HW8

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```
library(stats)
library(glmnet)
```

```
## Loading required package: Matrix
```

```
## Loaded glmnet 4.1-8
```

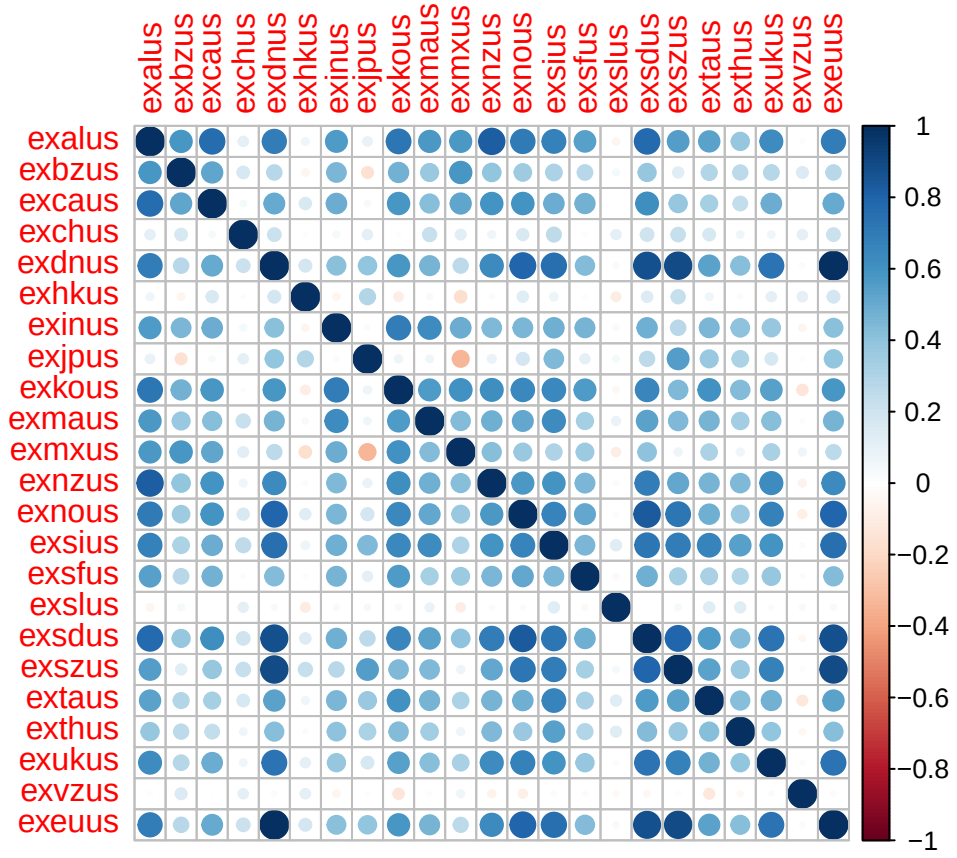
```
library(Rcpp)
library(ggplot2)
library(reshape2)
library(corrplot)
```

```
## corrplot 0.92 loaded
```

```
fx <- read.csv("FXmonthly.csv")
fx <- (fx[2:120,]-fx[1:119,])/(fx[1:119,])
sp500 <- read.csv("sp500.csv")
```

Q1

```
# Calculate and visualize the correlation matrix
cor_matrix <- cor(fx)
corrplot::corrplot(cor_matrix, method = "circle")
```




```
print(cor_matrix)
```

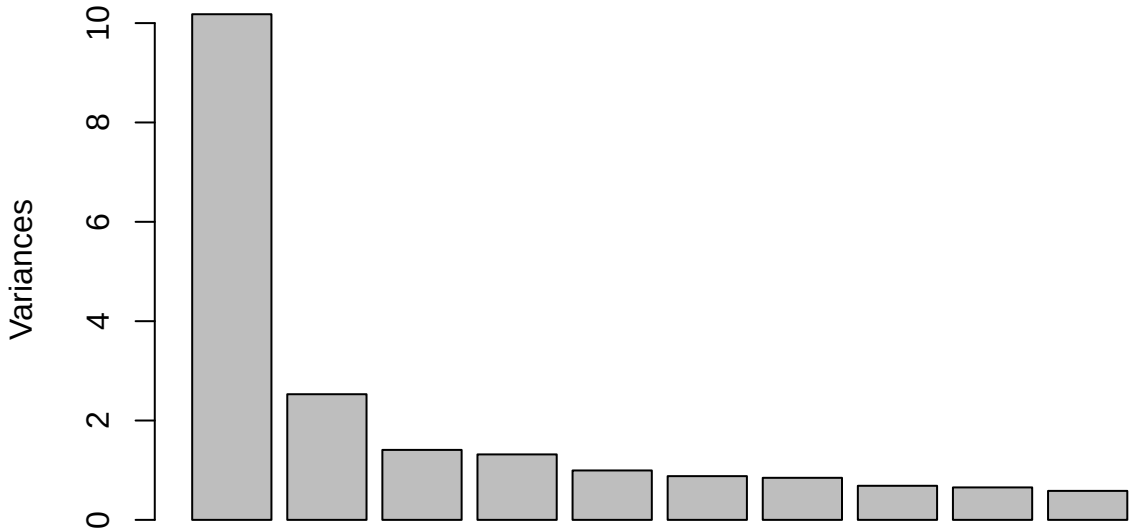
```
##              exalus      exbzus       excaus      exchus     exdnus      exhkus
## exalus  1.00000000  0.58175989  0.767082047  0.11727915 0.69337237  0.06537836
## exbzus  0.58175989  1.00000000  0.528220372  0.17863302 0.27143808 -0.05635785
## excaus  0.76708205  0.52822037  1.000000000  0.04068525 0.50909233  0.16829975
## exchus  0.11727915  0.17863302  0.040685248  1.00000000 0.21193710 -0.01373482
## exdnus  0.69337237  0.27143808  0.509092334  0.21193710 1.00000000  0.18356138
## exhkus  0.06537836 -0.05635785  0.168299746 -0.01373482 0.18356138  1.00000000
## exinus  0.56643366  0.45185923  0.491889601  0.04784365 0.41593014 -0.05615073
## exjpus  0.09801590 -0.15749270  0.039220986  0.11571297 0.39359908  0.29574596
## exkous  0.72814970  0.47861233  0.588068900 -0.01249390 0.58492032 -0.09805734
## exmaus  0.57712730  0.37631122  0.424050033  0.22761219 0.46697366  0.03852689
## exmxus  0.57254436  0.58550185  0.523839090  0.12889329 0.26236374 -0.17344927
## exnzus  0.82643030  0.39802430  0.590478508  0.06429703 0.63476982  0.02107797
## exnous  0.70315971  0.35869709  0.593670045  0.16323701 0.79875447  0.13939685
## exsius  0.67269014  0.31908519  0.491869495  0.25519693 0.75405973  0.07872857
## exsfus  0.54559249  0.27818141  0.478810449 -0.01594770 0.43347314 -0.01759496
## exslus -0.05625596  0.04774288 -0.003387010  0.11146100 0.03304917 -0.10181141
## exsdus  0.77314442  0.38226603  0.614459190  0.20973735 0.87510355  0.14334424
## exszus  0.55127199  0.13824224  0.389702628  0.23866511 0.89673015  0.23019774
## extaus  0.53241829  0.29459519  0.333242030  0.17812196 0.53115545  0.06545395
## exthus  0.38798709  0.26515836  0.245459175  0.06064813 0.42328082 -0.02434322
## exukus  0.62107036  0.28193360  0.492751835  0.06004167 0.73577586  0.11450973
## exvzus -0.01779933  0.15666509 -0.001398935  0.11587775 0.02679405  0.11752392
## exeuus  0.69194861  0.27158106  0.504834190  0.21198720 0.99969760  0.18334955
##              exinus      exjpus      exkous      exmaus      exmxus      exnzus
```

```
## exalus  0.56643366  0.09801590  0.72814970  0.57712730  0.57254436  0.82643030
## exbzus  0.45185923 -0.15749270  0.47861233  0.37631122  0.58550185  0.39802430
## excaus  0.49188960  0.03922099  0.58806890  0.42405003  0.52383909  0.59047851
## exchus  0.04784365  0.11571297 -0.01249390  0.22761219  0.12889329  0.06429703
## exdnus  0.41593014  0.39359908  0.58492032  0.46697366  0.26236374  0.63476982
## exhkus -0.05615073  0.29574596 -0.09805734  0.03852689 -0.17344927  0.02107797
## exinus  1.00000000  0.02629958  0.69868912  0.62858503  0.49929499  0.44375739
## exjpus  0.02629958  1.00000000  0.07230273  0.06031551 -0.33065785  0.08599334
## exkous  0.69868912  0.07230273  1.00000000  0.56874190  0.60836124  0.61913120
## exmaus  0.62858503  0.06031551  0.56874190  1.00000000  0.43272821  0.48709449
## exmxus  0.49929499 -0.33065785  0.60836124  0.43272821  1.00000000  0.42427106
## exnzus  0.44375739  0.08599334  0.61913120  0.48709449  0.42427106  1.00000000
## exnous  0.45568544  0.18986625  0.64859119  0.51163568  0.37117974  0.57617907
## exsius  0.48821506  0.44334003  0.64944801  0.62731643  0.30814886  0.59447977
## exsfus  0.46126593  0.11062863  0.56572912  0.33905995  0.36649642  0.45755149
## exslus  0.03547963  0.04199605 -0.03763470  0.08669653 -0.09266344 -0.02565823
## exsdus  0.48308539  0.26558951  0.65546644  0.53858563  0.40278409  0.69924506
## exszus  0.27106252  0.55556312  0.44009345  0.44036337  0.07137343  0.51715164
## extaus  0.45827196  0.37505875  0.60340968  0.46628391  0.31284204  0.46960797
## exthus  0.40372659  0.31791591  0.43751317  0.34751629  0.06834804  0.44506296
## exukus  0.38619538  0.17870941  0.54446050  0.42637156  0.32033512  0.62730344
## exvzus -0.05660536 -0.01543783 -0.13978309 -0.01630159  0.06837558 -0.06886414
## exeuus  0.41482667  0.39230675  0.58340259  0.46725497  0.26173544  0.63450577
##             exnous      exsius      exsfus       exslus       exsdus
## exalus  0.70315971  0.67269014  0.54559249 -0.056255956  0.773144416
## exbzus  0.35869709  0.31908519  0.27818141  0.047742881  0.382266032
## excaus  0.59367004  0.49186949  0.47881045 -0.003387010  0.614459190
## exchus  0.16323701  0.25519693 -0.01594770  0.111461004  0.209737346
## exdnus  0.79875447  0.75405973  0.43347314  0.033049174  0.875103547
## exhkus  0.13939685  0.07872857 -0.01759496 -0.101811413  0.143344237
## exinus  0.45568544  0.48821506  0.46126593  0.035479633  0.483085389
## exjpus  0.18986625  0.44334003  0.11062863  0.041996048  0.265589507
## exkous  0.64859119  0.64944801  0.56572912 -0.037634701  0.655466435
## exmaus  0.51163568  0.62731643  0.33905995  0.086696532  0.538585629
## exmxus  0.37117974  0.30814886  0.36649642 -0.092663441  0.402784092
## exnzus  0.57617907  0.59447977  0.45755149 -0.025658225  0.699245061
## exnous  1.00000000  0.66737540  0.51236031  0.022308998  0.834378993
## exsius  0.66737540  1.00000000  0.45356322  0.139018508  0.721657909
## exsfus  0.51236031  0.45356322  1.00000000 -0.036317889  0.488569655
## exslus  0.02230900  0.13901851 -0.03631789  1.000000000 -0.001847732
## exsdus  0.83437899  0.72165791  0.48856965 -0.001847732  1.000000000
## exszus  0.72799036  0.69781934  0.33353238  0.043268845  0.797027907
## extaus  0.48710314  0.66451614  0.32376293  0.137020618  0.566664748
## exthus  0.37097575  0.54304525  0.29471735  0.135590097  0.431078059
## exukus  0.67703722  0.59904549  0.38843005  0.023796836  0.736155303
## exvzus -0.08760748 -0.02065454 -0.02102668 -0.032644674 -0.040674882
## exeuus  0.79573687  0.75407025  0.43231367  0.036629370  0.873324184
##             exszus      extaus      exthus      exukus       exvzus     exeuus
## exalus  0.55127199  0.53241829  0.38798709  0.62107036 -0.017799328 0.69194861
## exbzus  0.13824224  0.29459519  0.26515836  0.28193360  0.156665087 0.27158106
## excaus  0.38970263  0.33324203  0.24545917  0.49275184 -0.001398935 0.50483419
## exchus  0.23866511  0.17812196  0.06064813  0.06004167  0.115877754 0.21198720
## exdnus  0.89673015  0.53115545  0.42328082  0.73577586  0.026794054 0.99969760
## exhkus  0.23019774  0.06545395 -0.02434322  0.11450973  0.117523924 0.18334955
```

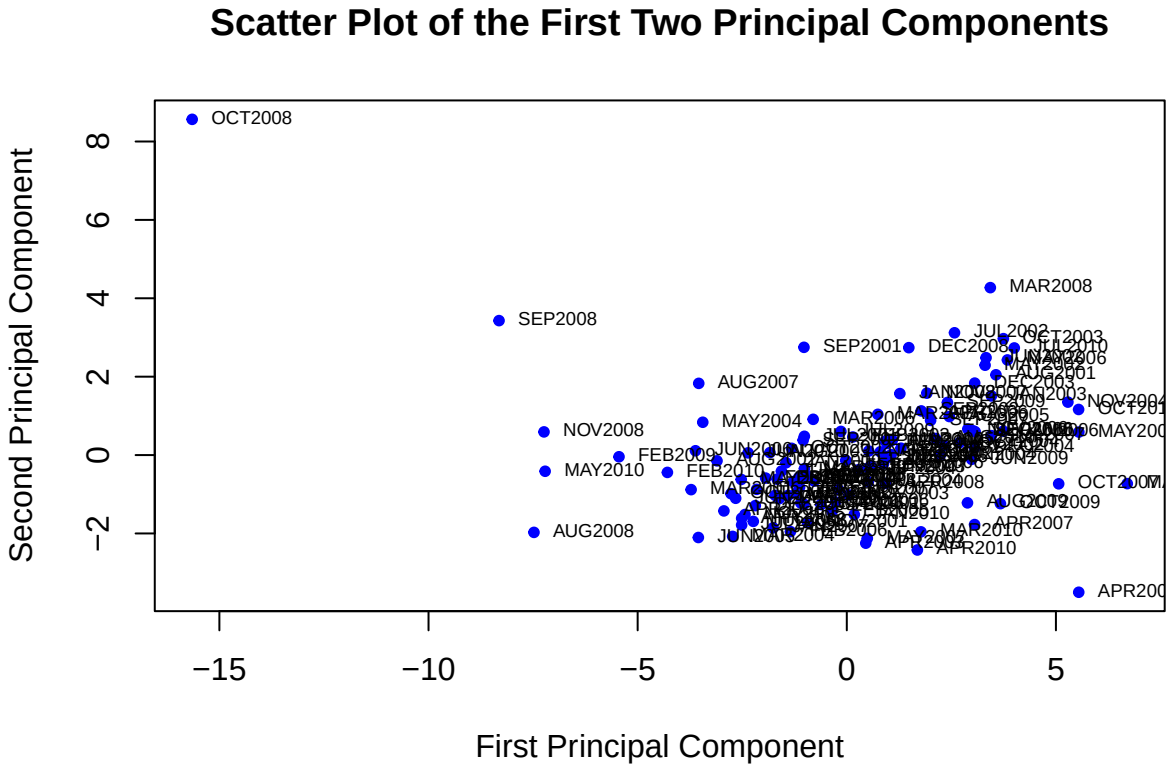
```
## exinus  0.27106252  0.45827196  0.40372659  0.38619538 -0.056605363 0.41482667
## exjpus  0.55556312  0.37505875  0.31791591  0.17870941 -0.015437827 0.39230675
## exkous  0.44009345  0.60340968  0.43751317  0.54446050 -0.139783095 0.58340259
## exmaus  0.44036337  0.46628391  0.34751629  0.42637156 -0.016301594 0.46725497
## exmxus  0.07137343  0.31284204  0.06834804  0.32033512  0.068375579 0.26173544
## exnzus  0.51715164  0.46960797  0.44506296  0.62730344 -0.068864136 0.63450577
## exnous  0.72799036  0.48710314  0.37097575  0.67703722 -0.087607476 0.79573687
## exsius  0.69781934  0.66451614  0.54304525  0.59904549 -0.020654537 0.75407025
## exsfus  0.33353238  0.32376293  0.29471735  0.38843005 -0.021026679 0.43231367
## exslus  0.04326884  0.13702062  0.13559010  0.02379684 -0.032644674 0.03662937
## exsdus  0.79702791  0.56666475  0.43107806  0.73615530 -0.040674882 0.87332418
## exszus  1.00000000  0.53815259  0.37443024  0.67677862 -0.018493536 0.89445029
## extaus  0.53815259  1.00000000  0.42588984  0.47378345 -0.126804225 0.53134140
## exthus  0.37443024  0.42588984  1.00000000  0.39123809 -0.039137403 0.42120387
## exukus  0.67677862  0.47378345  0.39123809  1.00000000 -0.027253590 0.73354533
## exvzus -0.01849354 -0.12680422 -0.03913740 -0.02725359  1.000000000 0.02657169
## exeuus  0.89445029  0.53134140  0.42120387  0.73354533  0.026571689 1.00000000
```

Q2

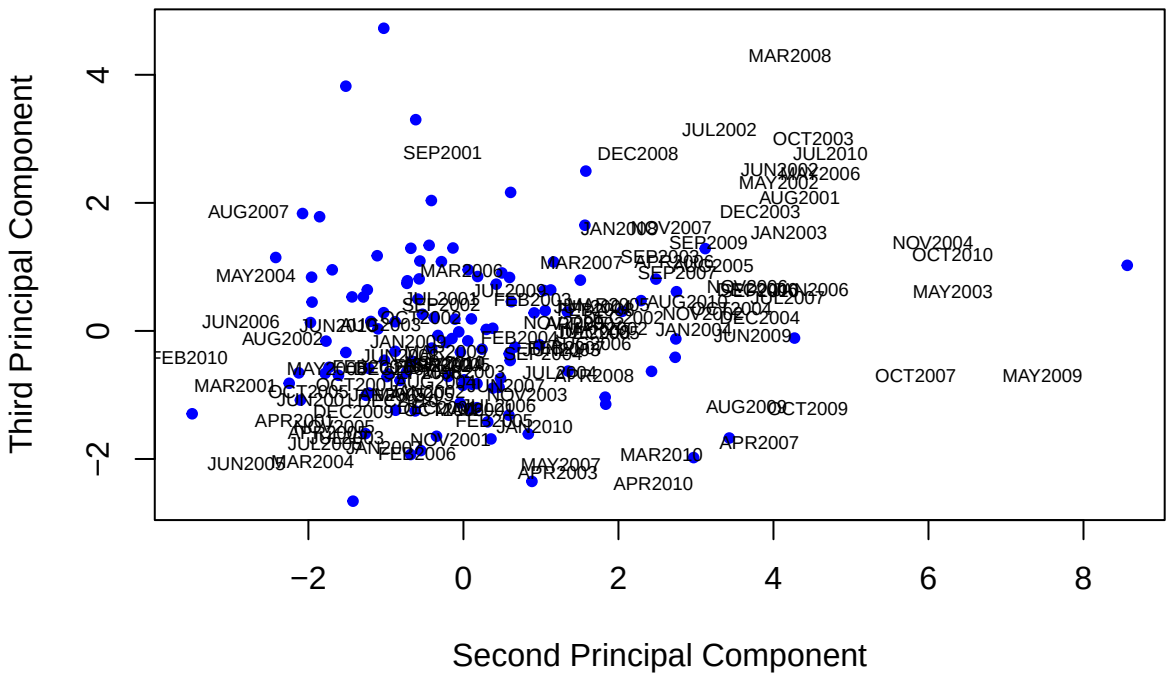
```r
# Fit PCA
pcfx <- prcomp(fx, scale = TRUE)

plot(pcfx, main="")
```




```r
pcs <- predict(pcfx)

plot(pcs[,1], pcs[,2], xlab = "First Principal Component", ylab = "Second Principal Component", main =

text(pcs[,1], pcs[,2], labels = rownames(pcs), pos = 4, cex = 0.6)
```




```
plot(pcs[,2], pcs[,3], xlab = "Second Principal Component", ylab = "Third Principal Component", main =

text(pcs[,1], pcs[,2], labels = rownames(pcs), pos = 4, cex = 0.6)
```



```
# far right
smallest_pcs <- sort(pcs[,1])[1:5]
smallest_pcs
```

```
##    OCT2008    SEP2008    AUG2008    NOV2008    MAY2010
## -15.650761  -8.314062  -7.479007  -7.239428  -7.212144
```

```
# far left
largest_pcs <- sort(pcs[,1], decreasing = TRUE)[1:5]
largest_pcs
```

```
##  MAY2009  MAY2003  APR2009  OCT2010  NOV2004
## 6.706182 5.548390 5.545457 5.542401 5.286064
```

```
t(round(pcfx$rotation[,1:2],2))
```

```
##     exalus exbzus excaus exchus exdnus exhkus exinus exjpus exkous exmaus
## PC1  -0.28  -0.16  -0.22  -0.06  -0.28  -0.03  -0.20  -0.09  -0.25  -0.21
## PC2   0.14   0.33   0.18  -0.08  -0.21  -0.26   0.23  -0.46   0.20   0.11
##     exmxus exnzus exnous exsius exsfus exslus exsdus exszus extaus exthus
## PC1  -0.16  -0.25  -0.27  -0.26  -0.19  -0.01  -0.29  -0.24  -0.21  -0.17
## PC2   0.43   0.08  -0.05  -0.12   0.12  -0.06  -0.08  -0.33  -0.07  -0.08
##     exukus exvzus exeuus
## PC1  -0.24   0.01  -0.28
## PC2  -0.08   0.01  -0.21
```

PC1 Loadings: - Mostly negative across many currencies, indicating a general pattern where an increase in the principal component score corresponds to a decrease in these currency values against their pair. - The magnitude of the loadings (e.g., -0.28 for exdnus) signifies how much a unit change in the principal component affects the currency. Larger absolute values mean greater sensitivity to changes in this component.

PC2 Loadings: - Mixed signs across different currencies indicate diverse influences captured by this component. For instance, a positive loading for exbzus (0.33) against a negative for exjpus (-0.46) highlights how different economic or market conditions might be driving movements in these currencies.

Q3

```
set.seed(4)

if (!requireNamespace("AICcmodavg", quietly = TRUE)) {
  install.packages("AICcmodavg")
}

# Load the AICcmodavg package
library(AICcmodavg)

# Convert the principal components to a data frame for modeling
zdf <- as.data.frame(pcs)

# Perform regression using the first two principal components
summary(fxglm <- glm(sp500$sp500 ~ ., data=zdf[, 1:2]))
```

```
##
## Call:
## glm(formula = sp500$sp500 ~ ., data = zdf[, 1:2])
##
```

```
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.0004431  0.0036555   0.121    0.904
## PC1          0.0059741  0.0011506   5.192 8.97e-07 ***
## PC2         -0.0111795  0.0023081  -4.844 3.98e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for gaussian family taken to be 0.001590122)
##
##     Null deviance: 0.26463  on 118  degrees of freedom
## Residual deviance: 0.18445  on 116  degrees of freedom
## AIC: -424.16
##
## Number of Fisher Scoring iterations: 2
```

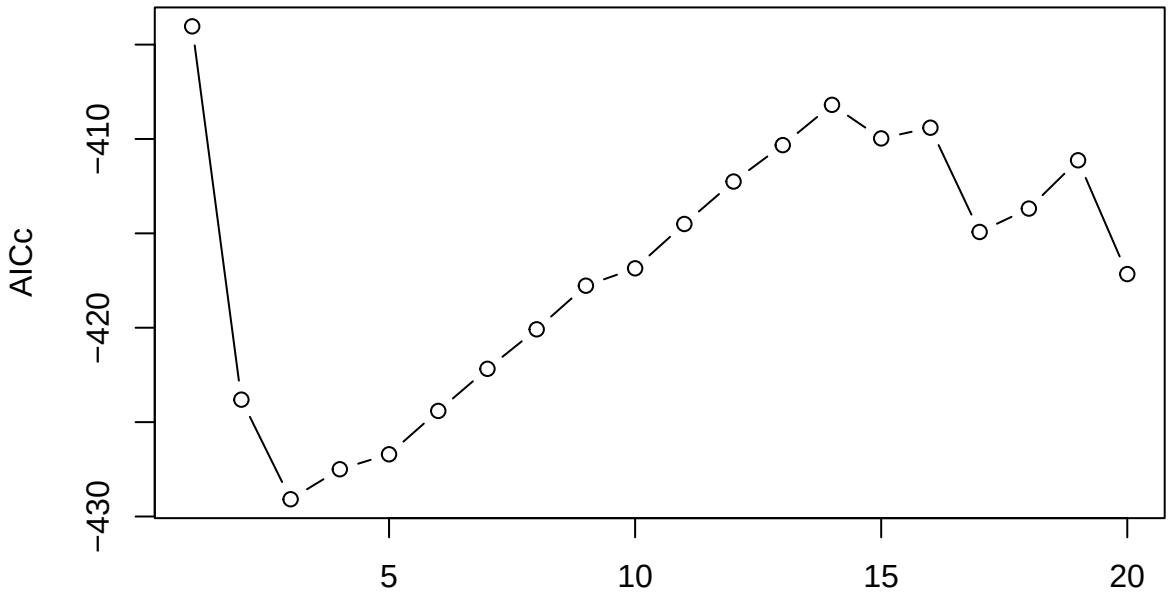
```
# Function to calculate AICc for a glm model
calculateAICc <- function(model) {
  AICc(model)
}

# Perform GLM fits on 1:20 factors and calculate AICc for each
kfits <- lapply(1:20, function(K) {
  glm(sp500$sp500 ~ ., data = zdf[, 1:K, drop = FALSE])
})

aicc <- sapply(kfits, calculateAICc) # Apply AICc calculation to each fit
which.min(aicc) # Determine which model size (number of factors) is preferred by AICc
```

```
## [1] 3
```

```
# Optionally, also calculate BIC for comparison
bic <- sapply(kfits, BIC)
which.min(bic) # Determine which model size (number of factors) is preferred by BIC
```

```
## [1] 3
```

```
# Plot the AICc values
plot(aicc, type = 'b', xlab = "Number of Factors", ylab = "AICc", main = "AICc by Number of Factors")
```

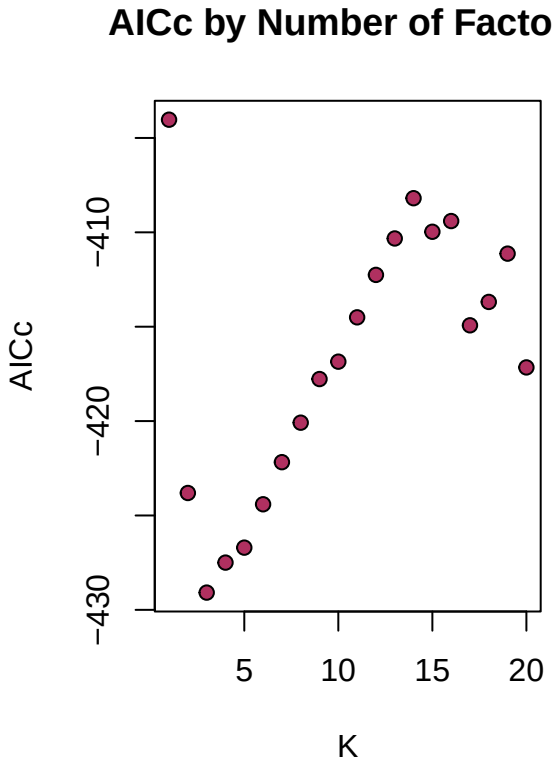


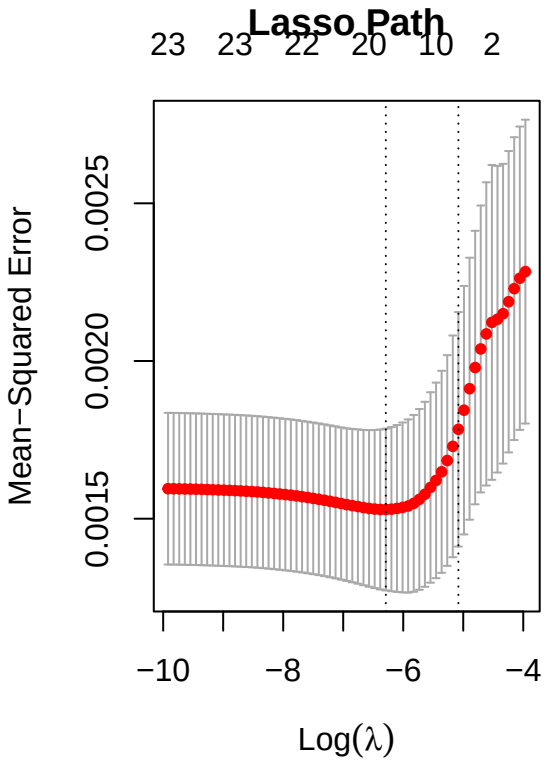

```
best_aicc_index <- which.min(aicc)
print(coef(kfits[[best_aicc_index]]))
```

```
##   (Intercept)           PC1           PC2           PC3
##  0.0004430924  0.0059741190 -0.0111794596 -0.0082100077
```

```
# Ensure the glmnet package is installed and loaded
if (!requireNamespace("glmnet", quietly = TRUE)) {
    install.packages("glmnet")
}
library(glmnet)

# Assuming 'pcs' is a data frame or matrix of principal components
# and 'sp500$sp500' is a vector of your response variable

# Convert 'pcs' to matrix if it is not already
pcs_matrix <- as.matrix(pcs)

# Set seed for reproducibility

# Perform Lasso regression with cross-validation
lassoPCR <- cv.glmnet(x = pcs_matrix, y = sp500$sp500, family = "gaussian", nfolds = 20, alpha = 1)

# Coefficients at the best lambda (lambda that gives minimum mean cross-validated error)
lasso_coef <- coef(lassoPCR, s = "lambda.min")

# Plotting the results
par(mfrow=c(1,2))  # Set up the plotting area to have 1 row and 2 columns

# Plot AICc
```

```r
plot(aicc, pch=21, bg="maroon", xlab="K", ylab="AICc", main="AICc by Number of Factors")

# Plot Lasso path
plot(lassoPCR)
title("Lasso Path")
```






```r
lambda_min <- lassoPCR$lambda.min
lasso_model_min <- glmnet(pcs_matrix, sp500$sp500, lambda = lambda_min)
coefficients_min <- coef(lassoPCR, s = "lambda.min")
print(coefficients_min)
```

```
## 24 x 1 sparse Matrix of class "dgCMatrix"
##                        s1
## (Intercept)  4.430924e-04
## PC1          5.390442e-03
## PC2         -1.000862e-02
## PC3         -6.640944e-03
## PC4          8.040491e-04
## PC5         -2.372076e-03
## PC6          .
## PC7          .
## PC8          2.511257e-05
## PC9          .
## PC10        -3.216481e-03
## PC11         .
## PC12         1.455595e-04
## PC13        -1.719840e-03
## PC14         1.176683e-03
## PC15        -9.666570e-03
## PC16         6.210347e-03
```

```
## PC17        -1.703749e-02
## PC18        -5.406683e-03
## PC19        -3.719735e-04
## PC20        -2.238073e-02
## PC21        -1.476752e-02
## PC22         .
## PC23         4.434570e-01
```

Q4