

1 Estimation of covariance matrix

The dataset used in the paper is in file "data.RData" which contains 4 vectors:

1. resid.CEES = Residuals from a GARCH (1,1) estimation of h_t of the CEES returns
2. resid.SPDR = Residuals from a GARCH (1,1) estimation of h_t of the SPDR returns
3. r.CEES = CEES returns
4. R.SPDR = SPDR returns

The code consists of 3 files

- corr.R = it contains function *corr*(*r*, *bw* = *NULL*).

Arguments:

- r an object of class matrix (or one that can be coerced to that class): it contains the returns for the NPCC estimation and residuals for the SPCC estimation
- bw a numerical object, it is the bandwidth for the local linear. If NULL, it is calculated by cross-validation

It returns:

- T data size
- R an array with dimensions T, number of variables, number of variables: it contains the correlation estimates of data in r
- H an array with dimensions T, number of variables, number of variables: it contains the covariance estimates of data in r
- bw bandwidth
- MSE mean square error between estimates and sample correlation from the residuals after the estimation

1.1 NP covariance and correlation matrices estimates

Bandwidths calculated by cross-validation for the CEES and SPDR returns are 0.0014 and 0.008 respectively

```
> source("./corr.R")
> load("./data.RData")
> r.CEES= data$r.CEES
> bw= 0.0014
> np.cees=corr(resid.CEES, bw)
> #covariance matrix
> H.np=np.cees$H
> #correlation matrix
> R.np=np.cees$R
> #bandwidth
> h.np=np.cees$bw
```

The covariance matrix $H_t = D_t R_t D_t$ where

- D_t is a diagonal matrix with the square root of \hat{h}_t , estimates obtained with GARCH(1,1),
- R_t is the correlation matrix estimate. and . This program does not calculate H

1.2 SPCC covariance matrix estimates

Bandwidths calculated by cross-validation for the CEES and SPDR residuals are 0.0557 and 0.1524 respectively

```
> source("./corr.R")
> load("./data.RData")
> resid.CEES= data$resid.CEES
> bw= 0.0557
> sp.cees=corr(resid.CEES, bw)
> #correlation matrix of residuals
> R.sp=sp.cees$R
> #bandwidth
> h.sp=sp.cees$bw
```

The covariance matrix of the residuals can also be obtained by `sp.cees$H`. Be aware that this is not the covariance matrix of the returns, for which it is necessary to know the GARCH (1,1) estimates of the volatility h_t of the returns.

1.3 Plot estimates comparison

To obtain the plot of correlations:

```
> plot(R.np[,1,2], type="l", main = paste(dimnames(R.np)[[2]][1], " vs ", dimnames(R.np)[[2]][2]),
> lines(R.sp[,1,2], col=2)
> legend("bottom", c("NPCC", "SPCC"), col=1:2, lty=1, border="white")
```

