.699204e-16   
## w.DS w.EM   
## 9.644896e-01 3.551035e-02   
##   
## $`2007-03-31`  
## mean StdDev out w.CA w.CTAG   
## 1.015691e-02 1.508489e-02 -1.010002e-02 0.000000e+00 3.380425e-16   
## w.DS w.EM   
## 1.000000e+00 2.220446e-16   
##   
## $`2007-06-30`  
## mean StdDev out w.CA w.CTAG   
## 1.053187e-02 3.200120e-02 -1.027586e-02 0.000000e+00 -1.461122e-17   
## w.DS w.EM   
## 1.608224e-01 8.391776e-01   
##   
## $`2007-09-30`  
## mean StdDev out w.CA w.CTAG   
## 1.067984e-02 3.578437e-02 -1.035971e-02 0.000000e+00 -6.327720e-17   
## w.DS w.EM   
## 1.998401e-15 1.000000e+00   
##   
## $`2007-12-31`  
## mean StdDev out w.CA w.CTAG   
## 1.072348e-02 3.565357e-02 -1.040569e-02 0.000000e+00 6.266547e-17   
## w.DS w.EM   
## 0.000000e+00 1.000000e+00   
##   
## $`2008-03-31`  
## mean StdDev out w.CA w.CTAG   
## 1.003926e-02 3.591528e-02 -9.716782e-03 1.551358e-16 4.686309e-31   
## w.DS w.EM   
## 0.000000e+00 1.000000e+00   
##   
## $`2008-06-30`  
## mean StdDev out w.CA w.CTAG   
## 9.878261e-03 3.567546e-02 -9.560076e-03 1.544404e-16 0.000000e+00   
## w.DS w.EM   
## 1.554312e-15 1.000000e+00   
##   
## $`2008-09-30`  
## mean StdDev out w.CA w.CTAG   
## 8.418440e-03 1.602578e-02 -8.354233e-03 4.445725e-16 0.000000e+00   
## w.DS w.EM   
## 1.000000e+00 -4.440892e-16   
##   
## $`2008-12-31`  
## mean StdDev out w.CA w.CTAG w.DS w.EM   
## NA NA NA NA NA NA NA   
##   
## $`2009-03-31`  
## mean StdDev out w.CA w.CTAG   
## 7.105442e-03 1.794859e-02 -7.024904e-03 5.161488e-18 0.000000e+00   
## w.DS w.EM   
## 1.000000e+00 1.110223e-15   
##   
## $`2009-06-30`  
## mean StdDev out w.CA w.CTAG   
## 7.791123e-03 2.514480e-02 -7.633058e-03 -2.658501e-16 0.000000e+00   
## w.DS w.EM   
## 6.013453e-01 3.986547e-01   
##   
## $`2009-09-30`  
## mean StdDev out w.CA w.CTAG   
## 8.449347e-03 3.280577e-02 -8.180292e-03 -6.678978e-17 0.000000e+00   
## w.DS w.EM   
## 2.495612e-01 7.504388e-01   
##   
## $`2009-12-31`  
## mean StdDev out w.CA w.CTAG   
## 8.543316e-03 2.536431e-02 -8.382479e-03 -2.284523e-16 0.000000e+00   
## w.DS w.EM   
## 5.848416e-01 4.151584e-01   
##   
## $`2010-03-31`  
## mean StdDev out w.CA w.CTAG   
## 8.627673e-03 1.838978e-02 -8.543127e-03 1.110223e-16 1.581894e-16   
## w.DS w.EM   
## 1.000000e+00 1.776357e-15   
##   
## $`2010-06-30`  
## mean StdDev out w.CA w.CTAG   
## 8.403704e-03 1.851522e-02 -8.318000e-03 0.000000e+00 1.570929e-16   
## w.DS w.EM   
## 1.000000e+00 3.330669e-16   
##   
## $`2010-09-30`  
## mean StdDev out w.CA w.CTAG   
## 8.492313e-03 2.243737e-02 -8.366455e-03 0.000000e+00 -1.565722e-16   
## w.DS w.EM   
## 7.305023e-01 2.694977e-01   
##   
## $`2010-12-31`  
## mean StdDev out w.CA w.CTAG   
## 8.635119e-03 1.835120e-02 -8.550927e-03 0.000000e+00 0.000000e+00   
## w.DS w.EM   
## 1.000000e+00 5.551115e-16   
##   
## $`2011-03-31`  
## mean StdDev out w.CA w.CTAG   
## 8.694152e-03 1.820900e-02 -8.611260e-03 0.000000e+00 -3.074847e-16   
## w.DS w.EM   
## 1.000000e+00 2.220446e-16   
##   
## $`2011-06-30`  
## mean StdDev out w.CA w.CTAG   
## 8.571264e-03 1.810751e-02 -8.489294e-03 0.000000e+00 0.000000e+00   
## w.DS w.EM   
## 1.000000e+00 6.661338e-16   
##   
## $`2011-09-30`  
## mean StdDev out w.CA w.CTAG   
## 7.981356e-03 1.865031e-02 -7.894397e-03 0.000000e+00 0.000000e+00   
## w.DS w.EM   
## 1.000000e+00 6.661338e-16   
##   
## $`2011-12-31`  
## mean StdDev out w.CA w.CTAG   
## 7.947778e-03 1.858504e-02 -7.861427e-03 0.000000e+00 0.000000e+00   
## w.DS w.EM   
## 1.000000e+00 4.440892e-16   
##   
## $`2012-03-31`  
## mean StdDev out w.CA w.CTAG   
## 8.154645e-03 1.854143e-02 -8.068699e-03 0.000000e+00 4.538389e-16   
## w.DS w.EM   
## 1.000000e+00 0.000000e+00   
##   
## $`2012-06-30`  
## mean StdDev out w.CA w.CTAG   
## 7.911828e-03 1.851853e-02 -7.826094e-03 0.000000e+00 -1.510361e-16   
## w.DS w.EM   
## 1.000000e+00 4.440892e-16   
##   
## $`2012-09-30`  
## mean StdDev out w.CA w.CTAG w.DS   
## 0.008007937 0.018391458 -0.007923375 0.000000000 0.000000000 1.000000000   
## w.EM   
## 0.000000000   
##   
## $`2012-12-31`  
## mean StdDev out w.CA w.CTAG   
## 8.121875e-03 1.829403e-02 -8.038207e-03 0.000000e+00 1.490868e-16   
## w.DS w.EM   
## 1.000000e+00 -2.220446e-16   
##   
## $`2013-03-31`  
## mean StdDev out w.CA w.CTAG   
## 8.212308e-03 1.818646e-02 -8.129621e-03 0.000000e+00 2.960303e-16   
## w.DS w.EM   
## 1.000000e+00 1.110223e-16   
##   
## $`2013-06-30`  
## mean StdDev out w.CA w.CTAG   
## 8.235859e-03 1.813650e-02 -8.153625e-03 0.000000e+00 -4.416281e-16   
## w.DS w.EM   
## 1.000000e+00 7.771561e-16   
##   
## $`2013-09-30`  
## mean StdDev out w.CA w.CTAG w.DS   
## 0.008247264 0.018032607 -0.008165970 0.000000000 0.000000000 1.000000000   
## w.EM   
## 0.000000000   
##   
## $`2013-12-31`  
## mean StdDev out w.CA w.CTAG   
## 8.323529e-03 1.791127e-02 -8.243326e-03 0.000000e+00 0.000000e+00   
## w.DS w.EM   
## 1.000000e+00 -6.661338e-16   
##   
## $`2014-03-31`  
## mean StdDev out w.CA w.CTAG   
## 8.373430e-03 1.781746e-02 -8.294065e-03 0.000000e+00 -1.448811e-16   
## w.DS w.EM   
## 1.000000e+00 4.440892e-16   
##   
## $`2014-06-30`  
## mean StdDev out w.CA w.CTAG   
## 8.378095e-03 1.769893e-02 -8.299782e-03 0.000000e+00 -1.439759e-16   
## w.DS w.EM   
## 1.000000e+00 4.440892e-16   
##   
## $`2014-09-30`  
## mean StdDev out w.CA w.CTAG   
## 8.133803e-03 1.771769e-02 -8.055324e-03 0.000000e+00 1.429946e-16   
## w.DS w.EM   
## 1.000000e+00 8.881784e-16   
##   
## $`2014-12-31`  
## mean StdDev out w.CA w.CTAG   
## 7.886111e-03 1.772948e-02 -7.807527e-03 0.000000e+00 -1.421090e-16   
## w.DS w.EM   
## 1.000000e+00 -1.221245e-15   
##   
## $`2015-03-31`  
## mean StdDev out w.CA w.CTAG   
## 7.804566e-03 1.769594e-02 -7.726280e-03 0.000000e+00 2.220446e-16   
## w.DS w.EM   
## 1.000000e+00 -8.881784e-16   
##   
## $`2015-06-30`  
## mean StdDev out w.CA w.CTAG   
## 7.670721e-03 1.765077e-02 -7.592833e-03 1.110223e-16 1.404122e-16   
## w.DS w.EM   
## 1.000000e+00 1.110223e-16   
##   
## $`2015-09-30`  
## mean StdDev out w.CA w.CTAG   
## 7.387111e-03 1.772273e-02 -7.308587e-03 -3.560813e-31 -1.643489e-31   
## w.DS w.EM   
## 1.000000e+00 0.000000e+00   
##   
## $`2015-12-31`  
## mean StdDev out w.CA w.CTAG   
## 7.171053e-03 1.771902e-02 -7.092562e-03 0.000000e+00 2.785997e-16   
## w.DS w.EM   
## 1.000000e+00 -6.661338e-16   
##   
## $`2016-03-31`  
## mean StdDev out w.CA w.CTAG   
## 7.003030e-03 1.778380e-02 -6.923964e-03 0.000000e+00 0.000000e+00   
## w.DS w.EM   
## 1.000000e+00 4.440892e-16   
##   
## $`2016-06-30`  
## mean StdDev out w.CA w.CTAG   
## 7.094872e-03 1.769710e-02 -7.016575e-03 0.000000e+00 -1.379660e-16   
## w.DS w.EM   
## 1.000000e+00 1.221245e-15   
##   
## $`2016-09-30`  
## mean StdDev out w.CA w.CTAG   
## 7.215190e-03 1.762523e-02 -7.137528e-03 0.000000e+00 0.000000e+00   
## w.DS w.EM   
## 1.000000e+00 9.992007e-16   
##   
## $`2016-12-31`  
## mean StdDev out w.CA w.CTAG   
## 7.334167e-03 1.755141e-02 -7.257154e-03 0.000000e+00 0.000000e+00   
## w.DS w.EM   
## 1.000000e+00 -2.220446e-16   
##   
## $`2017-03-31`  
## mean StdDev out w.CA w.CTAG   
## 7.316872e-03 1.748794e-02 -7.240415e-03 0.000000e+00 0.000000e+00   
## w.DS w.EM   
## 1.000000e+00 1.110223e-16   
##   
## $`2017-06-30`  
## mean StdDev out w.CA w.CTAG   
## 7.240244e-03 1.740057e-02 -7.164549e-03 0.000000e+00 -1.348155e-16   
## w.DS w.EM   
## 1.000000e+00 1.332268e-15   
##   
## $`2017-09-30`  
## mean StdDev out w.CA w.CTAG   
## 7.221687e-03 1.730436e-02 -7.146827e-03 0.000000e+00 0.000000e+00   
## w.DS w.EM   
## 1.000000e+00 -2.220446e-16   
##   
## $`2017-12-31`  
## mean StdDev out w.CA w.CTAG   
## 7.205159e-03 1.722147e-02 -7.131014e-03 0.000000e+00 0.000000e+00   
## w.DS w.EM   
## 1.000000e+00 4.440892e-16   
##   
## $`2018-03-31`  
## mean StdDev out w.CA w.CTAG   
## 7.157647e-03 1.716141e-02 -7.084019e-03 0.000000e+00 1.330476e-16   
## w.DS w.EM   
## 1.000000e+00 4.440892e-16   
##   
## $`2018-06-30`  
## mean StdDev out w.CA w.CTAG   
## 7.160465e-03 1.706209e-02 -7.087686e-03 0.000000e+00 -2.654893e-16   
## w.DS w.EM   
## 1.000000e+00 4.440892e-16   
##   
## $`2018-09-30`  
## mean StdDev out w.CA w.CTAG   
## 7.133716e-03 1.696989e-02 -7.061722e-03 0.000000e+00 -1.324144e-16   
## w.DS w.EM   
## 1.000000e+00 8.881784e-16   
##   
## $`2018-12-31`  
## mean StdDev out w.CA w.CTAG   
## 6.831061e-03 1.711145e-02 -6.757860e-03 1.709127e-31 1.320061e-16   
## w.DS w.EM   
## 1.000000e+00 0.000000e+00   
##   
## $`2019-03-31`  
## mean StdDev out w.CA w.CTAG   
## 6.853184e-03 1.704818e-02 -6.780523e-03 0.000000e+00 1.313924e-16   
## w.DS w.EM   
## 1.000000e+00 4.440892e-16   
##   
## $`2019-06-30`  
## mean StdDev out w.CA w.CTAG   
## 6.825556e-03 1.697085e-02 -6.753553e-03 -1.110223e-16 -2.619477e-16   
## w.DS w.EM   
## 1.000000e+00 6.661338e-16   
##   
## $`2019-09-30`  
## mean StdDev out w.CA w.CTAG   
## 6.698168e-03 1.692321e-02 -6.626570e-03 0.000000e+00 3.922686e-16   
## w.DS w.EM   
## 1.000000e+00 -8.881784e-16   
##   
## $`2019-11-30`  
## mean StdDev out w.CA w.CTAG   
## 6.621818e-03 1.688505e-02 -6.550542e-03 0.000000e+00 2.607881e-16   
## w.DS w.EM   
## 1.000000e+00 0.000000e+00

extractWeights(opt\_qu)

## CA CTAG DS EM   
## 0.000000e+00 2.607881e-16 1.000000e+00 0.000000e+00

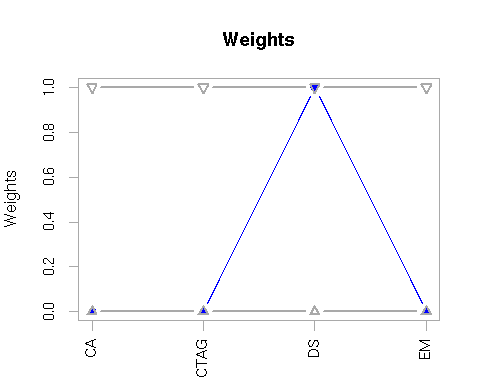
extractWeights(bt\_qu)

## CA CTAG DS EM  
## 1999-12-31 1.000000e+00 2.182070e-17 2.287059e-14 0.000000e+00  
## 2000-03-31 7.556488e-01 -5.504568e-17 0.000000e+00 2.443512e-01  
## 2000-06-30 1.000000e+00 0.000000e+00 2.153833e-14 0.000000e+00  
## 2000-09-30 1.000000e+00 -9.369392e-17 0.000000e+00 0.000000e+00  
## 2000-12-31 1.000000e+00 0.000000e+00 -2.220446e-16 -5.286908e-17  
## 2001-03-31 1.000000e+00 0.000000e+00 1.325329e-14 0.000000e+00  
## 2001-06-30 1.000000e+00 1.203510e-30 0.000000e+00 1.784556e-16  
## 2001-09-30 1.000000e+00 0.000000e+00 2.198242e-14 1.747802e-16  
## 2001-12-31 1.000000e+00 -8.709944e-17 1.398881e-14 0.000000e+00  
## 2002-03-31 1.000000e+00 -5.693326e-31 2.220446e-16 0.000000e+00  
## 2002-06-30 1.000000e+00 8.402358e-17 2.220446e-15 0.000000e+00  
## 2002-09-30 1.000000e+00 0.000000e+00 4.163779e-30 5.162658e-17  
## 2002-12-31 1.000000e+00 -3.041291e-31 6.661338e-16 -4.508381e-17  
## 2003-03-31 1.000000e+00 0.000000e+00 1.765255e-14 -5.308605e-17  
## 2003-06-30 1.000000e+00 -1.433757e-30 3.330669e-16 8.879249e-17  
## 2003-09-30 1.000000e+00 -1.273131e-30 6.661338e-16 0.000000e+00  
## 2003-12-31 2.003848e-01 9.461819e-18 7.996152e-01 0.000000e+00  
## 2004-03-31 5.551115e-17 4.290624e-17 1.000000e+00 -5.551115e-17  
## 2004-06-30 5.551115e-16 0.000000e+00 1.000000e+00 0.000000e+00  
## 2004-09-30 5.551115e-16 1.932332e-17 1.000000e+00 0.000000e+00  
## 2004-12-31 -1.110223e-16 -1.383496e-16 1.000000e+00 3.330669e-16  
## 2005-03-31 2.551128e-31 1.826609e-16 1.000000e+00 0.000000e+00  
## 2005-06-30 0.000000e+00 1.806270e-16 1.000000e+00 0.000000e+00  
## 2005-09-30 0.000000e+00 1.784641e-16 1.000000e+00 -2.220446e-16  
## 2005-12-31 1.110223e-16 0.000000e+00 1.000000e+00 1.332268e-15  
## 2006-03-31 0.000000e+00 1.749255e-16 9.999277e-01 7.232907e-05  
## 2006-06-30 NA NA NA NA  
## 2006-09-30 0.000000e+00 -1.726289e-16 1.000000e+00 0.000000e+00  
## 2006-12-31 -3.469447e-18 1.699204e-16 9.644896e-01 3.551035e-02  
## 2007-03-31 0.000000e+00 3.380425e-16 1.000000e+00 2.220446e-16  
## 2007-06-30 0.000000e+00 -1.461122e-17 1.608224e-01 8.391776e-01  
## 2007-09-30 0.000000e+00 -6.327720e-17 1.998401e-15 1.000000e+00  
## 2007-12-31 0.000000e+00 6.266547e-17 0.000000e+00 1.000000e+00  
## 2008-03-31 1.551358e-16 4.686309e-31 0.000000e+00 1.000000e+00  
## 2008-06-30 1.544404e-16 0.000000e+00 1.554312e-15 1.000000e+00  
## 2008-09-30 4.445725e-16 0.000000e+00 1.000000e+00 -4.440892e-16  
## 2008-12-31 NA NA NA NA  
## 2009-03-31 5.161488e-18 0.000000e+00 1.000000e+00 1.110223e-15  
## 2009-06-30 -2.658501e-16 0.000000e+00 6.013453e-01 3.986547e-01  
## 2009-09-30 -6.678978e-17 0.000000e+00 2.495612e-01 7.504388e-01  
## 2009-12-31 -2.284523e-16 0.000000e+00 5.848416e-01 4.151584e-01  
## 2010-03-31 1.110223e-16 1.581894e-16 1.000000e+00 1.776357e-15  
## 2010-06-30 0.000000e+00 1.570929e-16 1.000000e+00 3.330669e-16  
## 2010-09-30 0.000000e+00 -1.565722e-16 7.305023e-01 2.694977e-01  
## 2010-12-31 0.000000e+00 0.000000e+00 1.000000e+00 5.551115e-16  
## 2011-03-31 0.000000e+00 -3.074847e-16 1.000000e+00 2.220446e-16  
## 2011-06-30 0.000000e+00 0.000000e+00 1.000000e+00 6.661338e-16  
## 2011-09-30 0.000000e+00 0.000000e+00 1.000000e+00 6.661338e-16  
## 2011-12-31 0.000000e+00 0.000000e+00 1.000000e+00 4.440892e-16  
## 2012-03-31 0.000000e+00 4.538389e-16 1.000000e+00 0.000000e+00  
## 2012-06-30 0.000000e+00 -1.510361e-16 1.000000e+00 4.440892e-16  
## 2012-09-30 0.000000e+00 0.000000e+00 1.000000e+00 0.000000e+00  
## 2012-12-31 0.000000e+00 1.490868e-16 1.000000e+00 -2.220446e-16  
## 2013-03-31 0.000000e+00 2.960303e-16 1.000000e+00 1.110223e-16  
## 2013-06-30 0.000000e+00 -4.416281e-16 1.000000e+00 7.771561e-16  
## 2013-09-30 0.000000e+00 0.000000e+00 1.000000e+00 0.000000e+00  
## 2013-12-31 0.000000e+00 0.000000e+00 1.000000e+00 -6.661338e-16  
## 2014-03-31 0.000000e+00 -1.448811e-16 1.000000e+00 4.440892e-16  
## 2014-06-30 0.000000e+00 -1.439759e-16 1.000000e+00 4.440892e-16  
## 2014-09-30 0.000000e+00 1.429946e-16 1.000000e+00 8.881784e-16  
## 2014-12-31 0.000000e+00 -1.421090e-16 1.000000e+00 -1.221245e-15  
## 2015-03-31 0.000000e+00 2.220446e-16 1.000000e+00 -8.881784e-16  
## 2015-06-30 1.110223e-16 1.404122e-16 1.000000e+00 1.110223e-16  
## 2015-09-30 -3.560813e-31 -1.643489e-31 1.000000e+00 0.000000e+00  
## 2015-12-31 0.000000e+00 2.785997e-16 1.000000e+00 -6.661338e-16  
## 2016-03-31 0.000000e+00 0.000000e+00 1.000000e+00 4.440892e-16  
## 2016-06-30 0.000000e+00 -1.379660e-16 1.000000e+00 1.221245e-15  
## 2016-09-30 0.000000e+00 0.000000e+00 1.000000e+00 9.992007e-16  
## 2016-12-31 0.000000e+00 0.000000e+00 1.000000e+00 -2.220446e-16  
## 2017-03-31 0.000000e+00 0.000000e+00 1.000000e+00 1.110223e-16  
## 2017-06-30 0.000000e+00 -1.348155e-16 1.000000e+00 1.332268e-15  
## 2017-09-30 0.000000e+00 0.000000e+00 1.000000e+00 -2.220446e-16  
## 2017-12-31 0.000000e+00 0.000000e+00 1.000000e+00 4.440892e-16  
## 2018-03-31 0.000000e+00 1.330476e-16 1.000000e+00 4.440892e-16  
## 2018-06-30 0.000000e+00 -2.654893e-16 1.000000e+00 4.440892e-16  
## 2018-09-30 0.000000e+00 -1.324144e-16 1.000000e+00 8.881784e-16  
## 2018-12-31 1.709127e-31 1.320061e-16 1.000000e+00 0.000000e+00  
## 2019-03-31 0.000000e+00 1.313924e-16 1.000000e+00 4.440892e-16  
## 2019-06-30 -1.110223e-16 -2.619477e-16 1.000000e+00 6.661338e-16  
## 2019-09-30 0.000000e+00 3.922686e-16 1.000000e+00 -8.881784e-16  
## 2019-11-30 0.000000e+00 2.607881e-16 1.000000e+00 0.000000e+00

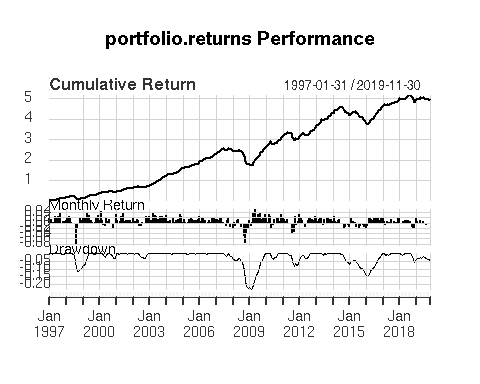
extractObjectiveMeasures(bt\_qu)

## mean StdDev  
## 1999-12-31 0.008936111 0.01189271  
## 2000-03-31 0.010234949 0.02009404  
## 2000-06-30 0.010726190 0.01194628  
## 2000-09-30 0.010891111 0.01157330  
## 2000-12-31 0.010145833 0.01165353  
## 2001-03-31 0.010898039 0.01186908  
## 2001-06-30 0.010666667 0.01166813  
## 2001-09-30 0.010650877 0.01136948  
## 2001-12-31 0.010290000 0.01138032  
## 2002-03-31 0.010041270 0.01129750  
## 2002-06-30 0.009786364 0.01112694  
## 2002-09-30 0.009414493 0.01133961  
## 2002-12-31 0.009733333 0.01127324  
## 2003-03-31 0.010017333 0.01125574  
## 2003-06-30 0.009924359 0.01120202  
## 2003-09-30 0.009571605 0.01137095  
## 2003-12-31 0.009633544 0.01526133  
## 2004-03-31 0.009800000 0.01707024  
## 2004-06-30 0.009790000 0.01685525  
## 2004-09-30 0.009701075 0.01659875  
## 2004-12-31 0.010175000 0.01660971  
## 2005-03-31 0.010071717 0.01638464  
## 2005-06-30 0.009860784 0.01624002  
## 2005-09-30 0.009968571 0.01602280  
## 2005-12-31 0.009867593 0.01584894  
## 2006-03-31 0.010042350 0.01571924  
## 2006-06-30 NA NA  
## 2006-09-30 0.009873504 0.01540371  
## 2006-12-31 0.010078936 0.01574027  
## 2007-03-31 0.010156911 0.01508489  
## 2007-06-30 0.010531875 0.03200120  
## 2007-09-30 0.010679845 0.03578437  
## 2007-12-31 0.010723485 0.03565357  
## 2008-03-31 0.010039259 0.03591528  
## 2008-06-30 0.009878261 0.03567546  
## 2008-09-30 0.008418440 0.01602578  
## 2008-12-31 NA NA  
## 2009-03-31 0.007105442 0.01794859  
## 2009-06-30 0.007791123 0.02514480  
## 2009-09-30 0.008449347 0.03280577  
## 2009-12-31 0.008543316 0.02536431  
## 2010-03-31 0.008627673 0.01838978  
## 2010-06-30 0.008403704 0.01851522  
## 2010-09-30 0.008492313 0.02243737  
## 2010-12-31 0.008635119 0.01835120  
## 2011-03-31 0.008694152 0.01820900  
## 2011-06-30 0.008571264 0.01810751  
## 2011-09-30 0.007981356 0.01865031  
## 2011-12-31 0.007947778 0.01858504  
## 2012-03-31 0.008154645 0.01854143  
## 2012-06-30 0.007911828 0.01851853  
## 2012-09-30 0.008007937 0.01839146  
## 2012-12-31 0.008121875 0.01829403  
## 2013-03-31 0.008212308 0.01818646  
## 2013-06-30 0.008235859 0.01813650  
## 2013-09-30 0.008247264 0.01803261  
## 2013-12-31 0.008323529 0.01791127  
## 2014-03-31 0.008373430 0.01781746  
## 2014-06-30 0.008378095 0.01769893  
## 2014-09-30 0.008133803 0.01771769  
## 2014-12-31 0.007886111 0.01772948  
## 2015-03-31 0.007804566 0.01769594  
## 2015-06-30 0.007670721 0.01765077  
## 2015-09-30 0.007387111 0.01772273  
## 2015-12-31 0.007171053 0.01771902  
## 2016-03-31 0.007003030 0.01778380  
## 2016-06-30 0.007094872 0.01769710  
## 2016-09-30 0.007215190 0.01762523  
## 2016-12-31 0.007334167 0.01755141  
## 2017-03-31 0.007316872 0.01748794  
## 2017-06-30 0.007240244 0.01740057  
## 2017-09-30 0.007221687 0.01730436  
## 2017-12-31 0.007205159 0.01722147  
## 2018-03-31 0.007157647 0.01716141  
## 2018-06-30 0.007160465 0.01706209  
## 2018-09-30 0.007133716 0.01696989  
## 2018-12-31 0.006831061 0.01711145  
## 2019-03-31 0.006853184 0.01704818  
## 2019-06-30 0.006825556 0.01697085  
## 2019-09-30 0.006698168 0.01692321  
## 2019-11-30 0.006621818 0.01688505

chart.Weights(opt\_qu)



rr <- Return.portfolio(returns, weights = extractWeights(opt\_qu))   
charts.PerformanceSummary(rr)

a

weights <- extractWeights(bt\_qu)  
  
 weights <- as.data.frame(weights)  
  
   
 weights <- weights %>%  
 filter(CA != "NA" & CTAG != "NA" & DS != "NA" & EM != "NA")   
   
  
 rr <- Return.portfolio(returns, weights = weights)   
charts.PerformanceSummary(rr)

