# Problem Set 5

Econ 510

Arinze Nwoye
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1a) The data uses UK GDP series from 1977 quarter 1 till 2015 quarter 1. We estimate a two state, AR(4) model for the GDP growth process allowing the AR coefficients to vary across regimes. The table of transition probabilities from the estimation is as follows:

	Regime 1	Regime 2
Regime 1	0.8898512	0.4105902
Regime 2	0.1101488	0.5894098

1b) Below is a plot of the filtered and smooth probabilities. Regime 1 is the expansionary regime and Regime 2 is the recession regime.

Regime 1

Regime 2
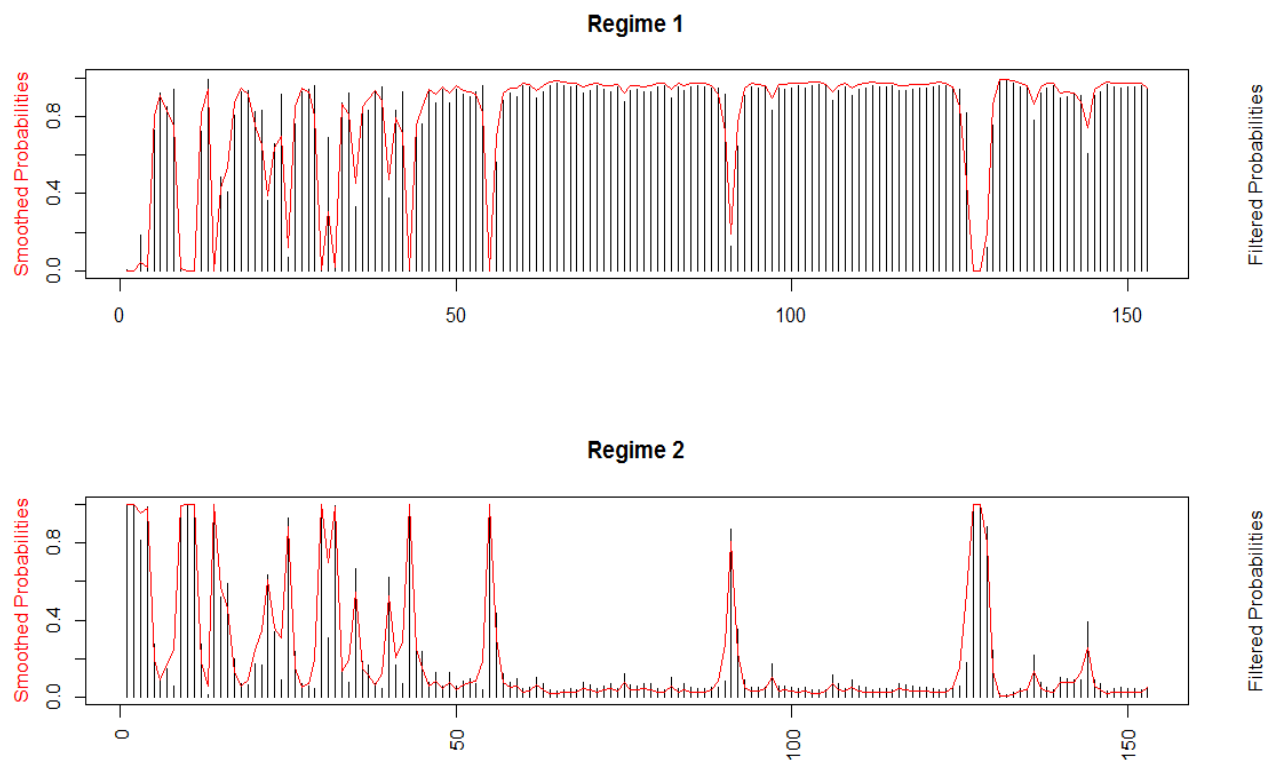
1c) The left table below is UK Quarterly Recession Dates derived from the model and assuming a smoothed probability of 50% or more is a recession. The right table is US Monthly Recession dates as gotten from NBER. Comparing the recessions of the US and the UK using the tables below, both the US and the UK had a recession in the third quarter of 1982. Both countries also had recessions in the third and fourth quarters of 2008 and the first quarter of 2009.

UK Quarterly Recession Data (Smoothed Probabilities)	US Monthly Recession Data		Duration
19770101	November 1973	March 1975	16
19770401	January 1980	July 1980	6
19770701	July 1981	November 1982	16
19771001	July 1990	March 1991	8
19780101	March 2001	November 2001	8
19790401	December 2007	June 2009	18
19790701			
19791001			
19800701			
19801001			
19820701			
19830401			
19840701			
19841001			
19850101			
19851001			
19870101			
19871001			
19901001			
19991001			
20080701			
20081001			
20090101			

1d) I also compare the quarters that the UK and the US are in recession using the alternative rule that a UK recession is two consecutive quarters of negative growth. The table below shows all the dates where the UK experienced negative growth. A look through the table for consecutive dates (quarters) will reveal consecutive quarters of negative growth.

I compare the table below with the right table above of US recession. Both countries experience a recession in the first two quarters of 1980. The US and the UK also experience a recession in the third and fourth quarters of 1990 and the first quarter of 1991. Finally, both countries also experience recessions in the second, third and fourth quarters of 2008. Also in the first and second quarters of 2009.

UK Dates of Low Growth
19770401
19790101
19790701
19800101
19800401
19800701
19801001
19810101
19840401
19850701
19900701
19901001
19910101
19910401
19910701
19920401
20080401
20080701
20081001
20090101
20090401
20111001
20120401
20121001

2a) The graph of the series below is the expected values of the growth rate constructed using the filtered probabilities and the conditional means of the two regimes.
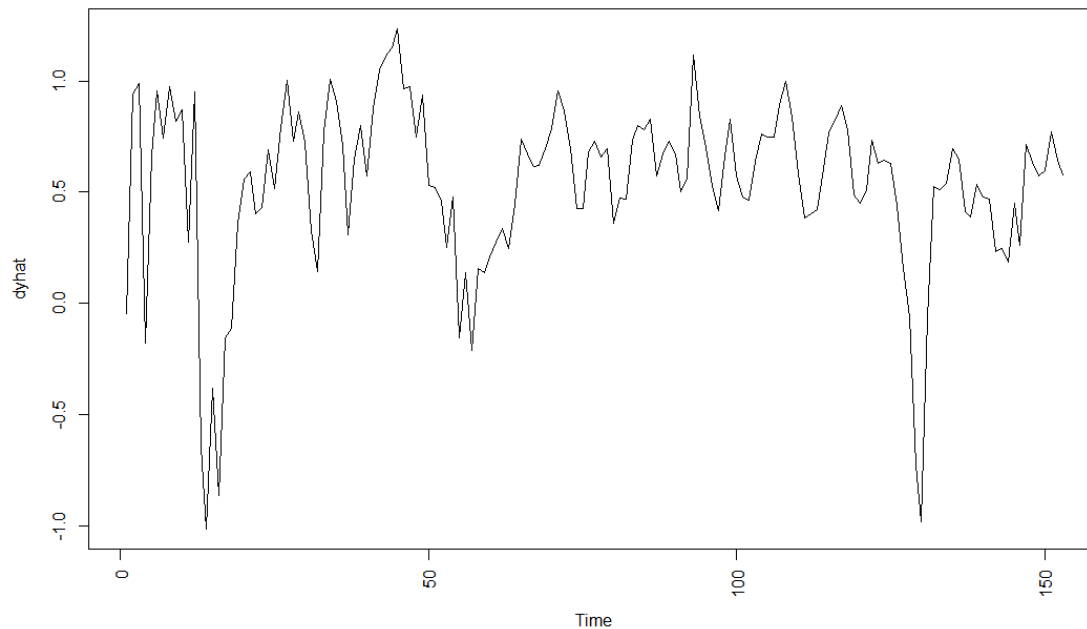
2b) I construct the residuals from the difference between UK GDP Growth (y_t) and the fitted linear model UK GDP Growth from the model (y_{hat}). A test for neglected nonlinearity is constructed using the BDS test using maximum embedding dimension of 4. The results are printed below:

```
BDS Test

data:  res

Embedding dimension =  2 3 4

Epsilon for close points =  0.3261 0.6522 0.9784 1.3045

Standard Normal =
        [ 0.3261 ] [ 0.6522 ] [ 0.9784 ] [ 1.3045 ]
[ 2 ]    -0.0194     0.7921     2.9173     3.9279
[ 3 ]     0.8162     1.8113     3.9887     4.9578
[ 4 ]     1.1886     2.3835     4.5159     5.1366

p-value =
        [ 0.3261 ] [ 0.6522 ] [ 0.9784 ] [ 1.3045 ]
[ 2 ]     0.9846     0.4283     0.0035     1e-04
[ 3 ]     0.4144     0.0701     0.0001     0e+00
[ 4 ]     0.2346     0.0172     0.0000     0e+00
```

The null hypothesis of the BDS test is that the data is iid and based on the P-values for the different combinations of m-dimensions and epsilon (standard deviations) we cannot reject the null hypothesis within 2 standard deviations (epsilon = 0.3261 and 0.6522) regardless of the dimension suggesting that there is no neglected nonlinearity in the series. However for epsilon=0.9784 and 1.3045, we reject the null hypothesis regardless of the dimension. The result is somewhat confusing. However, it might be due to seasonality in the data.

2c) A Voltera polynomial approximation to UK GDP Growth was estimated

2d) The residuals of the model of the Voltera polynomial approximation of UK GDP Growth was tested for neglected nonlinearity using the BDS test.

```
BDS Test

data:  res2

Embedding dimension =  2 3 4

Epsilon for close points =  0.3488 0.6977 1.0465 1.3953

Standard Normal =
      [ 0.3488 ] [ 0.6977 ] [ 1.0465 ] [ 1.3953 ]
[ 2 ]     3.4644      3.7023      3.8304      3.2372
[ 3 ]     2.6770      4.0465      4.3072      4.3272
[ 4 ]     2.7175      4.8310      4.7604      4.6222

p-value =
      [ 0.3488 ] [ 0.6977 ] [ 1.0465 ] [ 1.3953 ]
[ 2 ]     0.0005      2e-04       1e-04       0.0012
[ 3 ]     0.0074      1e-04       0e+00       0.0000
[ 4 ]     0.0066      0e+00       0e+00       0.0000
```

The results of the BDS test show that you can reject the null hypothesis at almost all combinations of m and epsilon. This suggests neglected nonlinearity in the model.