Financial Risk Forecasting
Seminar Seminar 8

Jon Danielsson
London School of Economics

Version 4.0 August 2024

8 Implementing Risk Forecasting

Our focus in this session is forecasting risk one day into the future. Please review the chapter on risk forecasting in the slides and the book.

Make sure that you are in the same folder as the data you created in the first session, as we will make use of the `Returns.RData` file that we created then.

8.1 The plan for this session:

2. Univariate estimate Expected Shortfall and Value-at-Risk using historical simulation
3. Use a function to do historical simulation
4. Multivariate estimate Expected Shortfall and Value-at-Risk using historical simulation
5. Historical simulation VaR with different estimation windows
6. EWMA VaR
7. GARCH VaR

8.2 Loading and setup

Load the returns data and pick two stocks, JP Morgan and McDonalds. There are two ways to extract them.

```
library(rugarch)
load('Returns.RData')
y1=Returns$JPM
y2=Returns$MCD
y=cbind(y1,y2)
# or
y=Returns[,c("JPM","MCD")]
matplot(y,type='l',lty=1)
```

Set the probability and portfolio value.

```
p=0.02
value=1000
```

8.3 Historical simulation (HS)

Decide on the estimation window.

```
We=1000
```

Plot the tails and find the VaR.

```
Asset="JPM"
window=tail(y$JPM,We)
SortedWindow=sort(window)
plot(SortedWindow)
```

Show the VaR

```
VaR=SortedWindow[p*We]
segments(p*We,-100,p*We,VaR,col='pink',lwd=4)
segments(p*We,VaR,-100,VaR,col='pink',lwd=4)
points(p*We,VaR,col='red',pch=16)
```

Calculate the VaR and ES

```
VaR=-value*SortedWindow[p*We]
ES=-value*mean(SortedWindow[1:(p*We)])
VaR
ES
VaR=round(VaR,1)
ES=round(ES,1)
VaR
ES
```

Print out the combined results, and put them into a string.

```
cat("The probability is ",100*p,"%",
  " and the portfolio value is $",
  value,". ", sep="")
cat("In this case, the VaR=$",VaR,
  ", while the ES is $",
  ES,"\n",sep="")
string=paste0("The probability is ",
  100*p,"%",
  " and the portfolio value is $",value,". ")
string=paste0(string,
  "In this case, the VaR=$",
  VaR,", while the ES is $",ES)
cat(string)
```

8.4 Use a function to do historical simulation

It can be convenient to do this as a function.

```
RunVaR=function(Returns,Asset,p,We){
  window=tail(y[,Asset],We)
  SortedWindow=sort(window)
  plot(SortedWindow,main=Asset)
  VaR=SortedWindow[p*We]
  segments(p*We,-100,p*We,VaR,col='pink',lwd=4)
  segments(p*We,VaR,-100,VaR,col='pink',lwd=4)
  points(p*We,VaR,col='red',pch=16)
  VaR=-value*SortedWindow[p*We]
  ES=-value*mean(SortedWindow[1:(p*We)])
  VaR=round(VaR,1)
  ES=round(ES,1)
  string=paste0("The probability is ",
    100*p,"%",
    " and the portfolio value is $",value,". ")
  string=paste0(string,
    "In this case, the ",Asset,
    " VaR=$",VaR,", while the ES is $",ES)
  return(list(VaR=VaR, ES=ES, sumamry=string))
}
RunVaR(Returns=Returns,Asset=Asset,p=p,We=We)
```

It can be useful to modify the function to allow for optionally choosing whether to make the plot and not, and even to save a plot to the disk. it is sometimes useful in practice to save plot in multiple formats, such as png, svg, pdf and eps.

8.5 Multivariate HS VaR and ES

Specify a portfolio weight and then multiply it into the matrix of returns. Note that we have to convert `Returns` into a matrix from a data frame.

```
weight=c(0.1,0.9)
Assets=c("JPM","AAPL")
yPortfolio=as.matrix(Returns[,Assets]) %*% weight
plot(yPortfolio)
```

We can then proceed as when doing the single asset risk.

8.6 Historical simulation VaR with different estimation windows

We can create a loop over a number of estimation windows and make a bar plot with the results.

```
win=c(100,300,500,1000,2000)
VaR=rep(NA,length(win))
for(i in 1:length(win)){
  window=tail(yPortfolio,win[i])
  VaR[i]=-value*sort(window)[p*win[i]]
```

```
}
barplot(VaR,names.arg=win)
```

8.7 EWMA VaR

For EWMA, specify λ and the number of observations to discard at the start, `Burn`.

```
lambda=0.94
Burn=30
y=Returns$JPM
s2=var(y)
N=length(y)
for(i in 1:Burn){
  s2=lambda*s2 + (1-lambda)*y[N-i]^2
}
VaR=-value*qnorm(p,sd=sqrt(s2))
VaR
```

8.8 GARCH VaR

For GARCH, estimate the volatility over the estimation window, and calculate the one day ahead forecast.

```
y=tail(Returns$JPM,We)
spec=ugarchspec(
  mean.model = list(
    armaOrder=c(0,0),
    include.mean=FALSE)
)
fit=ugarchfit(spec=spec,data=y,solver = "hybrid")
coef(fit)
tail(y,1)[1]
tail(fit@fit$var,1)
s2=coef(fit)[1] +
  coef(fit)[2] * tail(y,1)^2 +
  coef(fit)[3] *tail(fit@fit$var,1 )
VaR=-value*qnorm(p,sd=sqrt(s2))
VaR
```

8.9 Recap

In this seminar we have covered:

- Making VaR forecasts

Some new functions used:

- `sort()`

8.10 Optional exercises

1. Make a function that takes a vector of returns, estimation method and the necessary parameters as inputs, and then writes image files with plots of the estimation results to the disk, which then can be used in other applications, such as PowerPoint or Word.
2. Make a function that takes as arguments a vector of returns, probability, λ and a vector of estimation window sizes, and makes a data frame with 3 columns, (method, estimation window, VaR, ES), where the rows are all the possible combinations of the estimation method and window size, like HS(500), HS1000, etc.
3. Add an option to the function in the last exercise that optionally makes a barplot with the method on the x-axis and VaR on the y-axis.
4. Add an option to the function in the last exercise that optionally makes informative printout of the results.
5. Add an option to the function in the last exercise that allows you to pick any number of the 7 stocks in `Returns` along with a portfolio weight, and uses that for analysis of portfolio risk.
6. Add an option to the function in the last exercise that allows you use DCC for the risk forecasts.
7. Make a R Quarto file that does this analysis and then makes a complete report as a pdf or word file.