Financial Risk Forecasting
Seminar 10

Jon Danielsson
London School of Economics

Version 4.0 August 2024

10 Backtesting

Our focus in this session is to evaluate the quality of our risk forecasts with backtesting.

10.1 Links from the R notebook

Backtesting.

10.2 The plan for this Seminar

1. Implement HS, EWMA and GARCH VaR and ES over a testing window
2. Analyse the risk forecasts graphically and statistically

10.3 Loading data and libraries

```
load('Returns.RData')
load('Prices.RData')
```

```
library(rugarch)
library(lubridate)
```

10.4 Set parameters

```
p=0.01
lambda=0.94
value=1
T=5000
WE=1000
WT=5000-WE
lambda=0.94
Burn=30
```

```
y=tail(Returns$MCD,T)
d=tail(Returns$date,T)
d=ymd(d)
plot(d,y,type='l')
```

10.5 Keeping track of the forecasts

We store all the forecasts in a `data frame` called `VaR`. We start by putting the returns into it, and then add the various methods as new columns. This ensures that all the dates match up correctly.

```
VaR=as.data.frame(matrix(NA,ncol=1,nrow=length(y)))
names(VaR)=c("y")
VaR$y=y
```

10.6 HS

Create a new column in the `VaR` data frame, fill it with `NA` and call it `HS`.

```
VaR$HS=NA
```

We can then run the HS forecasts. Note that it is very easy to make a mistake with the windows and the forecast date, and by using the explicit approach below, we minimise the chance of mistakes. To ensure the data correct, it can be useful to print them in the loop.

```
for(t in (WE+1):T) {
  t1=t-WE
  t2=t-1
  window=VaR$y[t1:t2]
# to debug
#  cat(t,t1,t2,length(w),'\n')
  VaR$HS[t]=-sort(window)[WE*p]*value
}
plot(VaR$y)
lines(-VaR$HS,type='s',col="red",lwd=2)
```

We can then calculate the vector of violations and the violation ratio.

```
V=VaR$y-VaR$HS
V=V[(WE+1):T]
V[V<0]=0
V[V>0]=1
VR=sum(V)/WT/p
cat('T',T,'WT',WT,'Violatios',sum(V),'VR',VR)
```

10.7 EWMA

We set EWMA up in the same way as HS, and initialise the first value to the unconditional variance.

```
VaR$EWMA=NA
VaR$EWMA[1]=var(y)
```

We can then run the loop.

```
for(t in 2:T){
  VaR$EWMA[t]=
    lambda*VaR$EWMA[t-1]+
    (1-lambda) *VaR$y[t-1]^2
}
VaR$EWMA=- sqrt(VaR$EWMA) * qnorm(p) * value
```

The first few observations of the forecast are not valid, and we set them to `NA`.

```
VaR$EWMA[1:Burn]=NA
plot(VaR$y,type='l')
lines(-VaR$HS,type='s',col="red",lwd=2)
lines(-VaR$EWMA,type='s',col="blue",lwd=2)
```

We can then calculate the violations.

```
V=VaR$y-VaR$EWMA
V[V<0]=0
V[V>0]=1
VR=sum(V)/WT/p
cat('T',T,'WT',WT,'Violatios',sum(V),'VR',VR)
```

There is a mistake in the code for the violations. Can you find it?

10.8 GARCH

We proceed with the GARCH model in the same way. Note we have to calculate the one day ahead forecasts of the volatility and use that for the VaR.

```
VaR$GARCH=NA
spec=ugarchspec(
  mean.model = list(
    armaOrder=c(0,0),
    include.mean=FALSE)
)
for(t in (WE+1):T) {
  t1=t-WE
  t2=t-1
  window=VaR$y[t1:t2]

  fit=ugarchfit(spec=spec,data=window,solver = "hybrid")
  s2=coef(fit)[1] +
    coef(fit)[2] * tail(window,1)^2 +
    coef(fit)[3] *tail(fit@fit$var,1 )
  VaR$GARCH[t]=-value*qnorm(p,sd=sqrt(s2))
}
plot(VaR$y,type='l')
```

```
lines(-VaR$HS,type='s',col="red",lwd=2)
lines(-VaR$EWMA,type='s',col="blue",lwd=2)
lines(-VaR$GARCH,type='s',col="green",lwd=2)
```

10.9 Violations

We will make a separate data frame for the violations, called `V`. In this case we start by copying `VaR` over the testing window.

```
V=VaR[(WE+1):T,]
for(i in c("HS","EWMA","GARCH")){
  V[,i]=V[,"y"]-V[,i]
  V[V[,i]<0,i]=0
  V[V[,i]>0,i]=1
}
```

We can then plot the violations and print the violation ratios.

```
V=V[,c("HS","EWMA","GARCH")]
matplot(V[,c("HS","EWMA","GARCH")])
colSums(V)
colSums(V)/WT/p
```

10.10 Recap

In this seminar we have covered:

- Backtesting VaR

10.11 Optional exercises

1. Repeat the analysis with the stocks in `Returns.RData`.
2. Test for violations with the coverage and independence tests.
3. Make a function to run the VaR analysis.
4. Make a function to evaluate the impact of different estimation window sizes on VaR.
5. Use this function to optionally save the plots to file, in png, svg and pdf formats, so you can include them in other programs.
6. Put the code into a R Quarto file file and use that to make Word and pdf reports.
7. Put the code into a R Quarto file and use that to make PowerPoint and PDF (Beamer) presentations.