

QRM CW2

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```
library(readr)
df <- read_csv("QRM-2021-cw2-data.csv")
price <- df$TSLA
```

a)

Fit GARCH(1,1) to loss data

```
#install.packages("expm")
#install.packages("rugarch")
library(rugarch)
```

```
n <- length(price)
r <- log(price[2:n]/price[1:n-1])

spec <- ugarchspec(variance.model = list(model = "sGARCH",
                                          garchOrder = c(1, 1)),
                  mean.model = list(armaOrder = c(0,0), include.mean = TRUE),
                  distribution.model = "norm")
garch <- ugarchfit(spec = spec, data = -r)
coef(garch)
```

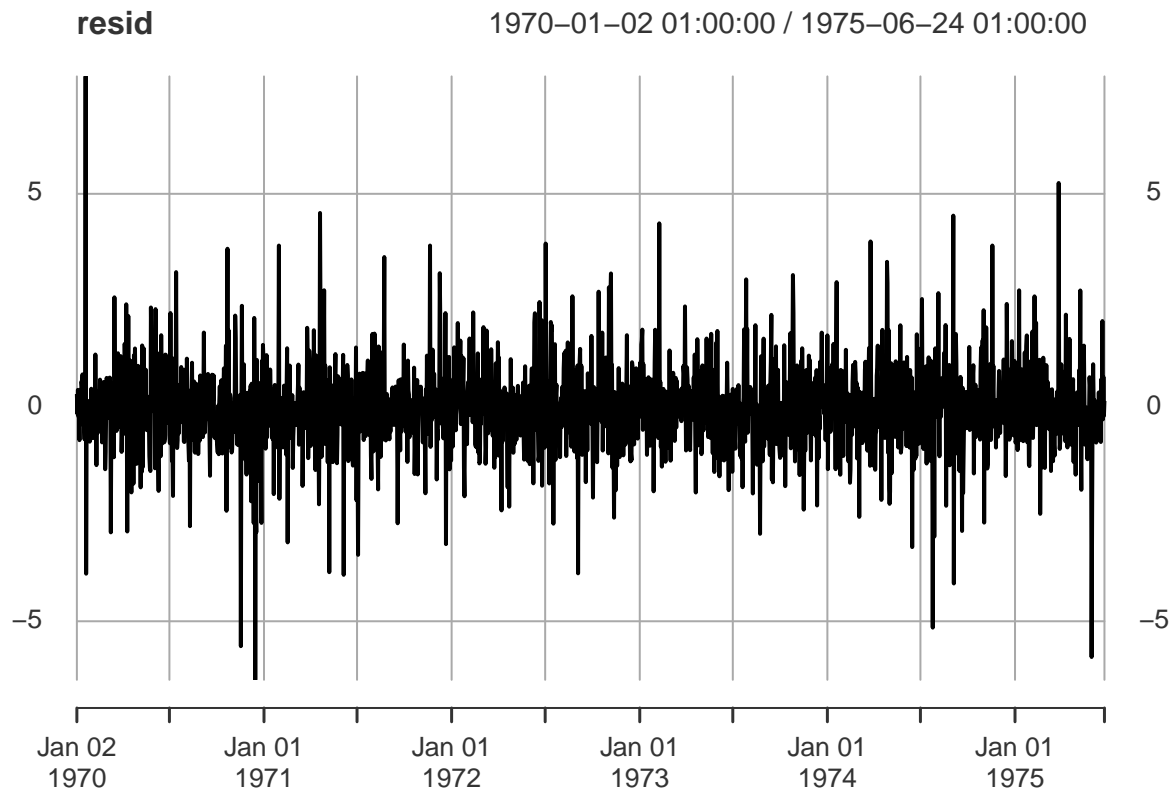
```
##           mu           omega         alpha1         beta1
## -8.416092e-04  5.618270e-06  1.725557e-02  9.767228e-01
```

Standardized residuals

```
resid <- residuals(garch, standardize=TRUE)
write_csv(resid, "garch_resid.csv", row.names = FALSE)
garch_resid <- read_csv("garch_resid.csv")
head(garch_resid)
```

```
##           V1
## 1  0.3140784
## 2 -0.1468106
## 3  0.4146921
## 4 -0.2093894
## 5 -0.1265794
## 6 -0.7631684
```

```
plot(resid)
```



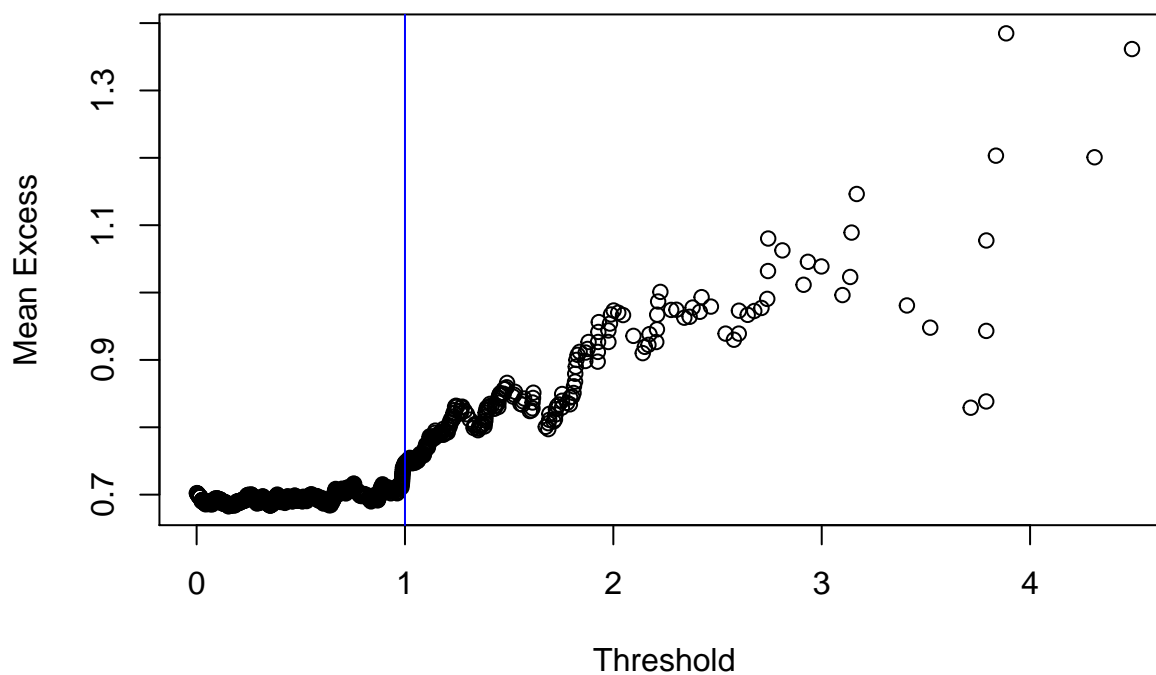
b)

Plot sample mean excess function

```
#install.packages("QRM")
require(QRM)

MEplot(garch_resid[,1][garch_resid[,1]>0], omit = 3., main = "Mean-Excess Plot", xlab = "Threshold", ylab = "Mean Excess", col = "blue", lty = 1)
u <- quantile(garch_resid[,1], probs=0.9, names=FALSE)
abline(v=u,col='blue')
```

Mean-Excess Plot

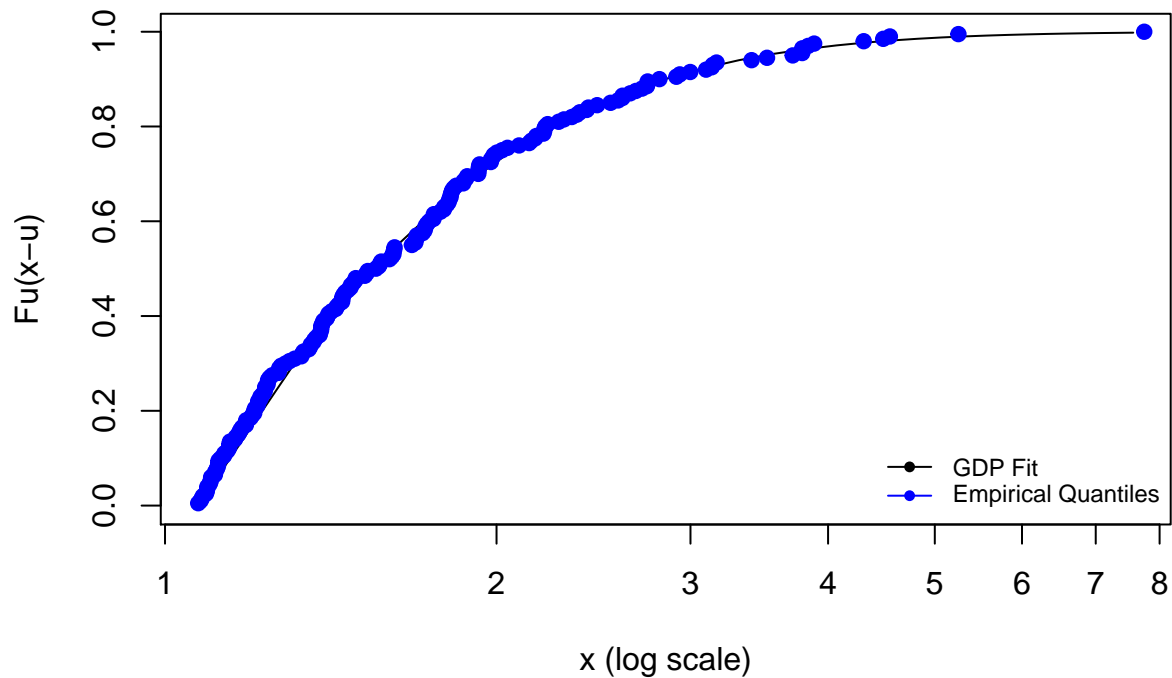


c)

Select a threshold $u > 0$

The threshold is selected as the point at which the MRL plot becomes linear, which is 1 on the MRL plot.

```
plotFittedGPDvsEmpiricalExcesses(garch_resid[,1], threshold = u)
legend("bottomright", inset=0, lty=c(1, 1), bty="n",
      col=c("black", "blue"),
      legend=as.expression(c("GDP Fit", "Empirical Quantiles")), cex = 0.75, pch = 16)
```

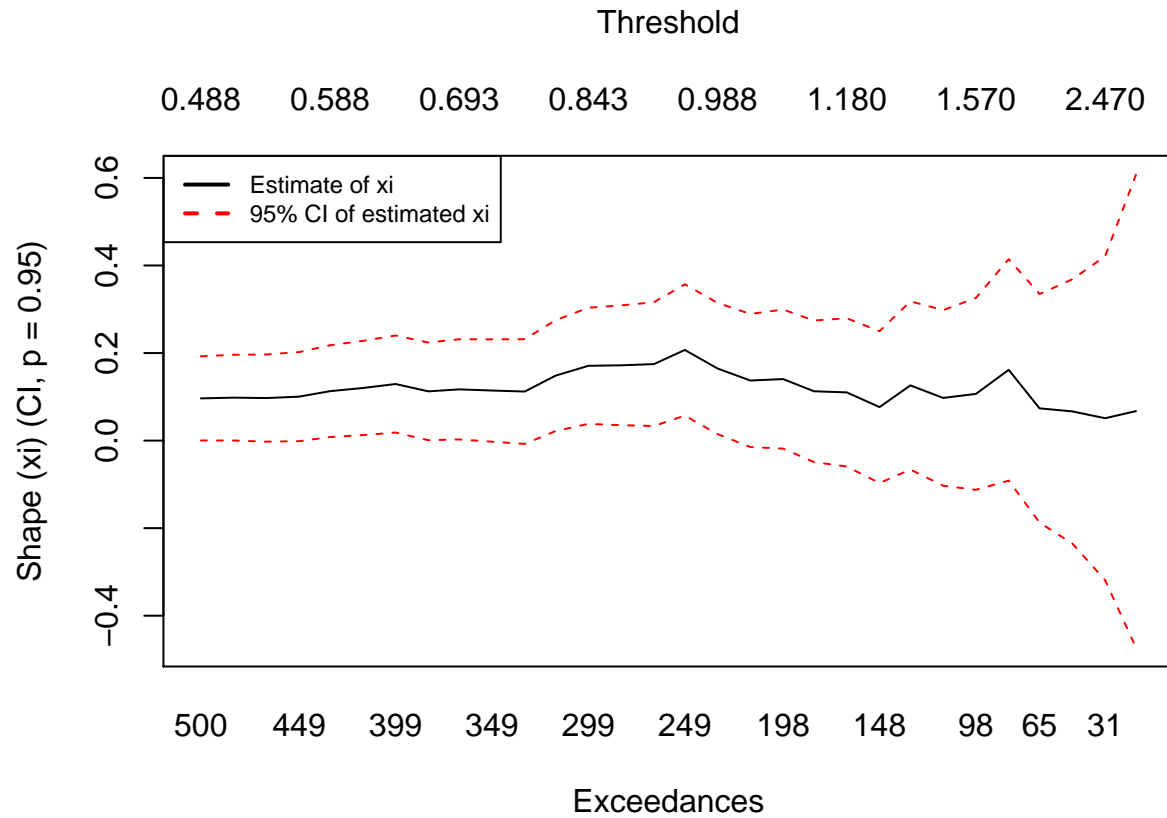


Fit GPD to standardized residuals exceeding the threshold

```
gpd <- fit.GPD(garch_resid[,1],threshold=1)
gpd_param <- as.vector(gpd$par.ests)
print(gpd$par.ests)

##          xi          beta
## 0.1446651 0.6370055

xiplot(garch_resid[,1])
legend("topleft", col=c("black", "red"),
      legend=as.expression(c("Estimate of xi", "95% CI of estimated xi")),
      lty = c(1, 2), lwd = 2, cex = 0.75)
```



d) Day-ahead VaR abd ES forecasts at 95% and 99% CI

```

vol <- sigma(garch)
t <- length(garch_resid[,1])
garch_param <- as.vector(coef(garch))
mu_pred <- garch_param[1]
vol_pred <- sqrt(garch_param[2]+garch_param[3]*(-r[t]-mu_pred)^2
                +garch_param[4]*as.numeric(vol[t])^2)

#install.packages("stats")
require(stats)
sorted_resid <- sort(garch_resid[,1])
F_hat <- ecdf(sorted_resid)

q_hat <-function(a){
  q <- gpd$threshold + (gpd_param[2]/gpd_param[1])*
    (((1-a)/(1-F_hat(gpd$threshold)))^(-gpd_param[1]))-1)
  return(q)}

var_gpd <-function(a){
  v <- mu_pred + vol_pred*q_hat(a)
  return(v)}

es_gpd <-function(a){
  es <- mu_pred + vol_pred*((q_hat(a)+gpd_param[2]-gpd_param[1]*gpd$threshold)/
    (1-gpd_param[1]))
  return(es)}

```

```

result <- matrix(c(var_gpd(0.95), es_gpd(0.95), var_gpd(0.99), es_gpd(0.99)),
                 ncol=2, byrow=FALSE)
rownames(result) <- c('day-ahead VaR forecast', 'day-ahead ES forecast')
colnames(result) <- c('95%', '99%')
result

```

```

##                95%        99%
## day-ahead VaR forecast 0.04796366 0.08894553
## day-ahead ES forecast  0.07440251 0.12231575

```