IMPLICATIONS OF ORDINAL SCALE CATEGORIZATION ON REGRESSION MODELS UNDER DIFFERENT DISTRIBUTIONS AND CONDITIONS:

AN ASSESSMENT OF THE ACCURACY AND INFORMATION OF LIKERT SCALES ON REGRESSION ANALYSIS.

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Abstract

Many of the measures obtained in educational research are Likert type responses on questionnaires. These Likert-type variables are sometimes used in ordinary least squares regression analysis. Little research has been done to examine how much information is lost and how inappropriate it is to use Likert variables in ordinary least squares regression. This study examined the effect of Likert-type data on the population bias of the R^2 index. It was found that the largest bias in the estimation of the three dependent variables occurred for fewer likert scale points and for skewed response data. Information loss did not substantially improve beyond the four point likert scale. Furthermore, skewed response distribution resulted in large biases in R^2.

Problem statement

- Given the effect of Likert scale points on the observed variables in linear regression, and the occurrence of errors in the measures, what information is lost in analyzing continuous concepts using Likert data in linear regression models?
- To address this problem, and the implications of the associated variables, the effect of the distribution of the responses, number of Likert scale points, and the underlying latent variable on the model R^2 were investigated.

Rationale

- Several Likert-type scales have been adapted for use, ranging from two to ten categories. However, the number of Likert scale points has been hypothesized to influence the accuracy of the criterion measures (Bollen and Barb,1981; Chang, 1994).). Findings indicated that Likert scaling of continuous variables was found to have a negative impact on parameter estimates and standard errors resulting in inaccuracy and information loss – measured in terms of R^2.
- The distribution of the observed Likert variables and that of the underlying latent variable have been shown to influence the accuracy of parameter estimates, and model fit in factor analysis (Babakus et.al, 1987; Green et al, 1997; Muthen & Kaplan, 1985; Muthen & Kaplan, 1992). However, this has not been shown in regression analysis.

Research Question

What are the effects of Likert data on the estimation of R^2, across number scale points, type of correlation matrices, response distribution and Likert conditions?

Purpose

To investigate the effect of likert data in linear regression models in terms of model fit and variable ordering, and relative importance.

Method - Simulation

Populations of 500,000 responses were simulated for each combination condition of the independent variables. By using a large finite population we sidestep the matter of sampling variability and focus on the population-level results. For each combination of the conditions of responses, multiple linear regression analysis were conducted for the predictors and criterion variable. The resulting R^2, and percent bias in R^2 were recorded to assess the effects of Likert data on multiple regression and the hypothesized information loss across the independent variables and conditions stated.

Method – Study Design

The study design is as follows: Responses were generated using (a) 3 correlation matrices, (b) 3 response patterns, and (c) 8 ordinal categories resulting Likert scales, ranging from 2 to 9 scale-points. We then conducted the ordinary least-squares regressions on 3 combinations of ordinal categories and continuous data for predictors and criterion variable. This results into a 3x3x3x8 factorial design with 216 cells. Each cell consisted of the dependent variables derived from the multiple linear regression analysis results. Because this is a population based study of bias, each cell has one replicate.

- These are the three correlation matrices for the simulation.
- From left to right, they are the low (R^2 =.118), moderate (R^2 =.752), and
- high inter-variable correlations. The R^2 are 0.118, 0.753, and 0.562, respectively.

Table 1

	Y	X_1	X_2	X_3
Y	1			
X_1	.20	1		
X_2	.10	.50	1	
X_3	.30	.40	.60	1

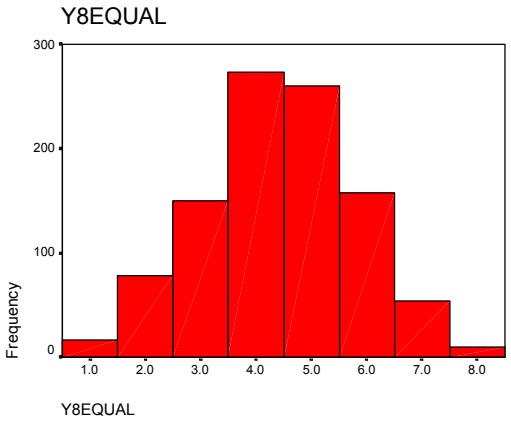
Table 2

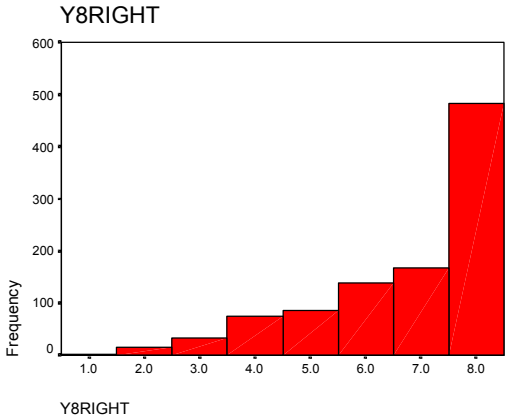
	Y	X_1	X_2	X_3
Y	1			
X_1	.60	1		
X_2	.50	.20	1	
X_3	.70	.30	.20	1

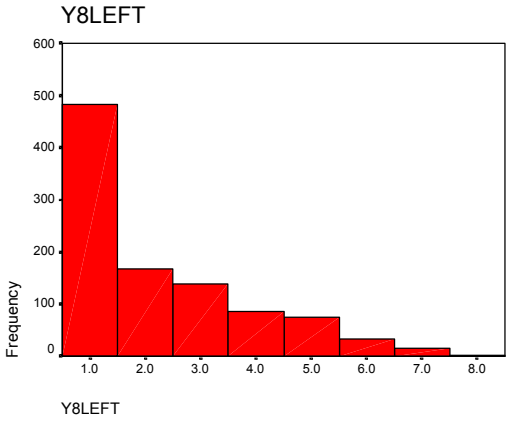
Table 3

	Y	X_1	X_2	X_3
Y	1			
X_1	.60	1		
X_2	.70	.70	1	
X_3	.70	.60	.80	1

Example of equal, right, and left bunched (skewed) Likert response distribution patterns.







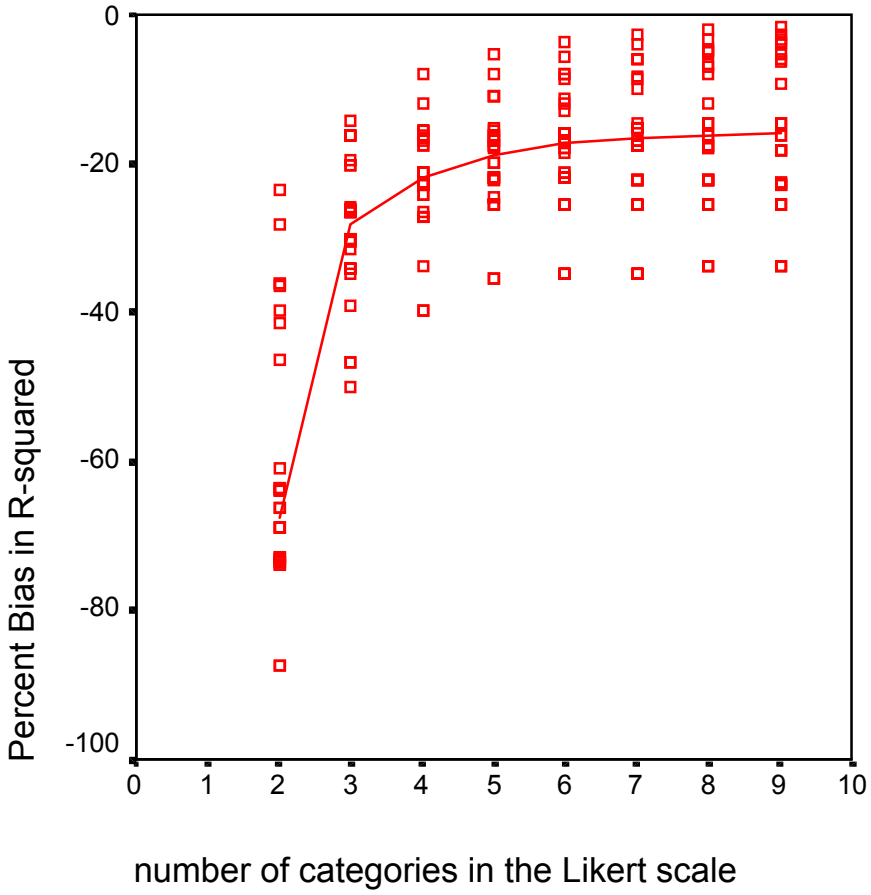
Results

- A model was fitted for all main effects and all interaction effects for the percent bias dependent variable. The number of categories was treated as a quantitative explanatory variable.
- The results indicate that all the main effects of (a) variable combination, (b) correlation matrix (c) response pattern, and (d) number of scale points were statistically significant.
- For variable combination where both the predictors and criterion variables are Likert there is a reduction in R^2 of nearly 7 percent.
- There were statistically significant difference in the means of percent bias between low and moderate correlation matrices, and low and high correlation matrices, with low correlation matrix have less of a reduction in R^2.

Results

- There were statistically significant differences between equal and right bunching, and equal versus left bunching response patterns. Unequal response pattern results in, on average, 12 percent reduction in R^2.

• As the following chart shows, the main effect of number of Likert scale points diminishes after 4 scale points. This is confirmed by post-hoc tests of pairwise comparison of mean differences.



Discussion and Conclusion

- Fewer number of Likert scale points resulted in larger biases. It is recommended that four or more Likert scale points be used. However, it should be noted that little or no substantial gain in information results in using more than four Likert points. Likert scaling and in particular, dichotomization of data results in substantial loss of information.
- Research implication of the findings on the bias in R^2 is that categorization of response data as a practice of simplifying analysis should be avoided, as this results in information loss. In these cases, where applicable, continuous data should be used.

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