C463. SAS PROGRAM TO PERFORM ANALYSIS OF FACTORIAL EXPERIMENTS USING ALIGNED RANKS

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Abstract:

In situations when analysis of variance procedures are utilized, it is generally thought important that the assumptions associated with analysis of variance be fulfilled. Two assumptions that are often examined in the course of an analysis are normality and homogeneity of variance. To what extent violation of one or both of these assumptions influences inferences made in an analysis of variance is not fully known, but remedial measures to deal with these problems have been often used.

Keywords: Factorial arrangement of treatments | SAS | Aligned ranks

Article:

1. INTRODUCTION

In situations when analysis of variance procedures are utilized, it is generally thought important that the assumptions associated with analysis of variance be fulfilled. Two assumptions that are often examined in the course of an analysis are normality and homogeneity of variance. To what extent violation of one or both of these assumptions influences inferences made in an analysis of variance is not fully known, but remedial measures to deal with these problems have been often used.

One remedy to analysis of variance assumption violations that was once very popular was the rank transform. Conover and Iman (1976) proposed using the rank transformation in conjunction with parameter procedures such as analysis of variance. Problems with this method were demonstrated, however, when the treatments were in a factorial arrangement and interaction was present. In these cases it has been shown that the rank transform is not robust and lacks power (see Akritas, 1990; Blair et al., 1987; Sawilowsky et al., 1989; Thompson and Ammann, 1990).

One way to combat the problems presented by the rank transformation is to use aligned ranks. Hodges and Lehmann (1962) first proposed this adjustment to the rank procedure. It has been found to be more robust and powerful in some situations, especially in designs with interactions. Higgins et al. (1990) and Higgins and Tashtoush (1994) investigated the use of aligned ranks specifically for testing main effects and interaction in a two-factor factorial experiment. They found that aligning ranks improves on the problems that the ordinary ranking presents. Richter and Payton (1999) advocate the use of aligned ranks in conjunction with exact tests to provide a robust and powerful alternative to parametric and ranking procedures.

Though aligned ranks procedures have been established as viable alternatives, an analysis of a data set is not readily available due to the lack of adequate computer code. This paper presents the code adequate to perform an aligned rank analysis with the use of SAS software (SAS Inst., 1996).

2. SAS PROGRAM

Below is a representation of the SAS code needed to perform the aligned rank analysis of variance for a two-factor factorial experiment in a completely randomized design. Note that the program includes the experimental data. The user must input data with factor levels denoted by 1, 2, . . . , nla and 1, 2, . . . , nlb for factors A and B, respectively. The observed values must be entered in the order shown in the program, and the data set must be named TWOWAY. There also must be at least two observations per treatment combination.

```
/*************************************************************/
data twoway; input a b resp @@;
datalines;
1 1 49 1 1 39 1 2 55 1 2 41 1 3 66 1 3 68 2 1 50 2 1 55 2 2 67 2 2 58 2 3 85 2 3 92
3 1 43 3 1 38 3 2 53 3 2 42 3 3 69 3 3 62 4 1 53 4 1 48 4 2 85 4 2 73 4 3 85 4 3 99;
/*************************************************************/
Routine to perform aligned rank test
*************************************************************/
proc iml; use twoway;                                  /*Identify input data set*/
read all var {a b resp} into data;                       /*Create data matrix*/
a=data [ ,1]; b=data[ ,2]; resp=data [ ,3];     /*Create column vectors*/
sum=0;
nla=max(a); nlb=max(b);                 /*Determine number of levels of each factor*/
NN=nrow(data);                          /*number of reps, total number of observations*/
nrep=NN/(nla*nlb);
gmean=sum(resp)/NN;                                /*Compute overall mean*/

/* Compute factor A means*/
index A;
read all var {a b resp} into dataA;                      /*Create data matrix*/
meana=1:nla;                                 /*Create vector to hold factor A means*/
respA=dataA[ ,3];
count=1;
n=nlb*nrep;
do i=1 to NN by n;
  row=n*count;
  submat=respA[i:row];
  meana[count]=sum(submat)/n;
  count=count+1;
end;

/* Compute factor B means */
index B;                                        /*Reindex data set by factor B*/
read all var {a b resp} into dataB;                  /*Create data matrix*/
meanb=1:nlb;                                 /*Create vector to hold factor B means*/
respB=dataB[,3];
count=1;
n=nla*nrep;
do i=1 to NN by n;
  row=n*count;
  submat=respB[i:row];
  meanb[count]=sum(submat)/n;
```

```
  count = count+1;
end;

/*Compute aligned observations */
/*** For testing interaction ***/
resp=data [ ,3];
dataAB=j (NN,1,0);                          /*Create matrix to hold aligned data*/
count = 1;
  do i=1 to nla;
    do j=1 to nlb;
      do k=1 to nrep;
        dataAB[count] = resp[count] - mcana[i] - mcanb[j];
        count =count+1;
    end;
  end;
end;
rnkdresp =ranktie(dataAB);                    /*Rank aligned observations*/
ardataAB =a||b||rnkdresp;                      /*Reassemble data matrix*/
create dataab var{a b arrespab};          /*Create new data set to test interaction*,
append from ardataab;
/*** For testing factor A ***/
count = 1;
n =nla*nrep;
do i=1 to nlb;
    do j=1 to n;
      dataB[count,3] =dataB[count,3]
       - meanb[i];                          /*Note:Using data indexed by factor B*/
count = count+1;
end;
end;
arrespB=ranktie(dataB[ ,3]);                  /*Rank aligned observations*/
ardataB=dataB[ ,1] || dataB[ ,2] || arrespB;     /*Reassemble data matrix*/
create dataA var{a b arrespa};            /*Create new data set to test interaction*,
append from ardataB;
index A;                                        /*Reindex by factor A*/
```

```
/*** For testing factor B ***/
respA = dataA [ ,3];                          /*Note: Using data indexed by factor A*/
count = 1;
n = nlb*nrep;
do i = 1 to nla;
    do j = 1 to n;
      respA[count] = respA[count] - meanA[i];
count = count+1;
end;
end;
rnkrespA = ranktie(respA);                        /*Rank aligned observations*/
ardataA = a||b||rnkrespA;                          /*Reassemble data matrix*/
create datab var{a b arespb};                 /*Create new data set to test interaction*/
append from ardataa;
index A;

quit;                                                      /***EXIT IML***/

/************************************************/
*Perform ANOVA using aligned ranks
************************************************/
*
Proc glm data=dataab noprint outstat=abtest;    /*Note: Using type I SS*/

       class a b;
       model arrespab = a b a*b/ssl;
     proc glm data=dataa noprint outstat=atest;
         class a b;
         model arrespa = a b a*b/ssl;
     proc glm data=datab noprint outstat=btest;
         class a b;
         model arrespb = a b a*b/ssl;
     run;
     /*****************************************/
     *Create nal ANOVA table for Output
     *****************************************/
     data atest2; set atest;
     if _source = 'A';
     drop _name_ _type_;

     data btest2; set btest;
     if _source_ = 'B';
     drop _name_ _type_;

     data abtest2; set abtest;
     if _source_ = 'A*B';
     drop _name_ _type_;

     data output; set atest2 btest2 abtest2;
     proc print data=output;
     title 'ANOVA Performed on the Aligned Ranks of the Original Observations';
     run; quit;
     /*****************************************/
```

Electronic copies of the above program can be obtained via email. Interested parties should contact either author at his respective email address.

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