Chapter 1
Introduction

Chapter Contents

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Overview of SAS/ETS Software

SAS/ETS software, a component of the SAS System, provides SAS procedures for

- econometric analysis
- time series analysis
- time series forecasting
- systems modeling and simulation
- discrete choice analysis
- analysis of qualitative and limited dependent variable models
- seasonal adjustment of time series data
- financial analysis and reporting
- access to economic and financial databases
- time series data management

In addition to SAS procedures, SAS/ETS software also includes interactive environments for time series forecasting and investment analysis.

Uses of SAS/ETS Software

SAS/ETS software provides tools for a wide variety of applications in business, government, and academia. Major uses of SAS/ETS procedures are economic analysis, forecasting, economic and financial modeling, time series analysis, financial reporting, and manipulation of time series data.

The common theme relating the many applications of the software is time series data: SAS/ETS software is useful whenever it is necessary to analyze or predict processes that take place over time or to analyze models that involve simultaneous relationships.

Although SAS/ETS software is most closely associated with business and economics, time series data also arise in many other fields. SAS/ETS software is useful whenever time dependencies, simultaneous relationships, or dynamic processes complicate data analysis. For example, an environmental quality study might use SAS/ETS software's time series analysis tools to analyze pollution emissions data. A pharmacokinetic study might use SAS/ETS software's features for nonlinear systems to model the dynamics of drug metabolism in different tissues.

The diversity of problems for which econometrics and time series analysis tools are needed is reflected in the applications reported by SAS users. The following listed items are some applications of SAS/ETS software presented by SAS users at past annual conferences of the SAS Users Group International (SUGI).

- forecasting college enrollment (Calise and Earley 1997)
- fit a pharmacokinetic model (Morelock et al. 1995)
- testing interaction effect in reducing SIDS (Fleming, Gibson, and Fleming 1996)
- forecasting operational indices to measure productivity changes (McCarty 1994)
- spectral decomposition and reconstruction of nuclear plant signals (Hoyer and Gross 1993)
- estimating parameters for the CES-Translog model (Hisnanick 1993)
- applying econometric analysis for mass appraisal of real property (Amal and Weselowski 1993)
- forecasting telephone usage data (Fishetti, Heathcote, and Perry 1993)
- forecasting demand and utilization of inpatient hospital services (Hisnanick 1992)
- using conditional demand estimation to determine electricity demand (Keshani and Taylor 1992)
- estimating tree biomass for measurement of forestry yields (Parresol and Thomas 1991)
- evaluating the theory of input separability in the production function of U.S. manufacturing (Hisnanick 1991)
- forecasting dairy milk yields and composition (Benseman 1990)
- predicting the gloss of coated aluminum products subject to weathering (Khan 1990)
- learning curve analysis for predicting manufacturing costs of aircraft (Le Bouton 1989)
- analyzing Dow Jones stock index trends (Early, Sweeney, and Zekavat 1989)
- analyzing the usefulness of the composite index of leading economic indicators for forecasting the economy (Lin and Myers 1988)

Contents of SAS/ETS Software

Procedures

SAS/ETS software includes the following SAS procedures:

ARIMA	ARIMA (Box-Jenkins) and ARIMAX (Box-Tiao) modeling and forecasting
AUTOREG	regression analysis with autocorrelated or heteroscedastic errors and ARCH and GARCH modeling
COMPUTAB	spreadsheet calculations and financial report generation
DATASOURCE	access to financial and economic databases

ENTROPY	maximum entropy-based regression
EXPAND	time series interpolation and frequency conversion, and transformation of time series
FORECAST	automatic forecasting
LOAN	loan analysis and comparison
MDC	multinomial discrete choice analysis
MODEL	nonlinear simultaneous equations regression and nonlinear systems modeling and simulation
PDLREG	polynomial distributed lag regression (Almon lags)
QLIM	qualitative and limited dependent variable analysis
SIMLIN	linear systems simulation
SPECTRA	spectral and cross spectral analysis
STATESPACE	state space modeling and automated forecasting of multivariate time series
SYSLIN	linear simultaneous equations models
TIMESERIES	analysis of time-stamped transactional data
TSCSREG	time series cross-sectional regression analysis
UCM	unobserved components analysis of time series
VARMAX	vector autoregressive and moving-average modeling and forecasting
X11	seasonal adjustment (Census X-11 and X-11 ARIMA)
X12	seasonal adjustment (Census X-12 ARIMA)

Macros

SAS/ETS software includes the following SAS macros:

%AR	generates statements to define autoregressive error models for the MODEL procedure
%BOXCOXAR	investigates Box-Cox transformations useful for modeling and forecasting a time series
%DFPVALUE	computes probabilities for Dickey-Fuller test statistics
%DFTEST	performs Dickey-Fuller tests for unit roots in a time series process
%LOGTEST	tests to see if a log transformation is appropriate for modeling and forecasting a time series
%MA	generates statements to define moving average error models for the MODEL procedure
%PDL	generates statements to define polynomial distributed lag models for the MODEL procedure

These macros are part of the SAS AUTOCALL facility and are automatically available for use in your SAS program. Refer to *SAS Macro Language: Reference* for information about the SAS macro facility.

The Time Series Forecasting System

In addition to SAS procedures and macros, SAS/ETS software also includes an interactive forecasting user interface. This user interface was developed with SAS/AF software and uses PROC ARIMA to perform time series forecasting. The TSF system makes it easy to forecast time series and provides many features for graphical data exploration and graphical comparisons of forecasting models and forecasts. (SAS/GRAPH is required to use the graphical features of the system.)

The Investment Analysis System

The Investment Analysis system is an interactive environment for the time-value of money of a variety of investments. Various analyses are provided to help analyze the value of investment alternatives: time value, periodic equivalent, internal rate of return, benefit-cost ratio, and breakeven analysis.

Some of the features of SAS/ETS software are also available through menu driven interfaces provided by SAS/ASSIST software. (Both SAS/ASSIST software and SAS/ETS software must be licensed for you to use these features.)

The following components of SAS/ASSIST software enable you to use SAS/ETS procedures through a menu interface:

- loan analysis (uses PROC LOAN)
- regression with correction for autocorrelation (uses PROC AUTOREG)
- seasonal adjustment (uses PROC X11)
- convert frequency of time series data (uses PROC EXPAND)

About This Book

This book is a user's guide to SAS/ETS software. Since SAS/ETS software is a part of the SAS System, this book assumes that you are familiar with Base SAS software and have the books *SAS Language: Reference* and *SAS Procedures Guide* available for reference. It also assumes that you are familiar with SAS data sets, the SAS DATA step, and with basic SAS procedures such as PROC PRINT and PROC SORT. Chapter 2, "Working with Time Series Data," in this book summarizes the aspects of Base SAS software most relevant to the use of SAS/ETS software.

Chapter Organization

Following a brief What's New section, this book is divided into four major parts. "Part One" contains general information to aid you in working with SAS/ETS Software. "Part Two" is the "Procedure Reference" that is comprised of chapters that explain the SAS procedures that make up SAS/ETS software. "Part Three" is the reference for the Time Series Forecasting System, an interactive forecasting menu system that uses PROC ARIMA to perform time series forecasting. Finally, "Part Four" is the reference for the Investment Analysis System.

The new features added to SAS/ETS software since the publication of *SAS/ETS Software: Changes and Enhancements for Release 8.2* are summarized in "What's New in SAS/ETS 9 and 9.1." If you have used SAS/ETS software in the past, you may want to skim this chapter to see what's new.

"Part One" contains the following chapters.

Chapter 1, the current chapter, provides an overview of SAS/ETS software and summarizes related SAS Institute publications, products, and services.

Chapter 2, "Working with Time Series Data," discusses the use of SAS data management and programming features for time series data.

Chapter 3, "Date Intervals, Formats, and Functions," summarizes the time intervals, date and datetime informats, date and datetime formats, and date and datetime functions available in the SAS System.

Chapter 4, "SAS Macros and Functions," documents SAS macros and DATA step financial functions provided with SAS/ETS software. The macros use SAS/ETS procedures to perform Dickey-Fuller tests, test for the need for log transformations, or select optimal Box-Cox transformation parameters for time series data.

Chapter 5, "The SASECRSP Interface Engine," documents the SASECRSP interface engine that 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.

Chapter 6, "The SASEFAME Interface Engine," documents the SASEFAME interface engine that 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.

Chapter 7, "The SASEHAVR Interface Engine," documents the SASEHAVR interface engine that provides Windows users random access to economic and financial data residing in a HAVER ANALYTICS Data Link Express (DLX) database.

Chapter 8, "Using the Output Delivery System," provides an introduction to the Output Delivery System (ODS).

Chapter 9, "Statistical Graphics Using ODS," provides an introduction to the experimental graphics extension to the Output Delivery System.

Chapter 10, "Nonlinear Optimization Methods," documents the NonLinear Optimization subsystem used by some ETS procedures to perform nonlinear optimization tasks.

"Part Two" contains the chapters that explain the SAS procedures that make up SAS/ETS software. These chapters appear in alphabetical order by procedure name.

The chapters documenting the SAS/ETS procedures are organized as follows:

1. Each chapter begins with an "Overview" section that gives a brief description of the procedure.

2. The “Getting Started” section provides a tutorial introduction on how to use the procedure.
3. The “Syntax” section is a reference to the SAS statements and options that control the procedure.
4. The “Details” section discusses various technical details.
5. The “Examples” section contains examples of the use of the procedure.
6. The “References” section contains technical references on methodology.

“Part Three” contains the chapters that document the features of the Time Series Forecasting System, while the features of the Investment Analysis System are documented in “Part Four.”

Typographical Conventions

This book uses several type styles for presenting information. The following list explains the meaning of the typographical conventions used in this book:

roman	is the standard type style used for most text.
UPPERCASE ROMAN	is used for SAS statements, options, and other SAS language elements when they appear in the text. However, you can enter these elements in your own SAS programs in lowercase, uppercase, or a mixture of the two.
UPPERCASE BOLD	is used in the “Syntax” sections’ initial lists of SAS statements and options.
oblique	is used for user-supplied values for options in the syntax definitions. In the text, these values are written in *italic*.
helvetica	is used for the names of variables and data sets when they appear in the text.
bold	is used to refer to matrices and vectors, and to refer to commands (e.g **end** or **cd**.)
italic	is used for terms that are defined in the text, for emphasis, and for references to publications.
`monospace`	is used for example code. In most cases, this book uses lowercase type for SAS code.

Options Used in Examples

Output of Examples

For each example, the procedure output is numbered consecutively starting with 1, and each output is given a title. Each page of output produced by a procedure is enclosed in a box.

Most of the output shown in this book is produced with the following SAS System options:

```
options linesize=80 pagesize=200 nonumber nodate;
```

The template STATDOC.TPL is used to create the HTML output that appears in the online (CD) version. A style template controls stylistic HTML elements such as colors, fonts, and presentation attributes. The style template is specified in the ODS HTML statement as follows:

```
ODS HTML style=statdoc;
```

If you run the examples, you may get slightly different output. This is a function of the SAS System options used and the precision used by your computer for floating-point calculations.

Graphics Options

The examples that contain graphical output are created with a specific set of options and symbol statements. The code you see in the examples creates the color graphics that appear in the online (CD) version of this book. A slightly different set of options and statements is used to create the black-and-white graphics that appear in the printed version of the book.

If you run the examples, you may get slightly different results. This may occur because not all graphic options for color devices translate directly to black-and-white output formats. For complete information on SAS/GRAPH software and graphics options, refer to *SAS/GRAPH Software: Reference*.

The following GOPTIONS statement is used to create the online (color) version of the graphic output.

```
filename GSASFILE  '<file-specification>';

goptions reset=all
         gaccess=GSASFILE    gsfmode=replace
         fileonly
         transparency        dev = gif
         ftext = swiss       lfactor = 1
         htext = 4.0pct      htitle = 4.5pct
         hsize = 5.5in       vsize = 3.5in
         noborder            cback = white
         horigin = 0in       vorigin = 0in ;
```

The following GOPTIONS statement is used to create the black-and-white version of the graphic output, which appears in the printed version of the manual.

```
filename GSASFILE  '<file-specification>';

goptions reset=all
         gaccess=GSASFILE    gsfmode=replace
         fileonly
```

```
dev = pslepsf
ftext = swiss          lfactor = 1
htext = 3.0pct         htitle = 3.5pct
hsize = 5.5in          vsize = 3.5in
border                 cback = white
horigin = 0in          vorigin = 0in;
```

In most of the online examples, the plot symbols are specified as follows:

```
symbol1 value=dot color=white height=3.5pct;
```

The SYMBOL*n* statements used in online examples order the symbol colors as follows: white, yellow, cyan, green, orange, blue, and black.

In the examples appearing in the printed manual, symbol statements specify COLOR=BLACK and order the plot symbols as follows: dot, square, triangle, circle, plus, x, diamond, and star.

Where to Turn for More Information

This section describes other sources of information about SAS/ETS software.

Accessing the SAS/ETS Sample Library

The SAS/ETS Sample Library includes many examples that illustrate the use of SAS/ETS software, including the examples used in this documentation. To access these sample programs, select **Help** from the menu and select **SAS Help and Documentation**. From the Contents list, choose **Learning to Use SAS** and then **Sample SAS Programs**.

Online Help System

You can access online help information about SAS/ETS software in two ways, depending on whether you are using the SAS windowing environment in the command line mode or the pull-down menu mode.

If you are using a command line, you can access the SAS/ETS help menus by typing **help** on the SAS windowing environment command line. Or you can or issue the command **help ARIMA** (or another procedure name) to bring up the help for that particular procedure.

If you are using the SAS windowing environment pull-down menus, you can pull-down the **Help** menu and make the following selections:

- SAS Help and Documentation
- Learning to Use SAS in the Contents list
- SAS Products
- SAS/ETS

The content of the Online Help System follows closely the one of this book.

Other Related SAS Institute Publications

In addition to this user's guide, SAS Institute publishes other books on using SAS/ETS software. The following books are companions to this user's guide:

- *SAS/ETS Software: Applications Guide 1, Version 6, First Edition*
- *SAS/ETS Software: Applications Guide 2, Version 6, First Edition*

The first volume, *SAS/ETS Software: Applications Guide 1*, discusses features of SAS/ETS software for time series modeling and forecasting, financial reporting, and loan analysis. The second volume, *SAS/ETS Software: Applications Guide 2*, discusses features of SAS/ETS software for econometric modeling and simulation.

Forecasting Examples for Business and Economics Using the SAS System, discusses forecasting using SAS/ETS software.

SAS Institute Short Courses

SAS Institute offers the following short course on using SAS/ETS software:

Introduction to Time Series Forecasting Using SAS/ETS Software is a Level III course is designed for statisticians, economists, business planners, inventory managers, market researchers, and others who analyze time series data and need to forecast time series data. This course uses the Time Series Forecasting System (TSFS) and the SAS/ETS procedures ARIMA, FORECAST, and EXPAND. After completing this course, you should be able to

- preprocess time series data using SAS date, time, and mathematical DATA step functions
- impute missing or invalid values in time series data using a variety of methods
- recognize and understand the basic components of time series data, including trend and seasonality
- forecast individual time series using regression, exponential smoothing, ARIMA, and composite models
- implement procedures for the automatic generation of forecasts for a large number of time series
- produce forecasts using data collected at different summary levels (for example, SKU, product group, product line, business line)
- produce effective graphics presentations of forecasts
- evaluate the accuracy of forecast models
- select from a variety of competing models

SAS Institute Technical Support Services

As with all SAS Institute products, the SAS Institute Technical Support staff is available to respond to problems and answer technical questions regarding the use of SAS/ETS software.

Major Features of SAS/ETS Software

The following sections briefly summarize major features of SAS/ETS software. See the chapters on individual procedures for more detailed information.

Discrete Choice and Qualitative and Limited Dependent Variable Analysis

The MDC procedure provides maximum likelihood (ML) or simulated maximum likelihood estimates of multinomial discrete choice models in which the choice set consists of unordered multiple alternatives. The MDC procedure supports the following models and features:

- conditional logit
- nested logit
- heteroscedastic extreme value
- multinomial probit
- mixed logit
- pseudo-random or quasi-random numbers for simulated maximum likelihood estimation
- bounds imposed on the parameter estimates
- linear restrictions imposed on the parameter estimates
- SAS data set containing predicted probabilities and linear predictor ($\mathbf{x}'\boldsymbol{\beta}$) values
- goodness-of-fit measures including
  - likelihood ratio
  - Aldrich-Nelson
  - Cragg-Uhler 1
  - Cragg-Uhler 2
  - Estrella
  - Adjusted Estrella
  - McFadden's LRI
  - Veall-Zimmermann
  - Akaike Information Criterion (AIC)
  - Schwarz Criterion

The QLIM procedure analyzes univariate and multivariate limited dependent variable models where dependent variables take discrete values or dependent variables are observed only in a limited range of values. This procedure includes logit, probit, tobit, and general simultaneous equations models. The QLIM procedure supports the following models:

- linear regression model with heteroscedasticity
- probit with heteroscedasticity
- logit with heteroscedasticity
- tobit (censored and truncated) with heteroscedasticity
- Box-Cox regression with heteroscedasticity
- bivariate probit
- bivariate tobit

Regression with Autocorrelated and Heteroscedastic Errors

The AUTOREG procedure provides regression analysis and forecasting of linear models with autocorrelated or heteroscedastic errors. The AUTOREG procedure includes the following features:

- estimation and prediction of linear regression models with autoregressive errors
- any order autoregressive or subset autoregressive process
- optional stepwise selection of autoregressive parameters
- choice of the following estimation methods:
  - exact maximum likelihood
  - exact nonlinear least squares
  - Yule-Walker
  - iterated Yule-Walker
- tests for any linear hypothesis involving the structural coefficients
- restrictions for any linear combination of the structural coefficients
- forecasts with confidence limits
- estimation and forecasting of ARCH (autoregressive conditional heteroscedasticity), GARCH (generalized autoregressive conditional heteroscedasticity), I-GARCH (integrated GARCH), E-GARCH (exponential GARCH), and GARCH-M (GARCH in mean) models
- ARCH and GARCH models can be combined with autoregressive models, with or without regressors
- estimation and testing of general heteroscedasticity models
- variety of model diagnostic information including
  - autocorrelation plots

  - partial autocorrelation plots
  - Durbin-Watson test statistic and generalized Durbin-Watson tests to any order
  - Durbin *h* and Durbin *t* statistics
  - Akaike information criterion
  - Schwarz information criterion
  - tests for ARCH errors
  - Ramsey's RESET test
  - Chow and PChow tests
  - Phillips-Perron stationarity test
  - CUSUM and CUMSUMSQ statistics
- exact significance levels (*p*-values) for the Durbin-Watson statistic
- embedded missing values

Simultaneous Systems Linear Regression

The SYSLIN and ENTROPY procedures provide regression analysis of a simultaneous system of linear equations. The SYSLIN procedure includes the following features:

- estimation of parameters in simultaneous systems of linear equations
- full range of estimation methods including
  - ordinary least squares (OLS)
  - two-stage least squares (2SLS)
  - three-stage least squares (3SLS)
  - iterated 3SLS
  - seemingly unrelated regression (SUR)
  - iterated SUR
  - limited-information maximum-likelihood (LIML)
  - full-information maximum-likelihood (FIML)
  - minimum-expected-loss (MELO)
  - general K-class estimators
- weighted regression
- any number of restrictions for any linear combination of coefficients, within a single model or across equations
- tests for any linear hypothesis, for the parameters of a single model or across equations
- wide range of model diagnostics and statistics including
  - usual ANOVA tables and R^2 statistics
  - Durbin-Watson statistics

  - standardized coefficients
  - test for over-identifying restrictions
  - residual plots
  - standard errors and T tests
  - covariance and correlation matrices of parameter estimates and equation errors

- predicted values, residuals, parameter estimates, and variance-covariance matrices saved in output SAS data sets

The ENTROPY procedure includes the following features:

- generalized maximum entropy (GME) estimation
- generalized cross entropy (GCE) estimation
- maximum entropy SUR (MESUR) estimation
- pure inverse estimation
- estimation of parameters in simultaneous systems of linear equations
- weighted regression
- any number of restrictions for any linear combination of coefficients, within a single model or across equations
- tests for any linear hypothesis, for the parameters of a single model or across equations

Linear Systems Simulation

The SIMLIN procedure performs simulation and multiplier analysis for simultaneous systems of linear regression models. The SIMLIN procedure includes the following features:

- reduced form coefficients
- interim multipliers
- total multipliers
- dynamic forecasts and simulations
- goodness-of-fit statistics
- processes equation system coefficients estimated by the SYSLIN procedure

Polynomial Distributed Lag Regression

The PDLREG procedure provides regression analysis for linear models with polynomial distributed (Almon) lags. The PDLREG procedure includes the following features:

- any number of regressors may enter as a polynomial lag distribution, and any number of covariates may be used
- any order lag length and degree polynomial for lag distribution may be used
- optional upper and lower endpoint restrictions
- any number of linear restrictions may be placed on covariates
- option to repeat analysis over a range of degrees for the lag distribution polynomials
- support for autoregressive errors to any lag
- forecasts with confidence limits

Nonlinear Systems Regression and Simulation

The MODEL procedure provides parameter estimation, simulation, and forecasting of dynamic nonlinear simultaneous equation models. The MODEL procedure includes the following features:

- nonlinear regression analysis for systems of simultaneous equations, including weighted nonlinear regression
- full range of parameter estimation methods including
  - nonlinear ordinary least squares (OLS)
  - nonlinear seemingly unrelated regression (SUR)
  - nonlinear two-stage least squares (2SLS)
  - nonlinear three-stage least squares (3SLS)
  - iterated SUR
  - iterated 3SLS
  - generalized method of moments (GMM)
  - nonlinear full information maximum likelihood (FIML)
  - simulated method of moments (SMM)
- supports dynamic multi-equation nonlinear models of any size or complexity
- uses the full power of the SAS programming language for model definition, including left-hand side expressions
- hypothesis tests of nonlinear functions of the parameter estimates
- linear and nonlinear restrictions of the parameter estimates
- bounds imposed on the parameter estimates
- computation of estimates and standard errors of nonlinear functions of the parameter estimates
- estimation and simulation of Ordinary Differential Equations (ODE's)
- vector autoregressive error processes and polynomial lag distributions easily specified for the nonlinear equations
- variance modeling (ARCH, GARCH, and others)

- computes goal-seeking solutions of nonlinear systems to find input values needed to produce target outputs
- dynamic, static, or *n*-period-ahead-forecast simulation modes
- simultaneous solution or single equation solution modes
- Monte Carlo simulation using parameter estimate covariance and across-equation residuals covariance matrices or user specified random functions
- a variety of diagnostic statistics including
  - model R^2 statistics
  - general Durbin-Watson statistics and exact p-values
  - asymptotic standard errors and T tests
  - first stage R^2 statistics
  - covariance estimates
  - collinearity diagnostics
  - simulation goodness-of-fit statistics
  - Theil inequality coefficient decompositions
  - Theil relative change forecast error measures
  - heteroscedasticity tests
  - Godfrey test for serial correlation
  - Chow tests
- block structure and dependency structure analysis for the nonlinear system
- listing and cross reference of fitted model
- automatic calculation of needed derivatives using exact analytic formula
- efficient sparse matrix methods used for model solution; choice of other solution methods
- model definition, parameter estimation, simulation, and forecasting may be performed interactively in a single SAS session or models can also be stored in files and reused and combined in later runs

ARIMA (Box-Jenkins) and ARIMAX (Box-Tiao) Modeling and Forecasting

The ARIMA procedure provides the identification, parameter estimation, and forecasting of autoregressive integrated moving average (Box-Jenkins) models, seasonal ARIMA models, transfer function models, and intervention models. The ARIMA procedure includes the following features:

- complete ARIMA (Box-Jenkins) modeling with no limits on the order of autoregressive or moving average processes
- model identification diagnostics, include the following:
  - autocorrelation function
  - partial autocorrelation function

  - inverse autocorrelation function
  - cross-correlation function
  - extended sample autocorrelation function
  - minimum information criterion for model identification
  - squared canonical correlations

- stationarity tests
- outlier detection
- intervention analysis
- regression with ARMA errors
- transfer function modeling with fully general rational transfer functions
- seasonal ARIMA models
- ARIMA model-based interpolation of missing values
- several parameter estimation methods including

  - exact maximum likelihood
  - conditional least squares
  - exact nonlinear unconditional least squares

- forecasts and confidence limits for all models
- forecasting tied to parameter estimation methods: finite memory forecasts for models estimated by maximum likelihood or exact nonlinear least squares methods and infinite memory forecasts for models estimated by conditional least squares
- a variety of model diagnostic statistics including

  - Akaike's information criterion (AIC)
  - Schwarz's Bayesian criterion (SBC or BIC)
  - Box-Ljung chi-square test statistics for white noise residuals
  - autocorrelation function of residuals
  - partial autocorrelation function of residuals
  - inverse autocorrelation function of residuals
  - automatic outlier detection

Vector Time Series Analysis

The VARMAX procedure enables you to model both the dynamic relationship between the dependent variables and between the dependent and independent variables. The VARMAX procedure includes the following features:

- several modeling features:

  - vector autoregressive model
  - vector autoregressive model with exogenous variables

  - vector autoregressive and moving-average model
  - Bayesian vector autoregressive model
  - vector error correction model
  - Bayesian vector error correction model
  - GARCH-type multivariate conditional heteroscedasticity models

- criteria for automatically determining AR and MA orders:

  - Akaike Information Criterion (AIC)
  - Corrected AIC (AICC)
  - Hannan-Quinn (HQ) Criterion
  - Final Prediction Error (FPE)
  - Schwarz Bayesian Criterion (SBC), also known as Bayesian Information Criterion (BIC)

- AR order identification aids:

  - partial cross-correlations
  - Yule-Walker estimates
  - partial autoregressive coefficients
  - partial canonical correlations

- testing the presence of unit roots and cointegration:

  - Dickey-Fuller tests
  - Johansen cointegration test for nonstationary vector processes of integrated order one
  - Stock-Watson common trends test for the possibility of cointegration among nonstationary vector processes of integrated order one
  - Johansen cointegration test for nonstationary vector processes of integrated order two

- model parameter estimation methods:

  - Least Squares (LS)
  - Maximum Likelihood (ML)

- model checks and residual analysis using the following tests:

  - Durbin-Watson (DW) statistics
  - F test for autoregressive conditional heteroscedastic (ARCH) disturbance
  - F test for AR disturbance
  - Jarque-Bera normality test
  - Portmanteau test

- seasonal deterministic terms
- subset models
- multiple regression with distributed lags

- dead-start model that does not have present values of the exogenous variables
- Granger-causal relationships between two distinct groups of variables.
- infinite order AR representation
- impulse response function (or infinite order MA representation)
- decomposition of the predicted error covariances
- roots of the characteristic functions for both the AR and MA parts to evaluate the proximity of the roots to the unit circle
- contemporaneous relationships among the components of the vector time series
- forecasts

State Space Modeling and Forecasting

The STATESPACE procedure provides automatic model selection, parameter estimation, and forecasting of state space models. (*State space models* encompass an alternative general formulation of multivariate ARIMA models.) The STATESPACE procedure includes the following features:

- multivariate ARIMA modeling using the general state space representation of the stochastic process
- automatic model selection using Akaike's information criterion (AIC)
- user-specified state space models including restrictions
- transfer function models with random inputs
- any combination of simple and seasonal differencing; input series can be differenced to any order for any lag lengths
- forecasts with confidence limits
- can save selected and fitted model in a data set and reuse for forecasting
- wide range of output options; print any statistics concerning the data and their covariance structure, the model selection process, and the final model fit

Spectral Analysis

The SPECTRA procedure provides spectral analysis and cross-spectral analysis of time series. The SPECTRA procedure includes the following features:

- efficient calculation of periodogram and smoothed periodogram using fast finite Fourier transform and Chirp algorithms
- multiple spectral analysis, including raw and smoothed spectral and cross-spectral function estimates, with user-specified window weights
- choice of kernel for smoothing
- outputs the following spectral estimates to a SAS data set:
  - Fourier sine and cosine coefficients

  - periodogram
  - smoothed periodogram
  - cospectrum
  - quadrature spectrum
  - amplitude
  - phase spectrum
  - squared coherency

- Fisher's Kappa and Bartlett's Kolmogorov-Smirnov test statistic for testing a null hypothesis of white noise

Seasonal Adjustment

The X11 procedure provides seasonal adjustment of time series using the Census X-11 or X-11 ARIMA method. The X11 procedure is based on the U.S. Bureau of the Census X-11 seasonal adjustment program and also supports the X-11 ARIMA method developed by Statistics Canada. The X11 procedure includes the following features:

- decomposition of monthly or quarterly series into seasonal, trend, trading day, and irregular components
- both multiplicative and additive form of the decomposition
- includes all the features of the Census Bureau program
- supports the X-11 ARIMA method
- supports sliding spans analysis
- processes any number of variables at once with no maximum length for a series
- performs tests for stable, moving and combined seasonality
- can optionally print or store in SAS data sets the individual X11 tables showing the various components at different stages of the computation. Full control over what is printed or output
- can project seasonal component one year ahead enabling reintroduction of seasonal factors for an extrapolated series

The X12 procedure provides seasonal adjustment of time series using the X-12 ARIMA method. The X12 procedure is based on the U.S. Bureau of the Census X-12 ARIMA seasonal adjustment program (version 0.3) and also supports the X-11 ARIMA method developed by Statistics Canada and the previous X-11 method of the U.S. Census Bureau. The X12 procedure includes the following features:

- decomposition of monthly or quarterly series into seasonal, trend, trading day, and irregular components
- supports multiplicative, additive, pseudo-additive, and log additive forms of decomposition

- supports the X-12 ARIMA method
- supports regARIMA modeling
- automatically identifies outliers
- supports TRAMO-based automatic model selection
- uses regressors to process missing values within the span of the series
- processes any number of variables at once with no maximum length for a series
- performs tests for stable, moving and combined seasonality
- provides spectral analysis of original, seasonally adjusted, and irregular series
- optionally prints or stores in SAS a data set the individual X11 tables showing the various components at different stages of the decomposition. Offers full control over what is printed or output
- optionally projects seasonal component one year ahead, enabling reintroduction of seasonal factors for an extrapolated series

Structural Time Series Modeling and Forecasting

The UCM procedure provides a very flexible environment for analyzing time series data using Structural Time Series models, also called Unobserved Components Models (UCM). These models represent the observed series as a sum of suitably chosen components such as trend, seasonals, cycles, and regression effects. You can use the UCM procedure to formulate very comprehensive models that bring out all the salient features of the series under consideration. Structural models are applicable in the same situations where Box-Jenkins ARIMA models are applicable; however, the structural models tend to be more informative about the underlying stochastic structure of the series. The UCM procedure includes the following features:

- General Unobserved Components modeling where the models can include trend, multiple seasons and cycles, and regression effects
- Maximum likelihood estimation of the model parameters
- Model diagnostics that includes a variety of Goodness of Fit statistics, and extensive graphical diagnosis of the model residuals
- Forecasts and confidence limits for the series and all the model components
- Model-based seasonal decomposition
- Extensive plotting capability that includes:
  - Forecast and confidence interval plots for the series and model components such as trend, cycles, and seasons
  - Diagnostic plots such as residual plot, residual auto-correlation plots, etc.
  - Seasonal decomposition plots such as trend, trend plus cycles, trend plus cycles plus seasons, etc.
- Model-based interpolation of series missing values
- Full sample (also called smoothed) estimates of the model components

Time Series Cross-Sectional Regression Analysis

The TSCSREG procedure provides combined time series cross-sectional regression analysis. The TSCSREG procedure includes the following features:

- estimation of the regression parameters under several common error structures:
  - Fuller and Battese method (variance component model)
  - Parks method (autoregressive model)
  - Da Silva method (mixed variance component moving-average model)
  - one-way fixed effects
  - two-way fixed effects
  - one-way random effects
  - two-way random effects
- any number of model specifications
- unbalanced panel data for the fixed or random effects models
- variety of estimates and statistics including
  - underlying error components estimates
  - regression parameter estimates
  - standard errors of estimates
  - *t*-tests
  - R-squared statistic
  - correlation matrix of estimates
  - covariance matrix of estimates
  - autoregressive parameter estimate
  - cross-sectional components estimates
  - autocovariance estimates
  - F-tests of linear hypotheses about the regression parameters
  - specification tests

Automatic Time Series Forecasting

The FORECAST procedure provides forecasting of univariate time series using automatic trend extrapolation. PROC FORECAST is an easy-to-use procedure for automatic forecasting that uses simple popular methods that do not require statistical modeling of the time series, such as exponential smoothing, time trend with autoregressive errors, and the Holt-Winters method.

The FORECAST procedure supplements the powerful forecasting capabilities of the econometric and time series analysis procedures described above. You can use PROC FORECAST when you have many series to forecast and want to extrapolate trends without developing a model for each series.

The FORECAST procedure includes the following features:

- choice of the following four forecasting methods:
  - exponential smoothing: single, double, triple, or Holt two-parameter smoothing
  - stepwise autoregressive models with constant, linear, or quadratic trend and autoregressive errors to any order
  - Holt-Winters forecasting method with constant, linear, or quadratic trend
  - additive variant of the Holt-Winters method
- support for up to three levels of seasonality for Holt-Winters method: time-of-year, day-of-week, or time-of-day
- ability to forecast any number of variables at once
- forecast confidence limits for all methods

Time Series Interpolation and Frequency Conversion

The EXPAND procedure provides time interval conversion and missing value interpolation for time series. The EXPAND procedure includes the following features:

- conversion of time series frequency; for example, constructing quarterly estimates from annual series or aggregating quarterly values to annual values
- conversion of irregular observations to periodic observations
- interpolation of missing values in time series
- conversion of observation types; for example, estimate stocks from flows and vice versa. All possible conversions supported between
  - beginning of period
  - end of period
  - period midpoint
  - period total
  - period average
- conversion of time series phase shift; for example, conversion between fiscal years and calendar years
- choice of four interpolation methods:
  - cubic splines
  - linear splines
  - step functions
  - simple aggregation
- ability to transform series before and after interpolation (or without interpolation) using:
  - constant shift or scale
  - sign change or absolute value

  - logarithm, exponential, square root, square, logistic, inverse logistic
  - lags, leads, differences
  - classical decomposition
  - bounds, trims, reverse series
  - centered moving, cumulative, or backward moving average
  - centered moving, cumulative, or backward moving corrected sum of squares
  - centered moving, cumulative, or backward moving sum
  - centered moving, cumulative, or backward moving median
  - centered moving, cumulative, or backward moving variance

- support for a wide range of time series frequencies:

  - YEAR
  - SEMIYEAR
  - QUARTER
  - MONTH
  - SEMIMONTH
  - TENDAY
  - WEEK
  - WEEKDAY
  - DAY
  - HOUR
  - MINUTE
  - SECOND

- The basic interval types can be repeated or shifted to define a great variety of different frequencies, such as fiscal years, biennial periods, work shifts, and so forth.

Access to Financial and Economic Databases

The DATASOURCE procedure provides a convenient way to read time series data from data files supplied by a variety of different commercial and governmental data vendors. The DATASOURCE procedure includes the following features:

- support for data files distributed by the following data vendors:

  - DRI/McGraw-Hill
  - FAME Information Services
  - Haver Analytics
  - Standard & Poors Compustat Service
  - Center for Research in Security Prices (CRSP)
  - International Monetary Fund
  - U.S. Bureau of Labor Statistics

  - U.S. Bureau of Economic Analysis
  - Organization for Economic Cooperation and Development (OECD)

- ability to select the series, time range, and cross sections of data extracted
- can create an output data set containing descriptive information on the series available in the data file
- can read EBCDIC tapes on ASCII systems and vice versa

The SASECRSP interface engine enables random access to time series data residing in CRSPAccess database 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 database, and how you would like to perform selection on the CRSP set you choose to access. The following data sets are available:

STKHEAD	header identification and summary data
NAMES	history array
SHARES	outstanding observation array
DELIST	delisting history array
PRC	Price or Bid/Ask Average Time Series
RET	Returns Time Series
BID, ASK, RETX	Returns without Dividends Time Series
SPREAD	Spread Between Bid and Ask Time Series
VOL	Volume Time Series
NUMTRD	Number of Trades Time Series
ALTPRCDT	Alternate Price Date Time Series
PORT1-PORT9	nine types of Portfolio Assignments and Portfolio Statistics.

The SASEFAME interface engine provides SAS and FAME users flexibility in accessing and processing time series data residing in either a FAME database or a SAS data set, 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. If you are running FAME in a client/server environment and have FAME CHLI capability on your FAME server, you can access your FAME remote data by specifying the port number of the TCP/IP service that is defined for your *frdb_m* and the node name of your FAME master server in your physical path.

The SASEHAVR interface engine is experimental for V9 and enables Windows users random access to economic and financial data residing in a HAVER ANALYTICS

Data Link Express (DLX) database. You can limit the range of data that is read from the time series and specify a desired conversion frequency. Start dates are recommended on the libname statement to help you save resources when processing large databases or when processing a large number of observations. You can further subsetting of your data by using the WHERE, KEEP, or DROP statements in your DATA step. You can use the SQL procedure to create a view of your resulting SAS data set.

Spreadsheet Calculations and Financial Report Generation

The COMPUTAB procedure generates tabular reports using a programmable data table.

The COMPUTAB procedure is especially useful when you need both the power of a programmable spreadsheet and a report generation system, and you want to set up a program to run in batch mode and generate routine reports. The COMPUTAB procedure includes the following features:

- report generation facility for creating tabular reports such as income statements, balance sheets, and other row and column reports for analyzing business or time series data
- can tailor report format to almost any desired specification
- uses the SAS programming language to provide complete control of the calculation and format of each item of the report
- reports definition in terms of a data table on which programming statements operate
- a single reference to a row or column brings the entire row or column into a calculation
- can create new rows and columns (such as totals, subtotals, and ratios) with a single programming statement
- access to individual table values is available when needed
- built-in features to provide consolidation reports over summarization variables

An alternate to the COMPUTAB procedure is the experimental SYLK procedure available in Base SAS. The documentation for the SYLK procedure can be found at http://support.sas.com/documentation/onlinedoc by selecting “Base SAS” from the Product-Specific Documentation list.

Loan Analysis, Comparison, and Amortization

The LOAN procedure provides analysis and comparison of mortgages and other installment loans. The LOAN procedure includes the following features:

- contract terms for any number of different loans may be input and various financing alternatives may be analyzed and compared
- analysis of four different types of loan contracts including

  - fixed rate
  - adjustable rate
  - buydown rate
  - balloon payment

- full control over adjustment terms for adjustable rate loans: life caps, adjustment frequency, and maximum and minimum rates
- support for a wide variety of payment and compounding intervals
- loan calculations can incorporate initialization costs, discount points, down payments, and prepayments (uniform or lump-sum)
- analysis of different rate adjustment scenarios for variable rate loans including
  - worst case
  - best case
  - fixed rate case
  - estimated case
- can make loan comparisons at different points in time
- can make loan comparisons at each analysis date on the basis of five different economic criteria
  - present worth of cost (net present value of all payments to date)
  - true interest rate (internal rate of return to date)
  - current periodic payment
  - total interest paid to date
  - outstanding balance
- can base loan comparisons on either after-tax or before-tax analysis
- reports best alternative when loans of equal amount are compared
- amortization schedules for each loan contract
- when starting date is specified, output shows payment dates rather than just payment sequence numbers
- can optionally print or output to SAS data sets the amortization schedules, loan summaries, and loan comparison information
- can specify rounding of payments to any number of decimal places

Time Series Forecasting System

SAS/ETS software includes the Time Series Forecasting System, a point-and-click application for exploring and analyzing univariate time series data. You can use the automatic model selection facility to select the best-fitting model for each time series, or you can use the system's diagnostic features and time series modeling tools interactively to develop forecasting models customized to best predict your time series. The system provides both graphical and statistical features to help you choose the best forecasting method for each series.

The system can be invoked from the Solutions menu under Analysis, by the Forecast command, and by the Forecasting icon in the Data Analysis folder of the SAS Desktop.

The following is a brief summary of the features of the Time Series Forecasting system. With the system you can

- use a wide variety of forecasting methods, including several kinds of exponential smoothing models, Winters method, and ARIMA (Box-Jenkins) models. You can also produce forecasts by combining the forecasts from several models.
- use predictor variables in forecasting models. Forecasting models can include time trend curves, regressors, intervention effects (dummy variables), adjustments you specify, and dynamic regression (transfer function) models.
- view plots of the data, predicted versus actual values, prediction errors, and forecasts with confidence limits. You can plot changes or transformations of series, zoom in on parts of the graphs, or plot autocorrelations.
- use hold-out samples to select the best forecasting method.
- compare goodness-of-fit measures for any two forecasting models side by side or list all models sorted by a particular fit statistic.
- view the predictions and errors for each model in a spreadsheet or view and compare the forecasts from any two models in a spreadsheet.
- examine the fitted parameters of each forecasting model and their statistical significance.
- control the automatic model selection process: the set of forecasting models considered, the goodness-of-fit measure used to select the best model, and the time period used to fit and evaluate models.
- customize the system by adding forecasting models for the automatic model selection process and for point-and-click manual selection.
- save your work in a project catalog.
- print an audit trail of the forecasting process.
- save and print system output including spreadsheets and graphs.

Investment Analysis System

The Investment Analysis System is an interactive environment for the time-value of money of a variety of investments:

- Loans
- Savings
- Depreciations
- Bonds
- Generic cashflows

Various analyses are provided to help analyze the value of investment alternatives: time value, periodic equivalent, internal rate of return, benefit-cost ratio, and breakeven analysis.

These analyses can help answer a number of questions you may have about your investments:

- Which option is more profitable or less costly?
- Is it better to buy or rent?
- Are the extra fees for refinancing at a lower interest rate justified?
- What is the balance of this account after saving this amount periodically for so many years?
- How much is legally tax-deductible?
- Is this a reasonable price?

Investment Analysis can be beneficial to users in many industries for a variety of decisions:

- manufacturing: cost justification of automation or any capital investment, replacement analysis of major equipment, or economic comparison of alternative designs
- government: setting funds for services
- finance: investment analysis and portfolio management for fixed-income securities

Related SAS Software

Many features not found in SAS/ETS software are available in other parts of the SAS System. If you do not find something you need in SAS/ETS software, you may find it in one of the following SAS software products.

Base SAS Software

The features provided by SAS/ETS software are extensions to the features provided by Base SAS software. Many data management and reporting capabilities you will need are part of Base SAS software. Refer to *SAS Language: Reference* and the *SAS Procedures Guide* for documentation of Base SAS software.

The following sections summarize Base SAS software features of interest to users of SAS/ETS software. See Chapter 2 for further discussion of some of these topics as they relate to time series data and SAS/ETS software.

SAS DATA Step

The DATA step is your primary tool for reading and processing data in the SAS System. The DATA step provides a powerful general purpose programming language that enables you to perform all kinds of data processing tasks. The DATA step is documented in *SAS Language: Reference*.

Base SAS Procedures

Base SAS software includes many useful SAS procedures. Base SAS procedures are documented in the *SAS Procedures Guide*. The following is a list of Base SAS procedures you may find useful:

CATALOG	for managing SAS catalogs
CHART	for printing charts and histograms
COMPARE	for comparing SAS data sets
CONTENTS	for displaying the contents of SAS data sets
COPY	for copying SAS data sets
CORR	for computing correlations
CPORT	for moving SAS data libraries between computer systems
DATASETS	for deleting or renaming SAS data sets
FREQ	for computing frequency crosstabulations
MEANS	for computing descriptive statistics and summarizing or collapsing data over cross sections
PLOT	for printing scatter plots
PRINT	for printing SAS data sets
RANK	for computing rankings or order statistics
SORT	for sorting SAS data sets
SQL	for processing SAS data sets with Structured Query Language
STANDARD	for standardizing variables to a fixed mean and variance
SYLK	for translating spreadsheets to batch SAS programs. The SYLK procedure is experimental. The documentation can be found at http://support.sas.com/documentation/onlinedoc by selecting “Base SAS” from the Product-Specific Documentation list

TABULATE	for printing descriptive statistics in tabular format
TIMEPLOT	for plotting variables over time
TRANSPOSE	for transposing SAS data sets
UNIVARIATE	for computing descriptive statistics

Global Statements

Global statements can be specified anywhere in your SAS program, and they remain in effect until changed. Global statements are documented in *SAS Language: Reference*. You may find the following SAS global statements useful:

FILENAME	for accessing data files
FOOTNOTE	for printing footnote lines at the bottom of each page
%INCLUDE	for including files of SAS statements
LIBNAME	for accessing SAS data libraries
OPTIONS	for setting various SAS system options
RUN	for executing the preceding SAS statements
TITLE	for printing title lines at the top of each page
X	for issuing host operating system commands from within your SAS session

Some Base SAS statements can be used with any SAS procedure, including SAS/ETS procedures. These statements are not global, and they only affect the SAS procedure they are used with. These statements are documented in *SAS Language: Reference*.

The following Base SAS statements are useful with SAS/ETS procedures:

BY	for computing separate analyses for groups of observations
FORMAT	for assigning formats to variables
LABEL	for assigning descriptive labels to variables
WHERE	for subsetting data to restrict the range of data processed or to select or exclude observations from the analysis

SAS Functions

SAS functions can be used in DATA step programs and in the COMPUTAB and MODEL procedures. The following kinds of functions are available:

- character functions for manipulating character strings
- date and time functions, for performing date and calendar calculations
- financial functions, for performing financial calculations such as depreciation, net present value, periodic savings, and internal rate of return

- lagging and differencing functions, for computing lags and differences
- mathematical functions, for computing data transformations and other mathematical calculations
- probability functions, for computing quantiles of statistical distributions and the significance of test statistics
- random number functions, for simulation experiments
- sample statistics functions, for computing means, standard deviations, kurtosis, and so forth

SAS functions are documented in *SAS Language: Reference*. Chapter 2, "Working with Time Series Data," discusses the use of date and time and lagging and differencing functions. Chapter 3, "Date Intervals, Formats, and Functions," contains a reference list of date and time functions. Chapter 4, "SAS Macros and Functions," documents more financial functions that are not listed in *SAS Language: Reference*.

Formats, Informats, and Time Intervals

Base SAS software provides formats to control the printing of data values, informats to read data values, and time intervals to define the frequency of time series. See Chapter 3, "Date Intervals, Formats, and Functions," for more information.

SAS/GRAPH Software

SAS/GRAPH software includes procedures that create two- and three-dimensional high resolution color graphics plots and charts. You can generate output that graphs the relationship of data values to one another, enhance existing graphs, or simply create graphics output that is not tied to data. SAS/GRAPH software can produce

- charts
- plots
- maps
- text
- three-dimensional graphs

With SAS/GRAPH software you can produce high-resolution color graphics plots of time series data.

SAS/STAT Software

SAS/STAT software is of interest to users of SAS/ETS software because many econometric and other statistical methods not included in SAS/ETS software are provided in SAS/STAT software.

SAS/STAT software includes procedures for a wide range of statistical methodologies including

- logistic regression
- censored regression
- principal component analysis
- structural equation models using covariance structure analysis
- factor analysis
- survival analysis
- discriminant analysis
- cluster analysis
- categorical data analysis; log-linear and conditional logistic models
- general linear models
- mixed linear and nonlinear models
- generalized linear models
- response surface analysis
- kernel density estimation
- LOESS regression
- spline regression
- two-dimensional kriging
- multiple imputation for missing values

SAS/IML Software

SAS/IML software gives you access to a powerful and flexible programming language (Interactive Matrix Language) in a dynamic, interactive environment. The fundamental object of the language is a data matrix. You can use SAS/IML software interactively (at the statement level) to see results immediately, or you can store statements in a module and execute them later. The programming is dynamic because necessary activities such as memory allocation and dimensioning of matrices are done automatically.

You can access built-in operators and call routines to perform complex tasks such as matrix inversion or eigenvector generation. You can define your own functions and subroutines using SAS/IML modules. You can perform operations on an entire data matrix. You have access to a wide choice of data management commands. You can read, create, and update SAS data sets from inside SAS/IML software without ever using the DATA step.

SAS/IML software is of interest to users of SAS/ETS software because it enables you to program your own econometric and time series methods in the SAS System. It contains subroutines for time series operators and for general function optimization. If you need to perform a statistical calculation not provided as an automated feature by SAS/ETS or other SAS software, you can use SAS/IML software to program the matrix equations for the calculation.

Kalman Filtering and Time Series Analysis in SAS/IML

SAS/IML software includes a library for Kalman filtering and time series analysis which provides the following functions:

- generating univariate, multivariate, and fractional time series
- computing likelihood function of ARMA, VARMA, and ARFIMA models
- computing an autocovariance function of ARMA, VARMA, and ARFIMA models
- checking the stationarity of ARMA and VARMA models
- filtering and smoothing of time series models using Kalman method
- fitting AR, periodic AR, time-varying coefficient AR, VAR, and ARFIMA models
- handling Bayesian seasonal adjustment model

Refer to Chapter 10, "Time Series Analysis and Examples," (*SAS/IML User's Guide*) for details.

SAS/INSIGHT Software

SAS/INSIGHT software is a highly interactive tool for data analysis. You can explore data through a variety of interactive graphs including bar charts, scatter plots, box plots, and three-dimensional rotating plots. You can examine distributions and perform parametric and nonparametric regression, analyze general linear models and generalized linear models, examine correlation matrixes, and perform principal component analyses. Any changes you make to your data show immediately in all graphs and analyses. You can also configure SAS/INSIGHT software to produce graphs and analyses tailored to the way you work.

SAS/INSIGHT software is an integral part of the SAS System. You can use it to examine output from a SAS procedure, and you can use any SAS procedure to analyze results from SAS/INSIGHT software.

SAS/INSIGHT software includes features for both displaying and analyzing data interactively. A data window displays a SAS data set as a table with columns of the table displaying variables and rows displaying observations. Data windows provide data management features for editing, transforming, subsetting, and sorting data. A graph window displays different types of graphs: bar charts, scatter plots, box plots, and rotating plots. Graph windows provide interactive exploratory techniques such as data brushing and highlighting. Analysis windows display statistical analyses in the form of graphs and tables. Analysis window features include

- univariate statistics
- robust estimates
- density estimates
- cumulative distribution functions

- theoretical quantile-quantile plots
- multiple regression analysis with numerous diagnostic capabilities
- general linear models
- generalized linear models
- smoothing spline estimates
- kernel density estimates
- correlations
- principal components

SAS/INSIGHT software may be of interest to users of SAS/ETS software for interactive graphical viewing of data, editing data, exploratory data analysis, and checking distributional assumptions.

SAS/OR Software

SAS/OR software provides SAS procedures for operations research and project planning and includes a menu driven system for project management. SAS/OR software has features for

- solving transportation problems
- linear, integer, and mixed-integer programming
- nonlinear programming and optimization
- scheduling projects
- plotting Gantt charts
- drawing network diagrams
- solving optimal assignment problems
- network flow programming

SAS/OR software may be of interest to users of SAS/ETS software for its mathematical programming features. In particular, the NLP procedure in SAS/OR software solves nonlinear programming problems and can be used for constrained and unconstrained maximization of user-defined likelihood functions.

SAS/QC Software

SAS/QC software provides a variety of procedures for statistical quality control and quality improvement. SAS/QC software includes procedures for

- Shewhart control charts
- cumulative sum control charts
- moving average control charts

- process capability analysis
- Ishikawa diagrams
- Pareto charts
- experimental design

SAS/QC software also includes the SQC menu system for interactive application of statistical quality control methods and the ADX Interface for experimental design.

MLE for User-Defined Likelihood Functions

There are three SAS procedures that enable you to do maximum likelihood estimation of parameters in an arbitrary model with a likelihood function that you define: PROC MODEL, PROC NLP, and PROC IML.

The MODEL procedure in SAS/ETS software enables you to minimize general log-likelihood functions for the error term of a model.

The NLP procedure in SAS/OR software is a general nonlinear programming procedure that can maximize a general function subject to linear equality or inequality constraints. You can use PROC NLP to maximize a user-defined nonlinear likelihood function.

You can use the IML procedure in SAS/IML software for maximum likelihood problems. The optimization routines used by PROC NLP are available through IML subroutines. You can write the likelihood function in the SAS/IML matrix language and call the constrained and unconstrained nonlinear programming subroutines to maximize the likelihood function with respect to the parameter vector.

Other Statistical Tools

Many other statistical tools are available in Base SAS, SAS/STAT, SAS/OR, SAS/QC, SAS/INSIGHT, and SAS/IML software. If you don't find something you need in SAS/ETS software, you may find it in SAS/STAT software and in Base SAS software. If you still don't find it, look in other SAS software products or contact the SAS Institute Technical Support staff.

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