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Part A：

```
library(stockPortfolio)
ticker <- c("NVDA", "NVEC", "SIGM", "SLAB", "MCHP", "COKE", "MNST",
"PEP", "LBIX",
    "JSDA", "PETM", "PERF", "HOLL", "ODP", "OUTR", "FCVA", "BAC",
"JPM", "KEY",
    "WFC", "BIOS", "BMY", "NBIX", "JNJ", "NVGN", "^GSPC")
length(ticker)
```

```
## [1] 26
```

(1) Assume short sales are allowed. Choose an appropriate value of Rf to find the composition of the point of tangency (use the classical Markowitz model). Also compute the expected return and standard deviation of the point of tangency. Draw the line and show the point of tangency on the line.

```
gr <- getReturns(ticker, start = "2006-12-31", end = "2011-12-31")
names(gr)
```

```
## [1] "R"      "ticker" "period" "start"  "end"    "full"
```

```
m1 <- stockModel(gr, model = "none", Rf = -0.002, drop = 26)
tangent <- optimalPort(m1)
tangent
```

```
## Model: no model specified.
## Expected return: 0.0397
## Risk estimate:   0.05644
##
## Portfolio allocation:
##       NVDA      NVEC      SIGM      SLAB      MCHP      COKE
MNST
##   0.053750  0.367896 -0.108227 -0.005591  0.057021  0.043535
0.027503
##        PEP      LBIX      JSDA      PETM      PERF      HOLL
ODP
##   0.822285 -0.054807  0.045957 -0.131078  0.040530  0.029330
-0.233478
##       OUTR      FCVA       BAC       JPM       KEY       WFC
BIOS
##   0.069260 -0.074626 -0.463897  0.152244 -0.179723  0.633118
0.133172
##        BMY      NBIX       JNJ      NVGN
##   0.244892  0.033571 -0.484758 -0.017880
```

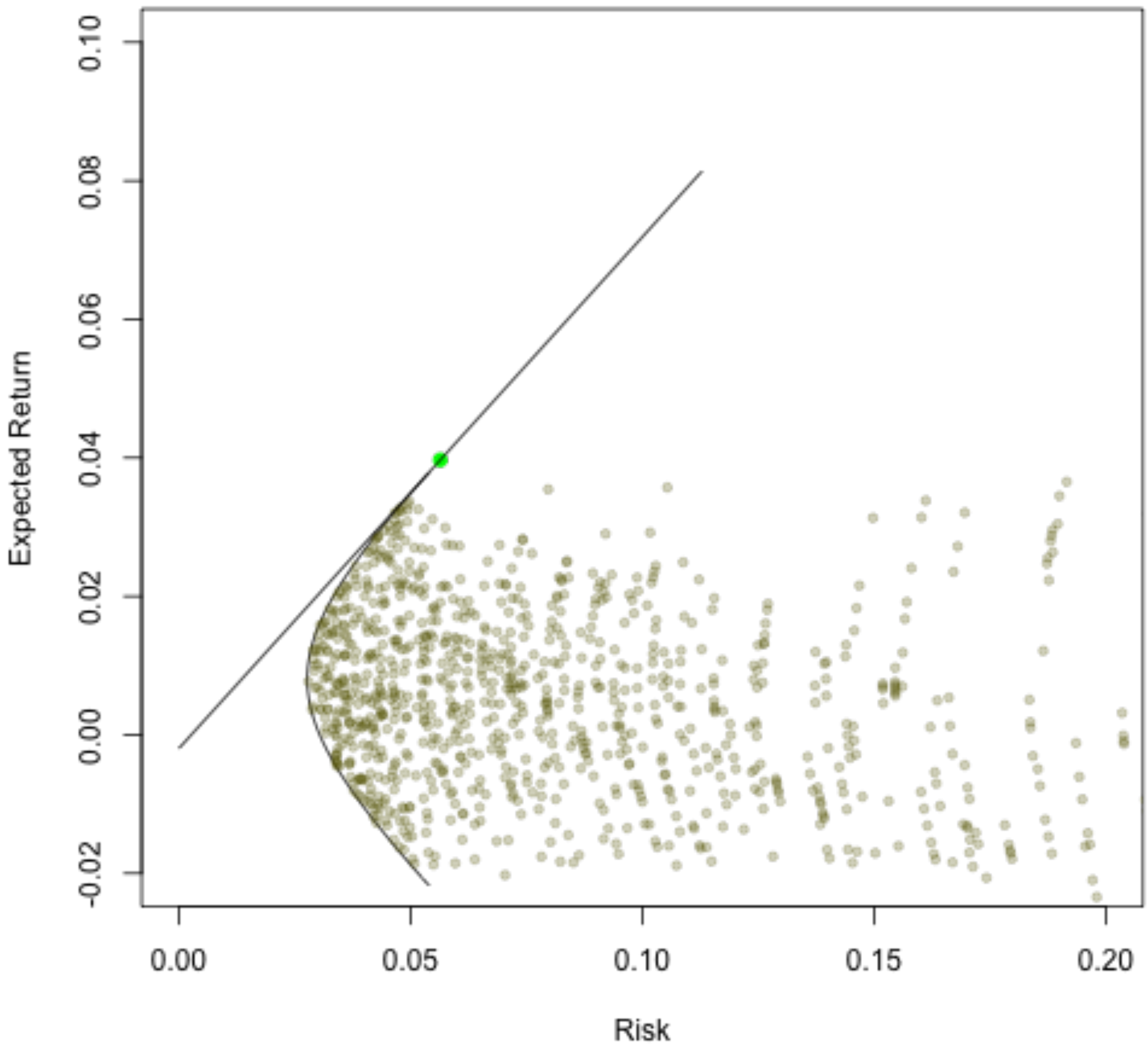
```
portPossCurve(m1, ylim = c(-0.02, 0.1), xlim = c(0, 0.2))
portCloud(m1, add = TRUE)
tangent$risk
```

```
## [1] 0.05644
```

```
tangent$R
```

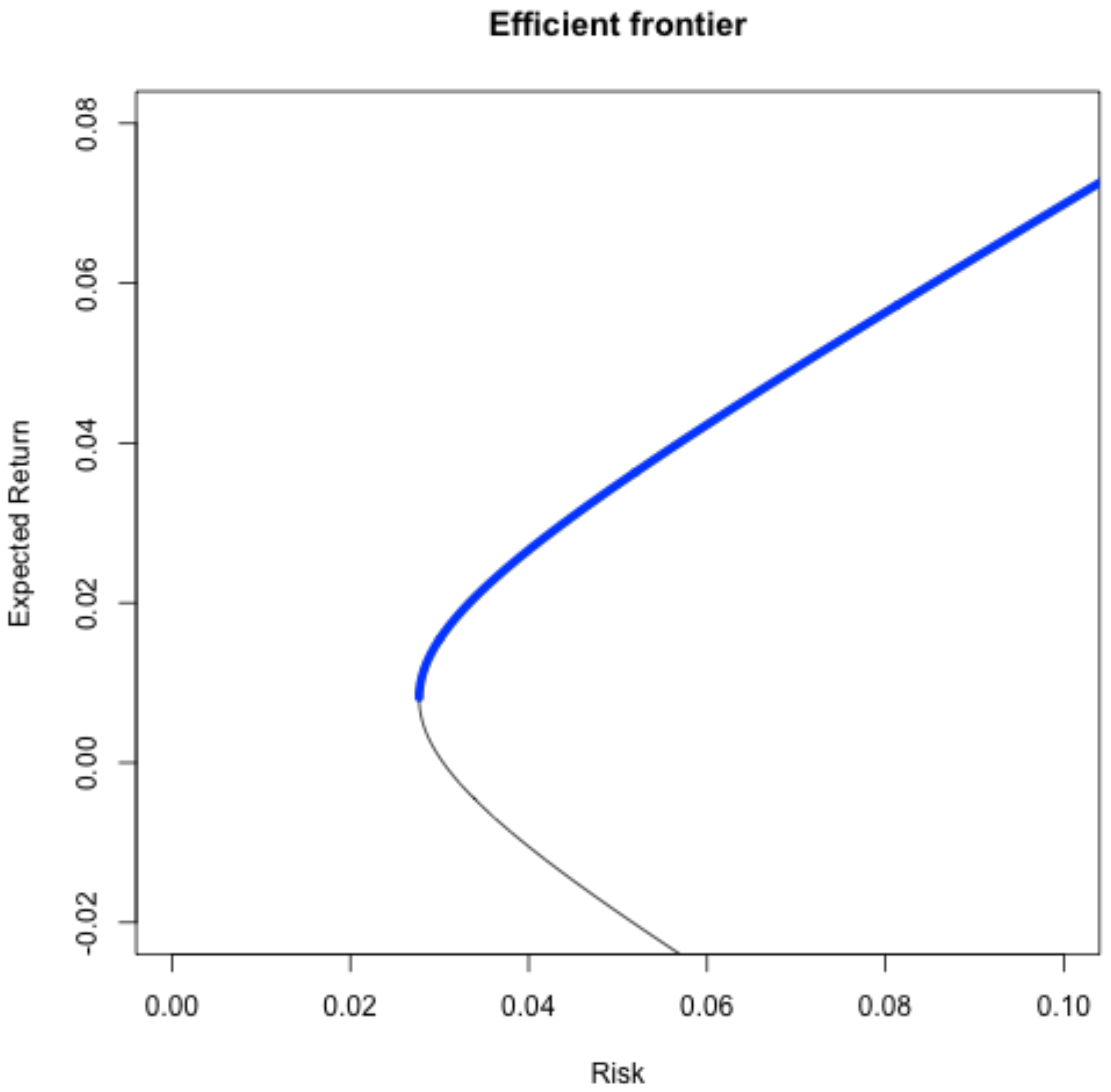
```
## [1] 0.0397
```

```
points(tangent$risk, tangent$R, pch = 19, col = "green")
segments(0, -0.002, 2 * tangent$risk, -0.002 + (tangent$R + 0.002)
* 2)
```



(2) Refer to part (1). Choose two values of Rf to trace out the efficient frontier.

```
tangent2 <- optimalPort(stockModel(gr, model = "none", Rf = 0.002,
drop = 26))
x1 <- seq(-5, 5, 0.01)
x2 <- 1 - x1
rr <- x1 * tangent$R + x2 * tangent2$R
cov_var <- var(gr$R[, -26])
risk2 <- sqrt(x1^2 * tangent$risk^2 + x2^2 * tangent2$risk^2 + 2 *
x1 * x2 *
    (tangent$X %*% cov_var %*% tangent2$X))
plot(rr ~ risk2, main = "Efficient frontier", xlab = "Risk", ylab =
"Expected Return",
    ylim = c(-0.02, 0.08), xlim = c(0, 0.1), type = "l")
pp <- as.data.frame(cbind(risk2, rr))
ef <- pp[pp$rr >= pp$rr[which(risk2 == min(risk2))], ]
points(ef$rr ~ ef$risk2, col = "blue", type = "l", lwd = 5)
```



(3) Equally allocate your funds into your stocks. Calculate the expected return and standard deviation of this portfolio (use historical means and standard deviations).

```
ea_f <- rep(1, 25)/25
R_bar <- as.data.frame(colMeans(gr$R[, -26]))
var_cov <- cov(gr$R[, -26])

ea_R <- t(R_bar) %*% ea_f
ea_R
```

```
##                            [,1]
## colMeans(gr$R[, -26]) 0.002697
```

```
ea_SD <- sqrt(t(ea_f) %*% var_cov %*% ea_f)
ea_SD
```

```
##          [,1]
## [1,] 0.07646
```

(4) Assume that the single index model holds and that risk-free lending and borrowing exists. Use the excess return to beta (you can work with unadjusted or adjusted betas) ratio to find:

```
# a. The composition of the optimum portfolio, its expected return, and its
# standard deviation when short sales are not allowed.

sim <- stockModel(gr, model = "SIM", Rf = -0.002, index = 26, shortSelling = FALSE)
sim_r1 <- optimalPort(sim)
sim_r1
```

```
## Model: single index model
## Expected return: 0.01712
## Risk estimate:   0.05623
##
## Portfolio allocation:
##      NVDA      NVEC      SIGM      SLAB      MCHP      COKE      MNST
## 0.0000000 0.1788022 0.0000000 0.0000000 0.0000000 0.0002635 0.2444786
##       PEP      LBIX      JSDA      PETM      PERF      HOLL      ODP
## 0.0000000 0.0000000 0.0000000 0.1916544 0.0000000 0.0000000 0.0000000
##      OUTR      FCVA       BAC       JPM       KEY       WFC      BIOS
## 0.0719406 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0575585
##       BMY      NBIX       JNJ      NVGN
## 0.2215342 0.0337680 0.0000000 0.0000000
```

```
# b. The alpha and beta of the optimum portfolio of part (a).
t(sim$alpha) %*% sim_r1$X
```

```
##          [,1]
## [1,] 0.01764
```

```
t(sim$beta) %*% sim_r1$X
```

```
##         [,1]
## [1,] 0.6941
```

```
# c. Repeat (a) and (b) when short sales are allowed.
sim2 <- stockModel(gr, model = "SIM", Rf = -0.002, index = 26)
sim_r2 <- optimalPort(sim2)
sim_r2
```

```
## Model: single index model
## Expected return: 0.03414
## Risk estimate:   0.06334
##
## Portfolio allocation:
##       NVDA       NVEC       SIGM       SLAB       MCHP
COKE
## -8.275e-05  1.632e-01 -6.898e-02  1.059e-01  1.248e-01  5.573e-
02
##       MNST        PEP       LBIX       JSDA       PETM
PERF
##  2.039e-01  1.969e-01 -1.576e-02 -4.392e-02  2.616e-01  2.759e-
02
##       HOLL        ODP       OUTR       FCVA        BAC
JPM
## -7.903e-02 -1.079e-01  8.695e-02 -5.077e-02 -1.474e-01 -8.763e-
02
##        KEY        WFC       BIOS        BMY       NBIX
JNJ
## -1.636e-01  1.166e-03  6.646e-02  2.600e-01  3.155e-02  2.157e-
01
##       NVGN
## -3.635e-02
```

```
t(sim2$alpha) %*% sim_r2$X
```

```
##         [,1]
## [1,] 0.0343
```

```
t(sim2$beta) %*% sim_r2$X
```

```
##         [,1]
## [1,] 0.2063
```

(5) Use the constant correlation model and the same risk-free rate as in part (4). Based on the excess return to standard deviation ratio find:

```
# a. The composition of the optimum portfolio, its expected return, and its
# standard deviation when short sales are not allowed.
ccm <- stockModel(gr, model = "CCM", Rf = -0.002, drop = 26, shortSelling = FALSE)
ccm_r1 <- optimalPort(ccm)
ccm_r1
```

```
## Model: constant correlation model
## Expected return: 0.01616
## Risk estimate:   0.05886
##
## Portfolio allocation:
##     NVDA     NVEC     SIGM     SLAB     MCHP     COKE     MNST      PEP
## 0.000000 0.165031 0.000000 0.013251 0.019262 0.000000 0.227547 0.022349
##     LBIX     JSDA     PETM     PERF     HOLL      ODP     OUTR     FCVA
## 0.000000 0.000000 0.232950 0.001575 0.000000 0.000000 0.031923 0.000000
##      BAC      JPM      KEY      WFC     BIOS      BMY     NBIX      JNJ
## 0.000000 0.000000 0.000000 0.000000 0.047071 0.218279 0.000000 0.020763
##     NVGN
## 0.000000
```

```
# b. Repeat (a) when short sales are allowed.
ccm2 <- stockModel(gr, model = "CCM", Rf = -0.002, drop = 26)
ccm_r2 <- optimalPort(ccm2)
ccm_r2
```

```
## Model: constant correlation model
## Expected return: 0.03537
## Risk estimate:   0.06363
##
## Portfolio allocation:
##      NVDA      NVEC      SIGM      SLAB      MCHP      COKE
MNST
##  0.005841  0.171267 -0.102033  0.104092  0.121922  0.040689
0.217030
##       PEP      LBIX      JSDA      PETM      PERF      HOLL
ODP
##  0.203028 -0.022087 -0.072171  0.254203  0.028598 -0.095175
-0.059922
##      OUTR      FCVA       BAC       JPM       KEY       WFC
BIOS
##  0.086509 -0.089955 -0.095732 -0.038243 -0.189313  0.014171
0.068030
##       BMY      NBIX       JNJ      NVGN
##  0.265501  0.010683  0.220195 -0.047128
```

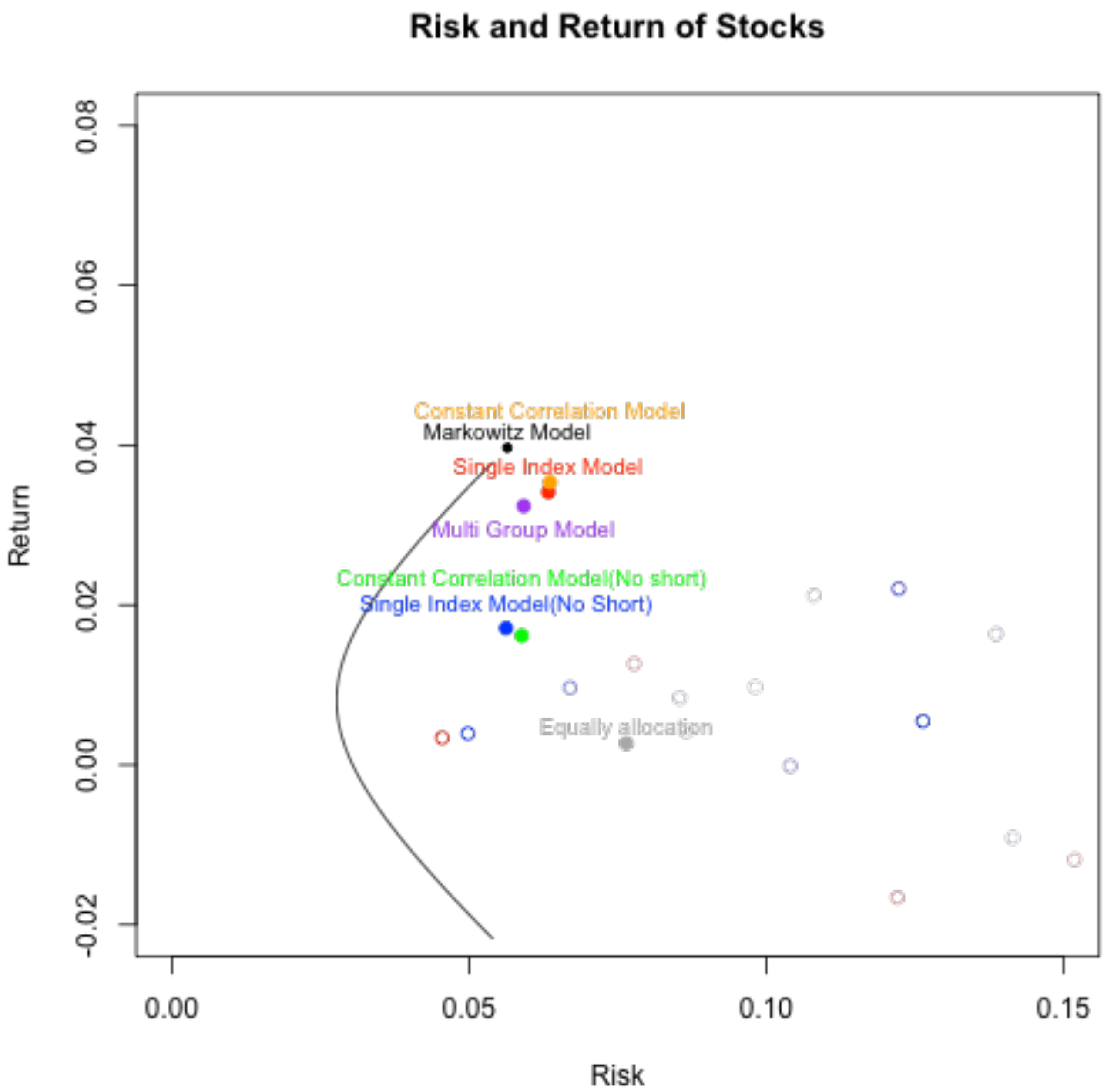
(6) Use the multigroup model, short sales allowed, and the same risk free rate as in (4) and (5), to find the composition of the optimum portfolio, its expected return, and its standard deviation.

```
ind <- c(rep("Semiconductor ", 5), rep("Beverages - Soft Drinks",
5), rep("Specialty Retail",
    5), rep("Money Center Banks", 5), rep("Drug Manufacturers", 5))
multi <- stockModel(gr, model = "MGM", Rf = -0.002, drop = 26,
industry = ind)
multi_r <- optimalPort(multi)
multi_r
```

```
## Model: multigroup model
## Expected return: 0.03239
## Risk estimate:   0.0592
##
## Portfolio allocation:
##     NVDA     NVEC     SIGM     SLAB     MCHP     COKE     MNST
PEP
## -0.02017  0.15898 -0.14595  0.07330  0.08686  0.04378  0.19234
0.18890
##     LBIX     JSDA     PETM     PERF     HOLL      ODP     OUTR
FCVA
## -0.01532 -0.05861  0.23694  0.02499 -0.10212 -0.06370  0.07743
-0.06780
##      BAC      JPM      KEY      WFC     BIOS      BMY     NBIX
JNJ
## -0.07284  0.03557 -0.16448  0.08606  0.06508  0.25268  0.01353
0.21565
##     NVGN
## -0.04109
```

(7) Place all the stocks you have used and all the portfolios you have constructed on the space expected return against standard deviation.

```
# Markowitz Model
plot(tangent, ylim = c(-0.02, 0.08), xlim = c(0, 0.15))
text(tangent$risk, tangent$R + 0.002, "Markowitz Model", cex = 0.8)
portPossCurve(m1, add = TRUE)
# Equally allocate
points(ea_R ~ ea_SD, pch = 19, col = "dark grey")
text(ea_SD, ea_R + 0.002, "Equally allocation", col = "dark grey",
cex = 0.8)
# sim/no short
points(sim_r1$R ~ sim_r1$risk, pch = 19, col = "blue")
text(sim_r1$risk, sim_r1$R + 0.003, "Single Index Model(No Short)",
col = "blue",
    cex = 0.8)
# sim/short
points(sim_r2$R ~ sim_r2$risk, pch = 19, col = "red")
text(sim_r2$risk, sim_r2$R + 0.003, "Single Index Model", col =
"red", cex = 0.8)
# ccm/no short
points(ccm_r1$R ~ ccm_r1$risk, pch = 19, col = "green")
text(ccm_r1$risk, ccm_r1$R + 0.007, "Constant Correlation Model(No
short)",
    col = "green", cex = 0.8)
# ccm/short
points(ccm_r2$R ~ ccm_r2$risk, pch = 19, col = "orange")
text(ccm_r2$risk, ccm_r2$R + 0.009, "Constant Correlation Model",
col = "orange",
    cex = 0.8)
# mig
points(multi_r$R ~ multi_r$risk, pch = 19, col = "purple")
text(multi_r$risk, multi_r$R - 0.003, "Multi Group Model", col =
"purple", cex = 0.8)
```

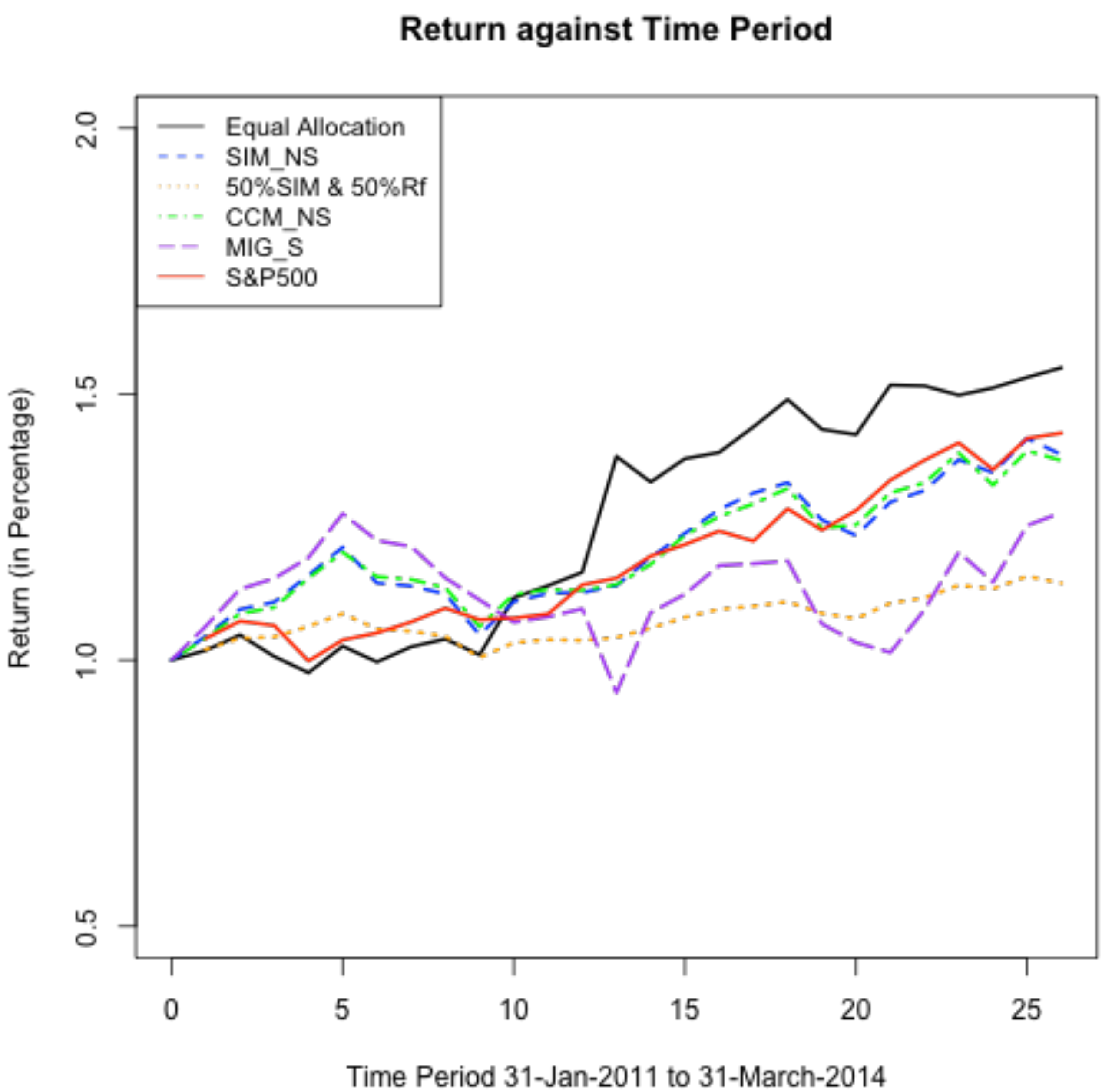


Part B: Compute now the monthly returns for each stock for the period 31-Dec-2011 to 31-Mar-2014 and use them to compute the monthly return for each of the following portfolios that you have constructed above:

```
gr2 <- getReturns(ticker, start = "2011-12-31", end = "2014-03-31")

# a. Equal allocation (part 3).
a <- gr2$R[, -26] %*% ea_f
# b. Single index model with no short sales allowed (part 4a).
b <- gr2$R[, -26] %*% sim_r1$X

# c. A portfolio that consists of 50% of the portfolio of part 4a
and 50% of
# the risk free asset.
c <- gr2$R[, -26] %*% sim_r1$X * 0.5 - 0.005 * 0.5

# d. Constant correlation model with no short sales allowed (part
5a).
d <- gr2$R[, -26] %*% ccm_r1$X

# e.Multigroup model (part 6).
e <- gr2$R[, -26] %*% multi_r$X

table <- cbind(a, b, c, d, e)
colnames(table) <- c("EA", "SIM_N", "SIM_50%50%", "CCM_N", "MIG")
table
```

```
##                   EA     SIM_N SIM_50%50%      CCM_N       MIG
## 2014-03-03  0.008439 -0.017643  -0.011322 -0.0097416  0.032165
## 2014-02-03  0.024011  0.046629   0.020814  0.0471015  0.070290
## 2014-01-02  0.028651 -0.006708  -0.005854 -0.0397925 -0.042370
## 2013-12-02  0.016239  0.047369   0.021185  0.0467167  0.079471
## 2013-11-01  0.004900  0.022805   0.008903  0.0196366  0.062025
## 2013-10-01  0.037223  0.059116   0.027058  0.0535521  0.036778
## 2013-09-03 -0.002118 -0.013146  -0.009073  0.0114744 -0.016815
## 2013-08-01 -0.024670 -0.034497  -0.019749 -0.0416076 -0.072767
## 2013-07-01  0.061042  0.020456   0.007728  0.0274361 -0.010914
## 2013-06-03  0.009890  0.015265   0.005133  0.0116124  0.002768
## 2013-05-01  0.051377  0.033228   0.014114  0.0257014 -0.002514
## 2013-04-01  0.028138  0.042938   0.018969  0.0507410  0.036225
## 2013-03-01  0.027040  0.039398   0.017199  0.0272440  0.040987
## 2013-02-01  0.104178  0.015336   0.005168  0.0121254 -0.041707
## 2013-01-02  0.037611  0.002092  -0.001454 -0.0009579  0.012617
## 2012-12-03  0.012597  0.015923   0.005461  0.0101597  0.023870
## 2012-11-01  0.161937  0.060945   0.027973  0.0585851 -0.111035
## 2012-10-01 -0.035652 -0.071785  -0.038392 -0.0674134 -0.032182
## 2012-09-04  0.021578 -0.012778  -0.008889 -0.0137161 -0.071965
## 2012-08-01  0.030403 -0.002923  -0.003962 -0.0026744 -0.014866
## 2012-07-02 -0.026841 -0.048363  -0.026682 -0.0325800 -0.025424
## 2012-06-01  0.053797  0.050050   0.022525  0.0454692  0.077568
## 2012-05-01 -0.031260  0.043401   0.019201  0.0481710  0.033124
## 2012-04-02 -0.038759  0.009437   0.002219  0.0080535  0.011000
## 2012-03-01  0.024047  0.046337   0.020669  0.0425581  0.071207
## 2012-02-01  0.018536  0.045141   0.020070  0.0415818  0.063534
```

```
tp_a <- testPort(gr2$R[, -26], X = rep(1, 25)/25)
tp_b <- testPort(gr2, sim_r1)
tp_c <- testPort(gr2, ccm_r1)
tp_d <- testPort(gr2, multi_r)

plot(tp_a, lty = 1, ylim = c(0.5, 2), lwd = 2, xlab = "Time Period
31-Jan-2011 to 31-March-2014",
    ylab = "Return (in Percentage)", main = "Return against Time
Period")  # Equal Allocation
lines(tp_b, lty = 2, col = "blue", lwd = 2)  # SIM
lines(cumprod(1 + rev(c)), lty = 3, col = "orange", lwd = 2)  # SIM
50%-50%
lines(tp_c, lty = 4, col = "green", lwd = 2)  # CCM
lines(tp_d, lty = 5, col = "purple", lwd = 2)  # MIG

lines(cumprod(1 + rev(gr2$R[, 26])), col = "red", lwd = 2, lty = 1)
# S&P 500
legend("topleft", lty = c(1:5, 1), c("Equal Allocation", "SIM_NS",
"50%SIM & 50%Rf",
    "CCM_NS", "MIG_S", "S&P500"), col = c("black", "blue",
"orange", "green",
    "purple", "red"), cex = 0.9)
```



average return of each portfolio in this period:

```
ExReturns <- colMeans(cbind(a, b, c, d, e))
names(ExReturns) <- c("Eq. Alloc.", "SIM_NS", "50%S_NS&50%Rf",
"CCM_NS", "MIG_S")
ExReturns
```

```
##    Eq. Alloc.        SIM_NS 50%S_NS&50%Rf        CCM_NS
MIG_S
##      0.023167      0.015693      0.005347      0.014594
0.008118
```

```
max(ExReturns)
```

```
## [1] 0.02317
```

```
min(ExReturns)
```

```
## [1] 0.005347
```

```
mean(gr2$R[, 26])
```

```
## [1] 0.01415
```

Based on the period 12/31/2006-12/31/2011, we see that SIM and CCM with short sell not allowed have lower return and risk. But when the short sell allowed, the risk and return are incresed. The EA model is the worst model because it has lowest return but highest risk.

For the future data(Dec/31/2011-Mar/31/2014), if we split the whole period to three, in the first period MIG, gives us the highest return. In the second and third period, the MIG decrease to the bottom and EA increases to the top. Overall, the combination of half SIM_NS and half Risk free model has the lowest return, and EA has the highest return. On the other hand, the return of EA model has huge diffienece between the period of before and after 2011, this telling me EA model is not stable. In this case, i will chose a stable model or change some stocks. Compare to the S&P 500 index, the return of SIM and CCM model are mostly close to the S&P 500.