ESTIMATING THE POWER TO DETECT DICHOTOMOUS MODERATORS WITH MODERATED MULTIPLE REGRESSION

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A QuickBASIC program for estimating the statistical power to detect the effects of dichotomous moderator variables using moderated multiple regression (MMR) is available. The program runs on IBM and IBM-compatible personal computers and estimates power based on specific values for (a) total sample size, (b) sample sizes across the two categories of the hypothesized moderator, and (c) correlation coefficients between predictor and criterion scores for each of the two moderator-based subgroups. The compiled run time and source code versions of the program can be obtained from the first author.

Researchers in education and psychology are often interested in testing hypotheses about the effects of dichotomous moderator variables such as gender or ethnicity. Variable Z is defined as a dichotomous moderator of the relationship between predictor variable X (e.g., test of aptitudes or abilities) and criterion variable Y (e.g., performance) when the nature of this relationship varies across two categories of Z (e.g., females, males) (cf. Zedeck, 1971).

Moderated multiple regression (MMR) is recognized as an appropriate statistical technique for detecting moderator variables (Aiken & West, 1991; Cohen & Cohen, 1983; Saunders, 1956). However, the results of attempts to detect moderators using MMR suggest that the search for such variables may be conducted with low levels of statistical power (e.g., Aguinis, 1993;

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Aguinis & Stone-Romero, 1994; Cronbach, 1987; Morris, Sherman, & Mansfield, 1986). Thus, unbeknownst to the researcher using MMR, tests of hypotheses about moderating effects may have insufficient power (cf. Cohen, 1988), and null findings regarding the effects of a dichotomous moderator may be due to Type II statistical error.

In a recent Monte Carlo investigation of the power of MMR, Stone-Romero, Alliger, and Aguinis (1994) found that when the number of cases in one of the two moderator-based subgroups (e.g., $Z = 1$, females) differs markedly from the number of cases in the other subgroup (e.g., $Z = 2$, males), the statistical power of MMR to detect the moderating effect is reduced well below the recommended .80 level (see Cohen, 1988). However, in educational and psychological research, the number of cases across two subgroups often differs markedly (e.g., Hunter, Schmidt, & Hunter, 1979; Hunter, Schmidt, & Rauschenberger, 1984), and factors beyond a researcher's control typically do not permit further data collection. Thus MMR is used with available samples (e.g., Hattrup & Schmitt, 1990). In such situations, researchers would benefit from being able to estimate the statistical power of MMR under specific conditions of (a) total sample size, (b) number of cases in each of two moderator variable-based subgroups, and (c) between-subgroup differences in the relationship between variables X and Y. Thus, as suggested by Trattner and O'Leary (1980), if statistical power is known to be low, null results would be interpreted as inconclusive findings and as an indication that further research with a more appropriate level of statistical power should be conducted.

The Program

A computer program was designed to address the need to estimate the statistical power of MMR to detect the effects of dichotomous moderator variables. The program was written in QuickBASIC (release 4.5) and runs on IBM and IBM-compatible personal computers.

The power estimate is computed based on the results of Stone-Romero et al. (1994), who conducted an MMR analysis with data generated by a Monte Carlo simulation. They regressed statistical power estimates (i.e., proportion of times that the null hypothesis regarding the existence of a moderator variable was correctly rejected) on variables representing the main and interactive effects of the manipulated parameters (i.e., differences in subgroup sample sizes, total sample size, and difference between within-subgroup correlation coefficients). The present computer program uses the intercept and b weights from the regression equation derived from Stone-Romero et al.'s simulation.

The user is prompted interactively to input the sample size in Subgroup 1 (i.e., n_1), the sample size in Subgroup 2 (i.e., n_2), the sample-based correlation coefficient between X and Y for Subgroup 1 ($r_{XY(1)}$), and the sample-based correlation coefficient between *X* and *Y* for Subgroup 2 ($r_{XY(2)}$). After the user inputs these values, the program displays the estimated power to detect a moderating effect for the specified conditions.

Program Availability

The executable (POWER.EXE) and source (POWER.BAS) versions of the program are available at no cost on either a 3.5-inch or a 5.25-inch diskette (double or high density). Users who wish to obtain the program should send a blank formatted diskette and a self-addressed, stamped envelope to Herman Aguinis, Ph.D., Department of Psychology, University of Colorado at Denver, Campus Box 173, P.O. Box 173364, Denver, CO 80217-3364.

References

Aguinis, H. (1993). *The detection of moderator variables using moderated multiple regression: The effects of range restriction, unreliability, sample size, and the proportion of subjects in subgroups.* Unpublished doctoral dissertation, University at Albany, State University of New York.

Aguinis, H., & Stone-Romero, E. F. (1994). *Methodological artifacts in moderated multiple regression: Effects on power.* Paper presented at the meeting of the Society for Industrial and Organizational Psychology, Nashville, TN.

Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions.* Newbury Park, CA: Sage.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum.

Cohen, J., & Cohen, P. (1983). *Applied multiple regression/correlation analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum.

Cronbach, L. J. (1987). Statistical tests for moderator variables: Flaws in analyses recently proposed. *Psychological Bulletin, 102,* 414-417.

Hattrup, K., & Schmitt, N. (1990). Prediction of trades apprentices' performance on job sample criteria. *Personnel Psychology, 43,* 453-466.

Hunter, J. E., Schmidt, F. L., & Hunter, R. (1979). Differential validity of employment tests by race: A comprehensive review and analysis. *Psychological Bulletin, 86,* 721-735.

Hunter, J. E., Schmidt, F. L., & Rauschenberger, J. (1984). Methodological, statistical, and ethical issues in the study of bias in psychological tests. In C. R. Reynolds & R. T. Brown (Eds.), *Perspective on bias in mental testing* (pp. 41-99). New York: Plenum.

Morris, J. H., Sherman, J., & Mansfield, E. R. (1986). Failures to detect moderating effects with ordinary least squares-moderated multiple regression: Some reasons and a remedy. *Psychological Bulletin, 99,* 282-288.

Saunders, D. R. (1956). Moderator variables in prediction. *Educational and Psychological Measurement, 16,* 209-222.

Stone-Romero, E. F., Alliger, G. M., & Aguinis, H. (1994). Type II error problems in the use of moderated multiple regression for the detection of moderating effects of dichotomous variables. *Journal of Management, 20,* 167-178.

Trattner, M. H., & O'Leary, B. S. (1980). Sample sizes for specified statistical power in testing for differential validity. *Journal of Applied Psychology, 65,* 127-134.

Zedeck, S. (1971). Problems with the use of "moderator" variables. *Psychological Bulletin, 76,* 295-310.