Analysis of variance

[Economics]

Introduction

When you have more than two groups, a t-test (or the nonparametric equivalent) is no longer applicable. Instead, we use a technique called analysis of variance. This chapter covers analysis of variance designs with one or more independent variables, as well as more advanced topics such as interpreting significant interactions, and unbalanced designs.

One-Way Analysis of Variance

The method used today for comparisons of three or more groups is called analysis of variance (ANOVA).

This method has the advantage of testing whether there are any differences between the groups with a single probability associated with the test. The hypothesis tested is that all groups have the same mean. Before we present an example, notice that there are several assumptions that should be met before an analysis of variance is used. Essentially, we must have independence between groups (unless a repeated measures design is used); the sampling distributions of sample means must be normally distributed; and the groups should come from populations with equal variances (called homogeneity of variance).

Example: 5 Subjects in three treatment groups X, Y and Z. X Y Z 700 480 500 850 460 550 820 500 480 640 570 600 920 580 610 The null hypothesis is that the mean(X)= mean(Y)= mean(Z). The alternative hypothesis is that the means are not all equal. How do we know if the means obtained are different because of difference in the reading programs(X, Y, Z) or because of random sampling error? By chance, the five subjects we choose for group X might be faster readers than those chosen for groups Y and Z. We might now ask the question, " What causes scores to vary from the grand mean? In this example, there are two possible sources of variation, the first source is the training method (X, Y or Z). The second source of variation is due to the fact that individuals are different.

SUM OF SQUARES total; SUM OF SQUARES between groups; SUM OF SQUARES error (within groups); F ratio = MEAN SQUARE between groups/MEAN SQUARE error = (SS between groups/(k-1)) / (SS error/(N-k)) SAS codes: DATA READING; INPUT GROUP $ WORDS @@; DATALINES; X 700 X 850 X 820 X 640 X 920 Y 480 Y 460 Y 500 Y 570 Y 580 Z 500 Z 550 Z 480 Z 600 Z 610 ; PROC ANOVA DATA= READING; TITLE 'ANALYSIS OF READING DATA'; CLASS GROUP; MODEL WORDS= GROUP; MEANS GROUP; RUN; The ANOVA

Procedure Dependent Variable

words Sum of Source DF Squares Mean Square F Value Pr > F Model 2 215613. 3333 107806. 6667 16. 78 0. 0003 Error 12 77080. 0000 6423. 3333 Corrected Total 14 292693. 3333 Now that we know the reading methods are different, we want to know what the differences are. Is X better than Y or Z? Are the means of groups Y and Z so close that we cannot consider them different?

In general , methods used to find group differences after the null hypothesis has been rejected are called post hoc, or multiple comparison test. These include Duncan's multiple-range test, the Student-Newman-Keuls' multiple-range test, least significant-difference test, Tukey's studentized range test, Scheffe's multiple-comparison procedure, and others. To request a post hoc test, place the SAS option name for the test you want, following a slash (/) on the MEANS statement. The SAS names for the post hoc tests previously listed are DUNCAN, SNK, LSD, TUKEY, AND SCHEFFE, respectively. For our example we have:

MEANS GROUP / DUNCAN; Or MEANS GROUP / SCHEFFE ALPHA=. 1 At the far left is a column labeled " Duncan Grouping. " Any groups that are not significantly different from one another will have the same letter in the Grouping column. The ANOVA Procedure Duncan's Multiple Range Test for words NOTE: This test controls the Type I comparison wise error rate, not the experiment wise error rate. Alpha 0. 05 Error Degrees of Freedom 12 Error Mean Square 6423. 333

Number of Means 2 3 Critical Range 110. 4 115. 6 Means with the same letter are not significantly different. Duncan Grouping Mean N group A 786. 00 5 x B 548. 00 5 z B B 518. 00 5 y

Computing Contrasts

Suppose you want to make some specific comparisons. For example, if method X is a new method and methods Y and Z are more traditional methods, you may decide to compare method X to the mean of method Y and method Z to see if there is a difference between the new and traditional methods.

You may also want to compare method Y to method Z to see if there is a difference. These comparisons are called contrasts, planned comparisons, or a priori comparisons. To specify comparisons using SAS software, you need to use PROC GLM (General Linear Model) instead of PROC ANOVA. PROC GLM is similar to PROC ANOVA and uses many of the same options and statements. However, PROC GLM is a more generalized program and can be used to compute contrasts or to analyze unbalanced designs. PROC GLM DATA= READING; TITLE 'ANALYSIS OF READING DATA -- PLANNED COMPARIONS'; CLASS GROUP;

MODEL WORDS = GROUP; CONTRAST 'X VS. Y AND Z' GROUP -2 1 1; CONTRAST 'Method Y VS. Z' GROUP 0 1 -1; RUN; The GLM Procedure Contrast DF Contrast SS Mean Square F Value Pr ; F X VS. Y AND Z 1 213363. 3333 213363. 3333 33. 22 F group 2 503215. 2667 251607. 6333 56. 62 F group 1 121. 0000000 121. 0000000 8. 00 0. 0152 drug 1 42. 2500000 42. 2500000 2. 79 0. 1205 group*drug 1 930. 500000 930. 2500000 61. 50 F Model 5 39. 96666667 7. 99333333 9. 36 0. 0002 Error 18 15. 36666667 0. 85370370 Corrected Total 23 55. 33333333 Source DF Type III SS Mean Square F Value Pr ; F sweet 2 29. 77706840 14. 88853420 17. 44 | t| for H0: LSMean(i)= LSMean(j) Dependent Variable: rating i/j 1 2 3 1 0. 3866