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On the Use of Some Selected Estimators in the Computation of Interactions in a Moderated Multiple Regression of a Masked Survey Data

[1]H.I. Okagbue, [2]M.O. Adamu, [1]S.O. Edeki and [1]A.A. Opanuga
[1]Department of Mathematical Sciences, Covenant University, Canaanland, Ota, Nigeria
[2]Department of Mathematics, University of Lagos, Akoka, Nigeria

Abstract: Mean has been traditionally used in the computation of the interactions in moderated linear regression. This research extended to the use of medium, mode, trimmed mean and some M-estimators which gave almost the same results when compared with mean. The values of R^2, MSR and F were the same for all the estimators. Also, simulated results vary slightly with the theoretical results due to the effects of outliers as a result of random numbers. The survey data was masked because it is a subset of an ongoing research work.

Key words: Estimators, regression, moderation, mean, MSR

INTRODUCTION

Moderation occurs in regression analysis when the relationship between variables depends on a third variable. This modification on regression analysis can be by a dichotomous moderator variable, a polytomous moderator variable or continuous moderator variable. The effect of a moderating variable is known as interaction (Cohen *et al*., 2003) which can be qualitative (sex, gender, marital status, race, class, caste) or quantitative (response time, exposure rate, temperature, child spacing).

Baron and Kenny (1986) wrote extensively on the statistical considerations of moderated regression analysis. Issues of multi-collinearity were addressed in the works by Cortina (1993), Stone and Hollenbeck (1984) and Arnold (1982). Evans (1985) studied the effects of correlated method variance in moderated multiple regression analysis by applying Monte Carlo Methods. Ratio scales is not required in the analysis of moderated regression (Arnold and Evans, 1979) while the model was applied to the analysis of dyadic data (Krackhardt, 1988). Also, Dunlap and Kemery (1988) gave a detailed effects of predictor inter-correlations and reliabilities on moderated multiple regression. A detailed analysis of hierarchical moderated linear multiple regression were done by Schriesheim (1995) and Rosopa and Stone-Romero (2008). However, problems arises in interpretation of interaction terms in moderated regression, this was tackled by Bedeian and Mossholder (1994).

Moderated regression analysis has been applied in many areas and fields of study. Cullen *et al*. (1983) applied it in the analysis of risk factors for cardiovascular disease and cancer mortality. Other applications can be summarized as follows: leadership competency profiles of successful project managers (Muller and Turner, 2010), management research (Aguinis, 1995), the relationship between service quality and customer relationship (Taylor and Baker, 1994), ostracism and prosocial behavior (Balliet and Ferris, 2013), budgeting research (Hartmann and Moers, 2003), leadership research (Villa *et al*., 2003) and economic performance (Wagner, 2010). The following are some of recent applications of moderated regression:

- The effects of work-life balance on several individual outcomes across cultures (Haar *et al*., 2014)
- To examine which individuals are less likely to seek feedback and what their underlying motives are (Niemann *et al*., 2015)
- Understand theory of leadership research (Rast III *et al*., 2015)
- Examine the relationship between moral disengagement and cyber bullying (Bussey *et al*., 2015)
- To examine the relationship between counter reproductive work behaviors observations and counter reproductive work behaviors reporting (Bowling and Lyons, 2015)
- On how political behavior influences decision success (Elbanna *et al*., 2015)
- Examine the relationship between work-school conflict, sleep quality and fatigue (Park and Sprung, 2015)

Corresponding Author: H.I. Okagbue, Department of Mathematical Sciences, Covenant University, Canaanland, Ota, Nigeria

- Investigate the boundary conditions in the relationship between feedback-seeking behavior and work performance (Nae *et al*., 2015)
- Examine the moderating role of corporate volunteers' attributions concerning the public relations motives underlying companies' employee volunteering programs (Gatignom-Turnau and Mignonac, 2015)

MATERIALS AND METHODS

The data used in this study is a subset of an ongoing survey and the masked nature means that the details of the survey contents are hidden. Different estimators were used to compute the interactions used in the moderated multiple regression model.

Multiple regression model:

$$y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_7 + b_8x_8 + b_9x_9 \quad (1)$$

Dependent variable = y, Independent variables = x_1-x_9

Moderated regression model:

$$y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_7 + b_8x_8 + b_9x_9 + b_{10}(x_1 \times x_7) + b_{11}(x_2 \times x_7) + b_{12}(x_3 \times x_8) + b_{13}(x_4 \times x_8) + b_{14}(x_5 \times x_9) + b_{15}(x_6 \times x_9)$$

Dependent variable = y

Independent variables = x_1-x_6

Moderating variables = x_7-x_9

(2)

Additional conditions:

- x_7 is moderating variable for x_1 and x_2
- x_8 is moderating variable for x_3 and x_4
- x_9 is moderating variable for x_5 and x_6

RESULTS AND DISCUSSION

Theoretical results

Multiple regression: The model fit and Analysis of Variance (ANOVA) results are summarized in Table 1 and 2:

$$y = 0.668 + 0.096x_1 + 0.130x_2 + 0.082x_3 + 0.053x_4 + 0.067x_5 + 0.113x_6 + 0.133x_7 + 0.088x_8 + 0.088x_9 \quad (3)$$

Moderated multiple regression: The 8 estimators were used to compute the interactions based on the moderating variables (Table 3-5). The simulation results of moderated multiple regression is given in Table 7-10:

- The model fit was almost the same with both regression and the moderated regression. However, moderation reduces the mean square regression and F while the mean square error remains constant as shown in Table 11
- The coefficients of constants for both the regression are almost the same except for the moderating variables (Table 12)
- All the 8 estimators used in the computation of the interactions with the moderating variables are almost the same, an indication of the absence of significant outliers. Hence, the survey does not contain extreme values. Simulation introduced some extreme values that reduced the model fit
- The models fit ANOVA results are unchanged for all the estimators
- The coefficients of constants are almost the same in the theoretical results except the mode that varies slightly from others
- The moderating variables are unchanged for both cases

Table 1: Model summary for the multiple regression analysis (model summary)

					Change statistics					
Model	R	R^2	Adjusted R^2	Std. error of the estimate	R^2 change	F change	df1	df2	Sig. F change	Durbin-Watson
1	0.483	0.234	0.231	1.11540	0.234	101.333	9	2990	0.000	1.886

Table 2: ANOVA table for the multiple regression

Model	Sum of squares	Deg. of freedom	Mean square	F-value	Sig.
1					
Regression	1134.641	9	126.071	101.333	0.000[b]
Residual	3719.943	2990	1.244	-	-
Total	4854.584	2999	-	-	-

Table 3: Estimators for the moderating variables

Estimators	x_7	x_8	x_9
Mean	3.7770	3.7233	3.7363
Median	4	4	4
Mode	5	5	5
5% Trimmed mean	3.8633	3.8037	3.7996
Huber's M-estimator	3.9538	3.9298	3.9368
Tukey's Biweight	3.9498	3.9283	3.9375
Hampel's M-estimator	3.8808	3.8471	3.8511
Andrew's wave	3.9488	3.9269	3.9361

Table 4: The model fit and ANOVA for the different models

Estimators	R^2	Adjusted R^2 change	MSR	F-values
Mean	0.241	0.237	78.055	63.228
Median	0.241	0.237	78.055	63.228
Mode	0.241	0.237	78.055	63.228
5% Trimmed mean	0.241	0.237	78.055	63.228
Huber's M-estimator	0.241	0.237	78.055	63.228
Tukey's Biweight	0.241	0.237	78.055	63.228
Hampel's M-estimator	0.241	0.237	78.055	63.228
Andrew's wave	0.241	0.237	78.055	63.228

Table 5: Coefficients of constants for the different variables for the estimators

Estimators	Constant	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
Mean	0.799	0.090	0.122	0.084	0.048	0.065	0.109	0.093	0.065
Median	0.799	0.092	0.123	0.086	0.047	0.071	0.104	0.093	0.065
Mode	0.799	0.101	0.124	0.095	0.042	0.095	0.082	0.093	0.065
5% Trimmed mean	0.799	0.091	0.122	0.085	0.048	0.066	0.108	0.093	0.065
Huber's M-estimator	0.799	0.092	0.123	0.086	0.047	0.069	0.105	0.093	0.065
Tukey's Biweight	0.799	0.092	0.123	0.086	0.047	0.069	0.105	0.093	0.065
Hampel's M-estimator	0.799	0.091	0.123	0.085	0.048	0.067	0.107	0.093	0.065
Andrew's wave	0.799	0.092	0.123	0.086	0.047	0.069	0.105	0.093	0.065

Table 6: Coefficients of constants of the variables and interactions

Estimators	x_9	x_1x_7	x_2x_7	x_3x_8	x_4x_8	x_5x_9	x_6x_9
Mean	0.122	0.028	0.005	0.035	-0.020	0.083	-0.079
Median	0.122	0.028	0.005	0.034	-0.020	0.082	-0.078
Mode	0.122	0.028	0.005	0.034	-0.020	0.083	-0.079
5% Trimmed mean	0.122	0.028	0.005	0.035	-0.020	0.083	-0.079
Huber's M-estimator	0.122	0.028	0.005	0.034	-0.020	0.082	-0.078
Tukey's Biweight	0.122	0.028	0.005	0.034	-0.020	0.082	-0.078
Hampel's M-estimator	0.122	0.028	0.005	0.034	-0.020	0.083	-0.078
Andrew's wave	0.122	0.028	0.005	0.034	-0.020	0.082	-0.078

Table 7: Estimators for the moderating variables

Estimators	x_7	x_8	x_9
Mean	3.7953	3.9640	3.9983
Median	4	4	4
Mode	3	3	3
5% Trimmed mean	3.7241	3.9600	3.9981
Huber's M-estimator	3.6977	3.9522	3.9928
Tukey's Biweight	3.5516	3.9512	3.9941
Hampel's M-estimator	3.6267	3.9506	3.9960
Andrew's wave	3.5484	3.9513	3.9941

Table 8: The model fit and ANOVA for the different models

Estimators	R^2	Adjusted R^2 change	MSR	F-values
Mean	0.006	0.001	4.350	1.199
Median	0.006	0.001	4.350	1.199
Mode	0.006	0.001	4.350	1.199
5% Trimmed mean	0.006	0.001	4.350	1.199
Huber's M-estimator	0.006	0.001	4.350	1.199
Tukey's Biweight	0.006	0.001	4.350	1.199
Hampel's M-estimator	0.006	0.001	4.350	1.199
Andrew's wave	0.006	0.001	4.350	1.199

Table 9: Coefficients of constants for the different variables for the estimators

Estimators	Constant	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
Mean	3.273	-0.023	-0.020	-0.040	0.001	0.006	0.014	0.065	0.011
Median	3.273	-0.023	-0.025	-0.040	0.001	0.006	0.014	0.065	0.011
Mode	3.273	-0.025	-0.001	0.002	-0.004	0.028	-0.012	0.065	0.011
5% Trimmed mean	3.273	-0.024	-0.018	-0.004	0.001	0.006	0.014	0.065	0.011
Huber's M-estimator	3.273	-0.024	-0.018	-0.004	0.001	0.006	0.013	0.065	0.011
Tukey's Biweight	3.273	-0.024	-0.014	-0.004	0.001	0.006	0.013	0.065	0.011
Hampel's M-estimator	3.273	-0.024	-0.016	-0.004	0.001	0.006	0.013	0.065	0.011
Andrew's wave	3.273	-0.024	-0.014	-0.004	0.001	0.006	0.013	0.065	0.011

Table 10: Coefficients of constants of the variables and interactions

Estimators	x_9	x_1x_7	x_2x_7	x_3x_8	x_4x_8	x_5x_9	x_6x_9
Mean	0.040	0.009	-0.100	-0.026	0.015	-0.101	0.076
Median	0.040	0.009	-0.100	-0.026	0.015	-0.101	0.076
Mode	0.040	0.009	-0.101	-0.027	0.016	-0.103	0.080
5% Trimmed mean	0.040	0.009	0.100	-0.026	0.015	-0.101	0.076
Huber's M-estimator	0.040	0.009	0.100	-0.026	0.015	-0.101	0.076
Tukey's Biweight	0.040	0.009	0.100	-0.026	0.015	-0.101	0.076
Hampel's M-estimator	0.040	0.009	0.100	-0.026	0.015	-0.101	0.076
Andrew's wave	0.040	0.009	0.100	-0.026	0.015	-0.101	0.076

Table 11: Comparison of the model fit and ANOVA

Model	R^2	Adjusted R^2 change	MSR	F-values
Regression	0.234	0.231	126.071	101.333
Moderated regression	0.241	0.237	78.055	63.228

Table 12: Comparison of the coefficients of constants of the variables

Models	Constant	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9
Regression	0.668	0.096	0.130	0.082	0.053	0.067	0.113	0.133	0.088	0.088
Moderation	0.799	0.090	0.122	0.084	0.048	0.065	0.109	0.093	0.065	0.122

- The interaction of the simulated differs from the theoretical results. This is because the survey data followed a particular form and pattern but the simulated data are purely random with no definite pattern. However, all the estimators used in the computation of the interactions with the moderating variables gave the same results

CONCLUSION

This study has shown that all 8 estimators used in the computation of interactions with the moderating variables gave the same results both in theory and in simulated data. But caution should be exercised in using mode especially in a case of multi-modal distributions and also the undue influence of extreme values.

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