Lab 4

Pstat 174/274

April 26, 2017

Importing Data into R

a. Once you have downloaded the dataset and naming it `monthly-australian-wine-sales-th.csv`, set the working directory using `setwd`.

b. Read the file into an R object using the following command:

```
wine.csv = read.table("monthly-australian-wine-sales-th.csv",
                                          sep=",", header=FALSE, skip=1, nrows=187)
```

The argunments of the generic command `read.table` are explained as follows: `header=FALSE` and `skip=1` tells `R` to ignore the first row of the file, `sep=","` tells `R` that elements to be read are separated by commas (since this is a comma separated file), and `nrows=187` specify to read no more than 187 rows (since there is some text at the end of the file that we don't want to read).

`wine.csv` is now a data frame with two columns; the first giving the year and month and the second giving the sales for that month in thousands of liters. One can use the `head` function to dsplay the first few observations of our `data.frame` object.

```
head(wine.csv)
```

```
##        V1   V2
## 1 1980-01  464
## 2 1980-02  675
## 3 1980-03  703
## 4 1980-04  887
## 5 1980-05 1139
## 6 1980-06 1077
```

c. Create a time series object using the following command.

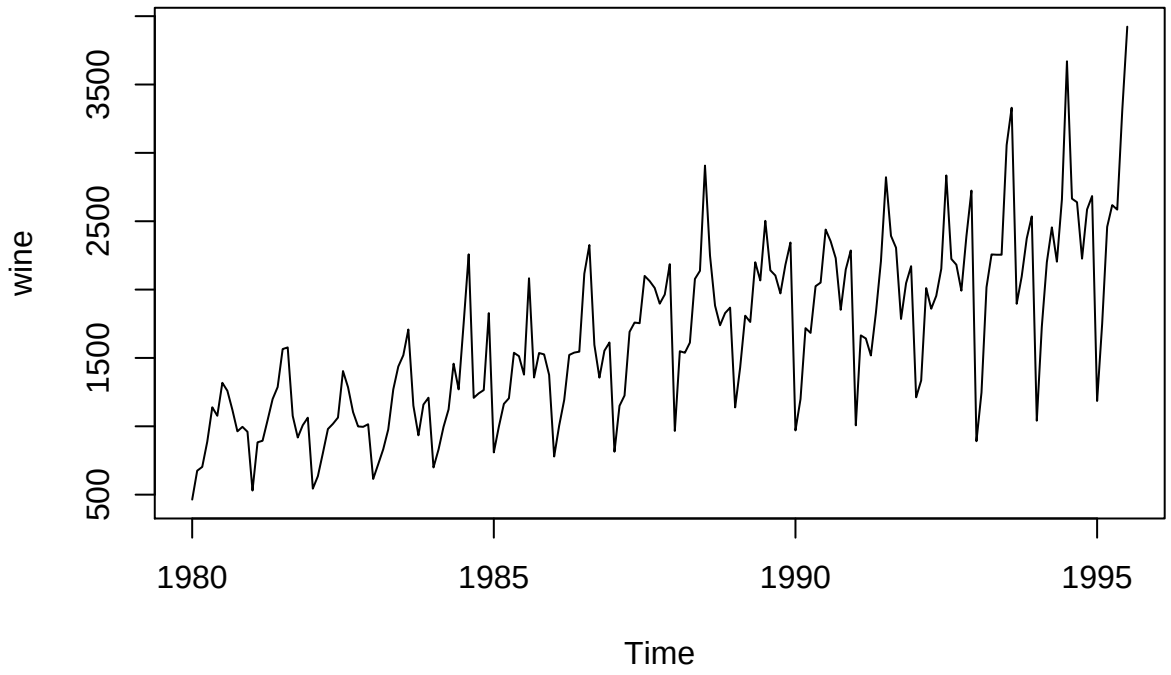
```
?ts # help file for ts()
wine = ts(wine.csv[,2], start = c(1980,1), frequency = 12)
```

`wine.csv[,2]` accesses the second column of `wine.csv`; `start = c(1980,1)` indicates that the first observation of the time series corresponds the first period of 1980; and `frequency = 12` tells `R` that these are monthly data starting from January of 1980.

Stabilizing the Variance and Removing Trend/Seasonality

a. Plot the time series using `ts.plot(wine)`. What do you notice? Does the variance change over time? Is their a trend and/or seasonal components?

```
ts.plot(wine)
```



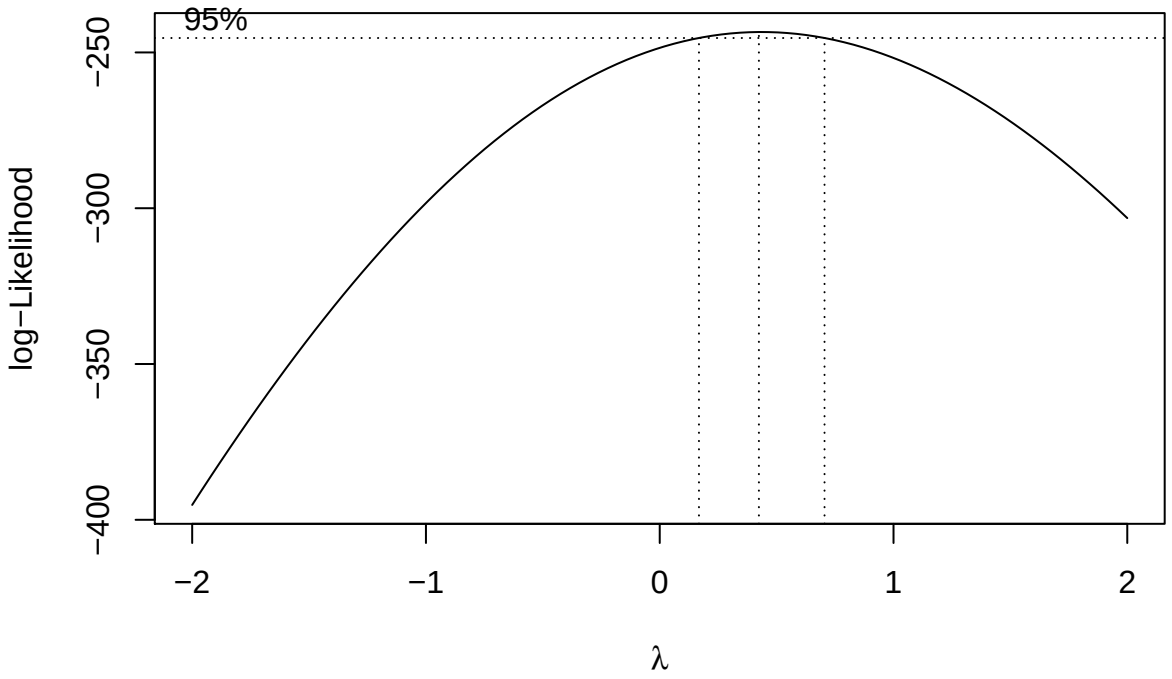
Remarks:

- There is an increasing trend in the data.
- The variability of the data changes according to time (as seen roughly by the changing range of values across different time intervals).
- There is also a strong seasonal component.

b. Apply a Box-Cox transformation to the time series. Use the function `boxcox()` in `R` package `MASS` to find the optimal λ, transform the data, and re-plot the time series. Calculate the sample variance and examine the ACF and PACF. What do you notice? Can you determine the seasonal period from the ACF?

Box-Cox Tranformation

```
library(MASS)
t = 1:length(wine)
fit = lm(wine ~ t)
bcTransform = boxcox(wine ~ t,plotit = TRUE)
```



The dashed vertical lines in the plot above (which is created automatically using the argument `plotit = TRUE`) corresponds to a 95% confidence interval for the true value of λ in the Box-Cox tranformation. If the confidence interval includes $\lambda = 0$, then the Box-Cox tranformation is given by $Y_t = \log X_t$, otherwise the Box-Cox tranformation for stabilizing the variance is given by:

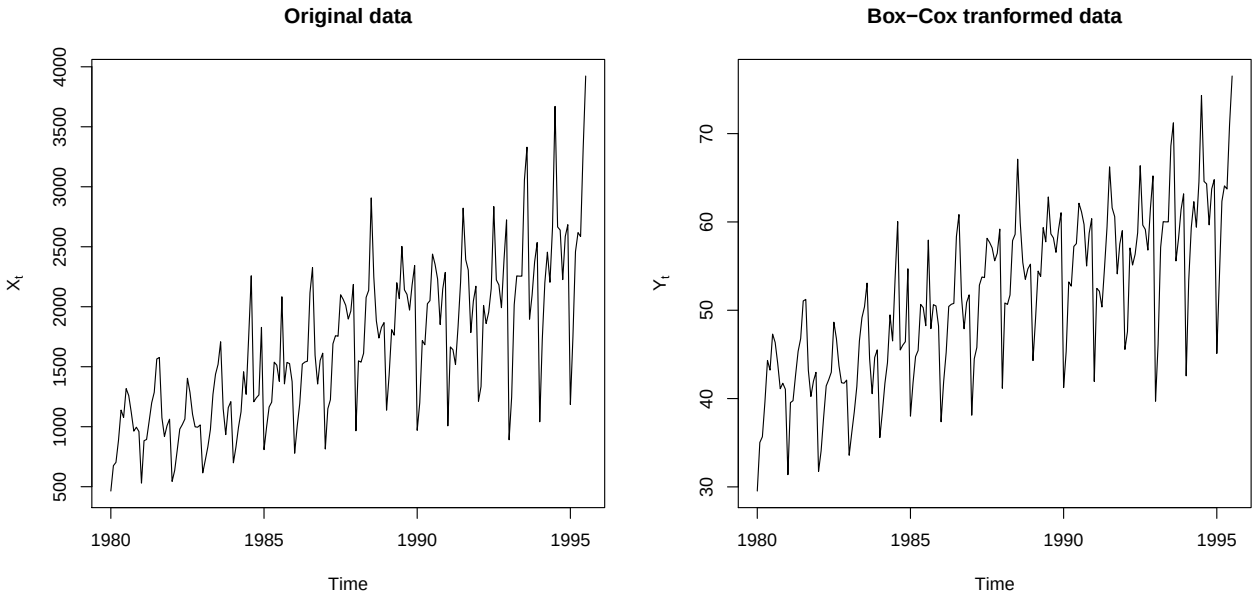
$$Y_t = \frac{1}{\lambda}(X_t^\lambda - 1);$$

as we implement in the code below:

```
lambda = bcTransform$x[which(bcTransform$y == max(bcTransform$y))]
wine.bc = (1/lambda)*(wine^lambda-1)
```

We now plot the original data vs Box-Cox transformed data:

```
op <- par(mfrow = c(1,2))
ts.plot(wine,main = "Original data",ylab = expression(X[t]))
ts.plot(wine.bc,main = "Box-Cox tranformed data", ylab = expression(Y[t]))
```




```
par(op)
```

ACF/PACF of transformed data

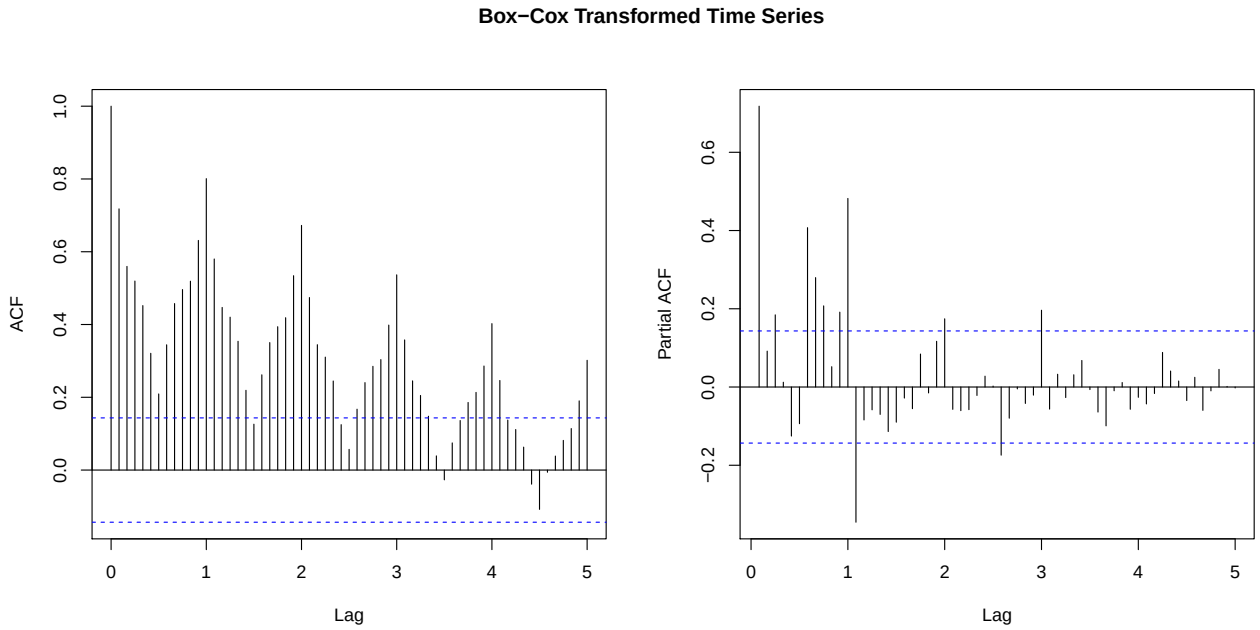
```
# Calculate the sample variance and plot the acf/pacf
var(wine)
```

```
## [1] 421174.6
```

```
var(wine.bc)
```

```
## [1] 83.60385
```

```
op = par(mfrow = c(1,2))
acf(wine.bc,lag.max = 60,main = "")
pacf(wine.bc,lag.max = 60,main = "")
title("Box-Cox Transformed Time Series", line = -1, outer=TRUE)
```

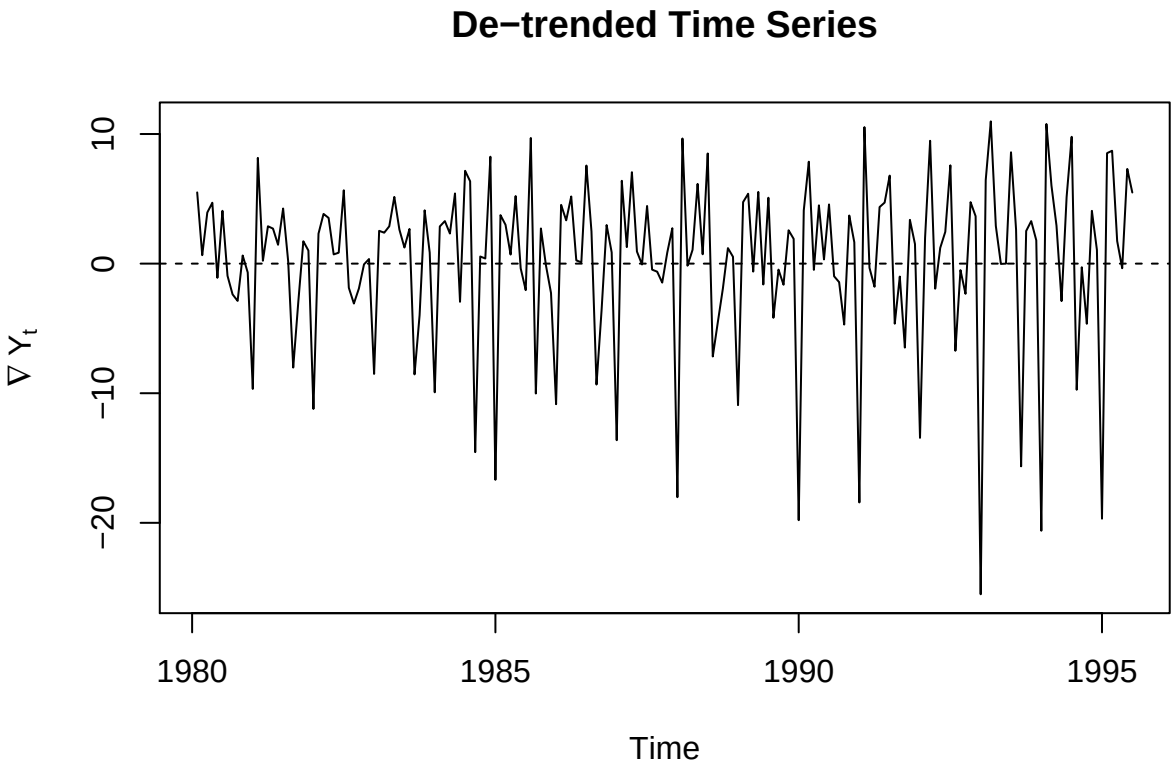



```
par(op)
```

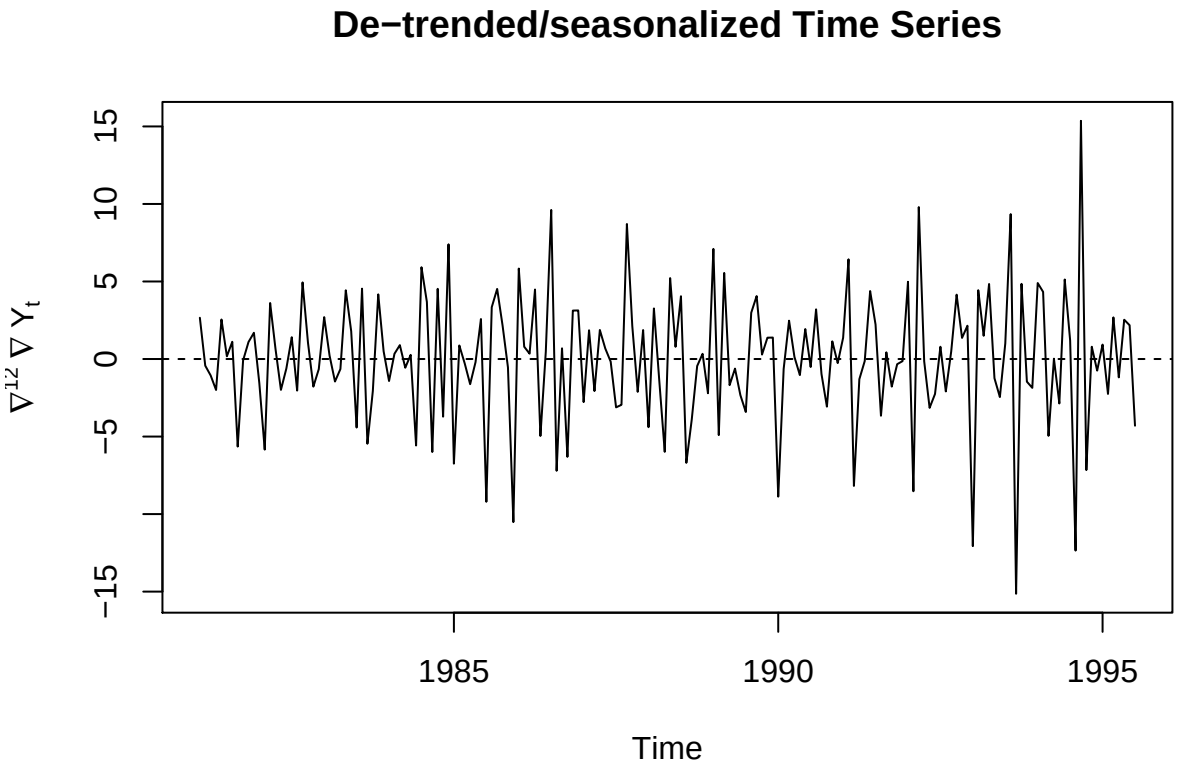
Notice the cyclical behaviour in the ACF of the transformed data. Also, notice that there are significant correlations with valuesmoving proportionally every 12 lags. Therefore, we can see that the period of the seasonal component is given by $d = 12$.

c. Remove the trend and seasonal components by differencing the transformed time series using the diff() function. Plot the differenced time series. Does it look stationary? Re-calculate the sample variance and examine the ACF and PACF. What do you notice?

```
# Diference at lag  = 1 to remove trend component
y1 = diff(wine.bc, 1)
plot(y1,main = "De-trended Time Series",ylab = expression(nabla~Y[t]))
abline(h = 0,lty = 2)
```

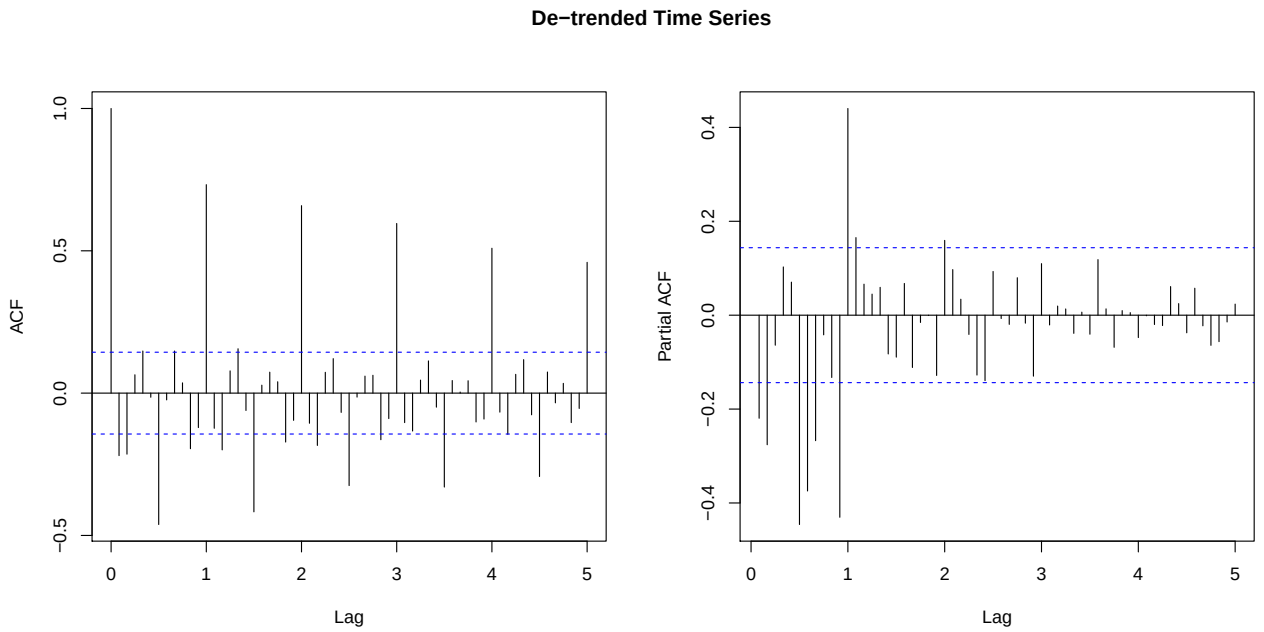



```
# Diference at lag  = 12 (cycle determined by the ACF) to remove seasonal component
y12 = diff(y1, 12)
ts.plot(y12,main = "De-trended/seasonalized Time Series",ylab = expression(nabla^{12}~nabla~Y[t]))
abline(h = 0,lty = 2)
```



ACF of de-trended time series ∇Y_t:

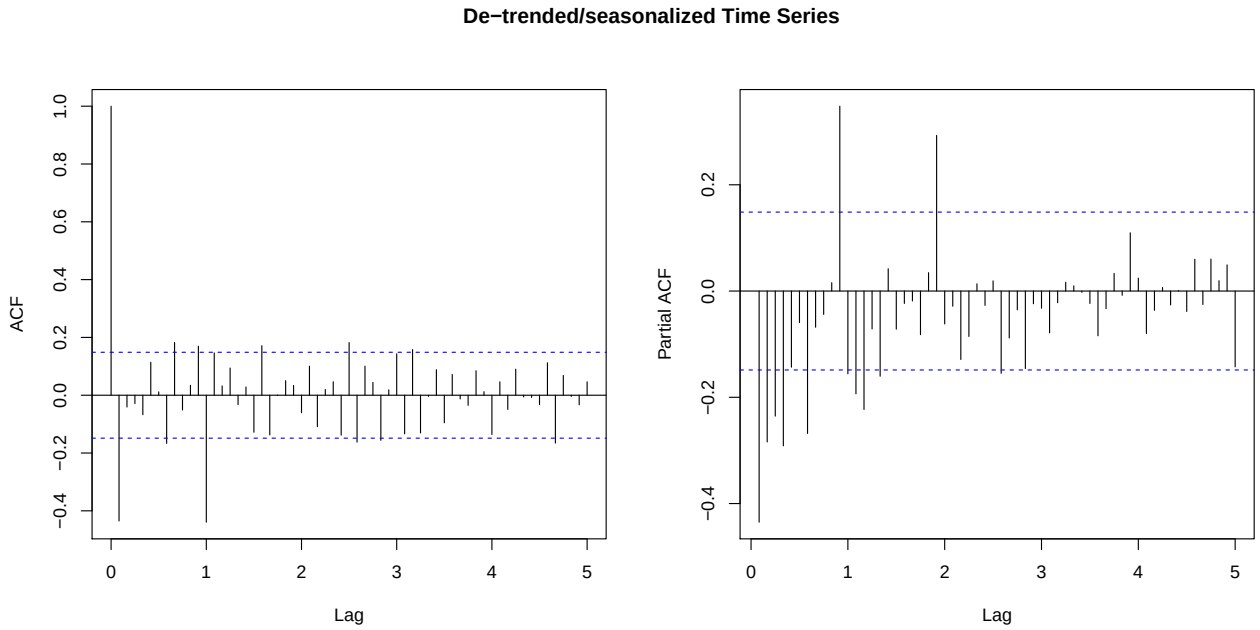
```r
# Re-calculate the sample variance and examine the ACF and PACF
op = par(mfrow = c(1,2))
acf(y1,lag.max = 60,main = "")
pacf(y1,lag.max = 60,main = "")
title("De-trended Time Series", line = -1, outer=TRUE)
```




```r
par(op)
```

ACF of de-trended/de-seasonalized time series $\nabla^{12}\nabla Y_t$:

```r
# Re-calculate the sample variance and examine the ACF and PACF
op = par(mfrow = c(1,2))
acf(y12,lag.max = 60,main = "")
pacf(y12,lag.max = 60,main = "")
title("De-trended/seasonalized Time Series",line = -1, outer=TRUE)
```




```
par(op)
```

d. Repeat b and c using a different transformation (e.g. try log or square root).