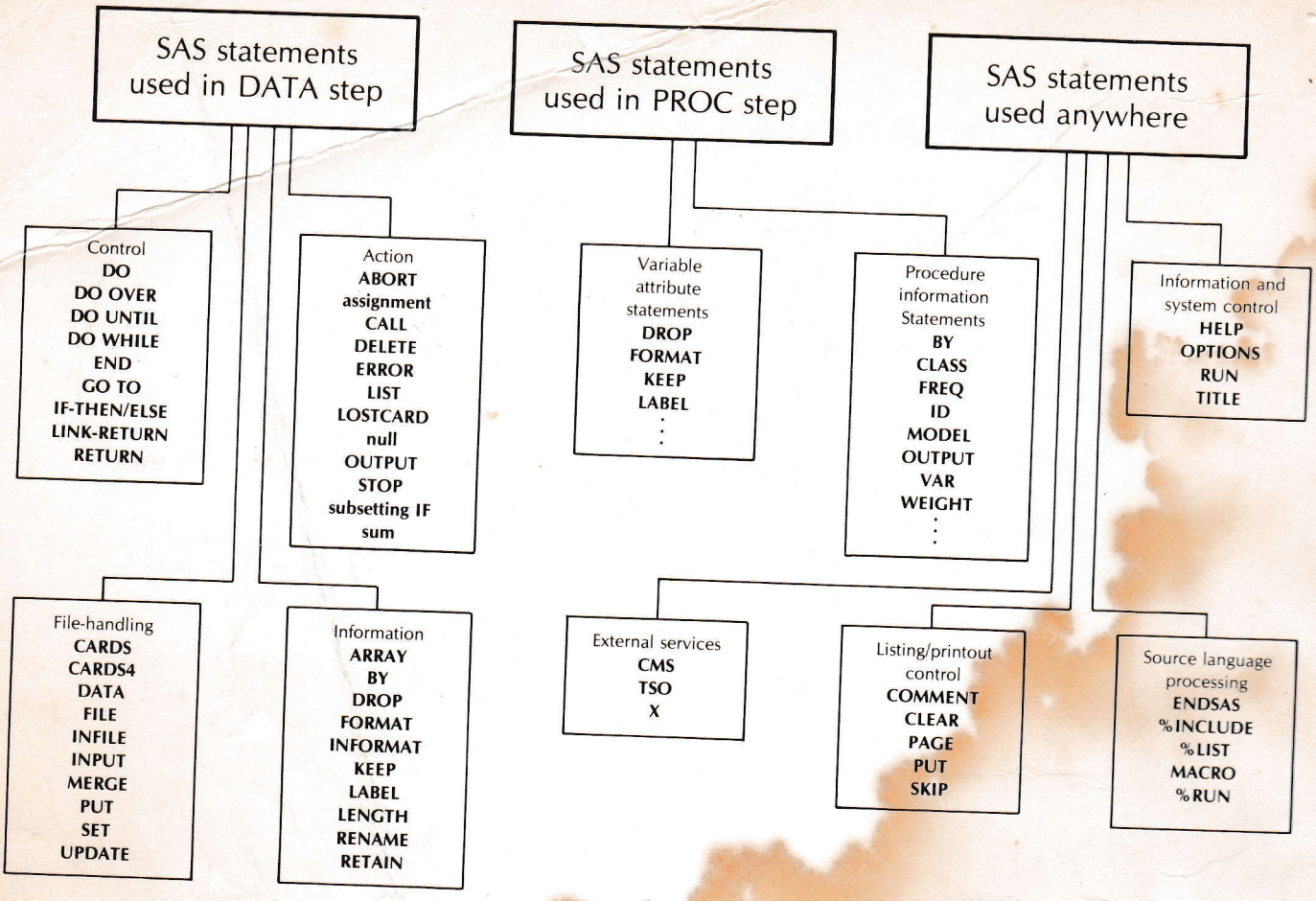
SAS USER'S GUIDE: Statistics

1982 Edition

SAS Institute
Statistical Analysis System


SAS statements used in DATA step
SAS statements used in PROC step
SAS statements used anywhere
Control
DO
DO OVER
DO UNTIL
DO WHILE
END
GO TO
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LINK-RETURN
RETURN
Action
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COMMENT
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PUT
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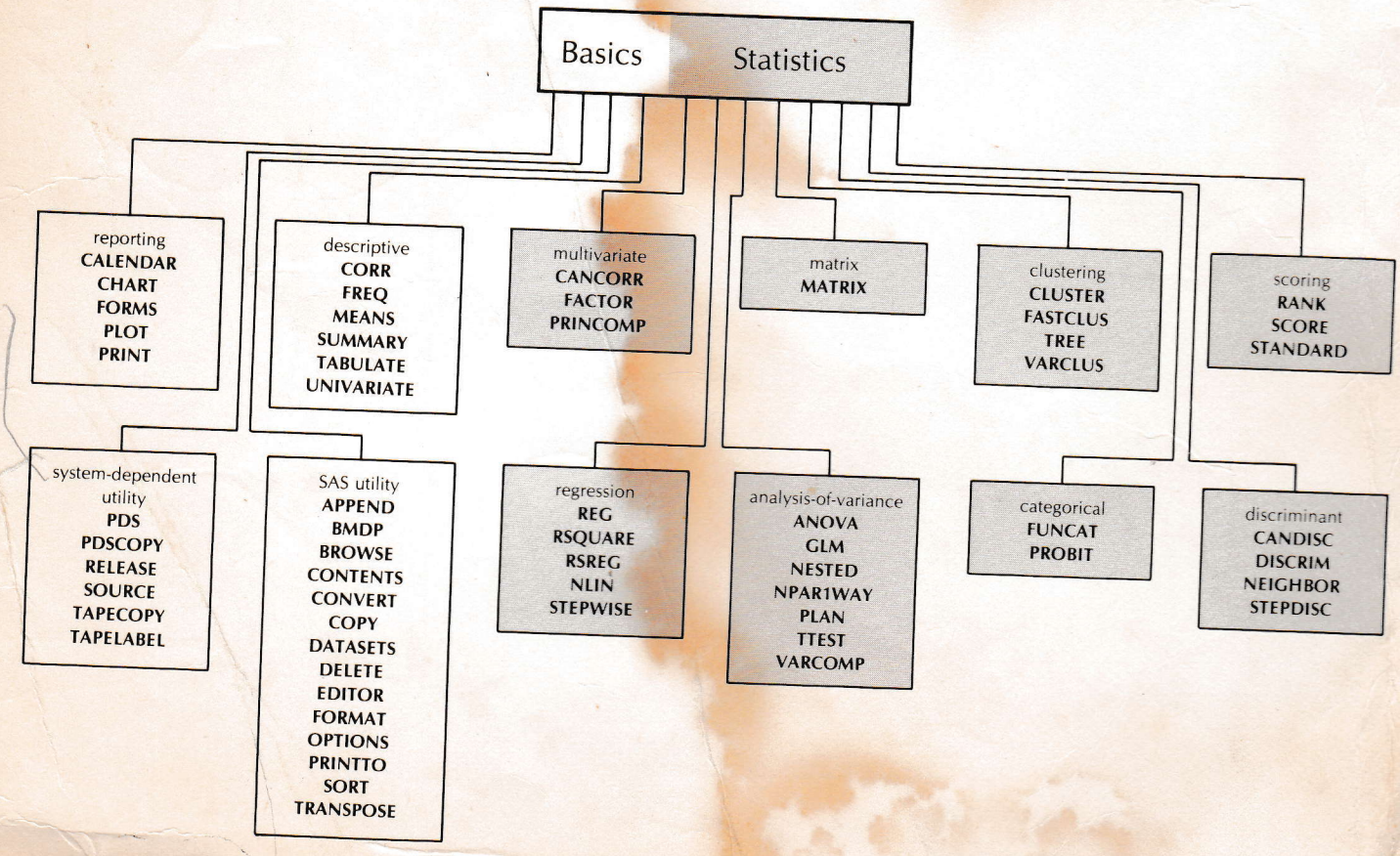
Source language processing
ENDSAS
%INCLUDE
%LIST
MACRO
%RUN

Procedures


Basics
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FACTOR
PRINCOMP
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MATRIX
clustering
CLUSTER
FASTCLUS
TREE
VARCLUS
scoring
RANK
SCORE
STANDARD
system-dependent utility
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RELEASE
SOURCE
TAPECOPY
TAPELABEL
SAS utility
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RSREG
NLIN
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analysis-of-variance
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NESTED
NPAR1WAY
PLAN
TTEST
VARCOMP
categorical
FUNCAT
PROBIT
discriminant
CANDISC
DISCRIM
NEIGHBOR
STEPDISC

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Introduction to the MATRIX Language

This chapter introduces MATRIX, which is both a SAS procedure and a programming language. The purpose of this section is to explain how MATRIX is used and to compare MATRIX to other programming languages.

MATRIX is a programming language. While most SAS procedures are prepackaged routines where the specifications merely control the details of an analysis, MATRIX is a complete programming language, and MATRIX statements are executable programming statements.

MATRIX makes SAS open-ended—suitable for custom work as well as packaged analyses. Analysts need two kinds of tools. They need packaged analysis programs for routine work and a general-purpose language for custom programming of methods too specialized or too new to be packaged. MATRIX provides a high-level programming language to serve the latter need. If a statistical method has not been implemented directly in a SAS procedure, you can program it using the MATRIX procedure.

MATRIX data elements are matrices. Most programming languages deal with single data elements; the fundamental data element in MATRIX is a matrix, a two-dimensional (row by column) array of numeric (double-precision real floating-point) values.

MATRIX expressions use operators that are applied to entire matrices. For example, the expression A+B in MATRIX adds the elements of the two matrices A and B. The expression A*B performs a matrix multiplication, while A#B does elementwise multiplication of the values in A and B.

MATRIX incorporates a powerful vocabulary of operators. Matrix operations that require calls to math-library subroutines in other languages are built into the language of MATRIX. Most programming languages have six to ten operators and a small function library. MATRIX offers 26 operators, 29 built-in functions, and all the functions of the DATA step; and MATRIX allows you to define your own functions.

MATRIX avoids housekeeping work typical in other programming languages. In many languages you have to explicitly declare, dimension, or allocate storage for a data item, and you cannot change its attributes once it is declared. In contrast, MATRIX does all the housekeeping automatically. The attributes of a matrix are determined when the matrix is given a value (this is called *late binding*). The procedure automatically finds space as needed for a matrix of any size. A matrix can change its size and attributes at any time.

MATRIX operations allow more direct programming. MATRIX eliminates most iterative specifications, calls to math subroutines, declarations, and allocations. For example, finding the sum of all positive elements of a matrix **X** requires one line in MATRIX:

```
S = SUM(X # (X>0)) .
```

The expression involves the sum of an elementwise product of two items. The first item is the matrix **X**; the second item is an indicator matrix showing the positive values of **X**. Once you have learned the matrix notation, this operation is clearer and more direct than an iterative specification that would be used in another programming language such as PL/I:

```
SUM=0;
DO I=1 TO N;
  DO J=1 TO M;
    IF X(I,J)>0 THEN SUM=SUM+X(I,J);
    END;
  END;
```

MATRIX notation is compact. Since MATRIX operations deal with arrays of numbers and the most commonly used mathematical and matrix operations are built directly into the language, programs that take hundreds of lines of code in other languages may take only a few lines in MATRIX.

MATRIX allows you to think directly in matrix algebra terms. If you are a statistician, you already know the formulas for many statistical methods. But in most languages it is no easy job to transcribe these formulas into a program. In MATRIX, you can transcribe almost directly from matrix algebra notation into MATRIX program statements. For example, the formula for the least-squares estimates of parameters in a linear model in matrix notation is written:

$$\mathbf{b} = (\mathbf{X'X})^{-1}\mathbf{X'y} .$$

It can be written in MATRIX as:

```
B=INV(X'*X)*X'*Y;
```

MATRIX is an alternative to APL. APL is another language that deals with matrices of values. Unlike MATRIX, however, APL works with a specialized character set that takes time to learn and is available only on special terminals. MATRIX can be learned more quickly than APL, since it builds on traditional and more familiar notation.

MATRIX has a rich set of control statements. MATRIX allows you to program with almost all of the control statements that exist in the DATA step, including LINK, GOTO, IF-THEN/ELSE, DO/END, iterative DO, and STOP.

MATRIX is preferred to DATA step programs for applications that must work across observations. The SAS DATA step is fine for programs that work with one observation at a time. The LAG function even allows you to work with a short set of observations. But to process across observations in ways that are impossible or difficult in the DATA step, use PROC MATRIX.