EVAL: An Application of SAS/ASSIST® Software to Forecast Evaluation

Philip E. Friend and Linda P. Atkinson
Economic Research Service, USDA

Abstract

SAS/ASSIST® software, currently distributed with base SAS® software of the SAS System for personal computers, gives applications developers a platform from which to use SAS/AF® software to build systems for end users. This example demonstrates such a system. SAS/ASSIST is used as a user-friendly front end for a forecast evaluation system. Full-screen menus guide a user into developing a processing request without needing to have a knowledge of SAS syntax. Help screens and automatic validation techniques provide assistance as the user pulls data in from SAS data sets, DOS files, or keyboard entry, and then chooses from groups of forecast evaluation statistics, including descriptive measures such as mean square error, Theil forecast error statistics, forecast revision ratios, and directional accuracy tables.

1. Introduction

Analysts at USDA's Economic Research Service are frequently called upon to compare and evaluate alternate sets of forecasts, such as predicted scenarios concerning agricultural production, prices, and so on. The EVAL Forecast Evaluation System was developed at researchers' requests for a comprehensive, easy to use package for evaluating price forecasts. Such a system was developed, and was in use during the 1970s, but it fell into disuse for several reasons. The database which was the source of the price data and with which the system interfaced was replaced with a new database, and the raw Fortran code in which the system itself was written was lost.

When researchers requested a replacement for the system, advantages and disadvantages of several languages and packages were considered, and the SAS system, with its SAS/ETS® econometric software and SAS/IML® matrix language software, seemed to offer the most power, with the most flexibility, for the least code. In addition, the multi-platform development which SAS is following, and the Institute's famous support, suggested that a forecast evaluation system written in SAS would be the most accessible to users with a variety of forecast evaluation problems.

While some of the forecast evaluation measures desired were available in various places in SAS procedures, others were not. We decided to develop a comprehensive package by combining forecast evaluation tools from SAS procedures already available with statistics calculated by macros using SAS/IML software. We wanted to make the system flexible enough so that newer, more accurate evaluation techniques could be added as they are developed by econometricians.

At about the same time, an update to the SAS/ASSIST front end to the SAS System added an "Applications" option to its Primary Menu. It was envisioned that this could serve as the vehicle by which applications of general interest could be shared within the Agency, a function which had been served by a "Macro Library" on our mainframe system. Until then we had not had a mechanism for sharing code among users in the PC environment. It was decided to use the EVAL system under development as a prototype application to be incorporated within the SAS/ASSIST framework, to serve as an example for others interested in developing such multi-user projects.

2. Development of EVAL as an ASSIST application

The first step in linking an application to SAS/ASSIST is to tell ASSIST where to find it. This is done by editing (or creating if it does not already exist) a data set called SASAPPL in the SASUSER directory which indicates the catalog where the application is filed. Directions for doing this can be obtained by choosing APPLICATIONS from the SAS/ASSIST Primary Menu, and choosing HELP on the next menu that appears.

In terms of writing the SCL code to provide the front end to the application, we found it easiest to adapt the programs already included in SAS/ASSIST. While in general it is often more difficult to decipher someone else's code than to write your own, in the case of the SAS/AF software used to develop ASSIST we found it to be a good learning experience to go through the programs that already existed. In that way we could see the results of certain programming techniques and learn how to incorporate some of the existing programs for general functions such as pulling in the variable list of a data set, without having to "reinvent the wheel" ourselves.

In order to modify parts of SAS/ASSIST, you must compile a set of macros that are used throughout ASSIST. We copied MACROS.PROGRAM from the SASHELP.ASSIST catalog into our own catalog, EVAL.ASSIST, and added the following to our ASSIST.SAS file:

```
dm "af c=eval.assist.macros.program";
```

This made the macros available to us during development work. When we were not planning to make changes we would comment out this line before running the application; leaving it in the file in case we needed to make later modifications.

As a starting point for the specification screen for EVAL, on which a user would indicate details for an analysis to be performed, we looked for a program in ASSIST that did something similar. In the REGRESSION option chosen from STATISTICS on the SAS/ASSIST Primary Menu, the user is presented with a panel on which to indicate a dependent and one or more independent variables to use in a regression. This was similar to our framework of needing to specify an Actual variable of observed values and one or more Forecast variables to compare to it. We copied SASHELP.ASSIST.STREG.PROGRAM into EVAL.ASSIST.FCST.PROGRAM and edited it to change the labelling to suit our purposes. This gave us already-defined options along the top of our screen for providing HELP, electing to RUN the SAS program generated, saving the program, customizing the output, and going back to a previous screen.

The regression specification screen also had a number of Yes/No options for analyzing residuals, etc. We modified these to indicate options for EVAL analysis such as computing Theil statistics. By seeing how these switches were implemented we were then able to add additional options, move things around on the screen, and so on.

Some references to other ASSIST programs expected them to be in the current catalog, so we needed to make their calls more explicit. For example,

```
 call display( 'customiz.program' );
```

was changed to

```
 call display
 ('sashelp.assist.customiz.program' );
```

In terms of adding Help screens for the forecast analysis specification screen in general and for particular fields, it was noticed that in SAS/ASSIST CBT entries were used instead of HELP. It turns out that with a CBT window displayed a user only needs to press ENTER to exit, rather than needing to know to type END. This seemed more intuitive for a novice user so we also coded CBT type entries in our catalog.

As we became more accustomed to using SAS/AF software, we also designed an introductory panel of information for the system and a preliminary menu before bringing the user into the main EVAL specification screen. A "Data Management" option branches the user to the same place that choosing DATA from the SAS/ASSIST Primary Menu would, again by a call to the same program ('sashelp.assist.datmenu.program').

EVAL was first coded as a set of SAS macros before being incorporated into ASSIST. As such, a "parameters" data set had to be created to pass to the macros information about the data and variables to be used and the analysis desired. To store values in the macro symbol table when the data step was executed required use of the SYMPUT routine. All of this was no longer necessary when EVAL was moved into ASSIST. Screen Control Language (SCL) variables, defined as fields on the EVAL display panel, pass information obtained through interactive user input to the macros which perform the requested computations.

3. Hardware, software, and data requirements

The software requirements for EVAL to run on an IBM or compatible personal computer are SAS, version 6.03 or higher, with the following products installed: SAS/BASE, SAS/STAT®, SAS/IML, SAS/ETS, and SAS/ASSIST. Extended memory is necessary; two megabytes is suggested. SAS/AF is needed to develop an application and link it to SAS/ASSIST; however, it is not needed to run it since the programs are compiled.

Although EVAL was developed with a particular data base in mind, we have tried to keep the requirements as general as possible. The SAS data set which is to be analyzed must have one or more variables containing "actual" values of series of interest and one or more variables containing "forecast" values which are to be compared to the actual observed data. In addition, there must be a variable to indicate the time period represented by each observation. It should be a numeric variable of the form yyyyppp, with a value of 1979004, for example, indicating the fourth period (month, quarter, etc.) of 1979 (in the future this may be generalized to handle true SAS date variables).

4. Running EVAL

To run the EVAL Forecast Evaluation System, a user moves the cursor on the SAS/ASSIST Primary Menu to APPLICATIONS and presses ENTER. The next screen provides a choice of PUBLIC (which we interpreted to mean applications provided by SAS Institute since they currently distribute some SAS/OR® examples with SAS/ASSIST) or PRIVATE (which is where we put EVAL, an application developed at our site). After choosing PRIVATE the user sees a "list" of applications, of which currently EVAL is the only one. Placing an X by Forecast Evaluation System and pressing ENTER places the user on another screen with options for running the Forecast Evaluation Program, data management, and exiting. After indicating that EVAL should be run, a final screen is presented for specification of such information as the data set to be analyzed, the variables to be used, the time periods to limit the analysis to, the periodicity of the data (monthly, quarterly, etc.), and the types of analyses to be performed. Context-specific help is available by pressing PF1 while positioned on any field.

By default the last analyzed data set is presented on the screen as the one to be used for EVAL. The user can change this by positioning the cursor on ACTIVE data set and pressing ENTER, and then selecting from a list of data sets presented (according to any libraries specified in ASSIST.SAS).

Also by default the program expects to use a variable called TIME as a date indicator. The user can override this by positioning the cursor on DATE indicator, pressing ENTER, and selecting from the variables shown.

By working within the ASSIST framework, the user also has available all of the other menus for commonly performed tasks within the SAS System. If graphics or tabular displays are wanted, these can be obtained by making appropriate choices from the SAS/ASSIST Primary Menu before (or after) choosing APPLICATIONS.

5. The Statistics

The statistics which the current version of EVAL can calculate and display follow.

Printing of the input data. Each analysis group is specified by a dataset name, initial time period to be analyzed, last period to be included in analysis, Actual variable name, and Forecast variable names. PROC IML is used to retrieve the data, and PROC PRINT to display it.

Statistics of Fit. These include the mean error, mean percent error, mean absolute error, mean absolute percent error, root mean square error, and root mean square percent error. These are generated by PROC SIMLIN.

Theil statistics. There are many Theil inequality coefficients in use. The ones EVAL calculates are based on relative change forecast errors, as recommended in, for example, Leuthold (1975), to overcome sensitivity to an additive transformation. The calculations are performed in PROC IML according to the following:

$$U1=\frac{\sqrt{\sum_{t=2}^{n}(F_t-A_t)^2}}{\sqrt{\sum_{t=2}^{n}(F_t-A_{t-1})^2}+\sqrt{\sum_{t=2}^{n}(A_t-A_{t-1})^2}}$$

$$U2=\sqrt{\frac{\sum_{t=2}^{n}(F_t-A_t)^2}{\sum_{t=2}^{n}(A_t-A_{t-1})^2}}$$

These statistics compare the predictive ability of the model generating the forecasts to the "naive" no-change model where the forecast for the next period is this period's actual observation. Both U1 and U2 have a lower limit of 0 which refers to an ideal forecast, $F_t=A_t$ (thus, the smaller these statistics, the better). For U1 the upper boundary is 1, when $F_t=A_{t-1}$, so that all models appear to predict at least as well as

the no-change model. The U2 statistic removes this limitation, so that its interpretation is:

U2 = 0	perfect forecast
0 < U2 < 1	forecast is better than naive model
U2 = 1	naive no-change extrapolation
U2 > 1	forecast is worse than naive model

(Leuthold, 1975).

Note: In some cases the computed values of the Theil statistics differ from those that would have been produced by the SAS procedure PROC SIMNLIN. We have been unable to duplicate by hand calculation the values that PROC SIMNLIN prints.

Regression of actual on predicted values, y=Mx+B, as a method of testing goodness of fit. Here y is the endogenous, actual variable A_t, x is the exogenous, forecast variable F_t, and M and B are the slope and intercept respectively. The solution is the result of an ordinary least squares fit of the actual and forecasted values, with M and B estimated by PROC REG in SAS/STAT. For perfect forecasts, $F_t=A_t$, so that the resulting regression would have zero intercept B and unit slope (M=1). Parameters of the regression would be tested to see if they differed significantly from zero and one (Kost, 1980).

Revision Ratios table and a Revision Ratio Analysis table. These are only appropriate for examining forecast variables from the same source, for the same actual variable, over the same time period, when the forecasts are made at different times. Thus more than one forecast variable name must be specified! The revision ratios are a measure of how well a forecast is revised as the forecast is made at a time closer to the period being predicted. The revision ratio between two forecasts $F_{A,t}$ and $F_{B,t}$, where $F_{B,t}$ is the forecast made later, is calculated as the ratio of the difference between the two forecasts (the "revision") and the forecast error (the difference between the original forecast and the actual observed value). That is,

$$RRatio_{AB,t}=\frac{F_{B,t}-F_{A,t}}{A_t-F_{A,t}}$$

A forecast made 3 months ago may be a good, bad, or indifferent revision of a forecast made six months ago, for example.

The revision ratio analysis table summarizes the revision ratios for the specified time period. It provides a count of the Revision ratios which fall into each of five categories for each of the ordered pairs of forecasts. The classes of revision ratios are:

Ratio = 1;
1 < Ratio < 2;
0 < Ratio < 1;
Ratio <= 0;
Ratio >= 2.

Revisions falling within each class may be interpreted in the following manner (Ippolito, 1979):
A ratio equal to 1 indicates a perfect revision (equal to the forecast error in the original time period). A ratio between 1 and 2 indicates a revision in the correct direction, but too large. The closer the value is to 1, the better the revision. A ratio between 0 and 1 indicates a revision in the right direction, but too small. A ratio equal to zero means that no revision was made, while a negative ratio indicates that the revision was in the wrong direction. A ratio greater than or equal to 2 means a very bad revision was made. Note that large revision ratios may result whenever the initial forecast itself was a very good forecast, even for revisions made in the right direction.

Prediction Realizations. There are several steps involved in computing prediction realization statistics, the first of which is a "call" for an additional year of input data. In order to eliminate seasonal bias, computations are made using the actual values of one time period and the values of the same relative time period of the previous year, hence the need for the additional data. To reduce the possibility of misunderstanding the nature of the calculations, the input data, including the additional year, are printed whenever prediction realization values are requested.

Given a frequency of observation f (4 for quarterly data, 12 for monthly, and so on), a "prediction realization" is computed as the percent change between the actual or forecast value at time t and the actual value observed f periods (one year) previously. That is,

$$PRedR_{P,t}=100*\frac{F_t-A_{t-f}}{A_{t-f}}$$

$$PRedR_{A,t}=100*\frac{A_t-A_{t-f}}{A_{t-f}}$$

A directional accuracy table, which relies upon the PR calculations, is also available through the PR request. However, you cannot get a directional accuracy table without the accompanying prediction realization table. This was built into the system to reduce possible misinterpretations of the results.

The directional accuracy table is an interpretation of the prediction realizations, and it uses a critical value specified by the user, used to set a range within which changes are considered to be essentially zero for the purpose of directional accuracy. Predicted and actual values that fall within the range

$$-\frac{CriticalValue}{2} < PRedR_t < +\frac{CriticalValue}{2}$$

are considered as "no change." If no critical value is specified, a default value of 1.0 is used. The possible values in the directional accuracy table are 0, 1, and 2, and they should be interpreted in the following manner: a value of 0 indicates a correct directional prediction, 1 indicates an incorrect directional prediction, and 2 indicates a truly bad directional prediction. Since "no change" is usually considered a direction in forecasting analysis, there are two steps from a correct forecast to a horrible forecast, hence the three possible values as explained above.

6. Anticipated enhancements

EVAL is an application under development rather than a finished product. Several additional tests that EVAL should perform have already been discussed with economists at

USDA/ERS. They include Fisher Forecast Evaluation, Fisher Forecast Comparison, Wilcoxin Signed Rank, Kendall Coefficient of Concordance, and the Mincer-Zarnowitz test. The scope of the system will thus be expanded to allow comparisons of forecasts from different sources, as well as evaluations of forecasts.

In order to improve performance somewhat, and to eliminate the need for the presence of SAS/ETS (and possibly SAS/STAT) when running the application, we intend to recode several EVAL modules. The menus, help screens, and flow of the system will be altered as suggestions are made, and time and resources allow. Output will be improved as needs or complaints demand.

7. Conclusion

We hope that EVAL will serve as a prototype application in SAS/ASSIST, so that others can use it as an example for sharing applications of general interest. This framework should be a powerful vehicle for disseminating and supporting such programs, so that we can develop a good library of useful procedures.

References

Granger, C.W.J. and P. Newbold, "Some Comments on the Evaluation of Economic Forecasts," Applied Economics, 5, 1973.

Ippolito, Pauline and Linda Lynn, Forecast Evaluation System (EVAL) User's Manual, Data Services Center Working Paper, USDA/ESCS, March, 1979.

Kost, William E., "Model Validation and the Net Trade Model", Agricultural Economics Research, Vol.32, No.2, April, 1980.

Leuthold, Raymond M., "On the Use of Theil's Inequality Coefficients", Amer. J. Agr. Econ., May 1975, p. 344-346.

Pindyck, Robert S. and Daniel L. Rubinfeld, Econometric Models & Economic Forecasts, McGraw-Hill, 1981.

SAS Institute Inc., SAS/AF User's Guide, Release 6.03 Edition, 1988.

SAS Institute Inc., SAS/AF Software Applications Using Screen Control Language Course Notes, 1989.

Theil, Henri, Economic Forecasts and Policy, North Holland, N.Y., 1961.

Thomson, James M., "Analysis of the Accuracy of USDA Hog Farrowings Statistics", Am. J. Agr. Econ., December, 1974.

Appendix A. Selected EVAL Screens

```
Welcome to EVAL !!!!!!!!

   The Forecast Evaluation System has been coded as an
application in SAS/ASSIST.  To access it, move the cursor to
APPLICATIONS on the ASSIST main menu and press ENTER.  The next
screen will give you a choice of PUBLIC (applications provided by
SAS Institute) or PRIVATE (applications developed at our site).
Choose PRIVATE.  You will then see a "list" of applications to
select from (currently EVAL is the only one).  Put an X by Forecast
Evaluation System and press ENTER.  You will be given another list
of options which include any data editing you would like to do or
running the Forecast Evaluation program.  Put an X by the appropriate
option and press ENTER.  Once in the menu for EVAL, you will move
your cursor around the screen to fill in such information as the
data set you wish to analyze, the variable which contains the actual
values for the series of interest, the variable or variables which
contain forecasts you would like to compare to the actual values, and
the types of analyses you wish to perform.  Press PF1 at any point at
which you need help.

   Press ENTER to continue.
```

```
SAS/ASSIST: Primary Menu                                    10:11AM

                    SAS/ASSIST Primary Menu

 TUTORIAL      DATA      R          Applications
                                    Tab and press ENTER to select.
                                    HELP  GOBACK
 STATISTICS    DESKTOP   P
                                    Type of Application:
                                    PUBLIC
                                    PRIVATE
      SETUP      PROCEDURES

                Tab to an option and press ENTER to select.
```

```
SAS/ASSIST: Application Selection                           10:11AM
Select the application you want to run.
Place any character in the field next to the application description.
Press ENTER to run the selected application; use GOBACK to return.
 Application Selection

  HELP  GOBACK

     Private Applications

  _  FORECAST EVALUATION SYSTEM
```

```
                                                            10:12AM

                FORECAST EVALUATION SYSTEM MAIN MENU

                Place an X next to your selection:

                _  Run Forecast Evaluation Program

                _  Data Management (select, edit, etc., if not
                       already done)

                _  Return to Previous Menu
```

```
EVAL: Forecast Evaluation Syste                             10:12AM
A variable of actual values is required. ENTER to make a selection.

 HELP  RUN  VIEWPGM  SAVEPGM  CUSTOMIZE  GOBACK

 ACTIVE data set:  AGDATA.PRICES

 DATE indicator:  TIME          FREQUENCY of data: ___

                                INITIAL TIME PERIOD:  _____
 ACTUAL value variable:
                                LAST TIME PERIOD:  _____

 FORECAST variables:

     DISPLAY input data: NO              THEIL statistics: NO

         REGRESSION of actual on predicted values: NO

             REVISION ratios: NO

  PREDICTION - realization and directional accuracy statistics: NO
    Critical value (for directional accuracy computations): 1.0
```

```
EVAL: Forecast Evaluation Syste                             10:14AM
Tab and press ENTER to select.

 HELP  RUN  VIEWPGM  SAVEPGM  CUSTOMIZE  GOBACK

 ACTIVE data set:  AGDATA.PRICES

 DATE indicator:  TIME          FREQUENCY of data:   4

                                INITIAL TIME PERIOD:  1981001
 ACTUAL value variable:
          BESCPUS               LAST TIME PERIOD:  1982004

 FORECAST variables:     BESCPU13 BESCPU16

     DISPLAY input data: YES             THEIL statistics: YES

         REGRESSION of actual on predicted values: YES

             REVISION ratios: YES

  PREDICTION - realization and directional accuracy statistics: YES
    Critical value (for directional accuracy computations): 1.0
```

OUTPUT 10:17AM
Command ===>

SAS 10:09 Thursday, March 15, 1990 3

THEIL: ENDOGENOUS - BESCPUS
EXOGENOUS - BESCPUI3

SIMLIN Procedure

Statistics of Fit

Variable	N	Mean Error	Mean % Error	Mean Abs Error	Mean Abs % Error	RMS Error	RMS % Error
BESCPUS	8	4.3759	0.0779	117.8168	2.13649	157.1593	2.8638

ZOOM

OUTPUT 10:17AM
Command ===>

SAS 10:09 Thursday, March 15, 1990 4

THEIL STATISTICS FOR BESCPUS, BESCPUI3

STAT	VALUE
U1 =	0.3817283595
U2 =	0.8579898678

ZOOM

OUTPUT 10:18AM
Command ===>

SAS 10:09 Thursday, March 15, 1990 10

REVISION RATIOS FOR BESCPUS BESCPUI3 BESCPUI6

PERIOD	T1_T2
1981Q1	13.6364
1981Q2	0.3738
1981Q3	1.3889
1981Q4	0.0000
1982Q1	-0.7895
1982Q2	0.8523
1982Q3	0.6250
1982Q4	0.8475

ZOOM

OUTPUT 10:18AM
Command ===>

SAS 10:09 Thursday, March 15, 1990 11

REVISION RATIO ANALYSIS TABLE
BESCPUS BESCPUI3 BESCPUI6

	COL1	COL2
Ratio = 1		0
1 < Ratio < 2		1
0 < Ratio < 1		4
Ratio <= 0		2
Ratio >= 2		1

ZOOM

OUTPUT 10:18AM
Command ===>

SAS 10:09 Thursday, March 15, 1990 13

PREDICTION REALIZATION
BESCPUS BESCPUI3 BESCPUI6

PERIOD	ACTUAL	PREDICT1	PREDICT2
1981Q1	5.94399	8.59211	5.73443
1981Q2	3.58489	-2.87564	-6.68444
1981Q3	2.91685	4.47623	-1.89584
1981Q4	1.64727	-1.52193	-1.52193
1982Q1	-1.98613	1.15887	-8.19781
1982Q2	-1.32475	-1.56394	-2.94388
1982Q3	3.41894	2.86952	1.96715
1982Q4	2.48371	2.16664	0.48514

ZOOM

OUTPUT 10:18AM
Command ===>

SAS 10:09 Thursday, March 15, 1990 14

DIRECTIONAL ACCURACY CRITICAL VALUE IS 1.8
BESCPUS BESCPUI3 BESCPUI6

PERIOD	PREDICT1	PREDICT2
1981Q1	0	0
1981Q2	2	2
1981Q3	0	2
1981Q4	2	2
1982Q1	2	1
1982Q2	0	0
1982Q3	0	0
1982Q4	0	1

ZOOM