# <u>ASSIGNMENT 10</u>. LAGGED CORRELATION

1. Run geosa10.m, selecting a nominal output and input series for analysis. The two series can be from any of the three data structures. Typically the output is a response variable and the input the variable eliciting the response.

   Choose either no transformation or log-10 transformation for the input series. This choice is unimportant for the exercise.

   Set a period for analysis. For the class assignment, make this period no longer than 100 observations. By default, the entire overlap of the two series is used. You may need to enter another start and end time for the analysis.

   In the interactive window, adjust the specifications of lag window and confidence interval.

   You should end up with seven Figure windows.

2. (Caption to Fig. 1) Time series plots. Point out some feature of the time series plot that might be evidence of lagged response of input to output and explain.

3. (Caption to Fig 2) Lagged scatterplot (y lagging u). Do these scatterplots suggest any lagged dependence of output on input? Refer to the annotated statistics as well as the shape of the cloud of points.

4. (Caption to Figs 4 and 5—see note below on how to put these into a single text box in MS word). Autocovariance functions and cross-covariance functions, Fig 4 (top)=original data. Fig 5 (bottom) = prewhitened input and output. Describe how and why the plotted acvfs of the input in figures 4 and 5 differ. From Figure 4, what is the variance of the output? What are the units of that variance?

5. (Caption to Figs 6 and 7). Do the ccf in Fig 6 and the IRF in Fig 7 suggest any lag in the relationship between input and output. Is the IRF in Fig 7 consistent with a causal system? Is your conclusion on lagged relationships from these "systems" oriented plots

different from you conclusion on lagged relationships from the plot (Fig 5) in which the two time series were regarded on an equal footing (non-systems approach)?

NOTE : combining multiple Matlab figures in one MS Word text box

Assume two Matlab figure windows, Figure 4 and Figure 5, and that you want to combine these in a single MS Word text box that we will label as Fig4-5. Follow these steps:

1. In Matlab, use Insert/textbox from the figure-window menu to put the label "Fig 4" somewhere on Figure 4. You can right click on that text and get a menu for changing the font size, etc. Be sure to use "pin to axes" tool so that text will stay in same relative position to axes if you reshape the figure window later.
2. In Matlab, do the same to put "Fig 5" somewhere on Figure 5.
3. In Word, insert a blank text box on a page
4. In Matlab, use Edit/CopyFigure and then paste in Word to put Figure 4 in the MS Word text box. Do likewise for Figure 5, placing it below Figure 5 in the Word text box
5. If necessary, drag the MS Word text box handles and resize the figures in Word by tugging on their corners.
6. Right click on Fig 5 (the lower figure) in the MS Word text box to bring up the "Caption" dialog. Enter a caption, using "Fig4-5" as the figure number.

**Running goesa10.m**

1. >geosa10
2. Message box: message introducing geosa10.m; click OK to remove message and move on
3. Respond to input dialog with the name of your data file; click OK
4. Menu: select data set the "y" series (nominal output from system) is to be selected from. The series will usually come from the V1 or V2 data. A message box will come up informing you of your selection and that next you will pick the data set for the input series. Click OK to remove the message box.
5. Menu: select data set the "u" series (nominal input to system) is to be selected from. The data set may be same as that for the "y" series, or may be different.
6. Menu: choose the output series, y, by clicking on it (a leading "Y" appears), then click "satisfied"
7. Menu: choose the input series, u, then "satisfied".
8. Menu: choose whether not to log10 transform the input series; note that you do not get an option to transform the input series
9. Edit dialog: enter an analysis period. For the assignment, make this no longer than 100 observations. (The default is the full length of overlap in the two series.) Click OK. If you have specified a period longer than 100 observations, a message box will tell you that and a question box will appear asking if you want to abort the operation.

Figure windows 1-6 are now produced on the screen; ignore them for now .

10. Edit dialog: enter start and end lags to be used in regression-based estimation of the the impulse response function. The defaults should be fine. Click OK.
11. Menu: click on desired significance level for confidence interval on the IRF. Use 99% because the 99% confidence band is used in other figures.

    Figure window 7, with the plotted IRF and its confidence interval now appears

12. Menu: Choose either to set or change the specifications for the IRF analysis or to accept the IRF as computed. This menu allows you to try different settings for the lag-window of the IRF and different alpha levels for the confidence band. You will be repeatedly prompted for the information in steps 10 and 11, and will see the resulting IRF. When finally satisfied with the IRF, select “Accept IRF results and move on”
13. Message box : “Finished” and some additional information on editing, exporting and printing the figures appears. Click OK to remove the message box and end the program. The final 7 figure windows are:

Fig 1. Time series plots, as z-scores, of the input and output series
Fig 2. Lagged scatterplots of output at time t on input a times t, t-1, t-2 and t-3
Fig 3. Lagged scatterplots of output at time t on input at times t, t+1, t+2, and t+3
Fig 4. A three-part figure with plots for an ccf analysis run using function **cra** and <u>no</u> prewhitening or filtering of the input and output series. UL (upper left) is the acvf of the output. UR is the acvf of the input. LL is the ccf between input and output at lags -10 to 10. Positive lags are for output lagging the input. The plotted ccf scaled differently is identical to the impulse response function of output to input. A 99% confidence interval approximately equal to ±3 standard deviations of the ccf is included.
Fig 5. A three-part figure with plots for an ccf analysis run using function **cra** on the prewhitening input and output series. For this analysis, AR(10) models were fit separately to the input and the output. Each series was then prewhitened with its respective AR model. The acvf’s and ccf were computed on these prewhitened series. UL is the acvf of the prewhitened output. UR is the acvf of the prewhitened input. LL is the ccf between the prewhitened input and output.
Fig 5. A three-part figure with plots for an ccf analysis run using function **cra** on the prewhitening input and <u>filtered</u> output series. For this analysis, an AR(10) model was fit to the input. That model was used to prewhiten the input, and also was applied to filter the output. This is a “systems approach”. UL is the acvf of the prewhitened output. UR is the acvf of the filtered input. LL is the ccf between the prewhitened input and filtered output.
Fig 7. Plot of the IRF (impulse response function) estimated using Matlab function **impulse.** The IRF is essentially a re-scaled ccf, and can be compared with the ccf’s in Figures 4-6 as alternative ways of looking a the lagged relationship between two time series. In this estimate of the IRF,
-the input was first prewhitened with a $10^{th}$ order AR model
-the output was filtered with the same model (up to here, same as in figure 6)
-the filtered output was regressed on the prewhitened input
-how many predictors (lags on input) in the regression are specified by you
-the confidence interval is based on standard errors of the regression coefficients

-IRF estimates outside the confidence bands indicate “significant” relationship at that lag

**PROGRAMMING NOTES**

Selected user-written Matlab functions called:
**lagscat2.m** lagged scatterplots for a pair of time series, with annotated correlation coefficient and confidence interval adjusted for loss of degrees of freedom due to autocorrelation

Selected Matlab functions called :
**cra** impulse response function by correlation analysis
**impulse** impulse response function by linear least squares