MTH 4230 R Notes 11

1 Time Series Analysis in R

1.1 Durbin-Watson Test for Autocorrelation

- To perform a ***Durbin-Watson test*** for autocorrelation, we need to install the `"lmtest"` package. Type:

```
install.packages("lmtest")
```

  Once the package has been installed, load it into the current R session by typing:

```
library(lmtest)
```

- Suppose we have a data frame called `my.data`:

```
head(my.data)

##    y.t x.t
## 1 10.0   1
## 2  9.2   2
## 3  8.6   3
## 4  9.7   4
## 5  8.8   5
## 6  9.2   6
```

  Plots of the data with fitted regression line are shown below:

```
## Error in plot.new():  figure margins too large
## Error in int_abline(a = a, b = b, h = h, v = v, untf = untf, ...):  plot.new
has not been called yet
## Error in plot.xy(xy, type, ...):  invalid graphics state
## Error in int_abline(a = a, b = b, h = h, v = v, untf = untf, ...):  invalid
graphics state
```

- The `"lmtest"` package has a function `dwtest()` function that will perform a ***Durbin-Watson test*** of

$$H_0 : \rho = 0$$
$$H_a : \rho > 0$$

where ρ is the AR(1) correlation for the errors ϵ_t in our regression model, using the residuals from a fitted regression model when we pass it the *lm* object.

- Suppose, for example, we want to perform the ***Durbin-Watson test*** after fitting a regression model to the data in `my.data`:

```
my.reg <- lm(y.t ~ x.t, data = my.data)
```

Having fitted the model, we pass the *lm* object to `dwtest()`:

```
dwtest(my.reg)

##
##  Durbin-Watson test
##
## data:  my.reg
## DW = 0.77969, p-value = 2.571e-07
## alternative hypothesis: true autocorrelation is greater than 0
```

From the output, we see that the test statistic value for the ***Durbin-Watson test*** is $\boldsymbol{D = 0.7797}$ and the p-value is $\mathbf{0}$. Thus we conclude that the errors ϵ are (positively) correlated.

1.2 Cochrane-Orcutt Procedure

- To carry out the ***Cochrane-Orcutt procedure*** for fitting a model to time series data with autocorrelated errors by estimating the AR(1) correlation parameter ρ, fitting a regression model to $Y_t' = Y_t - rY_{t-1}$ and $X_t' = X_t - rX_{t-1}$, where r is the estimate of ρ, and then "backtransforming" the parameter estimates, we'll use the `cochrane.orcutt()` function, which is in the `"orcutt"` package.

- After installing and loading the `"orcutt"` package:

```
install.packages("orcutt")

library("orcutt")
```

we carry out the **Cochrane-Orcutt** procedure by passing `cochrane.orcutt()` an `"lm"` object `my.reg`:

```
my.cochrane <- cochrane.orcutt(my.reg)

my.cochrane
```

```
## Cochrane-orcutt estimation for first order autocorrelation
##
## Call:
## lm(formula = y.t ~ x.t, data = my.data)
##
##  number of interaction: 4
##  rho 0.609843
##
## Durbin-Watson statistic
## (original):    0.77969 , p-value: 2.571e-07
## (transformed): 1.83946 , p-value: 2.363e-01
##
##  coefficients:
## (Intercept)         x.t
##    9.217639    0.202890
```

Then look at the summary by typing:

```
summary(my.cochrane)
```

From the output, among other things, the ***estimate*** of $\boldsymbol{\rho}$ is $\boldsymbol{r = 0.6098}$ and the fitted model (after ”backtransforming” the parameter estimates to the original units of Y of the intercept and Y per unit of X for the slope) is

$$\boldsymbol{\hat{Y} = 9.2176 + 0.2029X}$$