Time Series Analysis

Homework of week 9
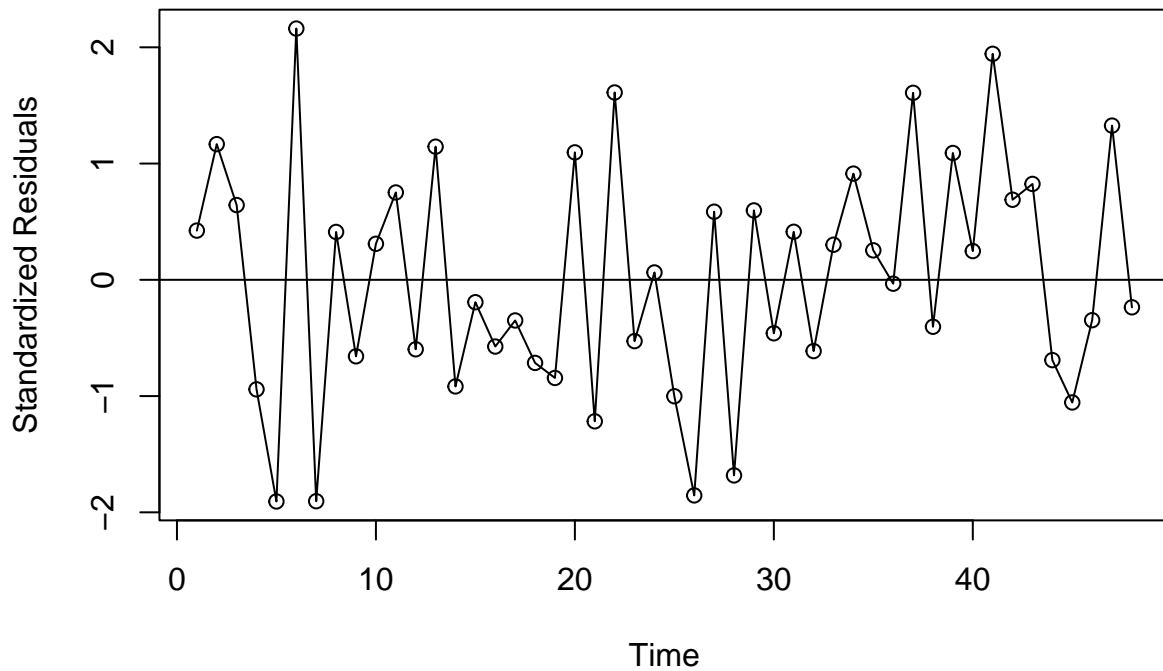
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8.6

```
set.seed(65423)
series <- arima.sim(n=48,list(ar=c(1.5,-0.75)))
```

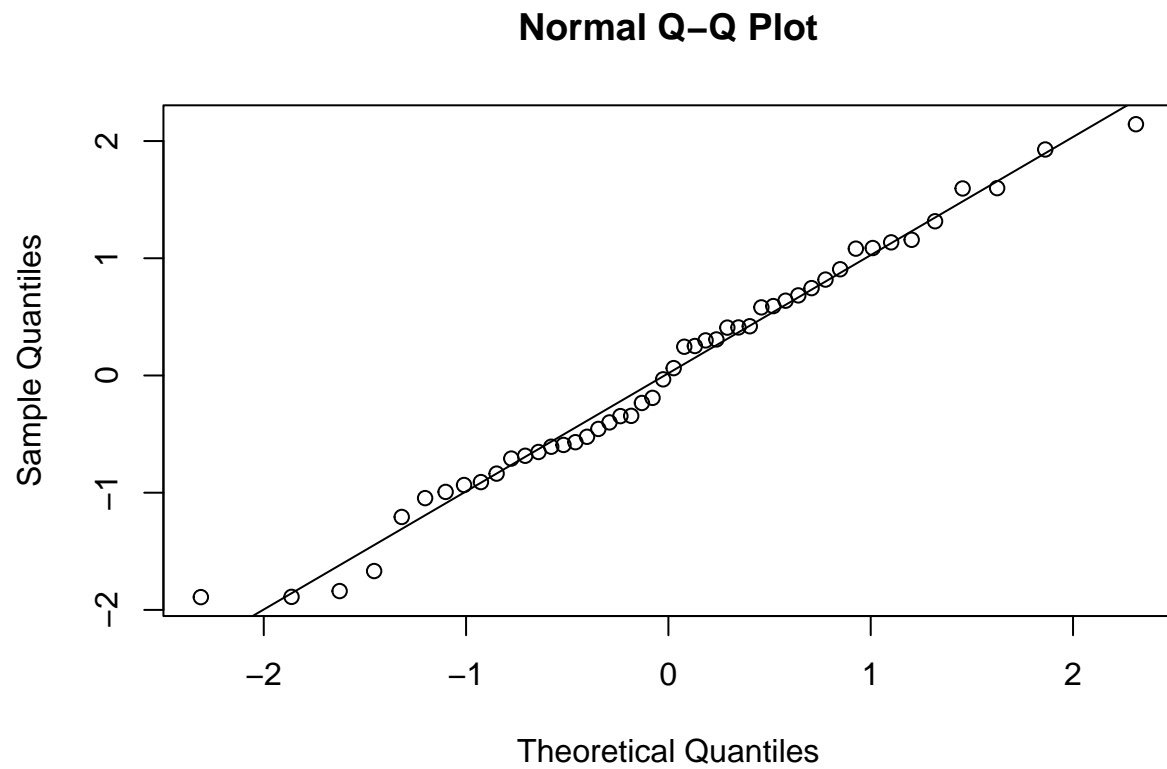### (a)

```
model <- arima(series,order=c(2,0,0))
plot(rstandard(model),ylab='Standardized Residuals',type='o')
abline(h=0)
```
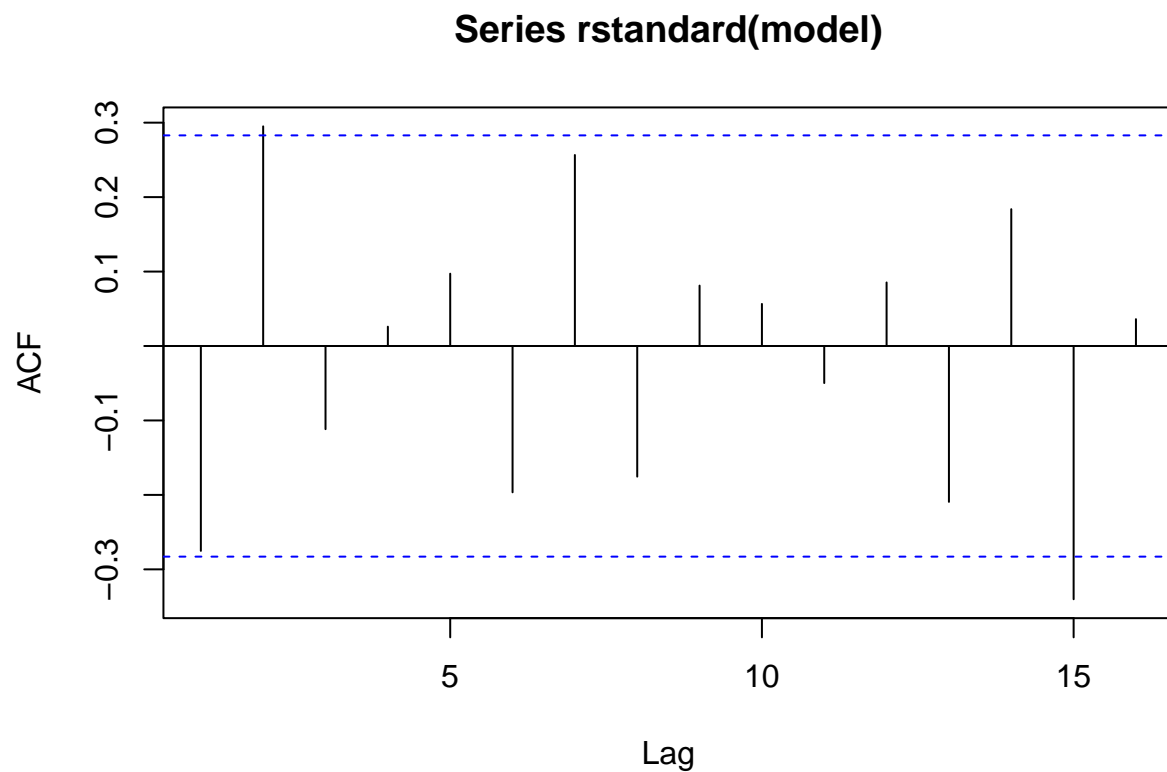

The rediduals look "random".

(b)

```
qqnorm(residuals(model))
qqline(residuals(model))
```

Normal Q–Q Plot

Yes. No problem with normality of the error terms.

(c)

```
acf(rstandard(model))
```

Series rstandard(model)

There are two residual autocorrelations that are "significant" at lags 2 and 15.

(d)

```
LB.test(model,lag=12)
```

```
##
##   Box-Ljung test
##
## data:  residuals from  model
## X-squared = 18.8, df = 10, p-value = 0.04288
```

Based on this test, we would reject the assumption of independent error terms at the 5% significance level for this simulation.

8.11

```
data(oil.price)
plot(diff(log(oil.price)),type='o',ylab='Diff(Log(oil.price))')
```

(a)
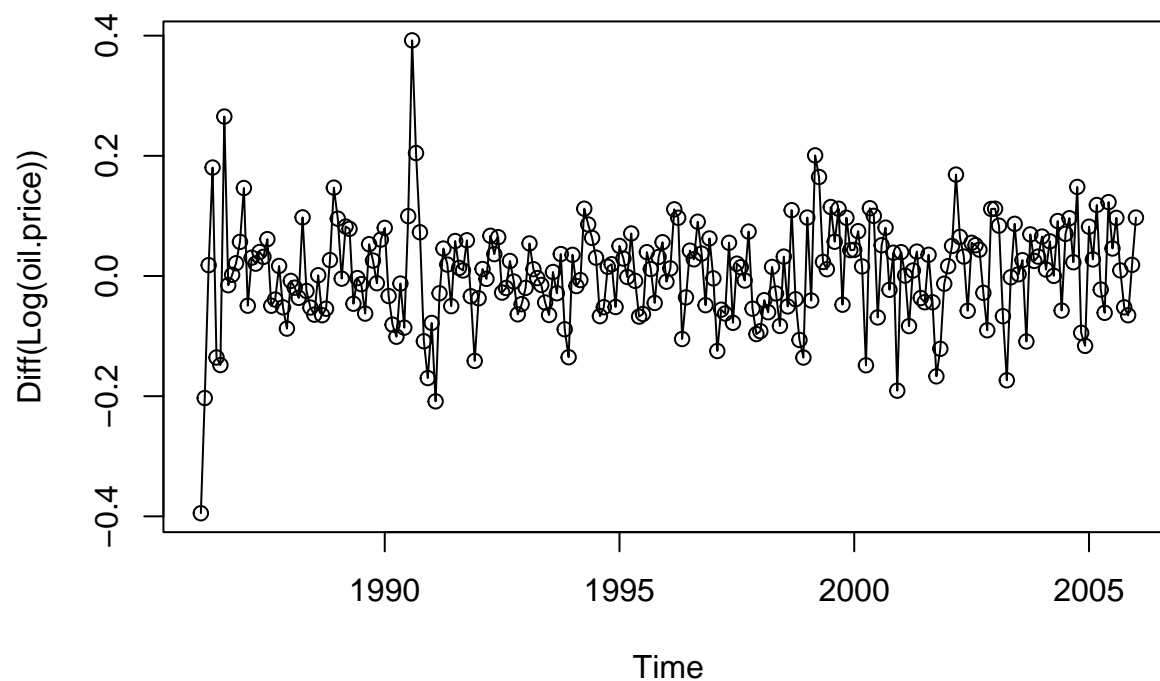
```
model1 <- arima(log(oil.price),order=c(1,1,0));model1
```

```
##
## Call:
## arima(x = log(oil.price), order = c(1, 1, 0))
##
## Coefficients:
##          ar1
##       0.2364
## s.e.  0.0660
##
## sigma^2 estimated as 0.006787:  log likelihood = 258.55,  aic = -515.11
```

```
model2 <- arima(log(oil.price),order=c(4,1,0));model2
```

```
##
## Call:
## arima(x = log(oil.price), order = c(4, 1, 0))
##
## Coefficients:
##          ar1      ar2     ar3      ar4
##       0.2673  -0.1550  0.0238  -0.0970
## s.e.  0.0669   0.0691  0.0691   0.0681
```

4

```
##
## sigma^2 estimated as 0.006603:  log likelihood = 261.82,  aic = -515.64
```

The ar3 and ar4 coefficients are not significant in the ARIMA(4,1,0) model and the AIC value is a tiny bit better in the simpler ARIMA(1,1,0) case. Furthermore, given the standard error of the ar1 coefficients, there is no real difference between the estimates of the ar1 coefficients in the two models. Let's try an ARIMA(2,1,0) model for comparison.

```
model3 <- arima(log(oil.price),order=c(2,1,0));model3
```

```
##
## Call:
## arima(x = log(oil.price), order = c(2, 1, 0))
##
## Coefficients:
##           ar1      ar2
##        0.2630  -0.1436
## s.e.   0.0666   0.0673
##
## sigma^2 estimated as 0.00666:  log likelihood = 260.81,  aic = -517.61
```

This model has the smallest AIC value of the three considered so far.

(b)

```
model4 <- arima(log(oil.price),order=c(0,1,1));model4
```

```
##
## Call:
## arima(x = log(oil.price), order = c(0, 1, 1))
##
## Coefficients:
##           ma1
##        0.2956
## s.e.   0.0693
##
## sigma^2 estimated as 0.006689:  log likelihood = 260.29,  aic = -518.58
```

This model has a significant ma1 coefficient and log-ikelihood and AIC values quite similar to the ARIMA(1,1,0) and ARIMA(0,1,1) models. This IMA(1,1) model does have the best AIC value. We will look at the diagnostics for these three models in part (c) before we decide which we prefer.


(c)

```
tsdiag(model1,main="Model 1")
```

Standardized Residuals

ACF of Residuals
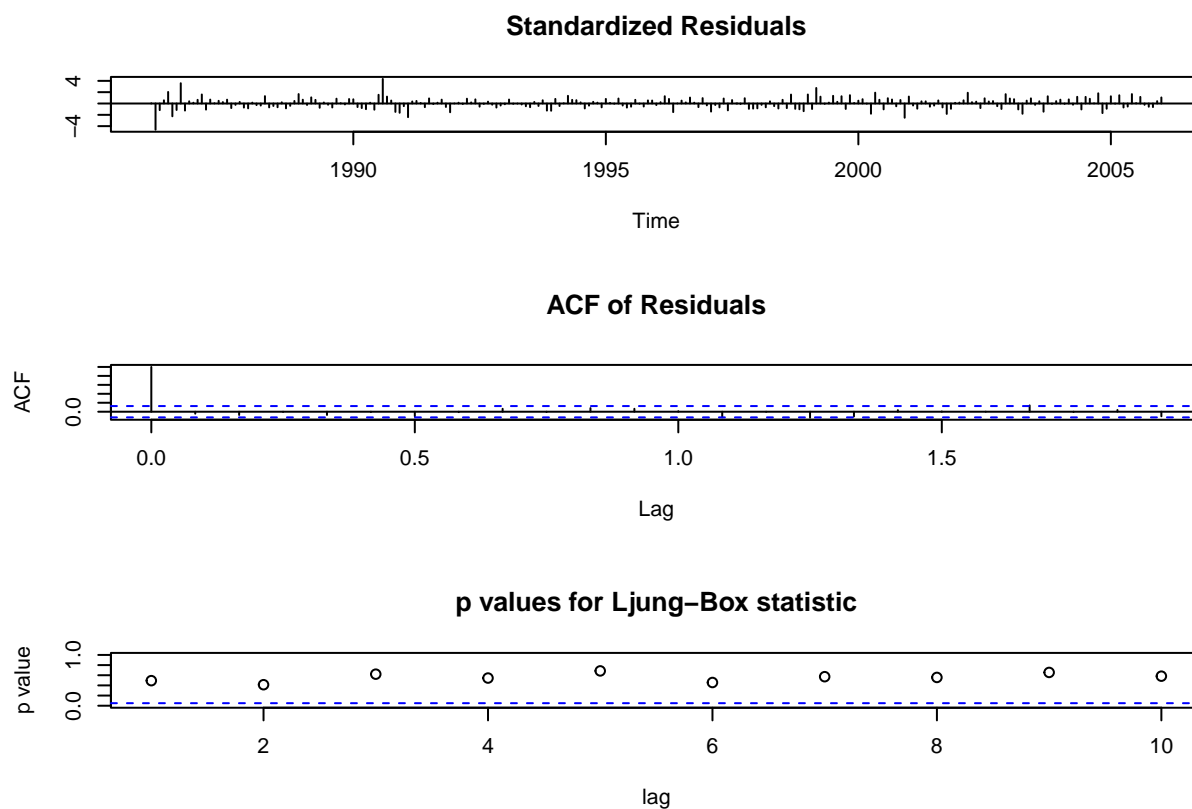

p values for Ljung–Box statistic
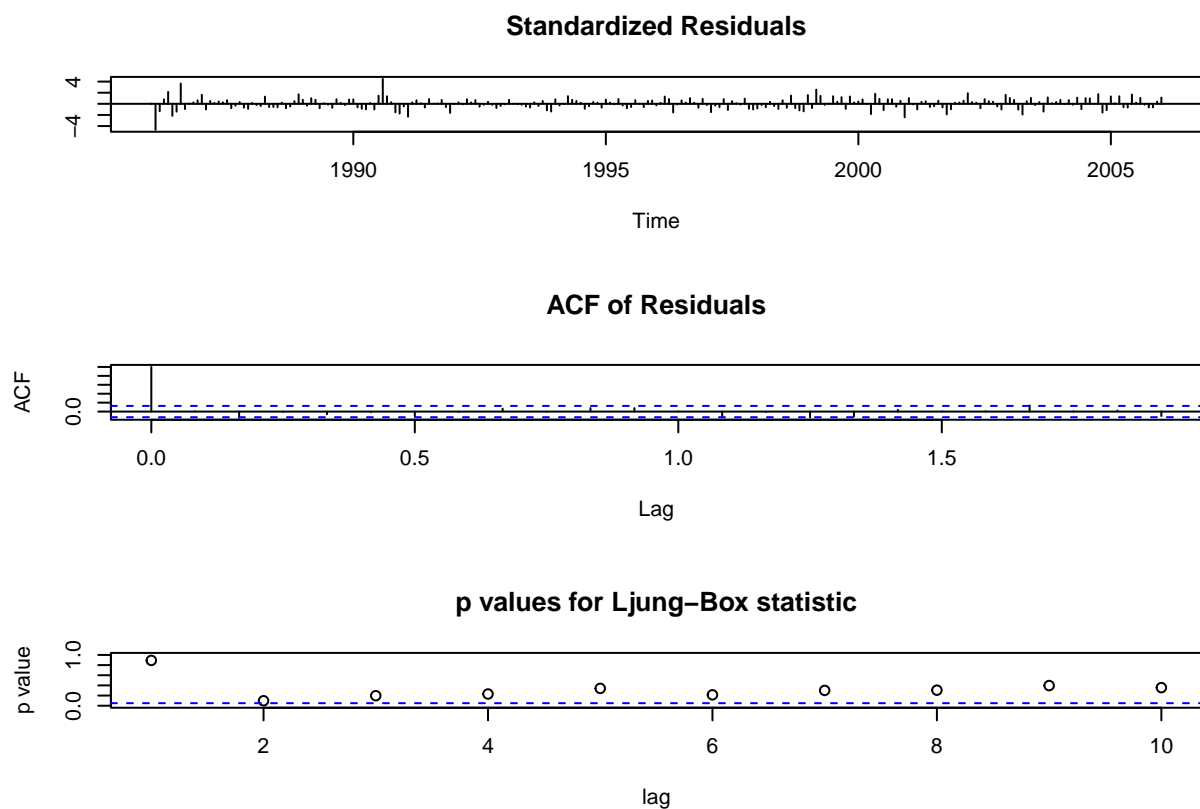
The possible outlier in August 1990 stands out in the plot of residuals and is "flagged" by the Bonferroni rule. There are also three residual acf values outside the critical limits.

```
# For Model 3
tsdiag(model3,main='Model 3')
```

Standardized Residuals

ACF of Residuals

p values for Ljung–Box statistic
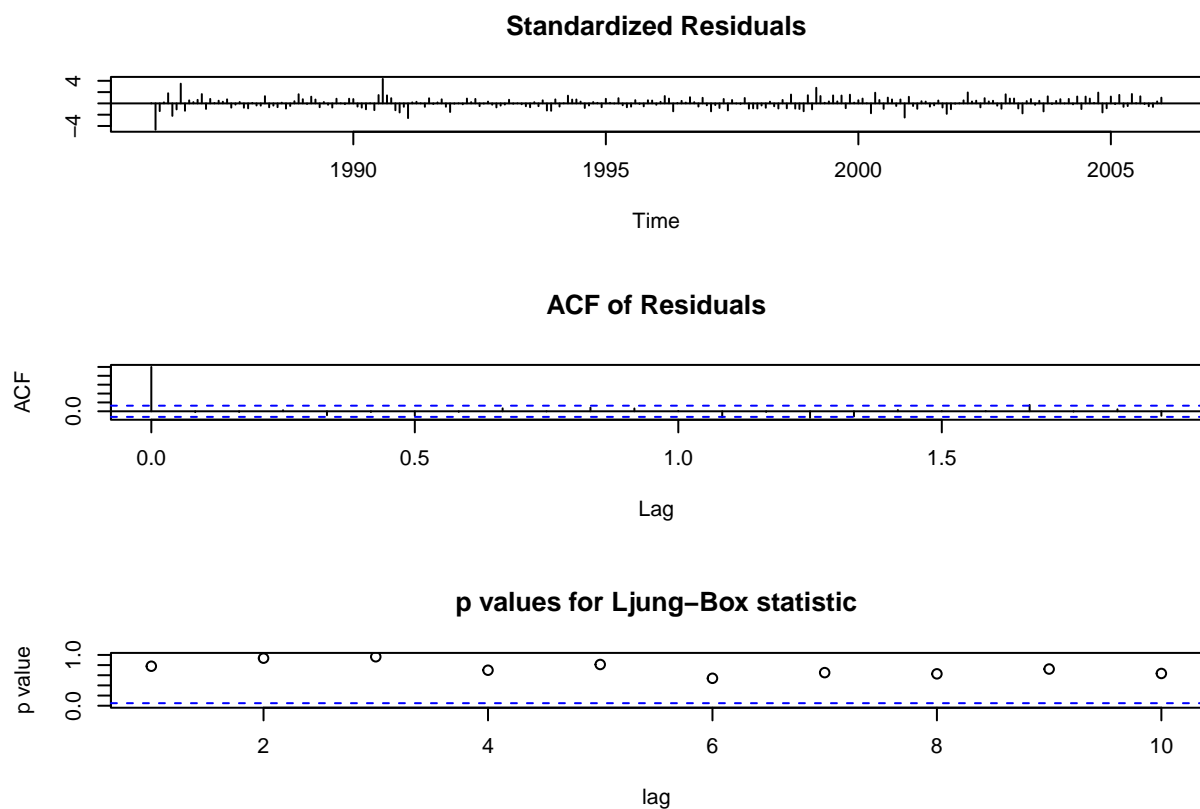
Model 3 diagnostics are similar to those for Model 1 with the exception that the Ljung-Box statistics are better as shown in the bottom display.

```
# For Model 4
tsdiag(model4,main='Model 4')
```

Standardized Residuals

ACF of Residuals

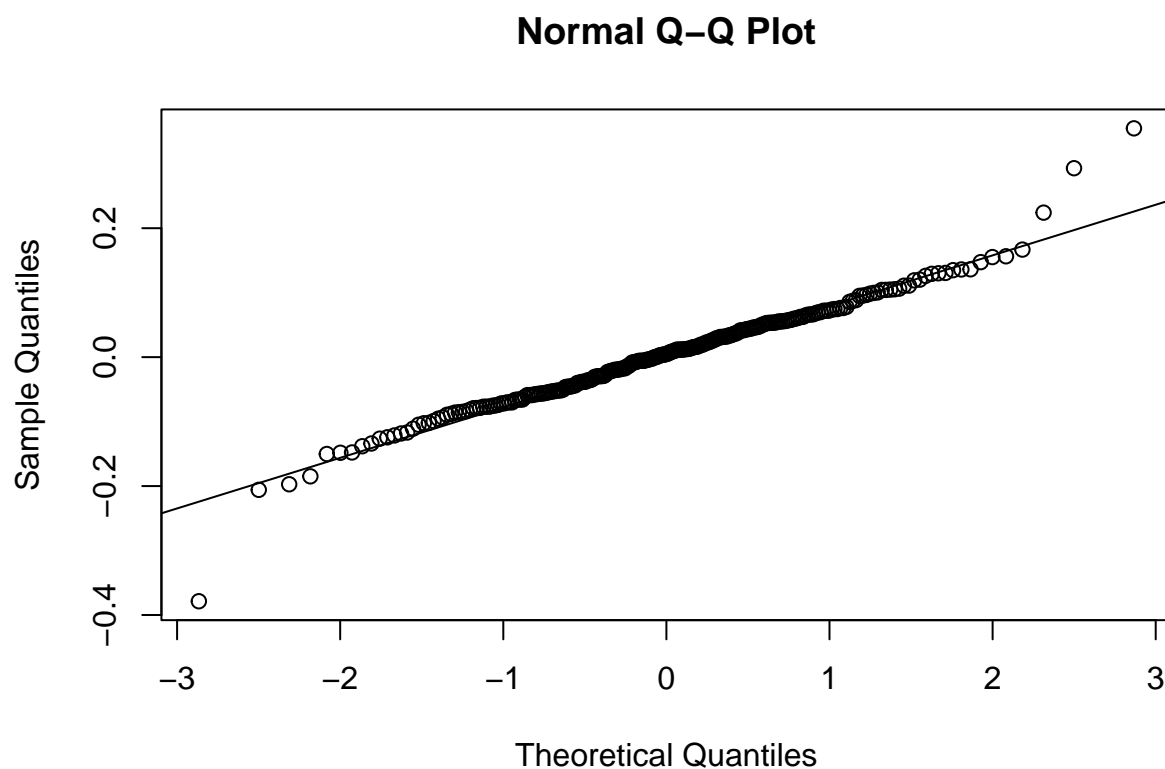**p values for Ljung–Box statistic**

Model 4 diagnostics are similar to those for Models 1 and 3. The Ljung-Box statistics are the best of the lot as shown in the bottom display.

Let's look at normality of the error terms for Model 4.

```
qqnorm(residuals(model4))
qqline(residuals(model4))
```

Normal Q–Q Plot


```
shapiro.test(residuals(model4))
```

```
##
##  Shapiro-Wilk normality test
##
## data:  residuals(model4)
## W = 0.96883, p-value = 3.937e-05
```

Both the Q-Q plot and the results of the Shapiro-Wilk test indicate that we should reject of normality for the error terms in this model but this could be caused by the suspected outliers in the series.