Question 3

(1)

In [40]:
```
library(quantmod)
getSymbols("^VIX")
getSymbols("^VIX",from="2015-01-01",to="2020-02-01",src="yahoo")
```

```
Warning message:
"'indexClass<-' is deprecated.
Use 'tclass<-' instead.
See help("Deprecated") and help("xts-deprecated")."

'^VIX'

Warning message:
"'indexClass<-' is deprecated.
Use 'tclass<-' instead.
See help("Deprecated") and help("xts-deprecated")."

'^VIX'
```

In [41]:
```
dim(VIX)
```

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In [42]:
```
head(VIX)
```

	VIX.Open	VIX.High	VIX.Low	VIX.Close	VIX.Volume	VIX.Adjusted
2015-01-02	17.76	20.14	17.05	17.79	0	17.79
2015-01-05	19.19	21.29	19.19	19.92	0	19.92
2015-01-06	20.33	22.90	19.52	21.12	0	21.12
2015-01-07	20.15	20.72	19.04	19.31	0	19.31
2015-01-08	17.93	18.09	16.99	17.01	0	17.01
2015-01-09	16.44	18.42	16.44	17.55	0	17.55

In [43]:
```
tail(VIX)
```

	VIX.Open	VIX.High	VIX.Low	VIX.Close	VIX.Volume	VIX.Adjusted
2020-01-24	12.75	15.98	12.62	14.56	0	14.56
2020-01-27	17.42	19.02	16.82	18.23	0	18.23
2020-01-28	16.94	18.03	15.69	16.28	0	16.28
2020-01-29	15.68	16.65	14.94	16.39	0	16.39
2020-01-30	17.82	18.39	15.30	15.49	0	15.49
2020-01-31	16.25	19.99	16.18	18.84	0	18.84

In [44]:
```
data<-VIX[ ,6]
```

In [49]:
```
rt=monthlyReturn(data,type="log")
```

In [56]:
```
model1<-ar(as.vector(rt) ,method="mle")
```

In [52]:
```
model1
```

```
Call:
ar(x = as.vector(rt), method = "mle")

Coefficients:
      1        2        3        4        5        6        7        8
-0.4629  -0.2384  -0.3682  -0.2955  -0.0783  -0.2963  -0.2295   0.2109

Order selected 8  sigma^2 estimated as  0.03511
```

In [54]:
```
names(model1)
```

'order' · 'ar' · 'var.pred' · 'x.mean' · 'aic' · 'n.used' · 'n.obs' · 'order.max' · 'partialacf' · 'resid' · 'method' · 'series' · 'frequency' · 'call' · 'asy.var.coef'

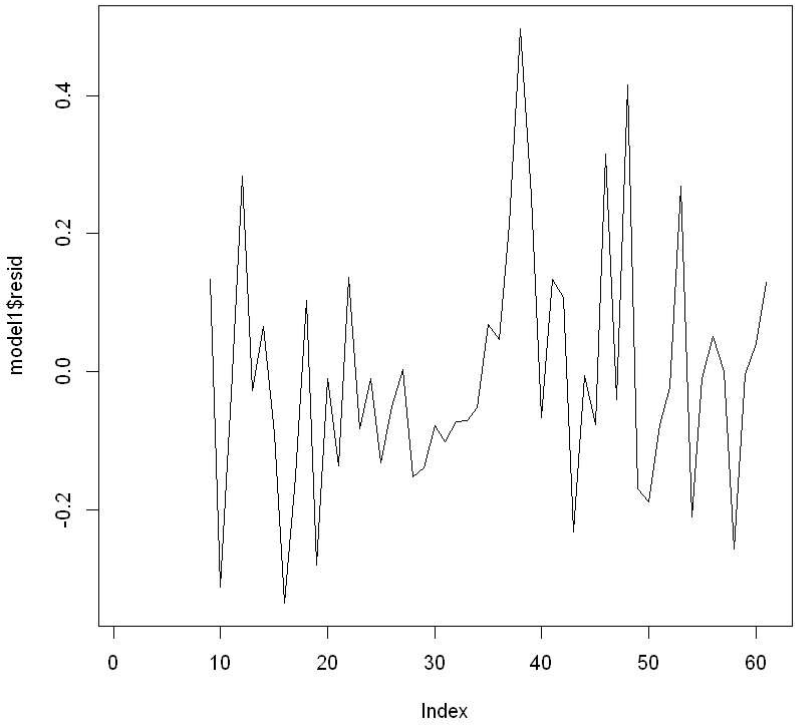
In [102]:
```
res<-model1$resid
```

In [104]:
```
res<-res[!is.na(res)]
```

In [105]:
```
sd(res)
```

0.173731189151805

In [57]:
```
plot(model1$resid,type='l')
```



In [58]:
```
## checks residuals to see if they look like white noises now.
Box.test(model1$resid,lag=10,type='Ljung')
```

```
        Box-Ljung test

data:  model1$resid
X-squared = 2.2242, df = 10, p-value = 0.9943
```

In [106]:
```
predict(model1)
```

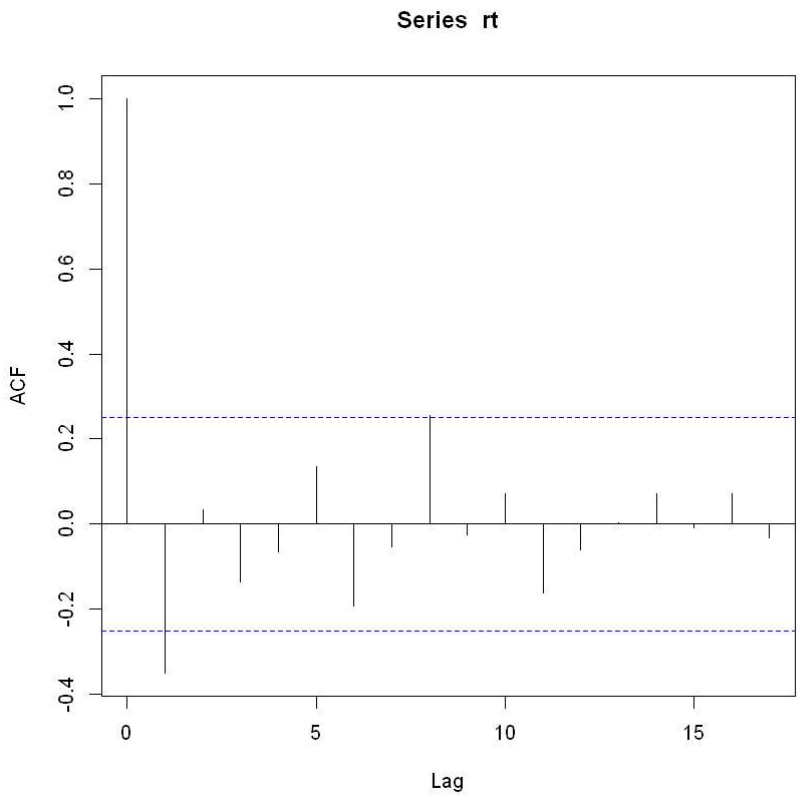
$pred
A Time Series:
-0.18561032543616
$se
A Time Series:
0.187374345464277

In [59]:
```
model1$x.mean # Predicted overal mean value
```

-0.000282344092043956

(2)

In [50]:
```
acf(rt)
```



In [95]:
```
m2<-arima(rt,order=c(0,0,8))
```

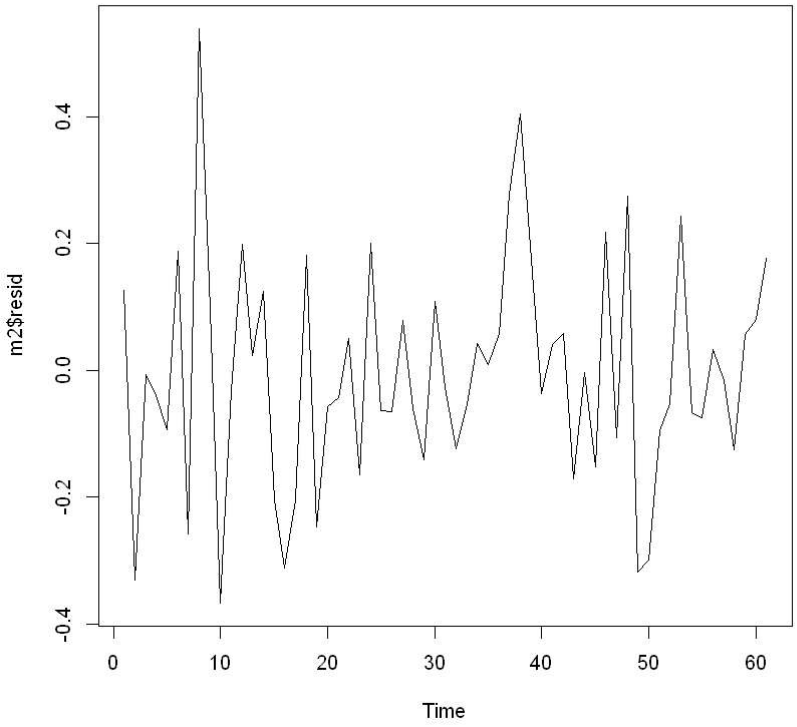
In [96]:
```
m2
```

```
Call:
arima(x = rt, order = c(0, 0, 8))

Coefficients:
          ma1     ma2      ma3     ma4     ma5      ma6     ma7     ma8
      -0.4069  0.0977  -0.3101  0.0789  0.1064  -0.3815  0.1521  0.4484
s.e.   0.1344  0.1524   0.1689  0.1348  0.1428   0.1371  0.1522  0.1500
      intercept
         0.0024
s.e.     0.0173

sigma^2 estimated as 0.03192:  log likelihood = 15.14,  aic = -10.29
```

In [97]:
```
names(m2)
```

'coef' · 'sigma2' · 'var.coef' · 'mask' · 'loglik' · 'aic' · 'arma' · 'residuals' · 'call' · 'series' · 'code' · 'n.cond' · 'nobs' · 'model'

In [98]:
```
plot(m2$resid,type='l')
```



For each coefficient, we can use quotient of coeficient and s.e., and if it is bigger than 1.96, we have 95% confidence to believe it is statistical significant. So according to this, ma1, ma6 and ma8 are significant.

Question 4

(1)

In [1]:
```
df<-read.table("C:\\Users\\zzzha\\Desktop\\m-unrate.txt",header=TRUE)
```

In [11]:
```
head(df)
```

A data.frame: 6 × 4

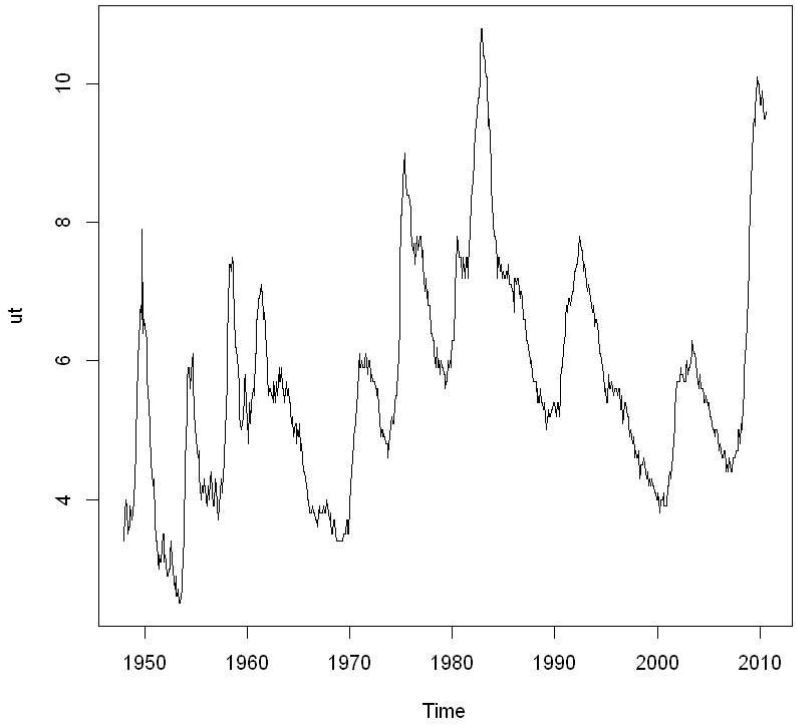
	Year	mon	dd	rate
	<int>	<int>	<int>	<dbl>
1	1948	1	1	3.4
2	1948	2	1	3.8
3	1948	3	1	4.0
4	1948	4	1	3.9
5	1948	5	1	3.5
6	1948	6	1	3.6

In [14]:
```
dim(df)
```

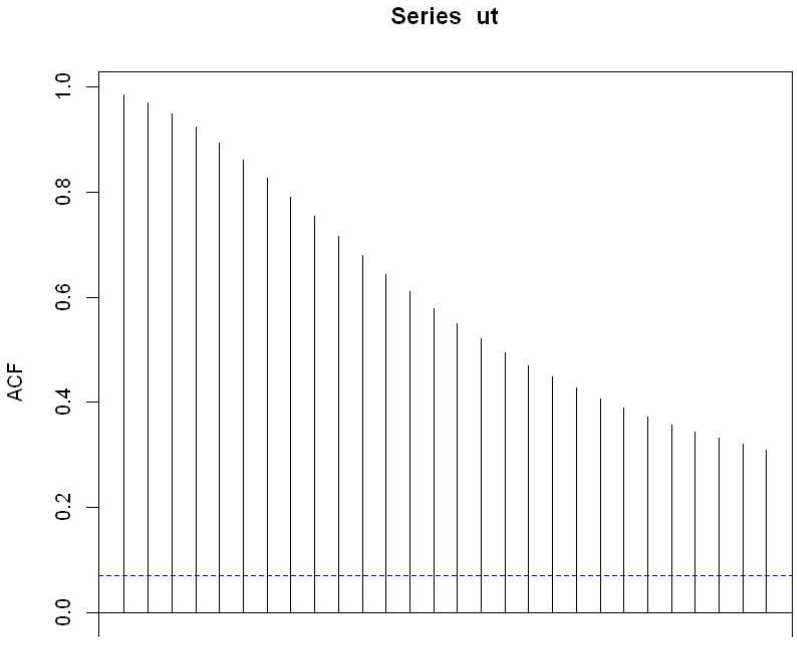
753 · 4

In [71]:
```
ut= ts(df[,4], start = c(1948,1), frequency = 12)
```

In [72]:
```
plot(ut)
```



In [85]:
```
Acf(ut)
```

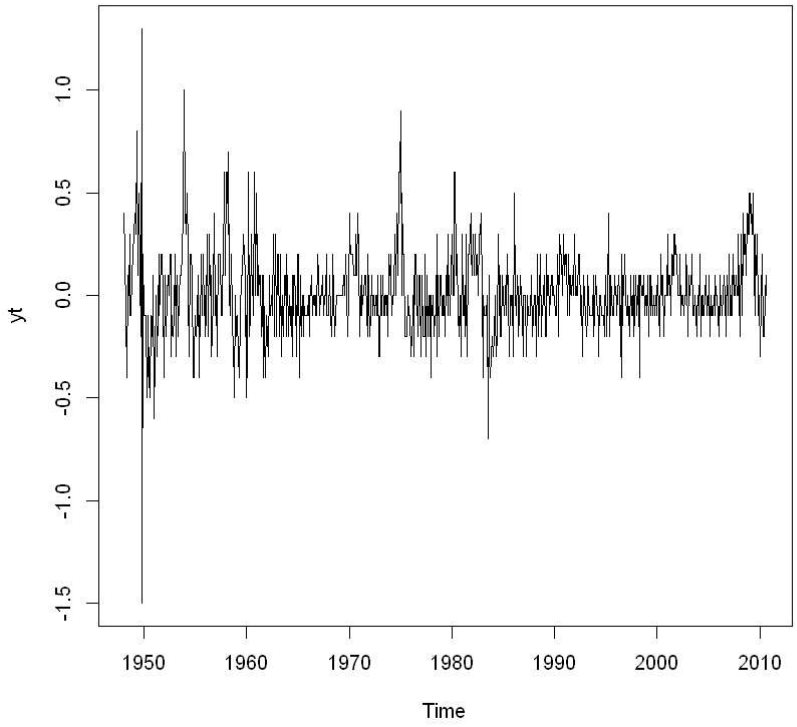


In [75]:
```
library(fpp)
ndiffs(ut)
```

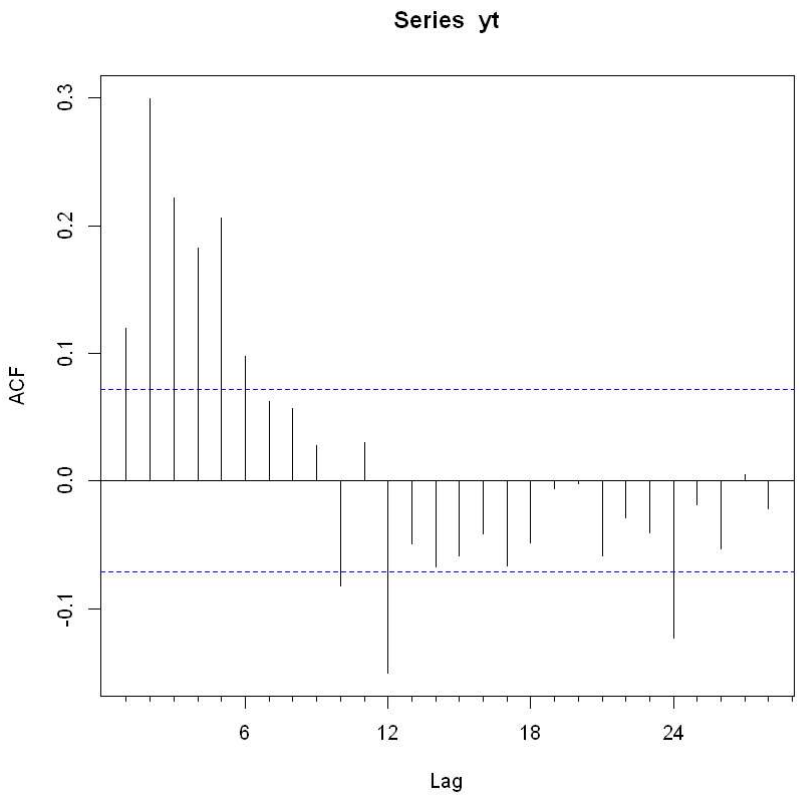
```
Warning message:
"package 'fpp' was built under R version 3.6.2"
Loading required package: forecast

Warning message:
"package 'forecast' was built under R version 3.6.2"
Registered S3 methods overwritten by 'forecast':
  method             from
  fitted.fracdiff    fracdiff
  residuals.fracdiff fracdiff

Loading required package: fma

Warning message:
"package 'fma' was built under R version 3.6.2"
Loading required package: expsmooth

Warning message:
"package 'expsmooth' was built under R version 3.6.2"
Loading required package: lmtest

Loading required package: tseries

Warning message:
"package 'tseries' was built under R version 3.6.2"

1
```

In [81]:
```
yt<-diff(ut,lag=1)
```

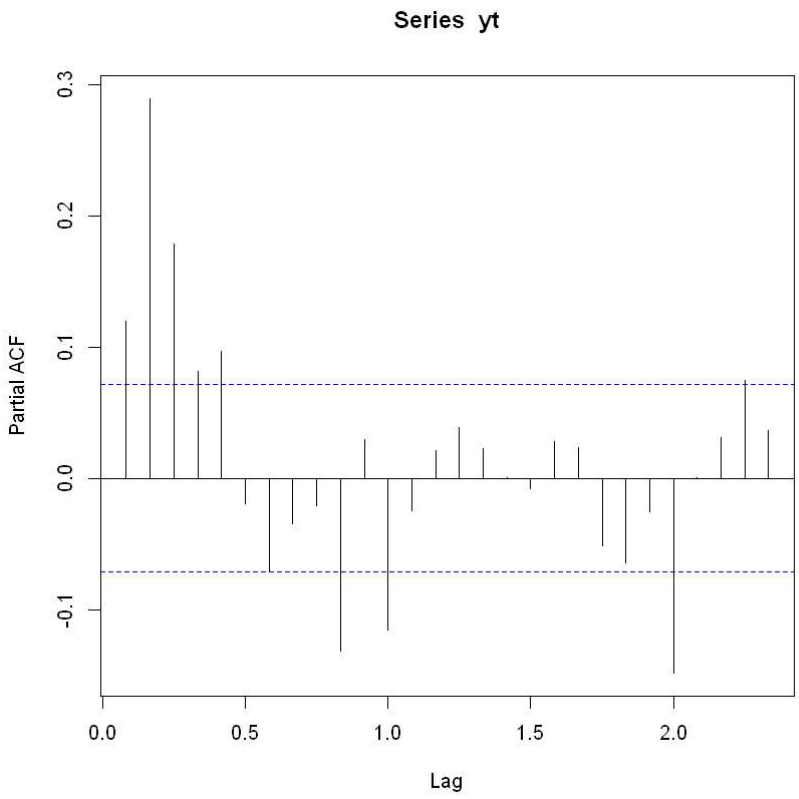
In [82]:
```
plot(yt)
```



In [87]:
```
Acf(yt)
```



In [88]:
```
pacf(yt)
```



(2)

In [91]:
```
yt.ar<-ar(yt,method='mle')
```

In [92]:
```
yt.ar
```

```
Call:
ar(x = yt, method = "mle")

Coefficients:
      1        2        3        4        5        6        7        8
 0.0114   0.2208   0.1536   0.1030   0.1319   0.0007  -0.0333   0.0047
      9       10       11       12
-0.0056  -0.1032   0.0302  -0.1174

Order selected 12  sigma^2 estimated as  0.03838
```

In [93]:
```
yt.ar$order
```

```
12
```

In [94]:
```
names(yt.ar)
```

```
'order' · 'ar' · 'var.pred' · 'x.mean' · 'aic' · 'n.used' · 'n.obs' · 'order.max' ·
'partialacf' · 'resid' · 'method' · 'series' · 'frequency' · 'call' · 'asy.var.coef'
```

In [33]:
```
print(yt.ar$aic,digits=3)
```

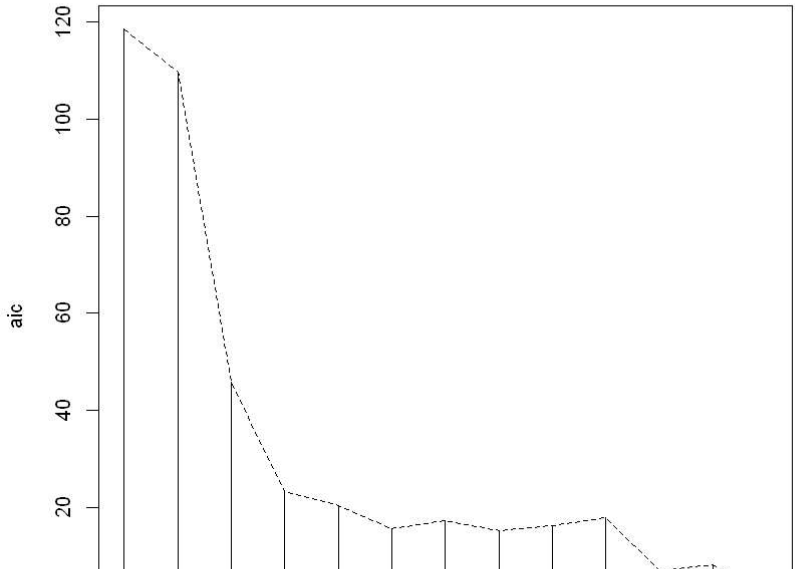
```
     0      1      2      3      4      5      6      7      8      9     1
0
118.67 109.83  45.74  23.25  20.28  15.52  17.20  15.14  16.18  17.87   6.8
6
    11     12
  8.19   0.00
```

In [34]:
```
aic=yt.ar$aic  # For plotting below.
```

In [35]:
```
length(aic)
```

```
13
```

In [67]:
```
plot(c(0:12),aic,type='h',xlab='order',ylab='aic')
lines(0:12,aic,lty=2)
```



From above, we can see that the order p=12.

In [89]:
```
model2<-arima(yt,order=c(12,0,0))
```

In [90]:
```
model2
```

```
Call:
arima(x = yt, order = c(12, 0, 0))

Coefficients:
         ar1     ar2     ar3     ar4     ar5     ar6      ar7     ar8
ar9
      0.0114  0.2208  0.1536  0.1030  0.1319  0.0007  -0.0333  0.0047  -0.0
056
s.e.  0.0363  0.0363  0.0370  0.0377  0.0379  0.0382   0.0382  0.0380   0.0
379
         ar10    ar11     ar12  intercept
      -0.1032  0.0302  -0.1174     0.0086
s.e.   0.0373  0.0365   0.0366     0.0119

sigma^2 estimated as 0.03838:  log likelihood = 158.4,  aic = -288.8
```