Lesson 5

Time Series I

5.1: Introduction

The problems involved in working with time series data is discussed with a simple example. Open the file fish.fit. Create time trend (time) and an intercept (int) and save the file.

This file contains data on fish catch (in money terms) and fish seed purchased by a co-operative. Sustainability requires that fish seed purchased (and hence released into the ponds) should be positively related to fish catch. That is, if the co-operative catches a greater amount of fish, then stock of fish will be reduced and will have to be replaced by seedlings. The regression model is:

SEED = A + B * Sales.

Estimate this regression model using the data given in the file.

SEED = - 16933.1 + 0.29510 Sales

[-0.91618] [18.2833]

R^2 = .93283 f = 334.2797 n = 25 DW = 1.7123

The F-statistic, R^2 and t-values are high, the signs are also as expected. To avoid the problem of auto-correlation we should also look at the Durbin-Watson statistic. The value of the statistic is also satisfactory. Since DW > d_u, we cannot reject the null hypothesis of no autocorrelation. Apparently the model is 'good'.

Now plot Seed and Sales against time. You should find that the trends are both upward rising but are divergent. Green suggests that we should plot the correlogram. The correlograms for Seed and Sales are both downward sloping.

The validity of the OLS model is doubtful, even though the value of DW is satisfactory.

¬ What are the problems with the DW statistic? This is given in Maddala, Section 6.2.

¬ Why is the OLS model likely to be invalid? In this context read the Appendix of the article by Holden & Perman.

5.2: Order of the Serial Correlation

One problem with the DW test is that it tests only for first order serial correlation. To find out the appropriate order of serial correlation we can use the LM test. Estimate the earlier equation again. Click on Close after you get the Results panel. You will see the Post Regression Menu. Previously we had used it to save Residuals/Predicted values. Now click on Option2: Hypothesis Testing Menu and look at the options given to you.

Choose Option 1: LM Test for Serial Correlation. You will be prompted for the order of the expected correlation. The maximum order is 12. If you do not have a theory stating the order, you should choose 12. You are given four columns. In the first column you are given the order. In the next three columns the coefficient, the standard error and finally the t-statistic (and probability value) are given. You should choose the order of correlation for which probability value is highest – here it is 6. That is why the DW test did not indicate serial correlation.

5.3: Autoregressive Models

After identifying the order of serial correlation we can estimate the Model using alternative methods. These models are called AR (Autoregresive) Models.

5.3.a: Cochrane Orcutt Method

Click on Univariate\Linear Regression Menus\AR Errors (Cochrane-Orcutt). Then click on start. You will be prompted for the appropriate order of serial correlation (Type 6). You will have to choose between Initial Estimates supplied by Computer and Initial Estimates supplied by you. Choose the former. Note that the results state that the model is unstable.

Re-estimate the model, for order 1. An extra option is provided to you.

5.3.b: Gauss-Newton Iterative Method

Another method is: Univariate\Linear Regression Menu\AR Errors (Gauss-Newton). Again you have to supply the appropriate order. Choose the initial estimates provided by the computer. After the results of the regression model, we get a plot of the Concentrated Log Likelihood Function.

5.4: Unit Root Test

The Dicky-Fuller test is another useful test used in time series models. This tests the stationarity of a variable. Go to the Command Window and type ADF SEED (n) when n is the order of the test. Although $n \leq 12$, in this case $n \leq 8$ due to the small sample size. The maximum order is 8. Enter 8. In the first columns you are given the order, in the second the value of the statistic. In the next four columns you are given four test statistics to choose the appropriate order. Minimise the Akaike Information Criterion, and choose the appropriate order (2 in this case). The corresponding test statistic has to be compared with the tabular values This is given at the bottom of the table (= -3.8731). Since the corresponding t-statistic is = -1.5730 we accept the null hypothesis of unit root.

Unit root tests for variable SEED
The Dickey-Fuller regressions include an intercept but not a trend
****
12 observations used in the estimation of all ADF regressions.
Sample period from 1988 to 1999
****

	Test Statistic	LL	AIC	SBC	HQC
DF	-1.1521	-155.3486	-157.3486	-157.8335	-157.1691
ADF(1)	-1.0266	-155.2452	-158.2452	-158.9726	-157.9759
ADF(2)	-.93865	-155.2445	-159.2445	-160.2143	-158.8854
ADF(3)	-1.0536	-154.9134	-159.9134	-161.1257	-159.4646
ADF(4)	-.75453	-154.8718	-160.8718	-162.3265	-160.3332
ADF(5)	-.79813	-154.6684	-161.6684	-163.3656	-161.0400
ADF(6)	.73070	-152.0684	-160.0684	-162.0080	-159.3503
ADF(7)	.60772	-151.8017	-160.8017	-162.9838	-159.9938
ADF(8)	.75916	-150.7712	-160.7712	-163.1957	-159.8735
ADF(9)	.55663	-150.5348	-161.5348	-164.2018	-160.5474
ADF(10)	*NONE*	*NONE*	*NONE*	*NONE*	*NONE*
ADF(11)	*NONE*	*NONE*	*NONE*	*NONE*	*NONE*
ADF(12)	*NONE*	*NONE*	*NONE*	*NONE*	*NONE*

****
95% critical value for the augmented Dickey-Fuller statistic = -3.1485
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable SEED
The Dickey-Fuller regressions include an intercept and a linear trend
****
12 observations used in the estimation of all ADF regressions.
Sample period from 1988 to 1999
****

	Test Statistic	LL	AIC	SBC	HQC
DF	-1.5879	-154.5093	-157.5093	-158.2367	-157.2400
ADF(1)	-1.4964	-154.2386	-158.2386	-159.2084	-157.8795
ADF(2)	-1.5730	-153.8799	-158.8799	-160.0921	-158.4310
ADF(3)	-2.3396	-151.6826	-157.6826	-159.1373	-157.1440
ADF(4)	-2.2327	-151.1905	-158.1905	-159.8876	-157.5621
ADF(5)	-2.6502	-149.2578	-157.2578	-159.1975	-156.5397
ADF(6)	-1.1217	-148.5477	-157.5477	-159.7297	-156.7398
ADF(7)	-1.4185	-145.9216	-155.9216	-158.3461	-155.0239
ADF(8)	-32.0974	-107.7707	-118.7707	-121.4377	-117.7833
ADF(9)	*NONE*	*NONE*	*NONE*	*NONE*	*NONE*
ADF(10)	*NONE*	*NONE*	*NONE*	*NONE*	*NONE*
ADF(11)	*NONE*	*NONE*	*NONE*	*NONE*	*NONE*
ADF(12)	*NONE*	*NONE*	*NONE*	*NONE*	*NONE*

****
95% critical value for the augmented Dickey-Fuller statistic = -3.8731
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

A better method would be to redo the above test for n=2. This will generate the correct tabulated t-statistic (-3.6331).

5.5: Co-Integration Test

Engle and Granger (1987) has suggested a Co-Integration Test. While Dicky-Fuller suggests that we apply the Unit Root Test taking Seed and Sales as dependent variables, Engle & Granger suggests that we regress Seed on Sales and then apply the Unit Root Test. To do this run SEES in INT SALES. Then proceed as follows:

Post Estimation Menu\Hypothesis Testing\Unit Root Test for Residuals. Enter the order of the test (again 11 in this case) and click start.

5.6: Exercises

The above is basically a primer to Time Series Analysis. We now turn to a serious exercise that provides meaningful results. This is the paper by Prabirjit Sarkar and Brototi Bhattacharyya (Occasional Papers, 2003). Read the paper carefully and rework the analysis. Note that the results for Dicky-Fuller Unit Root Tests had been undertaken using the Hypothesis testing Menu and not using the ADF command. So your conclusions should be slightly different. Though this has been done using Microfit you may have a slight divergence of other results also. You will also learn two concepts – Trend Stationary Models and Difference Stationary Models. These concepts are discussed in details in the next Module.

5.7: Co-Integrability

The Engle-Granger 2-step procedure has its limitations – notably we have to distinguish between the direction of causality. Johansen suggests a better method that can be applied using Microfit. However, in order to use it, we have to determine the order of the VAR model. This can be done using the LM test for serial correlation.

5.7.a: Choosing Model Type

The Estimation Menu for Cointegrability provides several options regarding the model form. Their meanings are given below.

1. **No intercepts or trends:** This option (Cases I) is relevant when there are no intercepts or time trends in the VAR model. This is rarely used.
2. **Restricted intercepts, no trends:** This option is appropriate when the jointly determined variables do not contain a deterministic trend, but may have non-zero means.
3. **Unrestricted intercepts, no trends:** This option is appropriate when the VAR model contains unrestricted intercepts. Notice, however, that the use of this option can lead to error correction models with different trend properties depending on the number of cointegrating relations that may exist among the variables.
4. **Unrestricted intercepts, restricted trends:** This option is appropriate when the jointly determined variables in the VAR have linear deterministic trends, and the trend coefficients are restricted, so that the level of the variables in the VAR also contain only linear deterministic trends.
5. **Unrestricted intercepts, unrestricted trends:** This option is relevant when the underlying VAR model contains both intercepts and deterministic linear trends, with the intercept and the trend coefficients being unrestricted Notice that the use of this option can lead to error correction models with different trend properties depending on the number of cointegrating relations that may exist among the variables.

We would suggest that you work with Options 1, 3 and 5. The reason is that the interpretation of restricted parameters is highly complicated. Model 1 should be used rarely - only when Y=0 when X=0. In most cases, however, when X=0, $Y \neq 0$. In such cases you should use Model 3 or 5. Note that intercepts and trend values are set automatically by the package – so do not add them to your variable list.

5.7.b: Structure of the Model

The Engle Granger Cointegratiion process assumed that Y = f(X). However, the direction of causality may be uncertain. In that case both Y = f(X) and X = f(Y) are possible. Accordingly we can think of two regressions:

$$Y_t = \alpha_1 + \beta_1 T + \gamma_1 X_t + \eta_{1i} \Sigma Y_{t-I} + \lambda_{1j} \Sigma X_{t-j}$$

$$X_t = \alpha_2 + \beta_2 T + \gamma_2 Y_t + \eta_{2i} \Sigma Y_{t-I} + \lambda_{2j} \Sigma X_{t-j}$$

The vector of coefficients (η_{1I} λ_{1j}) and (η_{2I} λ_{2j}) are called vector auto regressions. The Johannsen Model estimates these vectors.

The econometric model that underlies the cointegrating VAR options is given by the following Vector Error Correcting Mechanism, VECM:

$$\delta y_t = a_{oy} + a_{1y} - \pi_y z_{t-1} + \sum_{i=1}^{\rho-1} \Gamma_{iy} \delta z_{t-1} + \psi_y w_t + u_{iy}$$

where: $z_i = (y_i \; x_i)^{-1}$

y: m_y * 1 vector of endogenous I(1) variables
x: m_x * 1 vector of exogenous I(1) variables
w: q * 1 vector of I(0) variables

Intercepts and deterministic linear trends

5.7.c: Choosing the Order of VAR

Choose Multivariate\Unrestricted VAR. Enter the list of jointly determined variables, followed by ‘&’. Then enter intercept, time and exogenous variables (if any). Click on Start. You will be presented with a Post Estimation meny. Choose Option 4: Hypothesis Testing and Lag Order Selection. Then choose Option 1: Testing and Selection Criteria for Order (lag period) of VAR Model. You have to choose the maximum order (≤ 24). If the dat size is not large enough then the maximum order has to be gradually reduced. In this case the maximum order is 6. The optimal order has to be chosen on the basis of the highest value of SBC or AIC. We can also use the Log Likelihood Test. This involves testing the hypothesis that the order of the VAR model is k against the hypothesis that it is k+1. In the last column the adjusted LR statistic is given. The optimal order from each ofthese tests may vary – for instance SBC generally gives a lower order than AIC. Here the two criterion tally – bpth suggesting 2 as the optimal order.

```
Test Statistics and Choice Criteria for Selecting the Order of the VAR Model
*******************************************************************************
 Based on 19 observations from 1981 to 1999. Order of VAR = 6
 List of variables included in the unrestricted VAR:
 SALES           SEED
 List of deterministic and/or exogenous variables:
 INT             TIME
*******************************************************************************
 Order    LL        AIC      SBC             LR test         Adjusted LR test
   6  -468.6969 -496.6969 -509.9190             ------             ------
   5  -474.9524 -498.9524 -510.2857  CHSQ(  4)=  12.5110[.014]    3.2924[.510]
   4  -482.8699 -502.8699 -512.3143  CHSQ(  8)=  28.3460[.000]    7.4595[.488]
   3  -486.8429 -502.8429 -510.3984  CHSQ( 12)=  36.2920[.000]    9.5505[.655]
   2  -492.0171 -504.0171 -509.6837  CHSQ( 16)=  46.6403[.000]   12.2738[.725]
   1  -494.1376 -502.1376 -505.9154  CHSQ( 20)=  50.8815[.000]   13.3899[.860]
   0  -500.5695 -504.5695 -506.4584  CHSQ( 24)=  63.7452[.000]   16.7751[.858]
*******************************************************************************
 AIC=Akaike Information Criterion     SBC=Schwarz Bayesian Criterion
```

5.7.d: Estimating the Model

Cancel to return to Estimation Window and choose the degree of VAR as 2 (or what ever) in the appropriate panel. Then choose Multivariate\Cointegrating Menu\Relevant Model. In this case choose Model 1. Click on start to get the number of cointegrating equations [r]. In this case r = 0 – that is thee is no relationship between SEED and SALES.

```
                 Cointegration with no intercepts or trends in the VAR
   Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix
*******************************************************************************
 23 observations from 1977 to 1999. Order of VAR = 2.
 List of variables included in the cointegrating vector:
 SALES           SEED
 List of eigenvalues in descending order:
.28707     .11373
*******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r = 1         7.7827           11.0300                 9.2800
 r<= 1      r = 2         2.7769            4.1600                 3.0400
*******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).
```

```
                 Cointegration with no intercepts or trends in the VAR
          Cointegration LR Test Based on Trace of the Stochastic Matrix
*******************************************************************************
 23 observations from 1977 to 1999. Order of VAR = 2.
 List of variables included in the cointegrating vector:
 SALES          SEED
 List of eigenvalues in descending order:
.28707     .11373
*******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r>= 1        10.5595           12.3600                10.2500
 r<= 1      r = 2         2.7769            4.1600                 3.0400
*******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).

             Cointegration with no intercepts or trends in the VAR
Choice of the Number of Cointegrating Relations Using Model Selection Criteria
*******************************************************************************
 23 observations from 1977 to 1999. Order of VAR = 2.
 List of variables included in the cointegrating vector:
 SALES          SEED
 List of eigenvalues in descending order:
.28707     .11373
*******************************************************************************
 Rank      Maximized LL        AIC            SBC             HQC
 r = 0      -606.3291       -610.3291       -612.6001       -610.9002
 r = 1      -602.4378       -609.4378       -613.4120       -610.4373
 r = 2      -601.0493       -609.0493       -613.5913       -610.1916
*******************************************************************************
 AIC = Akaike Information Criterion    SBC = Schwarz Bayesian Criterion
 HQC = Hannan-Quinn Criterion
```

If on the other hand we use DSEED and DSALES then we get the following test statistics for r:

```
                 Cointegration with no intercepts or trends in the VAR
   Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix
*******************************************************************************
 22 observations from 1978 to 1999. Order of VAR = 2.
 List of variables included in the cointegrating vector:
 DSALES         DSEED
 List of eigenvalues in descending order:
.57000     .23562
*******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r = 1        18.5674           11.0300                 9.2800
 r<= 1      r = 2         5.9111            4.1600                 3.0400
*******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).


             Cointegration with no intercepts or trends in the VAR
          Cointegration LR Test Based on Trace of the Stochastic Matrix
*******************************************************************************
 22 observations from 1978 to 1999. Order of VAR = 2.
 List of variables included in the cointegrating vector:
 DSALES         DSEED
 List of eigenvalues in descending order:
.57000     .23562
*******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r>= 1        24.4786           12.3600                10.2500
 r<= 1      r = 2         5.9111            4.1600                 3.0400
*******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).



             Cointegration with no intercepts or trends in the VAR
Choice of the Number of Cointegrating Relations Using Model Selection Criteria
*******************************************************************************
 22 observations from 1978 to 1999. Order of VAR = 2.
 List of variables included in the cointegrating vector:
 DSALES         DSEED
```

```
 List of eigenvalues in descending order:
.57000     .23562
*******************************************************************************
 Rank      Maximized LL        AIC             SBC             HQC
 r = 0      -589.2083       -593.2083       -595.3904       -593.7223
 r = 1      -579.9246       -586.9246       -590.7432       -587.8241
 r = 2      -576.9690       -584.9690       -589.3332       -585.9971
*******************************************************************************
 AIC = Akaike Information Criterion    SBC = Schwarz Bayesian Criterion
 HQC = Hannan-Quinn Criterion
```

Here r=2. Click Cancel to get the following options:

Option 0: Move to backtracking menu

Option 1: Display cointegration tests again

Option 2: Specify r, the number of cointegrating vectors

Option 3: Display CVs using Johansen's just identifying restrictions

Option 4: Display system covariance matrix of errors

Option 5: Display matrix of long run multipliers for r

Option 7: Long run structural modelling, IR Analysis and Forecasting

Option 8: Compute multivariate dynamic forecasts

Choose Option 2 and specify r as 2 (or what ever r is). Then you can choose Option 3, 4 and 5 to get Cointegrating vectors, system covariance matrix of errors and matrix of long run multipliers.