

R Notebook

```
library(rugarch)
```

```
## Warning: package 'rugarch' was built under R version 4.1.2
```

```
## Loading required package: parallel
```

```
##
```

```
## Attaching package: 'rugarch'
```

```
## The following object is masked from 'package:stats':
```

```
##
```

```
##      sigma
```

```
library(ggplot2)
```

```
setwd("../")
```

```
#Inputting log-returns
```

```
sp_logret<-read.csv("Data/Processed/sp_logret.csv")$x
```

```
dow_logret<-read.csv("Data/Processed/dow_logret.csv")$x
```

```
nas_logret<-read.csv("Data/Processed/nas_logret.csv")$x
```

```
#Inputting residuals
```

```
sp_residuals<-read.csv("Data/Processed/sp_residuals.csv")$x
```

```
dow_residuals<-read.csv("Data/Processed/dow_residuals.csv")$x
```

```
nas_residuals<-read.csv("Data/Processed/nas_residuals.csv")$x
```

```
#Inputting predicted squared residuals
```

```
sp_residuals_predict <- sqrt(abs(read.csv('Data/Processed/spPredictSQ.csv')[2])$X0)
```

```
dow_residuals_predict <- sqrt(abs(read.csv('Data/Processed/dowPredictSQ.csv')[2])$X0)
```

```
nas_residuals_predict <- sqrt(abs(read.csv('Data/Processed/nasPredictSQ.csv')[2])$X0)
```

```
#Inputting predicted GARCH sigma
```

```
sp_sigmas_predict <- abs(read.csv('Data/Processed/spGarchPredict.csv')[2])$X0
```

```
dow_sigmas_predict <- abs(read.csv('Data/Processed/dowGarchPredict.csv')[2])$X0
```

```
nas_sigmas_predict <- abs(read.csv('Data/Processed/nasGarchPredict.csv')[2])$X0
```

```
#Calculating AR
```

```
sp_ar <- sp_logret - sp_residuals
```

```
dow_ar <- dow_logret - dow_residuals
```

```
nas_ar <- nas_logret - nas_residuals
```

```

sp_train_data_residuals <- sp_residuals[1:4000]
sp_test_data_residuals <- sp_residuals[4001:length(sp_residuals)]

dow_train_data_residuals <- dow_residuals[1:4000]
dow_test_data_residuals <- dow_residuals[4001:length(dow_residuals)]

nas_train_data_residuals <- nas_residuals[1:4000]
nas_test_data_residuals <- nas_residuals[4001:length(nas_residuals)]

sp_train_data_logret <- sp_logret[1:4000]
sp_test_data_logret <- sp_logret[4001:length(sp_logret)]

dow_train_data_logret <- dow_logret[1:4000]
dow_test_data_logret <- dow_logret[4001:length(dow_logret)]

nas_train_data_logret <- nas_logret[1:4000]
nas_test_data_logret <- nas_logret[4001:length(nas_logret)]

sp_residuals_predict <- sp_residuals_predict[4001:length(sp_residuals_predict)]
dow_residuals_predict <- dow_residuals_predict[4001:length(dow_residuals_predict)]
nas_residuals_predict <- nas_residuals_predict[4001:length(nas_residuals_predict)]

sp_sigmas_predict <- sp_sigmas_predict[4001:length(sp_sigmas_predict)]
dow_sigmas_predict <- dow_sigmas_predict[4001:length(dow_sigmas_predict)]
nas_sigmas_predict <- nas_sigmas_predict[4001:length(nas_sigmas_predict)]

VaR <- function(sigma_pred,x_train_data_residuals,x_test_data_residuals,x_test_data_logret,x_ar,alpha){
  x_shape <- fitdist(distribution = 'std' , x = x_train_data_residuals)$pars[3]
  n = ceiling(length(x_test_data_residuals)/100)
  x_list <- rep(0,times=n)
  for (i in (1:(n))){
    mean = na.omit(x_ar[4001:length(x_ar)][(100*(i-1)+1):(100*i)])
    sigma = na.omit(sigma_pred[(100*(i-1)+1):(100*i)])
    VaR95_td <- mean+sigma*qdist(distribution='std', shape=x_shape, p=alpha)
    x_list[i] <- sum(na.omit(x_test_data_logret[(100*(i-1)+1):(100*i)]) < VaR95_td)
  }
  return(x_list)
}

sp_list_VaR_sigma <- VaR(sp_sigmas_predict,sp_train_data_residuals,sp_test_data_residuals,sp_test_data_logret,x_ar,alpha)
dow_list_VaR_sigma <- VaR(dow_sigmas_predict,dow_train_data_residuals,dow_test_data_residuals,dow_test_data_logret,x_ar,alpha)
nas_list_VaR_sigma <- VaR(nas_sigmas_predict,nas_train_data_residuals,nas_test_data_residuals,nas_test_data_logret,x_ar,alpha)

mean(sp_list_VaR_sigma[1:12])

## [1] 0.75

mean(dow_list_VaR_sigma[1:12])

## [1] 1.083333

```

```
mean(nas_list_VaR_sigma[1:12])
```

```
## [1] 1.416667
```

```
VaRalpha <- function(sigma_pred,x_train_data,x_test_data,x_ar,alpha,j,i){  
  x_shape <- fitdist(distribution = 'std' , x = x_train_data)$pars[3]  
  mean = x_ar[4001:length(x_ar)][(100*(i-1)+1):(100*i)]  
  sigma = sigma_pred[(100*(i-1)+1):(100*i)]  
  VaR95_td <- mean[j]+sigma[j]*qdist(distribution='std', shape=x_shape, p=alpha)  
}
```

```
ES <- function(sigma_pred,x_train_data,x_test_data,x_ar,alpha){  
  n = ceiling(length(x_test_data)/100)  
  x_list <- rep(0,times=n)  
  for (i in (1:n)){  
    if (i==n){  
      x_integrate <- rep(0,length(x_test_data)-(100)*(i-1))  
      for (j in 1:(length(x_integrate))){  
        x_integrate[j] <- as.numeric(integrate(VaRalpha,lower=0,upper=alpha,sigma_pred=sigma_pred,x_train_data=x_train_data,x_test_data=x_test_data,x_ar=x_ar,alpha=alpha,j=j,i=i)$val)  
        x_list[i] <- mean(x_integrate)  
      }  
    }  
    else {  
      x_integrate <- rep(0,(100))  
      for (j in 1:(length(x_integrate))){  
        x_integrate[j] <- as.numeric(integrate(VaRalpha,lower=0,upper=alpha,sigma_pred=sigma_pred,x_train_data=x_train_data,x_test_data=x_test_data,x_ar=x_ar,alpha=alpha,j=j,i=i)$val)  
        x_list[i] <- mean(x_integrate)  
      }  
    }  
    print(i)  
  }  
  return(x_list)  
}
```

```
setwd('..')
```

```
#sp_list_ES_sigma_LSTM <- ES(sp_sigmas_predict,sp_train_data_residuals,sp_test_data_residuals,sp_ar,0.05)  
#write.csv(sp_list_ES_sigma_LSTM, 'Data/Processed/sp_list_ES_sigma_LSTM.csv', row.names=T)
```

```
#dow_list_ES_sigma_LSTM <- ES(dow_sigmas_predict,dow_train_data_residuals,dow_test_data_residuals,dow_ar,0.05)  
#write.csv(dow_list_ES_sigma_LSTM, 'Data/Processed/dow_list_ES_sigma_LSTM.csv', row.names=T)
```

```
#nas_list_ES_sigma_LSTM <- ES(nas_sigmas_predict,nas_train_data_residuals,nas_test_data_residuals,nas_ar,0.05)  
#write.csv(nas_list_ES_sigma_LSTM, 'Data/Processed/nas_list_ES_sigma_LSTM.csv', row.names=T)
```

```
sp_list_ES_sigma_LSTM<-read.csv("Data/Processed/sp_list_ES_sigma_LSTM.csv")$x  
dow_list_ES_sigma_LSTM<-read.csv("Data/Processed/dow_list_ES_sigma_LSTM.csv")$x  
nas_list_ES_sigma_LSTM<-read.csv("Data/Processed/nas_list_ES_sigma_LSTM.csv")$x
```

```
sp_logret_pred <- sp_ar[4001:length(sp_ar)]+sp_residuals_predict  
dow_logret_pred <- dow_ar[4001:length(dow_ar)]+dow_residuals_predict  
nas_logret_pred <- nas_ar[4001:length(nas_ar)]+nas_residuals_predict
```

```

VaR_pred <- function(logpred,x_test_data_logret,alpha){
  n <- ceiling(length(logpred)/100)
  x_list <- rep(0,times=n)
  for (i in (1:n)){
    if (i==n){
      x_data <- logpred[(100*(i-1)+1):length(logpred)]
      VaR <- quantile(x_data,alpha)
      x_list[i] <- sum(na.omit(x_test_data_logret[(100*(i-1)+1):(100*i)]) < VaR)
    }
    else {
      x_data <- logpred[(100*(i-1)+1):(100*i)]
      VaR <- quantile(x_data,alpha)
      x_list[i] <- sum(na.omit(x_test_data_logret[(100*(i-1)+1):(100*i)]) < VaR)
    }
  }
  return(x_list)
}

```

```

sp_logret_pred_VaR <- VaR_pred(sp_logret_pred,sp_test_data_logret,0.05)
dow_logret_pred_VaR <- VaR_pred(dow_logret_pred,dow_test_data_logret,0.05)
nas_logret_pred_VaR <- VaR_pred(nas_logret_pred,nas_test_data_logret,0.05)

mean(sp_logret_pred_VaR[1:12])

```

```
## [1] 100
```

```
mean(dow_logret_pred_VaR[1:12])
```

```
## [1] 100
```

```
mean(nas_logret_pred_VaR[1:12])
```

```
## [1] 100
```

```

ES_historical <- function(x_test_data,alpha){
  n <- ceiling(length(x_test_data)/100)
  x_list <- rep(0,times=n)
  for (i in (1:n)){
    if (i==n){
      x_data <- x_test_data[(100*(i-1)+1):length(x_test_data)]
      x_list[i] <- mean(x_data[x_data <= quantile(x_data,alpha)])
    }
    else {
      x_data <- x_test_data[(100*(i-1)+1):(100*i)]
      x_list[i] <- mean(x_data[x_data <= quantile(x_data,alpha)])
    }
  }
  return(x_list)
}

```

```

sp_ES_historical <- ES_historical(sp_logret_pred,0.05)
dow_ES_historical <- ES_historical(dow_logret_pred,0.05)
nas_ES_historical <- ES_historical(nas_logret_pred,0.05)

sp_ES_historical_actual <- ES_historical(sp_test_data_logret,0.05)
dow_ES_historical_actual <- ES_historical(dow_test_data_logret,0.05)
nas_ES_historical_actual <- ES_historical(nas_test_data_logret,0.05)

sp_ES_change_historical <- mean((sp_ES_historical_actual - sp_ES_historical)^2)
dow_ES_change_historical <- mean((dow_ES_historical_actual - dow_ES_historical)^2)
nas_ES_change_historical <- mean((nas_ES_historical_actual - nas_ES_historical)^2)

sp_ES_change_sigma <- mean((sp_list_ES_sigma_LSTM - sp_ES_historical_actual)^2)
dow_ES_change_sigma <- mean((dow_list_ES_sigma_LSTM - dow_ES_historical_actual)^2)
nas_ES_change_sigma <- mean((nas_list_ES_sigma_LSTM - nas_ES_historical_actual)^2)

```