Problem set 5: An introduction to time series

September 20, 2013

1 Introduction

This problem set accompanies the Youtube lecture series, and roughly corresponds to videos 156-180, covering an introduction to time series.

2 Practical - Eurozone & World economic data

1. In this problem we are going to take a break from the sorts of micro data which we have been looking at over the past problem sets, and are going to examine some macro data from the Eurozone and World in general. The data we are going to use for this assignment is prebuilt into Gretl, so it should be already present in the sample datasets - it is called AWM. However, I provide the dataset in Excel format for download should you wish to use a different statistical program to analyse the data. The data is available for download here:
`http://www.oxbridge-tutor.co.uk/#!datasets/culy`

   The dataset is quarterly time series data covering 1970 - 1998[1], and contains macroeconomic indicators for the Eurozone, and in some cases, the World as a whole.

   (a) The most important step with time series data is to get a sense of what your different series look like across time, and to understand what may be causing movements in them. Draw multiple time series plots of The Eurozone GDP, Wage rate, Wealth, Effective Exchange rate, Unemployment and Inflation.

   (b) Which of these series appear stationary?

[1]Euro Area macroeconomic time series from the Area Wide Model (AWM) dataset by Gabriel Fagan, Jerome Henry, and Ricardo Mestre. The dataset covers a wide range of quarterly Euro Area macroeconomic time series and has become a standard reference for empirical studies on the Euro Area economy.

For a description of this database, see the ECB working paper No. 42: An Area-wide Model (AWM) for the euro area by Gabriel Fagan, Jerome Henry, and Ricardo Mestre (January 2001). The paper is available here for download: `ttp://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp042.pdf`

(c) One way of investigating the nature of a particular series is to observe its correlogram. This is a graphical depiction of the correlation of a particular series with lagged values of itself. In order to draw a correlogram from the GUI just right click on a series of your choosing, then select the appropriate option. What do the correlograms for the individual series graphed in the last part suggest about the nature of the series?

(d) Which of the series require a time trend in a test for a unit root?

(e) Conduct tests for unit roots for each of the aforementioned series, ensuring that a sufficient number of lags of differences is included in the specification. What is the conclusion of this?

(f) A student suspects there is a long-run relationship between the level of inflation and the level of GDP. Evaluate this hypothesis.

(g) How do we test for the order of integration of each of the time series?

(h) Test for the order of integration of each series.

(i) A student wanting to test for a long run relationship between interest rates, GDP and inflation suggests running a regression using the first differences between the variables to circumvent the potential issue of non-stationarity. Evaluate this statement.

(j) A researcher thinks that there may be a relationship between the growth of GDP and lags of inflation changes. As such the regression which he suggests running is of the form:

$$\Delta GDP_t = \beta_0 + \beta_1 \Delta \pi_{t-1} + \beta \Delta \pi_{t-2} + \nu_t$$

Where π_t indicates the level of inflation at time t. Run this regression. Can we be sure that we have not run into the issue of spurious regressions?

(k) Graphically inspect for serial correlation by looking at a correlogram of the residuals. Is any serial correlation present? Is it possible to decipher the type?

(l) Check for the presence of serial correlation using an appropriate test.

3 Theory - time series

2. A researcher is interested in evaluating the effect of advertising on sales and estimates the following regression via ordinary least squares.

$$\widehat{sales}_t = \underset{(0.23)}{2.12} - \underset{(0.21)}{0.96}\, price_t + \underset{(0.14)}{0.45}\, advt_t$$

$$N = 100 \quad R^2 = 0.65 \quad F = 44.84$$

(standard errors in parentheses)

Where *sales*, *price* and *advrt* are the logs of unit sales, price and advertising spend respectively. The residuals from the above regression are then used in an auxillary regression against a linear time trend.

$$\widehat{resid}_t = \underset{(0.21)}{0.12} + \underset{(0.14)}{1.01}\, trend_t$$
$$N = 100 \quad R^2 = 0.65 \quad F = 44.84$$
(standard errors in parentheses)

(a) Are there any non-stationary variables in this regression?

(b) Has the researcher found a cointegrated relationship between *sales*, *price* and *advrt*?

(c) What can be concluded about the price elasticity of sales?

(d) The researcher now includes explictly a linear time trend in the regression equation, and gets the following results.

$$\widehat{sales}_t = \underset{(0.56)}{1.12} - \underset{(0.22)}{1.32}\, price_t + \underset{(0.37)}{0.45}\, advt_t + \underset{(0.04)}{0.75}\, trend_t$$
$$N = 100 \quad R^2 = 0.75 \quad F = 50.82$$
(standard errors in parentheses)

The researcher also runs Dickey-Fuller tests on the residuals from this regression and obtains a p value of 0.00236 against the appropriate distribution. What can be concluded from the these results?

(e) What can be inferred from the results of this last regression? Are there any methods that can be used to be able to draw conclusions?

3. The process X_t can be modelled as an ARMA(1,1) process.

$$X_t = \rho X_{t-1} + \varepsilon_t + \theta\varepsilon_{t-1}$$

(a) Which of the following could be modelled by the processes (X_t, ε_t)? ○ $(GDP, civilwar)$ ○ $(GDP, weather)$ ○ Both of the above ○ Neither

(b) What is the mean of the above process (assuming $X_0 = 0$)?

(c) Find the variance of the process in terms of the parameters.

(d) What are the conditions on the parameters for this process to stationary?

(e) Is this process weakly dependent?

(f) Another process is modelled by an AR(2) process. What are the conditions for a this process to be stationary?