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MODELLING BY INTER-REACTION EFFECTS

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We present a model on inter reaction forces among the variables of a multiple regression model The Number Cruncher Statistical System(NCSS 9,trial version) digital package was used for model formulation and analysis. The $\frac{(K+1)(K+2)}{2}$ method developed here uses fewer independent variables than other methods in use. A practical case of the Nigerian Defence Academy (NDA) Kaduna , cadet's offences showed that results obtained from considering inter-reaction between the dependent variable and the independent variables is better than those from the conventional multiple regression model in terms of forecast accuracies.

Keywords: Inter- reaction effects, cadets, offences, Multiple Regression, dependent variables, model.

INTRODUCTION

In multiple regression analysis, interaction effects consider the product of one independent variable with other dependent variables. According to Pedhazur and Schmelkin (1991),the idea that multiple regression effects be incorporated into research is a great contribution by Sir Ronald Fisher. Walpole et al (2007) said that interactions are accounted for in regression models by product terms and that from it one can ascertain the combination of the factors that results in maximum effects or efficiency. Hargens(2007) distinguished between the regression surface produced by estimating a product-variable model of an interaction effect, and the casual mechanism that produced the regression surface. Kang and Waller(2005) in an item response theory(IRT) model showed that item response theory provides a viable means of explaining the interactions between variables in models .Aiken and West(1991),Cohen and Cohen(1983) showed how to interpret the interaction effects of two continuous predictor variables. Pedhazur(1997) illustrated how to test for significance of coefficients in an interaction model.

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Assumptions of the Study

The study assumes the following according to Tembe (2008), Mark and David (1979) and Okafor (2008).

a. It is assumed that the primary and secondary sources of data are accurate.

b. It is assumed that the study is worth conducting for problem solving and decision making by the appropriate authorities and multiple regression analysis.

c. It is assumed that statistical soft ware's and the hard ware's used in this study and research are the appropriate technology.

d. It is assumed that this prototype as a case study is accurate and gives appropriate fit.

e. The model is predicated on the assumption that those factors which have influenced the number of convicts in the past and present will continue to do so in more or less the same manner in the future.

f. As in all forecasting tools, the model may not be the correct forecast all the time.

CASE DESCRIPTION

Maintenance of discipline is the trade mark of the military profession. The importance of discipline to the Armed Forces

is well captured in the words of George Washington, a one time President of United States of America. “Nothing can be more hurtful to the service than the neglect of discipline; for that discipline, more than numbers, gives one army the superiority over another”

At the Nigerian Defence Academy, once cadets take oath of allegiance on admission into the NDA, they become liable to military as well as civil laws of Nigeria. As a military personnel, each cadet is bound to keep to the oat to the letter.

Uba (2008) while speaking after cadets oath taking ceremony said:“As officer cadets they are bound to honour all the pledges they have sworn (to as) the Academy does not expect any breach or attempt to break their promise now or in the future as such as action will incur legal consequences”.

Cadets at NDA are not only here for academic pursuits but also to get prepared to provide useful services to the nation.

Dzarma (2007) said :“As for you cadets, it is not sufficient that you should acquire only technical skills but you are expected to show qualities of leadership and integrity and above all loyalty and patriotism. By doing this, you are providing an umbrella under whose shadows and protection every citizen of this country will thus be enabled to pursue his or her own chosen occupation and thus be enabled to give the fullest expression of his creative ability”.

There are laid down rules and regulations in NDA and anyone found contravening any of these rules will be charged and tried. Those found guilty or convicted of any charge can be reprimanded, relegated, withdrawn, made to pay fine or confined to the guardroom or the Battalion line. Indiscipline in the armed forces has severe consequences or punishment. It is the enforcement of discipline that makes the military organisation a unique one. Cadets at NDA are expected to stick to discipline either in the classroom/Academic Branch, the battalion has a separate book for recording of charges against anyone that contravenes any breach of the established laws of either the country or the school authorities or even civil offences outside the Academy. The offences which cadets can be charged for and convicted are stated in APPENDIX 1. The offences which cadets can be charged for and convicted are stated in APPENDIX 1….

There are situations where we may need to take decision involving many issues of life in relation to one other issue. For instance, how to spend our monthly salary (Y), depends on other factors such as feeding money to the family, children school fees and pocket money, car maintenance, house rent etc. Here, our variable of interest depends on other variables. In a situation such as this, we will like to formulate a model that will help us construct the relationship between our variable of interest spending of salary (Y) and other variables feeding money, children school fees and pocket money (Xs) etc. The (Y) variable is called the dependent variable and the Xs variables are called the independent variables.

To establish the relationship between Y and the X variables in order to formulate the correct model, we use a technique called multiple regression. Therefore, when several independent variables are included in the regression equation the model we obtain is called the multiple regression models

Black(2005) proposed getting the number of coefficients from 2^k -1 formula and Walpole et al(2007) favoured the use of 2^k factorial for interaction model

In considering interaction effects using existing n methods, the multiple regression equation is

$$\dot{Y}_t = b_0 + b_1x_{1j} + b_2x_{2j} + b_3x_3 + \ldots + b_px_{pj} + b_{p+1}x_{1j}x_{2j+} b_{13}x_{3j} + b_{123p}x_1x_2x_3x_p + b_kx_1^2 + b_2x_2^2 + + \ldots + b_px^2_p + b_{jp}x_p \quad (2)$$

$$\dot{Y}_t = b_0 + b_1x_{1j} + b_2x_{2j} + b_3x_3 + \ldots + b_px_{pj} + b_{p+1}x_{1j}x_{2j+} b_{13}x_{3j} + b_{123p}x1x_2x_3x_p + b_kx_1^2 + b_2x_2^2 + + \ldots + b_px^2_p + b_{jp}x_p \quad (4$$

In our case of 9 independent variables, using the $\frac{(K+1)(K+2)}{2}$ method:

.The model equation will be

$$Y=\beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_1^2 + \beta_{11}X_2^2 + \beta_{12}X_3^2 + \beta_{13}X_4^2 + \beta_{14}X_5^2 + \beta_{15}X_9X_{1+} + \beta_{16}X_9X_2 + + \beta_{17}X_9X_3 + \beta_{18}X_9X_4 + + \beta_{19}X_9X_5 + \beta_{20}X_9X_6 + \beta_{21}X_9X_7 + \beta_{22}X_9X_8 + \beta_{23}X_8X_1 + \beta_{24}X_8X_2 + \beta_{25}X_8X_3 + \beta_{26}X_8X_4 + \beta_{27}X_8X_5 + \beta_{28}X_8X_6 + \beta_{29}X_8X_7 + \beta_{30}X_7X_1 + \beta_{31}X_7X_2 + \beta_{32}X_7X_4 + \beta_{33}X_7X_5 + \beta_{34}X_7X_6 + \beta_{35}X_6X_1 + \beta_{36}X_6X_2 + \beta_{37}X_6X_3 + \beta_{38}X_6X_4 + \beta_{39}X_6X_4 + \beta_{40}X_6X_5 + \beta_{41}X_5X_1 + \beta_{42}X_5X_2 + \beta_{43}X_5X_3 + \beta_{44}X_5X_4 + \beta_{45}X_4X_1 + \beta_{46}X_4X_2 + \beta_{47}X_4X_3 + \beta_{48}X_3X_1 + \beta_{49}X_3X_2 + \beta_{50}X_2X_1 + \beta_{51}X_6^2 + \beta_{52}X_7^2 + \beta_{53}X_8^2 + \beta_{54}X_9^2 + e_t \quad (4)$$

In equation (4) ,there are 9- effect or k dependent variables,36 or $\frac{K(K-1)}{2}$ two factor interaction variables , 9 second order compliments of terms of all the 9 variables and a constant term.For k=9, we have ($\frac{(K+1)(K+2)}{2} = \frac{(9+1)(9+2)}{2}$,or or $\frac{(11*10)}{2}$ =55 coefficients, which is made up of 54 independent variables and a constant term.

The estimated model from the NCSS 9 prints out is shown in equation (5) below:

ESTIMATED EQUATION

$$\dot{Y}_t = 757.852 - 12.006\ X_8 + 19.347\ X_9 - 31.406\ X_1 - 17.794\ X_2 + 58.027\ X_3 - 40.0195\ X_4 + 10.166\ X_5 + 78.26856\ X_6 + 16.836\ X_7 - 0.121\ X^2_8 - 4.264\ X_8X_9 + 2.134\ X_8X_1 - 0.434\ X_8X_2 - 3.649\ X_8X_3 + 0.520X_8X_4 + 0.834\ X_8X_5 + 1.198\ X_8X_6 + 0.718\ X_8X_7 + 4.678\ X^2_9 + 1.206\ X_9X_1 - 2.90^*\ X_9X_2 - 1.744\ X_9X_3 + 0.926\ X_9X_4 + 0.786\ X_9X_5 - 0.768\ X_9X_6 + 3.21\ X_9X_7 - 0.058\ X^2_1 + 0.446\ X_1X_2 + 2.238\ X_1X_3 - 1.345\ X_1X_4 + 0.428\ X_1X_5 + 0.061\ X_1X_6 - 1.526\ X_1X_7 + 0.047\ X^2_2 + 0.283\ X_2X_3 + 0.123\ X_2X_4 + 0.475\ X_2X_5 + 0.265^*\ X_2X_6 + 0.456\ X_2X_7 - 0.381\ X^2_3 + 0.953\ X_3X_4 - 0.544X_3X_5\ 4.311\ X_3X_6 - 0.513\ X_3X_7 + 0.286\ X^2_4 - 0.273\ X_4X_5 - 0.706\ X_4X_6 + 0.978^*\ X_4X_7 - 0.169\ X^2_5 + 0.158\ X_5X_6 - 1.56\ X_5X_7 - 1.342\ X^2_6 + 1.021\ X_6X_7 - 0.898\ X^2_7 \quad (5)$$

The Run Summary Report is shown in Table 1.

Table1 -Runs Summary

Item	Value
Dependent variable	Y
Number of Independent variable	54
R^2	0.987074
Adjusted R^2	0.9289033
Coefficient of Variation	0.1440463
Mean Square Error	599.5295
Square Root of MSE	24.48529
Ave.Pct .Error	1.713956
Completion Status	Normal Completion

Using the multiple regression method the model equation is

$Y_t = \alpha_0 + \alpha_1 x_1 ++ \alpha_2 x_2 + \alpha_3 x_3 ++ \alpha_4 x_4 + \alpha_5 x_5 ++ \alpha_6 x_6 + \alpha_7 x_7 + \alpha_8 x_8 + \alpha_9 x_9 + e_t$ (6)

And the estimate model is as shown in equation(7) and the run summary in shown in Table2.

$\dot{Y}_t =$

$159.129 - 1.205x_8 + 1.194X_9 + 1.324X_1 + 0.756x2 + 0.589x_3 - 1.972x_4 + 0.488x_5 + 0.216x_6 + 0.718\, x_7$ (7)

Table 2. Run Summary Report

Item	Value
Dependent Variable	Y
Number Ind. Variables	9
Weight Variable	None
R^2	0.1753071
Adj R^2	0.01395408
Coefficient of Variation	0.4705266
Mean Square Error	5684.178
Square Root of MSE	75.39349
Ave Abs Pct Error	44.21139
Completion Status	Normal Completion

DISCUSSION AND EVALUTION

Table 2 in Appendix A represents the annotated computer printout for regression analysis for fitted interaction model. The computer system used is the Number Cruncher Statistical System (NCSS 9,trial version) by Jerry Hintz 2007) (NCSS 9, trial version). The table in Appendix 2 shows the parameter estimates, regression coefficients, Standard Errors,, Standardized coefficients,.T-statistics,probability level and the power of T- test at 5% level of significance. The parameter estimates represent coefficients in the model and almost all the coefficients are significant.

CONCLUSION

In this paper, we analyzed the relationship between the various offences committed by Cadets and the number of Cadets charged and proposed a model that adequately represented the relationship. We employed the factor interactions model for the analysis. Interactions represent the combined effects of variables on the criterion or dependent measure..Under an interaction effect, the impact of on variable depends on the level of the other variables By including interaction the coefficient for that variable shows the effect of that variable when the other variables involved in

the interaction is zero.(Alan Taylor(2007).
We applied the interaction model to our data set. We concluded that the interaction model explains the relationship be the offences committed and cadets charged better than the model without the interaction effects. The parameters were estimated for the data set and were later used for prediction purposes. We used various tests to check for the normality assumption of the errors and results show that the errors are normally and independently distributed, showing that normality assumptions are met
The findings from the model with interaction effects show that it eliminates the problem of multicollinearity.Another feature of.the interaction model is that the combined effect of one variable with another independent variable is clearly manifested.

Definition of Key Variables

a. X_1 = Insubordination
b. X_2 = Absence from Duty
c. X_3 = Malingering and Drunkenness
d. X_4 = Offences in Relation to Property
e. X_5 = Offences in Relation to and by Person in Custody
f. X_6 = Miscellaneous Offences
g. X_7 = Conduct to Prejudice Service Discipline
h. X8 = Civil Offence
i. X_9 = Sexual Offences

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APPENDIX 1. LIST OF OFFENCES AND CADETS CHARGED.

Period(t	Y_t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9
1	200	30	20	8	10	20	10	10	10	10
2	215	18	20	10	6	18	8	0	20	20
3	185	10	40	6	8	20	20	0	10	10
4	300	19	32	9	0	22	22	16	15	0
5	268	22	40	2	9	32	23	18	16	3
6	99	23	60	10	20	40	24	0	18	14

7	85	29	70	18	2	28	28	20	20	20
8	100	10	40	20	8	29	29	0	22	22
9	93	10	50	21	19	40	30	20	18	10
10	70	20	39	8	14	22	42	0	20	10
11	270	4	60	9	0	24	50	2	23	15
12	250	5	29	11	8	40	29	0	41	20
13	186	40	18	9	0	18	40	11	24	20
14	67	10	20	10	3	20	20	0	20	30
15	58	6	5	8	0	22	0	0	18	41
16	89	11	20	20	4	24	3	0	17	20
17	70	18	10	4	0	33	4	0	20	33
18	100	10	18	5	0	41	6	0	29	0
19	72	20	40	20	0	42	0	41	32	40
20	66	4	28	22	9	29	10	0	24	20
21	200	9	32	20	20	40	23	20	28	0
22	205	40	40	9	18	30	21	22	38	22
23	290	18	60	12	14	25	40	0	24	23
24	225	20	43	14	16	40	0	0	29	10
25	285	7	30	20	2	20	6	16	32	20
26	162	20	29	11	9	21	7	0	10	20
27	174	10	16	14	20	22	18	18	6	22
28	120	20	18	22	18	25	18	19	19	23
29	90	15	30	9	12	32	19	0	9	24
30	86	16	8	9	14	40	24	0	10	28
31	90	20	20	22	18	44	29	9	11	29
32	182	20	16	28	20	32	10	10	2	14
33	133	30	18	20	10	40	1	0	4	20
34	148	50	30	13	12	32	0	20	3	22
35	277	52	40	18	14	32	3	10	5	28
36	320	40	70	19	0	40	41	0	20	29
37	185	20	2	22	3	21	9	20	4	10
38	120	6	19	12	4	23	0	16	3	22
39	91	9	20	15	11	22	1	19	4	20
40	280	29	34	24	17	28	10	20	8	23
41	75	32	32	9	18	33	11	14	9	24
42	82	19	35	10	1	48	13	5	20	28
43	96	28	10	20	0	44	19	6	20	29
44	200	40	10	28	3	20	20	10	25	40
45	128	30	18	23	4	26	0	20	28	30
46	230	20	10	15	3	2	4	30	18	0
47	200	55	16	20	8	40	5	0	10	24
48	270	40	9	20	0	43	0	10	40	29
49	250	18	20	20	20	9	20	8	0	20
50	280	19	32	20	4	24	22	20	4	42

51	220	22	10	20	19	26	25	22	9	10
52	140	30	18	32	20	27	0	14	20	20
53	130	28	6	29	22	29	9	15	0	22
54	99	20	9	18	4	40	10	0	4	23
55	98	22	10	22	30	45	14	7	20	14
56	69	49	20	29	0	29	18	122	22	15

APPENDIX 2. Regression Coefficients T-Tests

Independent Variable	Regression Coefficient b(i)	Standard Error Sb(i)	Standard-ized Coefficient	T-Statistic to Test H0: β(i)=0	Prob Level	Reject H0 at 5%?	Power of Test at 5%
Intercept	757.8516	658.0529	0	1.151658	0.4552025	No	0.07976279
X_8	-12.00603	10.97918	-1.302648	-1.093527	0.4715783	No	0.07709175
X_9	19.3471	27.02899	1.143913	0.7157906	0.604503	No	0.06223184
X_1	-31.40565	11.95389	-4.34078	-2.627234	0.2315361	No	0.1634794
X_2	-17.79439	9.82459	-3.173557	-1.81121	0.3211538	No	0.1147453
X_3	58.02723	40.08559	4.471426	1.447584	0.3848552	No	0.09456588
X_4	-40.0195	22.52031	-3.687622	-1.77704	0.3263101	No	0.1127834
X5	10.1655	5.729124	1.403913	1.774356	0.3267217	No	0.1126297
X_6	78.26857	14.81389	8.341578	5.283459	0.1190843	No	0.321518
X_7	16.83606	21.24386	1.879474	0.7925143	0.5733631	No	0.064858
X_8*X_8	-0.1212051	0.09725733	-0.5546705	-1.246231	0.4304914	No	0.08428863
X_8*X_9	-4.264334	0.987256	-5.750127	-4.31938	0.1448351	No	0.2653111
X_8*X_1	2.133954	0.6085341	8.974289	3.506712	0.1768491	No	0.2167935
X_8X_2	-0.4339265	0.1986796	-1.997677	-2.184052	0.2733485	No	0.1367001
X_8*X_3	-3.648748	0.8844267	-9.200487	-4.125552	0.1513915	No	0.2538256
X_8*X4	0.5202839	0.338576	2.097353	1.536683	0.3672684	No	0.09934656
X_8*X_5	0.8339459	0.2041264	2.713756	4.085438	0.1528219	No	0.2514414
X_8*X_6	1.197822	0.5342312	3.609121	2.242142	0.2670774	No	0.1401841
X_8*X_7	0.7178974	0.3144989	2.398409	2.28267	0.2628603	No	0.1426213
X_9*X_9	4.678154	2.157518	4.298558	2.168304	0.2750964	No	0.1357577
X_9*X_1	1.206033	0.4339073	2.113473	2.779473	0.2198638	No	0.1727316
X_9*X_2	-2.902351	0.4659001	-8.041658	-6.229556	0.101329	No	0.3749921
X_9*X_3	-1.744235	0.5297186	-1.964713	-3.292758	0.1877041	No	0.2038772
X_9*X_4	0.9259178	0.6323484	1.886033	1.464253	0.3814535	No	0.09545055
X_9*X_5	0.7856955	0.5908929	1.291231	1.329675	0.4105054	No	0.08845004
X_9*X_6	-0.7677004	0.9886187	-0.6344161	-0.7765384	0.5796587	No	0.06429317
X_9*X_7	3.211989	1.142004	4.00037	2.812589	0.2174728	No	0.1747447
X_1*X_1	-0.05827167	0.1443685	-0.4539392	-0.4036314	0.7557717	No	0.05400137
X_1*X_2	0.4457766	0.279771	2.68958	1.593362	0.3568059	No	0.1024499
X_1*X_3	2.237918	0.421106	7.671027	5.314381	0.1184073	No	0.3232935
X_1*X_4	-1.345189	0.4754178	-6.79796	-2.829488	0.2162718	No	0.1757719
X_1*X_5	0.4278113	0.1273295	1.642372	3.359877	0.184162	No	0.2079345
X_1*X_6	0.06104328	0.1737866	0.1861084	0.3512543	0.784955	No	0.05304024
X_1*X_7	-1.526315	0.3605172	-5.745862	-4.233682	0.1476639	No	0.26024
X_2*X_2	0.04671789	0.2382651	0.5911996	0.1960753	0.8767383	No	0.0509541
X_2*X_3	0.2831562	0.2043726	0.8816818	1.38549	0.3980054	No	0.09131293
X_2*X_4	0.1229135	0.1725227	0.7909652	0.7124487	0.605912	No	0.0621225
X_2*X_5	0.474629	0.3021661	3.638073	1.570755	0.3609147	No	0.1012067
X_2*X_6	0.265317	0.2671655	1.019861	0.9930813	0.50221	No	0.07269548
X_2*X_7	0.4557751	0.3231436	2.216536	1.410441	0.3926285	No	0.0926118
X_3*X_3	-0.3809835	0.3765447	-0.9941844	-1.011788	0.4962698	No	0.07349211
X_3*X_4	0.9525595	0.5225749	2.704041	1.822819	0.3194357	No	0.1154143
X_3*X_5	-0.544456	0.4138624	-1.211119	-1.315548	0.4137766	No	0.087735217
X_3*X_6	-4.311178	0.9147472	-9.408371	-4.712972	0.1331042	No	0.2884503
X_3*X_7	-0.5126145	0.3723943	-1.179845	-1.376537	0.3999659	No	0.09084968

X_4*X_4	0.2856572	0.3663198	1.685024	0.7798029	0.5783644	No	0.06440783
X_4*X_5	-0.2733197	0.1219258	-1.195197	-2.241688	0.2671254	No	0.1401569
X_4*X_6	-0.7056226	0.6408073	-2.476379	-1.101146	0.4693776	No	0.07743677
X_4*X_7	0.977725	0.3534533	4.234068	2.766207	0.2208358	No	0.1719252
X_5*X_5	-0.1687766	0.1685532	-0.9795105	-1.001325	0.4995784	No	0.07304526
X_4*X_6	0.1579895	0.2377519	0.3108284	0.6645139	0.6266156	No	0.06060191
X_4*X_7	-1.559868	0.3384412	-5.404259	-4.608979	0.1360178	No	0.2823613
X_6*X_6	-1.341818	0.3927729	-4.125247	-3.41627	0.1812849	No	0.2113397
X_6*X_7	1.020513	0.3667063	2.771856	2.782915	0.2196129	No	0.1729409
X_7*X_7	-0.8982974	0.3485434	-3.871997	-2.57729	0.2356275	No	0.1604464