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UTILITY OF REGRESSİON BASED RESEARCH IN SCHOOL İMPROVEMENT

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Results from regression based studies on determinants of academic achievement provide the knowledge base forschool improvement efforts. This stıdy demonstrates that results of these studies may be misleading for policy purposes when multicollinearity exists among explanatory variables. Although a large portion of the variance in student achievement is explained by socioeconomic status variables, organizational variables and student characteristics and student attitudes explain a considerable amount of the variation if appropriate measures are taken for controlling multicollinearity.

The purpose of this study is to examine the utility of regression based research findings on determinants of academic achievement for policy purposes in the area of school improvement. The empirical research is designed to compare results of analyses from an oblique versus an orthogonal model by using data from 1,056 public schools in Pennsylvania. Effect of multicollinearity on relative effect size of explanatory variables and its implications for policy purposes are discussed.

Early research on determinants of academic achievement generally concluded that demographic variables such as family background and socioeconomic status (SES) are much more pov^rful than school inputs in determining achievement outcomes. (Burkhead, Fox & Holland, 1967; Jenks, Srnith, Acland, Bane, Cohen, Gintis, Heyns & Michelson, 1972; Moynihan & Mosteller, 1972). These studies contained serious conceptual and methodological flavvs, as Cronbach (1976) concluded:

> The majority of studies of educational effects -\vhether classroom experiments, or evaluations of programs, oı surveys- have collected and analyzed data in ways that they conceal more than they reveal. The estabHshed methods have generated false conclusions in many studies. (p.l)

As noted by Ferguson (1990), the conventional vvisdom that measurable school characteristics must play an important role in determining student achievement is stili largely intact. Ferguson notes that "the idea that they might be unimportant is simply too counter-inmitive" (p.4). .Hovvever, the primary importance of family background variables in explaining sources of variation in academic achievement has not been rejected by empirical evidence.

Literatüre on determinants of student achievement does not subscribe to a single hst of determinants of academic achievement. Although existing literatüre offer a range of process variables and organizational variables related to student achievement (Averch, et al., 1974; Levine & Lezotte, 1990; Purkey & Smith, 1985), these variables at the school level for policy purposes may be grouped around: socioeconomic status and home environment; organizational and personnel characteristics; and school related student characteristics and attitudes.

Hovvever, findings related to organizational characteristics, student characteristics, and resource inputs have been inconsistent (Bernstein, 1990; Bernauer, 1991; Ferguson, 1990; Friedkin & Necochea, 1988; Hanushek, 1989; Levine & Lezotte, 1990; Rutter, Maughan, Mortimore & Ouston, 1979; Seymour, 1971; Silberman, 1970; Stedman 1987).

The student background and family based explanations of determinants of student achievement offer educators and policy makers very little help in crafting educational policies and practices aimed at improving educational quahty. Presumably povverful variables such as family background and SES are nearly immune to manipulation by policy makers. On the other hand, those other variables which might be subject to control by policy makers are often identified as relatively insignificant

A cross examination of studies vvith different research models and statistical techniques suggests that various explanations of determinants of student achievement may be attributed to the researcher's choice of variables vvhich in most cases consists of a narrow set of factors. Hovvever, even if a greater range of variables is being examined, commonly employed variance portioning or regression techniques may not generate very conclusive findings as long as the problem of multicollinearity is not adequately addressed. Since, most regression models reach the maximum level of variance explained after 4 or 5 variables are entered into the equation (Koeske, 1990) becaııse of multicollinearity, large numbers of variables are expected to generate unreliable results (Teddlie & Stringfield, 1993).

Multicollinearity: The tenn multicollinearity refers to high intercorrelations among predictor variables in a regression model (Madaus, et.al., 1980). Although large correlation coefficients betvveen independent variables indicates multicollinearity, it may exist even if correlation coefficients are not very high. Therefore, it is suggested that tolerance of the independent variables should be examined to detect multicollinearity. In addition to examining bivariate correlation coefficients, Berry and Feldman (1990) suggest that a test for multicollinearity should be perfonned by regressing each independent variable in the regression model on ali other independent variables. If this test produces an R^2 close to 1.00, this indicates the presence of high multicollinearity.

Tlıere are no clear guidelines to determine what constitutes high multicollinearity. Berry and Feldman (1990) note that, in general, a bivariate correlation value över 0.70 among independent variables may be considered as high multicollinearity. Hovvever, if the purpose of the research is explanatory rather than being predictive, a lower degree of relationship betueen independent variables can pose a serious problem in estimating reliable regression coefficients. Consequently, interpretation of effects may be misleading (Pedhazur, 1982). A regression equation with high multicollinearity among independent variables can be very parsimonious and can produce a high R^2 value, but can provide little informätion about relative effect of each independent variable.

Although there is not an ultimate solution about dealing vvith multicollinearity in regression analysis, there have been several methods suggested in literatüre. These include (a) collecting additional data, (b) increasing sample size, (c) combining two or more variables into one composite variable by using methods of principal component analysis or factor analysiş, (d) centering values around the mean and, (e) deleting one of the independent variables which exhibits high multicolHnearity (Bryk and Raudenbush, 1992; Feldman & Berry, 1990; Pedhazur, 1982). Hovvever, none of these proposed remedies for multicollinearity is free of some other problems. In most cases it is not feasible to collect additional information or increase sample size. The most cornmon approach to deal **Vvith** multicollinearity has been to examine the degree of dependence among independent variables by using zero-order correlations. Hovvever, as noted by Pedhazur (1982), "inspection of the zero-order correlations is not sufficient to reveal the potential usefülness of variables when they are used simultaneously to predict or explain a dependent variable" (p. 104). Deleting one or more variables on the basis of multicollinearity may alsb result in model misspecification (Feldman & Berry, 1990).

Obtaining composite variables by using factor analysis can be done if these variables are measuring conceptually similar characteristics and conceptually can form a meaningful factor. Composite variables may be detrimental to utilization of research findings for policy purposes (Pedhazur, 1982) as it hinders the ability of researcher to make inferences about effect of specific variables vvhich may provide policy implications.

Multicollinearity has several disturbing implications in regression analysis and variance portioning. First of ali, when multicollinearity exists, the statistical model produces high Standard errors for highly correlated variables in the model (Pedhazur, 1982). Therefore, multicollinearity affects the magnimde of t values and, thus, significance of t values. Second, the variances of the predictors are inflated. Any change in the patterns of correlations betvveen independent variables may cause majör fluctuations in coefficient magnimdes. Furthermore, when large number of variables are used in data analysis, it becomes very difficult to interpret the unique effects or the importance of each predictive variable (Madaus, et al., 1980; Pedhazur, 1982).

Methodology

Data: Data for this study are obtained from the Pennsylvania Educational Policy Studies (PEPS) individual level database files. Units of analysis are 1,056 out of 1837 public elementary schools in Pennsylvania. Incomplete data for 781 schools resulted in exclusion of these schools from statistical analysis. The outcome measures are school mean of fifth grade reading and mathematics scores as measured by the Test of Essential Learning Skills (TELS). TELS is a criterion referenced test designed to diagnose "reading and mathematics problems early in a studenfs school career" (PDE, 1989, p.l). Students scoring belovv the cut-off point are placed in remedial programs. Descriptive s*atistics and the KR-20, or Kuder Richardson reliabihty estimates are given in Table 1 both for reading (.92) and mathematics (.92) indicate that the TELS is an internally consistent instrument.

Table 1. Descriptive Results for 1989 Fifth Grade TELS Scores

Subject	Items	NofStud.	Mean	St. Dev.	S.E.M.	KR-20
Reading	59	107,250	44.9	10.20	2.88	.92
Math.	65	107,244	51.4	10.32	2.92	.92

Figüre 1. Factors by variables loaded to each factor

Factors	Variables	Labels
Student attitudes and school related student characteristics		
SF1 *Student attitude factor*	MSPREAD5	Kind of reader
	MHOVVFAR5	How far expect to go in school
	MSPMATH5	Attitude toward math
	MTRFFUN5	Time read for fun alone
	MAMATH5	Like math in school
	MHHVVK5	Time on homevvork
SF2 *Student disadvantage factor*	PCHP1MT5	Percent in Chapter I math
	PCHP1RD5	Percent in Chapter I reading
	MTV5	Time watching TV
	PSPED	Percent in special ed. programs
Student attitudes and school related student characteristics		
HF1 *Socioeconomic status factor*	MNBOOKS5	Number of books at home
	PCTLLNC	Percent low-income
	MNMAGZ5	Number of magazines get regularly
	PNWHtTE5	Percent non-white
	PPRSCHL5	Percent attented preschool
HF2 *Home-motJvation and encouragement factor*	MSPTALK5	Times parents talk about school
	MPGDJOB5	Times parents praise good job
	MHENCR5	Number of times encouraged at home
	PKNGTN5	Percent attented kindergarten
Personel Characteristics		
PF1 *Personnel salary and education factor*	TCH9SAL	Teachers' salary
	TCH9LEV	Teachers' education level
	COR9SAL	Coordinators' salary
	ADM9SAL	Administrators' salaıy
	COR9LEV	Coordinators' education level
	ADM9LEV	Administrators' education level
PF2 *Teachers' experience factor*	TCH9USRV	Teachers' years of exp. in same unit
	TCH9SRV	Teachers' total years of expeıience
PF3 *Support staffs' experience factor*	COR9SRV	Coordinators' total years of service
	COR9USRV	Coordinators' years of exp in unit
PF4 *Administrators' experience factor*	ADM9SRV	Administrators' years of service
	ADM9USRV	Administrators' years of exp in unit
Organizational characteristics		
OFİ *Unit size factor*	ENROLL	School enrollment
	TCHADMRT	Teacher/administrator ratio
OF2 *Teacher-student interaction factor*	MTREHVVK5	Times teacher talks about homevvork
	MTTENCR5	Times teacher encourage students
OF3 *Teachers' work load factor*	PTRATIO	Pupil/teacher ratio
	TCHCORRT	Teacher/coordinator ratio

Initial list of independent variables include thirty-seven variables. These variables are conceptuahzed into four categories: (1) socioeconomic status and home motivation; (2) school-related student characteristics and student attitudes; organizational characteristics; and personnel characteristics. An obiquely rotated factor analysis is performed to reduce the number of predictors to a manageable size for each of the four variable groups. Factor loadings are determined based on four criteria: an eigenvalue = 1.00, meaningfulness, interpretability, and a scree test (Rummel, 1975). Factor scores obtained from an oblique solution are correlated among themselves. Since factor scores are used as predictors of the outcome measures, multicollinearity among independent variables pose a problem in assessing the relative effect of each factor.

Because there are four non-achievement variable groups, performing a separate varimax rotated factor analysis for each data set ensures linear independency among factors extracted from each variable set. Hovvever, factors extracted from each variable set can exhibit some degree of linear relationship vvith the factors extracted from other variable sets. In order to ensure orthogonality among ali predictor factors, the oblique factor scores from previous factor analysis are varimax rotated in a subsequent factor analysis[1]. The orthogonal solution allovvs controlling for multicollinearity (Rummel, 1975).

Oblique factor scores are used as predictors of the fifth grade mean TELS scores in reading and mathematics in a simultaneous regression model. It is difficult to assess the relative effect of each factor in this model, since oblique factor scores are correlated among themselves (Rummel, 1975). As noted by Rummel (9175), "orthogonality restriction ensures that factors will delineate statistically independent variation" (p. 385). Since the "orthogonal factors are linearly independent and uncorrelated, a correlation matrix of factors vvill be an identity matrix" (Rummel, 1975, p. 386) whose diagonal elements are 1.00 and off diagonal elements are 0.00. VVhen orthogonal factors are used as independent variables, unique effects of each factor on outcome measures can be assessed.

Analyses of Fifth Grade Reading and Fifth Grade Mathematics

Zero-order correlations of the obliquely-rotated factors presented in Table 1 suggest that there is some level of multicollinearity among predictor factors. The existence of multicollinearity is particularly evident among student attitude factor (SFO1), student disadvantage factor (SF02), socioeconomic status factor (HFO1), and home motivation and encouragement factor (HF02).

Fifth Grade Reading: The results reported in Table 2 indicate that 80% of the variance observed in fifth grade reading achievement is explained by explanatory factors. In the oblique model, a large proportion of observed variance is explained by home-related factors. In addition to home-related factors, only tvvo other factors are significantly ($p < .01$) related to fifth grade reading in the

[1] Personal communication vvith Charles Teddlie, University of Louisiana State Urüversity, Baton Rouge, LA, on April 12,1994.

Table 2. Correlations for Oblique Factors

	MREAD5	MMATH5	MREAD3	MMATH3	SFOl	SF02	HFOl
MREAD5	1.00						
MMATH5	88**	1.00					
KREAD3	90**	.81**	1.00				
MMA.TH3	79**	.78**	.87**	1.00			
SF01	21**	.23**	.15**	.13**	1.00		
SF02	68**	-.61**	-.68**	-.63**	.32**	1.00	
HFOl	- 64**	.52**	.65**	.54**	-.04	-.64 **	1.00

	HF02	PFOl	PF02	PF03	PF04	OFOl	OF02	OF03 -
HF02	1.00							
PFOl	-.13**	1.00						
PF02	.13**	.02	1.00					
PF03	.03	-.16	-.05	1.00				
PF04	.03	-.16**	-.13**	-.04	1.00			
OFOl	.05	.15**	-.13**	-.03	.05	1.00		
OF02	- 49**	-.08*	-.01	-.01	.02	.01	1.00	
OF03	.07*	-.23**	.12**	-.04	-.07*	.18**	.02	1.00

* - Signif. LE .05 / ** - Signıf. LE .01

Table 3. Regression Analysis for Fifth Grade Reading

Cfc>lique Factors			Orthogonal Factors		
Var	B	B(Bda)	Var	B	B(fleta)
PFOl	-.578**	-.111	PF1	-1.006**	-.188
HPOl	3.143**	.658	HF1	2.911**	.546
RFD2	2.421**	.507	HF2	1.514**	.284
SF02	-1.640**	-.325	SF2	-2.839**	-.532
SFD1	.163	.032	SF1	1.167**	.219
PP02	.009	.001	PF2	.645**	.121
PP03	-.048	-.009	PF3	.278**	.052
PF04	-.087	-.016	PF4	-.178*	-.033
OFOl	-.197*	-.037	OFİ	-.819	-.153
OF02	.073	.011	OF2	-.070	-.013
OF03	.172*	.032	OF3	.571**	.107
CONST	44.362**		CONST	15.562**	
Mıltiple R		.89461	Mıltiple R		.89461
R Squaxe		.80032	R Square		.80032
Adjusted R Sq		.79822	Adjusted R Sq.		.79822
Standard Error		2.39400	Standard Error		2.39400

* - Signif. LE .05 / ** - Signif. LE .01

oblique model: personnel salary and education factor (PFOl) and student disadvantage factor (SF02). Although these tvvo factors exhibit significant relationships vvith fifth grade reading achievement, the magnitude of B (Beta) coefficients is relatively small compared to size of the B coefficients for home related factors. Remaining eight factors contribute very little or none at ali tovvard explaining observed variance in school mean of the fifth grade reading scores.

Magnitudes of 13 coefficients for the socioeconomic status factor and home motivation and encouragement factor are infiated in the oblique model. These tvvo explanatory factors exhibit a suppressor effect on ali remaining factors. Reductions are observed in both standardized (13) and unstandardized regression (B) coefficients for nine explanatory factors. Tlıese reductions are particularly large for student attitude (SFOl), student disadvantage (SF02), teachers' experience (PF02), unit size (OFOl), and personnel salary and education factors (PFOl).

Effects of personnel factors, organizational factors and student-related factors are underestimafed in the oblique model. Although, home-related factors remain significantly related to reading achievement and explain a large portion of observed variance in the orthogonal model, a number of other factors such as student attitude, student disadvantage, and teacher-student interaction factors also make relatively large contributions toward explaining observed variance in reading achievement.

Fifth Grade Mathematics: Explanatory factors show different effects on fifth grade mathematics achievement in the oblique and orthogonal models. There is a clear indication of infiated effects on mathematics achievement in the oblique model for the socioeconomic status factor and home motivation and encouragement factor. Although the magnitude of 13 coefficients are relatively small compared to B's for home-related factors, teacher-student interaction factor and support staff s experience factor exhibit a larger relative effect size on fifth

Table 4. Regression Analysis for Fifth Grade Mathematics

Oblique Factors			Orthogonal Factors		
Var	B	İS (Bek)	Var	B	fi (Bek)
OFOl	-.340"	-.059	OFİ	-.995**	-.170
OF02	.648**'.	.111	OF2	.544**	.093
PFOl	-.858**	-.151	PF1	-1.288**	-.220
PF03	-.291**	-.050	PF3	.061	.011
SFOl	.677**	. 123	SF1	1.412	.241
SP02	-2.112	-.382	SF2	-2.943**	-.504
HFOl	2.522**	.482	HFİ	2.550**	.482
HF02	1.980**	.378	HF2	1.506**	.258
PF02	.168	.029	PF2	.829**	.142
PF04	-.173	-.030	PF4	-.231*	-.039
0F03	.167	.029	OF3	.605**	.103
CONST	51.038**		CONST	51.038**	
Mıltiple R		.82928	Mıltiple R		.82928
R Sguare		.68770	R Sguare		.68770
Adjusted R Square		.68441	TAdjusted R Sq		.68441
Standard Error		3.28300	Standard Error		3.28300

* - Signif. LE .05 / ** - Signif. LE .01

grade mathematics achievement in the oblique model than in the orthogonal model. The support staffs experience factor (PF03) has a significant (p = .004) negative relationship vvith fifth grade mathematics achievement in the oblique model, but it has a positive nonsignificant (p = .54) relationship in the orthogonal model.

Ali remaining seven predictors in the regression analyses of fifth grade mathematics have smaller relative effect size on mathematics achievement in the oblique model than in the orthogonal model. The teachers' vvork load factor is not significantly related to outcome measure in the oblique model, vdıile it exhibits a significant relationship in the orthogonal model. The unit size factor also has a relatively small Beta coefficient in the oblique model compared to its relative effect in the orthogonal model. There are dramatic changes in 13 coefficients for the teachers' experience factor and personnel salary and education factor betvveen the oblique and orthogonal models.

Both the student attitude and student disadvantage factors are significantiy (p < .01) related to mathematics achievement in the orthogonal and oblique models. The student disadvantage factor has a dramatically lower ß value (13_{s}F02 = -.38) compared to it Beta value (flsre - 50) in the orthogonal model. The Beta coefficient for student attitude factor ($f3_{SFO}1$ = .12) in the oblique model is only half of the size of the Beta coefficient in the orthogonal model (13_{SF1} = .24).

In the oblique model, home-related factors (HFOl and HF02) seem to have infiated relative effects on the outcome measure, vvhile student-related factors (SFOl and SF02) exhibit relatively small effect size. This is particularly evident when the magnitude of f3 coefficients are examined in relation to magnitude of zero-order correlations for home-related factors and student-related factor. Although, the student disadvantage factor (HF02) has the highest zero-order correlation vvith fifth grade mathematics, the results of regression analysis suggests that home-related factors explain a larger proportion of the observed variance in mathematics achievement. These results are affected primarily by interrelationship betvveen home-related factors and student attitude factors. The student attitude factor (SFOl) exhibit a high correlation (r = .61; p < .01) vvith home motivation and encouragement factor (HF02). The student disadvantage factor (SF02) also has a significant high correlation (r = -.64; p < .01) vvith socioeconomic status factor (HFOl).

Table 5. Percentage of Variance Explained by Each Group of Factors in Total Explained Variance in the Orthogonal Model

Factors	Fifth Grade Reading (%)	Fitti Grade Mathematics (%)
Home-related	47.33	37.32
Organizational	4.37	7.00
Personnel-related	6.73	10.21
Student-related	41.35	45.39

The home related factors, socioeconomic status factor and home motivation and encouragement factor explained about 47% of the total variance explained in reading achievement, while explained variance attributed to these two factors in mathematics achievement was about 37%. Organizational factors, personnel-related factors, and student related factors explained a larger portion of variance in mathematics achievement than in reading achievement.

This finding is particularly important to highlight as it suggests that school-related and student-related variables play an important role in determining level of mathematics achievement. Most school and student-related variables can be manipulated through various intervention strategies, vvhile socioeconomic status variables can not be controlled and manipulated in school improvement efforts.

Discussion and Conclusions

A comparison of the regression results vvith oblique versus orthogonal factors clearly illustrate that results obtained from the analysis vvith oblique factors can be misleading for policy purposes. It should also be noted that if the purpose of analysis is prediction rather than pursuing for explanations for the variation in the outcome measure, multicollinearity vvould not be an important issue. Hovvever, results of studies on student achievement are very often used for policy purposes as explanations of the variance in achievement outcomes. Results of these tvvo different models lead to totally different policy implications and conclusions. Results of the oblique model echoe vvith results from most previous research findings as it indicates that a large portion of variance in fifth grade reading and mathematics scores is attributed to SES factors and very little is explained by ali remaining factors in the regression equation. Hovvever, this finding is contradicted by the results of orthogonal model vvhere some personnel related, organizational, and student related factors also show significant relationships vvith academic achievement. The orthogonal model indicates that variables other than socioeconomic status and family background may also play significant role in explaining the sources of variation in academic achievement. It is important to note that some these factors such as home motivation and encouragement factor, student attitudes and school related student characteristics factor, and teachers' experience factor are positively related to both mathematics and reading achievement. Contrary to previous findings, this study indicates that even vvhen the socioeconomic status factor is included in the regression equation, home motivation and encouragement factor, student attitudes ana school related student characteristics factor, and teachers' experience factor explaine 18% of the total explained variance in fifth grade reading and 21% of the total explained variance in fifth grade mathematics.

Since these three factors can be manipulated by schools, this study suggests that schools could use various intervention strategies to improve student achievement. For example, because positive student attitudes are related to improvement of student achievement, schools could design intervention strategies to develop and enhance positive student attitudes tovvard school and subjects. Although home motivation and encouragement variables are home related variables, schools can also design and implement programs to help parents provide appropriate encouragement and motivation at home for studenf s school work (see Seymour, 1971; Silberman, 1970; Stedman, 1987).

This study demonstrates that the student disadvantage factor, unit size factor, and personnel education level and salary factors also contributed significantly tovvard explaining observed variance in achievement scores. Hovvever, these factors were negatively related to student achievement. The negative relationship betvveen student disadvantage factor and student achievement suggests that schools vvith a larger percentage of their students in remedial programs and special education programs are in need of fıırther assistance for improving the level of student achievement. The intervention strategies and programs to improve student achievement may require additional resources and schools should consider strategies that can be implemented by utilization of available resources.

Evidence provided by this study and many others indicates that having teachers vvith higher levels of education and providing higlıer levels of salaries for teachers in a particular school does not necessarily translate into higher achievement scores. VVhat matters more than level of education and salary is the teachers' attitudes, expectations, knovvledge and skills about the subject matter being taught (Clark, 1980).

As noted by Pedhazur (1980), a causal model is only as good as its underlying theory. If there are substantial questions about the validity of underlying theory, then, dravving policy implications from research findings vvith an assumption of causalıty vvould be inappropriate. The relationships betvveen factors being examined in tlıis study and smdent achievement measures are primarify associations. The nature of these relationships should be examined vvithin the local context. The type of analysis used in tlıis study describes the degrees of associations betvveen variables, but it does not lend itself for ansvvering the question of why and lıow these variables affect smdent aclıievement. In other words, it can not explain the processes in vvhich teaching-learning activities take place.

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