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Financial Econometrics ECON3206/5206

Term 2 2020

Sample Answers/Hints to Tutorial 5

1. (Error correction and common trend)

The first VEC equation is directly obtained from the assumption that $\Delta x_t = \gamma \Delta x_{t-1} + \eta_t$ with $\alpha_1 = 0$, $\phi_{11} = \gamma$ and $u_{1t} = \eta_t$. The second VEC equation can be found from $y_t = \beta x_t + \varepsilon_t$

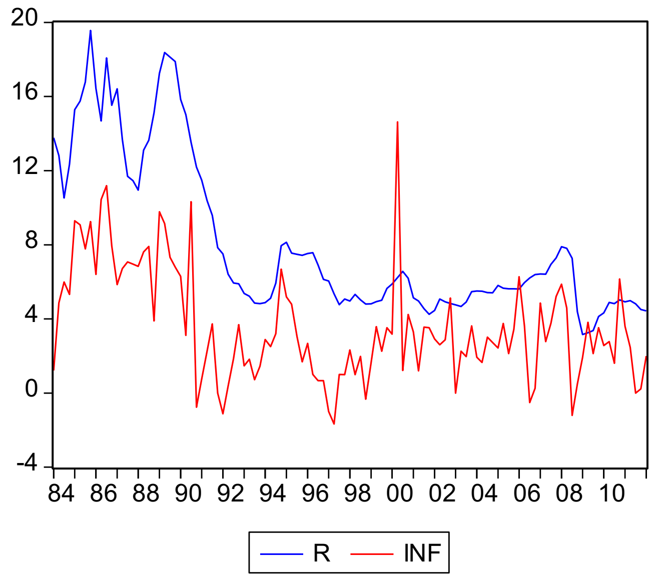
$$
\begin{aligned}
\Delta y_t &= y_t - y_{t-1} \\
&= -y_{t-1} + \beta x_t + \varepsilon_t \\
&= -(y_{t-1} - \beta x_{t-1}) + \beta x_t - \beta x_{t-1} + \varepsilon_t \\
&= -(y_{t-1} - \beta x_{t-1}) + \beta(\gamma \Delta x_{t-1} + \eta_t) + \varepsilon_t \\
&= -(y_{t-1} - \beta x_{t-1}) + \beta\gamma \Delta x_{t-1} + (\beta \eta_t + \varepsilon_t)\ .
\end{aligned}
$$

Comparing the last expression against the second VEC equation leads to $\alpha_2 = -1$, $\phi_{21} = \beta\gamma$, and $u_{2t} = \beta \eta_t + \varepsilon_t$. In this example, because x_t does not depend on the last period's cointegration error ($\alpha_1 = 0$) and the adjustment toward long-run equilibrium is entirely done by y_t ($\alpha_2 = -1$), x_t is the common trend that drives y_t moving along.

2. AR(p), MA(q) and ARMA(p,q) imply linear predictability. We learned that for financial return there is no linear predictability. Moreover, all these models have constant variance, while financial returns exhibit time-varying variance and volatility clustering. We will get to these exiting models very soon.

3. (Cointegration and error correction model)

(a) The time series plot of R and INF does visually suggest that they move together in the sample period: both were high in 80s and low in post 1990 period.



(b) The estimation results for $\mathrm{R}_t = \beta_0 + \beta_1 \mathrm{INF}_t + \varepsilon_t$ indicate that the residuals are strongly autocorrelated (tiny p-values for Q-stats in residual correlogram). The ADF unit-root test on resid01, using the Dickey-Fuller critical values (which are incorrect in this context; see part (c) below), strongly rejects the null hypothesis of a unit-root (p-value = .0007).

Dependent Variable: R
Method: Least Squares

Sample: 1984Q1 2012Q1
Included observations: 113

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.727418	0.485456	9.738090	0.0000
INF	0.918825	0.103577	8.870954	0.0000

R-squared	0.414847	Mean dependent var	8.037522
Adjusted R-squared	0.409575	S.D. dependent var	4.296092
S.E. of regression	3.301080	Akaike info criterion	5.243917
Sum squared resid	1209.581	Schwarz criterion	5.292189
Log likelihood	-294.2813	F-statistic	78.69382
Durbin-Watson stat	0.701208	Prob(F-statistic)	0.000000

Correlogram of Residuals

Sample: 1984Q1 2012Q1
Included observations: 113

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.622	0.622	44.834	0.000
		2	0.569	0.298	82.733	0.000
		3	0.531	0.175	116.05	0.000
		4	0.542	0.190	151.02	0.000
		5	0.498	0.070	180.85	0.000
		6	0.445	-0.002	204.92	0.000
		7	0.416	0.007	226.09	0.000
		8	0.362	-0.052	242.30	0.000
		9	0.308	-0.073	254.13	0.000
		10	0.281	-0.022	264.06	0.000
		11	0.235	-0.047	271.12	0.000
		12	0.246	0.060	278.94	0.000
		13	0.200	-0.009	284.14	0.000
		14	0.194	0.034	289.08	0.000
		15	0.176	0.026	293.17	0.000
		16	0.160	0.004	296.58	0.000

Augmented Dickey-Fuller Unit Root Test on RESID01

Null Hypothesis: RESID01 has a unit root
Exogenous: None
Lag Length: 1 (Automatic based on SIC, MAXLAG=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.459213	0.0007
Test critical values:	1% level	-2.585962	
	5% level	-1.943741	
	10% level	-1.614818	

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

(c) The Engle-Granger cointegration test is just the ADF on the residual from part (b) without intercept and time trend. However the critical values of the EG test differ from the Dickey-Fuller critical values because the test is performed on the residual from a regression involving I(1) time series. In fact, the 1%, 5%, 10% critical values for EG test involving two I(1) series are approximately -4.1, -3.4, -3.1 respectively. Hence the test result shows that we may reject the null hypothesis of a unit-root in residual (or spurious regression) at approximately 5% level. The reported p-value (0.0007) is under the Dickey-Fuller critical values and are invalid in this context.

(d) Given that β_1 is positive, if the cointegration error $\varepsilon_t = \mathrm{R}_t - \beta_0 - \beta_1 \mathrm{INF}_t$ is positive at t, R_{t+1} and INF_{t+1} should move toward eliminating the error. Hence R_{t+1} would likely move downward or INF_{t+1} would likely move upward.

(e) The estimation results, where E = resid01, suggest that many of the coefficients on the lags of DR and DINF are statistically insignificant. For the adjustment coefficients on E(-1), α_1 is only statistically significant at about 15% (p-value=0.1342) and α_2 is at about 30% (p-value=0.2994).

Dependent Variable: DR
Method: Least Squares

Sample (adjusted): 1984Q2 2012Q1
Included observations: 112 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.068242	0.094035	0.725707	0.4697
E(-1)	0.054172	0.035881	1.509753	0.1342
DR(-1)	0.095159	0.102556	0.927873	0.3557
DR(-2)	0.013995	0.092036	0.152059	0.8794
DR(-3)	0.217247	0.085789	2.532337	0.0129
DR(-4)	-0.075634	0.083956	-0.900872	0.3698
DINF(-1)	-0.029474	0.049132	-0.599890	0.5499
DINF(-2)	-0.044087	0.050898	-0.866183	0.3884
DINF(-3)	0.034231	0.049238	0.695219	0.4885
DINF(-4)	0.050601	0.039576	1.278605	0.2039

R-squared	0.181211	Mean dependent var	0.083214
Adjusted R-squared	0.108965	S.D. dependent var	1.047904
S.E. of regression	0.989165	Akaike info criterion	2.901135
Sum squared resid	99.80168	Schwarz criterion	3.143858
Log likelihood	-152.4635	F-statistic	2.508255
Durbin-Watson stat	2.007214	Prob(F-statistic)	0.012322

Dependent Variable: DINF
Method: Least Squares

Sample (adjusted): 1984Q2 2012Q1
Included observations: 112 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.042511	0.221627	0.191814	0.8483
E(-1)	0.088206	0.084566	1.043033	0.2994
DR(-1)	-0.949470	0.241710	-3.928138	0.0002
DR(-2)	-0.381278	0.216916	-1.757718	0.0818
DR(-3)	-0.021145	0.202192	-0.104581	0.9169
DR(-4)	0.015634	0.197871	0.079013	0.9372
DINF(-1)	-0.712485	0.115797	-6.152859	0.0000
DINF(-2)	-0.544431	0.119958	-4.538509	0.0000
DINF(-3)	-0.446453	0.116047	-3.847159	0.0002
DINF(-4)	-0.161552	0.093274	-1.732026	0.0863

R-squared	0.411134	Mean dependent var	0.006924
Adjusted R-squared	0.359175	S.D. dependent var	2.912268
S.E. of regression	2.331315	Akaike info criterion	4.615788
Sum squared resid	554.3731	Schwarz criterion	4.858511
Log likelihood	-248.4841	F-statistic	7.912690
Durbin-Watson stat	2.055841	Prob(F-statistic)	0.000000

Hence the assumed cointegration cannot be statistically justified at even 13.42% level because it is necessary to have the error correction mechanism in place for the cointegration to hold. However the model here may have been overly "large" and included too many irrelevant lags. Including too many irrelevant lags may have raised the variance (or standard errors) of the OLS estimators.

(f) As many of the coefficients on the lags of DR and DINF are statistically insignificant, the model size can indeed be reduced. For example, we can test the exclusion of the DINF lags from the first equation and the exclusion of DR(-3) and DR(-4) from the second equation. The Wald tests below confirm that the exclusions cannot be rejected (large p-values). See Tutorial 2 for EViews clicks for the Wald test (tips iii). From the new estimation results, indeed, the standard errors on the adjustment coefficients are smaller than those in part (e). The adjustment coefficient α_1 is now statistically significant at 5% (p-value=0.0231) whilst α_2 remains insignificant. An interpretation is that the interest rate makes adjustments according to the inflation and the latter acts as the common trend, which does not respond to the deviation from the long-run relationship.

Wald Test:
Equation: EQN4

Test Statistic	Value	df	Probability
F-statistic	1.311935	(4, 102)	0.2706
Chi-square	5.247740	4	0.2628

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(7)	-0.029474	0.049132
C(8)	-0.044087	0.050898
C(9)	0.034231	0.049238
C(10)	0.050601	0.039576

Wald Test:
Equation: EQN5

Test Statistic	Value	df	Probability
F-statistic	0.008300	(2, 102)	0.9917
Chi-square	0.016599	2	0.9917

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(5)	-0.021145	0.202192
C(6)	0.015634	0.197871

Dependent Variable: DR
Method: Least Squares

Sample (adjusted): 1984Q2 2012Q1
Included observations: 112 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.068053	0.094578	0.719543	0.4734
E(-1)	0.069750	0.030260	2.305005	0.0231
DR(-1)	0.107971	0.099253	1.087840	0.2791
DR(-2)	-0.021571	0.083630	-0.257930	0.7970
DR(-3)	0.226945	0.081229	2.793907	0.0062
DR(-4)	-0.084482	0.082638	-1.022311	0.3090

R-squared	0.139086	Mean dependent var	0.083214
Adjusted R-squared	0.098477	S.D. dependent var	1.047904
S.E. of regression	0.994970	Akaike info criterion	2.879875
Sum squared resid	104.9363	Schwarz criterion	3.025509
Log likelihood	-155.2730	F-statistic	3.424994
Durbin-Watson stat	2.000971	Prob(F-statistic)	0.006577

Dependent Variable: DINF
Method: Least Squares

Sample (adjusted): 1984Q2 2012Q1
Included observations: 112 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.042457	0.219071	0.193804	0.8467
E(-1)	0.088531	0.082615	1.071600	0.2864
DR(-1)	-0.943837	0.232946	-4.051751	0.0001
DR(-2)	-0.382355	0.211139	-1.810916	0.0730
DINF(-1)	-0.710166	0.111908	-6.345996	0.0000
DINF(-2)	-0.541910	0.112432	-4.819876	0.0000
DINF(-3)	-0.445855	0.110805	-4.023790	0.0001
DINF(-4)	-0.159725	0.089154	-1.791550	0.0761

R-squared	0.411038	Mean dependent var	0.006924
Adjusted R-squared	0.371396	S.D. dependent var	2.912268
S.E. of regression	2.308978	Akaike info criterion	4.580236
Sum squared resid	554.4634	Schwarz criterion	4.774415
Log likelihood	-248.4932	F-statistic	10.36883
Durbin-Watson stat	2.058307	Prob(F-statistic)	0.000000

4. While the specific results will be different due to random numbers, this is my output:

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	**0.452819**							
R Square	0.205045							
Adjusted R Square	0.204248							
Standard Error	6.467619							
Observations	1000							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	10767.78	10767.78	257.4169915	1.03657E-51			
Residual	998	41746.44	41.8301					
Total	999	52514.21						
	Coefficients	*Standard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	16.0075	0.220029	**72.75172**	0	15.57572369	16.43926929	15.57572369	16.43926929
X Variable 1	0.169708	0.010578	**16.04422**	1.03657E-51	0.148951156	0.190464572	0.148951156	0.190464572

The common theme will be that the coefficient estimates of the regression will be super significant. The R^2 is also relatively high. However, the regression does not make any sense (we regress two totally unrelated random walks) and we would expect coefficient estimates to be equal to zero. This is an example of spurious regression.

More cute examples of spurious regression:

http://www.eco.uc3m.es/~jgonzalo/teaching/timeseriesMA/examplesspuriousregression.pdf

*[Nice discussion and remedy "Is the Spurious Regression Problem Spurious?"
http://www.nber.org/papers/w15690.pdf]