Simple analysis of covariance: A BASIC program for microcomputers

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Simple analysis of variance is a useful and powerful statistical technique for testing the hypothesis of equal means. It allows for the comparison of two or more treatment samples, does not require equal ns for each treatment, and may be used with random or within-subject group assignment. Flexibility in subject group assignment is among its most useful features, since matched and repeated measures designs are often used to control for specific extraneous variables. Such direct experimental control often facilitates determination of significant differences in the criterion measure attributed to the treatment by providing a smaller estimate of experimental error.

For a variety of reasons, however, researchers are not always able to employ a within-group design to control for specific variables. If practical limitations prohibit such a design, but a particular variable should nevertheless be controlled, the researcher may employ the analysis of covariance. This procedure permits statistical, rather than experimental, control of variables in a manner similar to matching groups with respect to an extraneous variable.

Procedure. The analysis of covariance requires two observations for each subject. One is designated X and is variously termed the concomitant, controlled, covariate, extraneous, or supplementary measure. This X variable is not of experimental interest to the researcher. The other variable is designated Y and represents the dependent or criterion variable.

The analysis of covariance takes into account the regression of the Y measures on the X measures. To the extent that an extraneous variable is correlated with the criterion variable, the covariance technique removes the influence of the extraneous variable through simple linear regression and thereby provides a smaller error variance than would be possible using simple analysis of variance. Moreover, like simple analysis of variance, simple covariance may be used with any number of samples and does not require equal observations for each treatment. This article describes a comprehensive yet easy to use BASIC program for simple analysis of covariance.

Program. The program automatically computes both a simple analysis of covariance and variance, a test for homogeneity of regression, means for the X and Y variables, and adjusted Y means. It also provides a summary analysis of covariance table and presents elapsed processing time. After the computations are made, the user is given the option of computing any user-specified pairwise

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Table 1
Sample Data for Simple Analysis of Covariance
Treatment Groups

1		2		3	
X	Y	X	Y	X	Y
1	5	2	1	1	10
6	12	3	2	4	13
3	9	6	7	5	16
4	8	4	3	3	12
5	11	7	8	6	17
Sum	19 45	22	21	19	68

Note—Sample data are from Edwards (1972, p. 373).

comparisons of means. The program is based on a variety of published statistical procedures for analysis of covariance (Edwards, 1972; Ferguson, 1976; Roscoe, 1975; Winer, 1962) and has been tested for accuracy with sample data from all referenced sources.

All computations are made with single-precision (six-digit) accuracy. However, answers are rounded back to three decimal places by formatting output with PRINT USING statements. This format allows for accuracy within the limits presented in the referenced sources while still providing manageable screen and hardcopy output.

Input. The program limits input to N = 100 treatment groups with 50 observations per X and Y variable. The user can alter this limitation by redimensioning the variables in line 370.

Data are read from DATA statements beginning in line 1000. The first DATA statement contains N, the number of treatments or levels of the independent variable. Subsequent DATA statements begin with n, the number of pairs of observations for a particular treatment, followed by the score data in pairs for that treatment. Table 1 provides sample data for the analysis, and Table 2 provides an example of how the DATA statements are set up using the sample data.

The program asks the user if instructions are required. If the answer is "yes," instructions on how to place the data into DATA statements, and how to receive a listing of the data, are given. If the answer is "no," the program assumes data have been entered and computes the analysis. If no new data have been entered, analysis of the sample data is performed.

Table 2
Sample Data Statements for Simple Analysis of Covariance

1000 DATA 3
1010 DATA 5, 1,5,6,12,3,9,4,8,5,11
1020 DATA 5, 2,1,3,2,6,7,4,3,7,8
1030 DATA 5, 1,10,4,13,5,16,3,12,6,17

Table 3
Sample Output

SUMMARY TABLE FOR ANALYSIS OF COVARIANCE								
SOURCE	DF	SSx	SP	SSy	DF'	SS'y	MS'y	F
Between	2	1.200	-14.200	220.933	2	258.905	129.452	258.545
Within	12	46.800	67.200	102.000	11	5.508	0.501	
Total	14	48.000	53.000	322.933	13	264.413		
Mean X1 =	3.80	Mean Y1 =	9.00	Mean Y'1 =	9.29			
Mean X2 =	4.40	Mean Y2 =	4.20	Mean Y'2 =	3.63			
Mean X3 =	3.80	Mean Y3 =	13.60	Mean Y'3 =	13.89			
Simple Analysis of Variance: F = 12.996 df = 2, 12								
Simple Analysis of Covariance: F = 258.545 df = 2, 11								
Homogeneity of Regression: F = 0.136 df = 2, 9								
Processing time = 2.25 seconds.								
A comparison test on any two adjusted means (Y/N)? Y								
Enter the mean one and n1, separated by a comma (e.g., 3.2,10). 13.89 5								
Mean 1 = 13.89 n1 = 5								
Enter mean two and n2. 9.29 5								
Mean 2 = 9.29 n2 = 5								
t = 10.213 df = 11								
A comparison test on any two adjusted means (Y/N)? N								

Output. Output is automatically directed to the display. However, the program asks the user whether or not output should also be sent to a printer. Sample output is presented in Table 3.

Program Language and Requirements. The program is written in IBM PC BASICA. It consists of 133 lines, including REMark and DATA statements, and uses approximately 6K bytes of RAM. No *essential* IBM-specific functions are included, so that the program is easily ported to other microcomputer BASICs. The program may be easily modified to read from INPUT statements or data files.

Availability. A listing of the program may be obtained by writing to the author. A disk copy may be obtained by sending a double-sided/double-density diskette in a *re-*

usable diskette mailer. Program users with suggestions or questions about the program may call the author at (215)499-7373.

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