Alternative Approaches for Estimating Educational Production Functions in Rural and Urban Areas*

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Public elementary and secondary education represents the largest single expenditure by units of state and local governments. Nearly 30 percent of all tax dollars raised at the state and local level is spent for the funding of public elementary and secondary schools. The magnitude of expenditures for public education relative to other public goods makes questions of resource allocation for the service extremely important. It is not surprising that a great deal of attention has been directed toward determining if the educational process can be made more efficient.

Politicians, school administrators and other decision makers who deal with school finance problems in rural and urban areas face a key policy question dealing with the internal efficiency of the educational production process: *"Does the spending of additional tax dollars in local public schools necessarily ensure an improved education for all students?"*

During the past 5 years, this author has conducted two studies which focused on this issue. The first study (Debertin, 1970) was undertaken in North Dakota, a sparsely populated state. The second study (Debertin, 1973) was conducted in Indiana, a state that encompasses a

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number of densely populated urban areas. Major differences exist in the public educational systems between the two states. At the time the North Dakota study was conducted, there had been minimal consolidation of school plants nor reorganization of administrative units. A comprehensive program of administrative reorganization and consolidation of school plants was virtually complete at the time the Indiana study was undertaken. The key public concern in North Dakota was whether or not consolidation and reorganization would lead to a "better" education for students. Indiana residents were rather concerned with the impacts of additional spending within the existing institutional structure. The analysis herein examines interrelationships between educational inputs (alternative uses for tax dollars with a school) and educational outputs (standardized test scores and other measures). Policy recommendations stemming from results of studies conducted in both states are presented.

Relationships Between Educational Inputs and Outputs

To determine the possible effect on the student of alternative uses of tax dollars for the purchase of school inputs, educational "production functions" were estimated in both studies. Both studies envisioned a public school system as a firm using inputs to produce an (perhaps multidimensional) output. School inputs considered in the studies included changes in salary levels, pupil/teacher ratios, the proportion of teachers holding graduate degrees and other measures. While the study conducted in Indiana employed substantially different data and methodology than did the North Dakota study, similar conclusions with respect to the impact of school inputs on alternative measures of outputs were reached in both studies.[1]

The North Dakota Study

Output measures in the North Dakota study consisted of standardized test scores in the nine tests comprising the Iowa Tests of Educational Development (the ITED bank) from scores of high school juniors in 207 North Dakota school districts. Measures of school inputs included average instructional cost per pupil, total enrollment, average salary of teachers, pupil/teacher ratios, accreditation, and courses offered at the secondary level. The school district was the unit of observation in the North Dakota study. Nearly all North Dakota school districts contain only one high school and one elementary school, or a single combined high school and elementary plant. Extreme variation in the size of high schools existed in North Dakota at the time the study was conducted--one high school was operating with a total enrollment of only 16 students, while a number of high schools in the larger cities had several thousand students. There was and continues to be a great deal of public concern in North Dakota as to the possible detrimental effects of the extremely small high school on the education of students.

Table 1 summarizes the impact of school input variables on standardized scores for the nine subject matter areas covered by ITED test bank. Variation explained by school inputs constituted an extremely small proportion of total variation in the ITED scores. Figure 1 illustrates the

Table 1. Coefficients of Determination for Nine ITED Test Scores Regressed Against Nine Selected School Inputs, North Dakota, 1968-69[a]

ITED Test	R^2
1. Social Studies Background	.055
2. Natural Sciences Background	.059
3. Correctness of Expression	.046
4. Quantitative Thinking	.025
5. Reading in Social Sciences	.028
6. Reading in Natural Sciences	.069
7. Reading in Literature	.023
8. General Vocabulary	.067
9. Use of Sources of Information	.091

[a]Source: Debertin (1970)

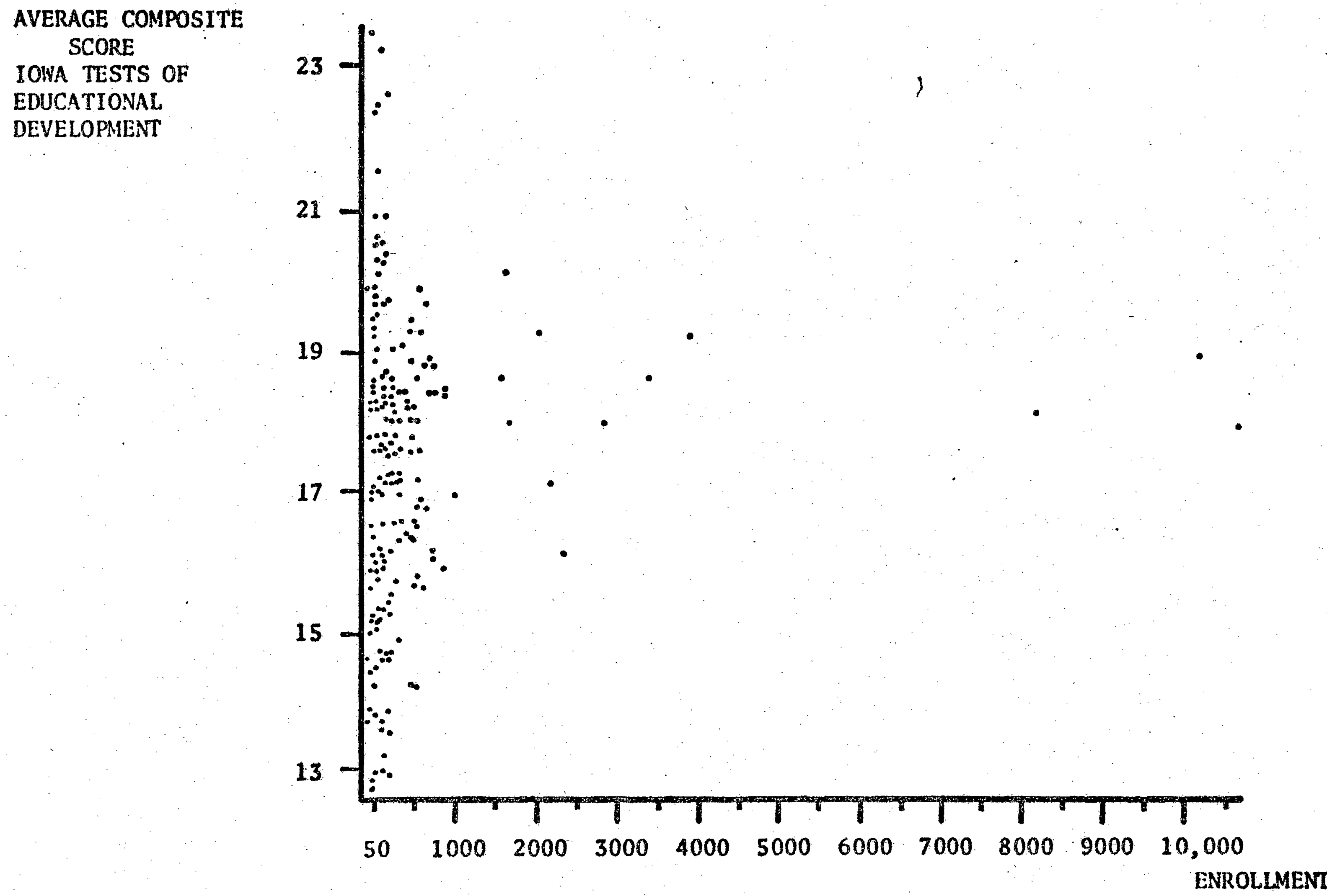

Figure 1. Relationship Between Total Enrollment and Average Composite Scores on the Iowa Tests of Educational Development, 207 School Districts, North Dakota, 1968-69

relationship between total enrollment of North Dakota schools and composite scores on the ITED test bank. There was a wide variation in composite scores among schools with small total enrollments and a number of small school produced classes of students with relatively high composite ITED scores. As enrollment increases, the number of students taking the ITED test bank also increases and the variance in ITED scores about the mean is reduced. Hence, Figure 1 does not provide empirical evidence to support the position that schools in North Dakota with the largest enrollments produce students with the highest test scores.

The Indiana Study

Since a standardized testing program is not conducted on a statewide basis in Indiana, global test score data for Indiana were not available. Observations used in the Indiana study consisted of data on an admittedly select group of students, incoming Purdue University freshmen who graduated from Indiana high schools. Outputs consisted of scores on the Scholastic Aptitude Test (SAT), the College Entrance Examination Board test bank (CEEB), and first semester grade point averages. The individual student rather than the school was the unit of observation.

School inputs consisted of highly detailed data on the characteristics of the high school each student attended. For example, data were obtained for salary levels, experience and degree held of science teachers in each high school building in the state. Similar detail was obtained for other subject matter areas such as English and mathematics. Control variables were used as independent variables in the analysis in addition to the school inputs. These included data on family income, the educational level of parents, and rank in the high school graduating class expressed as percentile.

No attempt is made here to present a rigorous justification for the model specification followed in the Indiana study. A rigorous theoretical presentation justifying the empirical approach that was followed can be found in Debertin (1973) or in Debertin and Huie, Secondary Education Impacts, (1974).

The initial sample of 2652 students was randomly divided into two sub-samples. The same regression equation was estimated on each sub-sample. A variable was considered significant only if its coefficient was different from zero in both sub-samples. The two step procedure thus minimized the possibility of reporting Type I error.

Data presented in Table 2 illustrate results for a production function using the score on the quantitative SAT exam as the output measure. Similar equations were estimated for the verbal SAT exam, the English, mathematics and chemistry scores of the CEEB exam, and for first semester grade point averages. While in a few instances, coefficients on school inputs in one of the two samples were found to be significantly different from zero, in no instance were any of the coefficients on school inputs found to be significantly different from zero in both samples. Conversely, in many instances, many of the control variables were found to have non-zero coefficients in both samples. Based on these findings it was concluded that (1) measures of school inputs contributed virtually nothing to ex-

Table 2. Exemplary Educational Production Function for Purdue University Freshmen, Fall, 1971[a]

	Sample 1	Sample 2
School Inputs:		
Pupil/Teacher Ratio in the High School	-1.41 (1.49)	3.36 (1.34)
Salary Differential Paid by School for an Advanced Degree	-.009 (.018)	-.041 (.018)
Salary Differential for Experience	-.063 (.076)	-.062 (.068)
Salary of Math Teachers	.010 (.005)	.002 (.005)
Degree of Math Teachers	-9.52 (12.51)	1.98 (14.94)
Experience of Math Teachers	-1.50 (0.96)	0.96 (1.07)
Courses Offered in Math	-0.16 (2.21)	-0.39 (2.17)
Control Variables:		
Rank in High School Graduating Class as a Percentile	79.0 (5.4)	59.3 (5.8)
Education of Parents	0.80 (0.77)	1.55 (0.58)
Family Income	.007 (.003)	-.003 (.003)
Race of Student	-87.2 (24.3)	-58.5 (23.0)
Size of Graduating Class	.003 (.024)	.038 (.026)
Semesters of Math taken while in High School	26.0 (2.1)	21.7 (2.3)
Intercept	217.7	256.7
R^2	.47	.41

[a]Standard errors are in parentheses. Source: Debertin (1973).

plained variation in the output measures, and (2) socioeconomic and other control variables have a substantial impact on the output measures considered in the analysis.

Intercorrelation existed between many of the measures of school inputs and control variables. Since collinearity may have masked the true impact of school inputs, an additional effort was made to determine the maximum amount of variation in the output measures that could be attributed to school inputs. Following a "hierarchial" regression procedure similar to that used by White (1972), all school inputs were forced into the regression equations first. Control variables were subsequently allowed to enter the regression. Table 3 summarizes the results. Values in the column labeled "Variation Explained by School Inputs" are probably overstated since variation in outputs that could be attributed to either school inputs or control variables was arbitrarily assigned to the school inputs. Even so, an extraordinarily small proportion of the variation in output measures could be attributed to school inputs.

To summarize, literature dealing with the empirical estimation of educational production functions has revealed little evidence to support the belief that quantifiable measures of educational outputs can be altered by changing levels of school inputs *as inputs and outputs are now measured.* Findings from two studies dealing with the empirical estimation of educational production functions in two states lead this author to conclude that if the desired objective of a school administrator is to increase standardized test scores or the performance of students upon entering college,

Table 3. Maximum Variation in Educational Achievement Attributable to School Inputs, Indiana, 1970-71

Output	Sample No.	Variation Explained by School Inputs	Additional Variation Explained by Control Variables
Verbal SAT	1	5.3 %	34.5 %
	2	2.4	24.0
Quantitative SAT	1	4.3	43.2
	2	0.8	40.3
English CEEB	1	3.1	38.6
	2	1.7	29.4
Math CEEB	1	6.3	51.2
	2	2.3	52.1
Chemistry CEEB	1	8.1	35.9
	2	3.1	34.3
Freshman GPA	1	4.2	20.3
	2	4.4	17.4

altering levels of school inputs under the control of school administrator will probably not achieve this end. Tweeten, in a recent article, summarized this well when he stated (pg. 48), "Unfortunately, it is becoming increasingly clear that the process by which resources are converted to favorable student outcomes in terms of schooling, achievement and future economic success is not well understood. The fact that achievement scores have not improved in recent decades despite vast increases in funding per student indicates that the productivity of school resources is declining. Numerous analysis of the relationship of specific schooling inputs to achievement reveal no profitable sources of significant gains in efficiency with the current organization of schools."

Policy Implications

The discussion has summarized key findings from this author's studies conducted in two states over a five year period. Policy recommendations which can be made on the basis of the two studies are as follows:

(1) *Evidence does not support the belief that consolidation can be justified on the basis of evidence of increased performance by students on standardized tests.* However, there may be other reasons for pursuing consolidation programs in rural areas. For example, a major benefit of a consolidation program is that a relatively large enrollment makes possible a comprehensive offering of courses in high schools without a low and therefore costly pupil/teacher ratio.

(2) *The spending of additional money for public education cannot be justified on the basis that the increased expenditure will lead to improved performance on standardized tests in either rural or urban areas.* Neither of this author's studies supported this widespread belief. There is justification for the spending of additional money to keep salaries of teachers in line with salaries of other comparatively trained people in the community, and to add programs which have benefits not measurable by standardized test scores.

(3) *Efforts to reduce pupil/teacher ratios, and increase the training, experience, and salaries of teachers have little if any impact on quantitative measures of student performance.* This is true in both sparsely populated rural areas and in urban centers.

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Footnotes

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[1]Other analyses dealing with the empirical estimation of educational production functions have usually found little evidence of a relationship between measures of educational inputs and outputs. The major controversy stems from the so called "Coleman" report, a study conducted in 1966, in which a "disappointingly" weak relationship between educational inputs and outputs was found. More recent literature dealing with the relationship between measures of educational inputs and outputs has included work by Kiesling (1967) and analyses by Mayeske, *et al.* (1970), Mosteller and Moynihan (1972), Jencks (1972), and Bowles (1970). The work by Bowles is an especially fascinating overview of the current state of the conceptual development and empirical estimation of educational production functions. Those interested in educational production function theory will find it to be a useful reference. It should be noted that nearly all the difficulties with the empirical estimation of agricultural production functions employing cross sectional data (i.e., multicollinearity and specification bias) are equally applicable to educational production functions estimated from cross sectional data. (See Debertin, 1973).