SAS Publishing

TECHNICAL REPORT

# SAS/ETS® Software: Changes and Enhancements, Release 8.2

The Power to Know™

58308

The correct bibliographic citation for this manual is as follows: SAS Institute Inc., *SAS/ETS® Software: Changes and Enhancements, Release 8.2*, Cary, NC: SAS Institute Inc., 2001

**SAS/ETS® Software: Changes and Enhancements, Release 8.2**


ISBN 1-58025-849-2



SAS Institute Inc., SAS Campus Drive, Cary, North Carolina 27513.

1st printing, January 2001

# Table of Contents

# Part 1
# General Information

## Table of Contents

Chapter 1
# The SASECRSP Interface Engine

## Chapter Table of Contents

Chapter 1
# The SASECRSP Interface Engine

## Overview

The SASECRSP interface engine enables SAS users to access and process time series data residing in CRSPAccess data files and provides a seamless interface between CRSP and SAS data processing.

The SASECRSP engine uses the LIBNAME statement to enable you to specify which time series you would like to read from the CRSPAccess data files, and how you would like to perform selection on the CRSP set you choose to access. You choose the daily CRSP data by specifying SETID=10, or the monthly CRSP data by specifying SETID=20. You can select which securities you wish to access by specifying PERMNO=*number*, and specify your range of dates for the selected time series by using RANGE='*begdt-enddt*', or specify an input SAS data set named *setname* as input for issues with the INSET='*setname*' option. The SAS Data step can then be used to perform further subsetting and to store the resulting time series into a SAS data set. You can perform more analysis if desired either in the same SAS session or in another session at a later time. Since CRSP and SAS use three different date representations, you can use the engine-provided CRSP date formats, informats, and functions for flexible seamless programming.

## Getting Started

### Structure of a SAS Data Set Containing Time Series Data

SAS requires time series data to be in a specific form that is recognizable by the SAS System. This form is a two-dimensional array, called a SAS data set, whose columns correspond to series variables and whose rows correspond to measurements of these variables at certain time periods. The time periods at which observations are recorded can be included in the data set as a time ID variable. The SASECRSP engine provides a time ID variable called CALDT.

### Reading CRSP Data Files

The SASECRSP engine supports reading time series, events, and portfolios from CRSPAccess data files. Only the series specified by the CRSP *setid* is written to the SAS data set. The CRSP environment variable CRSPDB_SASCAL must be defined to allow the SASECRSP engine access to the CRSPAccess database calendars.

## Using the SAS DATA Step

If desired, you can store the selected series in a SAS data set by using the SAS DATA step. You can also perform other operations on your data inside the DATA step. Once the data is stored in a SAS data set you can use it as you would any other SAS data set.

## Using SAS Procedures

You can print the output SAS data set by using the PRINT procedure and report information concerning the contents of your data set by using the CONTENTS procedure. You can create a view of the CRSPAccess data base by using the SQL procedure to create your view using the SASECRSP engine in your *libref*, along with the USING clause.

## Using CRSP Date Formats, Informats, and Functions

CRSP has historically used two different methods to represent dates, and SAS has used a third. The SASECRSP engine provides 22 functions, 15 informats, and 10 formats to enable you to easily translate the dates from one internal representation to another. See the section "Understanding CRSP Date Formats, Informats, and Functions" on page 14 for details.

# Syntax

The SASECRSP engine uses standard engine syntax. Options used by SASECRSP are summarized in the table below.

| **Description** | **Statement** | **Option** |
|---|---|---|
| specify a CRSPAccess set id where 10 is daily and 20 monthly. This is a required option. | LIBNAME *libref* SASECRSP | SETID= |
| specify the PERMNO of a security to be kept in the SAS data set. | LIBNAME *libref* SASECRSP | PERMNO= |
| specify the range of data in format YYYYMMDD using the *crsp_begdt* and *crsp_enddt*. | LIBNAME *libref* SASECRSP | RANGE= |
| use a SAS data set named *setname* as input for issues. | LIBNAME *libref* SASECRSP | INSET= |

## The LIBNAME *libref* SASECRSP Statement

**LIBNAME** *libref* **SASECRSP** **'***physical name***'** *options;*

The CRSP environment variable CRSPDB_SASCAL must be defined to allow the SASECRSP engine access to the CRSPAccess database calendars. Often your CRSPDB_SASCAL will be pointing to the same path as your *physical name*. You must use a fully qualified pathname. Your *physical name* must end with either a forward slash if you are on a UNIX system, or a backward slash if you are on WINNT.

For a more complete description of SASECRSP set names, key fields, and date fields, see Table 1.1.

The following options can be used in the LIBNAME *libref* SASECRSP statement:

**SETID=***crsp_setidnumber*
specifies the CRSP set ID number where 10 is the daily data set ID and 20 is the monthly data set ID number. Two possible values for *crsp_setidnumber* are 10 or 20. The SETID limits the frequency selection of time series that are included in the SAS data set. SETID is a required option for the SASECRSP engine. Depending on your host system, both should end in either a forward slash (UNIX) or a backward slash (WINNT). For more details about the CRSPAccess *crsp_setidnumber*, refer to "Using Multiple Products" in the *CRSPAccess Database Format Installation Guide*. As an example, to access monthly data, you would use the following statements:

```
LIBNAME myLib sasecrsp 'physical-name'
   SETID=20;
```

**PERMNO=***crsp_permnumber*
By default, the SASECRSP engine reads all PERMNOs in the CRSPAccess database that you name in your SASECRSP *libref*. You can limit the time series read from the CRSP database by specifying the PERMNO= option on your LIBNAME statement. From a performance standpoint, the PERMNO= option does random access and reads only the data for the PERMNOs listed. There is no limit to the number of *crsp_permnumber* options that you can use. As an example, to access monthly data for Microsoft Corporation and for International Business Machine Corporation, you could use the following statements:

```
LIBNAME myLib sasecrsp 'physical-name'
   SETID=20
   PERMNO=10107
   PERMNO=12490;
```

**RANGE=***'crsp_begdt-crsp_enddt'*
To limit the time range of data read from the CRSPAccess database, specify the RANGE= option in your SASECRSP *libref*, where *crsp_begdt* is the beginning date in YYYYMMDD format and *crsp_enddt* is the ending date of the range in

YYYYMMDD format. From a performance standpoint, the engine reads all the data for a company and then restricts the data range before passing it back.

As an example, to access monthly data for Microsoft Corporation and for International Business Machine Corporation for the first quarter of 2000, you could use the following statements:

```
LIBNAME myLib sasecrsp 'physical-name'
   SETID=20
   PERMNO=10107
   PERMNO=12490
   RANGE='19990101-19990331';
```

**INSET=***'setname[,keyfieldname][,keyfieldtype][,date1field][,date2field]'*

When you specify a SAS data set named *setname* as input for issues, the SASECRSP engine assumes a default PERMNO field containing selected CRSP PERMNOs is present in the data set. If optional parameters are included, the first one is the CRSPAccess supported key name, and the second is the key type. The third optional parameter is the beginning date or event date, and the fourth is the ending date in YYYYMMDD format. For more details about the CRSPAccess keyfields and keyfieldtypes, refer to "Stock and Indices Data Structures" in the *CRSP Data Description Guide*.

The following example might be used to extract the data for a portfolio of four companies to access monthly data where the range of dates is left open:

```
data testin1;
   permno = 10107; output;
   permno = 12490; output;
   permno = 14322; output;
   permno = 25788; output;
run;

LIBNAME mstk sasecrsp 'physical-name'
   SETID=20
   INSET='testin1';

data a;
   set mstk.prc;
run;

proc print data=a;
run;
```

Suppose you want to restrict the dates for each PERMNO specifically. The example below shows how to specify the INSET= option with the *'setname[,keyfieldname][,keyfieldtype][,date1field][,date2field]'* parameters:

```
data testin2;
   permno = 10107; date1 = 19990101; date2 = 19991231; output;
   permno = 12490; date1 = 19970101; date2 = 19971231; output;
   permno = 14322; date1 = 19990901; date2 = 19991231; output;
   permno = 25788; date1 = 19950101; date2 = 19950331; output;
run;

LIBNAME mstk2 sasecrsp 'physical-name'
   SETID=20
   INSET='testin2,PERMNO,PERMNO,DATE1,DATE2';

data b;
   set mstk2.prc;
run;

proc print data=b;
run;
```

# Details

## The SAS Output Data Set

You can use the SAS DATA step to write the selected CRSP data to a SAS data set. This enables the user to easily analyze the data using SAS. The name of the output data set is specified by you on the DATA statement. This causes the engine supervisor to create a SAS data set using the specified name in either the SAS WORK library or, if specified, the USER library.

The contents of the SAS data set include the DATE of each observation, the series names of each series read from the CRSPAccess database, event variables, and the label or description of each series/event.

## Available Data Sets

Table 1.1 shows the available data sets provided by the SASECRSP interface. Missing values are represented as '.' in the SAS data set. You can see the available data sets in the SAS LIBNAME window of the SAS Display Manager by selecting the SASECRSP libref in the LIBNAME window that you have previously used in your libname statement. You can use PROC PRINT and PROC CONTENTS to print your output data set and its contents. You can view your SAS output observations by double clicking on the desired output data set libref in the libname window of the Display Manager. You can use PROC SQL along with the SASECRSP engine to create a view of your SAS data set.

**Table 1.1.** Data Sets Available

| Dataset | Fields | Label | Type |
|---|---|---|---|
| STKHEAD | PERMNO | PERMNO | Numeric |
| Header Identification | PERMCO | PERMCO | Numeric |
| and Summary Data | COMPNO | Nasdaq Company Number | Numeric |
| | ISSUNO | Nasdaq Issue Number | Numeric |
| | HEXCD | Exchange Code Header | Numeric |
| | HSHRCD | Share Code Header | Numeric |
| | HSICCD | Standard Industrial Classification Code | Numeric |
| | BEGDT | Begin of Stock Data | Numeric |
| | ENDDT | End of Stock Data | Numeric |
| | DLSTCD | Delisting Code Header | Numeric |
| | HCUSIP | CUSIP Header | Character |
| | HTICK | Ticker Symbol Header | Character |
| | HCOMNAM | Company Name Header | Character |
| NAMES | PERMNO | PERMNO | Numeric |
| Name History Array | NAMEDT | Names Date | Numeric |
| | NAMEENDDT | Names Ending Date | Numeric |
| | SHRCD | Share Code | Numeric |
| | EXCHCD | Exchange Code | Numeric |
| | SICCD | Standard Industrial Classification Code | Numeric |
| | NCUSIP | CUSIP | Numeric |
| | TICKER | Ticker Symbol | Character |
| | COMNAM | Company Name | Character |
| | SHRCLS | Share Class | Numeric |
| DISTS | PERMNO | PERMNO | Numeric |
| Distribution Event | DISTCD | Distribution Code | Numeric |
| Array | DIVAMT | Dividend Cash Amount | Numeric |
| | FACPR | Factor to Adjust Price | Numeric |
| | FACSHR | Factor to Adjust Share | Numeric |
| | DCLRDT | Distribution Declaration Date | Numeric |
| | EXDT | Ex-Distribution Date | Numeric |
| | RCRDDT | Record Date | Numeric |
| | PAYDT | Payment Date | Numeric |
| | ACPERM | Acquiring PERMNO | Numeric |
| | ACCOMP | Acquiring PERMCO | Numeric |
| SHARES | PERMNO | PERMNO | Numeric |
| Shares Outstanding | SHROUT | Shares Outstanding | Numeric |
| Observation Array | SHRSDT | Shares Outstanding Observation Date | Numeric<br>Numeric |
| | SHRENDDT | Shares Outstanding Observation End Date | Numeric |
| | SHRFLG | Shares Outstanding Observation Flag | Numeric |

**Table 1.1.** (continued)

| Dataset | Fields | Label | Type |
|---|---|---|---|
| DELIST | PERMNO | PERMNO | Numeric |
| Delisting | DLSTDT | Delisting Date | Numeric |
| History Array | DLSTCD | Delisting Code | Numeric |
| | NWPERM | New PERMNO | Numeric |
| | NWCOMP | New PERMCO | Numeric |
| | NEXTDT | Delisting | Numeric |
| | | Next Price Date | |
| | DLAMT | Delisting Amount | Numeric |
| | DLRETX | Delisting Return | Numeric |
| | | Without Dividends | |
| | DLPRC | Delisting Price | Numeric |
| | DLPDT | Delisting Amount Date | Numeric |
| | DLRET | Delisting Return | Numeric |
| NASDIN | PERMNO | PERMNO | Numeric |
| Nasdaq Information | TRTSCD | Nasdaq Traits Code | Numeric |
| Array | TRTSDT | Nasdaq Traits Date | Numeric |
| | TRTSENDDT | Nasdaq Traits End Date | Numeric |
| | NMSIND | Nasdaq National Market | Numeric |
| | | Indicator | |
| | MMCNT | Market Maker Count | Numeric |
| | NSDINX | Nasd Index Code | Numeric |
| PRC | PERMNO | PERMNO | Numeric |
| Price or Bid/Ask | CALDT | Calendar Trading Date | Numeric |
| Average Time Series | PRC | Price or Bid/Ask Aver | Numeric |
| RET | PERMNO | PERMNO | Numeric |
| Returns Time Series | CALDT | Calendar Trading Date | Numeric |
| | RET | Returns | Numeric |
| ASKHI | PERMNO | PERMNO | Numeric |
| Ask or High | CALDT | Calendar Trading Date | Numeric |
| Time Series | ASKHI | Ask or High | Numeric |
| BIDLO | PERMNO | PERMNO | Numeric |
| Bid or Low | CALDT | Calendar Trading Date | Numeric |
| Time Series | BIDLO | Bid or Low | Numeric |
| BID | PERMNO | PERMNO | Numeric |
| Bid Time Series | CALDT | Calendar Trading Date | Numeric |
| | BID | Bid | Numeric |
| ASK | PERMNO | PERMNO | Numeric |
| Ask Time Series | CALDT | Calendar Trading Date | Numeric |
| | ASK | Ask | Numeric |
| RETX | PERMNO | PERMNO | Numeric |
| Returns without | CALDT | Calendar Trading Date | Numeric |
| Dividends Time Series | RETX | Returns w/o Dividends | Numeric |
| SPREAD | PERMNO | PERMNO | Numeric |
| Spread Between Bid | CALDT | Calendar Trading Date | Numeric |
| and Ask Time Series | SPREAD | Spread Between Bid Ask | Numeric |

**Table 1.1.** (continued)

| Dataset | Fields | Label | Type |
|---|---|---|---|
| ALTPRC | PERMNO | PERMNO | Numeric |
| Price Alternate | CALDT | Calendar Trading Date | Numeric |
| Time Series | ALTPRC | Price Alternate | Numeric |
| VOL | PERMNO | PERMNO | Numeric |
| Volume Time Series | CALDT | Calendar Trading Date | Numeric |
| | VOL | Volume | Numeric |
| NUMTRD | PERMNO | PERMNO | Numeric |
| Number of Trades | CALDT | Calendar Trading Date | Numeric |
| Time Series | NUMTRD | Number of Trades | Numeric |
| ALTPRCDT | PERMNO | PERMNO | Numeric |
| Alternate Price Date | CALDT | Calendar Trading Date | Numeric |
| Time Series | ALTPRCDT | Alternate Price Date | Numeric |
| PORT1 | PERMNO | PERMNO | Numeric |
| Portfolio Data for | CALDT | Calendar Trading Date | Numeric |
| Portfolio Type 1 | PORT1 | Portfolio Assignment | Numeric |
| | | for Portfolio Type 1 | Numeric |
| | STAT1 | Portfolio Statistic | Numeric |
| | | for Portfolio Type 1 | Numeric |
| PORT2 | PERMNO | PERMNO | Numeric |
| Portfolio Data for | CALDT | Calendar Trading Date | Numeric |
| Portfolio Type 2 | PORT2 | Portfolio Assignment | Numeric |
| | | for Portfolio Type 2 | Numeric |
| | STAT2 | Portfolio Statistic | Numeric |
| | | for Portfolio Type 2 | Numeric |
| PORT3 | PERMNO | PERMNO | Numeric |
| Portfolio Data for | CALDT | Calendar Trading Date | Numeric |
| Portfolio Type 3 | PORT3 | Portfolio Assignment | Numeric |
| | | for Portfolio Type 3 | Numeric |
| | STAT3 | Portfolio Statistic | Numeric |
| | | for Portfolio Type 3 | Numeric |
| PORT4 | PERMNO | PERMNO | Numeric |
| Portfolio Data for | CALDT | Calendar Trading Date | Numeric |
| Portfolio Type 4 | PORT4 | Portfolio Assignment | Numeric |
| | | for Portfolio Type 4 | Numeric |
| | STAT4 | Portfolio Statistic | Numeric |
| | | for Portfolio Type 4 | Numeric |
| PORT5 | PERMNO | PERMNO | Numeric |
| Portfolio Data for | CALDT | Calendar Trading Date | Numeric |
| Portfolio Type 5 | PORT5 | Portfolio Assignment | Numeric |
| | | for Portfolio Type 5 | Numeric |
| | STAT5 | Portfolio Statistic | Numeric |
| | | for Portfolio Type 5 | Numeric |
| PORT6 | PERMNO | PERMNO | Numeric |
| Portfolio Data for | CALDT | Calendar Trading Date | Numeric |
| Portfolio Type 6 | PORT6 | Portfolio Assignment | Numeric |

**Table 1.1.** (continued)

| Dataset | Fields | Label | Type |
|---|---|---|---|
| | | for Portfolio Type 6 | Numeric |
| | STAT6 | Portfolio Statistic | Numeric |
| | | for Portfolio Type 6 | Numeric |
| PORT7 | PERMNO | PERMNO | Numeric |
| Portfolio Data for | CALDT | Calendar Trading Date | Numeric |
| Portfolio Type 7 | PORT7 | Portfolio Assignment | Numeric |
| | | for Portfolio Type 7 | Numeric |
| | STAT7 | Portfolio Statistic | Numeric |
| | | for Portfolio Type 7 | Numeric |
| PORT8 | PERMNO | PERMNO | Numeric |
| Portfolio Data for | CALDT | Calendar Trading Date | Numeric |
| Portfolio Type 8 | PORT8 | Portfolio Assignment | Numeric |
| | | for Portfolio Type 8 | Numeric |
| | STAT8 | Portfolio Statistic | Numeric |
| | | for Portfolio Type 8 | Numeric |
| PORT9 | PERMNO | PERMNO | Numeric |
| Portfolio Data for | CALDT | Calendar Trading Date | Numeric |
| Portfolio Type 9 | PORT9 | Portfolio Assignment | Numeric |
| | | for Portfolio Type 9 | Numeric |
| | STAT9 | Portfolio Statistic | Numeric |
| | | for Portfolio Type 9 | Numeric |

## Understanding CRSP Date Formats, Informats, and Functions

CRSP has historically used two different methods to represent dates, while SAS has used a third. The three formats are SAS Dates, CRSP Dates, and Integer Dates. The SASECRSP engine provides 22 functions, 15 informats, and 10 formats to enable you to easily translate the dates from one internal representation to another. A SASECRSP libname assign must be active to use these date access methods.

SAS dates are internally stored as the number of days since January 1, 1960. The SAS method is an industry standard and provides a great deal of flexibility, including a wide variety of informats, formats, and functions.

CRSP dates are designed to ease time series storage and access. Internally the dates are stored as an offset into an array of trading days. Note that there are five different CRSP trading day calendars: Annual, Quarterly, Monthly, Weekly, and Daily. The CRSP method provides fewer missing values and makes trading period calculations very easy. However, there are also many valid calendar dates that are not available in the CRSP trading calendars, and care must be taken when using other dates.

Integer dates are a way to represent dates that are platform independent and maintain the correct sort order. However, the distance between dates is not maintained.

The best way to illustrate these formats is with some sample data. The table below only shows CRSP Daily and Monthly dates.

**Table 1.2.** Date Representations for Daily and Monthly Data

| Date | SAS Date | CRSP Date (Daily) | CRSP Date (Monthly) | Integer Date |
|---|---|---|---|---|
| July 31, 1962 | 942 | 21 | 440 | 19620731 |
| August 31, 1962 | 973 | 44 | 441 | 19620831 |
| December 30, 1998 | 14,243 | 9190 | NA* | 19981230 |
| December 31, 1998 | 14,244 | 9191 | 877 | 19981231 |

* Not available if an exact match is requested.

Having an understanding of the internal differences in representing SAS dates, CRSP dates, and CRSP integer dates will help you use the SASECRSP formats, informats, and functions effectively. Always keep in mind the frequency of the CRSP calendar that you are accessing when you specify a CRSP date.

### *The CRSP Date Formats*

There are two types of formats for CRSP dates, and five frequencies are available for each of the two types. The two types are exact dates (CRSPDT*) and range dates (CRSPDR*), where * can be A for annual, Q for quarterly, M for monthly, W for weekly, or D for daily. The ten formats are: CRSPDTA, CRSPDTQ, CRSPDTM, CRSPDTW, CRSPDTD, CRSPDRA, CRSPDRQ, CRSPDRM, CRSPDRW, and CRSPDRD.

Here are some samples using the monthly and daily calendar as examples. The Annual (CRSPDTA and CRSPDRA), Quarterly (CRSPDTQ and CRSPDRQ), and the Weekly (CRSPDTW and CRSPDRW) work analogously.

**Table 1.3.** Sample CRSPDT Formats for Daily and Monthly Data

| Date | CRSP Date Daily , Monthly | CRSPDTD8. Daily Date | CRSPDRD8. Daily Range | CRSPDTM8. Monthly Date | CRSPDRM8. Monthly Range |
|---|---|---|---|---|---|
| July 31,1962 | 21 , 440 | 19620731 | 19620731 + | 19620731 | 19620630-19620731 |
| August31,1962 | 44 , 441 | 19620831 | 19620831 + | 19620831 | 19620801-19620831 |
| December30, 1998 | 9190 , NA * | 19981230 | 19981230 + | NA* | NA* |
| December31, 1998 | 9191 , 877 | 19981231 | 19981231 + | 19981231 | 19981201-19981231 |

+ Daily ranges will look similar to Monthly Ranges if they are Mondays or immediately following a trading holiday.
* When working with exact matches, no CRSP monthly date exists for December 30, 1998.

### *The @CRSP Date Informats*

There are three types of informats for CRSP dates, and five frequencies are available for each of the three types. The three types are exact (@CRSPDT*), range (@CRSPDR*), and backward (@CRSPDB*) dates, where * can be A for annual, Q for quarterly, M for monthly, W for weekly, or D for daily. The fifteen formats are: @CRSPDTA, @CRSPDTQ, @CRSPDTM, @CRSPDTW, @CRSPDTD, @CRSPDRA, @CRSPDRQ, @CRSPDRM, @CRSPDRW, @CRSPDRD, @CRSPDBA, @CRSPDBQ, @CRSPDBM, @CRSPDBW, and @CRSPDBD.

The five CRSPDT* informats find exact matches only. The five CRSPDR* informats look for an exact match, and if it is not found it goes forward, matching the CRSPDR* formats. The five CRSPDB* informats look for an exact match, and if it is not found it goes backward. Here is a sample using only the CRSP monthly calendar as an example, but the daily, weekly, quarterly, and annual frequencies work analogously.

**Table 1.4.** Sample @CRSP Date Informats Using Monthly Data

| Input Date (Integer Date) | CRSP Date CRSPDTM | CRSP Date CRSPDRM | CRSP Date CRSPDBM | CRSPDTM8. Monthly Date | CRSPDRM8. Monthly Range |
|---|---|---|---|---|---|
| 19620731 | 440 | 440 | 440 | 19620731 | 19620630-19620731 |
| 19620815 | .(missing) | 441 | 440 | See below+ | See below* |
| 19620831 | 441 | 441 | 441 | 19620831 | 19620801-19620831 |

+ If missing, then missing. If 441, then 19620831. If 440, then 19620731.

* If missing, then missing. If 441, then 19620801-19620831. If 440, then 19620630-19620731.

### *The CRSP Date Functions*

There are 22 date functions provided with the SASECRSP engine. These functions are used internally by the engine, but also are available to the end users. There are six groups of functions. The first four have five functions each, one for each CRSP calendar frequency.

**Table 1.5.** CRSP Date Functions

| Function Group | Function Name | Argument One | Argument Two | Return Value |
|---|---|---|---|---|
| **CRSP dates to Integer dates for December 31, 1998** | | | | |
| Annual | crspdcia | 74 | None | 19981231 |
| Quarterly | crspdciq | 293 | None | 19981231 |
| Monthly | crspdcim | 877 | None | 19981231 |
| Weekly | crspdciw | 1905 | None | 19981231 |
| Daily | crspdcid | 9191 | None | 19981231 |
| **CRSP dates to SAS dates for December 31, 1998** | | | | |
| Annual | crspdcsa | 74 | None | 14,244 |
| Quarterly | crspdcsq | 293 | None | 14,244 |
| Monthly | crspdcsm | 877 | None | 14,244 |
| Weekly | crspdcsw | 1905 | None | 14,244 |
| Daily | crspdcsd | 9191 | None | 14,244 |
| **Integer dates to CRSP dates exact is illustrated, but can be forward or backward** | | | | |
| Annual | crspdica | 19981231 | 0 | 74 |
| Quarterly | crspdicq | 19981231 | 0 | 293 |
| Monthly | crspdicm | 19981231 | 0 | 877 |
| Weekly | crspdicw | 19981231 | 0 | 1905 |
| Daily | crspdicd | 19981231 | 0 | 9191 |
| **SAS dates to CRSP dates exact is illustrated, but can be forward or backward** | | | | |
| Annual | crspdsca | 14,244 | 0 | 74 |
| Quarterly | crspdscq | 14,244 | 0 | 293 |
| Monthly | crspdscm | 14,244 | 0 | 877 |
| Weekly | crspdscw | 14,244 | 0 | 1905 |
| Daily | crspdscd | 14,244 | 0 | 9191 |

**Table 1.5.** (continued)

| Function Group | Function Name | Argument One | Argument Two | Return Value |
|---|---|---|---|---|
| **Integer dates to SAS dates for December 31, 1998** | | | | |
| Integer to SAS | crspdi2s | 19981231 | None | 14,244 |
| **SAS dates to Integer dates for December 31, 1998** | | | | |
| SAS to Integer | crspds2i | 14,244 | None | 19981231 |

# Examples

## Example 1.1. Extracting a List of PERMNOs Using a RANGE

This example specifies a list of PERMNOs that are desired from the monthly set of CRSPAccess data. Suppose you want the range of data starting January 1, 1995, and ending June 30, 1996.

```
title2 'Define a range inside the data range ';
title3 'Valid trading dates (19890131--19981231)';
title4 'My range is ( 19950101-19960630 )';

libname testit1 sasecrsp '/mydata/crspeng/m_sampdata/'
   setid=20
   permno=81871
   permno=82200
   permno=82224
   permno=83435
   permno=83696
   permno=83776
   permno=84788
   range='19950101-19960630';

data a;
   set testit1.ask;
run;

proc print data=a;
run;
```

**Output 1.1.1.** Printout of the ASK Monthly Time Series Data with RANGE

The SAS System 1
Define a range inside the data range
Valid trading dates (19890131--19981231)
My range is ( 19950101-19960630 )

| Obs | PERMNO | CALDT | ASK |
|---|---|---|---|
| 1 | 81871 | 19950731 | 18.25000 |
| 2 | 81871 | 19950831 | 19.25000 |
| 3 | 81871 | 19950929 | 26.00000 |
| 4 | 81871 | 19951031 | 26.00000 |
| 5 | 81871 | 19951130 | 25.50000 |
| 6 | 81871 | 19951229 | 24.25000 |
| 7 | 81871 | 19960131 | 22.00000 |
| 8 | 81871 | 19960229 | 32.50000 |
| 9 | 81871 | 19960329 | 30.25000 |
| 10 | 81871 | 19960430 | 33.75000 |
| 11 | 81871 | 19960531 | 27.50000 |
| 12 | 81871 | 19960628 | 30.50000 |
| 13 | 82200 | 19950831 | 49.50000 |
| 14 | 82200 | 19950929 | 62.75000 |
| 15 | 82200 | 19951031 | 88.00000 |
| 16 | 82200 | 19951130 | 138.50000 |
| 17 | 82200 | 19951229 | 139.25000 |
| 18 | 82200 | 19960131 | 164.25000 |
| 19 | 82200 | 19960229 | 51.00000 |
| 20 | 82200 | 19960329 | 41.62500 |
| 21 | 82200 | 19960430 | 61.25000 |
| 22 | 82200 | 19960531 | . |
| 23 | 82200 | 19960628 | 62.50000 |
| 24 | 82224 | 19950929 | 46.50000 |
| 25 | 82224 | 19951031 | 48.50000 |
| 26 | 82224 | 19951130 | 47.75000 |
| 27 | 82224 | 19951229 | 49.75000 |
| 28 | 82224 | 19960131 | 49.00000 |
| 29 | 82224 | 19960229 | 47.00000 |
| 30 | 82224 | 19960329 | 53.00000 |
| 31 | 82224 | 19960430 | 55.50000 |
| 32 | 82224 | 19960531 | . |
| 33 | 82224 | 19960628 | 51.00000 |
| 34 | 83435 | 19960430 | 30.25000 |
| 35 | 83435 | 19960531 | . |
| 36 | 83435 | 19960628 | 21.00000 |
| 37 | 83696 | 19960628 | 19.12500 |

## Example 1.2. Extracting All PERMNOs Using a RANGE

If you want all PERMNOs extracted for the ASK time series from the monthly data set, then you would not specify the PERMNO= option.

```
title2 'Define a range inside the data range ';
title3 'Valid trading dates (19890131--19981231)';
title4 'My range is ( 19950101-19950228 )';

libname testit2 sasecrsp '/mydata/crspeng/m_sampdata/'
   setid=20
   range='19950101-19950228';

data b;
   set testit2.ask;
run;

proc print data=b;
run;
```

**Output 1.2.1.** Printout of All PERMNOs of ASK Monthly with RANGE

```
                    The SAS System                                  1
            Define a range inside the data range
           Valid trading dates (19890131--19981231)
              My range is ( 19950101-19950228 )

        Obs      PERMNO    CALDT             ASK

          1       10078    19950131       32.75000
          2       10078    19950228       32.12500
          3       10104    19950131       42.87500
          4       10104    19950228       31.50000
          5       10107    19950131       59.37500
          6       10107    19950228       63.00000
          7       10155    19950131        2.43750
          8       10155    19950228        3.00000
          9       10837    19950131        3.12500
         10       10837    19950228        3.50000
         11       11042    19950131       21.87500
         12       11042    19950228       23.50000
         13       11081    19950131       42.62500
         14       11081    19950228       41.62500
         15       14593    19950131       40.50000
         16       14593    19950228       39.62500
         17       40484    19950131       35.75000
         18       40484    19950228       38.50000
         19       44194    19950131       14.25000
         20       44194    19950228       15.25000
         21       49606    19950131      139.00000
         22       49606    19950228      129.50000
         23       50156    19950131       44.75000
         24       50156    19950228       41.75000
         25       50404    19950131       18.37500
         26       50404    19950228       20.12500
         27       59248    19950131       16.75000
         28       59248    19950228       16.25000
         29       59328    19950131       69.37500
         30       59328    19950228       79.75000
         31       75030    19950131       21.25000
         32       75030    19950228       22.87500
         33       76535    19950131        2.75000
         34       76535    19950228        2.75000
         35       76829    19950131       21.50000
         36       76829    19950228       25.00000
         37       77352    19950131       15.25000
         38       77352    19950228       16.00000
         39       77418    19950131       54.50000
         40       77418    19950228       71.25000
         41       77882    19950131        6.50000
         42       77882    19950228        7.12500
         43       78083    19950131       32.75000
         44       78083    19950228       34.75000
         45       78117    19950131       39.25000
         46       78117    19950228       39.00000
         47       78987    19950131       22.50000
         48       78987    19950228       25.25000
         49       81181    19950131        3.75000
         50       81181    19950228        3.62500
         51       91708    19950131         .
         52       91708    19950228         .
```

## Example 1.3. Extracting One PERMNO Using No RANGE, Wide Open

If you want the entire range of available data for one particular PERMNO extracted from the monthly data set, then you would not specify the RANGE= option.

```
title2 'Select only PERMNO = 81871';
title3 'Valid trading dates (19890131--19981231)';
title4 'No range option, leave wide open';

libname testit3 sasecrsp '/mydata/crspeng/m_sampdata/'
   setid=20
   permno=81871;

data c;
   set testit3.ask;
run;

proc print data=c;
run;
```

**Output 1.3.1.** Printout of PERMNO = 81871 of ASK Monthly without RANGE

```
                        The SAS System                              1
                    Select only PERMNO = 81871
             Valid trading dates (19890131--19981231)
                 No range option, leave wide open

             Obs     PERMNO    CALDT             ASK

               1      81871    19950731      18.25000
               2      81871    19950831      19.25000
               3      81871    19950929      26.00000
               4      81871    19951031      26.00000
               5      81871    19951130      25.50000
               6      81871    19951229      24.25000
               7      81871    19960131      22.00000
               8      81871    19960229      32.50000
               9      81871    19960329      30.25000
              10      81871    19960430      33.75000
              11      81871    19960531      27.50000
              12      81871    19960628      30.50000
              13      81871    19960731      26.12500
              14      81871    19960830      19.12500
              15      81871    19960930      19.50000
              16      81871    19961031      14.00000
              17      81871    19961129      18.75000
              18      81871    19961231      24.25000
              19      81871    19970131      29.75000
              20      81871    19970228      24.37500
              21      81871    19970331      15.00000
              22      81871    19970430      18.25000
              23      81871    19970530      25.12500
              24      81871    19970630      31.12500
              25      81871    19970731      35.00000
              26      81871    19970829      33.00000
              27      81871    19970930      26.81250
              28      81871    19971031      18.37500
              29      81871    19971128      16.50000
              30      81871    19971231      16.25000
              31      81871    19980130      22.75000
              32      81871    19980227      21.00000
              33      81871    19980331      22.50000
              34      81871    19980430      16.12500
              35      81871    19980529      11.12500
              36      81871    19980630      13.43750
              37      81871    19980731      22.87500
              38      81871    19980831      17.75000
              39      81871    19980930      24.25000
              40      81871    19981030      26.00000
```

## Example 1.4. Extracting Selected PERMNOs in Range Using INSET= Option

You can select the PERMNOs you want to extract and specify the range of data to extract by defining an INSET such as testin2.

```
title2 'INSET=testin2 uses date ranges along with PERMNOs:';
title3 '10107, 12490, 14322, 25788';
title4 'Begin dates and end dates for each permno are used in the INSET';

data testin2;
   permno = 10107; date1 = 19980731; date2 = 19981231; output;
   permno = 12490; date1 = 19970101; date2 = 19971231; output;
   permno = 14322; date1 = 19950731; date2 = 19960131; output;
   permno = 25778; date1 = 19950101; date2 = 19950331; output;
run;

libname mstk2 sasecrsp '/mydata/crspeng/m_sampdata/' setid=20
   inset='testin2,PERMNO,PERMNO,DATE1,DATE2';

data b;
   set mstk2.prc;
run;

proc print data=b;
run;
```

**Output 1.4.1.** Printout of PRC Monthly Time Series Using INSET= Option

```
                          The SAS System                               1
         Second INSET=testin2 uses date ranges along with PERMNOs:
                        10107, 12490, 14322, 25788
      Begin dates and end dates for each permno are used in the INSET

                Obs      PERMNO    CALDT              PRC

                  1       10107    19980731       109.93750
                  2       10107    19980831        95.93750
                  3       10107    19980930       110.06250
                  4       10107    19981030       105.87500
                  5       10107    19981130       122.00000
                  6       10107    19981231       138.68750
                  7       12490    19970131       156.87500
                  8       12490    19970228       143.75000
                  9       12490    19970331       137.25000
                 10       12490    19970430       160.50000
                 11       12490    19970530        86.50000
                 12       12490    19970630        90.25000
                 13       12490    19970731       105.75000
                 14       12490    19970829       101.37500
                 15       12490    19970930       106.00000
                 16       12490    19971031        98.50000
                 17       12490    19971128       109.50000
                 18       12490    19971231       104.62500
                 19       14322    19950731        32.62500
                 20       14322    19950831        32.37500
                 21       14322    19950929        36.87500
                 22       14322    19951031        34.00000
                 23       14322    19951130        39.37500
                 24       14322    19951229        39.00000
                 25       14322    19960131        41.50000
                 26       25778    19950131        49.87500
                 27       25778    19950228        57.25000
                 28       25778    19950331        59.37500
```

## Example 1.5. Converting Dates Using the CRSP Date Functions

This example shows how to use the CRSP date functions and formats. The CRSPDTD formats are used for all the crspdt variables, while the YYMMDD format is used for the sasdt variables.

```
title2 'OUT= Data Set';
title3 'CRSP Functions for sasecrsp';
title4 'Always assign the libname sasecrsp first';

libname mstk sasecrsp '/mydata/crspeng/m_sampdata/' setid=20;

data a (keep = crspdt crspdt2 crspdt3
               sasdt sasdt2 sasdt3
               intdt intdt2 intdt3);
   format crspdt crspdt2 crspdt3 crspdtd8.;
   format sasdt sasdt2 sasdt3 yymmdd6.;
   format intdt intdt2 intdt3 8.;
   format exact 2.;
   crspdt = 1;
   sasdt = '2jul1962'd;
   intdt = 19620702;
   exact = 0;

/* Call the CRSP date to Integer function*/
   intdt2 = crspdcid(crspdt);

/* Call the SAS date to Integer function*/
   intdt3 = crspds2i(sasdt);

/* Call the Integer to Crsp date function*/
   crspdt2 = crspdicd(intdt,exact);

/* Call the Sas date to Crsp date conversion function*/
   crspdt3 = crspdscd(sasdt,exact);

/* Call the CRSP date to SAS date conversion function*/
   sasdt2 = crspdcsd(crspdt);

/* Call the Integer to Sas date conversion function*/
   sasdt3 = crspdi2s(intdt);
   run;

proc print;
   run;

title2 'Proc CONTENTS showing formats for sasecrsp';
proc contents data=a;
   run;
```

**Output 1.5.1.** Printout of Date Conversions Using the CRSP Date Functions

```
                                The SAS System                              1
                                OUT= Data Set
                         CRSP Functions for sasecrsp
                   Always assign the libname sasecrsp first

Obs crspdt   crspdt2  crspdt3   sasdt sasdt2 sasdt3    intdt   intdt2   intdt3

 1  19620702 19620702 19620702 620702 620702 620702 19620702 19620702 19620702

                  Proc CONTENTS showing formats for sasecrsp
                         CRSP Functions for sasecrsp
                   Always assign the libname sasecrsp first

                            The CONTENTS Procedure

Data Set Name: WORK.A                                  Observations:         1
Member Type:   DATA                                    Variables:            9
Engine:        V8                                      Indexes:              0
Created:       13:15 Monday, November 27, 2000         Observation Length:   72
Last Modified: 13:15 Monday, November 27, 2000         Deleted Observations: 0
Protection:                                            Compressed:           NO
Data Set Type:                                         Sorted:               NO
Label:


                  -----Engine/Host Dependent Information-----

       Data Set Page Size:         8192
       Number of Data Set Pages:   1
       First Data Page:            1
       Max Obs per Page:           113
       Obs in First Data Page:     1
       Number of Data Set Repairs: 0
       File Name:                  /tmp/SAS_work67560000352F/a.sas7bdat
       Release Created:            8.0202M0
       Host Created:               HP-UX
       Inode Number:               414
       Access Permission:          rw-r--r--
       Owner Name:                 saskff
       File Size (bytes):          16384


              -----Alphabetic List of Variables and Attributes-----

                #    Variable    Type    Len    Pos    Format
                ------------------------------------------------
                1    crspdt      Num       8      0    CRSPDTD8.
                2    crspdt2     Num       8      8    CRSPDTD8.
                3    crspdt3     Num       8     16    CRSPDTD8.
                7    intdt       Num       8     48    8.
                8    intdt2      Num       8     56    8.
                9    intdt3      Num       8     64    8.
                4    sasdt       Num       8     24    YYMMDD6.
                5    sasdt2      Num       8     32    YYMMDD6.
                6    sasdt3      Num       8     40    YYMMDD6.
```

# References

Center for Research in Security Prices (2000), *CRSP Data Description Guide*, Chicago: The University of Chicago Graduate School of Business, [http://www.crsp.uchicago.edu/file_guides/stock_ind_data_descriptions.pdf].

Center for Research in Security Prices (2000), *CRSP Programmer's Guide*, Chicago: The University of Chicago Graduate School of Business, [http://www.crsp.uchicago.edu/file_guides/stock_ind_programming.pdf].

Center for Research in Security Prices (2000), *CRSPAccess Database Format Release Notes*, Chicago: The University of Chicago Graduate School of Business, [http://www.crsp.uchicago.edu/file_guides/ca_release_notes.pdf].

Center for Research in Security Prices (2000), *CRSP Utilities Guide*, Chicago: The University of Chicago Graduate School of Business, [http://www.crsp.uchicago.edu/file_guides/stock_ind_utilities.pdf].

Center for Research in Security Prices (2000), *CRSP SFA Guide*, Chicago: The University of Chicago Graduate School of Business, [http://www.crsp.uchicago.edu/file_guides/stock_ind_sfa.pdf].

# Chapter 2
# The SASEFAME Interface Engine

## Chapter Table of Contents

# Chapter 2
# The SASEFAME Interface Engine

## Overview

The SASEFAME interface engine enables SAS users to access and process time series data residing in a FAME database, and provides a seamless interface between FAME and SAS data processing.

The SASEFAME engine uses the LIBNAME statement to enable you to specify which time series you would like to read from the FAME database, and how you would like to convert the selected time series to the same time scale. The SAS DATA step can then be used to perform further subsetting and to store the resulting time series into a SAS data set. You can perform more analysis if desired either in the same SAS session or in another session at a later time.

## Getting Started

### Using Remote FAME Data Access

There are two ways to access your remote FAME data bases. The first way is to use SAS/CONNECT to submit a remote SAS session to your FAME server, and then use PROC DOWNLOAD to bring your results back to your SAS client. For an illustration, see Example 2.1. You can also refer to *Communications Access Methods for SAS/CONNECT and SAS/SHARE Software* for more about SAS/CONNECT.

The second way uses an experimental feature of the SASEFAME interface where the FAME CHLI communicates with your remote FAME server using the frdb_m port number and the node name of your FAME master server in your *libref*. For an illustration, see Example 2.2. You can also refer to “Starting the Master Server” in the *Guide to FAME Database Servers*.

# Syntax

The SASEFAME engine uses standard engine syntax. Options used by SASEFAME are summarized in the following table.

| Description | Statement | Option |
|---|---|---|
| specifies the FAME frequency and the FAME technique. | LIBNAME *libref* SASEFAME | CONVERT= |
| specifies a FAME wildcard to match data object series names within the FAME database, which limits the selection of time series that are included in the SAS data set. | LIBNAME *libref* SASEFAME | WILDCARD= |

## The LIBNAME *libref* SASEFAME Statement

**LIBNAME** *libref* **SASEFAME 'physical name'** *options;*

If you are accessing a remote FAME database using FAME CHLI, you can use the following syntax for *physical name* :
'**#port number\@hostname physical path name**'

# Examples

## Example 2.1. Remote FAME Access, Using SAS CONNECT

Suppose you are running SAS in a client/server environment and have SAS/CONNECT capability allowing you access to your FAME server. You could access your FAME remote data by signing on to your FAME server from your client session and doing a remote submit to access your FAME data. You could then use PROC DOWNLOAD to bring your remote data into the local client SAS session.

If you start your program by signing on to the remote server and checking your FAME environment variable definitions, your code might look like this:

```
options validvarname=any;
/* VALIDVARNAME set to ANY allows
   glue character in the time series names */

%let remnode=mysunbox.unx.sas.com;
/* name the sastcpd service for the connection */
signon remnode.shr2;
rsubmit;

%let FAME=%sysget(FAME);
%put(&FAME);

options validvarname=any;
libname lib1 sasefame "/usr/local/famelib/util"
             convert=(frequency=annual technique=constant)
             wildcard="?";
```

Here is the corresponding segment of the SAS log showing the remote sign-on process and the definition of the FAME environment variable on the remote host, as well as the warning generated when you use the VALIDVARNAME option allowing special characters in your SAS variable names:

**Output 2.1.1.** SAS Log of the SAS/CONNECT Remote Access to FAME Data

```
1                    The SAS System
NOTE: Copyright (c) 1999-2000 by SAS Institute Inc., Cary, NC, USA.
NOTE: SAS (r) Proprietary Software Release 8.2 (TS02.02M0D05092000)
      Licensed to SAS Institute Inc., Site 0000000001.
NOTE: This session is executing on the HP-UX B.10.20 platform.

          options validvarname=any;
WARNING: VALIDVARNAME=ANY is an experimental option.  The DATA Step and
         the SQL procedure have been tested for use with this
         option.  Other use of this option may cause undetected errors.
2
3          %let remnode=mysunbox.unx.sas.com;
4
5
6          /* use this one on the AIX box
7          filename rlink '/users/myuser/connect/sunbox.scr';
8           */
9          /* use this one on H8X */
10         filename rlink '/u/myuser/connect/sunbox.scr';
11
12         /* options remote=remnode comamid=tcp;  */
13         signon remnode.shr2;
NOTE: Remote signon to REMNODE.SHR2 commencing (SAS Release 8.02.02M0D050900).
SESSION ESTABLISHED
TRACE:    Stop;
NOTE: End of script file trace.
NOTE: Copyright (c) 1999-2000 by SAS Institute Inc., Cary, NC, USA.
NOTE: SAS (r) Proprietary Software Release 8.1 (TS01.01M0P05082000)
      Licensed to SAS Institute Y2K Testing, Site 0000000001.
NOTE: This session is executing on the SunOS 5.6 platform.
This message is contained in the SAS news file, and is presented upon
initialization.  Edit the files "news" in the "misc/base" directory to
display site-specific news and information in the program log.
The command line option "-nonews" will prevent this display.
NOTE: SAS initialization used:
      real time           0.26 seconds
      cpu time            0.25 seconds

NOTE: Remote signon to REMNODE.SHR2 complete.
14         rsubmit;

NOTE: Remote submit to REMNODE.SHR2 commencing.
1    %let FAME=%sysget(FAME);
2    %put(&FAME);
(/usr/local/famelib80)
3
4    options mprint validvarname=any;
WARNING: VALIDVARNAME=ANY is an experimental option.  The DATA Step and
         the SQL procedure have been tested for use with this option.
         Other use of this option may cause undetected errors.
5
NOTE: Libref LIB1 was successfully assigned as follows:
      Engine:        FAMECHLI
      Physical Name: /usr/local/famelib/util
```

Next, you would use your libname assignment to access the remote data like this:

```
data oecd1;
   set lib1.oecd1;
run;

title2 'OECD1: PRINT Procedure';
```

```
proc print data=oecd1(obs=10);
run;

title2 'OECD1: CONTENTS Procedure';
proc contents data=oecd1;
run;

proc sort data=oecd1;
   by date;
run;

title2 'OECD1: MEANS Procedure';
proc means data=oecd1 sum;
   by date;
   var 'fin.herd'n;
run;

proc download inlib=work  /* remote SASWORK */
   outlib=work;  /* local SASWORK */
run;


proc datasets lib=work;
   contents data=_ALL_;
run;

endrsubmit;
signoff;

/* NOW the local work has the fame data */
proc datasets lib=work;
   contents data=_ALL_;
run;
```

Here is the remainder of the segment of the SAS log showing the download process and the remote sign-off along with the PROC DATASETS work directory results:

**Output 2.1.2.** SAS Log of the SAS/CONNECT Remote Access to FAME Data

```
NOTE: Download in progress from data=WORK.OECD1 to out=WORK.OECD1
NOTE: 2744 bytes were transferred at 52406 bytes/second.
NOTE: The data set WORK.OECD1 has 7 observations and 49 variables.
NOTE: Downloaded 7 observations of 49 variables.
NOTE: The data set WORK.OECD1 has 7 observations and 49 variables.

NOTE: PROCEDURE DOWNLOAD used:
      real time           2.71 seconds
      cpu time            0.04 seconds

275  proc datasets lib=work;

                -----Directory-----
    Libref:            WORK
    Engine:            V8
    Physical Name:     /usr/tmp/SAS_work3EEB00002CC4_sunbox
    File Name:         /usr/tmp/SAS_work3EEB00002CC4_sunbox
    Inode Number:      212060504
    Access Permission: rwxrwxrwx
    Owner Name:        myuser
                -----Directory-----
    File Size (bytes): 398
                               File
        #  Name     Memtype    Size  Last Modified
        -------------------------------------------------
        1  OECD1    DATA      40960   10MAY2000:13:19:58

277      contents data=_ALL_;
278  run;

NOTE: Remote submit to REMNODE.SHR2 complete.
15         signoff;
NOTE: Remote signoff from REMNODE.SHR2 commencing.
NOTE: The PROCEDURE DATASETS printed pages 43-48.
NOTE: PROCEDURE DATASETS used:
      real time           0.17 seconds
      cpu time            0.09 seconds

NOTE: Remote signoff from REMNODE.SHR2 complete.
16
17         proc datasets lib=work;
                -----Directory-----
    Libref:            WORK
    Engine:            V8
                -----Directory-----
    Physical Name:     /tmp/SAS_workDF8500003D1D
    File Name:         /tmp/SAS_workDF8500003D1D
    Inode Number:      1089
    Access Permission: rwxr-xr-x
    Owner Name:        myuser
    File Size (bytes): 1024

                         File
  #  Name     Memtype    Size  Last Modified
  -------------------------------------------------
  1  OECD1    DATA      40960   10MAY2000:13:20:03

            /* NOW the local work has the fame data */
18
19            contents data=_ALL_;
20         run;

21
22         endsas;
```

**Output 2.1.3.** Printout of the SAS/CONNECT Remote Access to FAME Data

```
             ***fameproc: Using FAME with a multitude of SAS Procs***          1
                               OECD1: PRINT Procedure

          AUS.              AUT.              BEL.              CAN.
Obs DATE  DIRDES AUS.HERD  DIRDES AUT.HERD  DIRDES BEL.HERD  DIRDES CAN.HERD

 1  1985    .         .   360.900  5990.60 334.700 14936.00 1345.90   1642
 2  1986 680.400   881.70    .         .   341.300 15459.80 1435.30   1755
 3  1987 725.800   983.80    .         .   369.200 16614.30 1486.50   1849
 4  1988 750.000  1072.90    .         .   374.000 16572.70 1589.60   2006
 5  1989    .         .      .         .      .    18310.70 1737.00   2214
 6  1990    .         .      .         .      .    18874.20 1859.20   2347
 7  1991    .         .      .         .      .         .   1959.60   2488

     CHE.              DEU.              DNK.              ESP.
Obs  DIRDES CHE.HERD  DIRDES DEU.HERD  DIRDES DNK.HERD  DIRDES ESP.HERD

 1     .         .   2702.10  6695.70 191.300  1873.70 335.500  31987.0
 2  366.600    900       .    7120.00 211.700  2123.00 354.800  36778.0
 3     .         .   3365.60  8338.50 232.700  2372.00 409.900  43667.0
 4  632.100   1532   3538.60  8780.00 258.100  2662.00 508.200  55365.5
 5     .      1648   3777.20  9226.60 284.800  2951.00 623.600  69270.5
 6     .         .   2953.30  9700.00    .         .   723.600  78848.0
 7     .         .       .        .      .         .      .     89908.0

     FIN.              FRA.              GBR.              GRC.
Obs  DIRDES FIN.HERD  DIRDES FRA.HERD  DIRDES GBR.HERD  DIRDES GRC.HERD

 1  183.700  1097.00 2191.60 15931.00 2068.40  1174.00    .         .
 2  202.000  1234.00 2272.90 17035.00 2226.10  1281.00  44.600  3961.00
 3  224.300  1401.30 2428.70 18193.00 2381.10  1397.20    .         .
 4  247.700  1602.00 2573.50 19272.00 2627.00  1592.00  60.600  6674.50
 5  259.700  1725.50 2856.50 21347.80 2844.10  1774.20 119.800 14485.20
 6  271.000  1839.00 3005.20 22240.00     .        .      .         .
 7     .         .       .        .       .        .      .         .

     IRL.              ISL.              ITA.              JPN.
Obs  DIRDES IRL.HERD  DIRDES ISL.HERD  DIRDES ITA.HERD  DIRDES  JPN.HERD

 1  39.2000  28.3707  7.1000  268.300 1344.90  1751008  8065.70  1789780
 2  46.5000  35.0000   .          .   1460.60  2004453  8290.10  1832575
 3  48.1000  36.0380  7.8000  420.400 1674.40  2362102  9120.80  1957921
 4  49.6000  37.0730   .          .   1861.50  2699927  9657.20  2014073
 5  50.2000  39.0130 10.3000  786.762 1968.00  2923504 10405.90  2129372
 6  51.7000     .    11.0000  902.498 2075.00  3183071      .    2296992
 7    .         .    11.8000  990.865 2137.80  3374000      .          .

     NLD.              NOR.              NZL.              PRT.
Obs  DIRDES NLD.HERD  DIRDES NOR.HERD  DIRDES NZL.HERD  DIRDES PRT.HERD

 1  798.400   2032   209.000  1802.50 59.2000   80.100    .         .
 2  836.000   2093      .         .      .         .    76.700  5988.90
 3  886.500   2146   250.000  2165.80    .         .      .         .
 4  883.000   2105      .         .      .         .   111.500 10158.20
 5  945.000   2202   308.900  2771.40 78.7000  143.800    .         .
 6     .         .      .         .      .         .      .         .
 7     .         .   352.000  3100.00    .         .      .         .

     SWE.              TUR.              USA.               YUG.
Obs  DIRDES SWE.HERD  DIRDES TUR.HERD  DIRDES  USA.HERD  DIRDES YUG.HERD

 1   840.10    6844  144.800   22196  14786.00 14786.00 175.900     1.87
 2     .         .   136.400   26957  16566.90 16566.90 208.600     4.10
 3  1016.90    8821  121.900   32309  18326.10 18326.10 237.000    10.21
 4     .         .   174.400   74474  20246.20 20246.20 233.000    29.81
 5  1076.00   11104  212.300  143951  22159.50 22159.50 205.100   375.22
 6     .         .      .          .  23556.10 23556.10    .     2588.50
 7     .         .      .          .  24953.80 24953.80    .         .
```

**Output 2.1.4.** PROC CONTENTS of the Remote FAME Data on the SUN Server Node

```
              ***fameproc: Using FAME on Remote Server ***
                             OECD1: CONTENTS Procedure
                               The CONTENTS Procedure

    Data Set Name: WORK.OECD1                            Observations:         7
    Member Type:   DATA                                  Variables:            49
    Engine:        V8                                    Indexes:              0
    Created:       13:19 Wednesday, May 10, 2000         Observation Length:   392
    Last Modified: 13:19 Wednesday, May 10, 2000         Deleted Observations: 0
    Protection:                                          Compressed:           NO
    Data Set Type:                                       Sorted:               NO
    Label:
                      -----Engine/Host Dependent Information-----

    Data Set Page Size:         32768
    Number of Data Set Pages:   1
    First Data Page:            1
    Max Obs per Page:           83
    Obs in First Data Page:     7
    Number of Data Set Repairs: 0
    File Name:                  /usr/tmp/SAS_work3EEB00002CC4_sunbox/oecd1.sas7bdat
    Release Created:            8.0101M0
    Host Created:               SunOS
    Inode Number:               211927040
    Access Permission:          rw-rw-rw-
    Owner Name:                 myuser
    File Size (bytes):          40960
```

**Output 2.1.5.** PROC CONTENTS of the Remote FAME Data on the SUN Server Node

```
                ***fameproc: Using FAME on Remote Server ***
                              OECD1: CONTENTS Procedure
                                The CONTENTS Procedure

                -----Alphabetic List of Variables and Attributes-----

 #    Variable      Type    Len    Pos    Format    Informat    Label
------------------------------------------------------------------------------------
 2    AUS.DIRDES    Num       8      8
 3    AUS.HERD      Num       8     16
 4    AUT.DIRDES    Num       8     24
 5    AUT.HERD      Num       8     32
 6    BEL.DIRDES    Num       8     40
 7    BEL.HERD      Num       8     48
 8    CAN.DIRDES    Num       8     56
 9    CAN.HERD      Num       8     64
10    CHE.DIRDES    Num       8     72
11    CHE.HERD      Num       8     80
 1    DATE          Num       8      0    YEAR4.    4.          Date of Observation
12    DEU.DIRDES    Num       8     88
13    DEU.HERD      Num       8     96
14    DNK.DIRDES    Num       8    104
15    DNK.HERD      Num       8    112
16    ESP.DIRDES    Num       8    120
17    ESP.HERD      Num       8    128
18    FIN.DIRDES    Num       8    136
19    FIN.HERD      Num       8    144
20    FRA.DIRDES    Num       8    152
21    FRA.HERD      Num       8    160
22    GBR.DIRDES    Num       8    168
23    GBR.HERD      Num       8    176
24    GRC.DIRDES    Num       8    184
25    GRC.HERD      Num       8    192
26    IRL.DIRDES    Num       8    200
27    IRL.HERD      Num       8    208
28    ISL.DIRDES    Num       8    216
29    ISL.HERD      Num       8    224
30    ITA.DIRDES    Num       8    232
31    ITA.HERD      Num       8    240
32    JPN.DIRDES    Num       8    248
33    JPN.HERD      Num       8    256
34    NLD.DIRDES    Num       8    264
35    NLD.HERD      Num       8    272
36    NOR.DIRDES    Num       8    280
37    NOR.HERD      Num       8    288
38    NZL.DIRDES    Num       8    296
39    NZL.HERD      Num       8    304
40    PRT.DIRDES    Num       8    312
41    PRT.HERD      Num       8    320
42    SWE.DIRDES    Num       8    328
43    SWE.HERD      Num       8    336
44    TUR.DIRDES    Num       8    344
45    TUR.HERD      Num       8    352
46    USA.DIRDES    Num       8    360
47    USA.HERD      Num       8    368
48    YUG.DIRDES    Num       8    376
49    YUG.HERD      Num       8    384
```

**Output 2.1.6.** PROC MEANS and PROC TABULATE of Remote FAME Data

```
    ***fameproc: Using FAME with a multitude of SAS Procs***
                    OECD1: MEANS Procedure

------------------ Date of Observation=1985 ------------------
                     The MEANS Procedure

                 Analysis Variable : FIN.HERD
                                  Sum
                         ------------
                              1097.00
                         ------------
------------------ Date of Observation=1986 ------------------
                 Analysis Variable : FIN.HERD
                                  Sum
                         ------------
                              1234.00
                         ------------
------------------ Date of Observation=1987 ------------------
                 Analysis Variable : FIN.HERD
                                  Sum
                         ------------
                              1401.30
                         ------------
------------------ Date of Observation=1988 ------------------
                 Analysis Variable : FIN.HERD
                                  Sum
                         ------------
                              1602.00
                         ------------
------------------ Date of Observation=1989 ------------------
                 Analysis Variable : FIN.HERD
                                  Sum
                         ------------
                              1725.50
                         ------------
------------------ Date of Observation=1990 ------------------
                     The MEANS Procedure

                 Analysis Variable : FIN.HERD
                                  Sum
                         ------------
                              1839.00
                         ------------
------------------ Date of Observation=1991 ------------------
                 Analysis Variable : FIN.HERD
                                  Sum
                         ------------
                                    .
                         ------------

                  OECD1: TABULATE Procedure

                        --------------
                        |  FIN.HERD  |
                        |------------|
                        |    Sum     |
                        |------------|
                        |     8898.80|
                        --------------
```

**Output 2.1.7.** PROC CONTENTS of the Remote FAME Data on the HP-UX Client Node

```
                          The DATASETS Procedure

Data Set Name: WORK.OECD1                             Observations:          7
Member Type:   DATA                                   Variables:             49
Engine:        V8                                     Indexes:               0
Created:       13:20 Wednesday, May 10, 2000          Observation Length:    392
Last Modified: 13:20 Wednesday, May 10, 2000          Deleted Observations:  0
Protection:                                           Compressed:            NO
Data Set Type:                                        Sorted:                YES
Label:

                  -----Engine/Host Dependent Information-----

      Data Set Page Size:         32768
      Number of Data Set Pages:   1
      First Data Page:            1
      Max Obs per Page:           83
      Obs in First Data Page:     7
      Number of Data Set Repairs: 0
      File Name:                  /tmp/SAS_workDF8500003D1D/oecd1.sas7bdat
      Release Created:            8.0202M0
      Host Created:               HP-UX
      Inode Number:               1452
      Access Permission:          rw-r--r--
      Owner Name:                 myuser
      File Size (bytes):          40960
```

**Output 2.1.8.** PROC CONTENTS of the Remote FAME Data on the HP-UX Client Node

```
           ***fameproc: Using FAME with a multitude of SAS Procs***          1
                              OECD1: CONTENTS Procedure
                                The CONTENTS Procedure

                 -----Alphabetic List of Variables and Attributes-----

 #    Variable      Type    Len    Pos    Format    Informat    Label
---------------------------------------------------------------------------------
 2    AUS.DIRDES    Num       8      8
 3    AUS.HERD      Num       8     16
 4    AUT.DIRDES    Num       8     24
 5    AUT.HERD      Num       8     32
 6    BEL.DIRDES    Num       8     40
 7    BEL.HERD      Num       8     48
 8    CAN.DIRDES    Num       8     56
 9    CAN.HERD      Num       8     64
10    CHE.DIRDES    Num       8     72
11    CHE.HERD      Num       8     80
 1    DATE          Num       8      0    YEAR4.    4.          Date of Observation
12    DEU.DIRDES    Num       8     88
13    DEU.HERD      Num       8     96
14    DNK.DIRDES    Num       8    104
15    DNK.HERD      Num       8    112
16    ESP.DIRDES    Num       8    120
17    ESP.HERD      Num       8    128
18    FIN.DIRDES    Num       8    136
19    FIN.HERD      Num       8    144
20    FRA.DIRDES    Num       8    152
21    FRA.HERD      Num       8    160
22    GBR.DIRDES    Num       8    168
23    GBR.HERD      Num       8    176
24    GRC.DIRDES    Num       8    184
25    GRC.HERD      Num       8    192
26    IRL.DIRDES    Num       8    200
27    IRL.HERD      Num       8    208
28    ISL.DIRDES    Num       8    216
29    ISL.HERD      Num       8    224
30    ITA.DIRDES    Num       8    232
31    ITA.HERD      Num       8    240
32    JPN.DIRDES    Num       8    248
33    JPN.HERD      Num       8    256
34    NLD.DIRDES    Num       8    264
35    NLD.HERD      Num       8    272
36    NOR.DIRDES    Num       8    280
37    NOR.HERD      Num       8    288
38    NZL.DIRDES    Num       8    296
39    NZL.HERD      Num       8    304
40    PRT.DIRDES    Num       8    312
41    PRT.HERD      Num       8    320
42    SWE.DIRDES    Num       8    328
43    SWE.HERD      Num       8    336
44    TUR.DIRDES    Num       8    344
45    TUR.HERD      Num       8    352
46    USA.DIRDES    Num       8    360
47    USA.HERD      Num       8    368
48    YUG.DIRDES    Num       8    376
49    YUG.HERD      Num       8    384

                              -----Sort Information-----

                                 Sortedby:      DATE
                                 Validated:     YES
                                 Character Set: ASCII
```

## Example 2.2. Remote FAME Access, Using FAME CHLI

Suppose you are running FAME in a client/server environment and have FAME CHLI capability allowing you access to your FAME server. You could access your FAME remote data by specifying the port number of the tcpip service that is defined for your frdb_m and the node name of your FAME master server in your physical path. In the following example, the FAME server node name is booker, and the port number is 5555, which was designated in the FAME master command. Refer to “Starting the Master Server” in the *Guide to FAME Database Servers* for more about starting your FAME master server.

```
 /* DRIECON Database, Using FAME with REMOTE ACCESS VIA CHLI */
 /*********************************************************/

libname test1 sasefame '#5555\@booker \$FAME/util';
data a;
   set test1.driecon;
   run;

proc contents data=a;
   run;
proc means data=a n;
   run;
```

Your log will show the FAME databases that are read in for conversion:

**Output 2.2.1.** SAS Log Segment of the FAME CHLI Remote Access to FAME Data

```
22          /* DRIECON Database, Using FAME with REMOTE ACCESS VIA HLI */
23          /************************************************************/
24
25         libname test1 sasefame '#5555\@booker \$FAME/util';
WARNING: Remote access using the FAME CHLI is an experimental feature of the
         FAME Engine. Please make sure your port number is defined correctly
         on your frdb_m master server.
NOTE: Libref TEST1 was successfully assigned as follows:
      Engine:        FAMECHLI
      Physical Name: #5555\@booker \$FAME/util
26         data a;
27            set test1.driecon;
$N -- SERIES (PRECISION by MONTHLY)
$N copied to work data base as $N.
BOPMERCH -- SERIES (PRECISION by QUARTERLY)
BOPMERCH copied to work data base as BOPMERCH.
CUSA0 -- SERIES (PRECISION by MONTHLY)
CUSA0 copied to work data base as CUSA0.
CUSA0NS -- SERIES (PRECISION by MONTHLY)
CUSA0NS copied to work data base as CUSA0NS.
DBTGFNS -- SERIES (PRECISION by MONTHLY)
DBTGFNS copied to work data base as DBTGFNS.
NOTE: DESC -- SERIES (STRING by CASE) rejected for conversion.
DJ30C -- SERIES (PRECISION by BUSINESS)
DJ30C copied to work data base as DJ30C.
DJ65CMC -- SERIES (PRECISION by BUSINESS)
DJ65CMC copied to work data base as DJ65CMC.
FBL3Y -- SERIES (PRECISION by BUSINESS)
FBL3Y copied to work data base as FBL3Y.
FCN30YY -- SERIES (PRECISION by BUSINESS)
FCN30YY copied to work data base as FCN30YY.
FIP1Q -- SERIES (PRECISION by BUSINESS)
FIP1Q copied to work data base as FIP1Q.
FIP30Q -- SERIES (PRECISION by BUSINESS)
FIP30Q copied to work data base as FIP30Q.
FSCD30Y -- SERIES (PRECISION by BUSINESS)
FSCD30Y copied to work data base as FSCD30Y.
GDP -- SERIES (PRECISION by QUARTERLY)
GDP copied to work data base as GDP.
GDP92C -- SERIES (PRECISION by QUARTERLY)
GDP92C copied to work data base as GDP92C.
GICV -- SERIES (PRECISION by MONTHLY)
GICV copied to work data base as GICV.
GNP -- SERIES (PRECISION by QUARTERLY)
GNP copied to work data base as GNP.
GNP92C -- SERIES (PRECISION by QUARTERLY)
GNP92C copied to work data base as GNP92C.
 .
 .
 .
JLAG -- SERIES (PRECISION by MONTHLY)
JLAG copied to work data base as JLAG.
JLEAD -- SERIES (PRECISION by MONTHLY)
JLEAD copied to work data base as JLEAD.
JQIND -- SERIES (PRECISION by MONTHLY)
JQIND copied to work data base as JQIND.
 .
 .
 .
NOTE: NAMES -- SERIES (STRING by CASE) rejected for conversion.
ZA.CP -- SERIES (PRECISION by ANNUAL)
ZB.CP -- SERIES (PRECISION by ANNUAL)
28            run;
NOTE: There were 53 observations read from the data set TEST1.DRIECON.
NOTE: The data set WORK.A has 53 observations and 53 variables.
```

**Output 2.2.2.** Printout of the FAME CHLI Remote Access to FAME Data

```
                              The SAS System                           1

                          The CONTENTS Procedure

Data Set Name: WORK.A                                 Observations:         53
Member Type:   DATA                                   Variables:            53
Engine:        V8                                     Indexes:              0
Created:       16:49 Friday, November 17, 2000        Observation Length:   424
Last Modified: 16:49 Friday, November 17, 2000        Deleted Observations: 0
Protection:                                           Compressed:           NO
Data Set Type:                                        Sorted:               NO
Label:


               -----Engine/Host Dependent Information-----

       Data Set Page Size:         40960
       Number of Data Set Pages:   1
       First Data Page:            1
       Max Obs per Page:           96
       Obs in First Data Page:     53
       Number of Data Set Repairs: 0
       File Name:                  /tmp/SAS_work30D40000397D/a.sas7bdat
       Release Created:            8.0202M0
       Host Created:               HP-UX
       Inode Number:               3076
       Access Permission:          rw-r--r--
       Owner Name:                 myuser
       File Size (bytes):          49152


            -----Alphabetic List of Variables and Attributes-----

 # Variable  Type Len Pos Format Informat Label
-----------------------------------------------------------------------------
 2 $N        Num    8   8                 POPULATION INCLUDING ARMED
                                          FORCES OVERSEAS (P25E)
 3 BOPMERCH  Num    8  16                 U.S. BALANCE ON MERCHANDISE
                                          TRADE (BOP)
 4 CUSA0     Num    8  24                 CPI (ALL URBAN) - ALL ITEMS
 5 CUSA0NS   Num    8  32                 CPIU - All items
 1 DATE      Num    8   0 YEAR4. 4.       Date of Observation
 6 DBTGFNS   Num    8  40
 7 DJ30C     Num    8  48                 DOW JONES: 30 INDUSTRIAL
                                          AVERAGE - CLOSE
 8 DJ65CMC   Num    8  56                 DOW JONES: 65 COMPOSITE AVERAGE
 9 FBL3Y     Num    8  64                 TREASURY BILL: SECONDARY, 3-MONTH
                                          BOND-EQUIVALENT YIELD (H15) - US
10 FCN30YY   Num    8  72                 GOVT ISSUE: CONSTANT MATURITY,
                                          30-YR (H15) - US
11 FIP1Q     Num    8  80                 COMMERCIAL PAPER: NON-FINAN,
                                          1-DAY QUOTED YIELD - US
12 FIP30Q    Num    8  88                 COMMERCIAL PAPER: NON-FINAN,
                                          1-MO QUOTED YIELD - US
13 FSCD30Y   Num    8  96                 CD: SECONDARY MKT, 1-MO YIELD - US
14 GDP       Num    8 104                 GROSS DOMESTIC PRODUCT
15 GDP92C    Num    8 112                 GROSS DOMESTIC PRODUCT (CHAINED)
16 GICV      Num    8 120                 NEW CONSTRUCTION PUT IN PLACE
                                          - PUBLIC TOTAL (C30)
17 GNP       Num    8 128                 GROSS NATIONAL PRODUCT
18 GNP92C    Num    8 136                 GROSS NATIONAL PRODUCT
19 HUCMPNC   Num    8 144                 HOUSING COMPLETIONS, PRIVATE
                                          - NORTH CENTRAL (C22)
20 HUCMPNE   Num    8 152                 HOUSING COMPLETIONS, PRIVATE
                                          - NORTHEAST (C22)
21 HUCMPSO   Num    8 160                 HOUSING COMPLETIONS,
                                          PRIVATE - SOUTH (C22)
22 HUCMPWT   Num    8 168                 HOUSING COMPLETIONS, PRIVATE-WEST(C22)
```

**Output 2.2.3.** PROC CONTENTS of the Remote FAME Data

```
                                The SAS System                              2

                             The CONTENTS Procedure

                -----Alphabetic List of Variables and Attributes-----

 # Variable  Type Len Pos Format Informat Label
-----------------------------------------------------------------------------
23 HUSTS     Num    8 176                 HOUSING STARTS, PRIVATE INCLUDING
                                          FARM - TOTAL (C20)
24 HUSTS1    Num    8 184                 HOUSING STARTS, PRIVATE INCL
                                          FARM - ONE UNIT (C20)
25 HUSTS1NS  Num    8 192                 HOUSING STARTS, PRIVATE INCL
                                          FARM - ONE UNIT (C20)
26 I         Num    8 200                 GROSS PRIVATE DOMESTIC INVESTMENT
27 I92C      Num    8 208                 GROSS PRIVATE DOMESTIC
                                          INVESTMENT (CHAINED)
28 ICV_G     Num    8 216                 NEW CONSTRUCTION PUT IN
                                          PLACE - TOTAL (C30)
29 JCOIN%LAG Num    8 224                 RATIO, COINCIDENT INDEX
                                          TO LAGGING INDEX (BCI)
30 JLAG      Num    8 232                 LAGGING INDICATORS COMPOSITE
                                          INDEX (BCI)
31 JLEAD     Num    8 240                 LEADING INDICATORS COMPOSITE
                                          INDEX (BCI)
32 JQIND     Num    8 248                 INDUSTRIAL PROD INDEX
                                          - TOTAL INDEX (G17)
33 JQIND20   Num    8 256                 INDUSTRIAL PROD INDEX - FOODS (G17)
35 JQIND21   Num    8 272                 INDUSTRIAL PROD INDEX -
                                          TOBACCO PRODUCTS (G17)
36 JQIND26   Num    8 280                 INDUSTRIAL PROD INDEX -
                                          PAPER & PRODUCTS (G17)
37 JQIND28   Num    8 288                 INDUSTRIAL PROD INDEX - CHEMICALS
                                          & PRODUCTS (G17)
38 JQIND37   Num    8 296                 INDUSTRIAL PROD INDEX -
                                          TRANSPORTATION EQUIPMENT (G17)
39 JQIND39   Num    8 304                 INDUSTRIAL PROD INDEX -
                                          MISC MANUFACTURES (G17)
34 JQIND208  Num    8 264                 INDUSTRIAL PROD INDEX
                                          - BEVERAGES (G17)
40 JQINDEQPB Num    8 312                 INDUSTRIAL PROD INDEX -
                                          BUSINESS EQUIPMENT (G17)
41 MNY1      Num    8 320                 MONEY SUPPLY - CURRENCY, DEMAND
                                          DEPOSITS, OTHER CHECKABLE
                                          DEPOSITS (H6)
42 MNY2      Num    8 328                 MONEY SUPPLY - M2 (H6)
43 PIDGNP    Num    8 336                 IMPLICIT PRICE DEFLATOR -
                                          GROSS NATIONAL PRODUCT
44 RUC       Num    8 344                 UNEMPLOYMENT RATE - CIVILIAN (ESIT)
45 RXC132%   Num    8 352                 EXCHANGE RATE IN NEW YORK - FRENCH
   USNS                                   FRANC PER U.S. DOLLAR (G5)
46 RXC134%   Num    8 360                 EXCHANGE RATE IN NEW YORK - GERMAN
   USNS                                   MARK PER U.S. DOLLAR (G5)
47 RXC158%   Num    8 368                 EXCHANGE RATE IN NEW YORK -
   USNS                                   JAPANESE YEN PER U.S. DOLLAR (G5)
48 RXUS%     Num    8 376                 EXCHANGE RATE IN NEW YORK - U.S.
   C112NS                                 CENTS PER BRITISH POUND (G5)
49 STR       Num    8 384                 RETAIL SALES -TOTAL (RTR)
50 WPINS     Num    8 392                 PRODUCER PRICE INDEX -
                                          ALL COMMODITIES (PPI)
51 YP        Num    8 400                 PERSONAL INCOME
52 ZA        Num    8 408                 CORPORATE PROFITS AFTER
                                          TAX EXCLUDING IVA
53 ZB        Num    8 416                 CORPORATE PROFITS BEFORE
                                          TAX EXCLUDING IVA
```

**Output 2.2.4.** PROC MEANS of the Remote Fame Data

```
                    The SAS System                              4

                  The MEANS Procedure

                    Variable
                    -----------
                    DATE
                    $N
                    BOPMERCH
                    CUSA0
                    CUSA0NS
                    DBTGFNS
                    DJ30C
                    DJ65CMC
                    FBL3Y
                    FCN30YY
                    FIP1Q
                    FIP30Q
                    FSCD30Y
                    GDP
                    GDP92C
                    GICV
                    GNP
                    GNP92C
                    HUCMPNC
                    HUCMPNE
                    HUCMPSO
                    HUCMPWT
                    HUSTS
                    HUSTS1
                    HUSTS1NS
                    I
                    I92C
                    ICV_G
                    JCOIN%LAG
                    JLAG
                    JLEAD
                    JQIND
                    JQIND20
                    JQIND208
                    JQIND21
                    JQIND26
                    JQIND28
                    JQIND37
                    JQIND39
                    JQINDEQPB
                    MNY1
                    MNY2
                    PIDGNP
                    RUC
                    RXC132%USNS
                    RXC134%USNS
                    RXC158%USNS
                    RXUS%C112NS
                    STR
                    WPINS
                    YP
                    ZA
                    ZB
                    -----------
```

**Output 2.2.5.** PROC MEANS of the Remote FAME Data

```
                               The SAS System                               5

                            The MEANS Procedure

Label                                                                      N
----------------------------------------------------------------------------
Date of Observation                                                       53
POPULATION INCLUDING ARMED FORCES OVERSEAS (P25E)                         49
U.S. BALANCE ON MERCHANDISE TRADE (BOP)                                   39
CPI (ALL URBAN) - ALL ITEMS                                               52
CPIU - All items                                                          52
                                                                          41
DOW JONES: 30 INDUSTRIAL AVERAGE - CLOSE                                  19
DOW JONES: 65 COMPOSITE AVERAGE                                           19
TREASURY BILL: SECONDARY, 3-MONTH BOND-EQUIVALENT YIELD (H15) - US        20
GOVT ISSUE: CONSTANT MATURITY, 30-YR (H15) - US                           22
COMMERCIAL PAPER: NON-FINAN, 1-DAY QUOTED YIELD - US                       1
COMMERCIAL PAPER: NON-FINAN, 1-MO QUOTED YIELD - US                       20
CD: SECONDARY MKT, 1-MO YIELD - US                                        23
GROSS DOMESTIC PRODUCT                                                    53
GROSS DOMESTIC PRODUCT (CHAINED)                                          52
NEW CONSTRUCTION PUT IN PLACE - PUBLIC TOTAL (C30)                        35
GROSS NATIONAL PRODUCT                                                    53
GROSS NATIONAL PRODUCT                                                    52
HOUSING COMPLETIONS, PRIVATE - NORTH CENTRAL (C22)                        20
HOUSING COMPLETIONS, PRIVATE - NORTHEAST (C22)                            20
HOUSING COMPLETIONS, PRIVATE - SOUTH (C22)                                20
HOUSING COMPLETIONS, PRIVATE - WEST (C22)                                 20
HOUSING STARTS, PRIVATE INCLUDING FARM - TOTAL (C20)                      52
HOUSING STARTS, PRIVATE INCL FARM - ONE UNIT (C20)                        40
HOUSING STARTS, PRIVATE INCL FARM - ONE UNIT (C20)                        40
GROSS PRIVATE DOMESTIC INVESTMENT                                         53
GROSS PRIVATE DOMESTIC INVESTMENT (CHAINED)                               52
NEW CONSTRUCTION PUT IN PLACE - TOTAL (C30)                               35
RATIO, COINCIDENT INDEX TO LAGGING INDEX (BCI)                            40
LAGGING INDICATORS COMPOSITE INDEX (BCI)                                  40
LEADING INDICATORS COMPOSITE INDEX (BCI)                                  40
INDUSTRIAL PROD INDEX - TOTAL INDEX (G17)                                 52
INDUSTRIAL PROD INDEX - FOODS (G17)                                       52
INDUSTRIAL PROD INDEX - BEVERAGES (G17)                                   45
INDUSTRIAL PROD INDEX - TOBACCO PRODUCTS (G17)                            52
INDUSTRIAL PROD INDEX - PAPER & PRODUCTS (G17)                            52
INDUSTRIAL PROD INDEX - CHEMICALS & PRODUCTS (G17)                        52
INDUSTRIAL PROD INDEX - TRANSPORTATION EQUIPMENT (G17)                    52
INDUSTRIAL PROD INDEX - MISC MANUFACTURES (G17)                           52
INDUSTRIAL PROD INDEX - BUSINESS EQUIPMENT (G17)                          52
MONEY SUPPLY - CURRENCY, DEMAND DEPOSITS, OTHER CHECKABLE DEPOSITS (H6)   40
MONEY SUPPLY - M2 (H6)                                                    40
IMPLICIT PRICE DEFLATOR -  GROSS NATIONAL PRODUCT                         52
UNEMPLOYMENT RATE - CIVILIAN (ESIT)                                        9
EXCHANGE RATE IN NEW YORK - FRENCH FRANC PER U.S. DOLLAR (G5)             32
EXCHANGE RATE IN NEW YORK - GERMAN MARK PER U.S. DOLLAR (G5)              32
EXCHANGE RATE IN NEW YORK - JAPANESE YEN PER U.S. DOLLAR (G5)             32
EXCHANGE RATE IN NEW YORK - U.S. CENTS PER BRITISH POUND (G5)             32
RETAIL SALES -TOTAL (RTR)                                                 32
PRODUCER PRICE INDEX - ALL COMMODITIES (PPI)                              52
PERSONAL INCOME                                                           53
CORPORATE PROFITS AFTER TAX EXCLUDING IVA                                 53
CORPORATE PROFITS BEFORE TAX EXCLUDING IVA                                53
----------------------------------------------------------------------------
```

# References


DRI/McGraw-Hill (1997), *DataLink*, Lexington, MA.

DRI/McGraw-Hill Data Search and Retrieval for Windows (1996), *DRIPRO User's Guide*, Lexington, MA.

FAME Information Services (1995), *Command Reference for Release 7.6, Vols. 1 and 2*, Ann Arbor, MI.

FAME Information Services (1998), *Guide to FAME Database Servers*, New York, NY, [http://www.fame.com].

FAME Information Services (1995), *Reference Guide to Seamless C HLI*, Ann Arbor, MI.

FAME Information Services (1995), *User's Guide to FAME*, Ann Arbor, MI.

Organization for Economic Cooperation and Development (1992), *Annual National Accounts: Volume I. Main Aggregates Content Documentation for Magnetic Tape Subscription*, Paris, France.

Organization for Economic Cooperation and Development (1992), *Annual National Accounts: Volume II. Detailed Tables Technical Documentation for Magnetic Tape Subscription*, Paris, France.

Organization for Economic Cooperation and Development (1992), *Main Economic Indicators Database Note*, Paris, France.

Organization for Economic Cooperation and Development (1992), *Main Economic Indicators Inventory*, Paris, France.

Organization for Economic Cooperation and Development (1992), *Main Economic Indicators OECD Statistics on Magnetic Tape Document*, Paris, France.

Organization for Economic Cooperation and Development (1992), *OECD Statistical Information Research and Inquiry System Magnetic Tape Format Documentation*, Paris, France.

Organization for Economic Cooperation and Development (1992), *Quarterly National Accounts Inventory of Series Codes*, Paris, France.

Organization for Economic Cooperation and Development (1992), *Quarterly National Accounts Technical Documentation*, Paris, France.

SAS Institute Inc. (1996), *Communications Access Methods for SAS/CONNECT and SAS/SHARE Software,* Cary, NC: SAS Institute, Inc.

# Part 2
# Procedure Reference

## Table of Contents

Chapter 3

# The ARIMA Procedure

## Chapter Table of Contents

# Chapter 3
# The ARIMA Procedure

## Overview

The OUTLIER statement is a new enhancement to the ARIMA procedure. This statement is used as a diagnostic tool to detect shifts in the mean level of the response series that are not accounted for by the model in the preceding ESTIMATE statement. You can control different aspects of this detection process, such as the type and number of changes to detect, the significance level of the underlying tests, etc., by setting various options. Currently three types of changes in the mean level can be detected. These types are

- **A**dditive **O**utlier (AO), which represents a spurious change in one of the measurements
- **L**evel **S**hift (LS), which stands for a permanent shift in the level starting at some point in the observation period
- **T**emporary **C**hange (TC( [ *d* ] )), which represents a temporary change in the level of duration *d*

## Syntax

### OUTLIER Statement

**OUTLIER** *options;*

The OUTLIER statement applies to the model fitted in the preceding ESTIMATE statement. The following options are used in the OUTLIER statement:

**TYPE = ADDITIVE | SHIFT | TEMP(** $d_1, \ldots, d_k$ **)**

The TYPE= option specifies the types of level shifts to search for. The default is TYPE= (ADDITIVE SHIFT), which requests searching for additive outliers and permanent level shifts. The option TEMP( $d_1, \ldots, d_k$ ) requests searching for temporary changes in the level of durations $d_1, \ldots, d_k$. These options can also be abbreviated as AO, LS, and TC.

**ALPHA=** *significance-level*

The ALPHA= option specifies the significance level for tests in the OUTLIER statement. The default is 0.05.

**SIGMA= ROBUST | MSE**

The statistical tests performed during the outlier detection require an estimate of error variance. Using the SIGMA= option you can choose between two types of error variance estimates. SIGMA= MSE corresponds to the usual mean squared error (MSE) estimate, and SIGMA= ROBUST corresponds to a robust estimate of the error variance. The default is SIGMA= ROBUST.

**MAXNUM=** *number*
This option is used to limit the number of outliers to search. The default is MAXNUM= 5.

**MAXPCT=** *number*
This option is similar to MAXNUM= option. In the MAXPCT= option you can limit the number of outliers to search to a percentage of the series length. The default is MAXPCT= 2. When both of these options are specified, the smaller of the two search numbers is used.

The following examples illustrate the various possibilities for the OUTLIER statement.

```
outlier;
```

This sets all the options to their default values, that is, it is equivalent to

```
outlier type=(ao ls) alpha=0.05 sigma=robust
        maxnum=5 maxpct=2;
```

The following statement requests a search for permanent level shifts and for temporary level changes of durations 6 and 12. The search is limited to at most three changes, and the significance level of the underlying tests is 0.001. MSE is used as the estimate of error variance.

```
outlier type=(ls tc(6 12)) alpha=0.001 sigma=mse maxnum=3;
```

# Details

You can use the OUTLIER statement to detect changes in the level of the response series that are not accounted for by the currently estimated model. The types of changes considered are Additive Outliers (AO), Level Shifts (LS), and Temporary Changes (TC).

Let $\eta_t$ be a regression variable describing some type of change in the mean response. In time series literature $\eta_t$ is called a shock signature. An additive outlier at some time point $i$ corresponds to a shock signature $\eta_t$ such that $\eta_i = 1.0$ and $\eta_t$ is 0.0 at all other points. Similarly a permanent level shift originating at time $i$ has a shock signature such that $\eta_t$ is 0.0 for $t < i$ and 1.0 for $t \geq i$. A temporary level shift of duration $d$ originating at time $i$ will have $\eta_t$ equal to 1.0 between $i$ and $i + d$ and 0.0 otherwise.

Suppose that the preceding ESTIMATE statement has the ARIMA model

$$D(B)Y_t = \mu_t + \frac{\theta(B)}{\phi(B)}a_t$$

where $Y_t$ is the response series, $D(B)$ is the differencing polynomial in the backward shift operator B (possibly identity), $\mu_t$ is the transfer function input, $\phi(B)$ and $\theta(B)$ are the AR and MA polynomials, and $a_t$ is the Gaussian white noise series.

The problem of detection of level shifts in the OUTLIER statement is formulated as a problem of sequential selection of shock signatures that improve the model in the ESTIMATE statement. This is similar to the forward selection process in the stepwise regression procedure. The selection process starts with considering shock signatures of the type specified in the TYPE= option, originating at each non-missing measurement. This involves testing $H_0\colon \beta = 0$ versus $H_a\colon \beta \neq 0$ in the model

$$D(B)(Y_t - \beta\eta_t) = \mu_t + \frac{\theta(B)}{\phi(B)}a_t$$

for each of these shock signatures. The most significant shock signature, if it also satisfies the significance criterion in ALPHA= option, is included in the model. If no significant shock signature is found then the outlier detection process stops, otherwise this augmented model, which incorporates the selected shock signature in its transfer function input, becomes the null model for the subsequent selection process. This iterative process stops if at any stage no more significant shock signatures are found or if the number of iterations exceed the maximum search number resulting due to the MAXNUM= and MAXPCT= settings. In all these iterations the parameters of the ARIMA model in the ESTIMATE statement are held fixed.

The precise details of the testing procedure for a given shock signature $\eta_t$ are as follows:

The preceding testing problem is equivalent to testing $H_0\colon \beta = 0$ versus $H_a\colon \beta \neq 0$ in the following “regression with ARMA errors” model

$$N_t = \beta\zeta_t + \frac{\theta(B)}{\phi(B)}a_t$$

where $N_t = (D(B)Y_t - \mu_t)$ is the “noise” process and $\zeta_t = D(B)\eta_t$ is the “effective” shock signature.

In this setting, under $H_0$, $N = (N_1, N_2, \ldots, N_n)^T$ is a mean zero Gaussian vector with variance covariance matrix $\sigma^2\Sigma$. Here $\sigma^2$ is the variance of the white noise process $a_t$ and $\Sigma$ is the variance covariance matrix associated with the ARMA model. Moreover, under $H_a$, $N$ has $\beta\zeta$ as the mean vector where $\zeta = (\zeta_1, \zeta_2, \ldots, \zeta_n)^T$. Additionally, the generalized least squares estimate of $\beta$ and its variance is given by

$$\begin{aligned}\hat{\beta} &= \delta/\kappa \\ \mathrm{Var}(\hat{\beta}) &= \sigma^2/\kappa\end{aligned}$$

where $\delta = \zeta^T\Sigma^{-1}N$ and $\kappa = \zeta^T\Sigma^{-1}\zeta$. The test statistic $\tau^2 = \delta^2/(\sigma^2\kappa)$ is used to test the significance of $\beta$, which has an approximate chi-squared distribution with 1 degree of freedom under $H_0$. The type of estimate of $\sigma^2$ used in the calculation of $\tau^2$ can be specified by the SIGMA= option. The default setting is SIGMA=ROBUST that corresponds to a robust estimate suggested in an outlier detection procedure in X-12-ARIMA, the Census Bureau's time series analysis program; refer to Findley et al. (1998) for additional information. The setting SIGMA=MSE corresponds to the usual mean squared error estimate (MSE) computed the same way as in the ESTIMATE statement with the NODF option. The robust estimate of $\sigma^2$ is computed by the formula

$$\hat{\sigma}^2 = (1.49 \times \mathrm{Median}(|\hat{a}_t|))^2$$

where $\hat{a}_t$ are the standardized residuals of the null ARIMA model.

The quantities $\delta$ and $\kappa$ are efficiently computed by a method described in de Jong and Penzer (1998); refer also to Kohn and Ansley (1985).

## Displayed Output

The output of the OUTLIER statement has two parts. The first part, the Outlier Summary, contains the information about the maximum number of outliers searched, the number of outliers actually detected, and the significance level used in the outlier detection. The second part, the Outlier Table, tabulates the results of the outlier detection process. The outliers are listed in the order in which they are found. This table contains five columns:

- The Obs column contains the observation number of the start of the level shift.
- The Type column lists the type of the level shift.
- The Estimate column contains $\hat{\beta}$, the estimate of the regression coefficient of the shock signature.
- The Chi-Square column lists the value of the test statistic $\tau^2$.
- The Approx Prob > ChiSq column lists the approximate *p*-value of the test statistic.

## Modeling in the Presence of Outliers

In practice, modeling and forecasting time series data in the presence of outliers is a difficult problem for several reasons. The presence of outliers can adversely affect the model identification and estimation steps. Their presence close to the end of the observation period can have a serious impact on the forecasting performance of the model. In some cases level shifts are associated with changes in the mechanism driving the observation process, and separate models may be appropriate to different sections of the data. In view of all these difficulties, diagnostic tools such as outlier detection and residual analysis are essential in any modeling process.

The following modeling strategy, which incorporates level shift detection in the familiar Box-Jenkins modeling methodology, seems to work in many cases:

1. Proceed with model identification and estimation as usual. Suppose this results in a tentative ARIMA model, say M.

2. Check for suspected level shifts unaccounted for by model M using the OUTLIER statement. In this step, unless there is evidence to justify it, the number of level shifts searched should be kept small.
3. Augment the original dataset with the regression variables corresponding to the detected outliers.
4. Include the first few of these regression variables in M, and call this model M1. Re-estimate all the parameters of M1. It is important not to include too many of these outlier variables in the model in order to avoid the danger of over-fitting.
5. Check the adequacy of M1 by examining the parameter estimates, residual analysis, and outlier detection. Refine it more if necessary.

# Examples

The following examples illustrate the syntax and usage of the OUTLIER statement in some simple situations.

## Example 3.1. Nile Data

This example is discussed in de Jong and Penzer (1998). The data consist of readings of the annual flow volume of the Nile River at Aswan from 1871 to 1970. These data have also been studied by Cobb (1978). These studies indicate that levels in the years 1877 and 1913, that is, the 7th and 43rd measurements, are strong candidates for additive outliers, and that there was a shift in the flow levels starting from the year 1899. The year 1899 corresponds to the 29th observation. This shift in 1899 is attributed partly to the weather changes and partly to the start of construction work for a new dam at Aswan.

```
data nile;
   input level @@;
   datalines;
1120  1160  963  1210  1160  1160  813  1230   1370  1140
995   935   1110 994   1020  960   1180 799    958   1140
1100  1210  1150 1250  1260  1220  1030 1100   774   840
874   694   940  833   701   916   692  1020   1050  969
831   726   456  824   702   1120  1100 832    764   821
768   845   864  862   698   845   744  796    1040  759
781   865   845  944   984   897   822  1010   771   676
649   846   812  742   801   1040  860  874    848   890
744   749   838  1050  918   986   797  923    975   815
1020  906   901  1170  912   746   919  718    714   740
;
```

You can start the modeling process with the ARIMA(0, 1, 1) model, an ARIMA model close to the Structural model suggested in de Jong and Penzer (1998), and examine the parameter estimates, the residual autocorrelations, and the outliers.

```
proc arima data=nile;
   identify var=level(1) noprint;
   estimate q=1 noint method=ml plot;
   outlier maxnum=5;
run;
```

A portion of the estimation and the outlier detection output is shown in Output 3.1.1.

**Output 3.1.1.** Output from Fitting ARIMA(0, 1, 1) Model

```
                              The ARIMA Procedure

                         Maximum Likelihood Estimation

                                   Standard                 Approx
  Parameter      Estimate         Error    t Value    Pr > |t|     Lag

  MA1,1           0.73271       0.07132      10.27      <.0001       1


                        Variance Estimate      20810.22
                        Std Error Estimate     144.2575
                        AIC                    1267.091
                        SBC                    1269.686
                        Number of Residuals          99


                           Model for variable level

                         Period(s) of Differencing    1

                          No mean term in this model.


                               Outlier Summary

                      Maximum number searched           5
                      Number found                      5
                      Significance used              0.05


                                 Outlier Table
                                                              Approx
                                                      Chi-     Prob>
       Obs    Type                  Estimate       Square     ChiSq

        29    Shift               -315.75346        13.13    0.0003
        43    Additive            -403.97105        11.83    0.0006
         7    Additive            -335.49351         7.69    0.0055
        94    Additive             305.03568         6.16    0.0131
        18    Additive            -287.81484         6.00    0.0143
```

Note that the first three outliers detected are indeed the ones discussed earlier. You can include the shock signatures corresponding to these three outliers in the Nile data set.

```
data nile;
   set nile;
      if _n_ = 7 then AO7 = 1.0;
      else AO7 = 0.0;
      if _n_ = 43 then AO43 = 1.0;
      else AO43 = 0.0;
      if _n_ >= 29 then LS29 = 1.0;
      else LS29 = 0.0;
run;
```

Now you can refine the earlier model by including these outliers. After examining the parameter estimates and residuals (not shown) of the ARIMA(0, 1, 1) model with these regressors, the following stationary MA1 model (with regressors) appears to fit the data well.

```
proc arima data=nile;
   identify var=level crosscorr=( AO7 AO43 LS29 ) noprint;
   estimate q=1 noint
      input=(AO7 AO43 LS29) method=ml plot;
   outlier maxnum=5 alpha=0.01;
run;
```

The relevant estimation output is shown in Output 3.1.2. No outliers, at significance level 0.01, were detected.

**Output 3.1.2.** MA1 Model with Outliers

```
                              The ARIMA Procedure

                         Maximum Likelihood Estimation

                           Standard                 Approx
Parameter    Estimate         Error   t Value   Pr > |t|    Lag   Variable  Shift

MU             1109.9      26.65625     41.64     <.0001      0   level         0
MA1,1        -0.19584       0.10148     -1.93     0.0536      1   level         0
NUM1       -319.63689     116.50628     -2.74     0.0061      0   AO7           0
NUM2       -376.48708     116.11662     -3.24     0.0012      0   AO43          0
NUM3       -255.20007      31.32609     -8.15     <.0001      0   LS29          0


                      Constant Estimate      1109.861
                      Variance Estimate      13761.25
                      Std Error Estimate     117.3083
                      AIC                    1241.659
                      SBC                    1254.685
                      Number of Residuals         100


                    Autocorrelation Check of Residuals

 To      Chi-          Pr >
Lag    Square   DF   ChiSq   ---------------Autocorrelations---------------

  6      3.43    5  0.6334  -0.000   0.007   0.074  -0.100  -0.068  -0.109
 12      9.73   11  0.5552  -0.070   0.100  -0.107  -0.123  -0.083  -0.087
 18     14.36   17  0.6417   0.079  -0.071  -0.025   0.132  -0.007   0.094
 24     17.22   23  0.7983   0.008  -0.058   0.055  -0.049  -0.073  -0.087


                              Outlier Summary

                    Maximum number searched          5
                    Number found                     0
                    Significance used             0.01
```

## Example 3.2. Airline Data

This is a test example where an additive outlier at observation number 50 and a level shift at observation number 100 are artificially introduced in the well-known airline passenger data, the Series G in Box and Jenkins (1976).

```
data airline;
   set sashelp.air;
   logair = log(air);
   if _n_ = 50 then logair = logair - 0.25;
   if _n_ >= 100 then logair = logair + 0.5;
run;
```

The "Airline model," ARIMA$(0,1,1) \times (0,1,1)_{12}$, is known to be a good fit to the unmodified log-transformed airline passenger series. The preliminary identification steps (not shown) again suggest the Airline model for the modified data because they exhibit a strong trend and seasonal behavior, and the Airline model has wide applicability in such cases.

```
proc arima data=airline;
   identify var=logair( 1, 12 )  noprint;
   estimate q=(1)(12) noint method=ml;
   outlier maxnum=3 alpha=0.01;
run;
```

A portion of the estimation and outlier detection output is shown in Output 3.2.1.

**Output 3.2.1.** Output of Airline Model

The ARIMA Procedure

Maximum Likelihood Estimation

| Parameter | Estimate | Standard Error | t Value | Approx Pr > \|t\| | Lag |
|---|---|---|---|---|---|
| MA1,1 | 0.20390 | 0.08309 | 2.45 | 0.0141 | 1 |
| MA2,1 | 0.76150 | 0.07875 | 9.67 | <.0001 | 12 |

| | |
|---|---|
| Variance Estimate | 0.004689 |
| Std Error Estimate | 0.068479 |
| AIC | -318.305 |
| SBC | -312.555 |
| Number of Residuals | 131 |

Model for variable logair

Period(s) of Differencing 1,12

No mean term in this model.

Outlier Summary

| | |
|---|---|
| Maximum number searched | 3 |
| Number found | 3 |
| Significance used | 0.01 |

Outlier Table

| Obs | Type | Estimate | Chi-Square | Approx Prob>ChiSq |
|---|---|---|---|---|
| 100 | Shift | 0.49325 | 199.36 | <.0001 |
| 50 | Additive | -0.27508 | 104.78 | <.0001 |
| 135 | Additive | -0.10488 | 13.08 | 0.0003 |

Clearly the level shift at observation number 100 and the additive outlier at observation number 50 are the dominant outliers. Moreover, the corresponding regression coefficients seem to correctly estimate the size and sign of the change. You can augment the airline data with these two regressors.

```
data airline;
   set airline;
   if _n_ = 50 then AO = 1;
   else AO = 0.0;
   if _n_ >= 100 then LS  = 1;
   else LS = 0.0;
run;
```

You can now refine the previous model by including these regressors. Note that the differencing order of the dependent series is matched to the differencing orders of the outlier regressors to get the correct “effective” outlier signatures.

```
proc arima data=airline;
   identify var=logair(1, 12)
      crosscorr=( AO(1, 12) LS(1, 12) ) noprint;
   estimate q=(1)(12) noint
      input=(AO LS) method=ml plot;
   outlier maxnum=3 alpha=0.01;
run;
```

The estimation and outlier detection results are shown in Output 3.2.2.

**Output 3.2.2.** Airline Model with Outliers

```
                         The ARIMA Procedure

                    Maximum Likelihood Estimation

                      Standard                 Approx
Parameter    Estimate        Error  t Value  Pr > |t|   Lag  Variable  Shift

MA1,1         0.39529     0.08117     4.87    <.0001     1  logair        0
MA2,1         0.55870     0.08678     6.44    <.0001    12  logair        0
NUM1         -0.27421     0.02761    -9.93    <.0001     0  AO            0
NUM2          0.49913     0.02985    16.72    <.0001     0  LS            0


                     Variance Estimate      0.001382
                     Std Error Estimate     0.037173
                     AIC                    -482.191
                     SBC                     -470.69
                     Number of Residuals         131

                       No mean term in this model.


                            Outlier Summary

                   Maximum number searched           3
                   Number found                      3
                   Significance used              0.01


                              Outlier Table
                                                          Approx
                                                   Chi-    Prob>
         Obs    Type                 Estimate    Square    ChiSq

         135    Additive             -0.10310     12.63   0.0004
          62    Additive             -0.08872     12.33   0.0004
          29    Additive              0.08686     11.66   0.0006
```

The output shows that a few outliers still remain to be accounted for and that the model could be refined further.

# References

Box, G.E.P. and Jenkins, G.M. (1976), *Time Series Analysis: Forecasting and Control*, San Francisco: Holden-Day.

Cobb, G.W. (1978), "The Problem of the Nile: Conditional Solution to a Change Point Problem," *Biometrika*, 65, 243-251.

de Jong, P. and Penzer, J. (1998), "Diagnosing Shocks in Time Series," *Journal of the American Statistical Association*, Vol. 93, No. 442.

Fidley, D.F., Monsell, B.C., Bell, W.R., Otto, M.C. and Chen, B.C. (1998), "New Capabilities and Methods of the X-12-ARIMA Seasonal Adjustment Program," *Journal of Business and Economic Statistics*, 16, 127-177.

Kohn, R. and Ansley, C. (1985), "Efficient Estimation and Prediction in Time Series Regression Models," *Biometrika*, 72, 3, 694-697.

Chapter 4
# The MODEL Procedure

## Chapter Table of Contents

Chapter 4
# The MODEL Procedure

## Overview

The MODEL procedure estimates and simulates systems of variables with correlated residuals. In prior releases, these residuals were restricted to have normal distributions with mean zero and non-constant variance. The following new distributions are now supported for multivariate estimation:

- The centered *t*-distribution with estimated degrees of freedom and non-constant variance
- A user-specified likelihood function

The following distributions are now supported for multivariate Monte Carlo simulation:

- Cauchy
- Chi-squared
- Empirical
- *F*
- Poisson
- *t*
- Uniform

A transformation technique is used to create a covariance matrix for generating the correct innovations in a Monte Carlo simulation.

# Syntax

## ERRORMODEL Statement

**ERRORMODEL** *equation-name* ~ *distribution [CDF=( CDF options )]* **;**

The ERRORMODEL statement is the mechanism for specifying the distribution of the residuals. You must specify the dependent/endogenous variables or general form model name, a tilde (~), and then a distribution with its parameters. The following options are used in the ERRORMODEL statement:

### *Options to Specify the Distribution*

**CAUCHY(** **<***location, scale***>** **)**
specifies the Cauchy distribution. This option is only supported for simulation. The arguments correspond to the arguments of the SAS CDF function (ignoring the random variable argument).

**CHISQUARED (** *df < , nc>* **)**
specifies the $\chi^2$ distribution. This option is only supported for simulation. The arguments correspond to the arguments of the SAS CDF function (ignoring the random variable argument).

**GENERAL(** *Likelihood <, parm1, parm2, . . . parmn***> )**
specifies a general log-likelihood function that you construct using SAS programming statements. $parm1, parm2, ...parmn$ are optional parameters for this distribution and are used for documentation purposes only.

**F(** *ndf, ddf < , nc>* **)**
specifies the $F$ distribution. This option is only supported for simulation. The arguments correspond to the arguments of the SAS CDF function (ignoring the random variable argument).

**NORMAL(** $v_1 v_2 \cdots v_n$ **)**
specifies a multivariate normal (Gaussian) distribution with mean $0$ and variances $v_1$ through $v_n$.

**POISSON(** *mean* **)**
specifies the Poisson distribution. This option is only supported for simulation. The arguments correspond to the arguments of the SAS CDF function (ignoring the random variable argument).

**T(** $v_1 v_2 \cdots v_n$, *df* **)**
specifies a multivariate $t$-distribution with noncentrality $0$, variance $v_1$ through $v_n$, and common degrees of freedom $df$.

**UNIFORM(** **<***left, right***> )**
specifies the uniform distribution. This option is only supported for simulation. The arguments correspond to the arguments of the SAS CDF function (ignoring the random variable argument).

#### ***Options to Specify the CDF for Simulation***

**CDF=(** *CDF(options)* **)**

specifies the univariate distribution that is used for simulation so that the estimation can be done for one set of distributional assumptions and the simulation for another. The CDF can be any of the distributions from the previous section with the exception of the General Likelihood. In addition, you can specify the empirical distribution of the residuals.

**EMPIRICAL= ( <TAILS=***(options)***> )**

uses the sorted residual data to create an empirical CDF.

**TAILS=(** *tail options* **)**

specifies how to handle the tails in computing the inverse CDF from an empirical distribution, where *Tail options* are:

| | |
|---|---|
| NORMAL | specifies the normal distribution to extrapolate the tails. |
| T( *df* ) | specifies the $t$-distribution to extrapolate the tails. |
| PERCENT= *p* | specifies the percent of the observations to use in constructing each tail. The default for the PERCENT= option is 10. A normal distribution or a $t$-distribution is used to extrapolate the tails to infinity. The variance for the tail distributions is obtained from the data so that the empirical CDF is continuous. |

## New FIT and SOLVE Statement Syntax

The following option is now available on the FIT statement and is used to output a residual covariance matrix for non-normal distributions. This covariance matrix should be used in a Monte Carlo simulation and is created by converting the residuals to a standard normal distribution and using these converted residuals to compute a covariance matrix.

**OUTSN= sas data-set**

specifies a data set that the normalized residual covariance matrix will be written to.

The following options are now available on the SOLVE statement and apply only when Monte Carlo simulation is selected.

**RESIDDATA= sas data-set**

specifies a data set that contains the residuals that are to be used in the empirical distribution. This data set can be created using the OUT= option on the FIT statement.

**WISHART=df**

specifies that a Wishart distribution with degrees of freedom *df* be used in place of the normal error covariance matrix. This option is used to model the variance of the error covariance matrix when Monte Carlo simulation is selected.

# Details

## Multivariate t-Distribution Estimation

The multivariate *t*-distribution is specified using the ERRORMODEL statement with the T option. Other method specifications ( FIML and OLS, for example ) are ignored when the ERRORMODEL statement is used for a distribution other than normal.

The probability density function for the multivariate *t*-distribution is

$$P_q = \frac{\Gamma(\frac{df+m}{2})}{(\pi * df)^{\frac{m}{2}} * \Gamma(\frac{df}{2})\,|\Sigma(\sigma)|^{\frac{1}{2}}} * \left(1 + \frac{\mathbf{q}'(\mathbf{y}_t, \mathbf{x}_t, \theta)\Sigma(\sigma)^{-1}\mathbf{q}(\mathbf{y}_t, \mathbf{x}_t, \theta)}{df}\right)^{-\frac{df+m}{2}}$$

where $m$ is the number of equations and $df$ is the degrees of freedom.

The maximum likelihood estimators of $\theta$ and $\sigma$ are the $\hat{\theta}$ and $\hat{\sigma}$ that minimize the negative log-likelihood function:

$$\begin{aligned} \mathbf{l}_n(\theta, \sigma) &= -\sum_{t=1}^{n} \ln\left(\frac{\Gamma(\frac{df+m}{2})}{(\pi * df)^{\frac{m}{2}} * \Gamma(\frac{df}{2})} * \left(1 + \frac{q_t'\Sigma^{-1}q_t}{df}\right)^{-\frac{df+m}{2}}\right) \\ &\quad + \frac{n}{2} * \ln(|\Sigma|) - \sum_{t=1}^{n} \ln\left(\left|\frac{\partial q_t}{\partial y_t'}\right|\right) \end{aligned}$$

The ERRORMODEL statement is used to request the *t*-distribution maximum likelihood estimation. An OLS estimation is done to obtain initial parameter estimates and MSE.*var* estimates. Use NOOLS to turn off this initial estimation. If the errors are distributed normally, *t*-distribution estimation will produce results similar to FIML.

The multivariate model has a single shared degrees of freedom parameter, which is estimated. The degrees of freedom parameter can also be set to a fixed value. The negative log-likelihood value and the $l_2$ norm of the gradient of the negative log-likelihood function are shown in the estimation summary.

### *t-Distribution Details*

Since a variance term is explicitly specified using the ERRORMODEL statement, $\Sigma(\theta)$ is estimated as a correlation matrix and $\mathbf{q}(\mathbf{y}_t, \mathbf{x}_t, \theta)$ is normalized by the variance.

The gradient of the negative log-likelihood function with respect to the degrees of freedom is

$$\begin{aligned} \frac{\partial l_n}{\partial df} &= \frac{nm}{2\,df} - \frac{n}{2}\Gamma'(\frac{df+m}{2}) + \frac{n}{2}\Gamma'(\frac{df}{2}) + \\ &\quad 0.5\log(1 + \frac{\mathbf{q}'\Sigma^{-1}\mathbf{q}}{df}) - \frac{0.5(df+m)}{(1 + \frac{\mathbf{q}'\Sigma^{-1}\mathbf{q}}{df})}\frac{\mathbf{q}'\Sigma^{-1}\mathbf{q}}{df^2} \end{aligned}$$

The gradient of the negative log-likelihood function with respect to the parameters is

$$\frac{\partial l_n}{\partial \theta_i} = \frac{0.5(df+m)}{(1+\mathbf{q}'\Sigma^{-1}\mathbf{q}/df)}\left[\frac{(2\,\mathbf{q}'\Sigma^{-1}\frac{\partial \mathbf{q}}{\partial \theta_i})}{df} + \mathbf{q}'\Sigma^{-1}\frac{\partial \Sigma}{\partial \theta_i}\Sigma^{-1}\mathbf{q}\right] - \frac{n}{2}\mathrm{trace}(\Sigma^{-1}\frac{\partial \Sigma}{\partial \theta_i})$$

where

$$\frac{\partial \Sigma(\theta)}{\partial \theta_i} = \frac{2}{n}\sum_{t=1}^{n}\mathbf{q}(\mathbf{y}_t,\mathbf{x}_t,\theta)\frac{\partial \mathbf{q}(\mathbf{y}_t,\mathbf{x}_t,\theta)'}{\partial \theta_i}$$

and

$$\mathbf{q}(\mathbf{y}_t,\mathbf{x}_t,\theta) = \frac{\epsilon(\theta)}{\sqrt{h(\theta)}} \in R^{m\times n}$$

The estimator of the variance-covariance of $\hat{\theta}$ (COVB) for the *t*-distribution is the inverse of the likelihood Hessian. The gradient is computed analytically and the Hessian is computed numerically.

## Multivariate t-Distribution Simulation

To perform a Monte Carlo analysis of models that have residuals distributed as a multivariate *t*, use the ERRORMODEL statement with either the $\sim$ t(*variance*, *df*) option or with the CDF=t(*variance*, *df*) option. The CDF= option specifies the distribution that is used for simulation so that the estimation can be done for one set of distributional assumptions and the simulation for another.

The following is an example of estimating and simulating a system of equations with *t*-distributed errors using the ERRORMODEL statement:

```
       /* generate simulation data set */
data five;
set xfrate end=last;
if last then do;
  todate = date +5;
  do date = date to todate;
     output;
  end;
end;
```

The preceding DATA step generates the data set to request a five-days-ahead forecast. The following statements estimate and forecast the three forward-rate models of the form

$$\begin{aligned} rate_t &= rate_{t-1} + \mu * rate_{t-1} + \nu \\ \nu &= \sigma * rate_{t-1} * \epsilon \\ \epsilon &\sim \mathrm{N}(0,1) \end{aligned}$$

```
Title "Daily Multivariate Geometric Brownian Motion Model "
         "of D-Mark/USDollar Forward Rates";

proc model data=xfrate;

  parms df 15;        /* Give initial value to df */

  demusd1m = lag(demusd1m) + mu1m * lag(demusd1m);
  var_demusd1m = sigma1m ** 2 * lag(demusd1m **2);
  demusd3m = lag(demusd3m) + mu3m * lag(demusd3m);
  var_demusd3m = sigma3m ** 2 * lag(demusd3m ** 2);
  demusd6m = lag(demusd6m) + mu6m * lag(demusd6m);
  var_demusd6m = sigma6m ** 2 * lag(demusd6m ** 2);

           /* Specify the error distribution */
  errormodel demusd1m demusd3m demusd6m
        ~ t( var_demusd1m var_demusd3m var_demusd6m, df );

      /* output normalized S matrix */
fit demusd1m demusd3m demusd6m / outsn=s;
run;
      /* forecast five days in advance */
solve demusd1m demusd3m demusd6m /
     data=five sdata=s random=1500 out=monte;
id date;
run;

   /* select out the last date -------------------*/
data monte; set monte;
  if date = '10dec95'd then output;
run;

title "Distribution of demusd1m Five Days Ahead";
proc univariate data=monte noprint;
      var demusd1m ;
      histogram demusd1m / normal(noprint color=red)
          kernel(noprint color=blue) cfill=ligr;
   run;
```

The Monte Carlo simulation specified in the preceding example draws from a multivariate *t*-distribution with constant degrees of freedom and forecasted variance and computes future states of DEMUSD1M, DEMUSD3M, and DEMUSD6M. The OUTSN= option on the FIT statement is used to specify the data set for the normalized $\Sigma$ matrix. That is the $\Sigma$ matrix is created by crossing the normally distributed residuals. The normally distributed residuals are created from the *t*-distributed residuals using the normal inverse CDF and the *t* CDF.

The distribution of DEMUSD1M on the fifth day is shown in Figure 4.1. The two curves overlayed on the graph are a kernel density estimation and a normal distribution fit to the results.

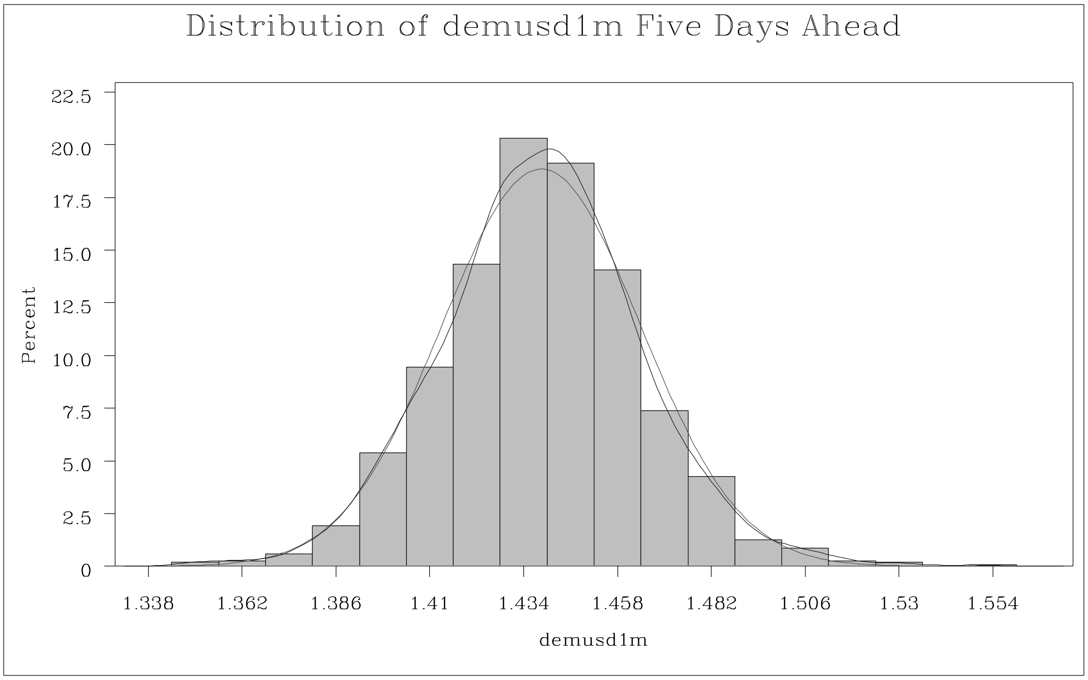



**Figure 4.1.** Distribution of DEMUSD1M

## General Likelihood Estimation and Simulation

The GENERAL option on the ERRORMODEL statement can be used to estimate distributions other than normal and *t*. The GENERAL option on the ERRORMODEL statement expects as its first argument a log-likelihood function.

When a general log-likelihood function is specified, a quasi-Newton method is used to find the minimum of the function. The standard errors are computed using the Hessian of the log-likelihood function at the solution. It is important to include all scale terms in the likelihood if correct standard errors are desired. The OUTS= data set is created from the cross of the residuals normalized according to the VARDEF= option. This S matrix is not normalized by any implied variance terms in the specified likelihood. This is important to consider if the S matrix is used in a Monte Carlo simulation.

For simulation and forecasting, the likelihood function is ignored. If Monte Carlo is requested, a CDF function can be specified using the CDF= option. If no CDF is specified, an empirical distribution with normal tails is used.

### *Empirical Distribution Estimation and Simulation*

For simulation, if the CDF for the model is not built in to the procedure, you can use the CDF=EMPIRICAL() option. This uses the sorted residual data to create an empirical CDF. For computing the inverse CDF the program needs to know how to handle the tails. For continuous data, the tail distribution is generally poorly determined. To counter this, the PERCENT= option specifies the percent of the observations to use in constructing each tail. The default for the PERCENT= option is 10. A normal distribution or a *t*-distribution is used to extrapolate the tails to infinity. The standard errors for this extrapolation are obtained from the data so that the empirical CDF is continuous.

The following SAS statements fit a model using least squares as the likelihood function, but represent the distribution of the residuals with an empirical CDF. The plot of the empirical probability distribution is shown in Figure 4.2.

```
data t;  /* Sum of two normals  */
   format date monyy.;
   do t=0 to 3 by 0.1;
     date = intnx( 'month', '1jun90'd,(t*10)-1);
     y =  (0.1 * rannor(123)-10) +
          ( .5 * rannor(456)+10);
     output;
   end;
run;

proc model data=t time=t itprint;
dependent y;
parm a 5 ;
y = a;
obj = resid.y * resid.y;
errormodel y ~ general( obj )
    cdf=(empirical=( tails=( t(15) percent= 5)));

fit y / outns=s out=r;
id  date;
solve y / data=t(where=(date='1jun95'd ))
  residdata=r sdata=s random=200 seed=6789 out=monte;
run;

    /* Generate the pdf -------------------------*/
proc kde data =monte out=density;
var y;
run;

symbol1 value=none interpol=join;
proc gplot data=density;
 plot density*y ;
run;
```

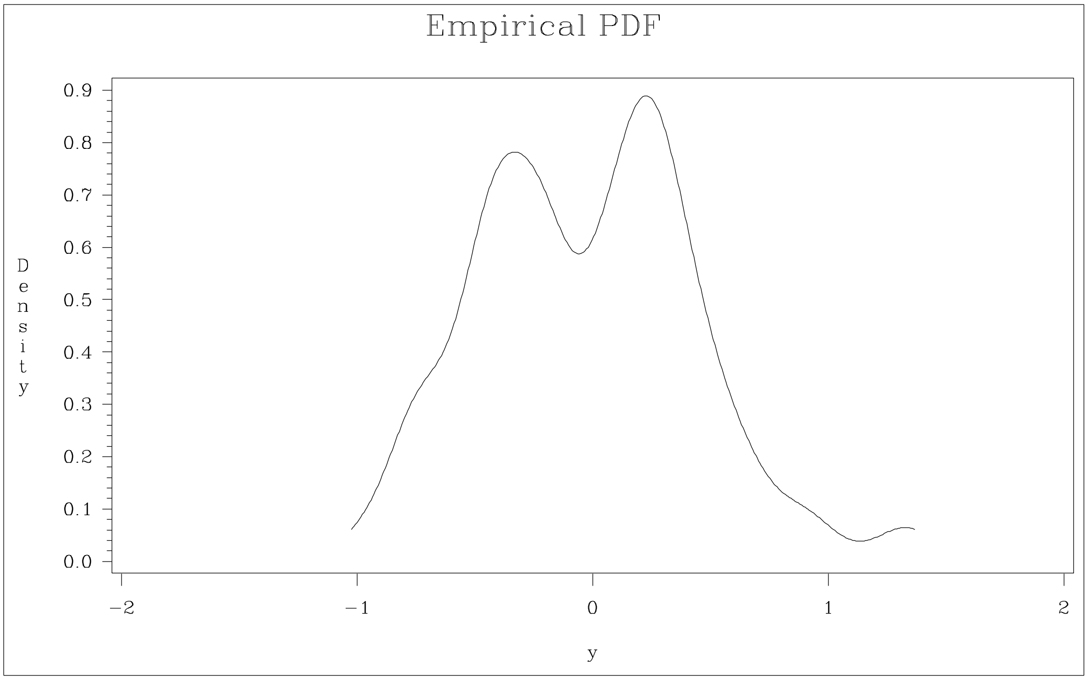



**Figure 4.2.** Empirical PDF Plot

## Alternate Distribution Simulation

As an alternate to the normal distribution, the ERRORMODEL statement can be used in a simulation to specify other distributions. The distributions available for simulation are Cauchy, Chi-squared, *F*, Poisson, *t*, and Uniform. An empirical distribution can also be used if the residuals are specified using the RESIDDATA= option on the SOLVE statement.

Except for the *t*, all of these alternate distributions are univariate but can be used together in a multivariate simulation. The ERRORMODEL statement applies to solved for equations only. That is, the normal form or general form equation referred to by the ERRORMODEL statement must be one of the equations you have selected in the SOLVE statement.

In the following example, two Poisson distributed variables are used to simulate the calls arriving and leaving a call center.

```
data s;      /* Covariance between arriving and leaving */
  arriving = 1; leaving = 0.7; _name_= "arriving";
  output;
  arriving = 0.7; leaving = 1.0; _name_= "leaving";
  output;
run;

data calls;
   date = '20mar2001'd;
   output;
run;
```

The first DATA step generates a data set containing a covariance matrix for the ARRIVING and LEAVING variables. The covariance is

$$\begin{vmatrix} 1 & .7 \\ .7 & 1 \end{vmatrix}$$

```
proc model data=calls;
   arriving = 10;
   errormodel arriving ~ poisson( 10 );
               /* Have four people answering the phone */
   leaving  = 4;
   errormodel leaving ~ poisson( 11 );

   waiting = arriving - leaving;
solve arriving leaving / random=500 sdata=s out=sim;
run;

title "Distribution of Clients Waiting";
proc univariate data=sim noprint;
      var waiting ;
      histogram waiting / cfill=ligr;
   run;
```

The distribution of number of waiting clients is shown in Figure 4.3.

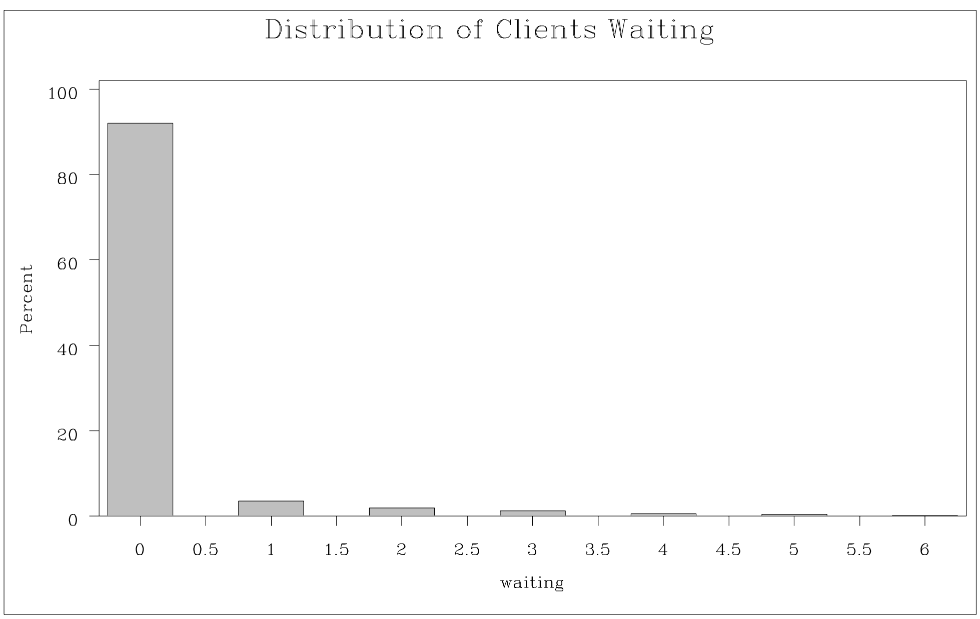



**Figure 4.3.** Distribution of Number of Clients Waiting

## Mixtures of Distributions - Copulas

The theory of copulas is what enables the MODEL procedure to combine and simulate multivariate distributions with different marginals. This section provides a brief overview of copulas.

Modeling a system of variables accurately is a difficult task. The underlying, ideal, distributional assumptions for each variable are usually different from each other. An individual variable may be best modeled as a *t*-distribution or as a Poisson process. The correlation of the various variables are very important to estimate as well. A joint estimation of a set of variables would make it possible to estimate a correlation structure but would restrict the modeling to single, simple multivariate distribution (for example, the normal). Even with a simple multivariate distribution, the joint estimation would be computationally difficult and would have to deal with issues of missing data.

Using the MODEL procedure ERRORMODEL statement you can combine and simulate from models of different distributions. The covariance matrix for the combined model is constructed using the copula induced by the multivariate normal distribution. A copula is a function that couples joint distributions to their marginal distributions.

The copula used by the model procedure is based on the multivariate normal. This particular multivariate normal has zero mean and covariance matrix R. The user provides R, which can be created using the following steps

1. Each model is estimated separately and their residuals saved.
2. The residuals for each model are converted to a normal distribution using their CDFs, $F_i(.)$, using the relationship $\Phi^{-1}(F(\epsilon_{it}))$.
3. Cross these normal residuals, to create a covariance matrix R.

If the model of interest can be estimated jointly, such as multivariate T, then the OUTSN= option can be used to generate the correct covariance matrix.

A draw from this mixture of distributions is created using the following steps that are performed automatically by the MODEL procedure.

1. Independent $N(0, 1)$ variables are generated.
2. These variables are transformed to a correlated set using the covariance matrix R.
3. These correlated normals are transformed to a uniform using $\Phi()$.
4. $F^{-1}()$ is used to compute the final sample value.

# Examples

## Example 4.1. Cauchy Distribution Estimation

In this example a nonlinear model is estimated using the Cauchy distribution. Then a simulation is done for one observation in the data.

The following DATA step creates the data for the model.

```
      /* Generate a Cauchy distributed Y */
data c;
 format date monyy.;
 call streaminit(156789);
 do t=0 to 20 by 0.1;
    date=intnx('month','01jun90'd,(t*10)-1);
    x=rand('normal');
    e=rand('cauchy') + 10 ;
    y=exp(4*x)+e;
    output;
    end;
run;
```

The model to be estimated is

$$\begin{aligned} y &= e^{-a\,x} + \epsilon \\ \epsilon &\sim \text{Cauchy}(nc) \end{aligned}$$

That is, the residuals of the model are distributed as a Cauchy distribution with noncentrality parameter $nc$.

The log likelihood for the Cauchy distribution is

$$like = -\log(1 + (x - nc)^2 * \pi)$$

The following SAS statements specify the model and the log-likelihood function.

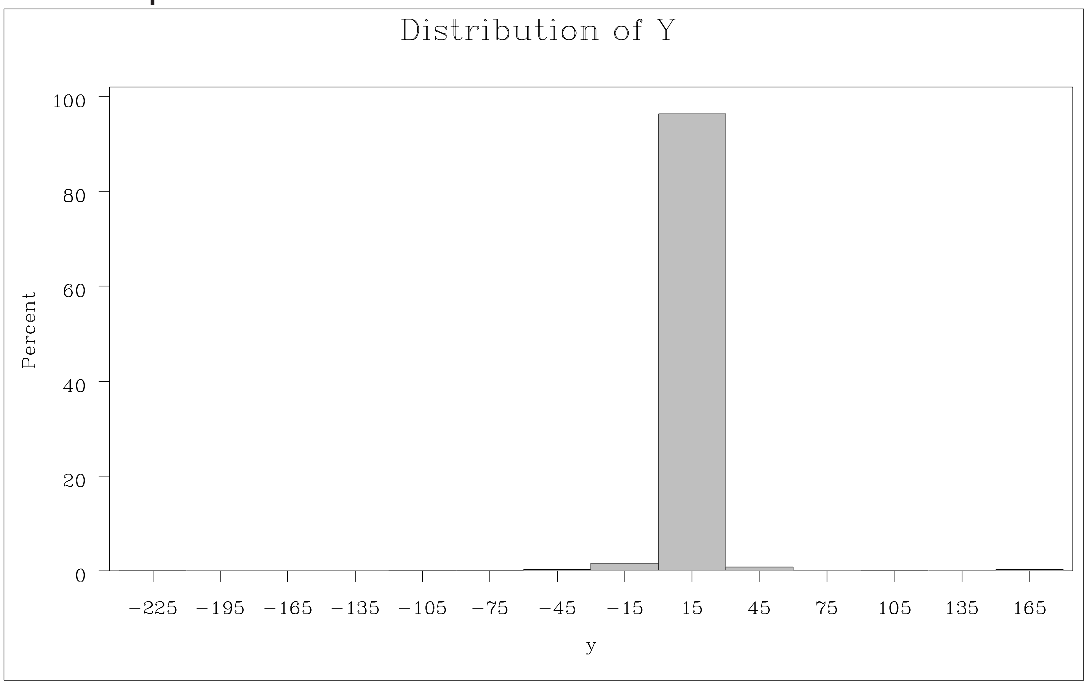
```
title2 'Cauchy Distribution';

proc model data=c ;
 dependent y;

 parm a -2 nc 4;

 y=exp(-a*x);

      /* Likelihood function for the residuals */
 obj = log(1+(-resid.y-nc)**2 * 3.1415926);
```

```
 errormodel y ~ general(obj) cdf=cauchy(nc);

 fit y / outsn=s1 method=marquardt;
 solve y / sdata=s1 data=c(obs=1) random=1000
          seed=256789 out=out1;
run;
```

The FIT statement uses the OUTSN= option to put out the $\Sigma$ matrix for residuals from the normal distribution. The $\Sigma$ matrix is $1 \times 1$ and has value $4.65824$. The OUTS= matrix is the scalar $2989.0$. Because the distribution is univariate (no covariances), the OUTS= would produce the same simulation results. The simulation is performed using the SOLVE statement.

The distribution of $y$ is shown in Output 4.1.1.

**Output 4.1.1.** Distribution of Y



## Example 4.2. Switching Regression Example

Take the usual linear regression problem

$$y = X\beta + u$$

where *Y* denotes the *n* column vector of the dependent variable, *X* denotes the (*n* $\times$ *k*) matrix of independent variables, $\beta$ denotes the *k* column vector of coefficients to be estimated, *n* denotes the number of observations (*i*=1,2,...,*n*), and *k* denotes the number of independent variables.

You can take this basic equation and split it into two regimes, where the *i*th observation on *y* is generated by one regime or the other.

$$y_i = \sum_{j=1}^{k} \beta_{1j} X_{ji} + u_{1i} = x_i' \beta_1 + u_{1i}$$

$$y_i = \sum_{j=1}^{k} \beta_{2j} X_{ji} + u_{2i} = x_i' \beta_2 + u_{2i}$$

where $x_{hi}$ and $x_{hj}$ are the *i*th and *j*th observations, respectively, on $x_h$. The errors, $u_{1i}$ and $u_{2i}$, are assumed to be distributed normally and independently, with mean zero and constant variance. The variance for the first regime is $\sigma_1^2$, and the variance for the second regime is $\sigma_2^2$. If $\sigma_1^2 \neq \sigma_2^2$ and $\beta_1 \neq \beta_2$, the regression system given previously is thought to be switching between the two regimes.

The problem is to estimate $\beta_1$, $\beta_2$, $\sigma_1$, and $\sigma_2$ without knowing *a priori* which of the *n* values of the dependent variable, *y*, was generated by which regime. If it is known *a priori* which observations belong to which regime, a simple Chow test can be used to test $\sigma_1^2 = \sigma_2^2$ and $\beta_1 = \beta_2$.

Using Goldfeld and Quandt's D-method for switching regression, you can solve this problem. Assume that there exists observations on some exogenous variables $z_{1i}$, $z_{2i}$, ..., $z_{pi}$, where *z* determines whether the *i*th observation is generated from one equation or the other.

$$y_i = x_i' \beta_1 + u_{1i} \quad \text{if} \sum_{j=1}^{p} \pi_j z_{ji} \leq 0$$

$$y_i = x_i' \beta_2 + u_{2i} \quad \text{if} \sum_{j=1}^{p} \pi_j z_{ji} > 0$$

where $\pi_j$ are unknown coefficients to be estimated. Define $d(z_i)$ as a continuous approximation to a step function. Replacing the unit step function with a continuous approximation using the cumulative normal integral enables a more practical method that produces consistent estimates.

$$d(z_i) \;=\; \frac{1}{\sqrt{2\pi}\sigma} \int_{-\infty}^{\sum \pi_j z_{ji}} exp \left[ -\frac{1}{2} \frac{\xi^2}{\sigma^2} \right] d\xi$$

*D* is the *n* dimensional diagonal matrix consisting of $d(z_i)$.

$$D \;=\; \begin{bmatrix} d(z_1) & 0 & 0 & 0 \\ 0 & d(z_2) & 0 & 0 \\ 0 & 0 & \ddots & 0 \\ 0 & 0 & 0 & d(z_n) \end{bmatrix}$$

The parameters to estimate are now the *k* $\beta_1$'s, the *k* $\beta_2$'s, $\sigma_1^2$, $\sigma_2^2$, *p* $\pi$'s, and the $\sigma$ introduced in the $d(z_i)$ equation. The $\sigma$ can be considered as given *a priori*, or it can be estimated, in which the estimated magnitude provides an estimate of the success in discriminating between the two regimes (Goldfeld and Quandt 1976).

$$Y = (I \;-\; D)\, X\beta_1 + DX\beta_2 + W$$

where $W \;=\; (I - D)U_1 \;+\; DU_2$, and *W* is a vector of unobservable and heteroscedastic error terms. The covariance matrix of *W* is denoted by $\Omega$, where $\Omega \;=\; (I - D)^2\sigma_1^2 \;+\; D^2\sigma_2^2$. The maximum likelihood parameter estimates maximize the following log-likelihood function.

$$\begin{aligned} logL \;\;=\;\; & -\frac{n}{2}\log 2\pi - \frac{1}{2}\log \mid \Omega \mid - \\ & \frac{1}{2} * \left[ [Y - (I - D)X\beta_1 - DX\beta_2]' \, \Omega^{-1} \, [Y - (I - D)X\beta_1 - DX\beta_2] \right] \end{aligned}$$

As an example, you now can use this switching regression likelihood to develop a model of housing starts as a function of changes in mortgage interest rates. The data for this example is from the U.S. Census Bureau and covers the period from January 1973 to March 1999. The hypothesis is that there will be different coefficients on your model based on whether the interest rates are going up or down.

So the model for $z_i$ will be the following

$$z_i = p * (rate_i - rate_{i-1})$$

where $rate_i$ is the mortgage interest rate at time $i$ and $p$ is a scale parameter to be estimated.

The regression model will be the following

$$\begin{aligned} starts_i &= intercept_1 + ar1 * starts_{i-1} + djf1 * decjanfeb \qquad z_i < 0 \\ starts_i &= intercept_2 + ar2 * starts_{i-1} + djf2 * decjanfeb \qquad z_i >= 0 \end{aligned}$$

where $starts_i$ is the number of housing starts at month $i$ and $decjanfeb$ is a dummy variable indicating that the current month is one of December, January, or February.

This model is written using the following SAS statements.

```
proc model data=switch;
   parms sig1=10 sig2=10 int1 b11 b13 int2 b21 b23 p;
   bounds 0.0001 < sig1 sig2;

   a = p*dif(rate);       /* Upper bound of integral */
   d = probnorm(a);       /* Normal CDF as an approx of switch */

                          /* Regime 1 */
   y1 = int1 + zlag(starts)*b11 + decjanfeb *b13 ;
                          /* Regime 2 */
   y2 = int2 + zlag(starts)*b21 + decjanfeb *b23 ;
                          /* Composite regression equation */
   starts  = (1 - d)*y1 +  d*y2;

                         /* Resulting log-likelihood function */
   logL = (1/2)*( (318*log(2*3.1415)) +
        log( (sig1**2)*((1-d)**2)+(sig2**2)*(d**2) )
       + (resid.starts*( 1/( (sig1**2)*((1-d)**2)+
        (sig2**2)*(d**2) ) )*resid.starts) ) ;

   errormodel starts ~ general(logL);

fit starts / method=marquardt converge=1.0e-5;

     /* Test for significant differences in the parms */
test int1 = int2 ,/ lm;
test b11 = b21 ,/ lm;
test b13 = b23 ,/ lm;
test sig1 = sig2 ,/ lm;

run;
```

Four TEST statements were added to test the hypothesis that the parameters were the same in both regimes. The parameter estimates and ANOVA table from this run are shown in Output 4.2.1.

**Output 4.2.1.** Parameter Estimates from the Switching Regression

**Nonlinear Liklhood Summary of Residual Errors**

| Equation | DF Model | DF Error | SSE | MSE | Root MSE | R-Square | Adj R-Sq |
|---|---|---|---|---|---|---|---|
| starts | 9 | 304 | 85877.9 | 282.5 | 16.8075 | 0.7806 | 0.7748 |

**Nonlinear Liklhood Parameter Estimates**

| Parameter | Estimate | Approx Std Err | t Value | Approx Pr > \|t\| |
|---|---|---|---|---|
| sig1 | 15.47451 | 0.9475 | 16.33 | <.0001 |
| sig2 | 19.77797 | 1.2710 | 15.56 | <.0001 |
| int1 | 32.82232 | 5.9070 | 5.56 | <.0001 |
| b11 | 0.739529 | 0.0444 | 16.65 | <.0001 |
| b13 | -15.456 | 3.1909 | -4.84 | <.0001 |
| int2 | 42.73243 | 6.8153 | 6.27 | <.0001 |
| b21 | 0.734112 | 0.0477 | 15.37 | <.0001 |
| b23 | -22.5178 | 4.2979 | -5.24 | <.0001 |
| p | 25.94332 | 8.5181 | 3.05 | 0.0025 |

The test results shown in Output 4.2.2 suggest that the variance of the housing starts, SIG1 and SIG2, are significantly different in the two regimes. The tests also show a significant difference in the AR term on the housing starts.

**Output 4.2.2.** Parameter Estimates from the Switching Regression

**Test Results**

| Test | Type | Statistic | Pr > ChiSq | Label |
|---|---|---|---|---|
| Test0 | L.M. | 0.02 | 0.8810 | int1 = int2 |
| Test1 | L.M. | 240001 | <.0001 | b11 = b21 |
| Test2 | L.M. | 0.02 | 0.8933 | b13 = b23 |
| Test3 | L.M. | 319354 | <.0001 | sig1 = sig2 |

## Example 4.3. Simulating from a Mixture of Distributions

This example illustrates how to perform a multivariate simulation using models that have different error distributions. Three models are used. The first model has *t*-distributed errors. The second model is a GARCH(1,1) model with normally distributed errors. The third model has a non-central Cauchy distribution.

The following SAS statements generate the data for this example. The T and the CAUCHY data sets use a common seed so that those two series will be correlated.

```
%let df = 7.5;
%let sig1 = .5;
%let var2 = 2.5;

data t;
   format date monyy.;
   do date='1jun2001'd  to '1nov2002'd;
              /* t-distribution with df,sig1 */
      t = .05 * date + 5000  + &sig1*tinv(ranuni(1234),&df);
     output;
   end;
run;

data normal;
   format date monyy.;
   le = &var2;
   lv = &var2;
   do date='1jun2001'd  to '1nov2002'd;
              /* Normal with GARCH error structure */
      v = 0.0001 + 0.2 * le**2 + .75 * lv;
      e = sqrt( v) * rannor(12345) ;
      normal = 25 + e;
      le = e;
      lv = v;
     output;
   end;
run;

data cauchy;
   format date monyy.;
   PI = 3.1415926;
   do date='1jun2001'd  to '1nov2002'd;
      cauchy = -4 + tan((ranuni(1234) - 0.5) * PI);
      output;
   end;
run;
```

Since the multivariate joint likelihood is unknown, the models must be estimated separately. The residuals for each model are saved using the OUT= option. Also, each model is saved using the OUTMODEL= option. The ID statement is used to provide a variable in the residual data set to merge by. The XLAG function is used to model the GARCH(1,1) process. The XLAG function returns the lag of the first argument if it is nonmissing, otherwise it returns the second argument.

```
proc model data=t outmod=t;
parms df 10 vt 4;
   t = a * date + c;
   errormodel t ~ t( vt, df );
fit t / out=tresid;
id date;
run;

proc model data=normal outmod=normal;
  normal = b0 ;
  h.normal = arch0 + arch1 * xlag(resid.normal **2 , mse.normal)  +
          GARCH1 * xlag(h.normal, mse.normal);

fit normal /fiml out=nresid;
id date;
run;


proc model data= cauchy outmod=cauchy;
parms nc = 1;
     /* nc is noncentrality parm to Cauchy dist */
 cauchy = nc;
 obj = log(1+resid.cauchy**2 * 3.1415926);
 errormodel cauchy ~ general(obj) cdf=cauchy(nc);

 fit cauchy / out=cresid;
 id date;
run;
```

The simulation requires a covariance matrix created from normal residuals. The following Data Step code uses the inverse CDFs of the *t* and Cauchy distributions to convert the residuals to the normal distribution. The CORR procedure is used to create a correlation matrix using the converted residuals.

```
   /* Merge and normalize the 3 residual data sets */
data c; merge tresid nresid cresid; by date;
t = probit(cdf("T", t/sqrt(0.2789), 16.58 ));
cauchy = probit(cdf("CAUCHY", cauchy, -4.0623));
run;

proc corr data=c out=s;
var t normal cauchy;
run;
```

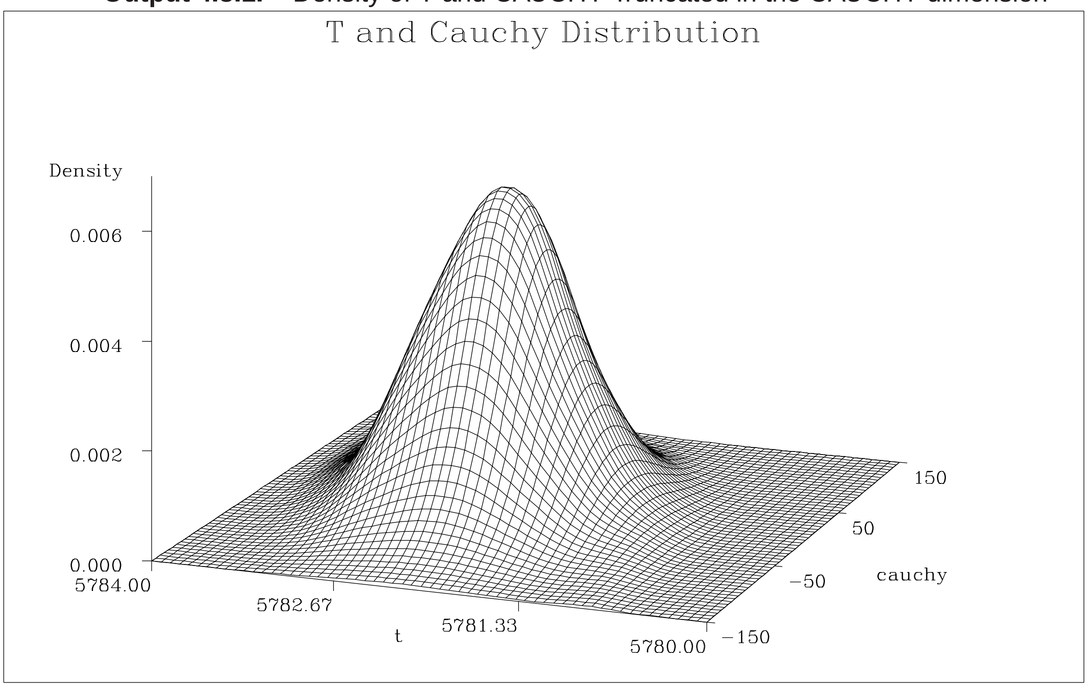
Now the models can be simulated together using the MODEL procedure SOLVE statement. The data set created by the CORR procedure is used as the correlation matrix. Note that the errormodel statement is not saved with the model and must be restated for this simulation.

```
   /* Create one observation driver data set */
data sim; merge t normal cauchy; by date;
data sim; set sim(firstobs = 519 );

proc model data=sim model=( t normal cauchy);
  errormodel t ~ t( vt, df );
  errormodel cauchy ~ cauchy(nc);
solve t cauchy normal / random=2000 seed=1962 out=monte
   sdata=s(where=(_type_="CORR"));
run;
```

An estimation of the joint density of the *t* and Cauchy distribution is created using the KDE procedure. Bounds were placed on the Cauchy dimension because of its fat tail behavior. The joint PDF is shown in Output 4.3.1.

```
proc kde gridl=5780,-150 gridu=5784,150 data=monte out=density;
var t cauchy;
run;

title "T and Cauchy Distribution";
proc g3d data=density;
  plot t*cauchy=density;
run;
```

**Output 4.3.1.** Density of T and CAUCHY Truncated in the CAUCHY dimension



# References

Goldfeld, S.M. and Quandt, R.E. (1972), *Nonlinear Methods in Econometrics*, Amsterdam: North-Holland Publishing Company.

Goldfeld, S.M. and Quandt, R.E. (1973), "A Markov Model for Switching Regressions," *Journal of Econometrics*, 3-16.

Goldfeld, S.M. and Quandt, R.E. (1973), "The Estimation of Structural Shifts by Switching Regressions," *Annals of Economic and Social Measurement*, 2/4.

Goldfeld, S.M. and Quandt, R.E. (1976), *Studies in Nonlinear Estimation*, Cambridge, MA: Ballinger Publishing Company.

Nelsen, Roger B. (1999), *Introduction to Copulas*, New York, New York: Springer-Verlag.

Chapter 5
# The VARMAX Procedure

## Chapter Table of Contents

Chapter 5

# The VARMAX Procedure

## Overview

The VARMAX procedure now includes maximum likelihood estimation for VARMA models and multivariate GARCH models:

Vector time series can now be estimated by a finite order VAR process with a finite order MA error term. The VARMA processes have infinite order pure VAR and MA representations. Impulse response analysis and forecasting VARMA processes are included.

Multivariate GARCH models now enable you to specify a functional form for the conditional covariance and also enable you to model the first and second moments jointly.

## Syntax

### MODEL Statement

#### *Lag Specification Options*

**Q=** *number*
**Q= (***number-list***)**
specifies the order of the moving-average error process. Subset models of moving-average orders can be specified as, for example, Q=(1,5). The default is Q=0.

#### *GARCH Model Estimation Options*

**GARCH=(Q=***number* **P=***number* **FORM=** *value* **MEAN )**
specifies a GARCH-type multivariate conditional heteroscedasticity model. The GARCH= option in the MODEL statement specifies the family of GARCH models to be estimated. See the "**??**" section on page **??** for details.

The following options can be used in the GARCH= option.

**FORM=** *value*
specifies the representation for a GARCH model. Valid values are as follows:

| | |
|---|---|
| BEKK | specifies a *BEKK* representation. This is the default. |
| BEW | specifies a vectorized representation. |
| DIAG | specifies a diagonal representation. |

**MEAN**
specifies the GARCH-M model.

**P=***number*

**P=(***number-list***)**
specifies the order of the process or the subset of GARCH terms to be fitted. By default, P=0.

**Q=***number*
**Q=(***number-list***)**
specifies the order of the process or the subset of ARCH terms to be fitted. This option is required in the GARCH= option.

### *Printing Options*

**PRINT=(ROOTS)**
In addition, when the GARCH= option is specified, this option prints the roots of the GARCH characteristic polynomials to check covariance stationarity for the GARCH process.

## RESTRICT Statement

The following keyword is for the fitted moving-average model:

MA($l,i,j$) is the moving-average parameter of the previous lag $l$ value of the $j$th error process, $\boldsymbol{\epsilon}_{j,t-l}$

The following keywords are for the fitted GARCH model. The indexes $i$ and $j$ refer to the position of the element in the coefficient matrix.

- GCHM($i$,$j$) is the GARCH-M parameter of $\mathrm{vech}(H_t)$ for $i = 1,\ldots,k$ and $j = 1,\ldots,k(k+1)/2$
- GCHC($i$,$j$) is the constant parameter of the covariance matrix, $H_t$, for $1 \leq i \leq j \leq k$
- ACH($l$,$i$,$j$) is the ARCH parameter of the previous lag $l$ value of $\boldsymbol{\epsilon}_t\boldsymbol{\epsilon}_t'$
- GCH($l$,$i$,$j$) is the GARCH parameter of the previous lag $l$ value of covariance matrix, $H_t$

The indexes $i$ and $j$ for ACH($l$,$i$,$j$) and GCH($l$,$i$,$j$) have different ranges according to the GARCH model representation. For example, $i,j = 1,\ldots,k$ for a *BEKK* representation, $i,j = 1,\ldots,k(k+1)/2$ for a *BEW* representation, and $i = j = 1,\ldots,k(k+1)/2$ for a *diagonal* representation.

## OUTEST= Data Set

The following keywords are for the fitted GARCH model:

- GCHM_$i$ are numeric variables containing the estimates of the GARCH-M parameters of the covariance matrix and their standard errors, where $i = 1,\ldots,k(k+1)/2$, $k$ is the number of endogenous variables.

- ACH$l$_$i$ are numeric variables containing the estimates of the ARCH parameters of the covariance matrix and their standard errors, where $l$ is the lag $l$th coefficient matrix and $i = 1, \ldots, k$ for a *BEKK* representation, or $i = 1, \ldots, k(k+1)/2$ for other representations. $k$ is the number of endogenous variables.
- GCH$l$_$i$ are numeric variables containing the estimates of the GARCH parameters of the covariance matrix and their standard errors, where $l$ is the lag $l$th coefficient matrix and $i = 1, \ldots, k$ for a *BEKK* representation, or $i = 1, \ldots, k(k+1)/2$ for other representations. $k$ is the number of endogenous variables.
- GCHC_$i$ are numeric variables containing the estimates of the constant parameters of the covariance matrix and their standard errors, where $i = 1, \ldots, k$ for a *BEKK* representation, $k$ is the number of endogenous variables. $i = 1$ for other representations.

Chapter 6
# The X12 Procedure

## Chapter Table of Contents

# Chapter 6
# The X12 Procedure

## Overview

The X12 procedure has several new and enhanced statements, as well as some new predefined regression variables and tables:

BY and ID statements have been added. The user can control forecasting with the FORECAST statement that has the LEAD option. In the TRANSFORM statement, some standard Box-Cox transformations can be requested using the FUNCTION= options, which include the values NONE, LOG, SQRT, INVERSE, LOGISTIC, and AUTO. The X11 statement has been greatly expanded with the addition of the OUTFORECAST, SEASONALMA=, and TRENDMA= options.

The new predefined regression variables available through the REGRESSION PREDEFINED= option are CONSTANT, LOMSTOCK, SEASONAL, TD, TDNOLPYEAR, TD1COEF, and TD1NOPYEAR.

The following new tables are available: prior-adjustment factors (A2), chi-squared tests for groups of regressors (RegressorGroupChisq), average absolute percentage error in win-sample forecasts (AvgFcstErr), seasonal MA roots (Roots), and day of the week trading day component factors (F4).

## Syntax

### BY Statement

**BY** *variables;*

A BY statement can be used with PROC X12 to obtain separate analyses on observations in groups defined by the BY variables. When a BY statement appears, the procedure expects the input DATA= data set to be sorted in order of the BY variables.

### ID Statement

**ID** *variables;*

If you are creating an output data set, use the ID statement to put values of the ID variables, in addition to the table values, into the output data set. The ID statement has no effect when an output data set is not created. If the DATE= variable is specified in the MONTHLY or QUARTERLY statement, this variable is included automatically in the OUTPUT data set. If no DATE= variable is specified, the variable _DATE_ is added.

The date variable (or _DATE_ ) values outside the range of the actual data (from forecasting) are extrapolated, while all other ID variables are missing.

## FORECAST Statement

**FORECAST** *options;*

The FORECAST statement is used to forecast the time series using the estimated model. The output contains point forecast and forecast statistics for the transformed and original series.

The following option can appear in the FORECAST statement.

**LEAD=** *value*

Specifies the number of periods ahead to forecast. The default is the number of periods in a year (4 or 12) and the maximum is 60.

Forecasts and Standard Errors Tables are displayed in association with the FORECAST statement. Confidence limits are also included. If the data are transformed, then two tables will be displayed, one table for the original data, and one table for the transformed data.

**REGRESSION** *options;*

The REGRESSION statement includes regression variables in a regARIMA model or specifies regression variables whose effects are to be removed by the IDENTIFY statement to aid in ARIMA model identification. Predefined regression variables are selected with the PREDEFINED option. Table A6 provides information related to trading-day effects. Table A8 provides information related to outlier factors. You should note that missing values in the input series automatically create missing value regressors. Combining your model with additional predefined regression variables may result in a singularity problem. If a singularity occurs, then you may need to alter either the model or the choices of the predefined regressors in order to successfully perform the regression.

The following options can appear in the REGRESSION statement.

**PREDEFINED= CONSTANT**
**PREDEFINED= LOM**
**PREDEFINED= LOMSTOCK**
**PREDEFINED= LOQ**
**PREDEFINED= LPYEAR**
**PREDEFINED= SEASONAL**
**PREDEFINED= TD**
**PREDEFINED= TDNOLPYEAR**
**PREDEFINED= TD1COEF**
**PREDEFINED= TD1NOLPYEAR**

lists the predefined regression variables to be included in the model. Data values for these variables are calculated by the program, mostly as functions of the calendar. The values LOM and LOQ are actually equivalent: the actual regression is controlled by the PROC X12 SEASONS= option. Multiple predefined regression variables can be used. The syntax for using both a length-of-month and a seasonal regression could be in one of the following forms:

```
regression predefined=lom seasonal;

regression predefined=(lom seasonal);

regression predefined=lom predefined=seasonal;
```

Certain restrictions apply when using more than one predefined regression variable. Only one of TD, TDNOLPYEAR, TD1COEF, or TD1NOLPYEAR may be specified. LPYEAR cannot be used with TD, TD1COEF, LOM, LOMSTOCK, or LOQ. LOM or LOQ cannot be used with TD or TD1COEF.

**Table 6.1.** Predefined Regression Variables in X-12-ARIMA

| Regression Effect | Variable Definitions |
|---|---|
| Trend Constant<br>CONSTANT | $(1-B)^{-d}(1-B^s)^{-D}I(t \geq 1)$,<br>where $I(t \geq 1) = \begin{cases} 1 & \text{for } t \geq 1 \\ 0 & \text{for } t < 1 \end{cases}$ |
| Length-of-Month<br>(monthly flow)<br>LOM | $m_t - \bar{m}$ where $m_t$ = length of month $t$ (in days)<br>and $\bar{m} = 30.4375$ (average length of month) |
| Stock Length-of-Month<br>LOMSTOCK | $SLOM_t = \begin{cases} m_t - \bar{m} - \mu(l) & \text{for t = 1} \\ SLOM_{t-1} + m_t - \bar{m} & \text{otherwise} \end{cases}$<br>where $\bar{m}$ and $m_t$ are defined in LOM and<br>$\mu(l) = \begin{cases} 0.375 & \text{when 1st February in series is a leap year} \\ 0.125 & \text{when 2nd February in series is a leap year} \\ -0.125 & \text{when 3rd February in series is a leap year} \\ -0.375 & \text{when 4th February in series is a leap year} \end{cases}$ |
| Length-of-Quarter<br>(quarterly flow)<br>LOQ | $q_t - \bar{q}$ where $q_t$ = length of quarter $t$ (in days)<br>and $\bar{q} = 91.3125$ (average length of quarter) |
| Leap Year<br>(monthly and quarterly flow)<br>LPYEAR | $LY_t = \begin{cases} 0.75 & \text{in leap year February (first quarter)} \\ -0.25 & \text{in other Februaries (first quarter)} \\ 0 & \text{otherwise} \end{cases}$ |
| Fixed Seasonal<br>SEASONAL | $M_{1,t} = \begin{cases} 1 & \text{in January} \\ -1 & \text{in December} \\ 0 & \text{otherwise} \end{cases}$,..., $M_{11,t} = \begin{cases} 1 & \text{in November} \\ -1 & \text{in December} \\ 0 & \text{otherwise} \end{cases}$ |
| Trading Day<br>TD, TDNOLPYEAR | $T_{1,t} = (\text{no. of Mondays}) - (\text{no. of Sundays})$, ...,<br>$T_{6,t} = (\text{no. of Saturdays}) - (\text{no. of Sundays})$ |
| One Coefficient Trading Day<br>TD1COEF, TD1NOLPYEAR | $(\text{no. of weekdays}) - \frac{5}{2}(\text{no. of Saturdays and Sundays})$ |

## TRANSFORM Statement

**TRANSFORM** *options;*

The TRANSFORM statement transforms or adjusts the series prior to estimating a regARIMA model. With this statement, the series can be Box-Cox (power) transformed. The Prior Adjustment Factors table is associated with the TRANSFORM statement.

Only one of the following options can appear in the TRANSFORM statement.

**POWER=** *value*

Transform the input series $Y_t$ using a Box-Cox power transformation,

$$Y_t \rightarrow y_t = \begin{cases} log(Y_t) & \lambda = 0 \\ \lambda^2 + (Y_t^{\lambda} - 1)/\lambda & \lambda \neq 0 \end{cases}$$

The power $\lambda$ must be specified (for example, POWER= $.33$). The default is no transformation ($\lambda = 1$); that is, POWER= $1$. The log transformation (POWER= $0$), square root transformation (POWER= $.5$), and the inverse transformation (POWER= $-1$) are equivalent to the corresponding FUNCTION= option.

**Table 6.2.** Power Values Related to the Census Bureau Function Argument

| function= | transformation | range for $Y_t$ | equivalent power argument |
|---|---|---|---|
| none | $Y_t$ | all values | $power = 1$ |
| log | $log(Y_t)$ | $Y_t > 0$ for all $t$ | $power = 0$ |
| sqrt | $2(\sqrt{Y_t} - 0.875)$ | $Y_t \geq 0$ for all $t$ | $power = 0.5$ |
| inverse | $2 - \frac{1}{Y_t}$ | $Y_t \neq 0$ for all $t$ | $power = -1$ |
| logistic | $log(\frac{Y_t}{1-Y_t})$ | $0 < Y_t < 1$ for all $t$ | *none equivalent* |

**FUNCTION=NONE**
**FUNCTION=LOG**
**FUNCTION=SQRT**
**FUNCTION=INVERSE**
**FUNCTION=LOGISTIC**
**FUNCTION=AUTO**

The transformation used by FUNCTION=NONE, LOG, SQRT, INVERSE, and LOGISTIC is related to the POWER= option as shown in Table 6.2. FUNCTION=AUTO uses an AIC-based selection to decide between a log transformation and no transformation. The default is FUNCTION=NONE.

However, the FUNCTION= and POWER= options are not completely equivalent. In some cases, using the FUNCTION= option causes the program to automatically select other options. For instance, FUNCTION=NONE causes the default mode to be MODE=ADD in the X11 statement. Also, the choice of transformation invoked by the FUNCTION=AUTO option may impact the default mode of the X11 statement.

Note that there are restrictions on the value used in the POWER and FUNCTION options when preadjustment factors for seasonal adjustment are generated from a regARIMA model. When seasonal adjustment is requested with the X11 statement, any value of the POWER option can be used for the purpose of forecasting the series with a regARIMA model. However, this is not the case when factors generated from the regression coefficients are used to adjust either the original series or the final seasonally adjusted series. In this case, the only accepted transformations are the log transformation, which can be specified as POWER = 0 (for multiplicative or log-additive seasonal adjustments) and no transformation, which can be specified as POWER = 1 (for additive seasonal adjustments). If no seasonal adjustment is performed, any POWER transformation can be used. The preceding restrictions also apply to FUNCTION=NONE and FUNCTION=LOG.

## X11 Statement

**X11** *options;*

The X11 statement is an optional statement for invoking seasonal adjustment by an enhanced version of the methodology of the Census Bureau X-11 and X-11Q programs. You can control the type of seasonal adjustment decomposition calculated with the MODE= option. The output includes the final tables and diagnostics for the X-11 seasonal adjustment method listed in Table 6.3.

**Table 6.3.** Tables Related to X11 Seasonal Adjustment

| Table Name | Description |
|---|---|
| B1 | original series, adjusted for prior effects and forecast extended |
| C17 | final weights for the irregular component |
| D8 | final unmodified SI ratios (differences) |
| D8A | *F* tests for stable and moving seasonality, D8 |
| D9 | final replacement values for extreme SI ratios (differences), D iteration |
| D9A | moving seasonality ratios for each period |
| D10 | final seasonal factors |
| D10D | final seasonal difference |
| D11 | final seasonally adjusted series |
| D12 | final trend-cycle |
| D13 | final irregular component |
| D16 | combined seasonal and trading day factors |
| D16B | final adjustment differences |
| D18 | combined calendar adjustment factors |
| E4 | ratio of yearly totals of original and seasonally adjusted series |
| E5 | percent changes (differences) in original series |
| E6 | percent changes (differences) in seasonally adjusted series |
| E7 | percent changes (differences) in final trend component series |
| F2A - F2I | X11 diagnostic summary |
| F3 | monitoring and quality assessment statistics |
| F4 | day of the week trading day component factors |
| G | spectral plots |

For more details on the X-11 seasonal adjustment diagnostics, refer to Shiskin, Young, and Musgrave (1967), Lothian and Morry (1978), and Ladiray and Quenneville (1999).

The following options can appear in the X11 statement.

**MODE= ADD**
**MODE= MULT**
**MODE= LOGADD**
**MODE= PSEUDOADD**

determines the mode of the seasonal adjustment decomposition to be performed. There are four choices: multiplicative (MODE=MULT), additive (MODE=ADD), pseudo-additive (MODE=PSEUDOADD), and log-additive (MODE=LOGADD) decomposition. If this option is omitted, the procedure performs multiplicative adjustments. Table 6.4 shows the values of the MODE= option and the corresponding models for the original (O) and the seasonally adjusted (SA) series.

**Table 6.4.** Modes of Seasonal Adjustment and Their Models

| Value of Mode Option | Name | Model for $O$ | Model for $SA$ |
|---|---|---|---|
| mult | Multiplicative | $O = C \times S \times I$ | $SA = C \times I$ |
| add | Additive | $O = C + S + I$ | $SA = C + I$ |
| pseudoadd | Pseudo-Additive | $O = C \times [S + I - 1]$ | $SA = C \times I$ |
| logadd | Log-Additive | $Log(O) = C + S + I$ | $SA = exp(C + I)$ |

**OUTFCST**
**OUTFORECAST**

determines if forecasts will be included in certain tables sent to the output data set. If OUTFORECAST is specified, then forecasted values will be included in the output data set for tables A6, A8, A16, B1, D10, and D16. The default is not to include forecasts.

**SEASONALMA=S3X1**
**SEASONALMA=S3X3**
**SEASONALMA=S3X5**
**SEASONALMA=S3X9**
**SEASONALMA=S3X15**
**SEASONALMA=STABLE**
**SEASONALMA=X11DEFAULT**
**SEASONALMA=MSR**

specifies which seasonal moving average (also called seasonal “filter”) will be used to estimate the seasonal factors. These seasonal moving averages are $n \times m$ *moving averages*, meaning that an $n$-term simple average is taken of a sequence of consecutive $m$-term simple averages. X11DEFAULT is the method used by the U.S. Census Bureau’s X-11-ARIMA program. The default for PROC X12 is SEASONALMA=MSR, which is the methodology of Statistic Canada’s X-11-ARIMA/88 program.

The following seasonal filters can be selected for the entire series:

**Table 6.5.** X-12-ARIMA Seasonal Filter Options and Descriptions

| Filter Name | Description of Filter |
|---|---|
| S3X1 | A $3 \times 1$ moving average. |
| S3X3 | A $3 \times 3$ moving average. |
| S3X5 | A $3 \times 5$ moving average. |
| S3X9 | A $3 \times 9$ moving average. |
| S3X15 | A $3 \times 15$ moving average. |
| STABLE | Stable seasonal filter. As single seasonal factor for each calendar month or quarter is generated by calculating the simple average of all the values for each month or quarter (taken after detrending and outlier adjustment). |
| X11DEFAULT | A $3 \times 3$ moving average is used to calculate the initial seasonal factors in each iteration, and a $3 \times 5$ moving average to calculate the final seasonal factors. |
| MSR | Choose filter automatically using moving seasonality ratio of X-11-ARIMA/88 (Dagum 1988). |

**TRENDMA=** *value*

specifies which Henderson moving average will be used to estimate the final trend-cycle. Any odd number greater than one and less than or equal to 101 can be specified. Example: trendma=23. If no selection is made the program will select a trend moving average based on statistical characteristics of the data. For monthly series, either a 9-, 13-, or 23-term Henderson moving average will be selected. For quarterly series, the program will choose either a 5- or a 7-term Henderson moving average.

# References

Ladiray, D. and Quenneville B. (2001), "Seasonal Adjustment with the X-11 Method," New York: Springer-Verlag.

Lothian, J. and Morry M., (1978), "A Test of Quality Control Statistics for the X-11-ARIMA Seasonal Adjustment Program," Research Paper, Seasonal Adjustment and Times Series Staff, Statistics Canada.

Shiskin, J., Young, A. H., and Musgrave, J. C. (1967), "The X-11 Variant of the Census Method II Seasonal Adjustment Program," Technical Paper No. 15, U.S. Department of Commerce, Bureau of the Census.

# Subject Index

# Syntax Index

## T



## U



## X

# Your Turn

If you have comments or suggestions about *SAS/ETS® Software: Changes and Enhancements, Release 8.2,* please send them to us on a photocopy of this page or send us electronic mail.

For comments about this book, please return the photocopy to

SAS Institute Inc.
SAS Publishing
SAS Campus Drive
Cary, NC 27513
**E-mail**: yourturn@sas.com

For suggestions about the software, please return the photocopy to

SAS Institute Inc.
Technical Support Division
SAS Campus Drive
Cary, NC 27513
**E-mail**: suggest@sas.com

## Create Customized Textbooks Quickly, Easily, and Affordably

SelecText® offers instructors at U.S. colleges and universities a way to create custom textbooks for courses that teach students how to use SAS software.

For more information, see our Web page at **www.sas.com/selectext**, or contact our SelecText coordinators by sending e-mail to **selectext@sas.com**.

## You're Invited to Publish with SAS Institute's User Publishing Program

If you enjoy writing about SAS software and how to use it, the User Publishing Program at SAS Institute offers a variety of publishing options. We are actively recruiting authors to publish books, articles, and sample code. Do you find the idea of writing a book or an article by yourself a little intimidating? Consider writing with a co-author. Keep in mind that you will receive complete editorial and publishing support, access to our users, technical advice and assistance, and competitive royalties. Please contact us for an author packet. E-mail us at **sasbbu@sas.com** or call 919-677-8000, then press 1-6479. See the SAS Institute Publishing Web page at **www.sas.com/pubs** for complete information.

## See *Observations*®, Our Online Technical Journal

Feature articles from *Observations*®: *The Technical Journal for SAS® Software Users* are now available online at **www.sas.com/obs**. Take a look at what your fellow SAS software users and SAS Institute experts have to tell you. You may decide that you, too, have information to share. If you are interested in writing for *Observations*, send e-mail to **sasbbu@sas.com** or call 919-677-8000, then press 1-6479.

## Book Discount Offered at SAS Public Training Courses!

When you attend one of our SAS Public Training Courses at any of our regional Training Centers in the U.S., you will receive a 15% discount on book orders that you place during the course. Take advantage of this offer at the next course you attend!

---

SAS Institute
SAS Campus Drive
Cary, NC 27513-2414
Fax 919-677-4444

E-mail: sasbook@sas.com
Web page: www.sas.com/pubs
To order books, call Fulfillment Services at 800-727-3228*
For other SAS Institute business, call 919-677-8000*

* **Note:** Customers outside the U.S. should contact their local SAS office.

*The Power to Know*™

SAS Publishing