STAT_626 Assignment 04

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```
library("astsa")
library("tidyverse")
```

Question 3.4

x_t = -0.9x_t-2 + w_t

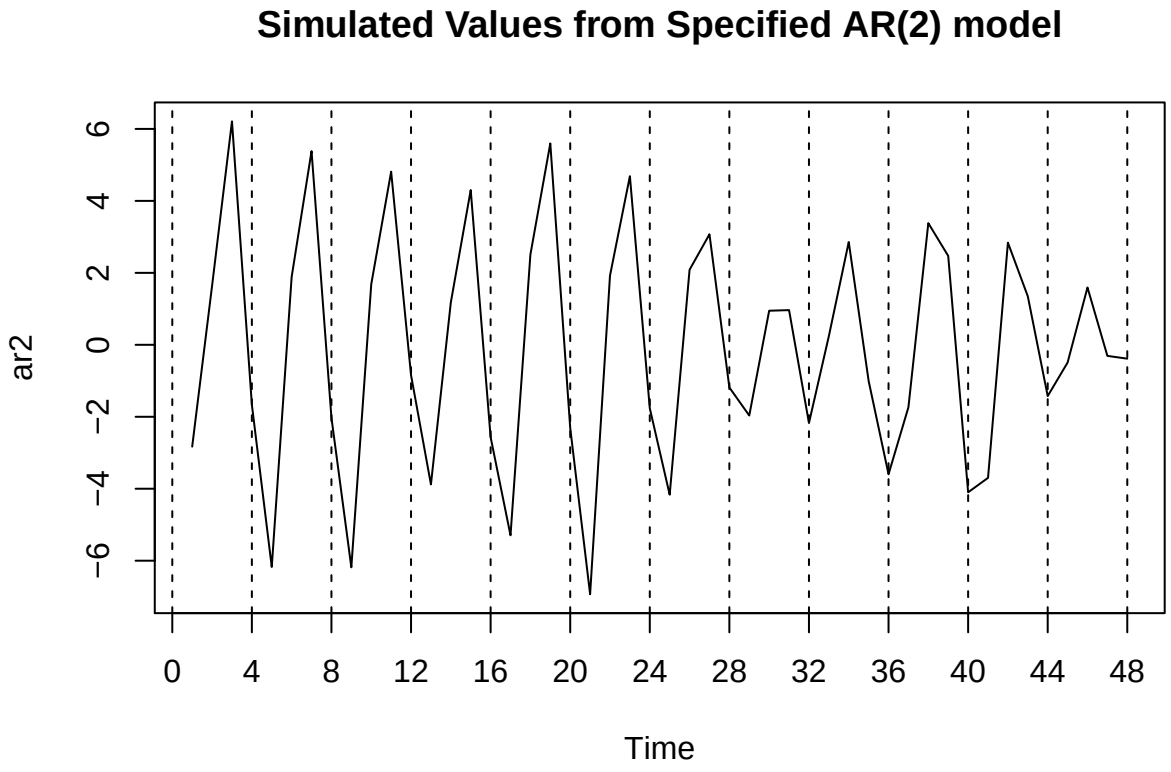
```
# give the roots of the characteristic equation
z <- c(1, 0, .9)
# solve for the roots of autoregressive polynomial
paste0("Roots of Autoregressive Polynomial given by: " ,(a <- polyroot(z)[1]))
```

```
## [1] "Roots of Autoregressive Polynomial given by: 0+1.05409255338946i"
```

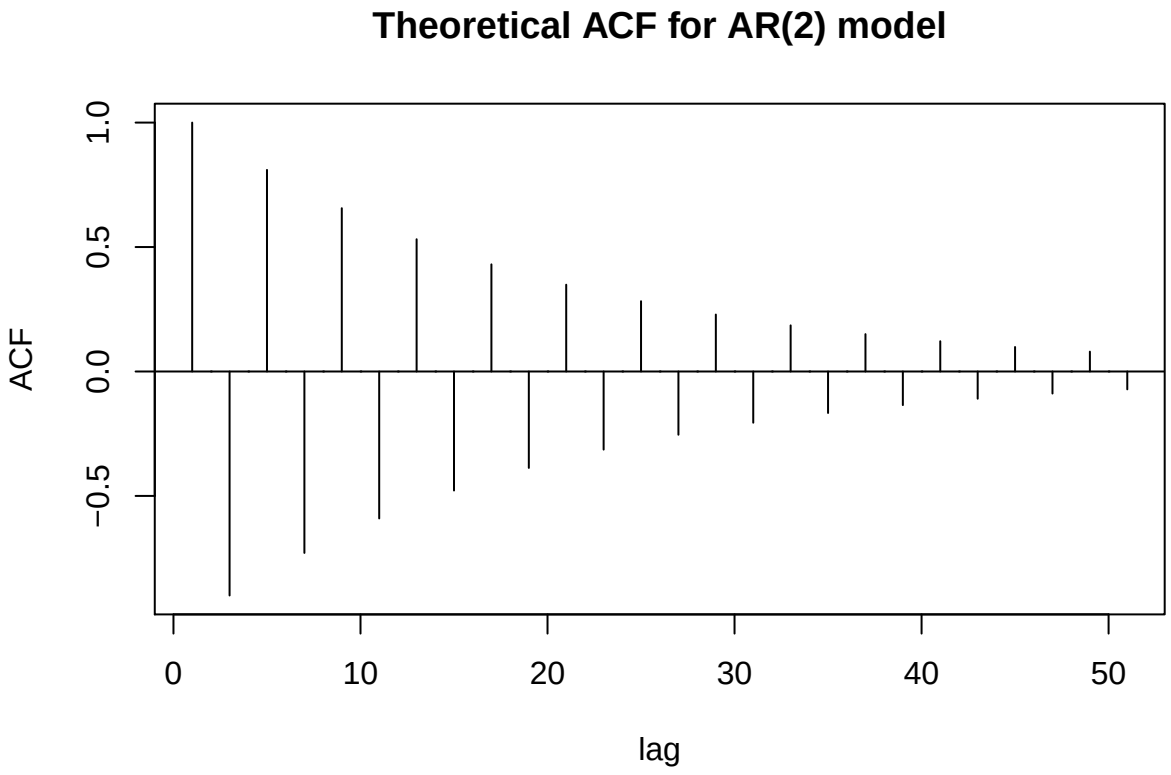
```
arg <- Arg(a)/(2*pi)
paste0("Pseudo-period given by: ", 1 / arg) # pseudo-period
```

```
## [1] "Pseudo-period given by: 4"
```

```
set.seed(1914)
ar2 = arima.sim(list(order=c(2,0,0), ar=c(0,-.9)), n = 48)
plot(ar2, axes=FALSE, xlab="Time",main="Simulated Values from Specified AR(2) model")
axis(2)
axis(1, at=seq(0,48,by=4))
box()
abline(v=seq(0,48,by=4), lty=2)
```




```r
# plot the ACF
ACF = ARMAacf(ar=c(0,-.9), ma=0, 50)
plot(ACF, type="h", xlab="lag", main="Theoretical ACF for AR(2) model")
abline(h=0)
```



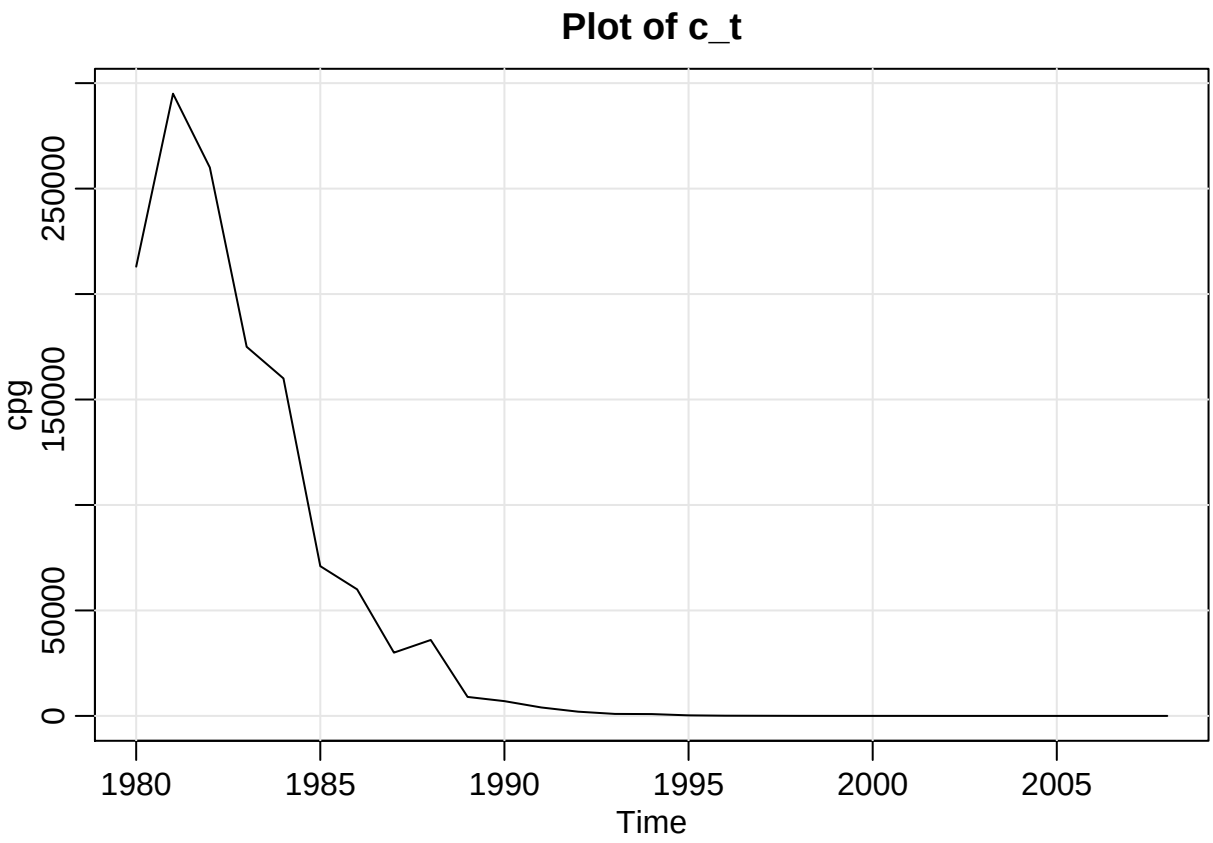
Because the coefficient on the AR model is negative, the lags will flip between being positive and negative at

every lag iteration.

Question 3.17

Question 3.17.A

```
astsa::tsplot(cpg ,main="Plot of c_t")
```

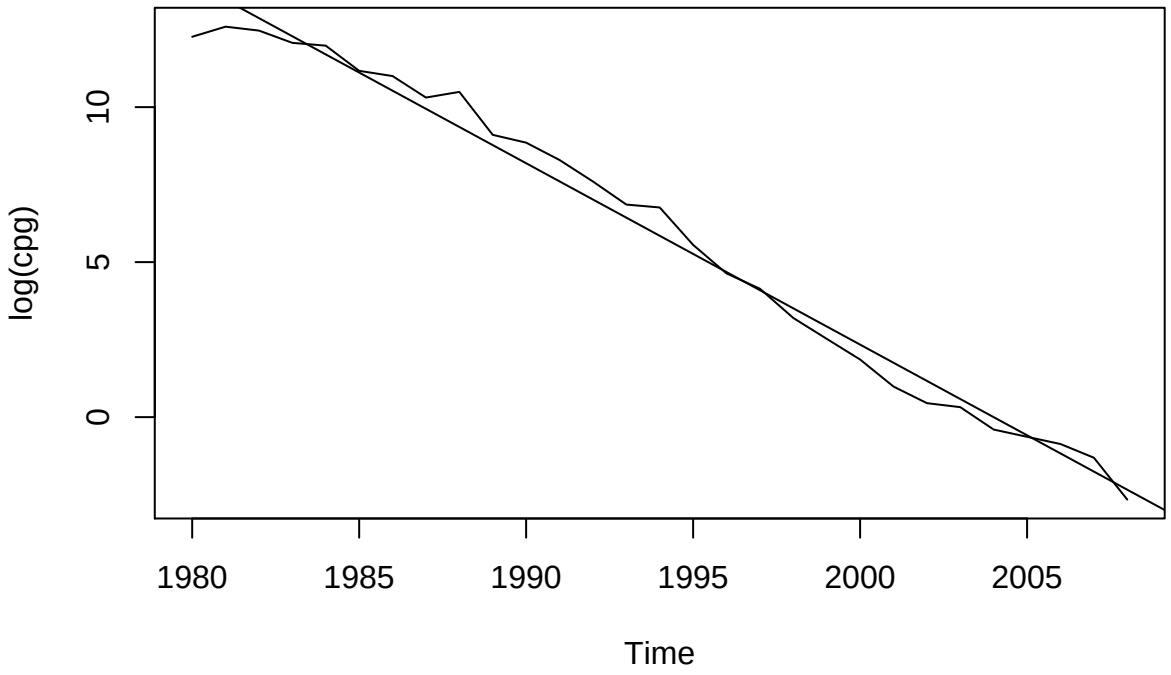


The plot seems to be showing an exponential decrease in the price per gigabyte of storage.

Question 3.17.B

```
# regress log(c_t) on a time index
lin_mod <- lm(log(cpg) ~ time(cpg))
```

```
# plot the fitted line to compare it to the logged data
ts.plot(log(cpg))
abline(lin_mod)
```



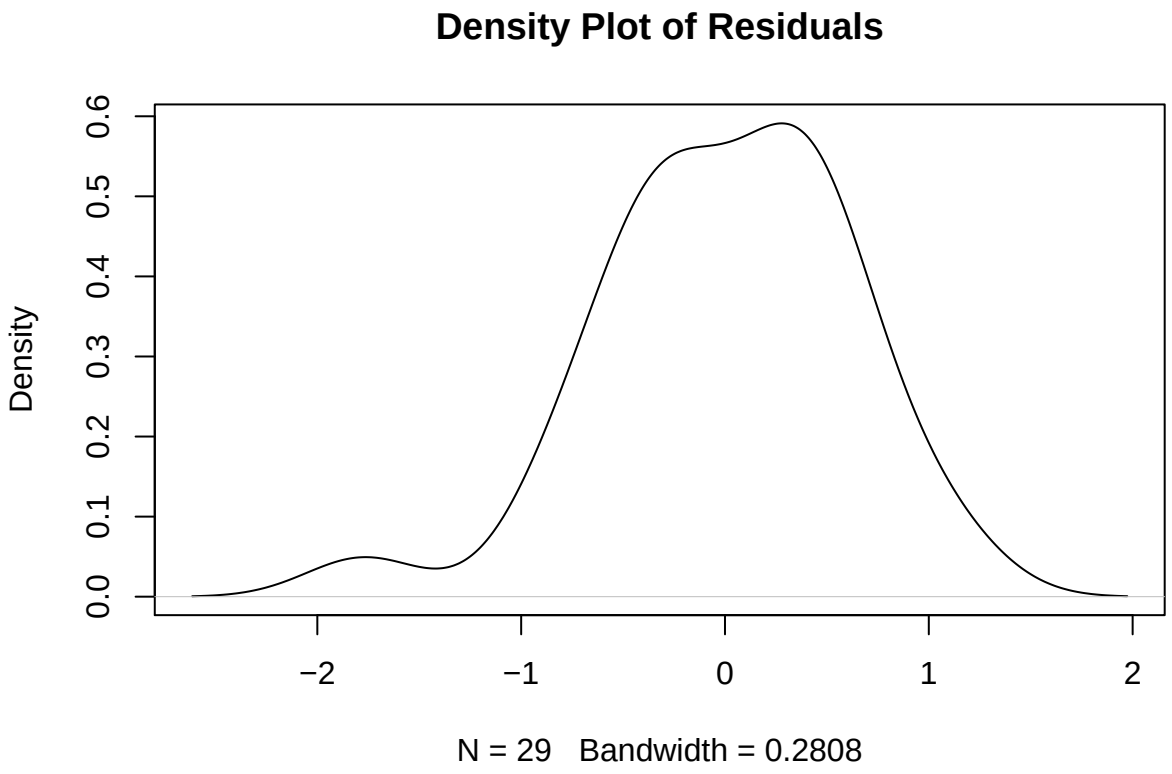
The fitted regression line is very close to the log transformation of the data.

$$c_t \approx \alpha exp(\beta t)$$

Question 3.17.C

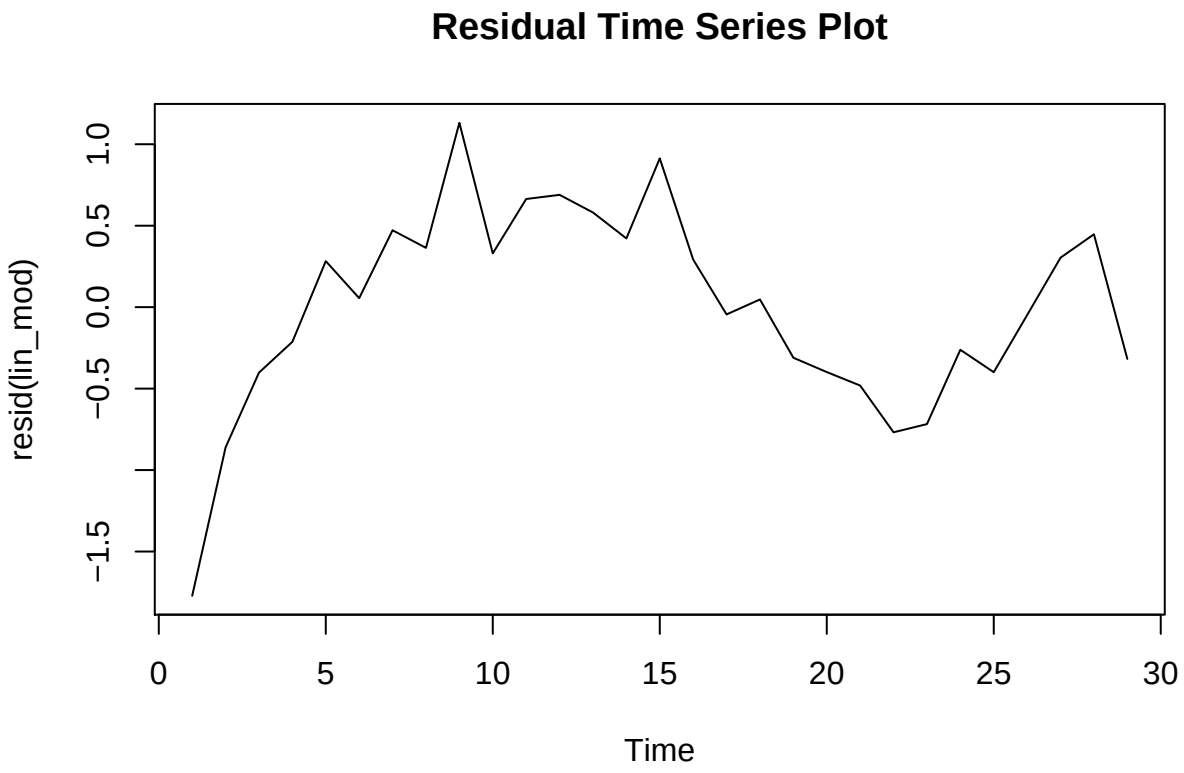
Plot the residuals of the model and comment.

```
plot(density(resid(lin_mod)), main="Density Plot of Residuals")
```

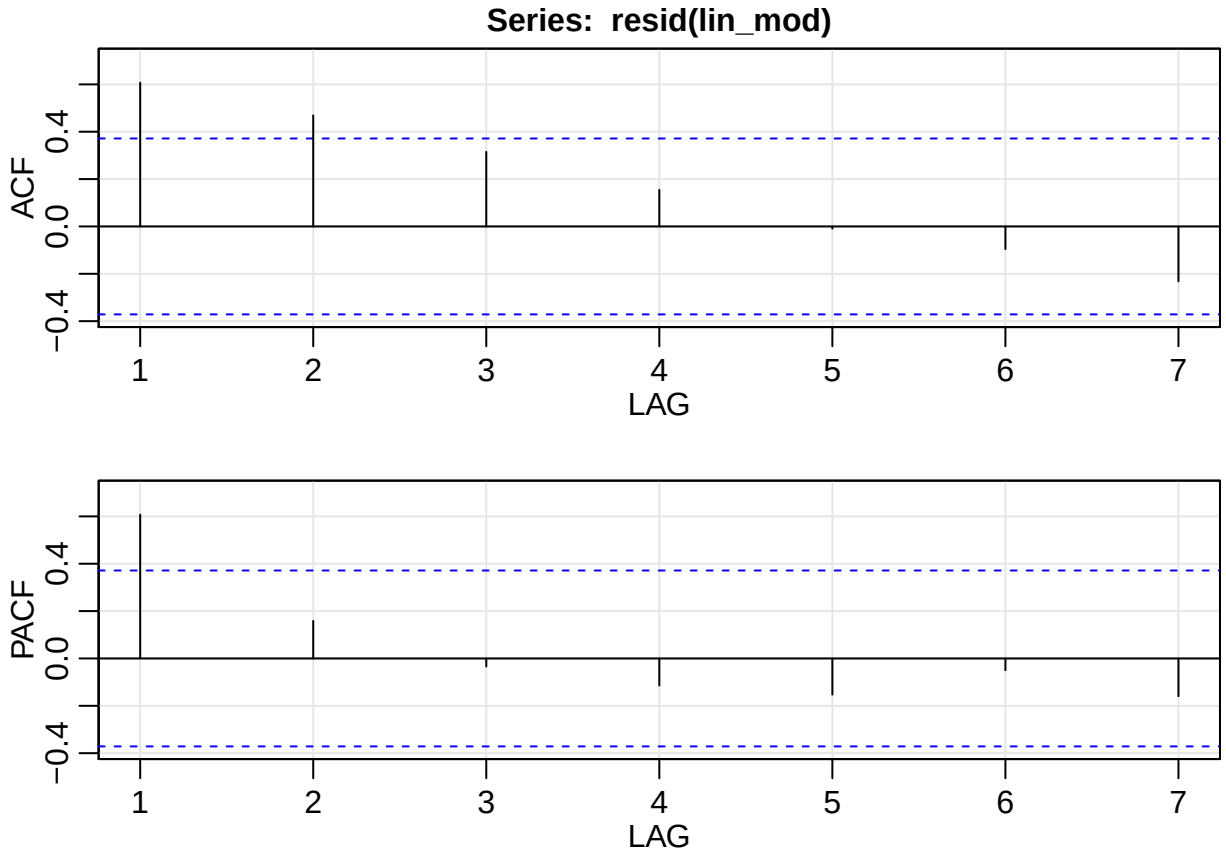


The density plot looks good, but keep in mind that we may have serial correlation that this isn't capturing.

```
ts.plot(resid(lin_mod), main="Residual Time Series Plot")
```



```
acf2(resid(lin_mod))
```




```
##         ACF  PACF
## [1,]  0.61  0.61
## [2,]  0.47  0.16
## [3,]  0.32 -0.03
## [4,]  0.15 -0.11
## [5,] -0.01 -0.15
## [6,] -0.10 -0.05
## [7,] -0.23 -0.16
```

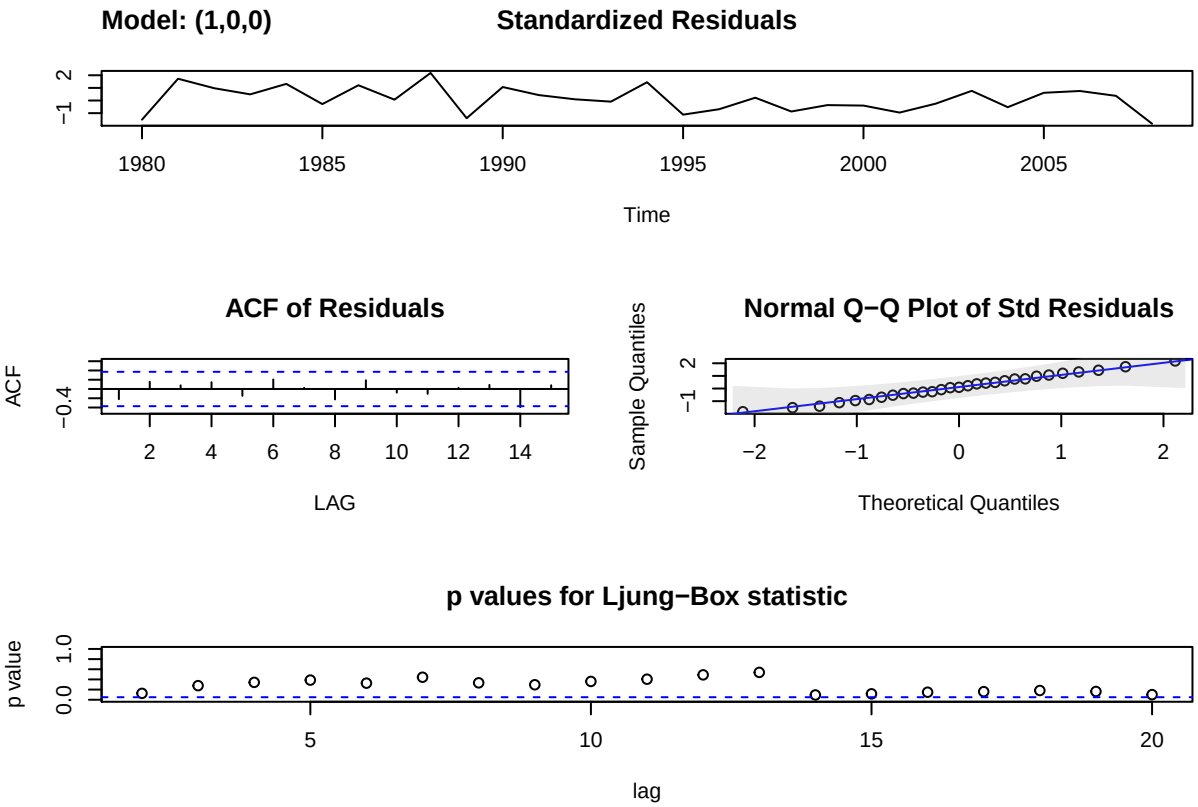
It appears from the time series plot and the ACF of the residuals that the errors display some level of serial or autocorrelation. A regression that does not assume the errors to be i.i.d. may be necessary.

Question 3.17.D

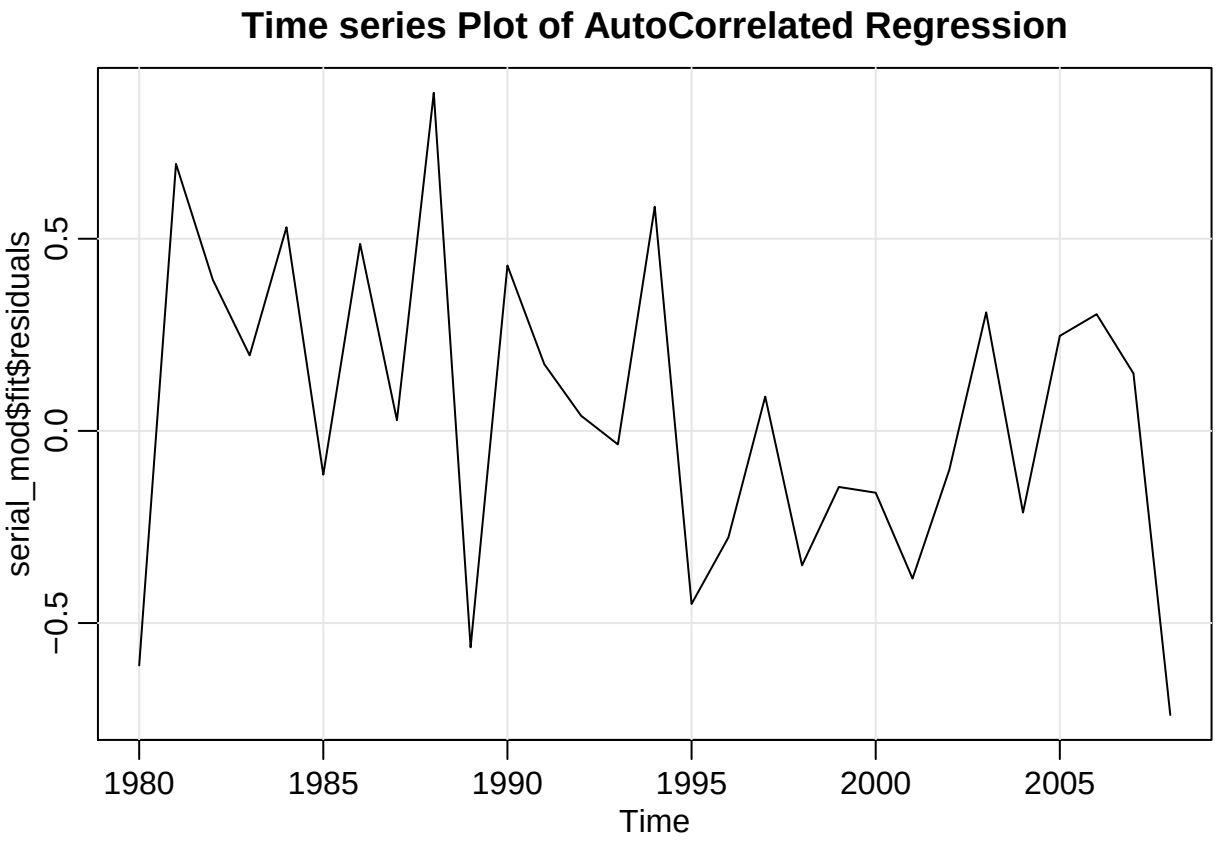
```
# refit the model, but using the fact that the errors are autocorrelated
serial_mod <- sarima(
                    xdata=log(cpg)
                    , p=c(1)
                    , d=c(0)
                    , q=c(0)
                    , xreg=c(time(cpg))
                    )
```

```
## initial  value -0.669056
```

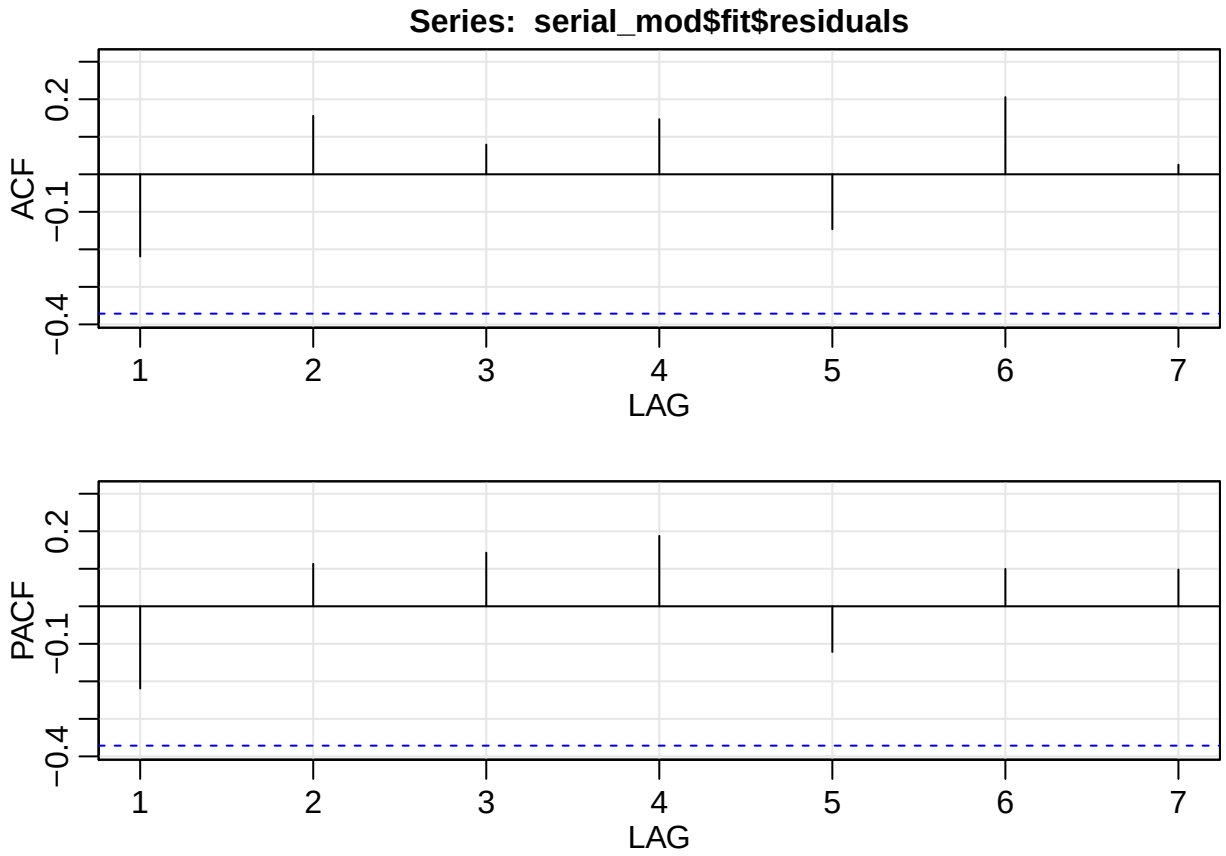
```
## iter   2 value -0.999488
## iter   3 value -1.088763
## iter   4 value -1.102248
## iter   5 value -1.128914
## iter   6 value -1.131945
## iter   7 value -1.132479
## iter   8 value -1.132525
## iter   9 value -1.132540
## iter  10 value -1.132543
## iter  11 value -1.132545
## iter  12 value -1.132545
## iter  12 value -1.132545
## iter  12 value -1.132545
## final  value -1.132545
## converged
## initial  value -0.701381
## iter   2 value -0.882862
## iter   3 value -0.886699
## iter   4 value -0.888651
## iter   5 value -0.888966
## iter   6 value -0.889035
## iter   7 value -0.889043
## iter   8 value -0.889045
## iter   9 value -0.889045
## iter  10 value -0.889045
## iter  10 value -0.889045
## iter  10 value -0.889045
## final  value -0.889045
## converged
```




```
astsa::tsplot(serial_mod$fit$residuals, main="Time series Plot of AutoCorrelated Regression")
```



```
acf2(serial_mod$fit$residuals)
```




```
##         ACF  PACF
## [1,] -0.22 -0.22
## [2,]  0.16  0.11
## [3,]  0.08  0.14
## [4,]  0.15  0.19
## [5,] -0.15 -0.12
## [6,]  0.21  0.10
## [7,]  0.03  0.10
```

This appears to be a better fit to the data - we have eliminated the evidence of serial correlation from the model errors.

```
paste0("Coefficients for new Model: ")
```

```
## [1] "Coefficients for new Model: "
```

```
print(serial_mod$fit$coef)
```

```
##          ar1    intercept         xreg
##    0.8297314 1113.0105454   -0.5553780
```

```
cat("\nCoefficients for Linear Model: ")
```

```
##
## Coefficients for Linear Model:
```

```
print(lin_mod$coefficients)
```

```
##  (Intercept)    time(cpg)
## 1172.4943103   -0.5850776
```