Chapter 12: Time Series Models

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The workfile named *macro14.wf1* will be used to demonstrate the procedures explained in *UE*, Chapter 12. The examples examine the relationship between current purchases of goods and services (*CO*) and the level of disposable income (*YD*).

Estimating an ad hoc distributed lag model (*UE* 12.1.3):

To estimate the ad hoc distributed lag model printed in *UE*, Equation 12.14, follow these steps:

Step 1. Open the EViews workfile named *Macro14.wf1*.
Step 2. Select **Objects/New Object/Equation** on the workfile menu bar, enter *CO C YD(0 to -3)* in the Equation Specification: window, and click **OK**.[1]
Step 3. Select **Name** on the equation menu bar, enter the name *EQ01*, and click **OK**.
Step 4. Select **Save** on the workfile menu bar to save your changes.

Estimating a Koyck distributed lag model (*UE* 12.1.3):

To estimate the Koyck distributed lag model printed in *UE*, Equation 12.11, follow these steps:

Step 1. Open the EViews workfile named *Macro14.wf1*.
Step 2. Select **Objects/New Object/Equation** on the workfile menu bar, enter *CO C YD CO(-1)* in the Equation Specification: window, and click **OK.**
Step 3. Select **Name** on the equation menu bar, enter the name *EQ02*, and click **OK**.
Step 4. Select **Save** on the workfile menu bar to save your changes.

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[1] You can include a consecutive range of lagged series by using the word "to" between the lags. *YD(0 to -3)* is equivalent to *YD YD(-1) YD(-2) YD(-3).*

Testing for serial correlation in Koyck distributed lag models using Durbin's h test (*UE* 12.2.2):

Estimate the Koyck distributed lag model before attempting this section (i.e., Equation *EQ02* should already be present in the workfile). To conduct a Durbin's h test for *UE*, Equation 12.11, follow these steps:

Step 1. Open the EViews workfile named *Macro14.wf1*.

Step 2. To determine whether the value in parenthesis, in the denominator under the square root sign in *UE*, Equation 12.17, is positive, enter the following command in the command window:

scalar denominator=1-eq02.@regobs(eq02.@stderrs(3)^2)*.

Press **Enter** to create a scalar object named *denominator*. Double click the scalar object icon named *denominator* in the EViews workfile and view its value in the left corner of the status bar (bottom of the EViews window). If the number is positive, continue with the next step; if not, Durbin's h test is not valid.

Step 3. To compute Durbin's h test statistic shown in *UE*, Equation 12.17, enter the following command in the command window and press **Enter**:

*scalar dhtest=(1-(0.5*eq02.@dw))*sqr(eq02.@regobs/denominator)*.

Step 4. To view this scalar, double click the scalar object icon named *dhtest* and view its value in the left corner of the status bar (bottom of the EViews window). If the number is ≥ 1.96, reject the null hypothesis of no first order serial correlation.

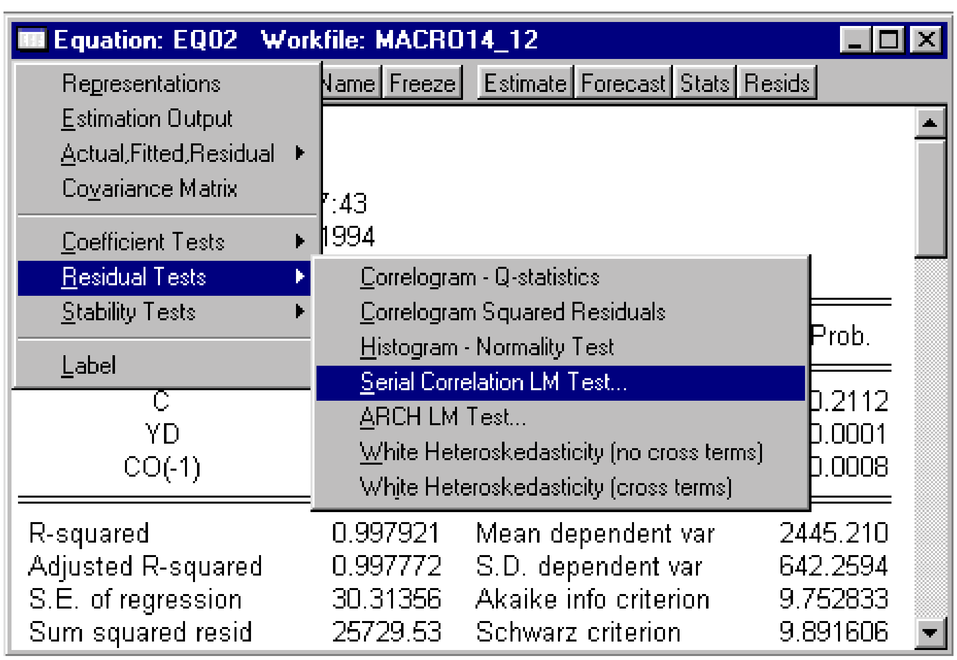
Testing for serial correlation in Koyck distributed lag models using the Lagrangian Multiplier (LM) (*UE* 12.2.2):

Estimate the Koyck distributed lag model before attempting this section (i.e., equation *EQ02* should already be present in the workfile). To conduct a Lagrangian Multiplier (LM) test for *UE*, Equation 12.11, follow these steps:

Step 1. Open the EViews workfile named *Macro14.wf1*.

Step 2. Open the Equation named *EQ02* by double clicking its icon in the workfile window.

Step 3. Select **View/Residuals Tests/Serial Correlation LM Test…** on the equation menu bar (see highlighted selections in the graphic on the right).



Step 4. Change the number in the Lags to include: to *1* in the Lag Specification: window.[2] Click **OK** to reveal the following EViews output:

Breusch-Godfrey Serial Correlation LM Test:				
F-statistic	11.77690	Probability		0.001946
Obs*R-squared	9.414982	Probability		0.002152
Test Equation:				
Dependent Variable: RESID				
Method: Least Squares				
Date: 07/01/00 Time: 10:25				
Presample missing value lagged residuals set to zero.				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-22.30297	26.12643	-0.853656	0.4008
YD	0.113797	0.104157	1.092547	0.2842
CO(-1)	-0.119235	0.110340	-1.080614	0.2894
RESID(-1)	0.602362	0.175526	3.431748	0.0019
R-squared	0.303709	Mean dependent var		3.67E-14
Adjusted R-squared	0.226343	S.D. dependent var		29.28568
S.E. of regression	25.75902	Akaike info criterion		9.455361
Sum squared resid	17915.24	Schwarz criterion		9.640392
Log likelihood	-142.5581	F-statistic		3.925632
Durbin-Watson stat	1.630947	Prob(F-statistic)		0.019027

The null hypothesis of the LM test is that there is no serial correlation up to lag order p, where p is equal to 1 in this case. The Obs*R-squared statistic is the Breusch-Godfrey LM test statistic. This LM statistic is computed as the number of observations times the R^2 from the test regression. The LM test statistic is asymptotically distributed as a χ^2 with p degrees of freedom (p is equal to 1 in this case).

Step 5. To determine whether the null hypothesis can be rejected in this case, determine the critical $\chi^2(1)$ value from *UE* Table B-8. The critical χ^2 value can also be calculated in EViews by typing the following formula in the EViews command window: *=@qchisq(.95,1)*.[3] EViews returns a scalar value of 3.84. Since the calculated Breusch-Godfrey LM test statistic of 9.42 exceeds the critical $\chi^2(1)$ value, we can reject the hypothesis of no serial correlation up to lag order 1 at the 95% confidence level. The probability printed to the right of the Obs*R-squared statistic in the EViews output (i.e., 0.002152) represents the probability that you would be incorrect if you rejected the null hypothesis of no serial correlation up to lag order 1 at the 95% confidence level.

[2] EViews enters 2 lags by default (i.e., testing for second order serial correlation). We will enter 1 lag to estimate the LM statistic for *UE*, Equation 12.20, p. 421.

[3] *c=@qchisq(p,v)* calculates the percentile of the χ^2 distribution . The formula finds the value c such that the prob(χ^2 with v degrees of freedom is $\leq c) = p$. In this case, the prob(χ^2 with 1 degree of freedom is $\leq 3.84) = 95\%$. In other words, *95%* of the area of a χ^2 distribution, with *v=1* degrees of freedom, is in the range from *0* to *3.84* and *5%* is in the range from *3.84* to ∞ (i.e., in the tail of the distribution).

Performing Granger Causality tests (*UE* 12.3):

To conduct Granger Causality test for *CO* and *YD*, follow these steps:

Step 1. Open the EViews workfile named *Macro14.wf1*.
Step 2. To Create an EViews group for the current purchases of goods and services (*CO*) and the level of disposable income (*YD*), hold down the **Ctrl** button, click on, *CO* and *YD*, select **Show** from the workfile toolbar, and click **OK**.
Step 3. Select **Name** on the Group Object menu bar, enter *GROUP01* in the Name to identify object: window, and click **OK**.
Step 4. Select **View/Granger Causality…** on the Group Object menu bar. When you select the Granger Causality view, you will first see a dialog box asking for the number of lags to use in the test regressions. Change the number in the Lags to include: to *3* in the Lag Specification: window, and click **OK**.[4] EViews returns the following pairwise Granger Causality Tests Table.

Pairwise Granger Causality Tests			
Date: 07/01/00 Time: 14:43			
Sample: 1963 1994			
Lags: 3			
Null Hypothesis:	Obs	F-Statistic	Probability
YD does not Granger Cause CO	28	2.05100	0.13748
CO does not Granger Cause YD		4.57141	0.01291

Step 5. Based on the Probability values reported in the table, the hypothesis that *YD* does not Granger Cause *CO* cannot be rejected, but the hypothesis that *CO* does not Granger cause *YD* can be rejected. Therefore, it appears that Granger causality runs one way, from *CO* to *YD*, but not the other way.[5]

Testing for nonstationarity by calculating the auto correlation function ACF (*UE* 12.4.1, Equation 12.24, p. 425):

Follow these steps to calculate the auto correlation function ACF:

Step 1. Open the EViews workfile named *Macro14.wf1*.
Step 2. Open *CO* in one window by double clicking the series icon in the workfile window.
Step 3. To view the Autocorrelation and Partial Correlation, Select **View/Correlogram…**, on the *CO* series menu bar and a Correlogram Specification dialog box appears. Select *level* in the Correlogram of: window and enter *16* (the EViews default in this case) in the Lag Specification: lags to include: window, and click **OK** to reveal the EViews output below.

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[4] In general, it is better to use more rather than fewer lags, since the theory is couched in terms of the relevance of all past information. You should pick a lag length that corresponds to reasonable beliefs about the longest time over which one of the variables could help predict the other.

[5] The reported F-statistics are the Wald statistics for the joint hypothesis that the coefficients on the lagged values of the other variable are zero for each equation (*CO* in the first equation and *YD* in the second equation for the table printed above). In case you want to determine significance by comparing the calculated F statistic with the critical F value from the F Table, the numerator degrees of freedom are given by the number of coefficient restrictions in the null hypothesis (i.e., the number of lags) and the denominator degrees of freedom are given by the total regression degrees of freedom.

Step 4. Since the AC's are significantly positive and the AC(k) dies off geometrically with increasing lag k, it is a sign that the series obeys a low-order autoregressive (AR) process.[6] In addition, since the partial autocorrelation (PAC) is significantly positive at lag 1 and close to zero thereafter, the pattern of autocorrelation can be captured by an autoregression of order one (i.e., AR(1)).

Date: 07/08/00 Time: 09:36
Sample: 1963 1994
Included observations: 32

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.900	0.900	28.426	0.000
		2	0.804	-0.032	51.858	0.000
		3	0.713	-0.024	70.944	0.000
		4	0.628	-0.026	86.250	0.000
		5	0.535	-0.088	97.787	0.000
		6	0.444	-0.053	106.03	0.000
		7	0.353	-0.060	111.47	0.000
		8	0.266	-0.050	114.68	0.000
		9	0.182	-0.052	116.25	0.000
		10	0.106	-0.024	116.81	0.000
		11	0.040	-0.017	116.89	0.000
		12	-0.024	-0.052	116.92	0.000
		13	-0.082	-0.029	117.30	0.000
		14	-0.134	-0.040	118.38	0.000
		15	-0.182	-0.046	120.50	0.000
		16	-0.228	-0.059	124.04	0.000

The finding in **Steps 3 & 4** indicates that the *CO* series violates the third criteria for stationarity (*UE*, top of p. 425) and provides strong evidence that the *CO* series is non-stationary.

Testing for nonstationarity with the Dickey-Fuller (DF) test (12.4.2):

Since the AC analysis in the previous section indicated that *CO* is most likely an AR(1) process, the Dickey-Fuller (DF) test is valid. Follow these steps to conduct the Dickey-Fuller test of the hypothesis that the *CO* series is non-stationary:

Step 1. Open the EViews workfile named *Macro14.wf1*.
Step 2. Open *CO* in one window by double clicking the series icon in the workfile window. Note that EViews will probably display the correlogram view for *CO* since that was the last view selected in the previous section. You can select **View/Spreadsheet** to view the series data or just proceed with the next step to test for stationarity.
Step 3. To conduct the Dickey-Fuller (DF) test, select **View/Unit Root Test…** on the *CO* series window menu bar.
Step 4. Four things have to be specified in the Unit Root Test dialog box to carry out a unit root test. First, choose the type of test—either the Augmented Dickey-Fuller (ADF) test or the Phillips-

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[6] If the AC(1) is nonzero, it means that the series is first order serially correlated. If AC(k) dies off more or less geometrically with increasing lag k, it is a sign that the series obeys a low-order autoregressive (AR) process. If AC(k) drops to zero after a small number of lags, it is a sign that the series obeys a low-order moving-average (MA) process. EViews also reports the Partial Correlations (PAC) in the same window. The partial correlation at lag k measures the correlation of *CO* values that are k periods apart, after removing the correlation from the intervening lags. If the pattern of autocorrelation is one that can be captured by an autoregression of order less than k, then the partial autocorrelation at lag k will be close to zero. The PAC of a pure autoregressive process of order k cuts off at lag k, while the PAC of a pure moving average (MA) process asymptotes gradually to zero.

Perron (PP) test (select *ADF* for this example).[7] Second, specify whether to test for a unit root in the Level, 1st difference, or 2nd difference of the series (select *level* for this example).[8] Third, specify whether to include an Intercept, a Trend and intercept, or None in the test regression. Select *Trend and intercept* for this example. To see why, read footnote 18, *UE*, p. 427. Fourth, specify the number of lagged first difference terms to add in the test regression (*0* for the DF test). The theory behind each of these selections is beyond the scope of *UE* and this guide. Advanced econometrics courses deal with these issues. When finished with the selections click **OK** to reveal the following table:

ADF Test Statistic	-1.633006	1% Critical Value*		-4.2826
		5% Critical Value		-3.5614
		10% Critical Value		-3.2138
*MacKinnon critical values for rejection of hypothesis of a unit root.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(CO)				
Method: Least Squares				
Date: 07/01/00 Time: 17:20				
Sample(adjusted): 1964 1994				
Included observations: 31 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
CO(-1)	-0.205313	0.125727	-1.633006	0.1137
C	320.1090	158.7047	2.017010	0.0534
@TREND(1963)	14.95367	8.798879	1.699497	0.1003
R-squared	0.107652	Mean dependent var		72.14839
Adjusted R-squared	0.043913	S.D. dependent var		38.54897
S.E. of regression	37.69307	Akaike info criterion		10.18860
Sum squared resid	39781.49	Schwarz criterion		10.32737
Log likelihood	-154.9232	F-statistic		1.688951
Durbin-Watson stat	1.191606	Prob(F-statistic)		0.202992

Step 5. The test fails to reject the null hypothesis of a unit root in the *CO* series at any of the reported significance levels, since the ADF Test Statistic[9] is not less than (i.e., does not lie to the left of) the MacKinnon critical values.

[7] EViews refers to both the Dickey-Fuller and the Augmented Dickey-Fuller tests as ADF tests. You will face two practical issues in performing the ADF test. First, you will have to specify the number of lagged first difference terms to add to the test regression (selecting zero yields the DF test; choosing numbers greater than zero generates ADF tests). The usual (though not particularly useful) advice is to include lags sufficient to remove any serial correlation in the residuals. Second, EViews asks you whether to include other exogenous variables in the test regression. You have the choice of including a constant, a constant and a linear time trend, or neither in the test regression.

[8] You can use this option to determine the number of unit roots in the series. If the test fails to reject the test in levels but rejects the test in first differences, then the series contains one unit root and is of integrated order one I(1). If the test fails to reject the test in levels and first differences but rejects the test in second differences, then the series contains two unit roots and is of integrated order two I(2).

[9] The output reports the ADF Test Statistic, but in reality, it is the DF test statistic, since zero lags were chosen.

Adjusting for nonstationarity (12.4.3):

In order to determine whether the first differenced series[10] is stationary, follow the steps in the previous section and select *1st difference* for the Test for unit root in: window and *Intercept* in the Include in test equation: window. Note that the null hypothesis of a unit root in the first difference of *CO* can be rejected at the 5% but not at the 1% level. This adds to the evidence from the ACF test that indicates *CO* is most likely an AR(1) process.

Exercises:

5. Open the EViews workfile named *Mouse12.wf1*.
   a. Follow the steps in estimating distributed lag models.
   b. Follow the steps in estimating Koyck lag models.

6. Open the EViews workfile named *Mouse12.wf1*.
   a. Complete Exercise 5b and follow the steps found in Testing for serial correlation in Koyck lag models using Durbin's h test.
   b. Complete Exercise 5b and follow the steps found in Testing for serial correlation in Koyck lag models using the Lagrangian Multiplier (LM) test.

7. Open the EViews workfile named *Mouse12.wf1*. Complete Exercise 5b and follow the steps found in using the Lagrangian Multiplier (LM) test to detect serial correlation tests in Koyck lag models.
   a.
   b.
   c. In **Step 5**, change the number in the Lags to include: to *2* in the Lag Specification: window.

8. Open the EViews workfile named *Macro14.wf1* and follow the steps in the Performing Granger Causality tests section for *I* and *Y* (instead of *CO* and *YD*).

10. Open the EViews workfile named *Macro14.wf1* and follow the steps in the Testing for nonstationarity by calculating the auto correlation function ACF section.

11. Open the EViews workfile named *Macro14.wf1* and follow the steps in the Testing for nonstationarity with the Dickey-Fuller test section.

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[10] To use first differencing to rid a series of nonstationarity, simply enter *D(CO)* for the series in any EViews procedure. For example, entering *D(CO)* as the dependent variable in a least squares regression is the same as entering *CO-CO(-1)*.