Wavelet Analysis

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2024-05-20

Performing Wavelet Analysis

Performing Maximum Overlap Discrete Wavelet Transform (MODWT), obtaining multi-resolution decomposition (MRD), compute (estimated) wavelet variances.

```
warning=FALSE
library(readxl)
```

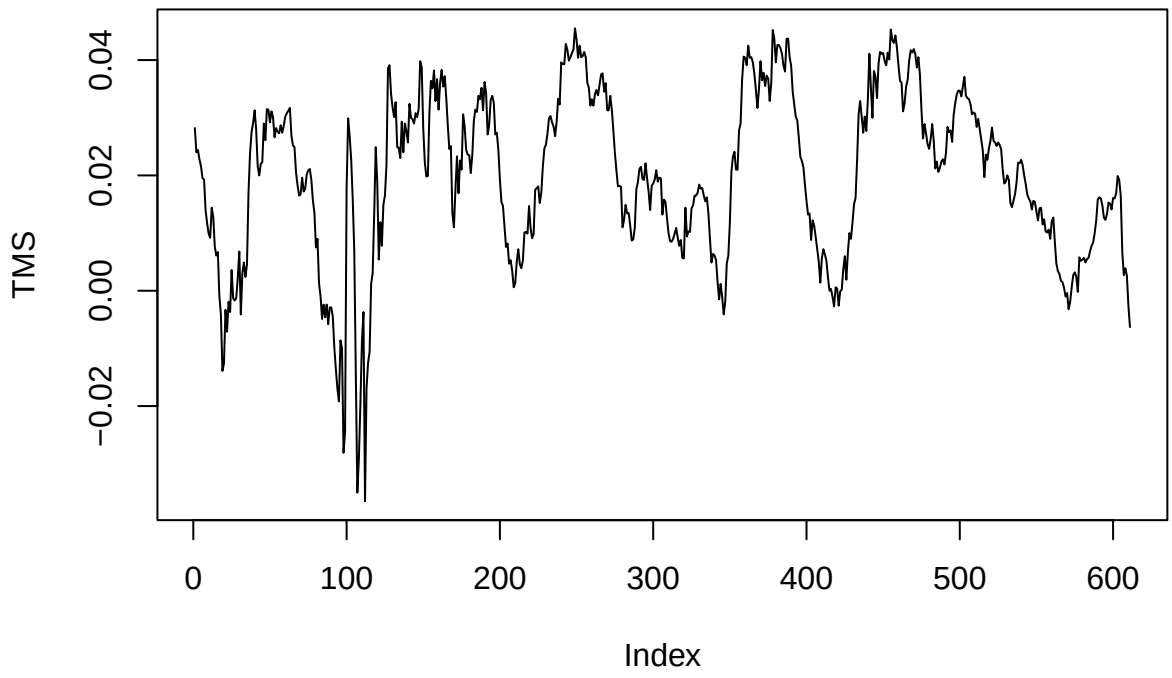
```
## Warning: package 'readxl' was built under R version 4.3.3
```

```
library(waveslim)
```

```
## Warning: package 'waveslim' was built under R version 4.3.3
```

```
##
## waveslim: Wavelet Method for 1/2/3D Signals (version = 1.8.4)
```

```
PredictorData2022 <- read_excel("C:/Users/dell/Desktop/Sem 2/Mathematical and Quantitative Finance/Rcod
data_new<-subset(PredictorData2022, yyyymm>=197202 & yyyymm<=202212)
TMS<-as.numeric(data_new$lty)-as.numeric(data_new$tbl)
plot(TMS, type='l')
```




```
modwt_tms<-modwt(x=TMS, wf='la8', n.levels=6)
modwt_bw_tms<-brick.wall(modwt_tms, wf='la8', method="modwt")
lapply(X=modwt_bw_tms,FUN='var',na.rm=TRUE)
```

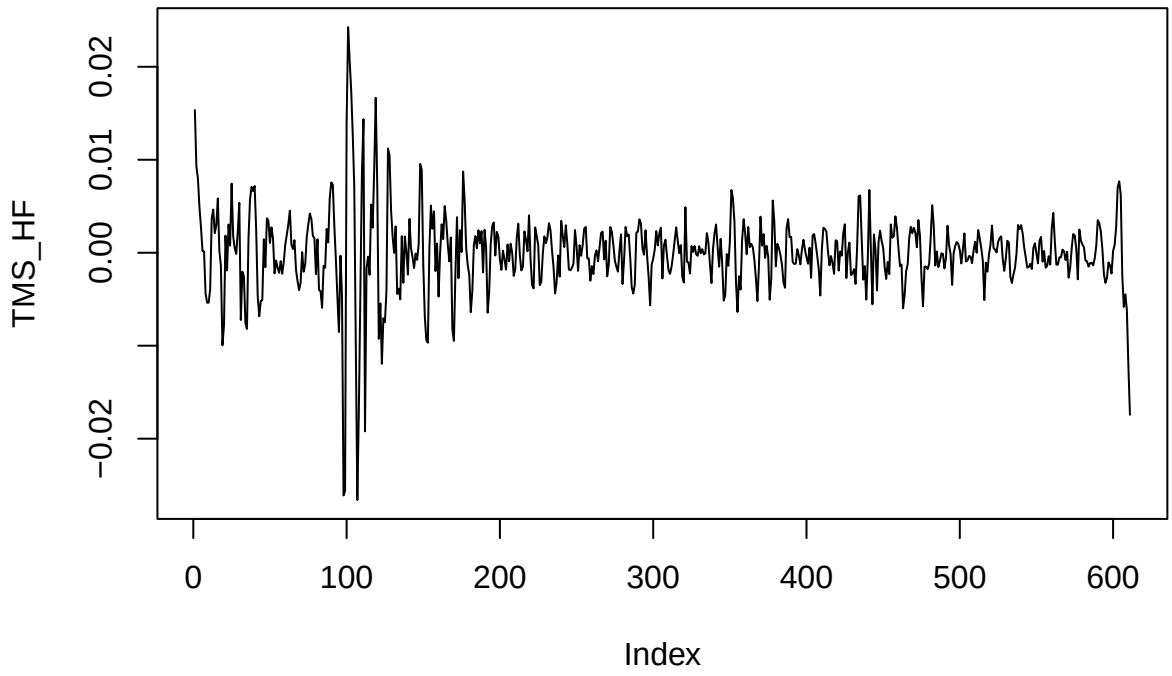
```
## $d1
## [1] 3.245806e-06
##
## $d2
## [1] 5.66157e-06
##
## $d3
## [1] 1.115451e-05
##
## $d4
## [1] 1.630325e-05
##
## $d5
## [1] 3.45499e-05
##
## $d6
## [1] 7.520181e-05
##
## $s6
## [1] 2.127183e-05
```

```r
round(var(TMS, na.rm = TRUE),5)
```

```
## [1] 0.00021
```

```r
mrd<-mra(x=TMS, wf='la8', J=6, method = 'modwt', boundary = 'periodic')
TMS_HF<-mrd$D1+mrd$D2+mrd$D3
TMS_BCF<-mrd$D4+mrd$D5+mrd$D6
TMS_LF<-mrd$S6
```

```r
plot(TMS_HF,type = 'l')
```




```r
summary(TMS_HF)
```

```
##       Min.    1st Qu.     Median       Mean    3rd Qu.       Max.
## -0.0265956 -0.0016717  0.0001281  0.0000000  0.0018743  0.0242661
```

```r
library('kohonen')
```

```
## Warning: package 'kohonen' was built under R version 4.3.3
```

```r
library('gmm')
```

```
## Warning: package 'gmm' was built under R version 4.3.3
```

```
## Loading required package: sandwich
```

```r
library('data.table')
```

```
## Warning: package 'data.table' was built under R version 4.3.2
```

```r
library('ggplot2')
```

```
## Warning: package 'ggplot2' was built under R version 4.3.3
```

```r
data<-read.table('C:/Users/dell/Desktop/Sem 2/Mathematical and Quantitative Finance/Rcode/Quiz7/stock_p
tickers<-c('APTV', 'WFC', 'UNM', 'DAL', 'JKHY', 'CVS', 'CBOE', 'KHC',
           'CFG', 'CNP', 'PFE', 'OKE', 'EW', 'MMC', 'CB', 'MAR', 'CLX',
           'HP', 'ORLY', 'AVY', 'PWR', 'LKQ', 'ILMN', 'HRB', 'DTE', 'ED',
           'VFC', 'MCK', 'WDC', 'AON', 'SCHW', 'AME', 'MCO', 'MTD',
           'NDAQ', 'FLR', 'ROK', 'NOV', 'LEG', 'LUV', 'NWS', 'OMC',
           'URI', 'AEE', 'WEC')
selected_stocks<-data[, c("Date", "yyyymmdd", tickers)]
Date <- selected_stocks$Date
yyyymmdd<-selected_stocks$yyyymmdd

calculate_simple_returns <- function(prices) {
  returns <- (diff(prices) / head(prices, -1)) * 100
  return(c(NA, returns))
}
selected_stocks_nodates<-selected_stocks[,-c(1,2)]
returns<-apply(X=selected_stocks_nodates, MARGIN = 2, FUN = "calculate_simple_returns" )

returns_new<-cbind(Date,yyyymmdd,returns)

returns_final<-subset(returns_new, yyyymmdd>=20180108 & yyyymmdd<=20240228)

famafrench<-read.table('C:/Users/dell/Desktop/Sem 2/Mathematical and Quantitative Finance/Rcode/Quiz7/F
famafrench<-subset(famafrench, Date>=20180108 & Date<=20240228)
famafrench<-famafrench[,-1]

data_final<-cbind(returns_final, famafrench)

mylm<-function(y,x1,x2,x3,x4,x5)
{
  fit<-lm(y~x1+x2+x3+x4+x5,na.action='na.omit')
  IVOLhat<-summary(fit)$sigma
  adjR2<-summary(fit)$adj.r.squared
  m<-mean(y,na.rm=TRUE)
  s<-sd(y,na.rm=TRUE)
  SRhat<-m/s
  IRhat<-coef(fit)[1]/IVOLhat

  coefficients<-c(coef(fit),IVOLhat,adjR2,SRhat,IRhat)
  names(coefficients)<-c('alphahat','betahat','shat','hhat', 'rhat',
                         'chat','sigmahat','adjR2','SRhat','IRhat')

  return(coefficients)
}

rstock<-data_final[,3:(ncol(data_final)-6)]
rf<-data_final[,'RF']
rmexcess<-data_final[,'Mkt.RF']
smb<-data_final[,'SMB']
hml<-data_final[,'HML']
```

```r
rmw<-data_final[,'RMW']
cma<-data_final[,'CMA']

rstock[] <- lapply(rstock, function(x) as.numeric(as.character(x)))

rstockexcess<-sweep(x=rstock,MARGIN=1,STATS=rf,FUN="-")

EST<-apply(X=rstockexcess,MARGIN=2,FUN="mylm",x1=rmexcess,x2=smb,x3=hml,x4=rmw,x5=cma)
EST<-t(EST)
X<-data.frame(EST)
X
```

```
##          alphahat   betahat         shat        hhat        rhat        chat
## APTV -0.023659100 1.2816815  0.920347161  0.37888023  0.24319690 -0.71383437
## WFC  -0.003312912 1.1074978 -0.129332824  1.39475555 -0.35283245 -0.68655158
## UNM  -0.002553335 1.3451647  0.007836778  1.34128018 -0.11663285  0.10974935
## DAL  -0.018680730 1.1668097  0.680869512  0.78251122  0.09246072 -0.35872609
## JKHY -0.008814536 0.7727472 -0.140372618 -0.18621759  0.16157862  0.38884370
## CVS  -0.020544999 0.7918967 -0.189678116  0.24351025  0.08312654  0.54730082
## CBOE  0.018142626 0.5813726 -0.168294035  0.22830608 -0.04970270 -0.18113507
## KHC  -0.062850963 0.7729631 -0.302198965  0.16421652  0.12791772  0.89721500
## CFG   0.004618190 1.2281381  0.348878870  1.75976832 -0.36744243 -1.18071813
## CNP  -0.016103998 0.8914312 -0.079077539  0.37447557  0.07486242  0.33400219
## PFE  -0.033183306 0.6777878 -0.323835796 -0.03614466  0.07262808  0.65330633
## OKE   0.053849943 1.1956747  0.508559737  1.06120045 -0.48672188 -0.06640452
## EW    0.022524988 0.9496903  0.018056190 -0.23397600 -0.14489885  0.02666710
## MMC   0.026424049 0.8313721 -0.253178261  0.08101671  0.14034928  0.05429721
## CB    0.018626222 0.8542520 -0.211201290  0.65848214  0.01213813  0.10416885
## MAR   0.025924422 0.9897347  0.603457608  0.54271223  0.37966534 -0.67755816
## CLX  -0.016635581 0.4252169 -0.046707274 -0.52517186  0.41288350  0.97273465
## HP    0.012748267 1.4546556  0.462951494  1.38538679 -0.87114021  0.61234456
## ORLY  0.052832438 0.8027550 -0.018313522 -0.09260796  0.48486484  0.28978407
## AVY   0.007973217 1.0240976  0.074248347  0.25594498  0.25638208  0.12655411
## PWR   0.092920781 1.0415816  0.445623019  0.29594769  0.02481456  0.07216197
## LKQ  -0.011125103 1.1013354  0.611431080  0.48174815  0.59303723 -0.31692570
## ILMN -0.044318203 1.0779077  0.404658253 -0.59200595 -0.63872802  0.24800093
## HRB   0.033309030 0.8874133  0.472179735  0.36188715  0.62548610  0.01351866
## DTE  -0.004853980 0.7468661 -0.075779408  0.32418967  0.16549224  0.35895052
## ED   -0.013192004 0.5862587 -0.323581682 -0.01294034  0.14061828  0.85965361
## VFC  -0.098531035 1.1186809  0.735182884  0.44083966  0.30513309 -0.17450224
## MCK   0.046688621 0.8182074 -0.190840639  0.08357608  0.19060949  0.69236465
## WDC  -0.034258442 1.3693264  0.558857175  0.28653221  0.16878937 -0.32181626
## AON   0.025116580 0.8023986 -0.315305052  0.11697292  0.03118486  0.10675932
## SCHW  0.016365492 1.0544139 -0.059260849  1.10729966 -0.39434160 -0.65622091
## AME   0.014555149 1.0598892  0.069338088  0.16067489  0.32207685  0.12155604
## MCO   0.020382955 1.1548744 -0.267607317  0.04575855 -0.03517833 -0.25906899
## MTD   0.004141561 1.0099056  0.053747287 -0.25282331  0.03016697  0.17011521
## NDAQ  0.020105268 0.9316336 -0.313394749  0.04077538 -0.18251415  0.11718343
## FLR   0.031448316 1.1928787  1.548613739  1.03384910 -0.08747024 -0.34214622
## ROK  -0.004019099 1.0906934  0.256220286  0.24361179  0.34917403 -0.26888031
## NOV  -0.023988877 1.2729460  0.458084924  1.44916195 -0.67047129  0.26213100
## LEG  -0.064424372 1.1144212  0.845057609  0.52272724  0.64111401 -0.19954310
## LUV  -0.049495568 0.9735983  0.598649946  0.54364432  0.14229760 -0.16253775
## NWS   0.011604427 0.9647551  0.479457315  0.25484376  0.10484898 -0.10753762
```

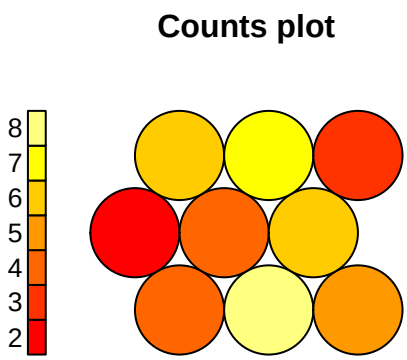
```
## OMC   0.001910695 0.8635499  0.352860209  0.45940733  0.28533154  0.07848137
## URI   0.066029429 1.4398350  0.914391956  0.54143898  0.42116241 -0.21888826
## AEE  -0.012757305 0.7225540 -0.279484284 -0.04556454  0.19823069  0.79521833
## WEC  -0.012994107 0.6466051 -0.385888540 -0.10110152  0.23694637  0.88285598
##      sigmahat     adjR2         SRhat        IRhat
## APTV 1.876565 0.5480771  0.0085678956 -0.012607666
## WFC  1.211651 0.7114026  0.0093330331 -0.002734212
## UNM  1.714100 0.6203935  0.0140644944 -0.001489607
## DAL  2.075323 0.4617041  0.0066086843 -0.009001362
## JKHY 1.327894 0.3436355  0.0210761842 -0.006637980
## CVS  1.448472 0.3324089  0.0098276755 -0.014183908
## CBOE 1.543657 0.2035152  0.0241004740  0.011753015
## KHC  1.605765 0.2813046 -0.0114694263 -0.039140822
## CFG  1.266078 0.7810417  0.0086760346  0.003647633
## CNP  1.473946 0.3957944  0.0120449723 -0.010925772
## PFE  1.389574 0.2617127  0.0028701301 -0.023880209
## OKE  1.976323 0.5142452  0.0283274531  0.027247547
## EW   1.615545 0.3975440  0.0318166786  0.013942654
## MMC  0.959124 0.5500002  0.0478879760  0.027550189
## CB   1.159139 0.5349971  0.0302209153  0.016069009
## MAR  1.721186 0.4702876  0.0268696051  0.015061957
## CLX  1.547069 0.1372278  0.0126735492 -0.010752964
## HP   2.531119 0.4967380  0.0117719390  0.005036614
## ORLY 1.428853 0.3363524  0.0576019992  0.036975430
## AVY  1.337875 0.5085485  0.0293239172  0.005959611
## PWR  1.543702 0.4859666  0.0618885676  0.060193473
## LKQ  1.571754 0.5422342  0.0161491112 -0.007078143
## ILMN 2.067959 0.4121880 -0.0007997736 -0.021430894
## HRB  1.911077 0.3369870  0.0326724901  0.017429455
## DTE  1.236035 0.4014465  0.0187271560 -0.003927058
## ED   1.258144 0.2647476  0.0150457970 -0.010485292
## VFC  2.034541 0.4245362 -0.0203894293 -0.048429118
## MCK  1.501809 0.3160655  0.0498325430  0.031088262
## WDC  2.318448 0.4219312  0.0070988337 -0.014776452
## AON  1.249504 0.3982486  0.0397424988  0.020101243
## SCHW 1.605754 0.5328211  0.0173691694  0.010191777
## AME  0.936972 0.6877106  0.0397955421  0.015534241
## MCO  1.160192 0.6406831  0.0379752235  0.017568607
## MTD  1.365334 0.4919102  0.0283442145  0.003033369
## NDAQ 1.159598 0.5169675  0.0370931976  0.017338131
## FLR  3.369370 0.3520297  0.0132484056  0.009333590
## ROK  1.462503 0.5199542  0.0218148932 -0.002748096
## NOV  2.393211 0.4886020 -0.0003415546 -0.010023722
## LEG  1.531617 0.5871322 -0.0069491423 -0.042062984
## LUV  1.810079 0.4275908 -0.0064639697 -0.027344419
## NWS  1.527016 0.4634721  0.0238014325  0.007599415
## OMC  1.376815 0.4765039  0.0198265193  0.001387765
## URI  1.744034 0.6205865  0.0436729819  0.037860173
## AEE  1.272555 0.3289720  0.0190966997 -0.010024955
## WEC  1.310467 0.2837035  0.0185163779 -0.009915634
```

```
sweep(x=X[,c('alphahat','sigmahat','SRhat','IRhat')],
      STATS=c(252*0.01,sqrt(252)*0.01,sqrt(252),sqrt(252)),MARGIN=2,FUN='*')
```

```
##          alphahat  sigmahat        SRhat       IRhat
```

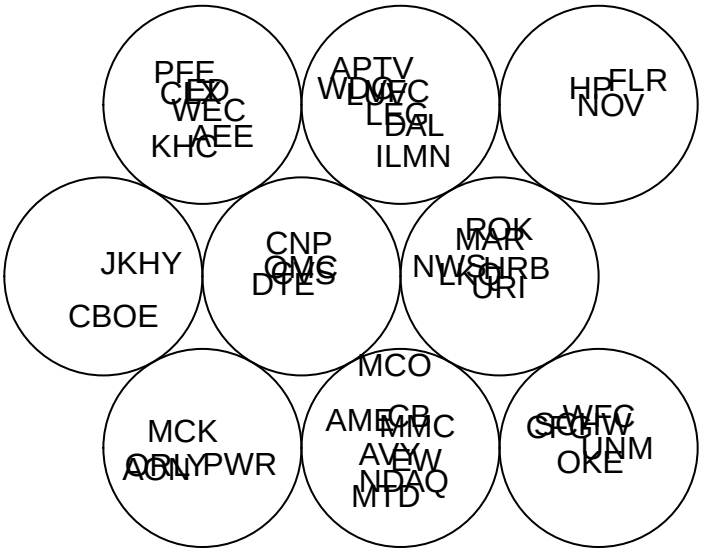
```
## APTV -0.059620933 0.2978954  0.136011125 -0.20014050
## WFC  -0.008348539 0.1923437  0.148157307 -0.04340427
## UNM  -0.006434405 0.2721049  0.223266926 -0.02364678
## DAL  -0.047075441 0.3294473  0.104909611 -0.14289219
## JKHY -0.022212632 0.2107967  0.334574051 -0.10537467
## CVS  -0.051773397 0.2299379  0.156009512 -0.22516256
## CBOE  0.045719416 0.2450480  0.382583164  0.18657333
## KHC  -0.158384426 0.2549073 -0.182071499 -0.62134129
## CFG   0.011637838 0.2009837  0.137727780  0.05790438
## CNP  -0.040582076 0.2339817  0.191208008 -0.17344125
## PFE  -0.083621932 0.2205880  0.045561903 -0.37908657
## OKE   0.135701857 0.3137315  0.449684377  0.43254139
## EW    0.056762969 0.2564598  0.505074115  0.22133278
## MMC   0.066588602 0.1522562  0.760198052  0.43734570
## CB    0.046938079 0.1840077  0.479742157  0.25508761
## MAR   0.065329544 0.2732297  0.426541757  0.23910116
## CLX  -0.041921665 0.2455897  0.201186357 -0.17069801
## HP    0.032125633 0.4018026  0.186873738  0.07995377
## ORLY  0.133137744 0.2268233  0.914403389  0.58696676
## AVY   0.020092507 0.2123811  0.465502755  0.09460589
## PWR   0.234160369 0.2450551  0.982450554  0.95554177
## LKQ  -0.028035260 0.2495083  0.256359194 -0.11236204
## ILMN -0.111681871 0.3282783 -0.012696012 -0.34020489
## HRB   0.083938756 0.3033741  0.518659701  0.27668403
## DTE  -0.012232030 0.1962144  0.297284385 -0.06234011
## ED   -0.033243851 0.1997241  0.238844623 -0.16644885
## VFC  -0.248298208 0.3229734 -0.323672156 -0.76878841
## MCK   0.117655324 0.2384047  0.791067096  0.49351085
## WDC  -0.086331273 0.3680423  0.112690491 -0.23456890
## AON   0.063293782 0.1983526  0.630892609  0.31909734
## SCHW  0.041241039 0.2549056  0.275727016  0.16178945
## AME   0.036678975 0.1487397  0.631734646  0.24659843
## MCO   0.051365046 0.1841747  0.602837984  0.27889299
## MTD   0.010436735 0.2167401  0.449950456  0.04815323
## NDAQ  0.050665275 0.1840805  0.588836258  0.27523430
## FLR   0.079249757 0.5348709  0.210311918  0.14816615
## ROK  -0.010128131 0.2321652  0.346300694 -0.04362467
## NOV  -0.060451969 0.3799104 -0.005422012 -0.15912165
## LEG  -0.162349418 0.2431366 -0.110314214 -0.66772917
## LUV  -0.124728832 0.2873412 -0.102612338 -0.43407919
## NWS   0.029243155 0.2424063  0.377836028  0.12063697
## OMC   0.004814952 0.2185626  0.314736237  0.02203008
## URI   0.166394160 0.2768568  0.693287095  0.60101161
## AEE  -0.032148409 0.2020118  0.303150710 -0.15914123
## WEC  -0.032745151 0.2080301  0.293938387 -0.15740582
```

```r
xdim<-ydim<-3
Xst<-scale(as.matrix(X))
mysom <- som(X=Xst, grid = somgrid(xdim=xdim, ydim=ydim, 'hexagonal'))
par(mfrow=c(2,2),mar=c(2, 4, 1, 1),cex=0.8)
plot(mysom,type='counts')
```



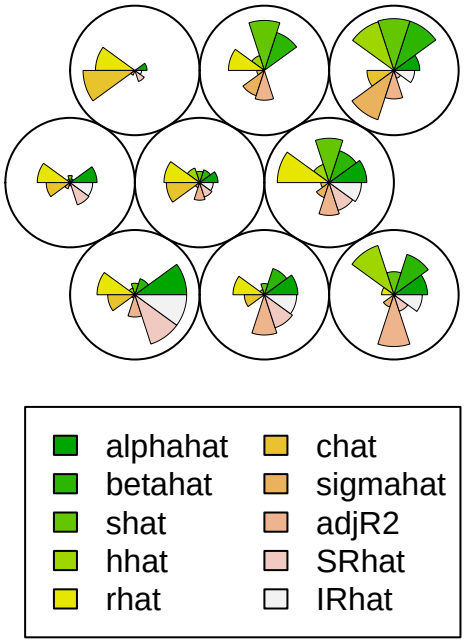

```
plot(mysom,type='mapping',labels=rownames(X))
```

Mapping plot




```
plot(mysom,type='codes')
```

Codes plot



Using Principal Component Analysis

```
pca_results <- prcomp(X, scale = TRUE)
print(summary(pca_results))
```

```
## Importance of components:
##                           PC1    PC2    PC3    PC4     PC5     PC6     PC7
## Standard deviation     1.9021 1.7420 1.1332 1.0874 0.64049 0.57214 0.31608
## Proportion of Variance 0.3618 0.3034 0.1284 0.1182 0.04102 0.03273 0.00999
## Cumulative Proportion  0.3618 0.6652 0.7936 0.9119 0.95290 0.98564 0.99563
##                           PC8     PC9    PC10
## Standard deviation     0.1518 0.12543 0.07045
## Proportion of Variance 0.0023 0.00157 0.00050
## Cumulative Proportion  0.9979 0.99950 1.00000
```

```
pca_loadings <- pca_results$rotation
round(pca_loadings,4)
```

```
##              PC1     PC2     PC3     PC4     PC5     PC6     PC7     PC8
## alphahat  0.0175 -0.5452  0.2308  0.0791  0.1427  0.0477  0.1112  0.5063
## betahat  -0.4764 -0.0739 -0.0072 -0.0189 -0.5475  0.1956 -0.4673  0.4055
## shat     -0.3951  0.0607  0.4115 -0.3688 -0.0486 -0.0172  0.6579  0.0821
## hhat     -0.4188 -0.0453 -0.1446  0.2500  0.6297  0.5380 -0.0479 -0.0620
## rhat      0.2023  0.0203  0.0507 -0.8086  0.1540  0.4184 -0.2603 -0.0080
## chat      0.3870  0.1380  0.2184  0.3223 -0.3670  0.6856  0.2673 -0.0145
## sigmahat -0.3173  0.1679  0.6333  0.1274 -0.0134 -0.0278 -0.2911 -0.4499
## adjR2    -0.3501 -0.2160 -0.5128 -0.1086 -0.3152  0.1488  0.3027 -0.3798
## SRhat     0.1634 -0.5339  0.1041 -0.0711 -0.1445  0.0295 -0.1357 -0.4634
```

```
## IRhat     0.0237 -0.5588  0.1771  0.0634  0.0477 -0.0275  0.0104 -0.0832
##               PC9    PC10
## alphahat -0.5524 -0.2155
## betahat   0.2141 -0.0225
## shat      0.2834 -0.1107
## hhat      0.1901 -0.1042
## rhat     -0.1410  0.1254
## chat     -0.0035  0.0561
## sigmahat -0.3998  0.0769
## adjR2    -0.4297  0.1186
## SRhat     0.3015 -0.5715
## IRhat     0.2779  0.7513
```

```
biplot(pca_results, scale=0)
```