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TITLE	ANALYSIS OF VARIANCE PACKAGE
AUTHOR	W.P. Ronald
COMPANY	Canada Department of Agriculture Vancouver, B.C., Canada
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Name: Analysis of variance package

Author: W. P. Ronald,
Research Station,
Canada Department of Agriculture,
Vancouver B.C., Canada

Category: Statistics

Language: FOCAL

Abstract: This package contains two programs, a one-way analysis and a two-way analysis with block effects. In both cases, the initial output consists of single sample statistics. These are followed by an analysis of variance table and an F ratio.

The analysis of variance tables produced by these programs may be used with an F test, such as Scheffé's or Duncan's, to determine whether any significant differences exist between group means.

PROGRAM DESCRIPTIONS

One-way analysis of variance

The one-way analysis of variance program performs single sample statistics on each sample group as soon as that group data has been entered. The output consists of the group number, degrees of freedom, mean, variance, and standard deviation.

The analysis of variance table is then typed by the computer, and consists of degrees of freedom (DF), sum of squares (SS), and mean square difference (MS). The sources of variation are Between, Within (error), and Total. The F ratio MS Between / MS Within, is also given.

Degrees of freedom and group numbers are given in defined format. All other values are in floating point format.

Calculations:

(Let X_{ij} = the i^{th} sample of the j^{th} group.)

Group mean = $\bar{X}_j = \dfrac{\sum_i X_{ij}}{N_j}$ (N_j = number of samples in j^{th} group)

Group sum of squares = $\sum_i (X_{ij} - \bar{X}_j)^2$

Group degrees of freedom = $N_j - 1$

Group variance = $S_j^2 = \dfrac{\sum_i (X_{ij} - \bar{X}_j)^2}{N_j - 1}$

Group standard deviation = $S_j = \sqrt{S_j^2}$

Total number of samples = $N = \sum_j N_j$

Grand mean = $\bar{X} = \dfrac{\sum_j (N_j \times \bar{X}_j)}{N}$

DF Between = G - 1 (G = number of sample groups)

$$\text{DF Within} = \sum_j (N_j - 1)$$

DF Total = DF Between + DF Within

$$\text{SS Between} = \sum_j N_j \, (\bar{X}_j - \bar{X})^2$$

$$\text{SS Within} = \sum_j (N_j - 1) \, S_j^2$$

SS Total = SS Between + SS Within

MS Between = SS Between / DF Between

MS Within = SS Within / DF Within

F ratio = MS Between / MS Within

Two-way analysis of variance with block effects.

The analysis with block effects performs the same basic steps as the one-way analysis. In addition it determines the variance due to replication by summing the blocks across the groups. Thus the Within variance is subdivided into the variances due to Replication and to Error. This allows a more accurate estimate of Error variance and therefore a more critical assessment of possible group mean differences. The F ratio calculated in this case is MS Between / MS Error.

This program should be run with the data in a radomized complete-block design.

Calculations:

The calculations for the two-way analysis program are the same as those used in the one-way analysis, up to the grand mean calculation. The following calculations are used in addition.

(Let X_{ij} = the i^{th} sample of the j^{th} group, or the j^{th} sample of the i^{th} block.)

$$\text{Block mean} = \bar{X}_i = \frac{\sum_j X_{ij}}{G} \quad (G = \text{number of sample groups})$$

DF Between = G - 1

DF Replication = N_j - 1

DF Error = DF Between x DF Replication

DF Total = DF Between + DF Replication + DF Error

$$\text{SS Between} = \sum_j N_j \, (\bar{X}_j - \bar{X})^2$$

$$\text{SS Within} = \sum_j (N_j - 1) \, S_j^2$$

$$\text{SS Replication} = \sum_i G \, (\bar{X}_i - \bar{X})^2$$

SS Error = SS Within - SS Replication

SS Total = SS Between + SS Within

MS Between = SS Between / DF Between

MS Replication = SS Replication / DF Replication

MS Error = SS Error / DF Error

F ratio = MS Between / MS Error

OPERATION

With 4K memory, these programs must be run using FOCAL with extended functions deleted.

Input: G = the number of related sample groups.

N = the number of samples in a group.

S = the value of a sample, (S will be asked N times for each group).

Correction of errors:

(1) If an input error is made and detected before termination of the asked value, it may be corrected by typing ← , and then giving the correct value.

e.g. N: 6←4 or S:48.3←38.3

(Where 4 and 38.3 are the correct values)

(2) If the error is not detected until after termination of the input, the data for the whole group must be entered again. This is done as follows:

(a) Press the "CONTROL" - "C" keys.

(b) The computer will type "?01.00 @ 1.05".

(c) Type "GOTO 1.04".

(d) The computer will ask "N:".

(e) Type in the group data again.

(3) If an error is found in a previous group, the program must be run again.

Limitation of input data:

Even with extended functions deleted, 4K FOCAL is still limited in storage space. For this reason, if there is a large amount of input data, it is best to determine whether there is sufficient space for it. This may be done as follows:

(1) Determine the total storage available in the FOCAL program.

ie. F I=1,300;S A(I)=I
(error diagnostic for "storage filled by variables")
T %4, I*5

(2) Determine your storage requirements.

(a) The storage requirements for the one-way analysis are:

(i) 470 locations for the program.

(ii) 85 locations for the set values.

(iii) 5(X + 3Y) locations for the remaining variables.

(b) The storage requirements for the two-way analysis are:

(i) 520 locations for the program.

(ii) 105 locations for the set values.

(iii) 5(2X + 2Y) locations for the remaining variables.

(X = the number of samples in the largest group.)

(Y = the number of sample groups.)

ONE-WAY ANALYSIS OF VARIANCE

SAMPLE OUTPUT

```
*G
G:3
N:6
S:34.9 S:64.3 S:43.5 S:33.9 S:38.7 S:41.6

GROUP    DF          MEAN              VARIANCE          STAND. DEV.
=  1  =  5  = 0.428167E+02  = 0.124522E+03  = 0.111589E+02


N:6
S:50.0 S:46.2 S:36.6 S:56.6 S:43.1 S:38.1

GROUP    DF          MEAN              VARIANCE          STAND. DEV.
=  2  =  5  = 0.451000E+02  = 0.565440E+02  = 0.751957E+01


N:6
S:7.0 S:16.0 S:4.9 S:5.5 S:0 S:3.8

GROUP    DF          MEAN              VARIANCE          STAND. DEV.
=  3  =  5  = 0.620000E+01  = 0.286120E+02  = 0.534902E+01


ANALYSIS OF VARIANCE TABLE:

    VARIATION          DF          SS                MS

BETWEEN:          =    2    = 0.571840E+04    = 0.285920E+04

WITHIN:           =   15    = 0.104839E+04    = 0.698925E+02

TOTAL:            =   17    = 0.676679E+04


RATIO:  BETWEEN/WITHIN= 0.409086E+02

*
```

TWO-WAY ANALYSIS OF VARIANCE WITH BLOCK EFFECTS

SAMPLE OUTPUT

```
*G
G:3
N:6
S:34.9 S:64.3 S:43.5 S:33.9 S:38.7 S:41.6

GROUP    DF          MEAN            VARIANCE        STAND. DEV.
=  1   =  5   = 0.428167E+02   = 0.124522E+03   = 0.111589E+02


N:6
S:50.0 S:46.2 S:36.6 S:56.6 S:43.1 S:38.1

GROUP    DF          MEAN            VARIANCE        STAND. DEV.
=  2   =  5   = 0.451000E+02   = 0.565440E+02   = 0.751957E+01


N:6
S:7.0 S:16.0 S:4.9 S:5.5 S:0 S:3.8

GROUP    DF          MEAN            VARIANCE        STAND. DEV.
=  3   =  5   = 0.620000E+01   = 0.286120E+02   = 0.534902E+01

ANALYSIS OF VARIANCE TABLE:

    VARIATION          DF          SS              MS

BETWEEN:           =    2    = 0.571840E+04   = 0.285920E+04

REPLICATION:       =    5    = 0.468222E+03   = 0.936445E+02

ERROR:             =   10    = 0.580165E+03   = 0.580165E+02

TOTAL:             =   17    = 0.676679E+04


RATIO:  BETWEEN/ERROR = 0.492825E+02

*
```

ONE-WAY ANALYSIS OF VARIANCE

```
C-FOCAL , 8/68

01.01 E
01.02 A "G"G;S J=1
01.04 A "N"N(J);S P=1;S S=0
01.05 A "S"X(P);S S=S+X(P)
01.07 S P=P+1;I (N(J)-P)1.08,1.05,1.05
01.08 DO 2
01.09 S J=J+1;I (G-J)1.10,1.04,1.04
01.10 F J=1,G;S SZ=SZ+(N(J)*M(J))/SN
01.11 T "ANALYSIS OF VARIANCE TABLE:",!!!;G 3.01

02.01 S M(J)=S/N(J);S K=N(J)-1;S SX=0;S SN=SN+N(J)
02.02 F P=1,N(J);S SX=SX+(X(P)-M(J))↑2
02.03 S V(J)=SX/K;S SD=FSQT(V(J));T !
02.04 T "GROUP   DF          MEAN            VARIANCE       STAND. DEV.",!
02.06 T %2 J,"  ",K,"  ";T %, M(J),"  ",V(J),"  ",SD,!!!

03.01 F J=1,G;S SB=SB+N(J)*(M(J)-SZ)↑2;S SW=SW+(N(J)-1)*V(J)
03.02 S KB=G-1;S MB=SB/KB;S ST=SB+SW
03.03 F J=1,G;S KW=KW+(N(J)-1)
03.04 S KT=KB+KW;S MW=SW/KW
03.05 T "    VARIATION                DF              SS                    MS",!!
03.06 T %4,"BETWEEN:                  "KB;T %,"     "SB,"     "MB,!!
03.07 T %4,"WITHIN:                   "KW;T %,"     "SW,"     "MW,!!
03.08 T %4,"TOTAL:                    "KT;T %,"     "ST,!!!
03.09 T "RATIO:  BETWEEN/WITHIN",MB/MW,!!;Q
*
```

TWO-WAY ANALYSIS OF VARIANCE WITH BLOCK EFFECTS

```
C-FOCAL , 8/68

01.01 E
01.02 A "G"G;S J=1
01.04 A "N"N;S P=1;S S=0
01.05 A "S"X(P);S S=S+X(P)
01.07 S P=P+1;I (N-P)1.08,1.05,1.05
01.08 DO 2
01.09 S J=J+1;I (G-J)1.10,1.04,1.04
01.10 F J=1,G;S SZ=SZ+N*M(J)/SN
01.11 T "ANALYSIS OF VARIANCE TABLE:",!!!;G 3.01

02.01 S M(J)=S/N;S KR=N-1;S SX=0;S SN=SN+N
02.02 F P=1,N;S SX=SX+(X(P)-M(J))↑2;S XM(P)=XM(P)+X(P)/G
02.03 S V(J)=SX/KR;S SD=FSQT(V(J));T !
02.04 T "GROUP   DF        MEAN          VARIANCE      STAND. DEV.",!
02.06 T %2 J,"  ",KR,"  ";T %, M(J),"  ",V(J),"  ",SD,!!!

03.01 F J=1,G;S SB=SB+N*(M(J)-SZ)↑2;S SW=SW+KR*V(J)
03.02 S KB=G-1;S MB=SB/KB;S ST=SB+SW;S KE=KB*KR;S KT=KB+KR+KE
03.03 T "    VARIATION          DF          SS                MS",!!
03.04 T %4,"BETWEEN:            "KB;T %,"    "SB,"    "MB,!!
03.05 F P=1,N;S SR=SR+G*(XM(P)-SZ)↑2
03.06 S SE=SW-SR;S MR=SR/KR;S ME=SE/KE
03.07 T %4,"REPLICATION:        "KR;T %,"    "SR,"    "MR,!!
03.08 T %4,"ERROR:              "KE;T %,"    "SE,"    "ME,!!
03.09 T %4,"TOTAL:              "KT;T %,"    "ST,!!!
03.10 T "RATIO:  BETWEEN/ERROR ",MB/ME,!!;Q
*
```