INTC GARCH comparison

- Data: 1973 to 2009 monthly returns
- Build low order GARCH model
- Demonstrate empirical analysis of GARCH processes
- Compare different GARCH models
- Show predictions

GARCH(1,1) with normal innovations

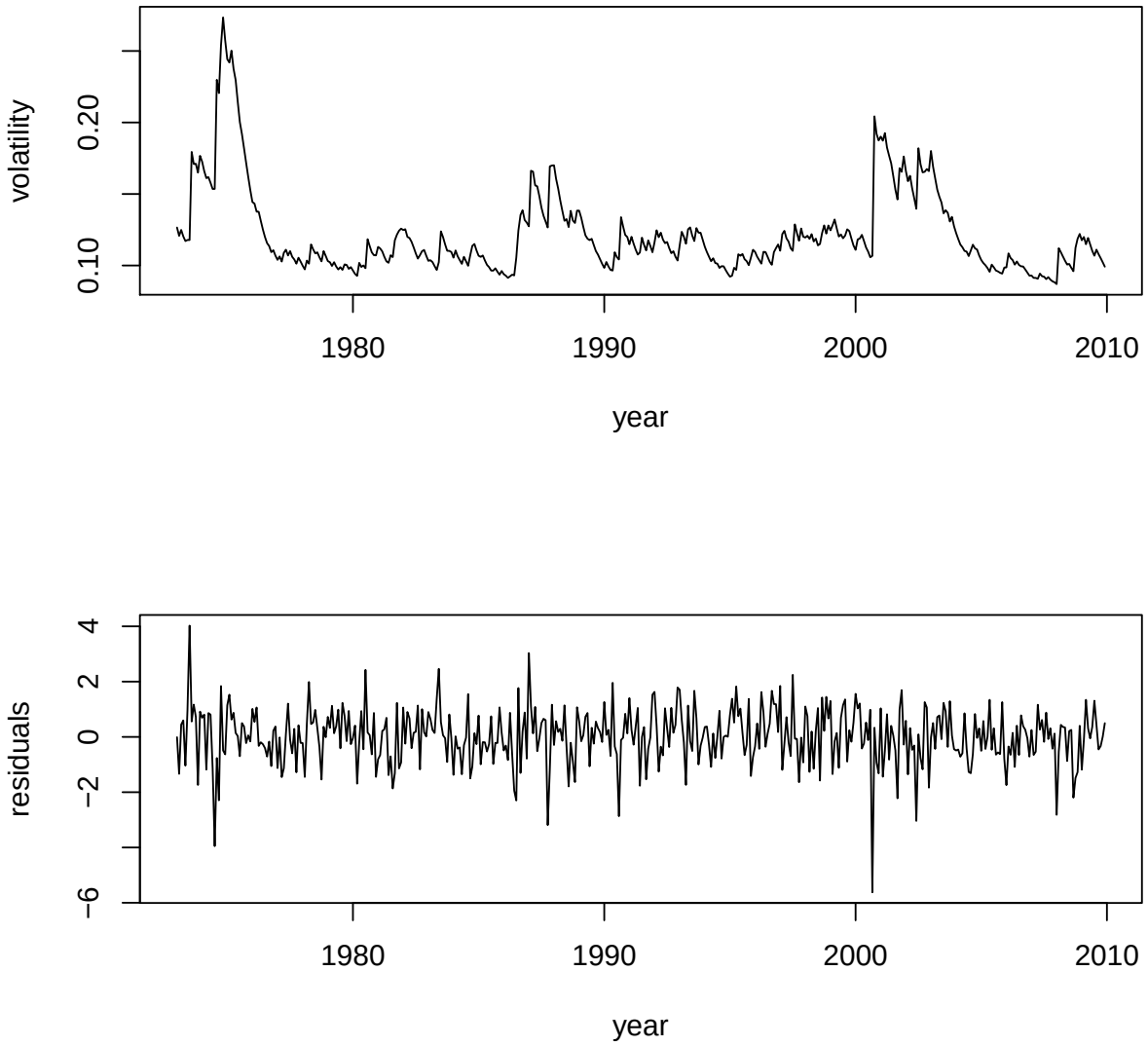
- The fitted model is

$$r_t = 0.0113 + a_t, a_t = \sigma_t \epsilon_t$$

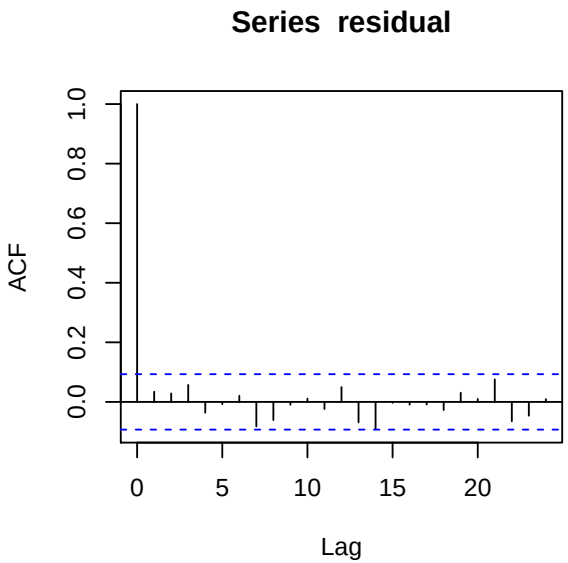
$$\sigma_t^2 = 0.00092 + 0.086 a_{t-1}^2 + 0.853 \sigma_{t-1}^2.$$

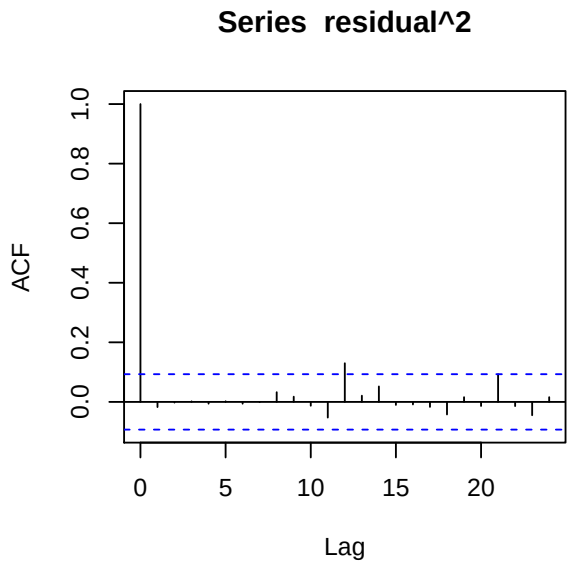
- All the estimates are significant, AIC=-1.3889.
- The unconditional variance is $0.000919/(1 - 0.0864 - 0.853) = 0.0152$. Sample variance is 0.0161.

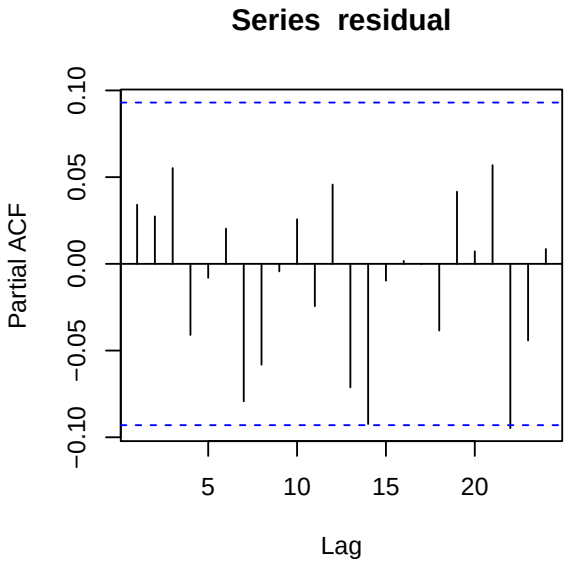
Time plot of volatility series and standardized residuals

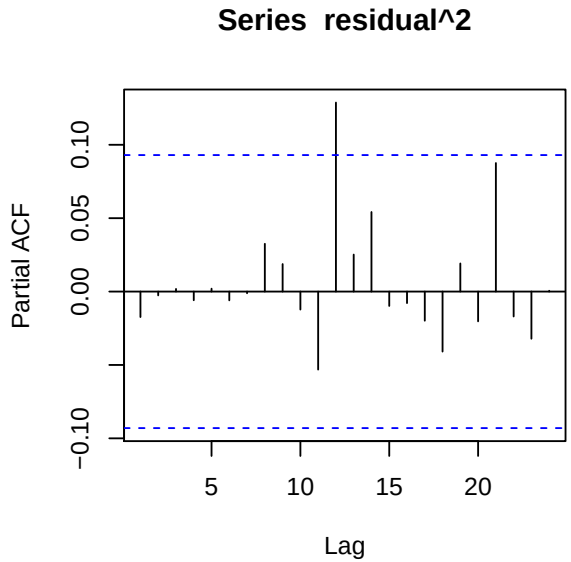


ACF and PACF of the residuals and residuals squares



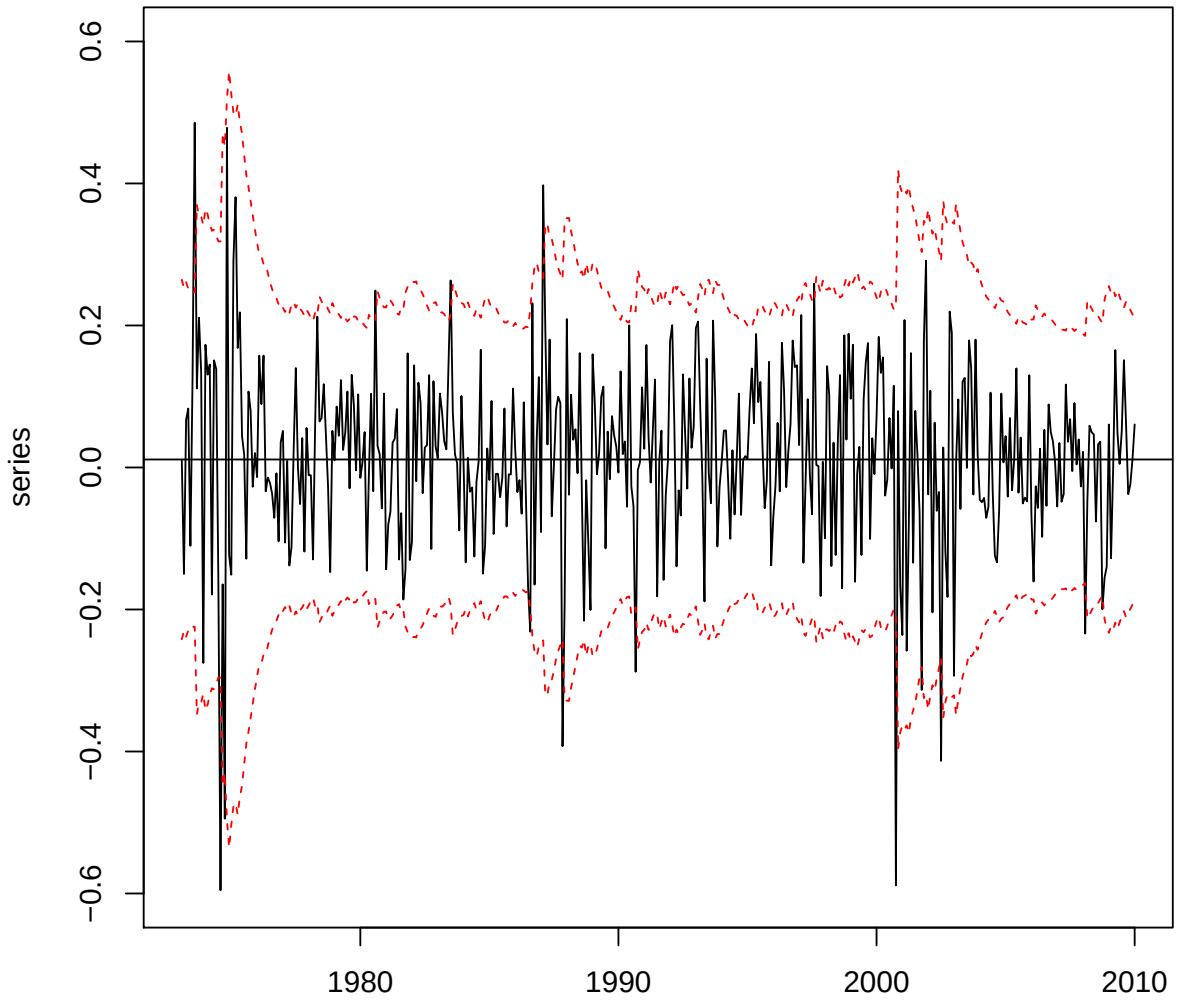




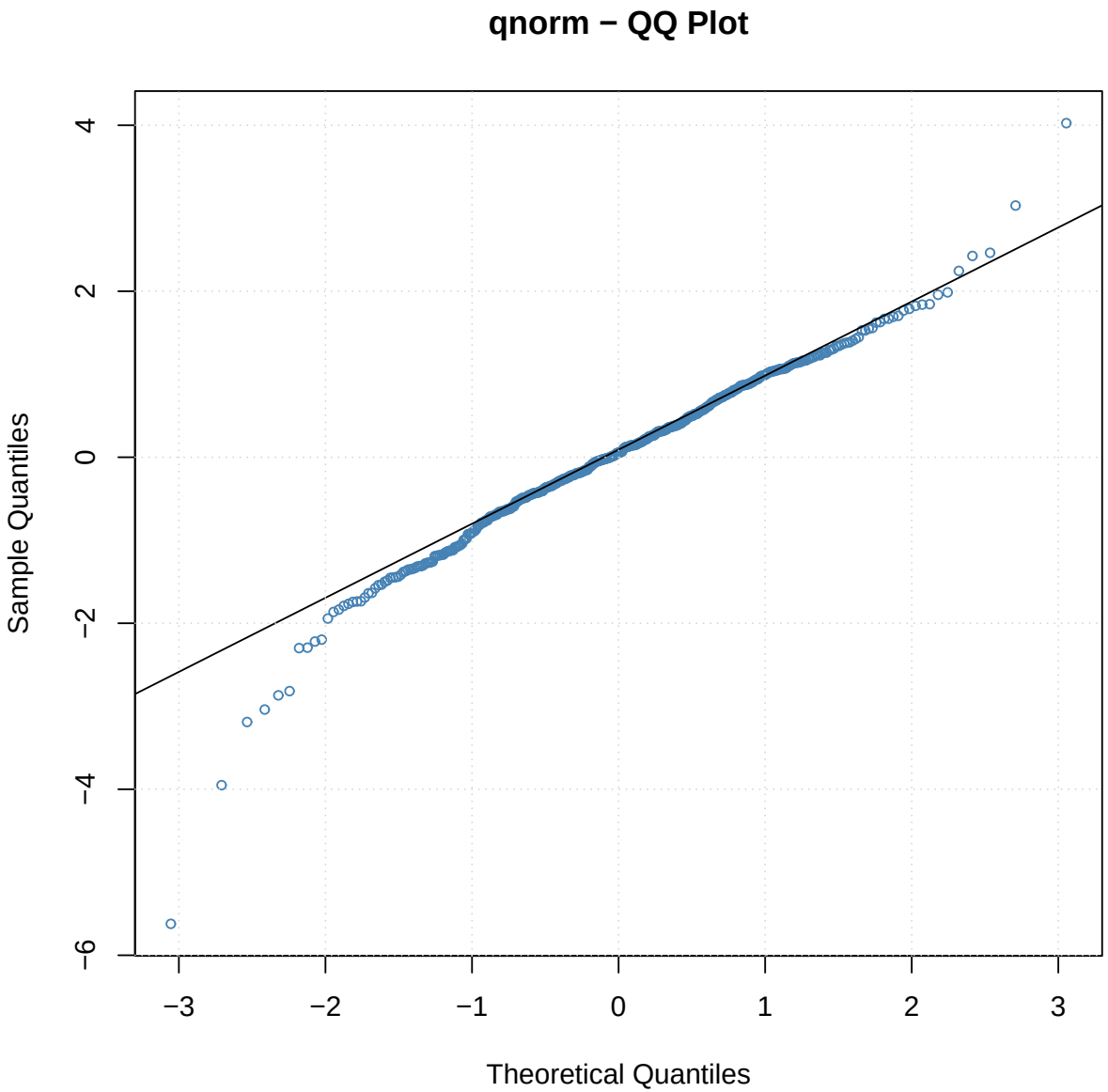


Predictive interval plot

This is the time plot of the 95% predictive intervals.



The QQ plots


qnorm − QQ Plot
Sample Quantiles
Theoretical Quantiles
4
2
0
−2
−4
−6
−3
−2
−1
0
1
2
3

GARCH(1,1) with t innovations

- From the qq plot it seems that innovations do not follow normal distribution.
- The fitted model with a t innovation is

$$r_t = 0.0165 + a_t, a_t = \sigma_t \epsilon_t, \epsilon_t \sim t_{6.77}.$$

$$\sigma_t^2 = 0.00116 + 0.1059 a_{t-1}^2 + 0.817 \sigma_{t-1}^2.$$

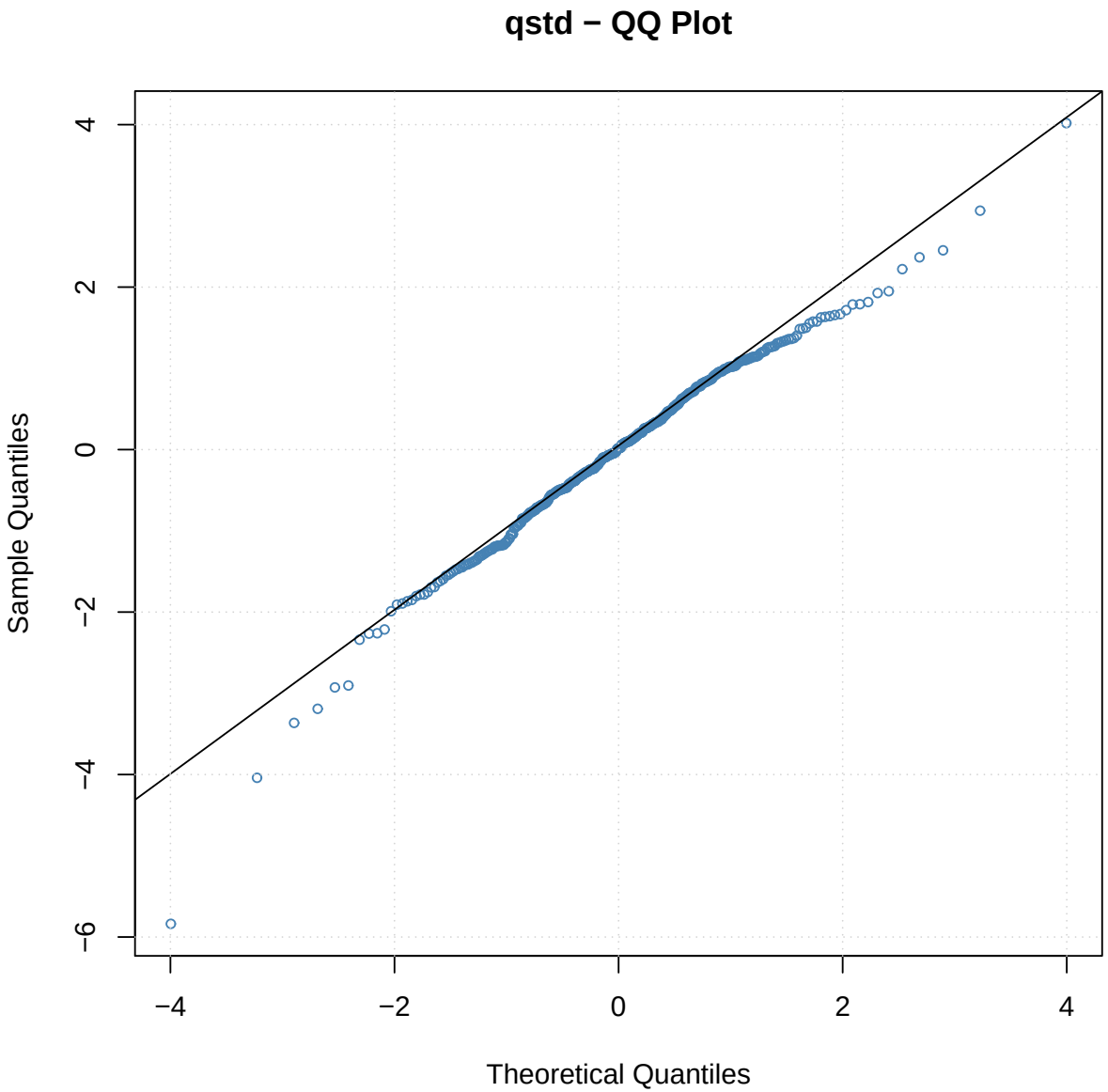
- All the estimates are significant, AIC=-1.447.
- The unconditional variance is $0.00116/(1 - 0.1059 - 0.817) = 0.015$.
- The fitted model with a skewed t innovation is

$$r_t = 0.0133 + a_t, a_t = \sigma_t \epsilon_t, \epsilon_t \sim t_{0.87,7.23}.$$

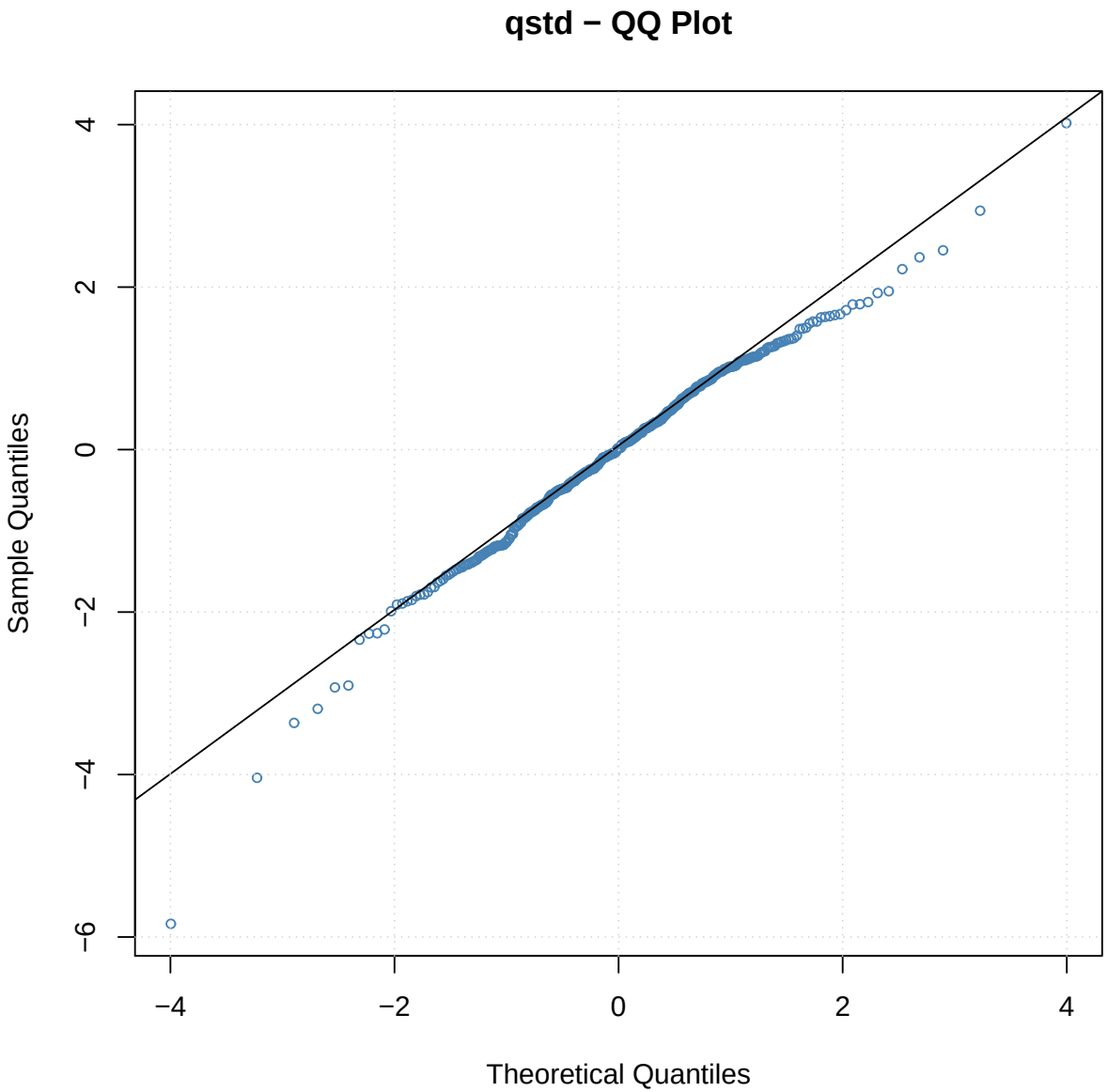
$$\sigma_t^2 = 0.00116 + 0.1049 a_{t-1}^2 + 0.8178 \sigma_{t-1}^2.$$

- All the estimates are significant, AIC=-1.4509.

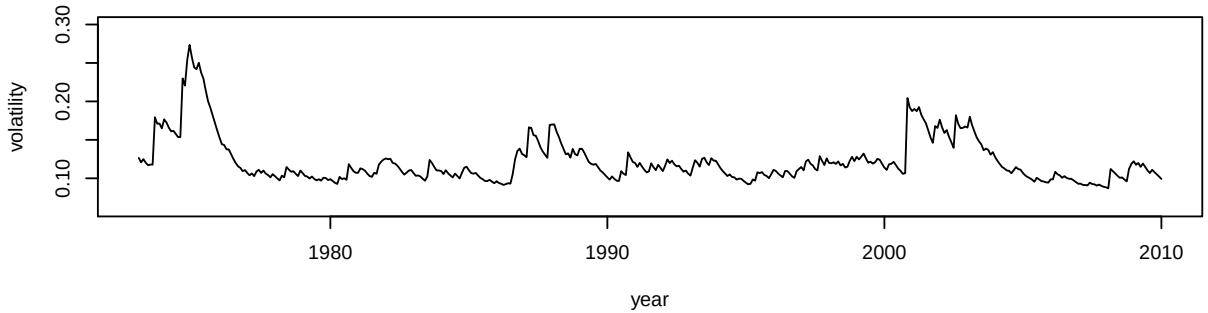
The QQ plots

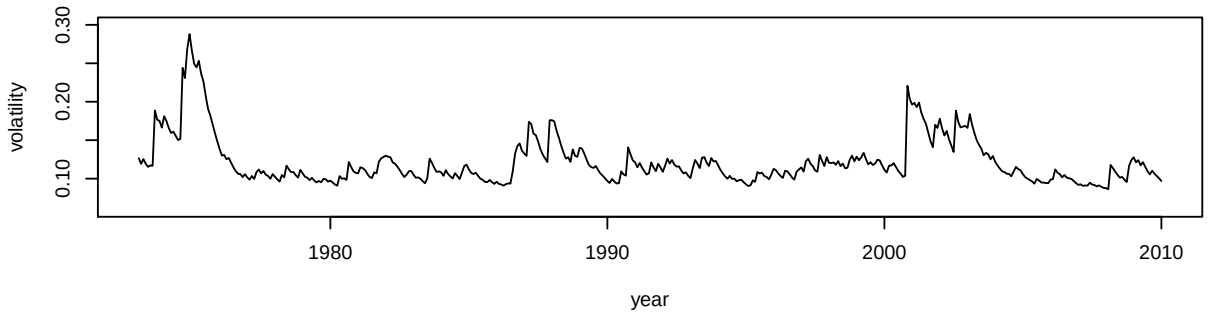

qstd − QQ Plot
Sample Quantiles
Theoretical Quantiles
4
2
0
−2
−4
−6
−4
−2
0
2
4

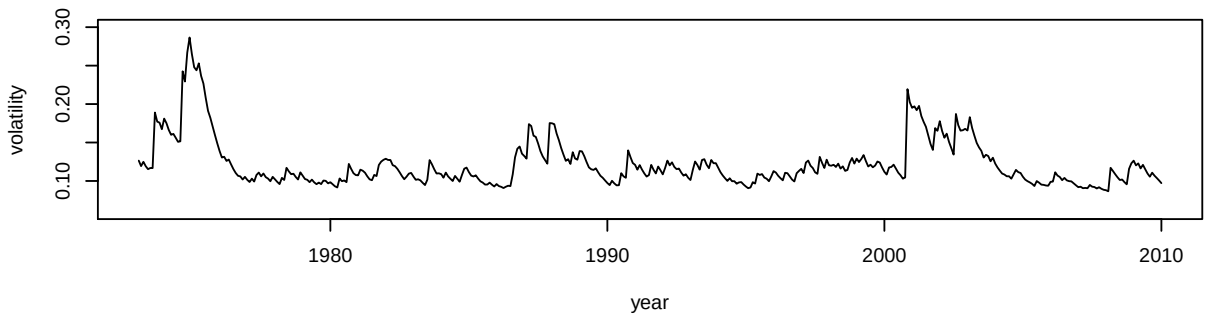
The QQ plots


qstd − QQ Plot
Sample Quantiles
Theoretical Quantiles
4
2
0
−2
−4
−6
−4
−2
0
2
4

The time plots of volatilities







Forecast comparisons

model	1	2	3	4	5
normal	0.0975	0.0993	0.1009	0.1023	0.1037
t	0.0951	0.0975	0.0997	0.1016	0.1034
skewed t	0.0954	0.0979	0.1000	0.1019	0.1037

Table: Volatility forecasts for monthly log returns of intel stock

code

```
library(fGarch)
da=read.table("m-intcsp7309.txt", header=T)
intc=log(da$intc+1)
m1=garchFit(~1+garch(1,1), data=intc,trace=F)

 summary(m1)
 garchFit(formula = ~1 + garch(1, 1), data = intc, trace = F)
Error Analysis:
        Estimate  Std. Error  t value Pr(>|t|)
mu     0.0112657   0.0053931    2.089  0.03672 *
omega  0.0009190   0.0003888    2.364  0.01808 *
alpha1 0.0864383   0.0265439    3.256  0.00113 **
beta1  0.8525855   0.0394322   21.622  < 2e-16 ***
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1

Log Likelihood:
 312.3307    normalized:  0.7034475
Standardised Residuals Tests:
                               Statistic p-Value
 Jarque-Bera Test   R    Chi^2  174.904   0
 Shapiro-Wilk Test  R    W      0.9709618 1.030402e-07
 Ljung-Box Test     R    Q(10)  8.016844  0.6271916
 Ljung-Box Test     R    Q(15)  15.5006   0.4159946
 Ljung-Box Test     R    Q(20)  16.41549  0.6905368
 Ljung-Box Test     R^2  Q(10)  0.8746345 0.9999072
 Ljung-Box Test     R^2  Q(15)  11.35935  0.7267295
 Ljung-Box Test     R^2  Q(20)  12.55994  0.8954573
 LM Arch Test       R    TR^2   10.51401  0.5709617
Information Criterion Statistics:
      AIC       BIC       SIC      HQIC
-1.388877 -1.351978 -1.389037 -1.374326
```

code

```
v1=volatility(m1)
residual=residuals(m1, standardize=T)
vol=ts(v1, frequency=12, start=c(1973,1))
res=ts(residual, frequency=12, start=c(1973,1))
par(mfcol=c(2,1))
plot(vol,xlab='year',ylab='volatility',type='l')
plot(res,xlab='year',ylab='residuals',type='l')
par(mfcol=c(2,2))
acf(residual, lag=24)
pacf(residual, lag=24)
acf(residual^2, lag=24)
pacf(residual^2, lag=24)
#obtain plots of predictive intervals
par(mfcol=c(1,1))
upp=0.01126568+2*v1
low=0.01126568-2*v1
tdx=c(1:444)/12+1973
plot(tdx, intc, xlab='year',ylab='series',type='l', ylim=c(-0.6, 0.6))
lines(tdx, upp, lty=2, col='red')
lines(tdx, low, lty=2, col='red')
abline(h=c(0.01126568))
m2=garchFit(~1+garch(1,1), data=intc,trace=F,cond.dist='std')

summary(m2)

Title:
 GARCH Modelling

Call:
 garchFit(formula = ~1 + garch(1, 1), data = intc, cond.dist = "std",
    trace = F)
```

code

```
        Estimate  Std. Error  t value Pr(>|t|)
mu     0.0165075   0.0051031    3.235 0.001217 **
omega  0.0011576   0.0005782    2.002 0.045286 *
alpha1 0.1059030   0.0372047    2.846 0.004420 **
beta1  0.8171313   0.0580141   14.085  < 2e-16 ***
shape  6.7723503   1.8572367    3.646 0.000266 ***
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1
Standardised Residuals Tests:
                               Statistic p-Value
 Jarque-Bera Test   R    Chi^2  203.4933  0
 Shapiro-Wilk Test  R    W      0.9687606 3.970356e-08
 Ljung-Box Test     R    Q(10)  7.877778  0.6407741
 Ljung-Box Test     R    Q(15)  15.5522   0.4124197
 Ljung-Box Test     R    Q(20)  16.50475  0.6848581
 Ljung-Box Test     R^2  Q(10)  1.066054  0.9997694
 Ljung-Box Test     R^2  Q(15)  11.49875  0.7165045
 Ljung-Box Test     R^2  Q(20)  12.61496  0.8932865
 LM Arch Test       R    TR^2   10.80739  0.5454935
Information Criterion Statistics:
      AIC       BIC       SIC      HQIC
-1.446966 -1.400841 -1.447215 -1.428776
```

```
v2=volatility(m2)
m3=garchFit(~1+garch(1,1), data=intc,trace=F,cond.dist='sstd')
summary(m3)
 garchFit(formula = ~1 + garch(1, 1), data = intc, cond.dist = "sstd",
    trace = F)
```

code

```
        Estimate  Std. Error  t value Pr(>|t|)
mu     0.0133343   0.0053430    2.496 0.012572 *
omega  0.0011621   0.0005587    2.080 0.037519 *
alpha1 0.1049289   0.0358860    2.924 0.003456 **
beta1  0.8177875   0.0559863   14.607  < 2e-16 ***
skew   0.8717220   0.0629129   13.856  < 2e-16 ***
shape  7.2344224   2.1018054    3.442 0.000577 ***
Standardised Residuals Tests:
                                Statistic p-Value
 Jarque-Bera Test   R    Chi^2  195.2178  0
 Shapiro-Wilk Test  R    W      0.969251  4.893319e-08
 Ljung-Box Test     R    Q(10)  7.882126  0.6403496
 Ljung-Box Test     R    Q(15)  15.62496  0.4074054
 Ljung-Box Test     R    Q(20)  16.5774   0.6802193
 Ljung-Box Test     R^2  Q(10)  1.078429  0.9997569
 Ljung-Box Test     R^2  Q(15)  11.95155  0.6826924
 Ljung-Box Test     R^2  Q(20)  13.03792  0.8757513
 LM Arch Test       R    TR^2   11.18826  0.5128574
Information Criterion Statistics:
      AIC       BIC       SIC      HQIC
-1.450899 -1.395550 -1.451257 -1.429071

v3=volatility(m3)
par(mfcol=c(3,1))
plot(tdx,v1,xlab='year',ylab='volatility',type='l', ylim=c(0.06, 0.3))
plot(tdx,v2,xlab='year',ylab='volatility',type='l', ylim=c(0.06, 0.3))
plot(tdx,v3,xlab='year',ylab='volatility',type='l', ylim=c(0.06, 0.3))
cor(cbind(v1,v2,v3))
```

code

```
x=intc[length(intc)]
at=(x-0.01126568)
f=0.0009190+0.0864383*at^2+0.8525855*(v1[length(v1)])^2

sqrt(f)

[1] 0.09754446

 predict(m1,5)
  meanForecast  meanError standardDeviation
1   0.01126568 0.09754454         0.09754454
2   0.01126568 0.09926616         0.09926616
3   0.01126568 0.10085604         0.10085604
4   0.01126568 0.10232650         0.10232650
5   0.01126568 0.10368830         0.10368830
```