Washington University
Department of Economics

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Economics 518B

Homework #2
GDP and ARMA Models
Due: Tuesday 9/15

As with the first homework assignment, try to conserve paper in presenting the output. In particular, the graphs do not need to be large, although I should be able to see what the units of measurement are. (Note: when it says, "paste" below, it refers to pasting the figure to the file you will print up and hand in.)

1. Written Exercise

For an AR(1) with $\phi = 0.5$, calculate and plot the true ACF, PACF, and the IRF for j=0,1,...,5.. Do the same for an AR(2) with $\phi_1 = 1.25$ and $\phi_2 = -0.75$. See Hamilton p. 111 on solving PACF given ACF.

2. EViews Exercise

Save "gdpq.prn" from the class website. Open up EViews. Select New from the File menu, then select Workfile. Select Quarterly and enter the dates from "1954:1" to "2007:3". Select Import from the File menu, then select Read Text/Lotus/Excel. Find the gdpq.prn file and select. Click OK. A box will open that will allow you to name the series. Name it "gdpq". The series is U.S. quarterly real GDP from St. Louis Fed website. Once you've imported the data, save your workfile using the title "hw2.wf1".

a. Double click on the series and select View and Line Graph to examine it. Note that the series has a somewhat exponential shape to it. Also note that the variance of the series appears to grow somewhat as the time progresses. Paste graph and comment. Transform the series by typing "genr lgdpq = log(gdpq)". (Note: the log function in EViews corresponds to natural logs, usually denoted "ln", which is what you want to use rather than base 10 logs.) Examine lgdpq. The resulting series should look more linear and, to some extent, more like it has a stable variance. Paste graph and comment.
b. Click View and select Correlogram. Click Okay to Levels. Paste the output. What ARMA model(s) would you consider for lgdpq given this correlogram?
c. Select Estimate Equation from the Quick menu. Estimate the model you chose in part b. Paste. Is the estimated model stable? Do you think this is a good model of log real gdp? Why or why not? What is the R-squared statistic? Why is it so high?
d. Create the First Differences Series: In the field just below the menus, type "genr dlgdpq=d(lgdpq)" (note: if you just type without selecting the field, it will work the same). The d(*) function takes first differences of a series. Then, select dlgdpq and click view and select line graph. The linearity of lgdpq should imply that dlgdpq has a

fairly stable mean. Meanwhile, the log transformation should keep the variance of the series reasonably stable. Having said that, note that the variance of output has been lower since 1984. Paste and comment.

e. Click View and select Correlogram. Click Okay to Levels. Paste the output. What ARMA model(s) would you consider for dlgdpq given this correlogram?
f. Since it is not as clear as before what the appropriate model is, estimate all the possible ARMA(p,q) models for max(p)=2 and max(q)=2. (I.e., run ARMA models in EViews such as AR(1), MA(1), ARMA(1,1), ARMA(1,2), ARMA(2,2), etc...) To run, say, an ARMA(2,2) model type "dlgdpq c ar(1) ar(2) ma(1) ma(2)". Make sure the adjusted sample period is the same in each case by adjusting Sample in the Quick menu to 1955:1-2007:3. Don't worry about pasting the output for each model. But, record the AIC and BIC numbers for each case and report. What model fits best according to the two criteria? Paste output for best model(s). Click View/Residual Test/Correlogram and Paste. Comment on the output.
g. Create the Linearly Detrended Series: Makes sure sample is 1954:1-2007:3. Type "genr t=@trend" in the main field. Select t. The series should be a linear progression (0,1,2,3,...). Now, select Estimate Equation from the Quick menu. Type "lgdpq c t". Then click on resids. Then type "genr tlgdpq=resid". Select tlgdpq and click view and select line graph. Note that by construction detrended gdp has a zero mean. The variance looks large, but relatively stable over the sample. Paste and comment.
h. Click View and select Correlogram. Click Okay to Levels. Paste the output. What ARMA model(s) would you consider for tlgdpq given this correlogram?
i. Since it is again not entirely clear what the appropriate model is, estimate all the possible ARMA(p,q) models for max(p)=2 and max(q)=2. Again, adjust the sample to 1955:1-2007:3. Record the AIC and BIC numbers for each case. What model fits best according to the two criteria? Paste output for best model(s). Click View/Residual Test/Correlogram and Paste. Do the selected models pass the residual diagnostic. Comment on the output.
j. Estimate an AR(2) model for the time trend case by typing the following in Quick/Estimate Equation, "lgdpq c t ar(1) ar(2)", with sample period set to "1955:1 1969:4" in the sample field. Paste output. Click the Forecast button. In the Forecast name field type "lgdpqf1". In the Standard Error field type "sef1". In the sample range field type "1970:1 2007:3". Click Okay. Type "genr uf1=lgdpqf1+1.96*sef1" and "genr lf1=lgdpqf1-1.96*sef1" to get standard error bands. Select lgdpq, lgdpqf1, uf1, and lf1 (hold down the ctrl key to select multiple series). Click View/Open Selected One Window/Open Group. Click View again and select Graph/Line. You should have a picture with the series forecast for the time trend model (with 95% confidence bands) and the actual realized series. Paste graph. What do you notice? [NOTE: be very careful to follow directions about sample periods here!!!]
k. Again, setting the sample to "1955:1 1969:4", estimate an AR(2) model for the first differences case (i.e., an ARIMA(2,1,0) model for lgdpq) by typing "d(lgdpq) c ar(1) ar(2)". By typing the equation in this d(*) format, you will get forecasts for the level, rather than first differences. Paste output. Click the Forecast button. In the Forecast name field type "lgdpqf2". In the Standard Error field type "sef2". In the sample range field type "1970:1 2007:3". Click Okay. Type "genr uf2=lgdpqf2+1.96*sef2" and "genr lf2=lgdpqf2-1.96*sef2". Select and graph series as in part j. Paste graph.

What do you notice? Comment on the standard error bands for the two models of gdp. [NOTE: again, be very careful to follow directions about sample periods here!!!]

3. GAUSS Exercise

Use "hw2.prg" (given at end of document). This program uses GAUSS to check the stability of our estimates and calculate impulse response functions.

a. Take your EViews output for the ARIMA(2,1,0) model and enter the estimated values for phi1 and phi2 in hw2.prg. Run the program. Record your output and paste the graph for the cumulative IRF. Note that the IRF is calculated using Yule-Walker equation.
b. Take your EViews output for the time trend AR(2) model and enter the estimated values for phi1 and phi2. Also, change line 9 to "i_order=0". Run the program. Record output and paste the graph for the IRF. Compare with part a. Note that n=40 means that you have the reaction of the series to a shock over a ten-year period (quarterly data).
c. Select phi1 and phi2 such that they lie *within* the complex region of the diagram in chapter 1 of Hamilton. Note and enter your values and run the program. Record output as before. What do you notice about your results compared to part b.? Try different values until you get very periodic behaviour.

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/* PROGRAM TESTS STABILITY OF AR(2) AND COMPUTES IRFs

PROGRAM DESIGNED BY JAMES MORLEY 10/2/04 */

@INITIAL GAUSS STUFF@
new;
format /m1 /rd 9,6;

i_order=1; @=0 for trend stationary and =1 for difference stationary@

phi1=?; @type in your estimate here, instead of ?@
phi2=?; @type in your estimate here, instead of ?@

@Set up companion matrix@

F =   phi1~phi2|
      1~0;

@Check eigenvalues for stability@
eF=eig(f); @eigenvalues of companion matrix@
"";
"eigenvalues of F=";;eF';
meF=abs(eF); @modulus of eigenvalues@
"";
"modulus of eigenvalues of F=";;meF';

@Check roots of characteristic equation for stability@
cphiz=-phi2|-phi1|1;
rphiz=polyroot(cphiz);
"";
"roots of phi(z)=";;rphiz';
mrphiz=abs(rphiz);
"";
"modulus of roots of phi(z)=";;mrphiz';

@Calculate IRF@
n=40; @number of multipliers@
irf=zeros(n,1); @initialize vector of IRFs@
cirf=zeros(n,1); @initialize vector of cumulative IRFs@
irf[1]=1; @normalize first element to one@
irf[2]=phi1*irf[1] + phi2* 0;
cirf[1]=1; @normalize first element to one@
cirf[2]=cirf[1]+irf[2];

j=3;
do until j>n;
irf[j] = phi1*irf[j-1] + phi2*irf[j-2];
cirf[j] = cirf[j-1]+irf[j];
j=j+1;
endo;

output file=hw2.dta reset;

if i_order==0; @print IRF for trend stationary estimates@
output on;
irf~zeros(n,1); @write the series and unconditional mean to a text file
for use in EViews or Excel@
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output off;
endif;

if i_order==1; @print cumulative IRF for difference stationary
estimates@
output on;
cirf~zeros(n,1); @write the series and unconditional mean to a text
file for use in EViews or Excel@
output off;
endif;

end;
```