FMBF: Computer lab 2

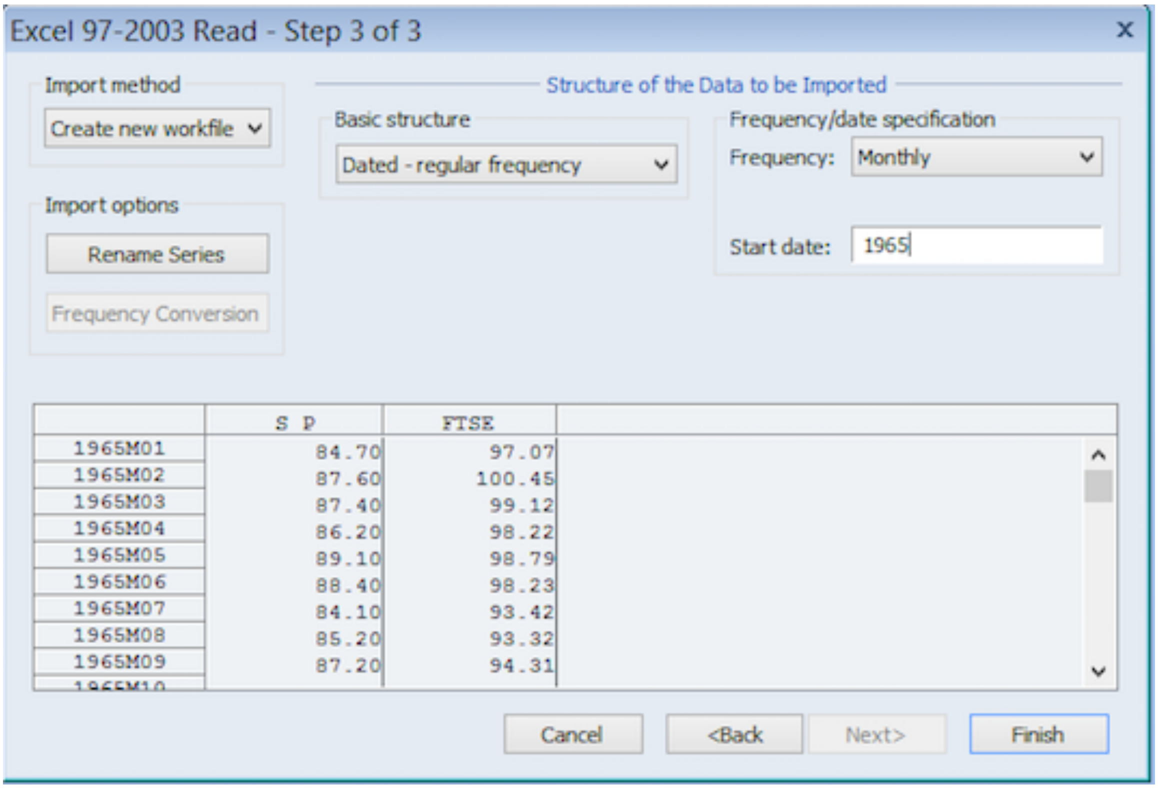
This session covers the topic of cointegration. Specifically, we will conduct cointegration analysis by using the Engle-Granger procedure and Johansen approach. Engle-Granger procedure is a residuals-based approach, while the Johansen technique is based on VARs.

Engle-Granger procedure

We will examine the cointegration between two stock price indexes – S&P 500 and FTSE All-Share.

Data Preparation

1. Download the data file 'FMBF Prac2.xls' from duo. The file contains monthly price index data on the S&P 500 and FTSE All Share from January 1965 to January 2004.
2. Open the data by EViews. In the first computer lab, we have explained how to open xls file by Eviews in detail. However, this data file does not include the time variable, we should manually change the structure of the data. Specifically, 'Basic structure' should be 'Dated – regular frequency'. 'Frequency' should be 'Monthly'. 'Start date' should be '1965'.



3. Generate the logarithms of the two time series. Quick > Generate Series

$$lnsp = \log{(s\_p)}$$

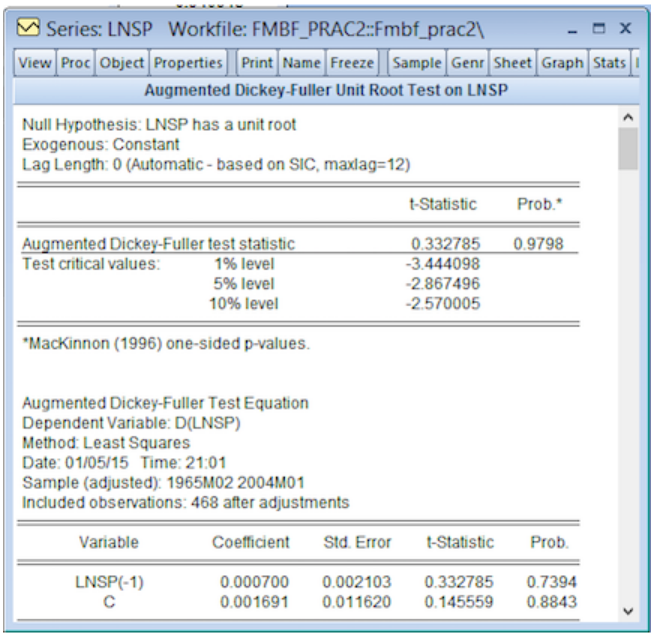
$$lnftse = \log{(ftse)}$$

Make sure that the two time series are I(1)

Most financial variables are I(1) series. To conduct the EG procedure, we should firstly check whether the two time series are I(1), by conducting unit root test.

1. Conduct unit root test for ‘lnsp’. Since unit root test has been explained in Computer lab 1, this session will not show it in detail.

   Following windows show the results for the unit root test for the level and first difference of the ‘lnsp’.



Series: LNSP Workfile: FMBF_PRAC2::Fmbf_prac2\

View | Proc | Object | Properties | Print | Name | Freeze | Sample | Genr | Sheet | Graph | Stats

Augmented Dickey-Fuller Unit Root Test on LNSP

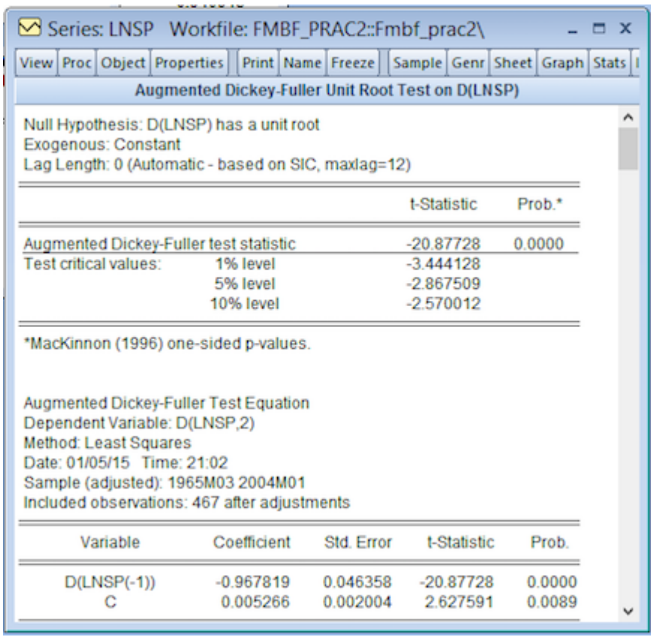
Null Hypothesis: LNSP has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.332785	0.9798
Test critical values:	1% level	-3.444098	
	5% level	-2.867496	
	10% level	-2.570005	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNSP)
Method: Least Squares
Date: 01/05/15 Time: 21:01
Sample (adjusted): 1965M02 2004M01
Included observations: 468 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNSP(-1)	0.000700	0.002103	0.332785	0.7394
C	0.001691	0.011620	0.145559	0.8843



Series: LNSP Workfile: FMBF_PRAC2::Fmbf_prac2\

View | Proc | Object | Properties | Print | Name | Freeze | Sample | Genr | Sheet | Graph | Stats

Augmented Dickey-Fuller Unit Root Test on D(LNSP)

Null Hypothesis: D(LNSP) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-20.87728	0.0000
Test critical values:	1% level	-3.444128	
	5% level	-2.867509	
	10% level	-2.570012	

*MacKinnon (1996) one-sided p-values.

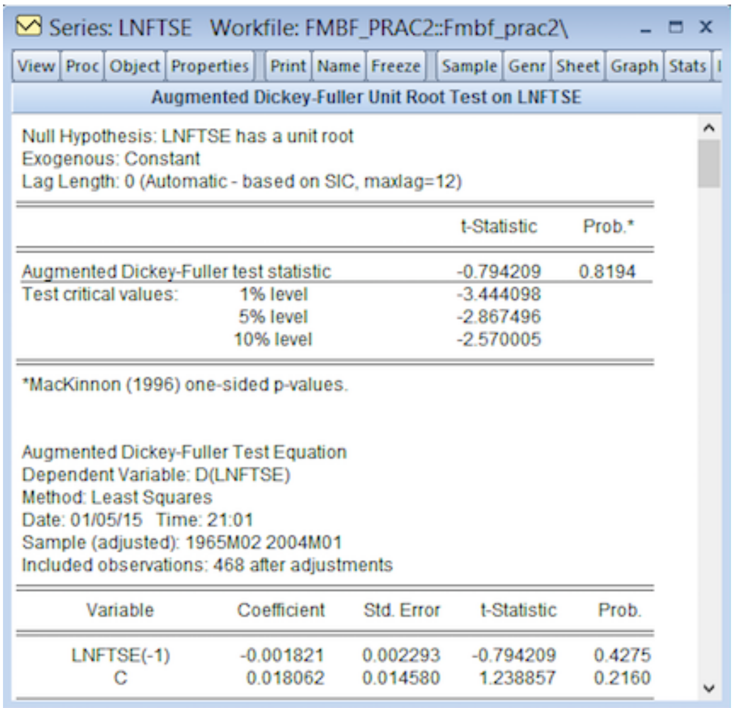
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNSP,2)
Method: Least Squares
Date: 01/05/15 Time: 21:02
Sample (adjusted): 1965M03 2004M01
Included observations: 467 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNSP(-1))	-0.967819	0.046358	-20.87728	0.0000
C	0.005266	0.002004	2.627591	0.0089

   LNSP is non-stationary, while D(LNSP) is stationary. The results suggest that the ‘lnsp’ is an I(1) variable.

2. Conduct unit root test for ‘lnftse’. Since unit root test has been explained in Computer lab 1, this session will not show it in detail.

   Following windows show the results for the unit root test for the level and first difference of the ‘lnftse’.



Series: LNFTSE Workfile: FMBF_PRAC2::Fmbf_prac2\

View Proc Object Properties Print Name Freeze Sample Genr Sheet Graph Stats

Augmented Dickey-Fuller Unit Root Test on LNFTSE

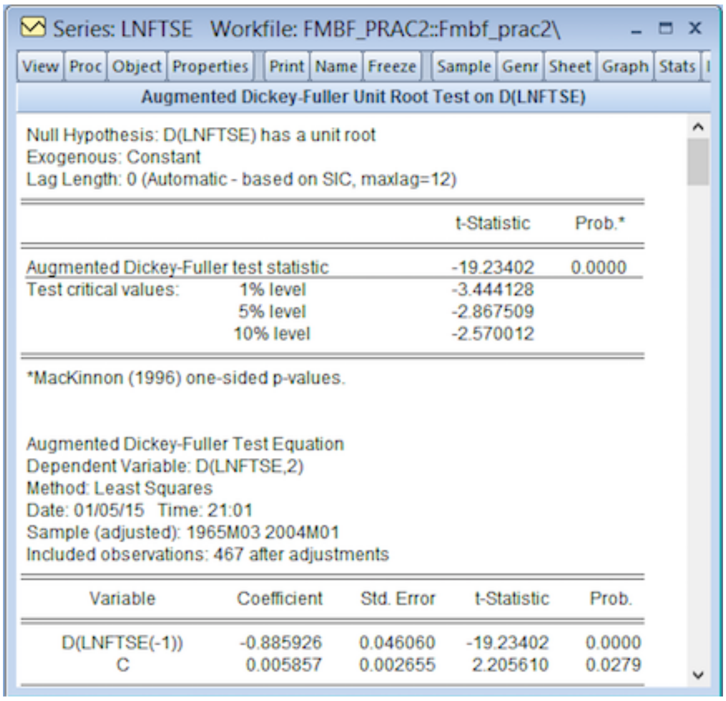
Null Hypothesis: LNFTSE has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.794209	0.8194
Test critical values:	1% level	-3.444098	
	5% level	-2.867496	
	10% level	-2.570005	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNFTSE)
Method: Least Squares
Date: 01/05/15 Time: 21:01
Sample (adjusted): 1965M02 2004M01
Included observations: 468 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNFTSE(-1)	-0.001821	0.002293	-0.794209	0.4275
C	0.018062	0.014580	1.238857	0.2160



Series: LNFTSE Workfile: FMBF_PRAC2::Fmbf_prac2\

View Proc Object Properties Print Name Freeze Sample Genr Sheet Graph Stats

Augmented Dickey-Fuller Unit Root Test on D(LNFTSE)

Null Hypothesis: D(LNFTSE) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-19.23402	0.0000
Test critical values:	1% level	-3.444128	
	5% level	-2.867509	
	10% level	-2.570012	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNFTSE,2)
Method: Least Squares
Date: 01/05/15 Time: 21:01
Sample (adjusted): 1965M03 2004M01
Included observations: 467 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNFTSE(-1))	-0.885926	0.046060	-19.23402	0.0000
C	0.005857	0.002655	2.205610	0.0279

   LNFTSE is non-stationary, while D(LNFTSE) is stationary. The results suggest that the ‘lnftse’ is an I(1) variable.

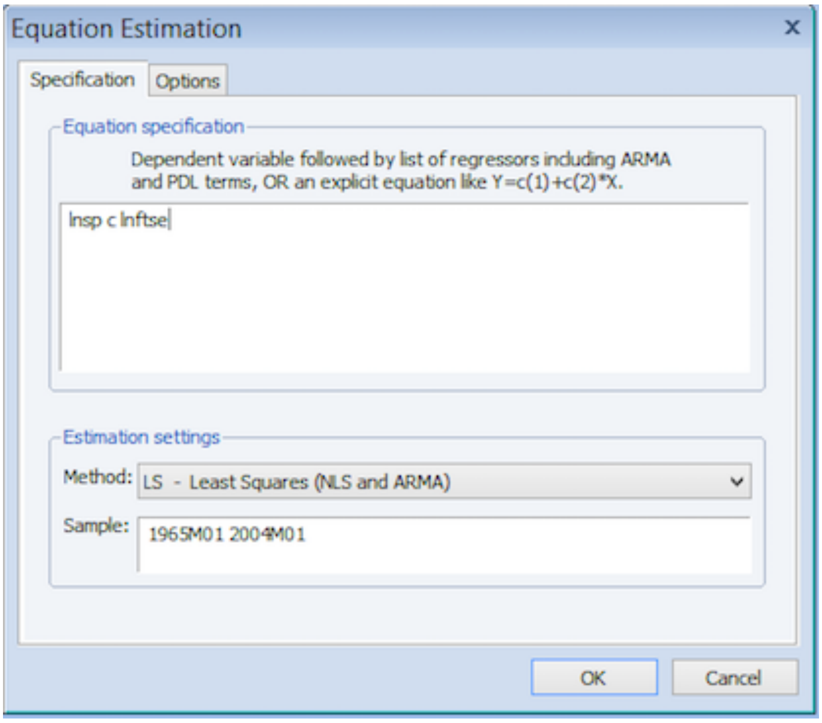
Overall, above results indicate that both the time series are I(1).

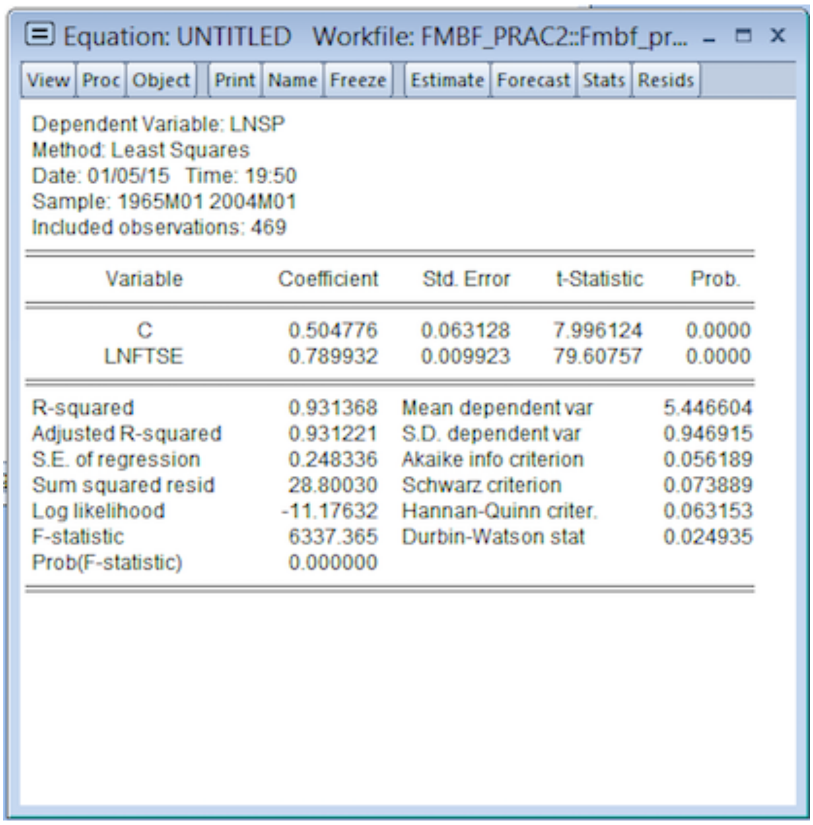
Generate the residuals of the cointegration regression and ensure the residuals are I(0)

1. Regress ‘lnsp’ on ‘lnftse’ and a constant using OLS.

   Quick > Estimate Equation

   In the Equation Estimation window, input ‘lnsp c lnftse’. ‘Method’ should be ‘LS – Least Squares (NLS and ARMA)’.





Dependent Variable: LNSP
Method: Least Squares
Date: 01/05/15 Time: 19:50
Sample: 1965M01 2004M01
Included observations: 469

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.504776	0.063128	7.996124	0.0000
LNFTSE	0.789932	0.009923	79.60757	0.0000

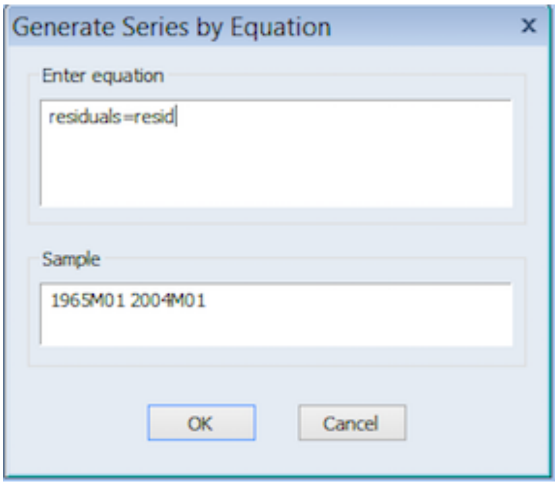
R-squared	0.931368	Mean dependent var	5.446604
Adjusted R-squared	0.931221	S.D. dependent var	0.946915
S.E. of regression	0.248336	Akaike info criterion	0.056189
Sum squared resid	28.80030	Schwarz criterion	0.073889
Log likelihood	-11.17632	Hannan-Quinn criter.	0.063153
F-statistic	6337.365	Durbin-Watson stat	0.024935
Prob(F-statistic)	0.000000		

2. Save the residuals by generating a new series that equals ‘resid’.

   Quick > Generate Series

   Input following equation:

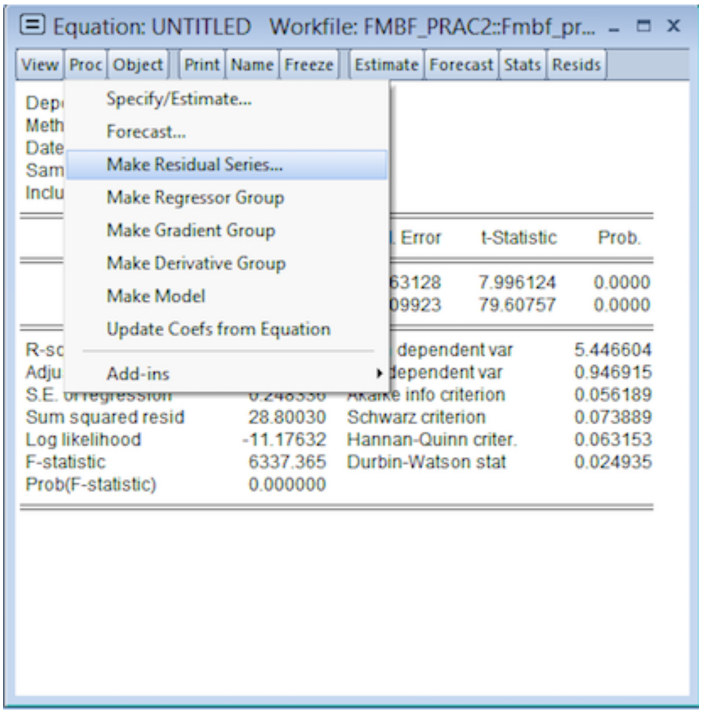
$$residuals = resid$$



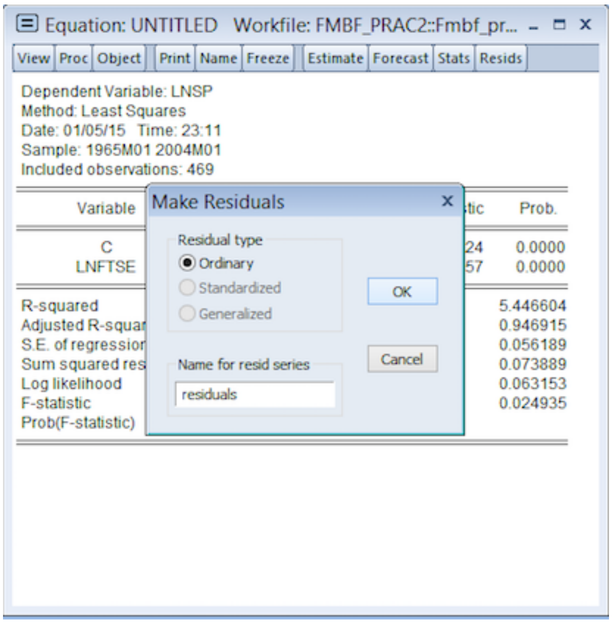
Note:

‘resid’ is an EViews series that gets filled up each time after you conduct a regression. It shows the residuals from the last estimation. If you want to further use the residuals (e.g. conduct ADF test for residuals), you should save them in a new series.

There is also another way to generate residuals. In the ‘Equation’ window, Proc > Make Residual Series



Then, in the ‘Name for resid series’ box, input ‘residuals’ as the variable name.

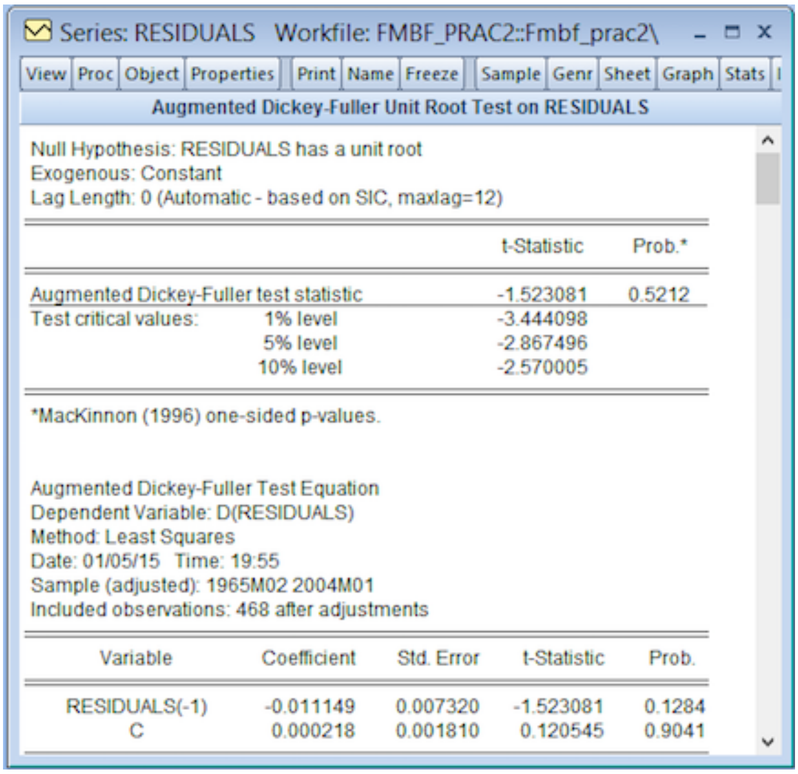


We will get same results.

3. Conduct unit root test for residuals to examine whether they are I(0).

Note:

The ADF test is performed but the Engle-Granger critical values should be applied. You should check the new critical value. The software here just shows the critical value for ADF test. The new critical values are larger than their Dickey-Fuller counterparts.



Above results suggest that the residuals are non-stationary.

Note:

If the two time series are cointegrated, the residuals should be stationary. However, in our case, residuals are non-stationary, indicating no cointegrating relation.

Construct ECM model

If appropriate (i.e. if the two series are cointegrated), build an ECM, by regressing d(lnsp) on a constant, d(lnftse) and the one-period lagged residuals that were previously saved. You can conduct the regression by inputting following codes in Equation Estimation window:

d(lnsp) c d(lnftse) residuals(-1)

or writing following codes in command window:

ls d(lnsp) c d(lnftse) residuals(-1)

In above codes, 'ls' refers to 'least square'. In other words, it will conduct OLS regression with dependent variable d(lnsp), and independent variables, including c, d(lnftse), and residuals(-1).

However, according to the unit root test of the residuals, since the residuals are not stationary, it is not appropriate to put the non-stationary residuals into the ECM. Therefore, we should estimate a model containing only first differences. We can write following codes in command window:

ls d(lnsp) c d(lnftse)

Johansen Approach

We will use Johansen technique to examine purchasing power parity (PPP) theory. The PPP theory can be described by following equation:

$$S_t = P_t/P_t^*$$

where S_t is the spot exchange rate (home currency price of a unit of foreign exchange), P_t is the price in the domestic country, and the P_t^* is the price in the foreign country.

Take the natural logarithm of both sides of above equation:

$$ln\ (S_t) = ln(P_t/P_t^*)$$

Finally, we get following equation

$$ln(S_t) = ln(P_t) - ln\ (P_t^*)$$

We can use Johansen approach to test above equation.

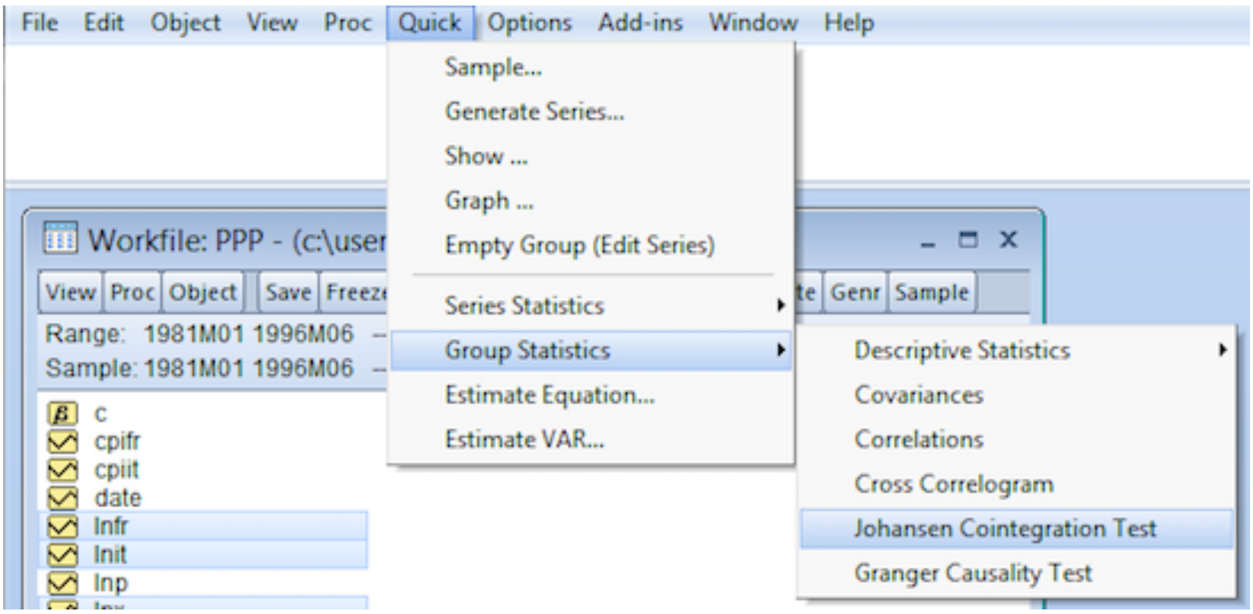
Please download the file ‘ppp.xls’ from DUO and use EViews to open it. The data contains monthly observations from January 1981 to June 1996 on price indices and exchange rates for France and Italy. The variables contained in the file are described as follows:

Variable	Description
lnit	log price index Italy
lnfr	log price index France
lnp	lnit-lnfr
lnx	log exchange rate France/Italy
cpiit	consumer price index Italy
cpifr	consumer price index France

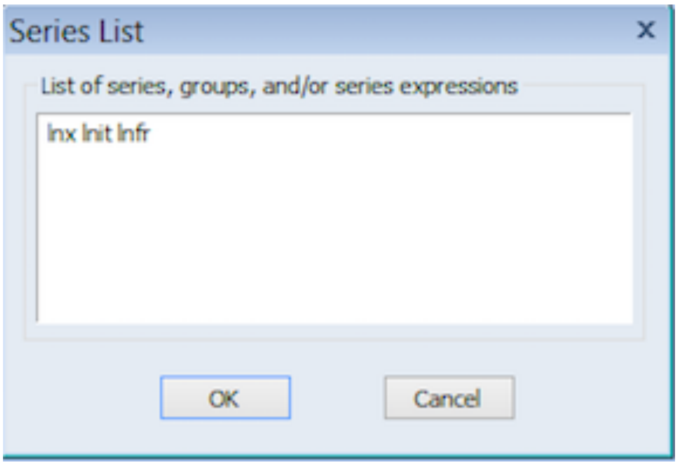
We will examine the relations between ‘lnx’, ‘lnit’ and ‘lnfr’.

Johansen Cointegration Test

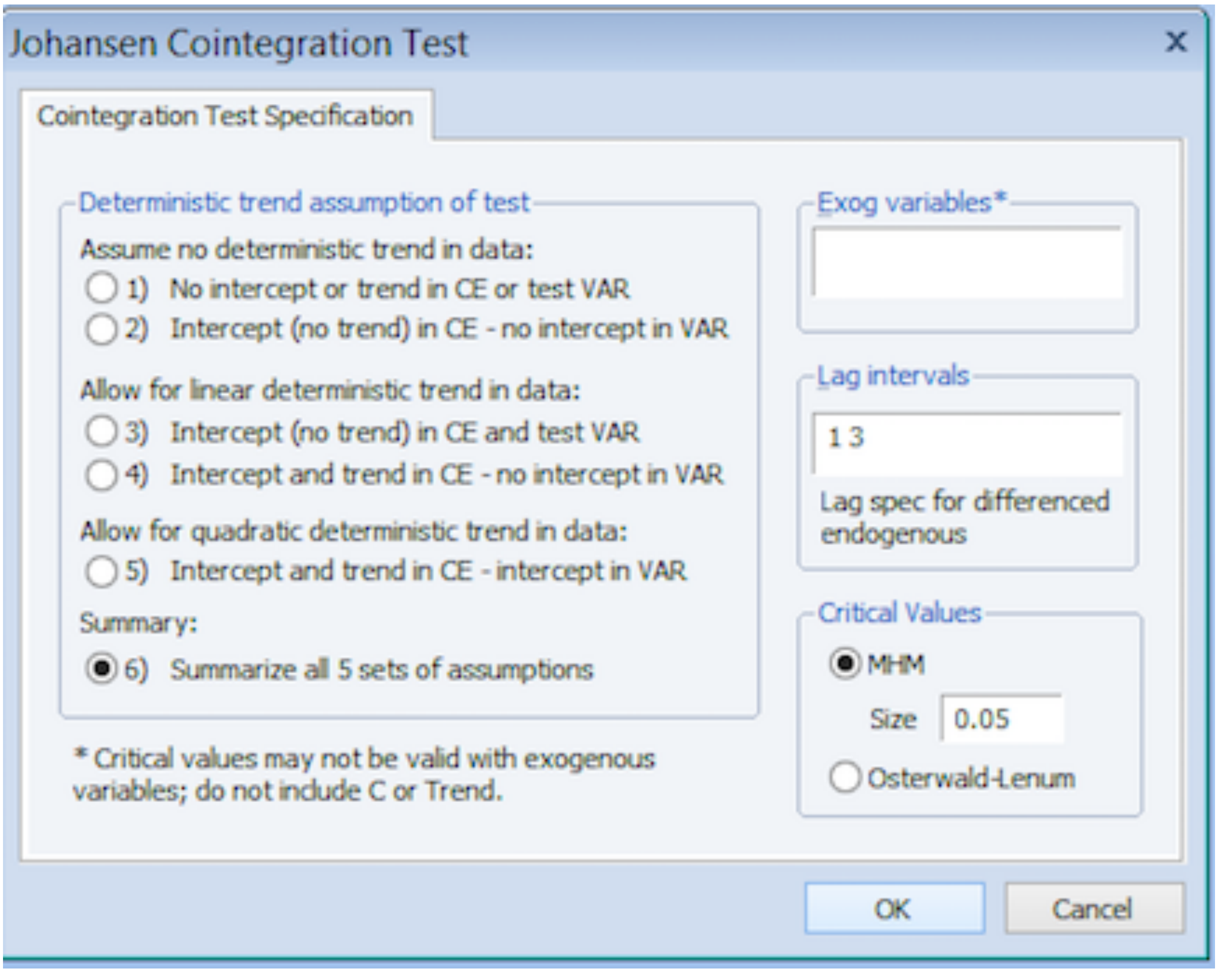
1. Select the three series ‘lnx’, ‘lnit’ and ‘lnfr’ and then click Quick > Group Statistics > Johansen Cointegration Test



Then, click on 'OK'

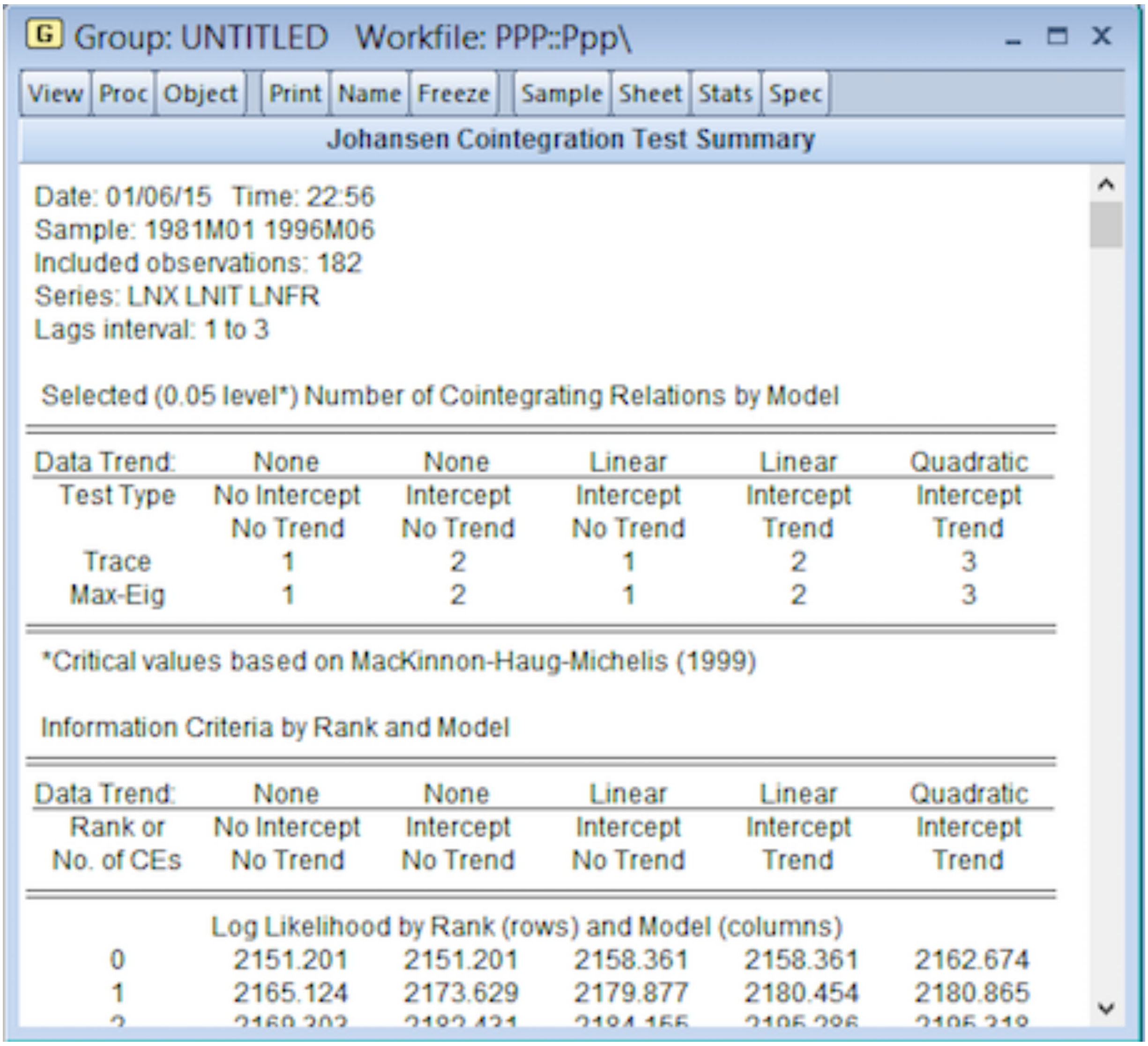


2. Choose '6) Summarize all 5 sets of assumptions', and input '1 3' in the 'Lag intervals' box.



The differences between models 1 to 5 focus on whether an intercept or a trend or both are included in the potentially cointegrating relationship and/or the VAR. We choose option 6 that summarize all 5 sets of assumptions to examine whether the results are sensitive to the type of specification used.

3. We get following results. The results show the number of cointegrating vectors based on trace statistics or max statistics. In our tests, trace statistics and max statistics lead to same results in all the specifications of VAR models. The first and third specifications suggest one cointegrating vector. The second and fourth specifications suggest two cointegrating vectors. Please pay attention on the fifth specification. We have three series. If the rank of the cointegrating matrix is three (i.e. full rank), all the series in the cointegrating space should be I(0).


Group: UNTITLED Workfile: PPP::Ppp\

View | Proc | Object | Print | Name | Freeze | Sample | Sheet | Stats | Spec

Johansen Cointegration Test Summary

Date: 01/06/15 Time: 22:56
Sample: 1981M01 1996M06
Included observations: 182
Series: LNX LNIT LNFR
Lags interval: 1 to 3

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	1	2	1	2	3
Max-Eig	1	2	1	2	3

*Critical values based on MacKinnon-Haug-Michelis (1999)

Information Criteria by Rank and Model

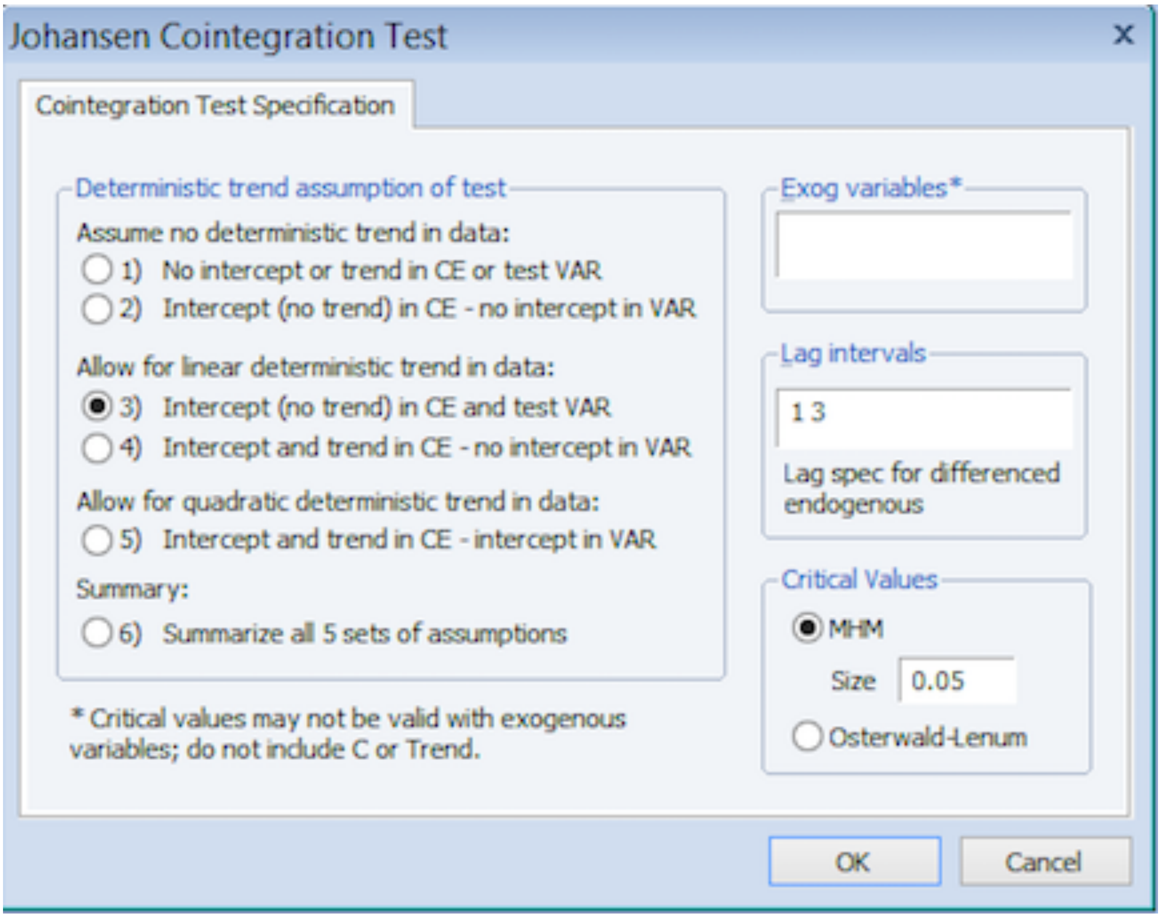
Data Trend:	None	None	Linear	Linear	Quadratic
Rank or No. of CEs	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
	Log Likelihood by Rank (rows) and Model (columns)				
0	2151.201	2151.201	2158.361	2158.361	2162.674
1	2165.124	2173.629	2179.877	2180.454	2180.865
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

We can use different lag intervals in the test. For example, we input ‘1 6’ in the ‘Lag intervals’ box. Try to do it, and find whether it will lead to different results.

For questions on how to decide the number of lagged terms to be used in the tests and how to choose the optimal specification, we have explained these kinds of issues in our first computer lab. Please check the note of our first computer lab.

Although we have inconclusive results on the number of cointegrating vectors, the results are in favor that the three series are cointegrated.

4. If we want to check more detailed information for particular test specification, we can just select one of the options rather than select the summary. For example, we select option ‘3) Intercept (no trend) in CE and test VAR’.



5. EViews generate a very large quantity of output. It shows the detailed information on trace test and max test. It also shows the cointegrating equations.

Group: UNTITLED Workfile: PPP::Ppp\

View | Proc | Object | Print | Name | Freeze | Sample | Sheet | Stats | Spec

Johansen Cointegration Test

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.210564	53.07868	29.79707	0.0000
At most 1	0.045930	10.04729	15.49471	0.2771
At most 2	0.008154	1.490050	3.841466	0.2222

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.210564	43.03138	21.13162	0.0000
At most 1	0.045930	8.557245	14.26460	0.3248
At most 2	0.008154	1.490050	3.841466	0.2222

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

LNX	LNIT	LNFR
7.400775	-54.20124	101.9697
-15.39709	57.19850	-83.44228
-6.329392	-13.72273	25.70504

Unrestricted Adjustment Coefficients (alpha):

D(LNX)	-0.002410	0.002096	0.001421
D(LNIT)	-0.000576	-0.000450	0.000106
D(LNFR)	-0.000881	9.16E-05	-3.48E-05

1 Cointegrating Equation(s): Log likelihood 2179.877

Normalized cointegrating coefficients (standard error in parentheses)

LNX	LNIT	LNFR
1.000000	-7.323725	13.77825
	(0.91587)	(1.72219)

Adjustment coefficients (standard error in parentheses)

D(LNX)	-0.017838
	(0.01081)
D(LNIT)	-0.004262
	(0.00150)
D(LNFR)	-0.006520
	(0.00102)

2 Cointegrating Equation(s): Log likelihood 2184.155

Normalized cointegrating coefficients (standard error in parentheses)

LNX	LNIT	LNFR
1.000000	0.000000	-3.185188
		(0.65140)
0.000000	1.000000	-2.316230
		(0.10832)

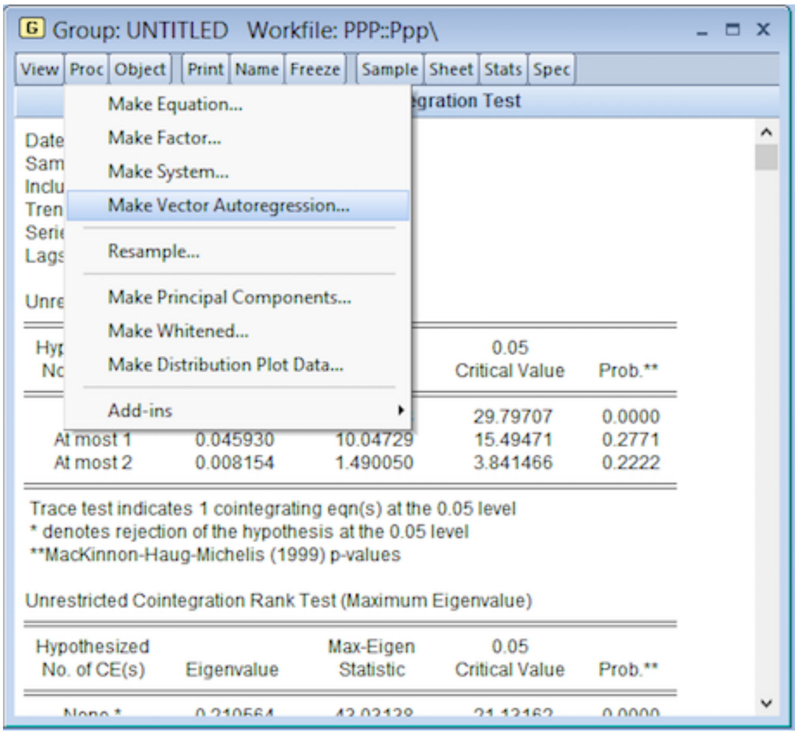
Adjustment coefficients (standard error in parentheses)

D(LNX)	-0.050117	0.250551
	(0.02481)	(0.11445)
D(LNIT)	0.002661	0.005493
	(0.00341)	(0.01574)
D(LNFR)	-0.007930	0.052987
	(0.00235)	(0.01083)

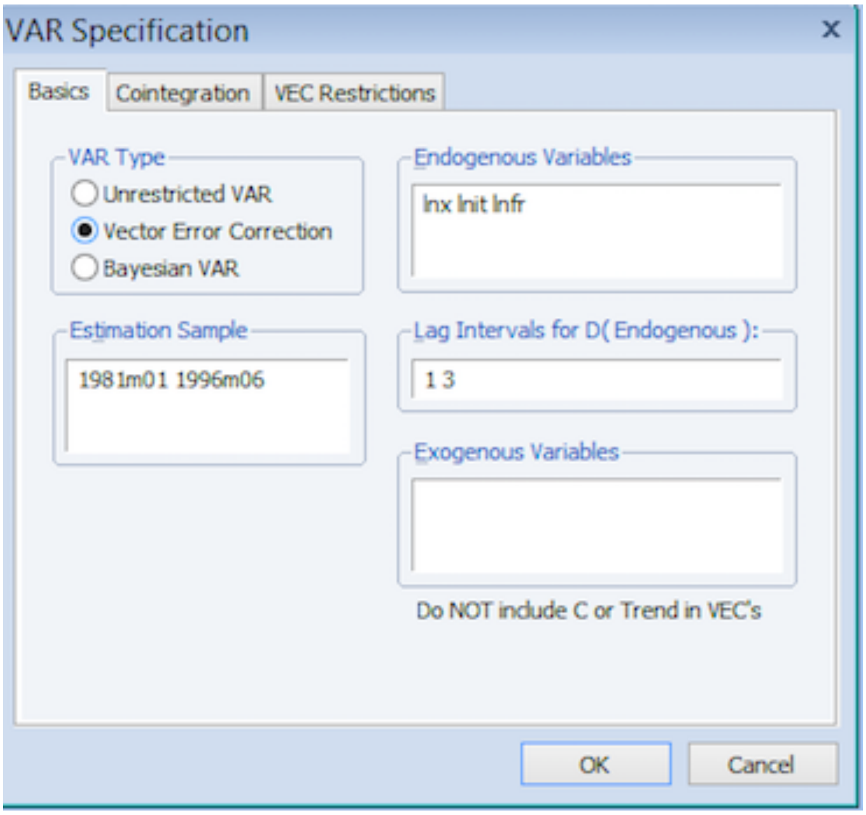
VECM specification for Johansen tests

To examine the entire VECM model, we should operate as follows.

1. In the 'Johansen Cointegration Test' window, click Proc > Make Vector Autoregression



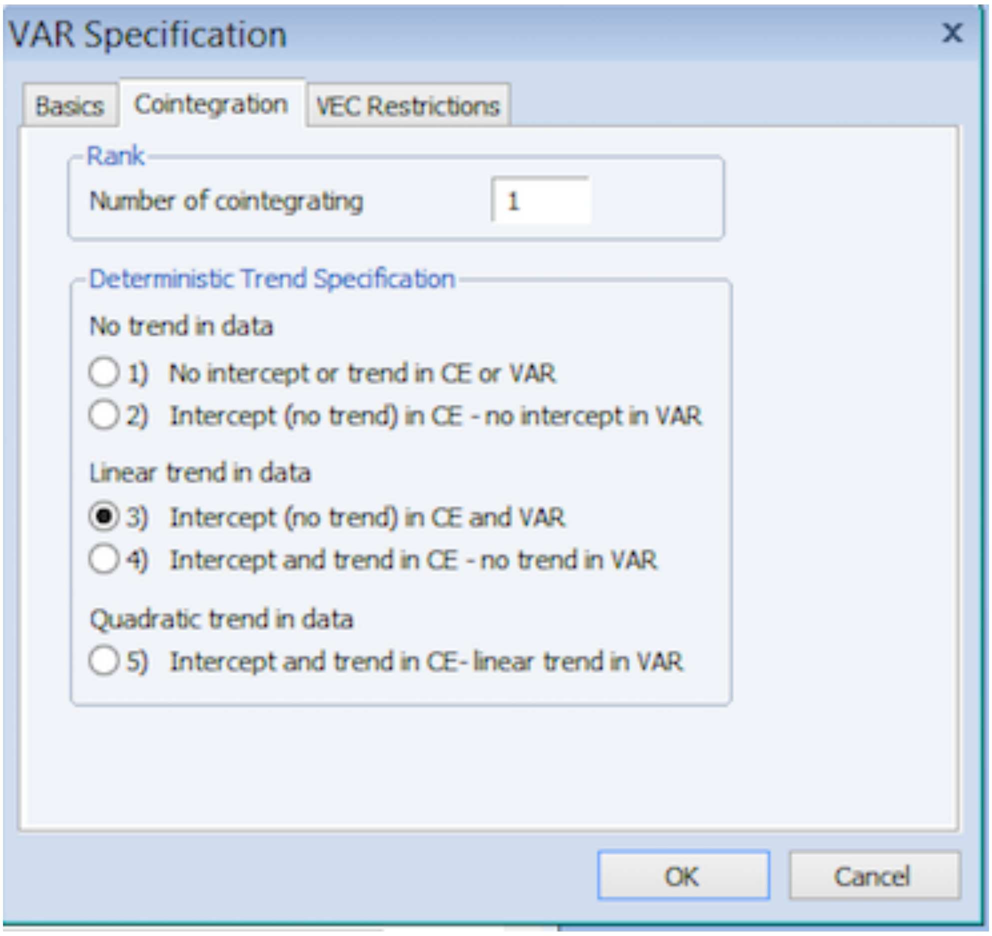
2. In 'Basics' tab, select 'Vector Error Correction' as 'VAR Type'. Input '1 3' in the 'Lag Intervals for D(Endogenous)' box.



3. Click ‘Cointegration’ tab.

   Input ‘1’ in the ‘Number of cointegrating’ box. In this case, we allow for only one cointegrating relationship.

   Select option ‘3) Intercept (no trend) in CE and VAR’. In other words, we construct a VECM model with constant (no trend) in cointegrating space and VAR.



4. Finally, we get following output. It shows the whole VECM model.

Var: UNTITLED Workfile: PPP::Ppp\

View | Proc | Object | Print | Name | Freeze | Estimate | Stats | Impulse | Resids

Vector Error Correction Estimates

Included observations: 182 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LNX(-1)	1.000000
LNIT(-1)	-7.323725 (0.91587) [-7.99650]
LNFR(-1)	13.77825 (1.72219) [8.00041]
C	-34.95677

Error Correction:	D(LNX)	D(LNIT)	D(LNFR)
CointEq1	-0.017838 (0.01081) [-1.64947]	-0.004262 (0.00150) [-2.84163]	-0.006520 (0.00102) [-6.39890]
D(LNX(-1))	0.025798 (0.07696) [0.33520]	-0.001177 (0.01067) [-0.11023]	0.005631 (0.00725) [0.77659]
D(LNX(-2))	-0.060404 (0.07525) [-0.80273]	0.008394 (0.01044) [0.80438]	0.011538 (0.00709) [1.62733]
D(LNX(-3))	0.090001 (0.07574) [1.18824]	0.001448 (0.01050) [0.13784]	-0.003868 (0.00714) [-0.54203]
D(LNIT(-1))	0.536944 (0.57352) [0.93622]	0.284263 (0.07954) [3.57395]	-0.132223 (0.05404) [-2.44691]
D(LNIT(-2))	-1.231853 (0.60718) [-2.02883]	-0.005679 (0.08420) [-0.06745]	0.085820 (0.05721) [1.50016]
D(LNIT(-3))	0.140394 (0.60207) [0.23318]	0.030498 (0.08350) [0.36526]	-0.051692 (0.05673) [-0.91125]
D(LNFR(-1))	-0.520290 (0.76037) [-0.68426]	0.211629 (0.10545) [2.00692]	0.357069 (0.07164) [4.98414]
D(LNFR(-2))	0.023461 (0.78766) [0.02979]	-0.141094 (0.10923) [-1.29166]	-0.213130 (0.07421) [-2.87190]
D(LNFR(-3))	-1.702787 (0.72512) [-2.34830]	0.067836 (0.10056) [0.67458]	0.117000 (0.06832) [1.71255]
C	0.013197 (0.00604) [2.18657]	0.003525 (0.00084) [4.21122]	0.003165 (0.00057) [5.56611]

R-squared	0.084431	0.527671	0.689828
Adj. R-squared	0.030889	0.500049	0.671689
Sum sq. resids	0.066450	0.001278	0.000590
S.E. equation	0.019713	0.002734	0.001857
F-statistic	1.576910	19.10356	38.03063
Log likelihood	462.0468	821.6012	891.9563
Akaike AIC	-4.956558	-8.907706	-9.680839
Schwarz SC	-4.762909	-8.714057	-9.487190
Mean dependent	0.001811	0.005890	0.003555
S.D. dependent	0.020025	0.003866	0.003241

Determinant resid covariance (dof adj.) 9.56E-15