Washington University Fall 2009
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Economics 518B

Homework #7
Testing for Cointegration
Due: Whenever

Part I
In this part of the assignment, you will test some long-run money/income relationships. To do this, you will need data from FRED (the St. Louis Fed's database at http://www.stls.frb.org/fred/index.html).

1. The first relationship is between real money balances and real GDP. You will need the following series:

   M1 Money Stock (1959:01)
   M2 Money Stock (1959:01)
   CPI (1959:01)
   Real GDP (1959:1)

   Make sure to use seasonally adjusted series. Convert the series to natural logarithms. Calculate real money balances using M1, M2, and the CPI.

   a. When testing for long-run relationships, frequency doesn't matter. Therefore, you should convert the real money aggregates to quarterly data (explain your method of conversion) to be consistent with real GDP. When you have converted the data, graph the series together.
   b. Then, run the appropriate ADF unit root tests on the three quarterly series. Remember to justify whether you include a constant and a trend in the test regression. Also, initially use four lags of quarterly data and the t=1.6 rule for lag inclusion.
   c. Assuming that you are unable to reject the null hypothesis of a unit root, you can move on to test whether the series are cointegrated. Monetarists might argue that velocity is at least stable over the long run—if not the short run. Therefore, you should use EViews to test whether log M1 velocity (e.g., v1≡y-m1, where y=ln(GDP) and m1=ln(M1/P)) has a unit root. Should you include a constant and/or a trend? Do the same test for M2 velocity. (Plot the velocity series.)
   d. What you have just done is actually a test for cointegration when the cointegrating vector (i.e., 1 –1) is suggested by economic theory. Now, run OLS regressions of log real money on log real GDP (should you include a constant and/or a trend in the regression). Is the regression coefficient on log real GDP anywhere close to one? Type "genr z=resid" and do unit root tests on z (should you include constants or trends?). Note that the critical values for this test are non-standard. Critical values for this Engle-Granger test of cointegration can be found in

Hamilton (see Hamilton's discussion of cointegration in ch. 19). What do you find? Repeat the exercise, but run log real GDP on log real money. What do you find?

2. M1 velocity does not appear to be particularly stationary. But, then again, interest rates do not appear to be stationary either. So, it may be that M1 velocity is a stable function of interest rates. Get the series "3-month t-bill, secondary market" and "1-year t-bill, secondary market" from the FRED website.

    a. Plot these series with M1 velocity (different scales).
    b. Do ADF unit root tests on the two interest rate series. What do you find?
    e. Run an OLS regression of the inverse of M1 velocity on the 1-year t-bill series and a time trend. What is the apparent interest elasticity of money demand? Type "genr z=resid" and do a unit root test on z, again using the Engle-Granger critical values found in Hamilton. This is a test for cointegration. What do you find?

3. Now that you have the interest rate series, and you found that you were unable to reject the unit root for them, you might want to see if the series are cointegrated. That is, test if the interest rate *spread* (i.e., cointegrating vector is known and is 1 –1) has a unit root. Plot the interest rate spread over time. Remember: when the cointegrating vector is known, you can use the standard Dickey-Fuller asymptotics for the unit root test. What do you find?

<u>Part II</u>

In the second part of this assignment, you will examine the question of whether forward and spot exchange rates are cointegrated. This is based on a paper by Eric Zivot.

Create a new EViews workfile. Choose monthly data for the period 1976:1 to 1996:6. Import the two EViews db files s.db and f.db (File/Import/Fetch from db…). Save the file as hw7.wf1. The two series are

s natural log of the US/UK spot exchange rate in month t;

f natural log of the US/UK forward exchange rate in month t for delivery in month t+1.

1. If forward and spot rates are to be cointegrated, they must be first be integrated. So, do the usual ADF unit root tests on the individual series.
2. Plot the series together. Do you think the series are cointegrated based on what you see? Why?
3. Calculate the forward premium (genr fp=f-s). Plot the forward premium. If forward and spot rates are cointegrated with CV=(1 –1)', then the forward premium should be I(0). Do an ADF unit root test on the forward premium to test for cointegration when the CV is known. Use the backward selection procedure from Homework #5 (start with at least 12 lags). Should you include a constant and/or a trend in the test regression? What does economic theory suggest?
4. Now assume y=(f s)' has a VAR(1) representation. Why might a VAR(1) model work well for this data? (Hint: what does it imply about the first differences under the null

of no cointegration?) What would the VECM look like given the assumption of CV=(1 –1)'? You can estimate the VECM by clicking on objects, selecting system, and typing

d(f)=c(1)+c(2)*fp(-1)
d(s)=c(3)+c(4)*fp(-1).

Then, to estimate the system of equations, click estimate and choose OLS (why can you use OLS to estimate this system of equations?). Print your output. Interpret the coefficients. Is the VECM stable? What is the implied AR(1) model for the forward premium?

5. Horvath and Watson propose a Wald test for cointegration based on the estimates for a VECM. To carry out the HW test, click view and select Wald Coefficient TEST and type "c(2)=c(4)=0". What are you testing and why is it a test of cointegration? What do you find? Note that the chi-squared critical values reported by EViews do not apply. The 1%, 5%, and 10% critical values from HW are 13.73, 10.18, and 8.30, respectively.
6. Thus far, you have examined the question of whether there is cointegration given a prespecified CV. The HW test is more powerful when the data are generated by a VAR process. Do your results reflect this? Now you should test for cointegration when the CV is estimated. First, do the Engle-Granger two-step procedure. That is, first regress f on s (ls f c s). Type "genr uhat=resid" and do a unit root test on uhat. Remember not to include a constant or a trend in this second stage regression. Also, remember to use the critical values given in Hamilton, Table B.9.
7. Now assume that y has a VAR(1) representation. Use the Johansen maximum eigenvalue test to determine the number of cointegrating vectors. Read through the EViews help on the cointegration to determine what assumptions to use about deterministic terms. Justify your choice. You can hedge by considering more than one choice. To do the test, highlight f and s and open them as a group. Click view and select cointegration test. Print the results. What do you find?
8. Having tested for cointegration when the CV is prespecified and when it is estimated, you should now estimate the CV and test the null that it is (1 –1)'. One way to do this is to employ Stock and Watson's dynamic OLS/GLS procedure. That is, type

   ls f(-2) c s(-2) d(s(-2)) d(s(-3)) d(s(-4)) d(s(-1)) d(s) ar(1).

   The AR(1) term for the errors is the classic Cochrane-Orcutt method for correcting for serial correlation. This should not materially affect your point estimates. But, it should make your standard errors consistent. Print output and use a simple *t*-test under the assumption of asymptotic normality to determine if the CV is significantly different than (1 –1)'.
9. Instead of using the Cochrane-Orcutt method, use the Newey-West consistent standard errors. That is, click estimate, remove the ar(1) term, click options, and check the heteroskedasticity consistent covariance box and the Newey-West option. Click OK twice and print the results. Is the CV is significantly different than (1 –1)'?