DOCUMENT RESUME

ED 364 606 TM 020 878

AUTHOR Bowling, John

TITLE The Importance of Structure Coefficients as against Beta Weights: Comments with Examples from the Counseling Psychology Literature.

PUB DATE Nov 93

NOTE 19p.; Paper presented at the Annual Meeting of the Mid-South Educational Research Association (22nd, New Orleans, LA, November 9-12, 1993).

PUB TYPE Information Analyses (070) -- Reports - Evaluative/Feasibility (142) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.

DESCRIPTORS *Counseling Psychology; Literature Reviews; Mathematical Models; *Predictor Variables; *Regression (Statistics); *Test Interpretation

IDENTIFIERS *Beta Weights; *Structure Coefficients

ABSTRACT

Recent empirical studies of actual research practice demonstrate that general linear models, such as regression, have become increasingly popular. The present paper explores issues related to the interpretation of regression results, with illustrations drawn from studies in the counseling psychology literature. The primary focus of this paper is on the interpretation of structure as against beta weights. It is argued that the interpretation of results based solely on beta weights can lead to entirely erroneous conclusions regarding the importance or relevance of predictor variables. In general, both beta weights and structure coefficients must be interpreted in order to reach valid conclusions. (Contains 15 references.) (Author)

The Importance of Structure Coefficients as Against Beta Weights: Comments with Examples from the Counseling Psychology Literature

John Bowling

Texas A&M University 77843-4225

Paper presented at the annual meeting of the Mid-South Educational Research Association, New Orleans, November 11, 1993.

The correct APA-style citation for this paper is:

Bowling, J.B. (1993, November). The importance of structure coefficients as against beta weights: Comments with examples from the Counseling Psychology literature. Paper presented at the annual meeting of the Mid-South Educational Research Association, New Orleans.

Running head: STRUCTURE COEFFICIENTS

Abstract

Recent empirical studies of actual research practice demonstrate that general linear models, such as regression, have become increasingly popular. The present paper explores issues related to the interpretation of regression results, with illustrations drawn from studies in the counseling psychology literature. The primary focus of this paper is on the interpretation of structure as against beta weights. It is argued that the interpretation of results based solely on beta weights can lead to entirely erroneous conclusions regarding the importance or relevance of predictor variables. In general, both beta weights and structure coefficients must be interpreted in order to reach valid conclusions.

The Importance of Structure Coefficients as Against Beta Weights: Comments with Examples from the Counseling Psychology Literature

Multiple regression analysis is frequently employed in research related to the field of Counseling Psychology. The primary journal in this field, The Journal of Counseling Psychology, published over 20 research-based articles between January of 1990 and April of 1993 that used multiple regression analysis. Multiple regression has been explained as a statistical procedure for which "the objective is to develop an equation where the predictor variables, denoted X_i, are optimally weighted such that the distance between each individuals predicted score, Y*, and the individual's actual score, Y, is minimized" (Friedrich, 1991, pp. 2-3). Regression is a least squares method that is able to handle both continuous and categorical independent variables and may be used equally well in experimental or nonexperimental research (Thompson & Borrello, 1985).

As the use of regression continues to increase (Willson, 1980), it is concommitantly important to understand the appropriate presentation and interpretation of regression results. When the effects of collinearity are not recognized, regression results may be misinterpreted with the consequence of less-than-sound research-based decisions. The concept of collinearity refers to a common situation in which predictor variables are correlated with each other to some degree. Thompson and Borrello (1985) outlined three potentially harmful effects of collinearity. First, the accuracy of least squares calculations can be affected. Second, the statistical accuracy of test statistics may be altered. The third danger involves the possibility for misinterpretation of results. The purpose of the present paper is to explore the correct interpretation of regression results when predictor variables are correlated with each other. Additionally, this paper will identify regression results, using examples of published research in The Journal of Counseling Psychology that are potentially misleading because of failure to correctly report the predictive strength of individual variables.

Collinearity

As mentioned above, collinearity involves the correlation of predictor variables with each other. This is often simply a reflection of the reality in which these variables occur. More specifically, it is unrealistic to assume that predictor variables chosen for analysis will naturally be mutually exclusive. Perry (1990) suggested that the use of correlated predictor variables in regression is often intentional. This is based on sound research decisions to examine those variables deemed to be the most important regardless of collinearity. When important variables are not perfectly correlated, several measures of a given construct may be used, and their "multioperationalized" predictors will obviously tend to be highly correlated.

Separate predictor variables that are correlated may account for the same predicted area of the dependent variable. Intuitively, the greater the collinearity the more likely the possibility for distortion of results. Pedzaur (1982) commented that not only can high collinearity lead to the distortion of results, it may also lead in extreme cases to the reversal of signs of b and beta weights. Obviously, this may confound accurate interpretation when interpretation is based solely on examinatiion of beta weights.

The Use of Beta Weights in Regression

In a multiple regression prediction equation, regression coefficients or "b weights" precede each of the predictor variables. These regression coefficients are weights used in the calculation of the multiple R value (correlation between the predictor variables taken as a whole and the dependent variable). It is important to note that because predictor variables are generally not on the same metric, their accompanying regression coefficients cannot be compared to determine which is the best predictor. This would be analogous to comparing months to meters or apples to grapefruit. Perry (1990) noted several problems with b weights. They are sensitive to (a) the influence of correlaticn between the predictors, (b) correlation between each predictor and the dependent variable, and (c) the relative variability of each predictor in relation to the dependent variable.

To allow for comparison of the predictive power of multiple predictor variables, it is possible to convert regression coefficients into beta weights. Huck, Cormier, and Bounds (1974) advised viewing beta weights as regression coefficients that would have been obtained if the various predictor variables were equal to one another in terms of standard deviation. They further suggested that the predictor variable with the largest beta weight in absolute value is the best predictor, while the beta weight with the smallest value contributes the least to prediction. This assertion is unfortunately misleading and can lead to incorrect conclusions about the relative importance of individual predictor variables.

While beta weights do involve all predictor variables having been converted into the same metric, the influence of the correlation of each predictor with Y and the correlation of the predictors with each other has not been removed. This makes it difficult for the researcher to accurately determine exactly what is contributing to either the large or small size of the beta weights. Beta weights of predictors reflect not only the effects of that variable but also collinearity with all other predictors included in the model. Pedzaur (1982, p. 246) commented, "...the presence of high collinearity poses serious threats to the interpretation of the regression coefficients [beta weights] as indices of effects".

Heuristic Example

A small heuristic example will help illustrate both the conversion of b weights to beta weights and the importance of structure coefficients or individual predictor-dependent variable r's in regression research. Table 1 presents data derived from an unpublished study of factors associated with level of alcohol consumption. QN is the quantity of alcohol consumed and is the dependent variable in this example. The predictors are: (a) alcohol-related knowledge (AK); (b) alcohol-related attitudes (AA); and (c) scores on the Michigan Alcoholism Screening Test (MT).

INSERT TABLE 1 ABOUT HERE.

The R for these data is .73404. The b weights, beta weights, individual predictor-dependent variable r's and structure coefficients for these data are presented in Table 2. It is important to note in the table that when the b weights are converted into beta weights, the order of predictive strength based upon interpretation of absolute value of weights changes completely. As mentioned previously, this is due to the effects of converting all predictor variables into the same metric of measurement.

It is also noteworthy that the person interpreting only beta weights might conclude that AK has little predictive value (.075132). The interpretation of structure coefficients changes the order of suggested predictive power of the independent variables in this case and indicates greater predictive power of the independent variables. This is best illustrated by the structure coefficient computed for AK (.6340). The researcher only looking at beta weights may interpret AK as a relatively useless predictor while the researcher that also looks at structure coefficients may interpret AK as having meaningful predictive power.

INSERT TABLE 2 ABOUT HERE.

The Use of Structure Coefficients

One method of comparing predictors, that eliminates the effects of collinearity, is the computation of structure coefficients. Structure coefficients are computed as the correlation between scores on an individual predictor and scores on YHAT. Another way of stating this is that structure coefficients are correlation coefficients between observed variable scores and scores on the latent synthetic variable (Thompson, 1990). Thompson and Borrello (1985) averred that structure coefficients help the researcher to understand what the synthetic variable, derived by weighting observed variables, actually is.

Evaluating structure coefficients may occasionally lead to a scenario in which a given predictor has a beta weight of zero, but a structure coefficient that indicates strong predictive power. Such a situation could occur when two or more predictors account for the same predictive area of the dependent variable. This highlights an important point. If structure coefficients had not been used in the above example, the researcher may incorrectly conclude that a powerful predictor actually has no predictive value.

Because structure coefficients are not effected by collinearity, they can be helpful in understanding the relative contribution of each predictor variable to the latent synthetic variable, YHAT. Friedrich (1991) pointed out that since structure coefficients are also correlation coefficients, they can be squared to explain the amount of variance in the predicted scores that can be explained by each of the individual predictors. This provides valuable additional information about predictors when compared with only interpreting beta weights.

Another option for the researcher is to compute individual predictor-dependent variable r's in addition to beta weights. This will yield interpretations identical to structure coefficients, though in a different metric. This can be observed in Table 2 by noting that both the structure coefficients and the individual predictor-dependent variable r's illustrate the same order and relationship of predictive strength of the independent variables. This relationship is illustrated by the following formula:

$$r_{\hat{y}.x1} = r_{y.x1} / R_{y.x1.x2.x3}$$

This formula states that the correlation between scores on YHAT and scores on an individual predictor variable is equal to the correlation between scores on the dependent variable Y and scores on an individual predictor variable divided by the multiple correlation between scores on Y and scores on all of the individual predictor variables.

One advantage of structure coefficients over bivariate r's involves the focus on the latent synthetic variable as opposed to the dependent criterion variable. Thompson and Borrello (1985) expressed a preference for structure coefficients because they are more consistent with the researcher's stated interest in an omnibus system of variables. They argued (p. 208) that "It appears inconsistent to first declare interest in an omnibus system of variables and then to consult values that consider the variables taken only two at a time".

Some researchers are less enthusiastic about the use of structure coefficients. Daniel (1990) reported on research that implied that structure coefficients may not provide stable indexes across studies. Daniel noted, however, that the higher the collinearity between predictors, the more useful the interpretation of structure coefficients. Thompson (1992) addressed the criticism that structure coefficients may violate reality since they are not affected by collinearity. He suggested that this is not an intrinsic weakness since beta weights are affected by collinearity resulting in possible changes when variables are added or deleted.

While structure coefficients offer different information than beta weights in interpretation, it is not proposed that beta weights simply be discarded. Rather, it is proffered that the interpretation of both beta weights and structure coefficients is important to further understanding of the relative contribution of predictors to the synthetic YHAT variable (Daniel, 1990; Thompson & Borrello, 1985). Thorndike (1978) agreed that it is important to interpret both beta weights and structure coefficients, but he further stated that structure coefficients appear to better honor the reality of the relationship of variables under study.

Friedrich (1990), Thompson and Borello (1985) and Daniel (1990) provided heuristic examples demonstrating different possible interpretations of regression results derived from interpreting beta weights versus interpreting structure coefficients. In each case the apparent relative contributions of predictor variables changed depending upon whether beta weights or structure coefficients were being reviewed. In several instances, the predictor variable signs were actually changed, suggesting dramatically different predictor-dependent relationships. These examples illustrated the danger of neglecting to compute structure coefficients or bivariate r's. With this mind, a review of a prominent research oriented journal was conducted to assess the prevalence of structure coefficient computations when using multiple regression as an analytic method.

Selected Review of Published Regression Results

The Journal of Counseling Psychology serves as the primary research journal aimed specifically at the field of counseling psychology. It gives particular attention to articles reporting the results of empirical studies related to counseling interventions, processes, theories, and evaluation. It is essential that such studies be methodologically sound since counseling psychologists look to the resulting information as a guide for future directions within their field. It has been popular in recent years to use regression as an analytic method. Some of the advantages offered by the use of regression techniques were outlined previously in this paper. As regression methods continue to be used in counseling psychology research, it is imperative that interpretation of results be both encompassing and accurate.

The Journal of Counseling Psychology published over 20 research based articles between January of 1990 and April of 1993 that used multiple regression analysis. Only three of these articles explicitly reported structure coefficients in their results. An article related to client attrition factors (Longo, Lent, & Brown, 1992) provided a good example of why it is essential to examine both structure coefficients and beta weights. Examination of the beta weights alone indicated that counselor experience was a relatively useless predictor of client attrition. A second look at this predictor variable's structure coefficient suggested that counselor experience may in fact have relatively strong predictive power. This difference between the interpretation of the beta weight and the interpretation of the structure coefficient was due to the high collinearity of counselor experience with the predictor, self-efficacy. This leads to a much different conclusion about the merit of counselor experience than had the researcher only interpreted beta weights.

Unfortunately, of the articles failing to report structure coefficients, only a few of them provided enough information so that the ambitious reader might have computed structure coefficients independently. This clearly leads to the potential for large misinterpretations of results. The primary focus of regression results involved interpretation of beta weights. A sampling of articles showed that the size of the beta weights was used to determine the most effective type of counseling intervention, explain the "most important" factors involved with white identity development, determine the impact of unemployment, and identify the "best" predictors of healthy adolescent development (Kivlighan, 1990; Lopez, Watkins, & Manus, 1992; Reynolds & Gilbert, 1991; Tokar & Swanson, 1991).

These are just a few examples of the types of issues being explored through the use of multiple regression. Identifying some of the topics of the published studies illustrates the potential impact of incorrect interpretation of regression results. Decisions related to program funding, interventions, and general understanding of human behavior may all be misdirected when structure coefficients are not computed as part of regression analysis, unless the predictor variables are perfectly uncorrelated.

Conclusion

Reasons for failure to report structure coefficients or bivariate r's are not clear. It may be that there is an absence of complete understanding of beta weights and the influence of collinearity. It is likely that some researchers may use regression techniques because of the weights' favorable reputation without fully understanding the concepts of regression. Another possible reason for failure to compute structure coefficients is the reluctance of some researchers to accept problems associated with beta weights. There are still numerous statistic textbooks that describe beta weights as the appropriate metric for comparison of predictor variables in regression. These same textbooks often neglect to mention structure coefficients at all.

Whatever the specific reasons that structure coefficients are reported so infrequently, it is unfortunate that many researchers rely solely on beta weight interpretation to make decisions about the strength of predictor variables. Regression is an analytic method that generally honors the complexities of the reality being studied. It accounts for a reality in which "...variables can interact in all sorts of complex and counterintuitive ways" (Thompson, 1992, p. 13). However, an analytic method is only useful if it is interpreted in an appropriate manner. The interpretation must reflect and account for the ways in which all of the variables interact together. Beta weights and structure coefficients must both be computed and interpreted when using regression so that results of studies in the field of counseling psychology have both meaning and utility.

References

Daniel, L.G. (1990, January). The use of structure coefficients in multivariate educational research: A heuristic example. Paper presented at the annual meeting of the Southwest Educational Research Association, Austin. (ERIC Document Reproduction Service No. ED 315 451)

Friedrich, K.R. (1991, April). The importance of structure coefficients in parametric analysis. Paper presented at the annual meeting of the American Educational Research Association, Chicago. (ERIC Document Reproduction Service No. ED 330 725)

Huck, S.W., Cormier, W.H., & Bounds, W.G. (1974). Reading research and statistics. New York: Harper and Row.

Kivlighan, D.M. (1990). Relation between counselor's use of intentions and clients perception of working alliance. The Journal of Counseling Psychology, 37, 27-32.

Longo, D.A., Lent, R.W. & Brown, S.D. (1992). Social cognitive variables in the prediction of client motivation and attrition. Journal of Counseling Psychology, 39, 447-452.

Lopez, F.G., Watkins, C.E., & Manus, M. (1992). Conflictual independence, mood regulation, and generalized self-efficacy: Test of a model of late adolescent identity. The Journal of Counseling Psychology, 39, 375-381.

Pedzauer, E.J. (1982). Multiple regression in behavioral research: Explanation and prediction (2nd ed.). New York: Holt, Rinehart and Winston.

Perry, L.N. (1990, January). The use of structure coefficients in regression research. Paper presented at the annual meeting of the Southwest Educational Research Association, Austin. (ERIC Document Reproduction Service No. ED 315 448)

Reynolds, S. & Gilbert, P. (1991). Psychological impact of unemployment: Interactive effects of vulnerability and protective factors on depression. The Journal of Counseling Psychology, 38, 76-84.

Thompson, B. (1990). Don't forget the structure coefficients. Measurement and Evaluation in Counseling and Development, 22, 178-179.

Thompson, B. (1992, April). Interpreting regression results: beta weights and structure coefficients are both important. Paper presented at the annual meeting of the American Educational Research Association, San Francisco. (ERIC Document Rep. Service No. ED 344 897)

Thompson, B. & Borrello, G.M. (1985). The importance of structure coefficients in regression research. Educational and Psychological Measurement, 45, 203-209.

Thorndike, R.M. (1978). Correlational procedures for research. New York: Gardner.

Tokar, D.M. & Swanson, J.L. (1991). An investigation of the validity of Helm's model of white racial identity development. The Journal of Counseling Psychology, 38, 296-301.

Willson, V.L. (1980). Research techniques in AERJ articles: 1969 to 1978. Educational Researcher, 9, 5-10.

TABLE 1
"Alcohol Consumption"

ID	QN	AK	AA	MT
100	18	07	91	02
101	16	06	79	03
102	16	09	86	09
103	29	09	75	07
104	40	08	84	04
105	31	09	69	12
106	31	07	78	07
107	19	11	80	06
108	30	11	66	04
109	60	12	70	19
110	30	10	59	09
111	26	10	71	04
112	31	10	71	09
113	36	08	65	10
114	22	07	64	03

TABLE 2
b Weights, beta Weights, Individual Predictor-Dependent Variable r's, and Structure Coefficients

	b Weights	beta Weights	I P-D Var. r's	Structure Coefficients
MT	1.62491	.641235	.7205	.9816
AA	-.14828	-.119259	-.3507	-.4778
AK	.48132	.075132	.4654	.6340