

X-12-Graph: Visual Diagnostics for Time Series Modeling and Seasonal Adjustment

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KEYWORDS

Graphs, Time series, SAS/GRAPH®, GPLOT procedure, SAS/AF®, Screen Control Language, SAS Macros

ABSTRACT

X-12-Graph is a program developed at the Census Bureau to provide graphical diagnostics for the Bureau's X-12-ARIMA program, a publicly-available program used worldwide for time series modeling and seasonal adjustment. Our goal in creating X-12-Graph was to provide specific types of time series graphs in a package that would be easy for everyone to use.

X-12-Graph is programmed with the SAS® System and comes in two versions — interactive and batch. Neither version requires previous SAS experience from the user.

X-12-Graph allows the user to

- ▶ select from 12 types of graphs;
- ▶ compare different X-12-ARIMA adjustments;
- ▶ choose options for the graphs, such as starting and ending dates, scale, and colors, and;
- ▶ assemble a combination graph from previously produced graphs.

The paper begins with an introduction discussing seasonal adjustment in general, batch versus interactive processing, the X-12-ARIMA program, and the general organization of X-12-Graph. I will then give a few examples of the graphs you can produce with X-12-Graph and the SAS code used for these graphs. I will also give some examples of the additional features that make the program easy to use.

X-12-Graph is available by anonymous FTP from the Census Bureau's site. User's Guides for the various versions are also available to download. For details on how to download the program and the User's Guides, please see the Appendix. You will find detailed instructions for installation and use of the program in the User's Guides (Hood, 1998a and 1998b).

INTRODUCTION

Seasonal Adjustment and X-12-ARIMA

The basic goal of seasonal adjustment is to decompose a time series into a seasonal component, a trend, and the residual or irregular component. X-12-ARIMA uses an iterative procedure to estimate the seasonal component and the trend with several types of moving averages. There are two basic decompositions: additive and multiplicative.

This paper reports the general results of research undertaken by Census Bureau staff. It has undergone a more limited review than official Census Bureau publications. This report is released to inform interested parties of research and to encourage discussion.

The additive decomposition is appropriate when the size of the seasonal movements is independent of the level of the series. The series decomposes into a sum of trend, seasonal, and irregular. The values of the estimated seasonal component are called seasonal factors. Factors for the additive decomposition are centered about zero.

Often for economic time series, the size of the seasonal oscillations increases as the level of the series increases. For these series, if the series has only positive values, a multiplicative decomposition is usually appropriate. Under a multiplicative decomposition, the seasonally-adjusted series is obtained by dividing the original series by the estimated seasonal component. Seasonal factors for the multiplicative decomposition are centered about one.

For more information on seasonal adjustment and X-12-ARIMA, see Findley, Monsell, Bell, Otto, and Chen (1998).

Graphs are an important part of seasonal adjustment diagnostics. Graphs help you see changes in the seasonal pattern, outliers, and changes in the level of the series. Other graphs can help you look at the behavior of the seasonal factors, the relationship between the different estimated components, the smoothness of the seasonally-adjusted series or trend, and the sizes of the revisions in the seasonally-adjusted series or trend over time.

Batch Versus Interactive Processing

Seasonal adjustment procedures fall into two basic groups: doing a routine seasonal adjustment procedure on hundreds or even thousands of series, or doing a detailed analysis of just a few series. For a general analysis of hundreds of series, we developed a batch version of X-12-Graph. To assist with the detailed analysis of a single time series, we developed X-12-Graph Interactive. The interactive version has more kinds of graphs and more options for the available graphs.

At the heart of both versions is the GPLOT and GREPLAY procedures in SAS/GRAPH®, templates, and annotate data sets. The batch program uses SAS Macros and can send selected graphs for any number of series directly to a printer. The interactive program uses SAS/AF® and Screen Control Language (SCL).

We developed batch and interactive programs for both PC and UNIX platforms since we support X-12-ARIMA on both platforms.

Interface from X-12-ARIMA to X-12-Graph

X-12-Graph uses output from X-12-ARIMA. So before you can run X-12-Graph, you must run X-12-ARIMA in graphics mode. When you run X-12-ARIMA in graphics mode, it creates files that correspond to the X-12-ARIMA options you choose. For more information on running X-12-ARIMA in graphics mode, see the X-12-ARIMA Reference Manual (U.S. Bureau of the Census, 1998).

X-12-ARIMA in graphics mode outputs a graphics metafile, identified by the extension .gmt. The metafile contains a list of all the graphics output files produced during the X-12-ARIMA run. The files listed in the .gmt file are identified only by a code; for example, "ori" stands for "Original Series." X-12-Graph uses a SAS data set called "namelist" that contains all the codes and the names of the associated elements so X-12-Graph can match the codes to the longer name.

X-12-ARIMA also creates a diagnostics file, identified by the extension .xdg. Besides information on some of the diagnostics, this file contains information on the title used for the series, the type of adjustment (multiplicative or additive), and the sampling frequency of the series (monthly or quarterly).

X-12-Graph Layout

X-12-ARIMA graphics output files are read into SAS and then merged into one file. Dates are stored as numbers, with January 1980 stored as 1980.0, February 1980 stored as 1980.083, March 1980 stored as 1980.167, etc. The information from the diagnostics file, such as the title and frequency, is stored in a separate data set.

X-12-Graph uses SAS/GRAPH and PROC GLOT to create the graphs and stores them in the catalog "plots" in the work directory. Options to save the graphs to other catalogs in other directories are discussed later in this paper.

TIME SERIES GRAPHS

Providing specific time series graphs is one way to help people who are using X-12-ARIMA for seasonal adjustment but are not familiar with the SAS System. There were several useful time series graphs in the literature that we wanted to program into X-12-Graph. So far, we have 12 different types of graphs available. Although space does not permit details for every type of graph, examples of all the graphs and instructions for producing them in X-12-Graph are available in the User's Guide.

I have selected four types of graphs as examples of the kind of graphs available in X-12-Graph. These graphs illustrate some of the challenges I faced getting all the needed information into the graphs.

Overlay Graphs

Overlay graphs allow you to select from one to three different graphical elements to plot above a single axis. Examples of the kind of elements in an overlay graph are the original series, the trend, and the seasonally-adjusted series. Overlay graphs are useful for getting a good general feel for the series and the seasonal adjustment.

A list box with each available graphical element is on the screen. Each item name you select is appended to a variable list for the plot statement. The full name of the item selected is added to a variable for the title statement. The example below is from the interactive version of the program written in SCL. The batch version contains similar statements.

In the code below, "graid" is the id number of the data set that populates the list box. This data set contains the SAS variable name and the full name of all the available graphical elements.

```

/** Read in the graphical elements          **/
/** chosen from the list box.              **/
numlist = getiteml(listbox1,2) ;
itemnum=listlen(numlist) ;
do i=1 to itemnum ;
    item = getitemn(numlist,i) ;
    rc = fetchobs(graid,item) ;
    abrv=getvarc(graid,varnum(graid,'gname')) ;
    grlab[i] = getvarc(graid,varnum(graid,'grlabel')) ;

/** Append the variable name to the list for the **/
/** plot statement.                            **/
    ovlylist = ovlylist || ' ' || abrv || 't' ;
end ;

/** Create the text for the title statement.    **/
if itemnum=1 then t1 = grlab1 ;
if itemnum=2 then t1 = grlab1 || ' and ' || grlab2 ;
if itemnum=3 then
    t1 = grlab1 || ' , ' || grlab2 || ' , and ' || grlab3 ;

```

Since the symbol statements are already in place, the order of selection determines not only the order of the names in the title, but also the symbol used to plot each element.

The SAS/GRAPH code that produces the plot is below.

```

proc gplot data=temp gout=plots ;
    plot &ovlylist / overlay
        haxis=axis1 vaxis=axis2 href=(&hreflist)
        lhref=35 frame ;
run ;
quit ;

```

X-12-Graph checks to see if level shifts have been calculated for the series. If there are level shifts, then X-12-Graph creates an annotate data set to draw a vertical line at the date of the level shift. Level shifts are marked when you choose to graph the trend or the outlier-adjusted original series.

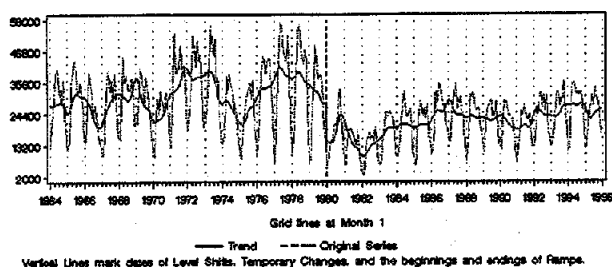
```

data annols (drop = lschk) ;
    retain xsys '2' ysys '2' ;
    set &seaname (keep=t lschk) ;
    where lschk='t' ;
    function='move' ;
        x=t ; y=&graphmin ; output ;
    function='draw' ;
        x=t ; y=&graphmax ; line=20 ;
        color="&outcolor" ; output ;
run ;

```

Figure 1 on the following page shows a graph with a vertical line marking the level shift in the trend in January, 1980.

Figure 1. Overlay Plot Showing a Level Shift
Trend and Original Series

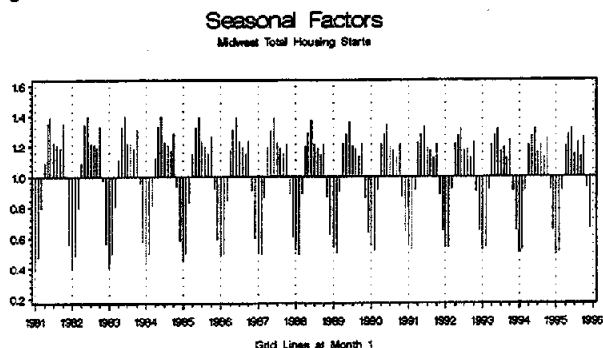


Component Graphs

For the factors, we wanted to show each month's (or quarter's) factors individually. We wanted a plot similar to the plot you get when you use the INTERPOL=needle option in the symbol statement. However, this works only if you want the horizontal line at zero. For multiplicative seasonal adjustment, the factors are centered at one. So I set up the data sets like the example below. Then I can use the INTERPOL=join option and get the plot I want.

```
data temp ;
  set &sename (keep = t &abrv) ;
  series = 1 ; output ;
  series = &abrv ; output ;
  series = 1 ; output ;
run;
```

Figure 2. Seasonal Factor Plot for a Multiplicative Adjustment



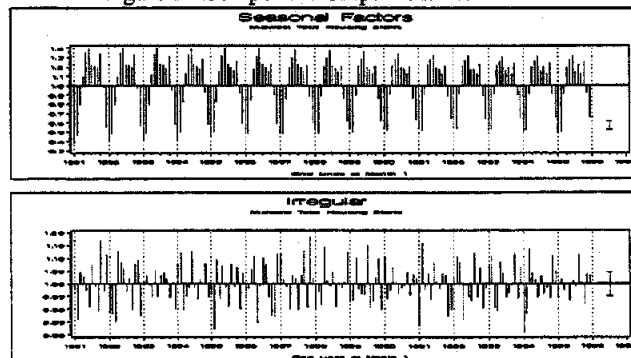
Most of the time, you will want graphs of more than one type of factor at a time. For example, you may want to graph the seasonal factors, the irregular, the trend, and the original series on the same screen or same page. You can select up to four different seasonal decomposition components to plot. The program graphs each component individually on a graphics output screen. If you choose more than one, the program shows all the components in reduced size on one screen. This is done using PROC GREPLAY with a TEMPLATE statement.

The example code for four elements on one screen is below. The names of the individual component plots are cmp1, cmp2, cmp3, and cmp4.

```
proc greplay igout=plots gout=plots
  tc=x12gappl.templt nofs ;
  template L2R2S ;
  treplay 1:'cmp1' 2:'cmp3'
  3:'cmp2' 4:'cmp4' ;
run;
quit;
```

To compare more than one factor, you want them to be on the same scale. However, sometimes it is difficult to see one of the factors because it is much smaller in magnitude than the other. You may want to choose the option to plot the factors on different scales. To compare the structure and size of the factors on different scales, we added "scaler bars" on the right side of the graph. The bars are drawn using annotate data sets.

Figure 3. Component Graph with Scaler Bars

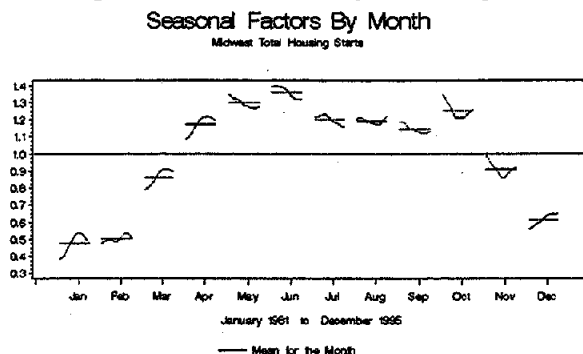


Seasonal Factors by Month or Quarter

Another useful graph is the Seasonal Factor by Month graph, developed by Cleveland and Terpenning (1982). This graph allows you to see the seasonal pattern clearly. It also gives you a picture of the size of the adjustments and the stability of the seasonal factors.

X-12-Graph creates a temporary data set to group the factors by month. The program calculates the mean for every month or quarter and uses an annotate data set to draw the mean for every calendar period.

Figure 4. Seasonal Factors by Month Graph



Percent Change in the Trend Graphs

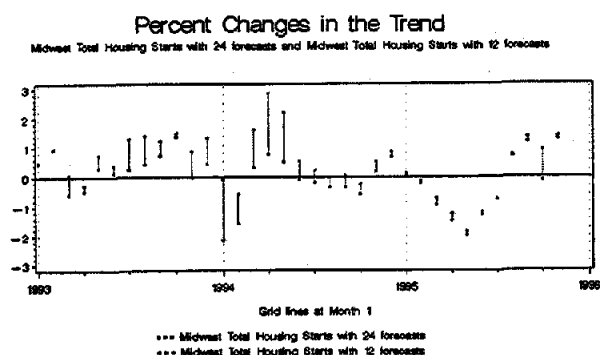
Looking at the smoothness of the trend or the seasonally-adjusted series is a useful way to compare two competing adjustments of the same series. You can look at the smoothness by looking at percent changes from the previous period in the trend or percent changes in the seasonally-adjusted series.

It is useful to see the original percent changes for both adjustments as well as the difference between the adjustments. For example, suppose the difference in the percent changes is 2%. If the percent change of the first adjustment is 3% and that of the second is 1%, then an improvement of 2% is good. But if the percent change for the two adjustments is 20% and 18%, then a 2% difference is not a dramatic improvement.

To see both the percent changes of the two adjustments and also which adjustment has the smallest percent changes, I developed a graph that superimposes the percent change from both adjustments onto a single graph. The differences between the two adjustments are marked by vertical lines. The color of the line is the same as the color of the adjustment whose percent change is closer to zero.

```
data annotemp ;
  retain xsys '2' ysys '2' ;
  set lagall ;
  length color $ 8 ;
  function='move' ;
  x=t ; y=series ; output ;
  function='draw' ;
  x=t ; y = zseries ; line=1 ; size=&lwid ;
  if (abs(series) < abs(zseries)) then
    color="&color1" ;
  else color="&color2" ;
  output ;
run ;
```

Figure 5. Percent Changes of the Trend for Two Adjustments of the Same Series



ADDITIONAL FEATURES

To help our users further, I added some additional features. Most of these features apply only to the interactive version.

Program Control

Using SAS/AF to set up list boxes of available graphs and of components within the specific graph is another big help to the novice SAS user.

For the interactive version, X-12-Graph has a main menu that drives the rest of the program. From the main menu, you can call the menu screens for the various types of graphs, or you can call menus that help with supporting tasks, like saving files or graphs, changing colors for the graphs, or inputting files for another series.

Frames for a specific kind of graph have a menu with a list of the available graphical elements. The frame also has text entry fields that correspond to other options, such as setting the axes and the vertical grid lines. Each menu frame also has links to help frames.

Most frames have a list box which is populated with a SAS data set. This allows us to present options that are relevant to that particular time series and the options chosen in X-12-ARIMA. For example, if a series has outliers, then an option to look at the original series adjusted for outliers is added to the list of available graphs. If you asked for the history diagnostic in X-12-ARIMA, then the option for history graphs appears on the main menu.

For the batch version, I set up two files that control most of the output of the program. This setup allows users with very little SAS experience to edit the files in any text editor without having to use SAS. I tried to keep the number of macro variables that you need to change to a minimum. All the macro variables that you can change are at the top of the program.

File maintenance

Since X-12-ARIMA file names can be longer than eight characters, each series is assigned a new name with an abbreviation and a number to conform to the SAS limitation of eight characters. To keep track of the names of the X-12-Graph data sets, the program creates an index data set that lists all the series it has read into SAS. The index file lists the name of the original X-12-ARIMA series, the new name with the abbreviation and number, the title from X-12-ARIMA, and the date and time the data set was created.

Both the batch and interactive version of X-12-Graph create data sets and indexes with the same file layout and the same convention for abbreviations. This setup allows you to run a large number of series with the batch program and then look at graphs of selected series with the interactive version without having to read the graphics output files a second time.

To accommodate users who don't know SAS, I set up menu items that allow users to search through the index file and choose the SAS data sets for a specific series. With the program's file maintenance options, you can copy the chosen data set to another directory or delete the data set.

Help screens

For the interactive version, besides having everything menu driven, I provide help screens for each menu screen, both general help for that particular type of graph and specific help for the options on the screen.

To see general help for that screen, click on the title of the screen. Each title has a hotspot with links to a help frame.

To see help for a specific option, click on the blue text associated with the option. I set up protected text entry fields with blue text for the initial value and linked this screen variable to a help frame.

For frames that produce graphs, if you selected an item in a list box and then clicked on an item to see the help, the SCL program to produce the graph would run. Consequently, the graph you wanted help with was produced before you saw the help screen and could change the options. To work around this problem, when you click on a link to a help screen, the program clears the list box of selections.

In the example below, the screen variable is named "datelab1." I initialized the variable with the text "date." When the user clicks on the word "date," the program calls the screen "dates.help."

```
datelab1:
  call display('x12graph\app\help.dates.help');
  call notify('LISTBOX1','UNSELECT_ALL');
return;
```

Text Entry

To minimize typing with the interactive version, I also set up an option so that you don't have to know the available .gmt files. When you check the box for a list of files, a list box appears that contains the output from a DOS "dir" command.

```
data _null_;
  file 'c:\x12graph\app\rundir.bat';
  put "dir &dirname".gmt /b
    > c:\x12graph\app\gmtlist.txt /
    "exit";
run;

X "c:\x12graph\app\rundir";

data gmttext;
  infile 'c:\x12graph\app\gmtlist.txt' pad;
  length filename $ 64;
  input filename $;
run;
```

Every text entry field has error checks that generate meaningful messages. The checks and messages also make the program easier to use.

Customizing the Available Graphs

For the interactive version, I have many options to help you customize the graphs. In the X-12-Graph User's Guide, I encourage our users to use the Graphics Editor available with SAS to add text to the graphs, if desired. I have also included some options that change the graphs themselves:

- ▶ Set both axes
- ▶ Mark specific months or quarters with vertical grid lines
- ▶ Take the log
- ▶ Change colors, lines, labels, and footnotes

Set Both Axes

For most types of graphs, you can set the starting and ending dates on the screen. For some graphs, you can set the limits for the vertical axis. This is helpful when you want to compare different adjustments and need the scale to be the same on different graphs.

Mark Specific Months or Quarters with Vertical Grid Lines

By default, vertical grid lines are marked at each January (or Quarter 1 for quarterly series). To help identify a problem month or an interesting month, or to help identify level shifts and outliers, you can mark a different month or quarter with vertical grid lines.

The variable "gridmon" is on the screen. A do-loop from the first year to the last year generates the list for the vertical reference lines. This list is input to the plot statement as a variable for the HREF= option.

Take the Log

For several different types of graphs, you can graph the log where appropriate. This is useful when you are doing a multiplicative adjustment. For some types of graphs, you can choose the log option from the list box. For other types of graphs, such as overlay, the entire graph would be on the log scale, so there is a text entry box for whether or not to graph on the log scale.

Change colors, lines, labels, and footnotes

The menu item called "Graphics Options" on the main menu lets you change the colors, the lines, and whether or not labels and footnotes are printed.

Options for Graphs Already Created

Another set of features is found under the menu choice "Output Options." This menu allows you to work with the graphs you have already produced. You can

- ▶ view existing graphs (landscape or portrait)
- ▶ save existing graphs
- ▶ delete existing graphs
- ▶ assemble a new graph from existing graphs (landscape or portrait)

These options use the CATLIST command in SCL to produce a list box of all the entries in that particular catalog.

You can view the graphs in the X-12-Graph default catalog ("work.plots"), or view any graphs you have saved to other catalogs in other directories.

The ability to save and delete graphs from any catalog is another option useful to people not familiar with the SAS System. Saving graphs from the default catalog allows you to keep them in a permanent directory and use them again in future X-12-Graph sessions. X-12-Graph asks you for a directory name and then assigns it a library name. Assigning library names automatically is another useful tool for the user who is not familiar with the SAS convention for library names.

Assembling graphs from existing graphs is useful if you want to produce a set of graphs on the same screen or same sheet of paper. For example, you can produce a screen containing an overlay graph and a component graph. You can choose up to four graphs and then PROC GREPLAY uses the template option to put them all on one screen.

CONCLUSION

With the SAS System, we have been able to develop a set of very useful programs for graphical seasonal adjustment diagnostics. X-12-Graph is easy to use and has a wide range of options for different types of graphs and options for those graphs.

ACKNOWLEDGMENTS

Brian Monsell wrote the basic SAS code for reading in the X-12-ARIMA files and for several of the graphs included in the program. David Findley and Brian Monsell provided valuable suggestions for the design of the graphs, the layout of the program, and the documentation. Thanks also go to Kathleen McDonald for her help in testing and design. Many thanks to everyone who gave us suggestions.

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APPENDIX

X-12-Graph is available by anonymous FTP from the Census Bureau's site (<ftp.census.gov>). All X-12-Graph distribution files contain the User's Guide in both PostScript and Adobe PDF format. You will find detailed instructions for installation and use of the program in the User's Guide.

All versions require Final X-12-ARIMA Version 0.1 or later. X-12-Graph Interactive requires SAS Version 6.11 or later.

The names and locations of the distribution files are listed below. They can be downloaded with an FTP client or WWW browser.

X-12-Graph for IBM® Compatible PCs

In your internet browser, go to
<http://www.census.gov/pub/ts/x12a/final/pc>

Available files:

x12gintr.exe: A compressed self-extracting file containing eight files needed to install and run X-12-Graph Interactive: `initx12g.sas`, `main.sc2`, `help.sc2`, `templt.sc2`, `namelist.sd2`, `indx.sd2`, `x12gpc.ps`, and `x12gpc.pdf`. The last two files contain the User's Guide, which includes instructions for installation.

x12gbat.exe: A compressed self-extracting file containing six files needed to install and run X-12-Graph Batch: `x12gmac.sas`, `templt.sc2`, `namelist.sd2`, `indx.sd2`, `x12gbat.ps`, and `x12gbat.pdf`. The last two files contain the User's Guide, which includes instructions for installation.

how2down: Instructions for downloading Final X-12-ARIMA

X-12-Graph for UNIX Workstations

In your internet browser, go to
<http://www.census.gov/pub/ts/x12a/final/unix>

Available files:

x12gintr.tar.Z: A compressed tar file containing eight files needed to install and run X-12-Graph Interactive: `initx12g.sas`, `main.sct01`, `help.sct01`, `templt.sct01`, `namelist.ssd01`, `indx.ssd01`, `x12gunix.ps`, and `x12gunix.pdf`.

x12gbat.tar.Z: A compressed self-extracting file containing six files needed to install and run X-12-Graph Batch: `x12gmac.sas`, `templt.sct01`, `namelist.ssd01`, `indx.ssd01`, `x12gbat.ps`, and `x12gbat.pdf`.

how2down: Instructions for downloading Final X-12-ARIMA

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For more information on X-12-Graph, please contact Catherine Hood by email at chood@census.gov or by telephone at (301) 457-4985.