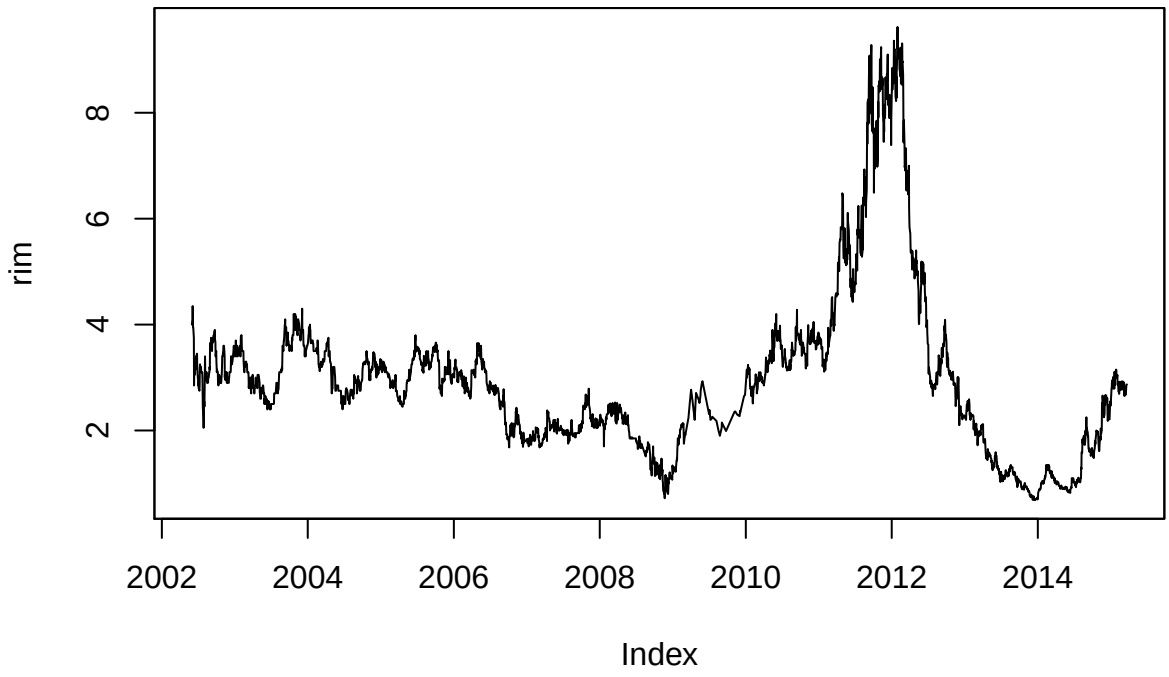
a4q3

part (a)

```
library("tseries")
rim<-get.hist.quote(instrument="rim",quote="Close")
```

```
## time series starts 2002-05-31
```

```
par(mfcol=c(1,1))
plot(rim)
```

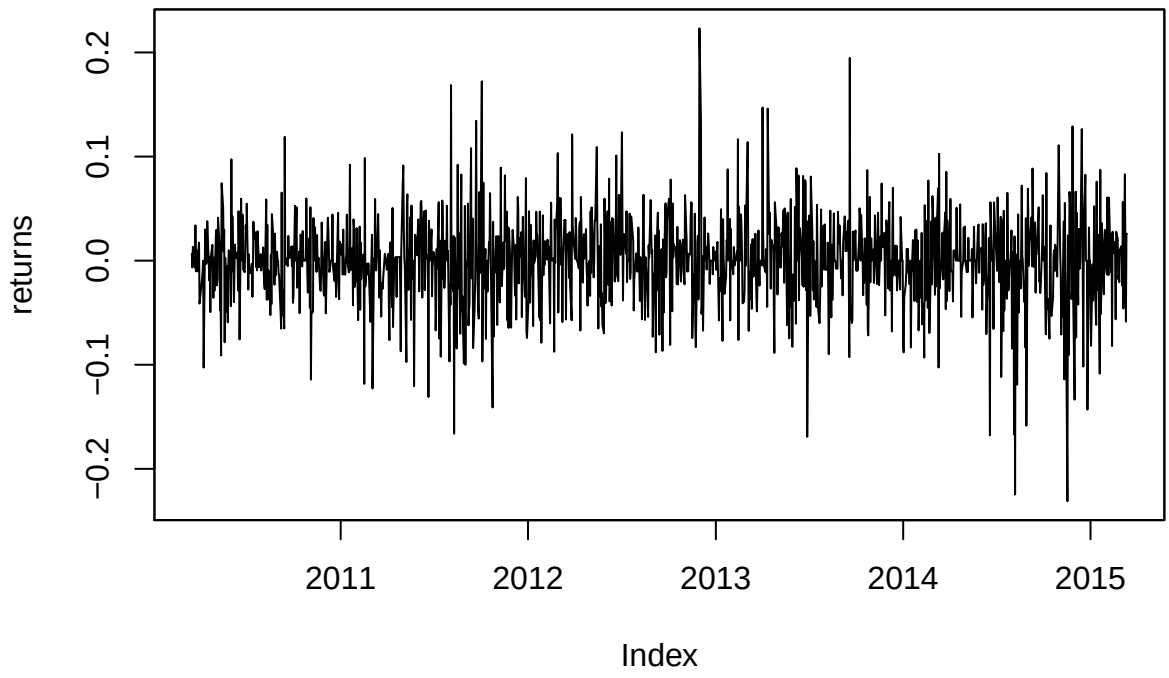


part b

```
rim<-get.hist.quote(instrument="rim",quote="Close",start="2010-03-17",end="2015-03-16")
returns<-log(rim/lag(rim,h=-1))
```

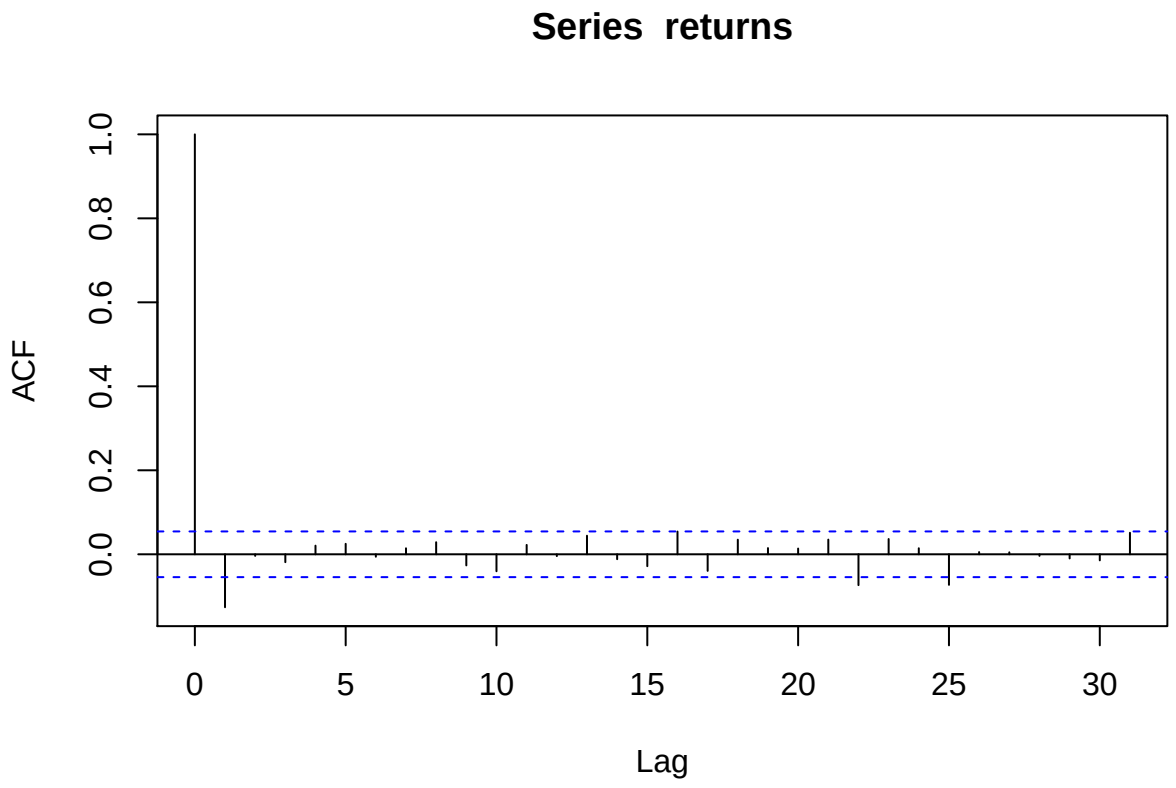
part c

```
plot(returns)
```

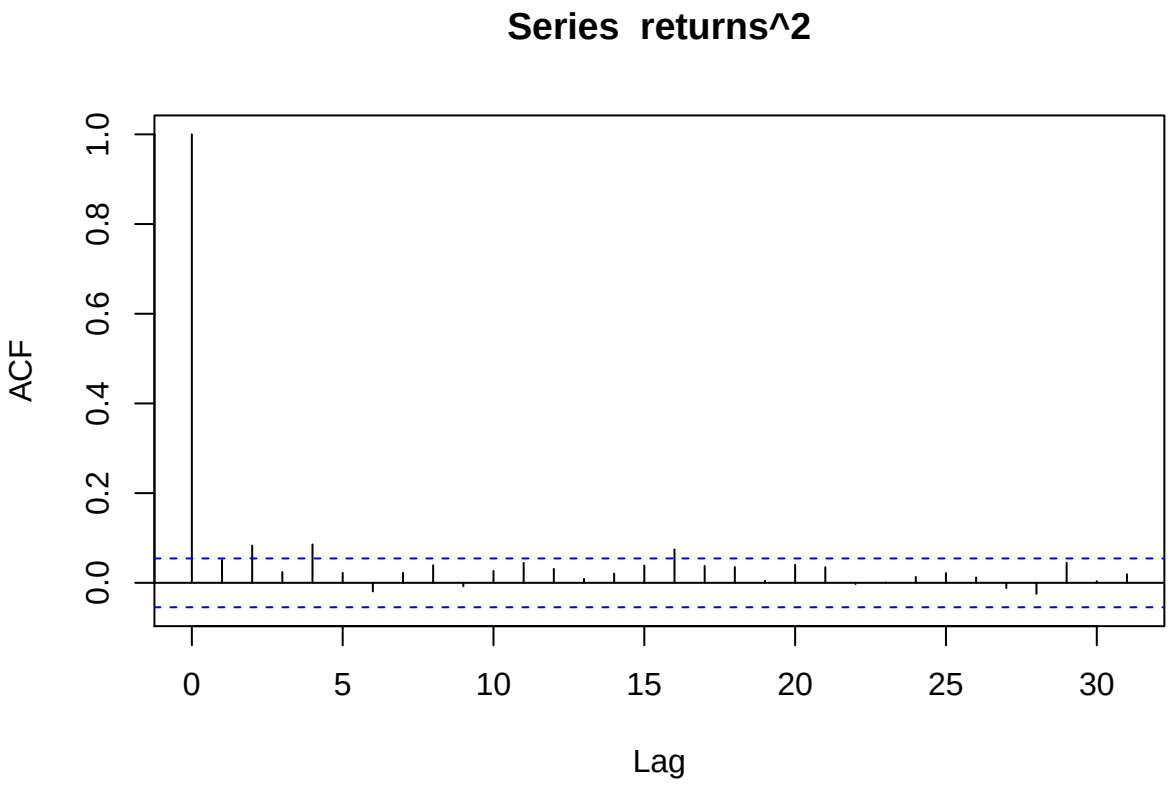


part d

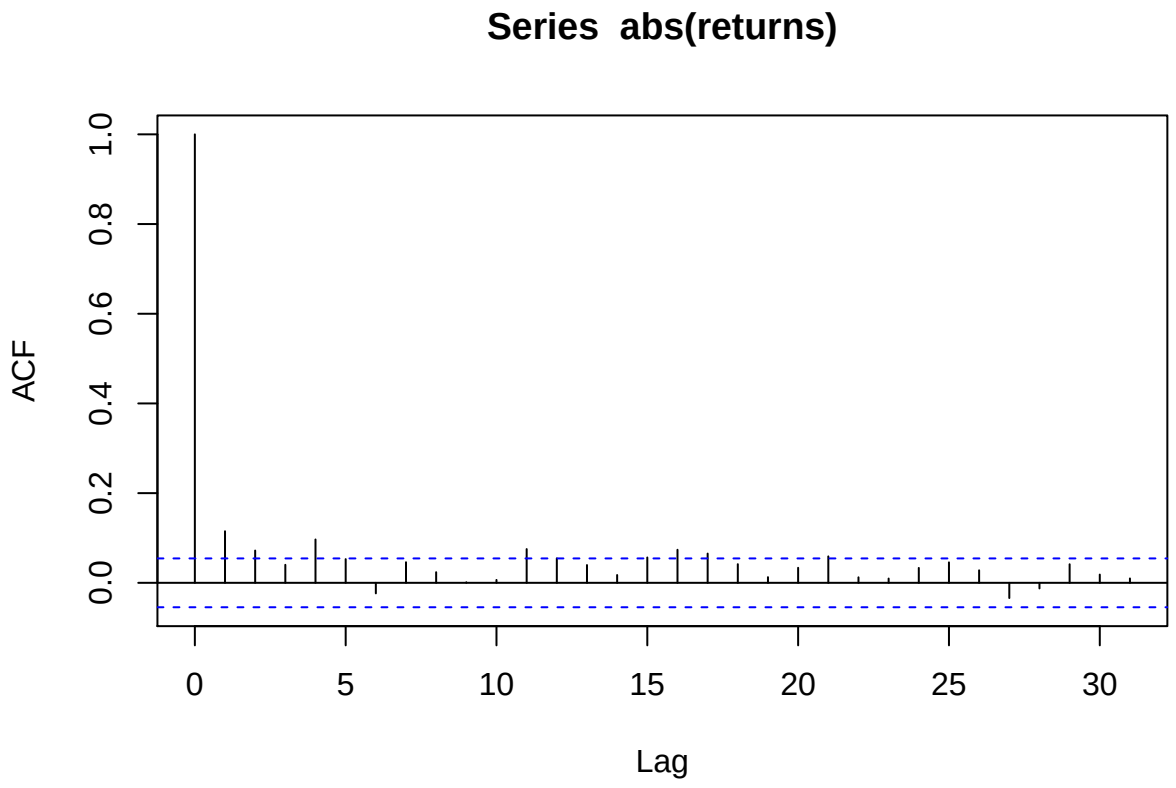
```
returns<-as.numeric(returns)
acf(returns)
```




```
acf(returns^2)
```




```
acf(abs(returns))
```




```
par(mfcol=c(1,2))
```

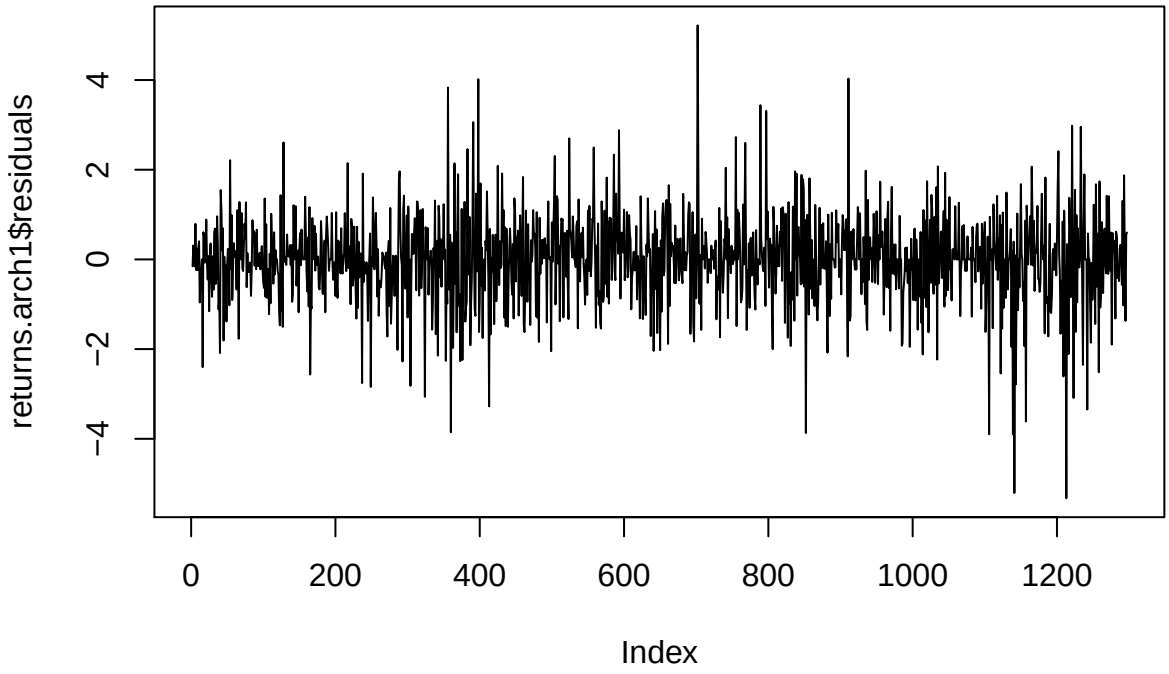
part e

```
returns.arch1 <- garch(returns, order=c(0,1), trace=F)
summary(returns.arch1)
```

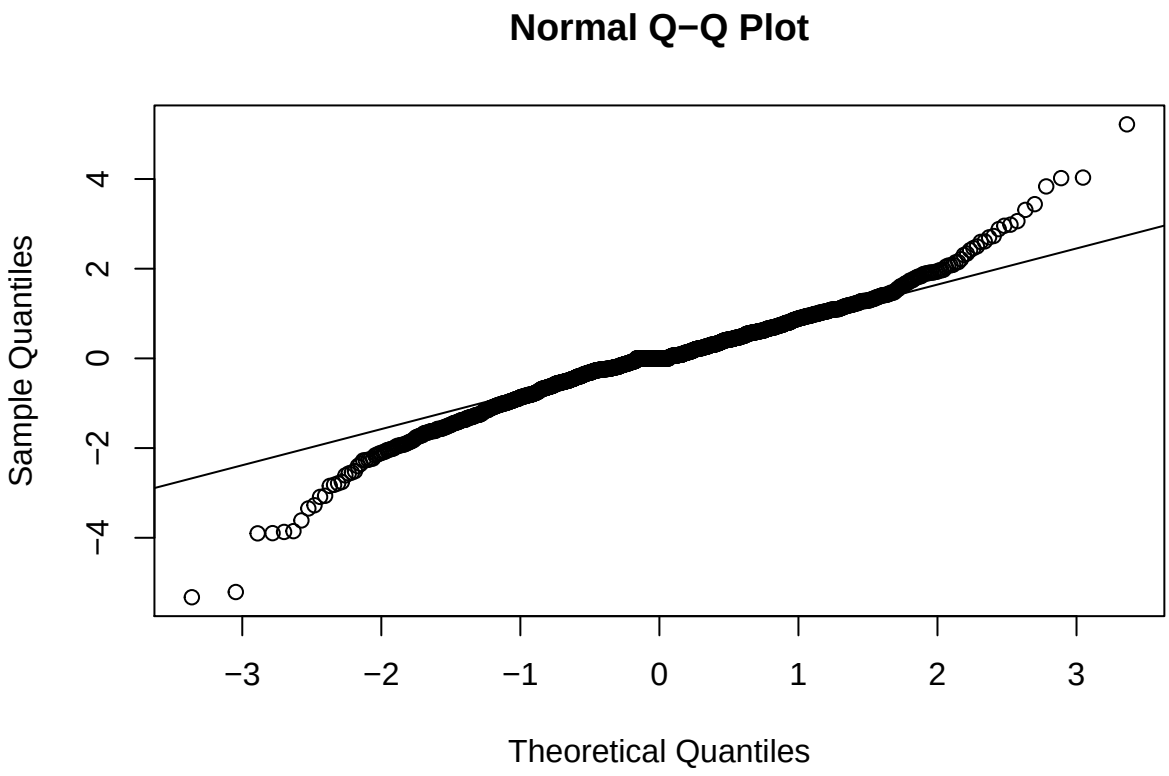
```
##
## Call:
## garch(x = returns, order = c(0, 1), trace = F)
##
## Model:
## GARCH(0,1)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -5.3258 -0.5088  0.0000  0.5779  5.2184
##
## Coefficient(s):
##     Estimate  Std. Error  t value Pr(>|t|)
## a0 1.828e-03   5.332e-05   34.290   <2e-16 ***
## a1 5.890e-02   2.502e-02    2.354   0.0186 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## Diagnostic Tests:
##  Jarque Bera Test
##
## data:  Residuals
## X-squared = 492.8855, df = 2, p-value < 2.2e-16
##
##
##  Box-Ljung test
##
## data:  Squared.Residuals
## X-squared = 0.0079, df = 1, p-value = 0.9291
```

```
plot(returns.arch1$residuals,type="l")
```




```
qqnorm(returns.arch1$residuals)
qqline(returns.arch1$residuals)
```



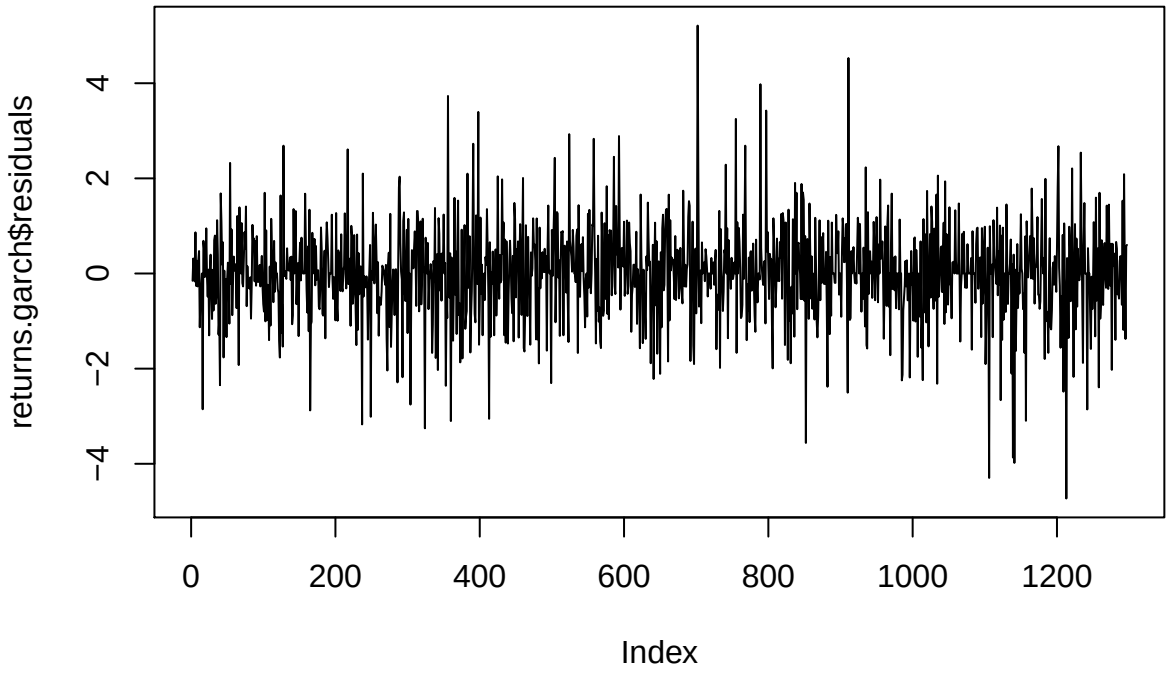
part f

```
returns.garch <- garch(returns, order=c(1,1), trace=F)
summary(returns.garch)
```

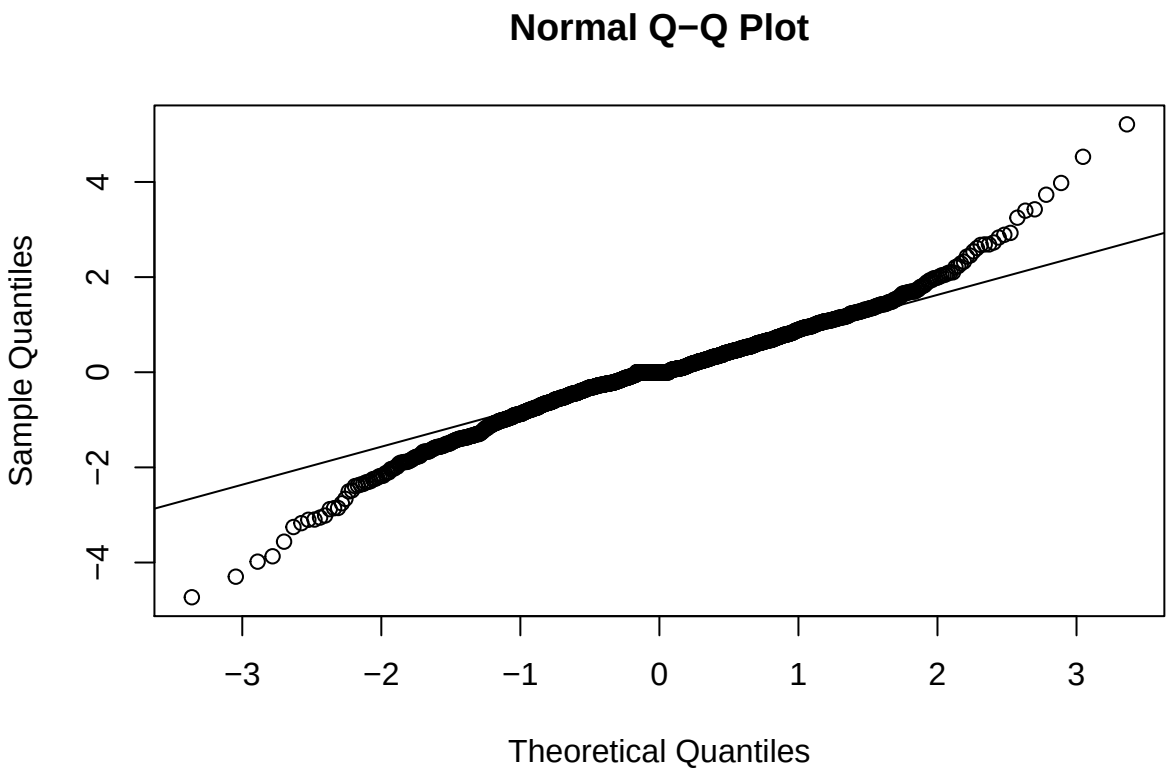
```
##
## Call:
## garch(x = returns, order = c(1, 1), trace = F)
##
## Model:
## GARCH(1,1)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4.7300 -0.5077  0.0000  0.5689  5.2114
##
## Coefficient(s):
##     Estimate  Std. Error  t value Pr(>|t|)
## a0 1.328e-04   3.352e-05    3.962 7.42e-05 ***
## a1 6.097e-02   1.114e-02    5.473 4.42e-08 ***
## b1 8.724e-01   2.424e-02   35.996  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Diagnostic Tests:
##  Jarque Bera Test
```

```
##
## data:  Residuals
## X-squared = 326.8644, df = 2, p-value < 2.2e-16
##
##
##  Box-Ljung test
##
## data:  Squared.Residuals
## X-squared = 0.4095, df = 1, p-value = 0.5222
```

```
plot(returns.garch$residuals,type="l")
```




```
qqnorm(returns.garch$residuals)
qqline(returns.garch$residuals)
```



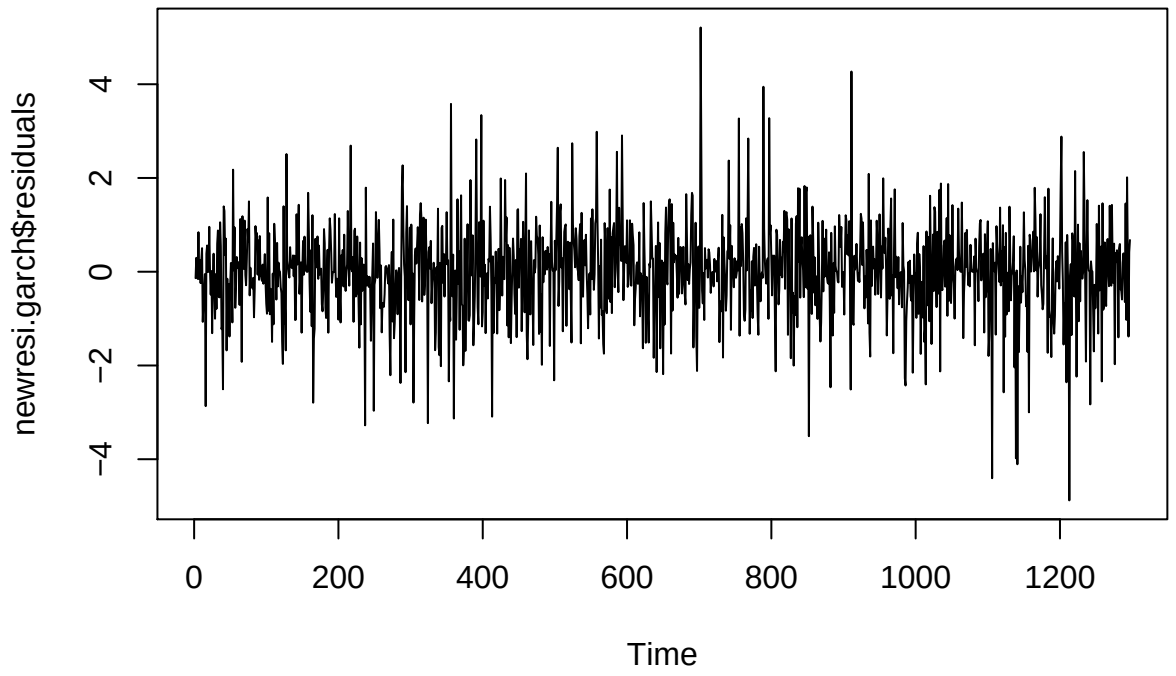
part g

```
new<-arima(returns,order=c(0,0,1),method="ML")
newresi.garch<-garch(new$residuals, order=c(1,1), trace=F)
summary(newresi.garch)
```

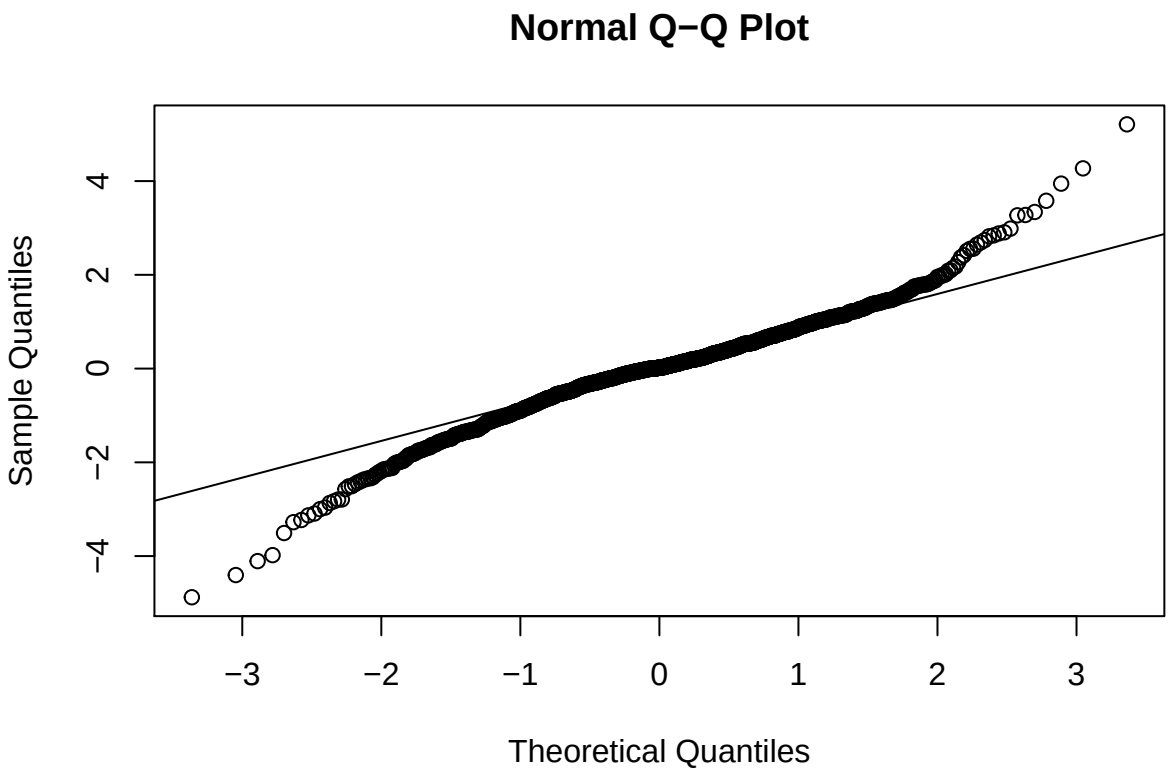
```
##
## Call:
## garch(x = new$residuals, order = c(1, 1), trace = F)
##
## Model:
## GARCH(1,1)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -4.87803 -0.50408  0.01952  0.55300  5.21028
##
## Coefficient(s):
##     Estimate  Std. Error  t value Pr(>|t|)
## a0 1.189e-04   3.068e-05    3.875 0.000107 ***
## a1 5.611e-02   1.023e-02    5.486 4.12e-08 ***
## b1 8.830e-01   2.264e-02   39.002  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Diagnostic Tests:
```

```
##  Jarque Bera Test
##
## data:  Residuals
## X-squared = 342.9794, df = 2, p-value < 2.2e-16
##
##
##  Box-Ljung test
##
## data:  Squared.Residuals
## X-squared = 0.2711, df = 1, p-value = 0.6026
```

```
plot(newresi.garch$residuals,type="l")
```




```
qqnorm(newresi.garch$residuals)
qqline(newresi.garch$residuals)
```


Normal Q−Q Plot
Sample Quantiles
Theoretical Quantiles
−4
−2
0
2
4
−3
−2
−1
0
1
2
3