Black-Litterman Assignment

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```r
library("readxl")
library('lubridate')
```

```
## Warning: package 'lubridate' was built under R version 3.6.3
```

```
##
## Attaching package: 'lubridate'
```

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

```r
library('dplyr')
```

```
## Warning: package 'dplyr' was built under R version 3.6.3
```

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

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

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

```r
library('zoo')
```

```
## Warning: package 'zoo' was built under R version 3.6.3
```

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

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

```r
library('moments')
```

```r
data <- read_excel("C:/Users/Zhongyun Zhang/desktop/data.xlsx",
sheet = 1, col_names = TRUE,
col_types = "guess")
```

```r
data <-  data[c(-1,-2)]
```

Part 1.

```r
covariance <- cov(data) %>% matrix(nrow=3)
eqweights <- c(0.5,0.4,0.1) %>% matrix(nrow = 3)

covariance%*%eqweights
```

```
##             [,1]
## [1,] 0.001765371
## [2,] 0.002013820
## [3,] 0.002411071
```

```r
aversion <- 3
tau <- 0.1

MktVar <- (t(eqweights))%*%(covariance%*%eqweights)

MarketExp.ExcessReturn <- aversion*MktVar
Std.Dev. <- sqrt(MktVar)

ShareRatio <- MarketExp.ExcessReturn/Std.Dev.


prior <- aversion*(covariance%*%eqweights)

adjcov <- tau*covariance
```

Views:

```r
ViewP <- c(1,0,0,1,0,-1) %>% matrix(nrow = 2)

ViewQ <- c(0.015,0.03) %>% matrix(nrow = 2)

RelativeConfidence <- 1

tau_omega <- 0.10



Omega <- tau_omega*(ViewP%*%(covariance%*%t(ViewP)))

diagomega <- Omega
diagomega[1,2] <- 0
```

```r
diagomega[2,1] <- 0


priorconf <- ViewP%*% ((tau*covariance)%*%(t(ViewP)))
```

Posterior Estimates:

```r
postret <- prior+((adjcov)%*% ((t(ViewP))%*% (solve(priorconf+Omega))))%*% (ViewQ-(ViewP%*%(prior)))


postdist <- covariance +adjcov-(((adjcov)%*%(t(ViewP)))%*%(solve(priorconf+Omega))) %*% (ViewP%*%adjcov
```

Portfolio Optimization:

```r
unconstrained_opt <- t(postret) %*% solve(aversion*postdist)

optweights <- unconstrained_opt/(sum(unconstrained_opt))
```

```r
Expected_Return <- t(postret)%*%t(optweights)

Variance <- ((optweights)%*%postdist)%*%(t(optweights))

SD <- sqrt(Variance)
Sharpe_Ratio <- Expected_Return/SD
```

```
## [1] "For part 1:"

## [1] "The market weights (prior) is:"

## [1] 0.5 0.4 0.1

## [1] "for US EQ, Foreign EQ, and Emerging EQ, respectively"

## [1] "The risk aversion parameter is:"

## [1] 3

## [1] "The scalar on the uncertainty in the prior is:"

## [1] 0.1

## [1] "The scalar on manager's views is:"

## [1] 0.1

## [1] "The matrices which capture the manager's views are:"

##      [,1] [,2] [,3]
## [1,]    1    0    0
## [2,]    0    1   -1
```

```
##       [,1]
## [1,] 0.015
## [2,] 0.030
```

```
## [1] "This means that, the manager believes the U.S. equity will earn an excess return of 1.5 %"
```

```
## [1] "and that, the manager believes that Foreign Equity will outperform Emerging Equity by 3 %"
```

```
## [1] "The posterior distribution of returns (expected returns and covariance matrix) are:"
```

```
##               [,1]
## [1,]  0.0101480562
## [2,]  0.0138731783
## [3,] -0.0005309452
```

```
##             [,1]        [,2]        [,3]
## [1,] 0.001937945 0.001678529 0.002132551
## [2,] 0.001678529 0.002608057 0.002560846
## [3,] 0.002132551 0.002560846 0.004650716
```

```
## [1] "The optimal weight in each security is:"
```

```
##           [,1]     [,2]     [,3]
## [1,] 0.8128368 1.280813 -1.09365
```

```
## [1] "for US Equity, Foreign Equity, and Emerging Equity, respectively"
```

```
## [1] "After optimization, the expected return is:"
```

```
## [1] 0.02659832
```

```
## [1] "Standard deviation is:"
```

```
## [1] 0.06042102
```

```
## [1] "Sharpe Ratio of the maximum Sharpe Ratio Portfolio is:"
```

```
## [1] 0.4402164
```

Part 2:

```
covariance <- cov(data) %>% matrix(nrow=3)
eqweights <- c(0.5,0.4,0.1) %>% matrix(nrow = 3)

covariance%*%eqweights
```

```
##             [,1]
## [1,] 0.001765371
## [2,] 0.002013820
## [3,] 0.002411071
```

```r
aversion <- 3
tau <- 0.1

MktVar <- (t(eqweights))%*%(covariance%*%eqweights)

MarketExp.ExcessReturn <- aversion*MktVar
Std.Dev. <- sqrt(MktVar)

ShareRatio <- MarketExp.ExcessReturn/Std.Dev.


prior <- aversion*(covariance%*%eqweights)

adjcov <- tau*covariance
```

Views:

```r
ViewP <- c(1,0,0,1,0,-1) %>% matrix(nrow = 2)

ViewQ <- c(0.015,0.03) %>% matrix(nrow = 2)

RelativeConfidence <- 1

tau_omega <- 0.01


Omega <- tau_omega*(ViewP%*%(covariance%*%t(ViewP)))

diagomega <- Omega
diagomega[1,2] <- 0
diagomega[2,1] <- 0


priorconf <- ViewP%*% ((tau*covariance)%*%(t(ViewP)))
```

Posterior Estimates:

```r
postret <- prior+((adjcov)%*% ((t(ViewP))%*% (solve(priorconf+Omega))))%*% (ViewQ-(ViewP%*%(prior)))


postdist <- covariance +adjcov-(((adjcov)%*%(t(ViewP)))%*%(solve(priorconf+Omega))) %*% (ViewP%*%adjcov
```

Portfolio Optimization:

```r
unconstrained_opt <- t(postret) %*% solve(aversion*postdist)

optweights <- unconstrained_opt/(sum(unconstrained_opt))
```

```r
Expected_Return <- t(postret)%*%t(optweights)

Variance <- ((optweights)%*%postdist)%*%(t(optweights))
```

```r
SD <- sqrt(Variance)
Sharpe_Ratio <- Expected_Return/SD
```

```
## [1] "For part 2:"

## [1] "The market weights (prior) is:"

## [1] 0.5 0.4 0.1

## [1] "for US EQ, Foreign EQ, and Emerging EQ, respectively"

## [1] "The risk aversion parameter is:"

## [1] 3

## [1] "The scalar on the uncertainty in the prior is:"

## [1] 0.1

## [1] "The scalar on manager's views is:"

## [1] 0.01

## [1] "The matrices which capture the manager's views are:"

##      [,1] [,2] [,3]
## [1,]    1    0    0
## [2,]    0    1   -1

##       [,1]
## [1,] 0.015
## [2,] 0.030

## [1] "This means that, the manager believes the U.S. equity will earn an excess return of 1.5 %"

## [1] "and that, the manager believes that Foreign Equity will outperform Emerging Equity by 3 %"

## [1] "The posterior distribution of returns (expected returns and covariance matrix) are:"

##              [,1]
## [1,]  0.014117828
## [2,]  0.020280948
## [3,] -0.006883438

##             [,1]        [,2]        [,3]
## [1,] 0.001862441 0.001613132 0.002049465
## [2,] 0.001613132 0.002547692 0.002502320
## [3,] 0.002049465 0.002502320 0.004510767
```

```
## [1] "The optimal weight in each security is:"

##           [,1]     [,2]      [,3]
## [1,] 0.8798722 1.469555 -1.349427

## [1] "for US Equity, Foreign Equity, and Emerging Equity, respectively"

## [1] "After optimization, the expected return is:"

## [1] 0.05151455

## [1] "Standard deviation is:"

## [1] 0.0673655

## [1] "Sharpe Ratio of the maximum Sharpe Ratio Portfolio is:"

## [1] 0.7647024
```

Part 3:

```r
covariance <- cov(data) %>% matrix(nrow=3)
eqweights <- c(0.5,0.4,0.1) %>% matrix(nrow = 3)

covariance%*%eqweights
```

```
##             [,1]
## [1,] 0.001765371
## [2,] 0.002013820
## [3,] 0.002411071
```

```r
aversion <- 3
tau <- 0.1

MktVar <- (t(eqweights))%*%(covariance%*%eqweights)

MarketExp.ExcessReturn <- aversion*MktVar
Std.Dev. <- sqrt(MktVar)

ShareRatio <- MarketExp.ExcessReturn/Std.Dev.


prior <- aversion*(covariance%*%eqweights)

adjcov <- tau*covariance
```

Views:

```r
ViewP <- c(0,1,0,-1,1,0) %>% matrix(nrow = 2)

ViewQ <- c(0.015,0.02) %>% matrix(nrow = 2)

tau_omega <- 0.10



Omega <- tau_omega*(ViewP%*%(covariance%*%t(ViewP)))

diagomega <- Omega
diagomega[1,2] <- 0
diagomega[2,1] <- 0


priorconf <- ViewP%*% ((tau*covariance)%*%(t(ViewP)))
```

Posterior Estimates:

```r
postret <- prior+((adjcov)%*% ((t(ViewP))%*% (solve(priorconf+Omega))))%*% (ViewQ-(ViewP%*%(prior)))


postdist <- covariance +adjcov-(((adjcov)%*%(t(ViewP)))%*%(solve(priorconf+Omega))) %*% (ViewP%*%adjcov
```

Portfolio Optimization:

```r
unconstrained_opt <- t(postret) %*% solve(aversion*postdist)

optweights <- unconstrained_opt/(sum(unconstrained_opt))
```

```r
Expected_Return <- t(postret)%*%t(optweights)

Variance <- ((optweights)%*%postdist)%*%(t(optweights))

SD <- sqrt(Variance)
Sharpe_Ratio <- Expected_Return/SD
```

```
## [1] "For part 3:"

## [1] "The market weights (prior) is:"

## [1] 0.5 0.4 0.1

## [1] "for US EQ, Foreign EQ, and Emerging EQ, respectively"

## [1] "The risk aversion parameter is:"

## [1] 3

## [1] "The scalar on the uncertainty in the prior is:"
```

```
## [1] 0.1

## [1] "The scalar on manager's views is:"

## [1] 0.1

## [1] "The matrices which capture the manager's views are:"

##      [,1] [,2] [,3]
## [1,]    0    0    1
## [2,]    1   -1    0

##       [,1]
## [1,] 0.015
## [2,] 0.020

## [1] "This means that, the manager believes Emerging Equity will earn an excess return of 1.5 %"

## [1] "and that, the manager believes that U.S. Equity will outperform Foreign Equity by 2 %"

## [1] "The posterior distribution of returns (expected returns and covariance matrix) are:"

##             [,1]
## [1,] 0.011293730
## [2,] 0.001666404
## [3,] 0.011116607

##             [,1]        [,2]        [,3]
## [1,] 0.001975033 0.001715618 0.002132551
## [2,] 0.001715618 0.002597023 0.002512724
## [3,] 0.002132551 0.002512724 0.004602595

## [1] "The optimal weight in each security is:"

##          [,1]      [,2]      [,3]
## [1,] 2.477713 -1.924651 0.4469385

## [1] "for US Equity, Foreign Equity, and Emerging Equity, respectively"

## [1] "After optimization, the expected return is:"

## [1] 0.02974381

## [1] "Standard deviation is:"

## [1] 0.08186523

## [1] "Sharpe Ratio of the maximum Sharpe Ratio Portfolio is:"

## [1] 0.3633266
```