DOCUMENT RESUME

ED 071 181 EA 004 771

TITLE Variables Related to Student Performance and Resource Allocation Decisions at the School District Level. A Survey of Research with Emphasis on the Policy Implications of the Findings.
INSTITUTION New York State Education Dept., Albany. Bureau of School Programs Evaluation.
PUB DATE Jun 72
NOTE 130p.

EDRS PRICE MF-$0.65 HC-$6.58
DESCRIPTORS *Cost Effectiveness; *Educational Economics; *Educational Policy; Educational Theories; Models; Multiple Regression Analysis; Productivity; Research Methodology; *Research Reviews (Publications); *Resource Allocations; Statistical Analysis
IDENTIFIERS *Economic Efficiency

ABSTRACT

This review was undertaken to organize and present the findings of educational production function research by educators and economists. A summary of these findings could be a valuable aid in the educational decision making process, especially to administrators working in local school districts. Research of this type concentrates on determining empirically the nature of the educational process and the efficiency with which the output of schools, however defined, is produced. The resulting information can suggest strategies for improving education by manipulating policy-controllable variables that have been empirically demonstrated to be related to some desired educational product. Questions of efficient resource allocation involve identifying which variables have the greatest impact on the level of educational product per dollar of expenditure and channeling resources into them. The review shows how major studies have dealt with questions of model specification and parameter estimation for an educational production function. It also describes the production theory and the findings of the studies as to what variables enter the educational production function and examines what is known about the impact of each variable on the production of educational output. (Author)

VARIABLES RELATED TO STUDENT PERFORMANCE AND RESOURCE ALLOCATION DECISIONS AT THE SCHOOL DISTRICT LEVEL

A Survey of Research With Emphasis
on the Policy Implications
of the Findings

The University of the State of New York
THE STATE EDUCATION DEPARTMENT
Bureau of School Programs Evaluation
Albany, New York 12224
June 1972

THE UNIVERSITY OF THE STATE OF NEW YORK

FOREWORD

This review was undertaken to organize and present the findings of educational production function research by educators and economists. A summary of these findings could be a valuable aid in the educational decision-making process, especially to administrators working in local school districts.

Research of this type concentrates on determining empirically the nature of the educational process and the efficiency with which the output of schools, however defined, is produced. The resulting information can suggest strategies for improving education by manipulating policy-controllable variables which have been empirically demonstrated to be related to some desired educational product. Questions of efficient resource allocation involve identifying which variables have the greatest impact on the level of educational product per dollar of expenditure and channeling resources into them.

The language of economics may be strange to many educators. It is not to imply a direct analogy between educational production and industrial production. If we fall into that trap, we will be poorer for it. Rather, economics terminology provides concepts which can illuminate the educational process, just as psychological terminology and sociological terminology have done. As education develops into a discipline in its own right, it will be shaped by the other disciplines which impinge upon it. If the economics of education are neglected in developing a discipline of education, it will be a truncated version of the reality in which schools operate.

The study would not have been possible without the generous support or assistance provided by many individuals of the State Education Department. William D. Firman, formerly Assistant Commissioner for Research and Evaluation, foresaw the need for a report of this type and helped determine the literature

which should be reviewed. Mr. Firman also offered valuable suggestions on the organization of the findings section of the review. Alan G. Robertson, Director of the Division of Evaluation, provided overall support for the project as did David J. Irvine, Chief of the Bureau of School Programs Evaluation, under whose direction the report was developed. Invaluable resource assistance was provided by all members of the Bureau, and especially by Gerald H. Wohlferd, associate in education research.

John J. Heim, an economist attached to the Bureau of School Programs Evaluation, was the author of the report.

Lorne H. Woollatt
Associate Commissioner for
Research and Evaluation

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INTRODUCTION

Since the late 1950's, numerous studies have been undertaken to determine input-output relationships in education. Education has been viewed as an industry which transforms inputs in the form of goods and services into a specific product. The review shows how major studies have dealt with questions of model specification and parameter estimation. It also describes the production theory and the findings of the studies as to what variables enter the educational production function (the formal statement of educational input-output relationships). The review also examines what is known about the impact of each variable on the production of educational output.

Various attempts to determine, in quantitative terms, an appropriate definition of the output of firms (schools or school districts) in the education industry are examined in chapter I. The chapter also considers factors which have been theorized as inputs which affect several definitions of educational output.

In chapter II, specific aspects of the problem of precisely formulating theoretical constructs are reviewed. The choice of linear or curvilinear input-output relationships, use of pretesting and posttesting, use of aggregate indices of inputs and outputs, the question of school and nonschool inputs, the assumption of different production functions for different socioeconomic groups, and the use of a school expenditure figure as a proxy for school inputs are some of the topics considered. Other questions discussed in chapter II include the use of outputs and inputs from different time periods, specification of partial production functions, the use of grouped variables, statistical methods for selecting variables to enter the regressions, the possible existence of a number of different production functions for education, use of production functions for cost comparison, use of only nonschool inputs, and the entry of socioeconomic status inputs into first difference equation production functions.

In chapter III, methods used for estima' ; production function parameters are reviewed. Generally, classic linear regression is the estimation method employed, but some interesting contributions have resulted from application of such simple statistical techniques as correlational analysis. In this chapter, different ways in which linear regression has been applied to the problem of estimating production relationships are also reviewed. They include the use of stepwise regression, variable grouping as a means of overcoming certain technical problems, the effects of interactions of inputs on putputs, the use of regression as a diagnostic tool, and the use of residuals from regression as indicators of the effects of school inputs on oucput.

In chapter IV, major data sources used in educational production function studies are reviewed briefly. It is shown that researchers in this field have relied heavily on the services of two government agencies for their data: The U.S. Office of Education and the New York State Education Department.

In chapter V, the findings related to the components of the educational production function are reviewed. The emphasis is on isolating individual policy or nonpolicy controllable variables, indicating the number of times the variable was tested, and what proportion of the time it was found to be significantly related to measures of student performance. The implications in terms of efficient resource allocation are also discussed.

An attempt is made to indicate the relative impact of various production inputs and, in general, how successful attempts have been at describing the production of educational outputs.

SUMMARY OF FINDINGS

Chapter I findings deal with educational inputs most frequently theorized as affecting student achievement. The variables are of two fairly distinct types: those which are largely or completely insensitive to policy control and those which can be manipulated by school administrators with the goal of improving student performance. The former type includes student socioeconomic status, student I.Q., school or school district size, and student race. The latter type includes teacher degree status and experience, class size, books and other instructional supplies, and numbers of special staff used. It is shown in chapter V that although these variables are commonly theorized as determinants of student performance, not all of them can be empirically verified as such.

The findings of chapters II and III center largely on how certain traditional methodological problems in production analysis are handled in the educational literature. Since most of the findings in this area are of a largely technical nature, they are not summarized individually here; they are discussed in detail in chapters II and III. At a more general level, however, the evidence strongly suggests that the utility of production analysis models depends heavily on how completely they account for the major inputs in the educational process and whether the models are framed in such a way as to permit them to answer policy-relevant questions. Extreme care must be exercised in selecting the statistical techniques to estimate the effects of educational inputs on student performance. Otherwise, policy implications stemming from the results can be ambiguous, defeating the whole purpose of the model building process.

The findings of chapter IV indicate how crucially analysis of production relationships in education depend on the existence of comprehensive and ongoing educational data systems.

Chapter V is devoted to organizing and presenting the findings of the research reviewed. There is a substantial consensus, based on empirical evidence, about the relationships of certain inputs in the educational process to student performance levels. There are also a number of policy-relevant implications about the efficient allocation of educational resources which derive from this evidence. Some of the more important findings follow:

1. It is possible to determine empirically whether variables thought to be related to the level of student development in either the cognitive and noncognitive domain really are related. All the studies reviewed found relationships between input and output measures. There was a remarkably high, though not perfect, consensus as to what inputs are related to differences in student performance.

2. Some of the inputs most consistently found related to the level of student performance are not amenable to policy control by educators. They usually cannot be altered by school authorities attempting to improve student performance. In this category are student socioeconomic status, student IQ, student race, and the extent of a student's previous formal schooling. In general, there was substantial consensus as to the effects of these variables. High socioeconomic status and IQ were both found to be related to high levels of student performance. The larger the percentage of students in a school who were white, the higher was the level of student performance. Student performance levels were found to be higher for students who had previous formal schooling in the areas tested than for those who had not.

3. Another category of educational inputs which influence the level of student performance includes those inputs which can be altered by school authorities. Most important among these are teacher degree status, teacher experience, teacher socioeconomic level, teacher verbal ability, principal and supervisor quality, textbook quality, and ratio of special staff (guidance counselors, social workers, etc.) to pupils. Teacher degree status and teacher socioeconomic level-verbal ability were found related to student performance in both the cognitive and noncognitive (affective) domains. Principal-supervisor quality and textbook quality were found to be related to student performance in the cognitive domain. Teacher experience and number of special staff were examined in both domains, but seem primarily to be associated with student noncognitive skill development.

4. Television teaching and programed learning methods resulted in student achievement levels equal to those obtained when the usual classroom method was used. However, the findings were based on performance of college-level students only. Whether this finding can be generalized [illegible] levels and types of students is not certain.

5. There was a substantial consensus in the literature reviewed that certain variables are not related to variation in student performance. These include current variations in school and school district size, class size, number of supervisors and administrators per pupil, and <u>quantity</u> of textbooks and other instructional supplies used per pupil.

6. For higher achievement levels to be attained, controllable variables which were found to be related to student performance (see point 3 above) must be increased. With the possible exception of teacher socioeconomic status and verbal ability, more extensive use will require greater expenditures. Hence, a strong relationship between cost and quality in education is indicated.

7. Though a relationship between cost and quality exists in education, it is possible for inefficient use of educational resources to obscure it. Investing heavily in resources not related to student performance may result in lower levels of student performance than might otherwise be possible. If so, reallocation of resources could increase school performance without additional expenditure. For example, there is some evidence to suggest that reallocation of resources from the purchase of <u>quantities</u> of teachers, administrators, and supervisors (i.e., the number related to pupils) into the purchase of fewer but more highly qualified personnel would result in improved school district performance. Alternatives to this strategy (in the cognitive skills area) may include replacing, where feasible, the usual instructional arrangement with appropriate technological approaches such as television teaching and programed learning.

8. The available evidence on student body quality strongly suggests that improvements in minority group and low socioeconomic level students' performance can be achieved if there is careful supervision of the way these students are distributed among individual schools. High concentrations of low socioeconomic level students in a school seem to result in individual student performance below usual levels expected due to just the effect of the student's own background. It was also found that high concentrations of middle or high socioeconomic level students in a school were associated with higher levels of individual student performance than the effects of the student's own background could account for. Hence, it would seem that the judicious dispersion of minority group and low socioeconomic level students among schools where the average socioeconomic status of students is relatively high could result in improvement of the performance of disadvantaged students.

9. The highest quality schools succeed in producing high levels of student development in both the cognitive and noncognitive domains. Frequently, the domains are considered as different types of school output, each worthy of being produced for its own sake. It is also frequently argued that the level of student development in the noncognitive domain can affect student cognitive development. There seems to be substantial empirical support for the idea. Other things equal, the more highly developed are such aspects of the noncognitive domain as student self-concept and attitude toward learning, the higher will be performance levels in intellectual skills.

10. Certain variables which are not amenable to policy control--such as student socioeconomic status, IQ, and race--strongly influence student performance. It does not follow, however, that the presence of certain negative conditions in a given school or school district must inevitably be tied to low levels of student performance. Districts can compensate for certain noncontrollable conditions by more extensive use of those resources which are under the control of school personnel. Almost without exception, the cost of these resources is closely tied to the extent of their use. Hence, it can be expected that attempts to produce student achievement levels in low socioeconomic, low IQ, or largely nonwhite school districts comparable to those found in other types of districts are likely to require larger outlays of money than are required in other districts.

CHAPTER I

IN SEARCH OF A PRODUCTION-ORIENTED THEORY OF EDUCATION

It is no easy matter to specify a theory of production as it applies to education. One reason is a tradition of defining the responsibility of schools to be that of offering opportunities for education rather than insuring that individuals receive an education. Opportunity in this sense has generally been taken to refer to whether sufficient space, materials, pedagogy, and personnel are provided by the school to enable the process of education to take place. If they have been well provided, the school was designated as a high quality school; if not, the school was given a poor quality designation. School factors frequently have been used as a reflection of output. Since production theory involves analysis of different methods of achieving output, development of a theory of production is more likely to occur where output levels are directly measured.

A second factor which has discouraged attempts to develop a theory of production of educational output is the difficulty of isolating unambiguously the school and nonschool influences which together result in the educational product.

A third reason for the primitive state of production theory in education has been the lack of agreement as to what the proper output of educational institutions should be. The lack of agreement has been substantial enough to incline educators toward finding some other criterion than school output by which to judge school quality and efficiency. When school outputs were considered as criteria, the advocate of one type of educational output frequently felt that encouraging the production of other types of educational products detracted from the production of those outputs he considered most important. Note, for example, how often emphasis on production of achievement in basic skills has been criticized by people who feel that the goal of producing creative individuals is being neglected. In this case, they consider pursuit of the former to be detrimental to the achievement of the latter. In similar fashion, those who hold the position that the major output of the educational process should be not only intellectual, but also social and emotional development find themselves criticized by those who claim that emphasis on the latter two goals is detrimental to the first. Whether evidence exists to support the contention that certain goals can be pursued only at the cost of others is a topic which will be discussed in chapter V.

As a result of these and other forces, proportionally less effort has been extended to the question of input-output relationships in the education industry than is typical of industries producing more tangible products. Considering the size and importance of the education industry, the lack is especially striking.

In the absence of a well specified theory of production for education, the investigator is relegated to the role of guessing or playing his hunches about what variables play an important role in the creation of <u>some</u> definition of educational output. This sort of process, while sometimes the only available alternative, is likely often to result in ambiguous constructs which do little to advance scientific knowledge of the production process in education. Even a cursory examination of many of the production functions hypothesized for education reveal, for example, closely related variables entered in the same equation as input. Teacher experience and teacher salary or class size and instructional cost are examples. In both cases, the former is a large component of the latter and estimates derived from these models are unnecessarily ambiguous as a result.

However, a review of the literature may show what consensus exists among researchers as to proper variables to enter into a production function study. These variables can serve as the basis for implicit theorizing. While still lacking the rigor of a well-specified theory of production, such a procedure is substantially more productive than conjecture is likely to be. The validity of this posture is of course qualified to the extent that data availability limits the researcher's ability to specify theoretical constructs to test. Therefore, this review examines the types of educational outputs which have been used as measures of productivity and types of inputs which have been postulated as determinants of the level of output. Examining of output and input definitions commonly used by researchers will provide an implicit theory of educational production. That is, it will make it possible to determine those relationships most commonly postulated as influencing production.

The studies reviewed are listed in the bibliography. Since they are frequently cited in the text and tables below, they are referred to by the numbers assigned to them in the bibliography.

Output or Product Measures Used

In the studies reviewed, the most commonly used measures of production were found to be achievement tests. Use of such tests as measures of school output implies the position that the product of the school is the student body's demonstrated ability to use certain types of skills such as computational or reading skills.

Thirty-seven of the 62 studies or models considered used some kind of achievement test score as a measure of educational output.[1] These tests generally measure "basic skills" such as verbal ability, vocabulary development, reading comprehension, computational ability, and abstract reasoning ability. Most such measures have been developed by nationally recognized test manufacturers.[2]

The other major type of achievement reviewed as a measure of educational output was achievement of economic understanding. Tests of economic understanding were used to determine students' ability to use economic tools and concepts after being exposed to a variety of educational processes. These tests are described in studies 4, 5, 41, 58, 60, 69, and 92.

Other output measures have been used in studies of educational production relationships, though not nearly so often as have measures of academic skills. Their use reflects the attitude that a valid definition of the production of the school must include not only the cognitive skills developed by students, but also a wide variety of other attitudes and skills: attitude toward life, educational desires and plans, study habits, self-esteem, appreciation of a variety of cultural patterns, attitude toward learning, citizenship, health habits, and creativity. Nontest output measures used in a number of studies are the school's record in placing graduates, students' progress relative to their age group, and

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[1]This group includes studies numbered 4, 5, 15, 31, 41, 48-52, 54, 57, 58, 60, 69, 76-78, 92, and 96.

[2]See, for example, E.F. Lindquist and A.N. Hieronymus. Iowa Tests of Basic Skills (Form 4). Boston: Houghton Mifflin Company, 1964; or E.F. Lindquist, et al. The Iowa Test of Educational Development. Chicago: Science Research Associates, 1952

the dropout rate for the school. The United States Office of Education and the Pennsylvania Department of Public Instruction have been primarily responsible for the development of an input-output literature using measures other than academic skills as definitions of school output. Studies 17, 19, 30, 36, 40, 42, and 52 describe these measures.

Clearly the schools are viewed as multiproduct firms by most investigators even if school products are limited to the basic skills, since the term "basic skills" is merely shorthand for many areas of learning. In fact, output measures covering a broad spectrum have been used by researchers and reflect the long standing belief of schoolmen that schools are producing best when they are producing a diversity of products.

Some effort has been applied to the problem of deriving a definition for educational output which includes a number of specific output measures such as those described above. Most of the effort has been restricted to the intellectual skills area and generally relies on arbitrary weighting of component measures to obtain a composite measure of output. Typically, each component is weighted equally.[3] Since these skills are not paid for directly in the job market, it is difficult to find an objective way of weighting the different components of the output composite according to their social desirability.

One class of indicators sometimes used in studying school productivity does not lend itself quite so precisely to definition as educational output as do the aforementioned variables. These indicators are often referred to as "process," "growing edge," or "adaptability" variables. They usually take

[3] See, for example Teacher's Manual: Iowa Tests of Basic Skills, Boston: Houghton Mifflin Company. 1964. p. 19.

the form of estimates of certain characteristics of the process by which knowledge is transmitted to students. As such, they can be specified more correctly as input variables than as output variables. Studies 67, 68, 79, 83, 90, and 97 discuss correlates of school quality using these types of variables as the criteria of school quality.

The values of these variables depend generally on a trained observer "discovering in a given school system the presence or absence of specific (educational) practices" which are thought to be associated with quality education.[4] These practices are methods reflecting <u>how</u> basic skills are taught, reflecting whether a wide variety of such skills are taught, and whether they are taught in relation to their meaning and usefulness.[5] The observer also notes whether practices and pedagogical techniques are used which are expected to result in discovery and development of the special aptitudes of individuals, their citizenship, character, and thinking behavior patterns.[6]

The observer notes the existence and frequency of occurrence of a wide variety of these criteria and uses an index reflecting them as the measure of the quality of a school. The indices compared between schools provide a means of analyzing quality difference.

Since, by a strict definition, these variables are more akin to inputs into the production process than outputs, the problem arises of deciding whether studies of this nature are properly examined in a review concentrating on the production function. However, a long tradition in

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[4]Paul R. Mort, W.S. Vincent, C.A. Newell. <u>The Growing Edge: An Instrument for Measuring the Adaptability of School Systems</u>. New York: Metropolitan School Study Council, 1946, p. iii.

[5]<u>ibid</u>., p. i.

[6]<u>ibid</u>., p. i.

education suggests that these variables may be proxies for a variety of educational outputs. With this in mind, some of the more notable studies of this type are included. Care is taken to distinguish conclusions stemming primarily from "school practice" studies and those stemming from examination of specific input-output studies. At a minimum, comparison of the characteristics of these two types of functions may provide insights into the question of whether "process" measures serve as reliable proxies for educational output--or the extent to which process affects the input-output relationship.

Inputs Postulated as Entering the Educational Production Function

In this section the studies reviewed are divided into four types:

1. Cognitive Output--Regression Techniques Studies
   Studies in which cognitive (e.g., scholastic achievement) variables are used as outputs and regression techniques are used to analyze input-output relationships.

2. Noncognitive Output--Regression Technique Studies
   Studies in which noncognitive variables are used as outputs and regression techniques are used to analyze input-output relationships.

3. Cognitive Output--Correlation Technique Studies
   Studies in which cognitive variables are used as outputs and correlational techniques are used to analyze input-output relationships.

4. Adaptability Studies Studies in which process or adaptability measures of school quality are used and correlational techniques are, for the most part, used to analyze relationships.

The studies are grouped in this manner as a means of retaining two fundamental differences in approach that exist in the literature: (1) the choice of definition of school output (and the resulting implications as to what constitute appropriate input-output relationships); and (2) the choice of empirical technique used to determine the effects of certain inputs on the production of a given educational output. In the former case we might reasonably expect differences in the inputs postulated when output definitions vary. In the latter case we might expect substantial differences in the knowledge gained concerning input-output relationships due to the choice of statistical techniques.

For each group, tables are presented to indicate which inputs were included in a given model and the overall frequency with which each type of input occurs. A brief elaboration of the relationship between the more commonly used input measures and the specified output type is also included.

Cognitive Output--Regression Technique Studies. The first group of studies to be considered includes those using a cognitive definition of school output and regression techniques as the primary analytical tools. Table 1 lists the input variables contained in this type study. Studies are identified by the numbers assigned to them in the bibliography.

Twenty-seven of the studies reviewed fall into this category. For these studies, 70 input variables are listed in table 1. Each represents an input postulated in at least one study as a factor causing, or thought associated with, variation in educational output. The list contains all input variables used in this group of studies except those whose precise use in the statistical analyses could not be determined from a reading of the study.

It is obvious that opinion varies as to what variables govern the production of educational output. Only a few of the 70 variables were used in any substantial number of the studies, and many were used in only one or two. This peculiar situation occurs for a number of reasons, including the lack of a tradition of viewing education as a

Table 1

INPUTS USED IN PRODUCTION FUNCTION STUDIES
(COGNITIVE OUTPUT AND REGRESSION TECHNIQUE STUDIES)

Input Variable	Studies By Number																										
	4	60	69	5	57	52	54	48	49	51	76	61	15	96	13	53	73	40	19	44	85	63	2	84	11	74	22
Type of instruction (programed or traditional)	X																										
Educational level of student	X																										
Student or teacher sex	X										X	X		X												X	
Scholastic aptitude of student	X																										
Type of school	X																			X							
Quality of school	X																										
Size of school	X		X			X		X	X	X	X	X			X	X			X	X		X	X				
Class size or teacher pupil ratio	X						X		X	X		X			X	X			X	X		X		X			
Number of years of teaching experience	X				X			X			X	X		X	X				X	X		X		X		X	
I.Q. of student		X				X			X	X	X		X	X		X	X	X								X	X
Reading ability of student		X																									
Pretest scores		X																									
Teacher degree status or other indication of level of formal training		X						X			X	X			X				X			X		X		X	

Table 1 (cont'd.)

INPUTS USED IN PRODUCTION FUNCTION STUDIES
(COGNITIVE OUTPUT AND REGRESSION TECHNIQUE STUDIES)

Input Variable	Studies By Number																										
	4	60	69	5	57	52	54	48	49	51	76	61	15	96	12	53	73	40	19	44	85	63	2	84	11	74	22
Student ability indicator (ACT Score)			X																								
Extent of mathematics training			X																								
Prior training in the subject			X	X																							
Student's major field of study			X	X																							
Grade level of student			X																								
Teacher verbal ability score					X							X							X			X		X	X		
Race of student					X							X	X						X			X		X			
Student characteristics (Many or unclearly specified)					X																						
Community characteristics (Many or unclearly specified)					X																						
School characteristics (Many or unclearly specified)												X										X					
Educational expenditure levels						X		X		X	X			X	X				X	X			X	X		X	
Socioeconomic level (Parent education level)						X		X				X		X			X					X			X		
Socioeconomic level (Parent occupation)						X	X	X		X	X	X	X	X			X					X				X	

Table 1 (cont'd)

INPUTS USED IN PRODUCTION FUNCTION STUDIES
(COGNITIVE OUTPUT AND REGRESSION TECHNIQUE STUDIES)

Input Variable	Studies By Number																										
	4	60	69	5	57	52	54	48	49	51	76	61	15	96	13	53	73	40	19	44	85	63	2	84	11	74	22
Socioeconomic level (other)												X						X	X	X	X	X		X	X		
Value, number, or quality of books and/or supplies	X	X					X			X		X	X		X				X	X	X	X		X			
Teacher salary							X	X	X		X	X			X	X			X	X		X		X	X	X	
Principals & supervisors per pupil or teacher							X		X	X					X	X											
School district property value per pupil							X				X															X	
Type of certification held by teacher								X			X															X	
Students per classroom												X															
Students per laboratory																											
Value of school owned property								X																			
Nonclassroom professionals salary								X																			
Principal's degree status								X				X										X					
Principal's years of exp.								X				X										X					
Past rate of growth of school									X	X																	
Principal's and/or superintendent's salary									X			X				X						X					

Table 1 (cont'd)

INPUTS USED IN PRODUCTION FUNCTION STUDIES
(COGNITIVE OUTPUT AND REGRESSION TECHNIQUE STUDIES)

Input Variable	Studies By Number																										
	4	60	69	5	57	52	54	48	49	51	76	61	15	96	13	53	73	40	19	44	85	63	2	84	11	74	22
Special staff per pupil									X	X		X			X					X		X					
Personnel quality (top average salary)										X		X										X					
Plant & equipment value										X																	
Teacher marital status											X															X	
Teaching out of certification											X															X	
Type of contract											X															X	
Teacher age											X															X	
Socioeconomic status (parent income)															X					X							
Library size																				X							
Age of school buildings												X			X							X					
Length of school year																				X							
Amount of homework																				X							
Number of study halls																				X							
Professional and para-professional staff characteristics																					X						
School area or rooms per pupil												X									X	X					

Table 1 (cont'd)

INPUTS USED IN PRODUCTION FUNCTION STUDIES
(COGNITIVE OUTPUT AND REGRESSION TECHNIQUE STUDIES)

Input Variable	Studies By Number																										
	4	60	69	5	57	52	54	48	49	51	76	61	15	96	13	53	73	40	19	44	85	63	2	84	11	74	22
Attendance																					X						
Location of school (urban, suburban, or rural)													X														
School tax rate																										X	
Science and/or language laboratory facilities												X							X			X		X	X		
Cafeterias												X							X			X		X			
Curriculum (tracking)												X							X	X		X		X			
Type of institution teachers trained at												X							X			X		X			
Teacher's socioeconomic status												X							X			X		X			
Percent of students planning to go to coll.																			X					X			
Percent of students with encyclopedias in home																			X					X			
Presence or absence of student derived problems																			X					X			
Teacher aspirations														X													
Effort index														X													
Teaching conditions												X															
Staff per pupil												X															

production process. Thus the researcher is forced to hypothesize, with very little background knowledge, input-output relationships to be tested. Other factors contributing to the inconsistency of model specification include the uneven availability of desired data and data series which only imperfectly represent a particular input. In the former case, the completeness of the model specification is hampered by the lack of the necessary data series; in the latter, the researcher must choose from a number of closely related data series the one he feels best represents a desired input, for example, choosing between parent education level, parent occupation, and family income as a definition of socioeconomic status.

Despite the wide variation in model specification found in the literature, some variables are included in a substantial number of studies. Table 2 lists the more frequently used variables. They indicate the inputs generally held by educators to be most important in the process of educational production.

The input most frequently postulated as entering into the educational production function is the socioeconomic status of the students, as reflected by such variables as the student's parents' educational or occupational level. Among other definitions of socioeconomic status are such variables as family income, housing quality, and number of books in the home. Socioeconomic status variables were used in 19 of the 27 studies of this type reviewed, suggesting an underlying consensus among schoolmen that the quality of the output of the educational system, defined in terms of cognitive skills, depends heavily on the initial quality of the student.

School size is the next most commonly used input variable, appearing in 14 of the studies reviewed here. Use of this variable by educational

Table 2

MORE FREQUENTLY USED INPUT VARIABLES IN PRODUCTION FUNCTION STUDIES USING COGNITIVE OUTPUT MEASURES AND REGRESSION TECHNIQUES

Input Variable	Frequency of Use	Input Variable	Frequency of use
Socioeconomic status(parent education, occupation, other)	19	Science or language laboratory facilities	5
Size of school	14	Curriculum (ability grouping)	5
Teacher salary	13	Principals or supervisors per pupil or per teacher	5
I.Q. of student	12	Cafeterias	4
Number of years of teaching experience	12	Principal and/or superintendent's salary	4
Value, number, or quality of books and/or institutional supplies	12	Type of school teacher trained at	4
Class size or teacher/pupil ratio	11	Teacher socioeconomic status	4
Educational expenditure level	11	School district owned property value per pupil	3
Teacher degree status or other indication of formal training	9	Type of certification held by teacher	3
Teacher verbal ability	6	Principal's degree status	3
Race of student	6	Principal's years of experience	3
Special staff (counselors, etc.) per pupil	6	Personnel quality (top average salary)	3
Student or teacher sex	5	Age of school buildings	3
		School area or rooms per pupil	3

researchers reflects a common concern over the effects school size may have on student achievement. This variable can also provide some information on returns to scale in education. Knowledge of how school size affects student performance can suggest increasing or decreasing returns to scale depending on whether an increase in school size leads to an improvement in student performance which is proportionally greater or less than the increase in school size.

Teacher salary was the next most commonly used input and is found in 13 of the cognitive output-regression studies. Teacher salary reflects both the teacher's degree status and years of teaching experience. Hence, this variable can be used to investigate the widely-held hypothesis that an experienced and well trained teacher is more effective in producing cognitive output than an inexperienced and untrained teacher. One of the next most commonly used inputs, years of teaching experience, is but another way of specifying one of the principal components of teacher salary. Teacher degree status is the other. Many of the studies used teacher experience alone, both degree status and experience, or some combination of these and salary variables. Degree status was used in nine studies.

Use of student I.Q. as an input, like use of socioeconomic status, implies that the educational output of the school depends in part on the quality of certain inputs into the educational process. Hence, it can be argued that school output varies, not only because of the effectiveness of the educational processes, but also because of the initial quality (narrowly defined) of the students.

Also widely hypothesized as important inputs in the educational production function were value, number, or quality of books and other instructional supplies (used in 12 studies); class size or teacher-pupil ratio (11 studies); and educational expenditure level (11 studies).

The remaining variables occur with substantially less frequency in the studies reviewed. Their relatively infrequent occurrence may reflect the data constraints researchers face rather than a lack of consensus as to the importance of these variables in the production of educational outcomes.

Certain variables may have been used infrequently in production function research for unique reasons. Race of student was found as an input in only six studies. However, all of these studies were carried out since the mid-1960's, reflecting a growing interest (or frankness) in race as a variable.

Teacher verbal ability was used as an input variable in six studies and teacher socioeconomic status in four. The movement toward hypothesizing more subtle teacher characteristics, such as these, illustrates (1) the need to go beyond more obvious (and more easily measured) teacher traits such as degree status and experience in order to understand more fully the educational production function; and (2) the danger of attaching importance to variables merely because they are used frequently. This issue is discussed further in chapter V.

Noncognitive Output--Regression Technique Studies. The second group of studies reviewed includes those using noncognitive criteria of school effectiveness, including variables such as study habits, self-esteem, holding power (dropout rate), creativity, and the school's ability to (occupationally) place its graduates. As in the first group of studies, the principal analytic tools were regression techniques.

Table 3 lists the input variables postulated as entering the process of production of noncognitive outputs. It also identifies each study by bibliography number and gives the definitions of output used in each study.

Table 3

INPUTS USED IN PRODUCTION FUNCTION STUDIES
(NONCOGNITIVE OUTPUT AND REGRESSION TECHNIQUE STUDIES)

Output Used and Study Number / Input Variables	Student attitude toward life		Student educa. plans & desires		Student study habits		Student expectations for excellence		Student self-esteem	Apprec. of other cultural groups	Attitude toward learning	Responsible citizenship	Health habits	Creativity	Preparation for productive life	Appreciation of science & arts achievements	Recognition of education as a lifelong process	Ability to place graduates	Completed years of schooling	Holding power of school
	61	63	61	63	61	63	61	63	15	15	15	15	15	15	15	15	15	24	20	91
Size of school or district	X	X	X	X	X	X	X	X				X								
Class size or teacher-pupil ratio	X	X	X	X	X	X	X	X												
Experience of teacher	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
Teacher verbal score	X	X	X	X	X	X	X	X												
Race of student	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X		X	
Value or number of books and supplies	X	X	X	X	X	X	X	X									X			
Teacher salary	X	X	X	X	X	X	X	X				X		X	X		X			
Principal's degree status	X	X	X	X	X	X	X	X												
Principal's experience	X	X	X	X	X	X	X	X												
Principal or superintendent's salary	X	X	X	X	X	X	X	X												
Special staff (counselors, etc.)	X	X	X	X	X	X	X	X		X	X	X	X	X	X					
Personnel quality	X	X	X	X	X	X	X	X												

Table 3 (cont'd)

INPUTS USED IN PRODUCTION FUNCTION STUDIES
(NONCOGNITIVE OUTPUT AND REGRESSION TECHNIQUE STUDIES)

Output Used and Study Number / Input Variables	Student attitude toward life		Student educa. plans & desires		Student study habits		Student expectations for excellence		Student self-esteem	Apprec. of other cultural groups	Attitude toward learning	Responsible citizenship	Health habits	Creativity	Preparation for productive life	Appreciation of science & arts achievements	Recognition of education as a lifelong process	Ability to place graduates	Completed years of schooling	Holding power of school
	61	63	61	63	61	63	61	63	15	15	15	15	15	15	15	15	15	24	20	91
School area (physical size)	X	X	X	X	X	X	X	X												
Laboratory facilities	X	X	X	X	X	X	X	X												
Cafeterias	X	X	X	X	X	X	X	X												
Curriculum (ability grouping)	X	X	X	X	X	X	X	X												
Type of school teacher trained at	X	X	X	X	X	X	X	X												
(Teacher) socioeconomic status	X	X	X	X	X	X	X	X	X	X						X				
Building age	X	X	X	X	X	X	X	X												
Socioeconomic status (parent education)	X	X	X	X	X	X	X	X	X	X	X	X		X			X		X	
Socioeconomic status (parent occupation)	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X			
Teacher age									X				X							
Teacher degree status	X	X	X	X	X	X	X	X	X	X				X						
Expenditure levels									X	X	X				X	X	X	X		

Table 3 (cont'd.)

INPUTS USED IN PRODUCTION FUNCTION STUDIES
(NONCOGNITIVE OUTPUT AND REGRESSION TECHNIQUE STUDIES)

Output Used and Study Number / Input Variables	Student attitude toward life		Student educa. plans & desires		Student study habits		Student expectations for excellence		Student self-esteem	Apprec. of other cultural groups	Attitude toward learning	Responsible citizenship	Health habits	Creativity	Preparation for productive life	Appreciation of science & arts achievements	Recognition of education as a lifelong process	Ability to place graduates	Completed years of schooling	Holding power of school
	61	63	61	63	61	63	61	63	15	15	15	15	15	15	15	15	15	24	20	91
I.Q.									X	X	X	X	X	X	X	X	X			
School location (urban, rural, etc.)										X	X			X	X	X			X	
Teacher aspirations											X				X		X			
Innovation											X									
School holding power													X		X		X			
Absentee rate												X	X	X		X	X			
Population trend													X							
Effort index													X		X	X	X			
Teacher view of professional recognition															X					
Staff pupil ratio																X	X			
Other school characteristics	X	X	X	X	X	X	X	X												X
Other socioeconomic variables	X	X	X	X	X	X	X	X	X	X	X		X		X	X			X	X

Table 3 (cont'd)

INPUTS USED IN PRODUCTION FUNCTION STUDIES
(NONCOGNITIVE OUTPUT AND REGRESSION TECHNIQUE STUDIES)

Output Used and Study Number / Input Variables	Student attitude toward life		Student education plans & desires		Student study habits		Student expectations for excellence		Student self-esteem	Apprec. of other cultural groups	Attitude toward learning	Responsible citizenship	Health habits	Creativity	Preparation for productive life	Appreciation of science & arts achievements	Recognition of education as a lifelong process	Ability to place graduates	Completed years of schooling	Holding power of school
	61	63	61	63	61	63	61	63	15	15	15	15	15	15	15	15	15	24	20	91
Student age																			X	
Student sex																			X	
Teacher perception of school climate									X						X					

Only six studies fitting this classification were reviewed, indicating the extent to which cognitive outcomes have dominated research on educational production function as well as the difficulty of studying noncognitive variables.

For clarity, each definition of noncognitive output used within a study is listed separately in table 3. For example, study 61, which used four different noncognitive output definitions, is entered four times in table 3. Organizing the studies in this way results in a listing in table 3 of 20 models, each one representing a different input-output configuration in the six studies reviewed.

Table 4 indicates the frequency of use of the most common inputs. Twenty-two of the 28 variables listed in table 4 are found among those most frequently used in the cognitive output studies. It seems that the basic inputs into the production of cognitive and noncognitive output are theorized to be generally the same. How adequate the inputs are for both domains remains to be seen.

In the 20 models reviewed, socioeconomic status was most frequently postulated as affecting the level of the various outputs. The race of the student, certain teacher characteristics (salary, degree status, experience), and number of special staff members were also frequently used. While the frequency of socioeconomic status and teacher characteristics roughly follows the pattern established in the cognitive output studies, the frequency of student race and use of special staff is higher in this group of studies. This reflects, presumably, the feeling that race and such special staff as counselors are fairly important determinants of student behavior patterns and attitudes.

Table 4

MORE FREQUENTLY USED INPUT VARIABLES IN PRODUCTION FUNCTION STUDIES USING NONCOGNITIVE OUTPUT MEASURES AND REGRESSION TECHNIQUES

Input Variable	Frequency of Use	Input Variable	Frequency of Use
Socioeconomic status(parent education,occupation,other)	18	Principal's experience	8
Race of student	17	Principal or superintendent's salary	8
Teacher experience	17	Personnel quality	8
Special staff(counselors, etc.)	14	School area	8
Teacher salary	12	Laboratory facilities	8
Teacher degree status	11	Cafeterias	8
Size of school or school district	9	Curriculum	8
I.Q.	9	Type of school teachers trained at	8
Other school characteristics	9	Building age	8
Value or number of books and/or other instructional supplies	9	Educational expenditure levels	7
Class size or T/P ratio	8	School location	6
Teachers' verbal ability	8	Student absentee rate	5
Principal's degree status	8	Effort index	4
		Teacher aspirations	3
		School holding power	3

Appearing with moderate frequency in this group of studies are such variables as I.Q., books and supplies, class size, principal and superintendent's characteristics, school size, principal and superintendent's characteristics, curriculum, and teacher ability, among others.

Cognitive Output--Correlation Technique Studies. The next group of studies reviewed includes those using a cognitive definition of output but, unlike the first group, correlational techniques were used to analyze input-output relationships. Though correlational analysis generally does not yield as much useful information about production relationships as regression analysis, an examination of such studies can throw additional light on the question of what variables are commonly thought to influence educational output.

Table 5 lists the inputs used in cognitive output--correlational technique studies. Unlike the two groups of studies previously discussed, the inputs listed tend to reflect only the variables the researcher found worthy of substantial comment, though this is not true in every case. Since the number of variables used in these studies tends to be smaller than in previous groups, the list of inputs and frequency-of-use table--presented separately in the preceding two sections--are combined in table 5. The input variables are listed in descending order of their frequency of occurrence in the studies reviewed.

The most commonly used input variable--level of educational expenditure--was used considerably more often than in the first two groups of studies. The relative frequency of socioeconomic status and I.Q., the second and third listed input variables, was similar to the other studies. Teacher experience, degree status, and adaptability variables were each used in three or four of the studies in this group.

Table 5

INPUTS USED IN PRODUCTION FUNCTION STUDIES
LISTED IN ORDER OF THEIR FREQUENCY OF USE
(COGNITIVE OUTPUT AND CORRELATIONAL TECHNIQUE STUDIES)

Input Variables in Order of Descending Frequency of Use	Studies By Number									
	16[a]	34	36	40	56	66	74	79	91[b]	95
Educational expenditure levels	X		X	X		X	X	X	X	X
Socioeconomic status		X	X	X	X		X		X	X
I.Q.			X	X	X		X			X
Teacher experience	X			X			X	X		
Teacher degree status			X				X	X		
Adaptability (adoption of new technique)		X		X				X		
Teacher-pupil ratio or class size								X	X	
Instruction						X				
Attitude toward learning						X				
Average teacher's salary									X	
Numerical staff adequacy									X	
Staff-pupil ratio									X	
Remedial reading specialists--pupil ratio									X	
Guidance specialists--pupil ratio									X	
Psychological services--pupil ratio									X	
Teacher turnover									X	
Total number of professional staff									X	
% staff with $5\frac{1}{2}$ years training									X	
% staff from outside district									X	
% staff belonging to six or more professional groups									X	
Staff travel									X	

[a]School holding power was the output measure used in this study.

[b]The technique used in this study is a combination of regression and correlation. Hence, the decision to enter it in this table was somewhat arbitrary.

One conclusion seems warranted from inspecting frequency of use of these variables. The inputs postulated by correlational analysts are much the same as those in other types of studies. This conclusion is qualified to the extent that variables used but not reported in these studies could change the list of inputs.

Adaptability Studies. The fourth and last type of study to be considered is characterized by the use of the adaptability criteria as the measure of school quality. With one exception (study 55), the method of analysis was correlation.

Adaptability studies, as noted earlier, do not easily fit the definition of input-output studies since the criteria of school quality are usually measures of school characteristics thought to be related to the learning process. As such they are assumed to be proxies for the level of student learning and not really direct measures of it. To the extent that adaptability criteria are good proxies for school output, their correlations with a variety of input variables will be useful in determining an implicit input-output theory of educational production.

Adaptability studies are included in this review merely to illustrate relationships which adaptability analysts feel are important. Therefore, only a few of the adaptability studies have been reviewed. They are thought to be indicative of major trends in this literature, however.

Table 6 consolidates the input list and frequency-of-use table for this set of studies. The relationship between educational expenditure and educational quality has been a central interest among adaptability researchers and table 6 reflects this. Expenditure in one form or another is postulated as a determinant of school quality in all the adaptability

Table 6

INPUTS USED IN PRODUCTION FUNCTION STUDIES
LISTED IN ORDER OF THEIR FREQUENCY OF USE
(ADAPTABILITY CRITERIA AND CORRELATIONAL TECHNIQUE STUDIES)

Input Variables in Order of Frequency Use	Studies By Number				
	67	79	83	90	97
Educational expenditure levels	X	X	X	X	X
Socioeconomic status	X		X	X	
Class size or P/T ratio	X	X	X		
Size of school system			X	X	
Teacher degree status		X			
Average age of professional staff	X				
Staff characteristics			X		
Wealth				X	
Average professional staff salary	X				
% mature, broadly trained, and experienced staff	X				
% Young, well grounded, and broadly interested staff	X				
Character of tax and budget power of school district	X				
Amount of state aid to school district	X				
District working arrangements with professionals and public _vis-a-vis_ decision making	X				
Legal structure and administration variables influencing school system policy	X				
Legal structure and administration variables influencing school characteristics	X				
Legal structure and admin. variables influencing the educ. process	X				
Location and function of community			X		

studies reviewed. Socioeconomic status and class size (pupil-teacher ratio) are also frequently postulated as determinants of school quality, although in this type of study, socioeconomic status is interpreted more as receptivity of the community to innovation than as an affector of the level of student performance.

With this we conclude our examination of inputs postulated as entering the production function. Next, we shall use this information to determine what overall consensus exists among schoolmen as to the factors which determine the level of school output.

Summary of Variables Generally Postulated as Entering the Production Function of Education

No single definition of educational output dominates the studies reviewed. One class of outputs, those related to student ability in certain academic skills such as reading and computation, is used more than any other. Output definitions falling within this classification are used in about 60 percent of the studies or models reviewed. Most of the other models use nonacademic measures as definitions of educational output. These measures include such criteria as attitudes, study habits, expectations, and creativity. Another major classification of studies includes those using adaptability criteria and is representative of much of the research into school quality undertaken in the decade after World War II.

A properly specified theory of educational production would show that the many inputs in educational systems produce a variety of outcomes. Few of the studies reviewed show this directly; those that do generally use a limited number of production functions, one for each postulated output, with no attempt to explicitly discern the joint effects on several outputs of a given input. In this sense, there is a fundamental gap in the research at this point; our knowledge of educational production relationships will be incomplete until it is filled.

A first step in filling this gap is to use the consensus among other investigators concerning the determinants of educational output as an implicit theory of production which can be tested in two ways: (1) by screening the results of studies in the four categories to learn which input variables did in fact prove to be important affectors of output as hypothesized; and (2) by developing new production function models based on the implicit theory and testing them on new data sets. Step 1 is carried out in the remainder of this paper. The empirical verification described in Step 2 is beyond the scope of this publication but is under way and will be described in a subsequent paper.

How can the consensus of the investigators conducting the described studies be obtained so as to provide proper emphasis on specific input variables? Simply summing the frequency of use of each variable in the four types of studies does not seem adequate. A somewhat more balanced, though still rather crude, way of selecting variables is to require that a given variable appear in a certain percent of the studies of a particular type. This is what was done here. It was arbitrarily decided to consider only variables which were used in at least 25 percent of the studies in at least one of the four groups. (It should be emphasized that eliminating variables which occurred in fewer than 25 percent of the studies in a group does not remove them from further consideration as input variables; however, for purposes of this analysis it was necessary to set a limit on variables to be considered as a starting point for hypothesizing models.) Once these variables were identified, the total frequency of occurrence for

Table 7

VARIABLES MOST FREQUENTLY POSTULATED AS DETERMINANTS OF EDUCATIONAL OUTPUT AND THEIR FREQUENCY OF USE

Input Postulated	Frequency*
Student socioeconomic status	47
Teacher experience	33
Educational expenditure levels	31
I.Q.	26
Teacher salary	25
School or district size	24
Class size or t/p ratio	24
Books and other materials & supplies	21
Student race	17
Special staff (counselors, etc.)	16
Teacher degree status	15
Teacher socioeconomic status	11
Other school characteristics	9
Teacher verbal ability	8
Principal's degree status	8
Principal's experience	8
Principal's or superintendent's salary	8
Personnel quality	8
School physical area	8
Laboratory facilities	8

Table 7 (cont'd.)

VARIABLES MOST FREQUENTLY POSTULATED AS
DETERMINANTS OF EDUCATIONAL OUTPUT
AND THEIR FREQUENCY OF USE

Input Postulated	Frequency*
Number of cafeterias	8
Ability grouping (curriculum)	8
Type school teacher trained at	8
Building age	8
School location (rural-urban)	6
Student absentee rate	5
Adaptability	3

*62 is maximum possible frequency

each was obtained by summing over the four groups of studies. The frequencies for the relevant variables are given in table 7.

The most commonly postulated determinant of educational performance is student socioeconomic status, used 47 times in the 62 models considered. This frequency of occurrence indicates the strong consensus among investigators that the socioeconomic level of the student is one of the major factors determining the level of school output.

Table 7 shows that 10 variables occurred rather frequently (between 15 and 33 times) in the studies reviewed. Considerable redundancy exists among these variables. For example, expenditure level reflects to a great extent such other variables as teacher salary, class size, books and other materials, and special staff. Teacher salary itself reflects teacher experience and degree status. This redundancy is due largely to differences among the studies reviewed in defining variables and to the different aims of the various studies.

Most of the variables fall rather easily into one of two groups: (1) those which cannot be easily manipulated by school authorities in the short run (fixed inputs); and (2) those which can be manipulated (controllable inputs). Student socioeconomic status, student I.Q., school or district size, and student race are examples of fixed inputs. Teacher degree status and experience, educational expenditure level, class size, books and supplies, and number of special staff are examples of controllable inputs. Viewing inputs in these two ways implies that circumstances beyond the control of school personnel will exert an influence on the output of the school. Hence, the level of school output is a good measure of quality only if fixed inputs are taken into consideration. Conversely, the existence of poor levels of fixed inputs may not inevitably lead to low levels of student performance, since many inputs thought to influence student performance are subject to manipulation by the school administrator. These input variables, then, form the basis for a theory of educational production which can be tested. Chapter V of this review describes the components of the theory which, when tested , were found to affect the level of production, components which were not, and components for which the evidence is not clear.

CHAPTER II

THE CONSTRUCTION OF MODELS FOR TESTING

On the basis of the frequency of their use in the literature, certain variables were selected in chapter I as representative of a theory of educational production. This chapter describes how these variables are assumed to be related to one another by examining specific ways in which models are constructed for testing. For example, are relationships postulated as linear or curvilinear, multiproduct or single product, subject to diminishing returns or not? This chapter also describes (1) the most commonly used levels of aggregation of data, (2) the usefulness of forming composite variables from highly intercorrelated variables, (3) methods for handling longitudinal data, and (4) alternative procedures by which the effects of certain inputs can be discerned.

Methods of Selecting Variables to Enter The Production Function

In most of the studies reviewed, the researcher seemed to rely on his *a priori* knowledge of what variables should be entered into models of the production function for education. In one study (67), however, a large number of variables were subjected to correlational analysis with a criterion of school quality. Variables which proved to be significantly correlated with the criterion were then used as the basis upon which a theory was derived to explain the interrelationships among these variables themselves and the criterion. Hence, the theory was derived from empirically observed relationships. It was not possible to determine if the theory was specified in the form of an equation and tested to determine whether components individually correlated held their same relationships under multivariate testing procedures.

In another study (15), variables correlated with a definition of school output were expressed as a linear model and subjected to regression to determine whether, controlling for the effects of the others, each one maintained its relationship with the output variable. It was found that many variables initially selected from correlational tables in this manner do not maintain significant relationships with the output measure when subjected to multiple regression analysis.

The efficacy of this method is subject to question since the interrelationships of input variables may obscure the unique contributions of each one to an output variable. It is entirely possible for a significant affector of output level to appear to be an insignificant correlate of output when only simple correlations are examined. This possibility may be minimized by applying judgment to the selection of input variables and by exploring multivariate procedures for obtaining a more accurate picture of the interrelationships among variables.

Estimating Production Functions of a Multiproduct Organization by Using Single-product Models

In many of the studies reviewed, only one type of output was of interest to the researcher. As a result, in these studies no attempt was made to determine a production function model of a multiproduct organization. In others, the problem of constructing a production function for a multiproduct firm was explicitly recognized and some attempt was made to develop production relationships for a number of different output measures. Studies 15, 34, 40, 44, 48, 49, 51, 52, 53, 54, 61, 63, 73, 74, 76, 95, 96, and 97 are of this type. Most of these studies expanded the output concept by using several measures of academic achievement. Three studies (15, 61, 63) used personality and behavioral traits as well as academic achievement.

Two methods were generally used in these studies to represent the multiple nature of the output. One was to construct an index to represent performance in a number of different areas. This index, in effect, became the measure of aggregate output. Specifying multi-output-input relationships in this manner amounts to hypothesizing a weighted average effect on a number of different outputs of a variation in an input. These studies do not discuss whether the amount of information about relationships between several outputs and an input gained by this approach is as great as that gained by simply specifying a number of single output production functions.

The second technique used to specify input-output relationships in the multiproduct case involved specifying separate production functions for each type of output of an organization. This approach makes it possible to determine the unique effects of a change in input on the level of output for each output. Using this method also provides useful information about the stability of each output-input relationship rather than just indicating the stability of the aggregate.

Preference for either method would seem to depend on the level of aggregation at which knowledge of input-output relationships is desired.

The Form of the Production Function

The simplest form of production function is one in which the inputs are postulated as determining the level of output in some linear additive way. Most of the attempts to determine educational input-output relationships are of this type, and as a result the marginal effect of a unit change in any input on output, as estimated by the appropriate regression coefficient, is postulated to be constant for all levels of that input or other inputs used in the educational process.

A few studies have used less restrictive forms of the production function. Studies 3 and 22 used nonlinear forms of inputs in additive models. Certain variables in these studies were theorized as having different incremental impacts on output depending on the level of input usage. This form of specification does recognize that the level of usage of an input may affect its productivity. In this type of a model, marginal productivity (the increase in output resulting from a small increase in input usage) is considered a function of the level of the particular input concerned, regardless of the level of the other inputs in the model.

Only studies 52 and 85 use the logarithmic form of the production function which allows the data to determine what kind of returns to scale (see p. 24) characterize the production function as well as whether the marginal product of a factor changes at different levels of input usage. In thse respects, the log linear form seems superior to the other forms which have been described here.

The Use of the Time Dimension in Specifying Educational Production Functions

Most of the studies reviewed specified models in which output in a given period was postulated as determined by a variety of inputs used in the same period. Hence, a typical model might postulate 1965 arithmetic test performance as the school output, and such factors as average number of years of teaching experience of teachers in the school in 1965, average teacher degree status of teachers in the school in 1965, average socioeconomic status of the school's students in 1965, etc., as input factor definitions. Such cross-sectional models neglect the time dimension. However, even these models may have an implicit time dimension: Since input can only affect output over time, cross-sectional analysis often uses the differences in input and output levels observed between different school district's in the same period of time as approximations of what happens to a given school district's output as inputs are varied over time. Certainly not all cross-sectional models rely on this assumption to justify their results but to the extent that some models do, the time factor does play a role.

More explicit uses of the time dimension can be found in the educational production function literature, though only in a few studies. In study 92, the change in the level of student test performance is postulated as determined by whether the student took a certain course of study during the interval between tests. In study 5, the retention of certain knowledge over an extended period of time (t + 8) was postulated as determined by factors acquired in an earlier period (t). Study 48 uses a similar model which postulates average school district output in period (t) as a function of input levels used primarily in period (t + 2). In this case, data limitations apparently forced the use of inputs collected at a later period as though they were affectors of output at an earlier period. If these inputs are indicative of relatively stable school policy and characteristics, then this inverted time relationship of input and output might be acceptable.

Study number 54 postulated the rate of change of output over time as being a function of the absolute level of inputs. Specifically, the model postulated takes the form

$$0_{t+2} - 0_t = f(I_t)$$

The model was then tested and compared with a cross-sectional model of the form

$$0_t = f(I_t)$$

to determine whether absolute values of the inputs were as powerful predictors of change in output as they were of the absolute value of output.

The two models were found to explain roughly the same amount of variance, though the relative significance of the separate inputs changed somewhat, some appearing to be more stable predictors in one model than in the other.

Study number 78 examined the question of the effect on the change in school output of certain nonschool controllable inputs, namely socioeconomic status and I.Q. It was concluded that, while these inputs are strongly associated with the absolute level of output, their effect on the changes in school output was minimal. This seems plausible if we view these variables as fixed inputs in the production process. Then observed changes in output could only result from changes in inputs whose levels can be controlled by the school manager (e.g., class size).

None of the studies reviewed attempted to specify a longitudinal production function model. This seems to be due primarily to the unavailability of proper data rather than commitment to cross-sectional analysis. For the same reason, even first difference (change) models are not found in the literature with the exception of study 78, which uses only two production inputs. From this review, it seems that the question of time has not yet received adequate treatment in the production function literature.

Variable Averaging in Production Function Models

Model specification depends in part on what is thought to be the relevant level of aggregation from which to view production relationships. Many of the studies reviewed used the school or school district as the appropriate level of aggregation. In these models, average student performance in the school or school district was postulated as determined by the average level of school and nonschool inputs. Studies of this type include numbers 3, 11, 13, 16, 19, 36, 40, 48, 49, 50, 51, 52, 53, 54, 57, 63, 66, 74, 78, 84, and 95. One reason the school or distict level of aggregation is so often used is because data on certain variables--especially school expenditure--tend to be available most frequently at this level of aggregation. Another reason may be that school managers, for whom the findings of such studies are usually intended, must view problems first and foremost at the school or district level. Models aggregated at the school or district level may be more usable for management purposes than are more disaggregated models.

Another way of specifying production function models is to postulate individual student performance as a function of the levels of various inputs which have been applied specifically to each student. Here the model is specified in terms of the individual student rather than the school or school district. Study number 73 is of this type.

The question whether the disaggregated or the aggregated form of model specification is to be preferred is not easily answered. It would seem reasonable to expect similar results from either method, though this need not always be the case. There is some evidence (see chapter V, p. 105) to suggest that a student's performance is affected not only by his own socioeconomic level, but also by the prevailing socioeconomic level in the school he attends. This can lead to individual student models underestimating the total socioeconomic effect if incorrectly constructed.

An example may illustrate this problem. Studies 73 and 96 used the same data sets to estimate educational input-output relationships. However, study 96 specified the model at the school district level of aggregation, whereas 73 specified the model in terms of individual students. Four regression models were specified in which fifth-grade composite achievement in the basic skills was postulated as determined by socioeconomic status variables, either mother's education or father's occupation level. The models were specified both in terms of the school district level of aggregation and the disaggregated individual student level. The former set used district averages for each variable while the latter set used individual student scores for the same variables. For each set, two equations were estimated: one using only mother's education and the other only father's occupation. Table 8 gives the standardized regression coefficients for these four models.

Table 8

BETA WEIGHTS RESULTING FROM ESTIMATION OF DISTRICT AVERAGE AND STUDENT LEVEL MODELS

Specification	Input	
	Mother's Education	Father's Education
District average model	+.65	+.49
Student level model	+.41	+.37

In this set of data, aggregating the student output and input observations resulted in an increase in the estimated regression coefficients. This could be expected since,in aggregated form, the variable represents both types of socioeconomic effect. On the other hand, the socioeconomic variable in the individual student model only accounts for the effect of a student's own socioeconomic level on his performance. This does not, however, imply that individual student models are less desirable, since the other type of socioeconomic effect can be accounted for by merely including average school or school district student socioeconomic status as a separate variable. It may well be that other inputs in the educational process also have such dual effects. Unfortunately, this can only be inferred at this time due to the lack of research in the area.

Use of Grouped or Clustered Variables

Studies 61 and 63 specified production functions in which the definition of input was somewhat different from that generally used. In these studies, all variables postulated a priori as possible determinants of the level of student performance were subjected to factor analysis[7] in an attempt to organize the large number of input variables into a smaller number of groups. For example, a number of indicators of student socioeconomic status would be grouped into a cluster or composite variable which presumably would more accurately specify socioeconomic status than any one of its components. Grouping may also reduce the degree of input intercorrelation (multicollinearity) in a model. This should result in better estimates of the independent effects variations in inputs have on output.

These advantages, however, are gained at no inconsiderable cost. It is not uncommon to find variables representing two or more conceptually different phenomena loaded on the same factor (grouped into the same cluster) as a result of being highly intercorrelated. Hence, interpreting such a factor is often difficult.

Another problem is associated with the use of factor analysis as a means of compositing input variables. Even if the meaning of composites is conceptually clear, the method permits the estimation of only one regression coefficient for each composite. Hence, it is difficult to determine unambiguously what changes in the level of output can be expected from changes in any given individual input, which makes the problem of allocating resources difficult since the method yields little information on individual input effects.

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[7] See for example, Horst, Paul. Factor Analysis of Data Matrices. Holt, Rinehart, and Winston, Inc. 1965.

Though the ambiguity of results severely detracts from the utility of clustering in regression analysis, use of clustering may not always result in less useful information than would otherwise be obtained. Factor grouping of variables may be most useful when a high degree of multicollinearity exists between input variables, a common problem in studying education production functions. Multicollinearity can be eliminated if data can be combined through factor analysis, or some other grouping technique, into clusters which are not highly intercorrelated. The gain is an increase in the accuracy with which regression statistics estimate the effects the input variables have on the level of output. The loss is that the regression coefficients of the resulting composite variables cannot be used as indicators of change in output when any component of a composite variable is changed. But this is an illusionary loss when the alternative to grouping is mutlicollinearity of any substantial degree. If the variables are such that they can be grouped in theoretically or policy meaningful terms (e.g., "teacher characteristics" or "socioeconomic characteristics"), then not grouping would seem to result in a decline in credibility of the regression statistics and a sacrifice of knowledge of the relative impact of different general types of inputs.

In summary, grouping variables would seem to provide a useful means of specifying production functions in certain situations, especially those involving high multicollinearity among input variables.

Model Specification and Socioeconomic Variables

Variables representing socioeconomic status play a unique role in educational production function analysis. Variables traditionally defined as inputs in the production process are those whose levels of usage can be altered by the manager as he attempts to change the level of output or the efficiency with which it is produced. Student socioeconomic status does not fall neatly into the categrory of alterable variables. It has been theorized, and empirically verified, that socioeconomic status is a major determinant of the level of school output, but it is not generally considered manipulatable by the educators to any appreciable extent. In this respect socioeconomic status in education is akin to the quality differences in intermediate goods used in the production of manufactured goods insofar as these differences affect the quantity or quality of output.

Thus, the socioeconomic status variable is awkward, and as a result it has been specified in a number of different ways in educational production function models. In many studies (for example, 60, 61,and 63) it has been entered explicitly as a determinant of output in the same way that other inputs are. In these models, its presence in the regression equation is the means by which its effect on output is controlled. In other studies (48 and 54) separate production functions are specified for each level of socioeconomic status, and the data set used for estimation purposes is similarly broken down for use with each of the functions. Theoretically, this allows the production function to be specified without the explicit inclusion of the "awkward" variable. It also allows for the possibility that the regression coefficients of inputs may vary with the type of student to which they are applied. Specification of a single relationship for students at all socioeconomic levels does not allow such variation in regression coefficients in simple linear additive models.

In another report (78) it is stated that student socioeconomic status affects the level of school achievement but not changes in achievement from one grade to another. The data upon which this conclusion is based are not reported. If the conclusion is correct, however, it implies that socioeconomic status is, for any individual, a constant which affects his standing as he enters the educational system, but not his progress through it. Further, it implies that the effects of socioeconomic status on student performance are independent of other inputs, however, these other variables may be related to each other in terms of output levels. Study 77 examines the former implication of this hypothesis in terms of different racial or ethnic groups rather than different socioeconomic groups. Studies 61 and 63 deal extensively with the latter implication through the use of the interaction effect method.

Several studies (40, 56, and 73) postulated student performance as a function only of socioeconomic status and student I.Q. The extent to which this method of specifying models is successful in ascertaining the independent effect of socioeconomic status on student performance depends largely on how near zero the intercorrelations are between other inputs and the socioeconomic status variable. This follows since the limit to which one variable can "proxy" for another is determined by the extent of intercorrelation between them. Hence, in data sets in which socioeconomic status is correlated with other production inputs not included in the model, the estimate of independent relationship is likely to be inaccurate.

Study 91 used an extension of this technique to specify a model which was used to determine whether certain policy controllable inputs did affect school performance. School holding power was regressed on a number of socioeconomic status variables, and the residuals resulting from this regression were postulated as being due to varying levels of school inputs. The residuals were then correlated with a variety of school inputs. It would seem that the residuals would depend in large part on the ability of the socioeconomic variables to proxy for school inputs. If socioeconomic variables correlate highly with school inputs, one would expect residuals from the regression to correlate negligibly with the school inputs even if the school inputs were important determinants of the level of school performance.

Use of Expenditure Figures

A number of studies (40, 50, 51, 79, 95, and 96) have postulated various definitions of educational expenditures as determinants of school output. These expenditure variables differ widely in definition, some being as narrowly defined as "teacher salary," others as broadly as "total expenses (on current account)." Implicit in the use of such variables is the hypothesis that the goods or services which educational expenditures buy affect school performance. Teacher salary, for example, buys teacher degree status and teacher experience; capital expenditures buy the facilities necessary for instruction. Thus, expenditure itself affects student learning only indirectly. Many of the things the expenditures buy are commonly postulated as affecting school output. However, some of the more gross expenditure measures also include such items as expenditures for building maintenance and student transportation. Such items are necessary for the operation of the school system, though one might reasonably suspect that substantial variation in expenditures for inputs of this type could occur without any discernable effect on most kinds of student performance. As a result, major movements in expenditures may coincide with little or no movement in output, yielding misleading estimates of expenditure-output relationships. This possibility becomes even more probable when the data set includes schools with distinctly different expenditures for such items as student transportation; note, for example, the differing transportation needs of urban, suburban, and rural school districts. Expenditure definitions which lend themselves to use in production functions are those which represent expenditures for variables displaying a rather direct influence on instruction and other processes through which an output such as student achievement is produced.

Some of the studies reviewed specified models which include both educational expenditures and the inputs these expenditures buy. These models would appear to be redundant and estimates of the effects of individual inputs are likely to be ambiguous as a result of this built-in multicollinearity.

Production Functions and Cost Functions

Production function analysis constitutes a major tool in the kit of the investigator of educational performance. With it he can obtain a picture of the impact on output of variations in the inputs into the educational process. But what implications do these variations in the inputs have on the cost of the educational process? To obtain a better understanding of this side of the coin, a second and parallel tool is available--cost function analysis.

If, as this review illustrates, the production function has been dealt with only implicitly in most of the relevant educational literature, the cost function has been all but ignored.

The cost function describes variations in educational cost which take place as input usage varies. Taken together, the cost function and the production function make it possible to determine (1) the least costly method of producing a given level of educational output or (2) the maximum output derivable from given levels of educational expenditure. Traditional mathematical methods of maximizing or minimizing a function subject to a constraint are used to achieve such objectives.

Typically, one would expect that in the presence of well specified production and cost functions, classical methods of constrained maximization and minimization or linear programing would be applied to determine efficient allocation of resources. This review has indicated that neither approach has been used explicitly in the educational production function literature, although some other attempts have been made to determine efficient resource allocation.

Most closely akin to classical methods of determining efficient means of resource allocation is the method used in study 57. Here a production function and a cost function were specified to allow comparison of marginal productivities and marginal costs. Working backwards through the production function made it possible to determine what increases in each economically relevant input were required to produce a given increase in output. Then the increase in cost incurred by raising the level of each input was computed and the increases in costs associated with the respective variables were compared. In this way, the least costly means of increasing output was identified. Though the procedure was computed arithmetically, the results were determined by the comparison of marginal productivities and marginal costs. In this respect, the procedure is analogous to conventional techniques.

Although differential effects on productivity and cost of different levels of a given variable are not dealt with explicitly, both the production and cost functions were linear. This means the marginal productivity-cost relationships are constant. Hence, the relative impacts of inputs remain the same, regardless of level; a resource (input) with a given impact at a low level of usage will have the same impact relative to other inputs at a high level.

Studies 49 and 54 used another approach to the question of resource allocation. In both studies, certain inputs into the production process were entered in monetary rather than real terms. The beta weights then represented the marginal contribution to output of a dollar change in the level of usage of each of these factors. The emphasis in the former study was to concentrate on identifying which of the expenditure-related inputs were statistically significant determinants of school output, while in the latter study, inputs found to be significant determinants were examined to determine their relative marginal contributions per additional $100 of expenditure on them.

The only other studies reviewed dealing with resource allocation concentrated on the problem of determining the form of the relationship between aggregate educational expenditure (in per pupil terms) and school output. In these studies (51, 52) estimates were made of the shape of the curve describing the expenditure-output relationship. This was done for several different types of school districts, distinguished primarily by size and location. It was found that the effect of expenditure on output varied among the types. The models specified in these studies were linear or log regressions of output on several inputs, one of which was level of per pupil expenditure.

Summary

Chapter II has reviewed questions of model specification as they are dealt with in the literature on educational production functions. It was found that most educational production function models are single output models, though the definition of output may vary; that the relationships between inputs and outputs are generally postulated as linear in nature; and that the marginal contribution of any input is only infrequently postulated as depending on the levels of usage of other inputs. The "typical" model used the average value of variables for a school or school district as the unit of specification. Variables may be specified in monetary, real, or in both monetary and real terms, sometimes redundantly so. A few studies postulated curvilinear relationships or relationships in which the effect on output of a given input may depend on the level of usage of other inputs; a small number of attempts were made to remove educational production function specification from the realm of cross-sectional analysis; however, few attempts were made to use the results of production function studies to determine patterns of efficient resource allocation.

Chapter III will review methods of model estimation used to determine empirical input-output relationships in education. Several statistical problems encountered in the literature and which affect the reliability of estimates will also be discussed.

CHAPTER III

TECHNIQUES OF MODEL ESTIMATION

This chapter examines methods of parameter estimation used most frequently in the educational production function literature. The first two parts of the chapter deal with basic variants of regression technique used in model estimation, including classic linear regression, stepwise regression, and the commonality or interaction effect method of regression analysis. The third part of this chapter reviews the use of correlational techniques as a means of model estimation.

Use of Classic Least Squares in Model Estimation

Classic least squares regression was found to be the most commonly used estimation technique. Least squares estimates are selected in such a way as to minimize the sum of the squared deviations about the regression line. When certain assumptions concerning the error term are met, least squares estimates of population parameters have the advantage of being BLUE estimates.[8] BLUE estimates are linear functions of the actual observations on the dependent variable; they are unbiased estimates of the relevant population parameters, i.e., the mean of the sampling distribution of any regression coefficient is equal to the relevant population parameter; and they are best linear unbiased estimators in the sense that the least squares estimates have the smallest possible variance.

In the classic least squares model the effects of all independent variables are estimated simultaneously. The effect of each independent

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[8]See for example, J. Johnson, Econometric Methods. McGraw-Hill Book Company, Inc. New York: 1963, pp. 14-17.

variable on the dependent variable is estimated, simultaneously taking into account the effects of the other independent variables on the dependent variable. Thus, the effect of any one independent variable on the dependent variable can be studied when the effect of all other variables, insofar as they are specified in the model, are held constant. This aspect of the classical model is one of its most attractive since the question of adequate controls is important in determining the credibility of statistical estimates.

Detracting from the efficacy of classic least squares estimates is their sensitivity to multicollinearity. Estimates of all parameters generated by classic least squares methods are a function of the level of multicollinearity in a model.[9] Only a few of the studies (49, 51, 53, 54) noted that multicollinearity among inputs could affect the accuracy of estimates and attempted to minimize the extent to which this problem characterized the data.

The most frequently used means of limiting the extent of multicollinearity among inputs was factor analysis. Once the factor analysis was accomplished, for each factor a variable which loaded highly on it was selected as representative of all the variables loaded on that factor and entered in the regression model as a proxy for them. Hence, while not all variables were entered, at least one representing each factor was, and this reduced the amount of intercorrelation that otherwise would have characterized the model.

Study 54 further pruned input intercorrelation by using stepwise regression to eliminate some of the factor-representative variables from the model.

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[9] For a fairly extensive discussion of this phenomenon, see Carl A. Fox. Intermediate Economic Statistics. John Wiley and Sons, Inc. New York: 1968, Chapters 7 and 13.

Another technique to reduce the effects of intercorrelation was used in study 51. A production function was specified which included several categories of inputs, but it was found that the policy-controllable input variables tended to be multicollinear. To circumvent this problem, several models were estimated, each including only one or two of the policy-controllable inputs along with all of the inputs in categories not under control of school officials.

It was not claimed in any of these studies that the procedures employed to reduce the pervasiveness of the multicollinearity problem were totally successful. Rather they may be viewed, in the loosest sense, as "second best"[10] alternatives, since the optimal situation was not feasible, and there were costs involved in reducing the level of collinearity. Each partial solution presented its own problems. Use of only factor-representative variables results in incomplete specification of the production function, although some information is gained about the relative effects of different categories of inputs in the production process. Use of stepwise regression in the presence of multicollinearity can result in ambiguous interpretations about the significance of inputs. Entry of only one of a group of intercorrelated inputs into an otherwise fully specified model makes it impossible to attribute the estimated relationship solely to the input of interest, since its apparent effect on the dependent variable may not indicate with certainty a direct influence; it may be instead serving as a proxy for another input which does affect the dependent variable.

[10] See study 51, p. 93 for the exact contextual usage of the term.

The only other procedure reviewed which may reduce the multicollinearity problem in classic least squares models was that of variable grouping (or clustering) of highly intercorrelated variables found in a data set. This approach was discussed in chapter II.

Use of Stepwise Regression in Model Estimation

Studies 11, 13, 15, 19, 44, 84, used stepwise regression to estimate production function parameters. In stepwise regression models, variables are added to (or subtracted from) the regression model one at a time to determine whether they significantly contribute to the explanatory power of the model. If so, they are maintained in the model; and if not, they are dropped from the model. It has been argued that this technique is equivalent to ascertaining the significance of a regression coefficient through the use of the t test.[11] Stepwise regression uses the classic least squares estimation technique and has all the properties of this technique pointed out in the previous section. However, unlike the least squares approach, which simultaneously estimates the parameters for all variables, stepwise regression ascertains the significance of inputs in terms of their relative contribution to the amount of explained variance.

Stepwise regression has been the subject of substantial controversy in the literature. Studies 11 and 84 show that in the presence of multicollinearity, the ability of a variable to explain variance in the regression depends on the order in which the variables are entered; the later a variable is entered, the smaller will be the estimate of its contribution to explained variance. Hence, given the same set of data, it is possible

[11] Johnson, op.cit. p. 125.

for an independent variable to appear to be either a major determinant or an insignificant determinant of the variation in the dependent variable, depending on whether the independent variable was entered first or last in the regression.

The Coleman Report (study 19) is a case in point. This report is one of the most impressive attempts to date to provide a comprehensive, empirically-based understanding of the multitude of school, student, and community factors that affect student achievement. Through the use of stepwise regression, Coleman and his associates determined that student background factors were the primary determinants of academic performance and that the impact of school resources was minimal. The credibility of these findings was questioned in part because of the use of "inappropriate statistical technique used in the presence of interdependence among the independent variables,"[12] namely, stepwise regression, in which "when the explanatory variables X_1 and X_2 are highly intercorrelated with each other, as are background characteristics of students and the characteristics of the schools that they attend, the addition to the proportion of variance in achievement that each will explain is dependent on the order in which each is entered into the regression equation."[13] Hence, given the order in which nonschool and school factors are entered into the Coleman regressions, ..."the importance of background factors in accounting for differences in achievement is systematically inflated and the role of school resources is consistently underestimated."[14] Data from the Coleman report itself illustrate the problem.[15] In one analysis, the amount of variance accounted for

[12]Study 13, p. 3.
[13]Study 12, p. 15.
[14]Study 12, p. 16.
[15]Study 18, p. 241.

by teacher characteristics when they were entered third in the regression, after family background and school characteristics, was 5.4 percent. When the student environment factor was then added, its contribution was 3.1 percent. Thus, it would seem that teacher characteristics have more impact on student achievement than does student environment. Yet, as Coleman shows, reversing their order of entry in the analysis reverses also their relative importance, leaving teacher characteristics accounting for only about one-third as much variance as the student environment variable.

Smith's examination of the Coleman data demonstrates even more clearly the ambiguity which can result when stepwise regression is used on multicollinear data.[16] Smith shows that when student background, student body characteristics, and school facilities and curriculum are entered into the regression analysis in that order, student background appears to be the most important influence on student achievement, student body characteristics next, and school characteristics least. This order of entry closely resembles Coleman's and the results are similar to his conclusions about the relative impact of these factors on student achievement. However, Smith shows that reversing the order of entry into the regression analysis reverses the apparent relative impact of factors. School characteristics now appear to be the most important determinants of school achievement and student background the least.

These studies illustrate some of the problems of using stepwise regression as a means of determining the relative importance of variables entering the production function. In the presence of multicollinear data the method yields ambiguous results. Simultaneous estimation of all production function parameters by specifying a complete model prior to estimation

[16] Study 84, p. 385.

may avoid this problem and is the method preferred by at least some of the stepwise regression critics.[17]

Given perfect orthogonality between the independent variables, order of entry in stepwise regression analysis does not affect estimates of the relative contribution of inputs to explained variance. However, perfect orthogonality is rarely, if ever, found in studying school systems. In the usual case, any one variable is partially orthogonal with respect to the others, but also imperfectly collinear with them. As a result, addition or subtraction of a variable from the regression will alter the amount of variance explained to some extent regardless of the order of entry. However the additional variance explained by a newly-entered variable will depend on its degree of collinearity with variables already entered; the greater the degree of collinearity, the less its independent contribution to explained variance can be. Studies 61 and 63 are responsible for developing a method of determining what part of the total variance in the dependent variable can be accounted for only by a given independent variable, and what part of the variance it and other variables share in common. Isolation of the unique and common portions of explained variance is achieved in the following manner, derived from simple set theory:

Let $C(X_1, X_2)$ = the part of the explained variance which can be accounted for equally by either X_1 or X_2 due to the collinearity between them.

Let $R^2(X_i)$ = the variance accounted for by regressing X_i on the dependent variable $(i = 1, 2)$.

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[17]See Study 11, p. 399.

Let $R^2(X_1, X_2)$ = the variance accounted for by regressing X_1 and X_2 on the dependent variable.

Let $U(X_i)$ = the part of the explained variance attributable to the orthogonal component of $X_i (i = 1, 2)$.

Then $U(X_1) = R^2(X_1,X_2)-R^2(X_2)$ = the unique contribution to explained variance of X_1.

And $U(X_2) = R^2(X_1,X_2)-R^2(X_1)$ = the unique contribution to explained variance of X_2.

As a result, the amount of variance which can be explained by either X_1 or X_2 is $C(X_1,X_2) = R^2(X_1,X_2)-U(X_1)-U(X_2)$.

This estimate provides information as to the extent to which the estimate of the relative contribution of a given variable to explained variance will vary as the order of entry of the variable into regression is altered. This follows since the first variable entered picks up that unique portion of the variance which either X_1 or X_2 can account for. The second variable entered can only pick up its own unique portion, since the commonality portion has already been attributed to entry of the first variable.

Use of Correlational Techniques in Model Estimation

A correlation coefficient is a measure of the linear relationship between two variables. In this respect it is similar to a regression coefficient, and in the simple regression case the slope of the regression line is merely the correlation coefficient for the independent and dependent variable adjusted for the difference in magnitude of the two variables. Hence, one might reasonably expect that application of correlation analysis to input-output data might yield insight into the nature of production relationships. Studies 16, 34, 36, 40, 56, 66, 67, 74, 79, 91, 95, and 97 used correlation analysis to estimate production relationships.

The correlation coefficient can be used to determine whether a relationship exists between two variables, and the square of a correlation coefficient indicates the proportion of variance in one variable explained by the other. However, they do not directly provide information about the magnitude of change in student performance to be expected from a given sized change in the level of input usage. Hence, as a method of estimation, correlation yields less information about production relationships than does regression analysis.

Correlation models can be completely or incompletely specified, as can regression models. A zero order correlation model is the most common correlation model in the literature reviewed and it represents the postulation of a single input production function. A few of the studies reviewed (studies 36, 40, 56, 67, 79) used multiple input models using partial correlation analysis to determine whether, controlling for the effects of other independent variables, any one independent variable was a significant correlate of the dependent variable.

Partial correlation estimates are sensitive to the presence of multicollinearity in the same way as are regression coefficients in stepwise regression. In the absence of perfect orthogonality between independent variables correlation coefficients can change substantially from their zero order levels when other independent variables are controlled for in partial correlation analysis. For this reason, the ability of a particular variable to contribute to explained variance depends in part on whether variables with which it is collinear are controlled for when the estimate is made.

CHAPTER IV

REVIEW OF DATA SYSTEMS USED

One of the most serious problems researchers must reckon with is that of finding a data base comprehensive enough and consistent enough to allow them to test hypotheses about interrelationships among variables. The problem of finding a data base for testing hypotheses about the nature and form of educational production functions is especially acute in this respect. Few data systems developed at either the state or national level have been comprehensive enough to serve as a data base for production function estimation. Researchers seeking to find empirical answers to questions concerning educational input-output relationships have found it necessary to search out educational institutions willing to participate in research projects, design their own sampling instruments, collect raw data, and process it in such a way as to make it usable for research purposes. The lack of time and resources on the part of individuals and the reluctance of institutions to invest in long-range research projects have stunted the development of comprehensive data systems in education.

The extent of the shortage of formal data systems for use in research is dramatized by the fact that not one of the studies examined in this review used data drawn entirely from established and continuing data systems, and only a few studies used any data at all from such sources. In all the studies reviewed, the data used was originally collected on a "one-shot" basis, generally with the needs of a specific study in mind.

Currently, the situation is improving somewhat. The need for comprehensive data systems for research and decision-making purposes is being recognized, and many educational agencies are rapidly developing and publishing comprehensive uniform educational data systems on a continuing basis. As a result, it seems that future efforts to analyze educational input-output relationships will not require nearly so much independent data collection and processing as has characterized research efforts in the past.

This section reviews briefly the major data bases used to estimate input-output relationships in education. Table 9 lists the major studies included in this review and the data bases used in each, insofar as it was determinable. Since specific studies often examined more than one model, the number of studies listed is fewer than the number of models analyzed in this review. Most data sets were used for only one study, though two sets of data have been used by a number of different researchers. The data collected in 1959 and 1965 by the New York State Education Department's Quality Measurement Project[18] were used as the data base for 16 individual studies considered in this review. These data include input and output data for 97 New York State school districts.

A second data set used by a number of researchers was that collected for the Coleman Report. It was based on a 5 percent nationwide sample of schools and was collected in 1965 under the sponsorship of the United States Office of Education.[19] This data set was used in eight of the studies reviewed.

[18] See study 40 and Toward an Evaluation of Education. New York State Education Department, Bureau of School Programs Evaluation. 1969.

[19] See study 19.

Table 9

DATA SYSTEMS USED IN PRODUCTION FUNCTION STUDIES

Study No.	
2	All California SMSA elementary schools
4	48 colleges; 4,121 students
4	Over 100 colleges & universities
11	Coleman data (4,000 schools; over 20,000 students)
13	39 Chicago; 22 Atlanta; and 206 small community high schools
15	100 Pennsylvania schools
16	Canadian education data
19	Coleman data
20	1960 census
22	45,000 students
24	6 schools
34	QMP (over 90 school districts; over 20,000 students)
36	39 Conn. schools;5,745 students
40	QMP
44	206 schools
48	QMP
49	QMP
51	QMP
52	QMP
53	QMP
54	QMP
56	Not noted in study
57	Coleman data
61	Coleman data
63	Coleman data
66	844 schools nationwide
67	Cross section of Penn. schools and 27 high expenditure NYS districts
69	281 college students
73	QMP
74	QMP
76	QMP
79	459 Iowa school districts
84	Coleman data
85	Not noted in study
90	339 NY Districts
91	65 NY Metropolitan districts
95	QMP
96	QMP
97	38 NY Metropolitan districts

CHAPTER V

THE DETERMINANTS OF THE LEVEL OF EDUCATIONAL PERFORMANCE: EMPIRICAL FINDINGS AND POLICY IMPLICATIONS

Earlier in this report* an attempt was made to ascertain whether consensus exists among educational researchers as to the determinants of educational output, where output was defined as the level of student performance in the cognitive and noncognitive domains. The underlying assumption was that the models specified in educational input-output analysis studies represent educators' understanding of what the major factors affecting student performance are. The larger the number of studies in which a given variable appeared, the more confidence could be felt in concluding that a "consensus" existed among schoolmen that the variable affected student performance. Table 7 (p. 39) lists the variables most frequently postulated as determinants of educational output.

It was found that these variables could be designated as either fixed or policy-controllable inputs in the production process. The fixed inputs most commonly used were student IQ, student socioeconomic status, student race, and school or school district size.

Another group of inputs, whose quantities could be varied by school managers were also commonly postulated as influencing the level of production. The most commonly used policy-controllable inputs were teacher experience and degree status, class size, the quantity and quality of books and other instructional supplies used, and the numbers of special staff (especially guidance counselors).

*See "Summary of Variables Generally Postulated as Entering the Production Function for Education," pp. 36-41.

Together, these fixed and policy-controllable inputs comprise a certain consensus. In this respect, they represent the component parts of what may be called the theory of education production--or at least they represent those components widely enough held to be determinants of student performance as to be frequently subjected to testing. Many other variables have been postulated as determining the level of student performance or some other definition of school quality, but not with the frequency of those listed above. Findings have been reported here of 110 variables thought to affect student performance; however, more than half of these variables have been used only in a single study and thus, do not fit into a meaninful definition of a theory of production.

This chapter summarizes research findings concerning the inputs which can be verified empirically as related to school output. It is shown that certain inputs are consistently verified by research to be related to the level of educational output, while others consistently fail to appear significant in attempts to verify their importance.

The first part of this chapter describes the method by which results of a large number of studies concerning a specific input are organized into an overall conclusion as to whether the variable is a significant determinant of the level of output. The second part discusses the findings of researchers concerning fixed inputs. The third part discusses the conclusions found in the literature concerning the question of the impact of schooling on the level of student achievement. A fourth part discusses the conclusions in the literature about which policy-controllable inputs affect school performance levels. A final section discusses the findings concerning financial variables and their relation to educational output.

Methods Used To Summarize the Findings

Table 10 presents the findings, variable by variable, of each study reviewed. Each column heading represents a variable used in a least one study and for which findings are reported. Each row represents a specific study, or model in a study. The study number can be used to identify, from the bibliography, the study represented by a particular row. The code next to the study number indicates whether the study used a cognitive output definition (i.e., academic skills) and a regression technique(CR), a cognitive output definition and correlational technique (CC), a noncognitive output definition (i.e., personality traits and attitudes) and regression technique (NCR), an adaptability definition (A), or some other combination of output and technique (O).

Each cell in the matrix represents the findings of a particular study concerning a particular variable. Four types of findings are given:

1. Sig+ indicates that, in the study in question, the variable was found to be a significant determinant of the relevant measure of school output.

2. Sig- indicates that the variable was perversely significant in the sense that it was found to affect (significantly) school output in a way opposite to that which theory suggests (e.g., the larger the class size, the better student performance).

3. Ambg indicates that results from the study were ambiguous, that is the variable was sometimes found to be significant and sometimes not or the results of testing the variables were not presented clearly enough to allow easy determination of its significance.

4. Nsig indicates that no relationship was found between the input variable and the output measure.

In a few instances, a cell contains more than one indication of the findings. This sometimes occurs when a particular study used more than one model. In such situations, findings for all variables entered in either model are reported.

Table 10

SIGNIFICANCE OF INDIVIDUAL INPUT VARIABLES IN EACH STUDY IN WHICH THEY WERE USED

Study Number & Type \ Input Variables	1 Programed Learning	2 Amount of Formal Education	3 Student Ability Score	4 General Quality of Students at School	5 College Type (State, L.A., Univ.)	6 Teaching Experience	7 Class Size or T/P	8 Formal Course in Subject	9 Quality of Course Materials	10 "Better" Trained Teachers in the Subject Taught	11 TV Teaching	12 Pretest Score	13 Student Major	14 Amount of Student Formal Training in the Subject	15 Teacher Verbal Score	17 IQ	18 School Size	19 Expenditure	20 S.E. (Father Occupation)	21 Instructional Material($)/P	22 Teacher Salary	23 Administrative Salary or Expend.	24 Teacher Degree Status	25 Teacher Certification	26 Special Staff / P	27 # of Prin. & Supvr. Per Pupil	28 Teacher Age	29 Teacher Marital Status	30 Noncognitive Outputs	31 S.E. (Many or Other)
4 (CR)	sig +	sig +	sig +	sig +	sig +	nsig	nsig		sig +								sig +													
92 (O)								sig +																						
60 (CR)								sig +	sig +	sig +		sig +				sig +														
41 (O)											3sg+ 1sg-																			
58 (O)	sig +																													
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5 (CR)													sig +	sig +																
57 (CR)						sig +									sig +															sig +
52 (CR)																sig +	nsig	nsig	sig +											
78 (O)																sig +			sig +											
54 (CR)							sig -												sig +	sig -	sig +	sig +								
48a (CR)						ambg sig+	nsig														nsig	sig +	nsig	nsig						
48b (CR)						nsig															sig +	sig +								
49 (CR)							sig +									sig +					sig +				nsig	nsig				
51 (CR)							sig +									sig +		ambg	sig +	ambg	sig +				sig +	sig -				
76 (CR)						sig -										sig +		sig+ ambg	sig +				ambg					sig +		
61a (CC)																													sig +	sig+
61b (CR, NCR)																														

Table 10 (cont'd)

SIGNIFICANCE OF INDIVIDUAL INPUT VARIABLES IN
EACH STUDY IN WHICH THEY WERE USED

Input Variables / Study Number & Type	32 School Inputs Uniquely	33 Community Uniquely	34 School & Community in Common	35 SE (Father's Education)	36 Teacher Perception of School Climate	37 SE (Mother's Education)	38 Continuing Education (% to College)	39 Library Books Pupils	40 Location (Urban-Rural) or Region	41 Teacher Aspirations	42 Staff/Pupil	43 SE Teacher	44 Effort Index	45 Housing Types	46 Innovative Scale	47 Holding Power	48 Absentee Rate	49 Population Trend	50 Teacher View of Prof. Recognition	51 Retention Rate	52 Instruction	53 Attitude Toward Learning	54 School Building Age	55 Putting Low SE in Higher SE School	56 Principal Salary	57 Superintendent's Salary	58 Growing Edge	59 Teaching Emphasis on Subject Matter	60 Careful Classroom Preparation	61 Imaginative Classroom Practice
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61a (CC)																														
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Table 10 (cont'd)

SIGNIFICANCE OF INDIVIDUAL INPUT VARIABLES IN EACH STUDY IN WHICH THEY WERE USED

Input Variables / Study Number & Type	62 Student Attitude Toward Life, Author.	63 Number of Laboratories	64 Presence of Extra-curricular Activ.	65 Availability of Col. Prep.& Accelr. Curr.	66 Comprehensive Curriculum Track.	67 School's Explain Variance	68 Student Feeling of Control over Destiny	69 SE (Family Background)	70 Race	71 Student Body Characteristics	72 Student Self-concept & Interest in School	73 Form of Variables in Equation(Linear,etc)	74 Student Motivation	75 SE (Income)	76 Community Size	77 Comprehensive H.S.	78 Small Grade Span in School	79 % of Pop. Not Enrolled in Schools	80 Property Tax	81 Average of Professional Staff (Age)	82 Average Staff Salary	83 % Mature, Broadly Trained & Exp. Staff	84 % Young, Well Grounded Staff	85 Character of Tax & Budget Power of Dist	86 State Aid to School District	87 Dist. working arrang. vis-a-vis decision making	88 Legal Structure, etc Influen. Policy	89 Legal Structure Influen. Sch. Charac.	90 Legal Structure, etc. Influen. Process	91 District Wealth
4 (CR)																														
92 (O)																														
60 (CR)																														
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49 (CR)																														
51 (CR)																														
76 (CR)																														
61a (CC)																														
61b (CR,NCR)																														

Table 10 (cont'd)

SIGNIFICANCE OF INDIVIDUAL INPUT VARIABLES IN EACH STUDY IN WHICH THEY WERE USED

Input Variables / Study Number & Type	Process or (See 58) Growing Edge 92	% Of Labor Force in Manufacturing 93	Amount of Homework 94	Dropouts 95	Delinquency Problems 96	Existence of Guidance Program 97	Numerical Staff Adequacy 98	Number of Curriculum Units 99	Teacher Turnover 100	Total Number of Professional Staff 101	% of Staff From Outside District 102	% of Staff in 6 or More Prof. Groups 103	Staff Travel 104	Student Sex 105	Reading Ability of Student 106	Extent of Math Training 107	Value of District Property 108	District Growth Rate 109	Plant and Equipment Value 110	Textbook Quality 111											
4 (CR)														sig +																	
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51 (CR)																		nsg	ambg												
76 (CR)																															
61a (CC)																															
61b (CR,NCR)																															

Table 10 (cont'd)

SIGNIFICANCE OF INDIVIDUAL INPUT VARIABLES IN EACH STUDY IN WHICH THEY WERE USED

Study Number & Type \ Input Variables	Programmed Learning 1	Amount of Formal Education 2	Student Ability Score 3	General Quality of Students at School 4	College Type(State, L.A. Univ) 5	Teaching Experience 6	Class Size or T/P 7	Formal Course in Subject 8	Quality of Course Materials 9	"Better" Trained Teachers in the Subject Taught 10	TV Teaching 11	Pretest Score 12	Student Major 13	Amount of Student Formal Training in the Subject 14	Teacher Verbal Score 15	IQ 17	School Size 18	Expenditure 19	S.E. (Father Occupation) 20	Instructional Material($)/P 21	Teacher Salary 22	Administrative Salary or Expend. 23	Teacher Degree Status 24	Teacher Certification 25	Special Staff / P 26	# of Prin. & Supvr. Per Pupil 27	Teacher Age 28	Teacher Marital Status 29	Noncognitive Outputs 30	S.E. (Many or Other) 31
15a (NCR)						nsig										sig +		nsig	nsig				sig +				sig +		sig +	
15b (NCR)						sig +										sig +		nsig	sig +				sig +		sig +					
15c (CR)						sig +	sig +									sig +			sig +											
15d (NCR)						sig +	nsig									sig +		sig +	nsg						sig +					
15e (NCR)						nsig	nsig									sig +	nsig	nsig	sig +		sig +				sig +	sig +				
15f (NCR)						sig +										sig+ nsig			sig+ nsig						nsig		sig +			
15g (NCR)						sig +										sig +					nsig		sig +	sig +	nsig					
15h (NCR)						sig +										sig .		nsig	sig -		nsig				sig +					
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15j (NCR)							nsig									sig +		sig +	sig +		sig +									
77 (CR)																														
96 (CR)																sig +		nsig	nsig											
36 (CC)						sig +										sig +		nsig												sig +
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13 (CR)						sig +	nsig										nsig	nsig		nsig	sig +				nsig	nsig				
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53 (CR)						nsig	sig +														sig +					sig -				
95 (CC)																sig +		sig +	sig +											

Table 10 (cont'd)

SIGNIFICANCE OF INDIVIDUAL INPUT VARIABLES IN
EACH STUDY IN WHICH THEY WERE USED

Input Variables / Study Number & Type	School Inputs Uniquely 32	Community Uniquely 33	School & Community in Common 34	SE (Father's Education) 35	Teacher Perception of School Climate 36	SE (Mother's Education) 37	Continuing Educ. (% to College) 38	Library Books / Pupils 39	Location (Urban Rural) or Region 40	Teacher Aspirations 41	Staff/Pupil 42	SE Teacher 43	Effort Index 44	Housing Types 45	Innovative Scale 46	Holding Power 47	Absentee Rate 48	Population Trend 49	Teacher View of Prof. Recognition 50	Retention Rate 51	Instruction 52	Attitude Toward Learning 53	School Building Age 54	Putting Low SE in Higher SE School 55	Principal Salary 56	Superintendent's Salary 57	Growing Edge 58	Teaching Emphasis on Subject Matter 59	Careful Classroom Preparation 60	Imaginative Classroom Practice 61
15a (NCR)				sig +	sig +	nsg	nsg					sig +																		
15b (NCR)						nsg	nsg		sig +			sig +																		
15c (CR)								sig +	sig +	sig +			sig +																	
15d (NCR)				sig +					sig +	sig +				sig +	sig +															
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Table 10 (cont'd)

SIGNIFICANCE OF INDIVIDUAL INPUT VARIABLES IN EACH STUDY IN WHICH THEY WERE USED

Study Number & Type / Input Variables	62 Student Attitude Toward Life	63 Number of Laboratories	64 Presence of Extra-Curricular Activ.	65 Availability of Col. Prep.& Accelr. Curr.	66 Comprehensive Curriculum Track	67 School's Explain Variance	68 Student Feeling of Control Over Destiny	69 SE (Family Background)	70 Race	71 Student Body Characteristics	72 Student Self-concept & Interest in School	73 Form of Variables in Equation (Linear, etc.	74 Student Motivation	75 SE (Income)	76 Community Size	77 Comprehensive H.S.	78 Small Grade Span in School	79 % of Pop. not Enrolled in Schools	80 Property Tax	81 Average of Professional Staff (Age)	82 Average Staff Salary	83 % Mature, Broadly Trained & Exp. Staff	84 % Young, Well Grounded Staff	85 Character of Tax & Budget Power of Dist	86 State Aid to School District	87 Dist. Working Arrang. Vis-a-vis Decision Making	88 Legal Structure, etc. Influen. Policy	89 Legal Structure, etc. Influen. Sch. Charac.	90 Legal Structure, etc. Influen. Ed. Process	91 District Wealth
15a (NCR)									nsg																					
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Table 10 (cont'd)

SIGNIFICANCE OF INDIVIDUAL INPUT VARIABLES IN EACH STUDY IN WHICH THEY WERE USED

Study Number & Type / Input Variables	Process or (see 58) Growing Edge 92	% Of Labor Force in Manufacturing 93	Amount of Homework 94	Dropouts 95	Delinquency Problems 96	Existence of Guidance Program 97	Numerical Staff Adequacy 98	Number of Curriculum Units 99	Teacher Turnover 100	Total Number of Professional Staff 101	% Of Staff From Outside District 102	% of Staff in 6 or More Prof. Groups 103	Staff Travel 104	Student Sex 105	Reading Ability of Student 106	Extent of Math Training 107	Value of District Property 108	District Growth Rate 109	Plant and Equipment Value 110	Textbook Quality 111
15a (NCR)																				
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53 (CR)																				
95 (CC)																				

Table 10 (cont'd)

SIGNIFICANCE OF INDIVIDUAL INPUT VARIABLES IN EACH STUDY IN WHICH THEY WERE USED

Study Number & Type \ Input Variables	1 Programmed Learning	2 Amount of Formal Education	3 Student Ability Score	4 General Quality of Students at School	5 College Type(State, L.A., Univ.)	6 Teaching Experience	7 Class Size or T/P	8 Formal Course in Subject	9 Quality of Course Materials	10 "Better" Trained Teachers in the Subject Taught	11 TV Teaching	12 Pretest Score	13 Student Major	14 Amount of Student Formal Training in the Subject	15 Teacher Verbal Score	17 IQ	18 School Size	19 Expenditure	20 S.E. (Father Occupation)	21 Instructional Material($)/P	22 Teacher Salary	23 Administrative Salary or Expend.	24 Teacher Degree Status	25 Teacher Certification	26 Special Staff P	27 # of Prin. & Supvr. Per Pupil	28 Teacher Age	29 Teacher Marital Status	30 Noncognitive Outputs	31 S.E. (Many or Other)
73 (CR)																sig +			sig +											
40 (CC)																sig +		ambg	sig +				sig +		ambg					
19 (CR)						sig +	nsig								sig +		nsig	nsig			sig +		sig +							sig +
24 (NCR)																		sig +												
3 (CR)																														
56 (CC)																sig +														sig +
44 (CR)						ambg	ambg											nsig			sig +									
36 (CR,NCR)																													sig +	
2 (CR)																	nsig	nsig												
20 (NCR)																														sig +
84 (CR)																														sig +
16 (CC)																		sig +					sig +							
11 (CR)															sig +						sig +									sig +
74 (CR)						sig -										sig +		sig +	sig +				sig +				sig -	sig +		
79 (A)						sig +	nsig											nsig					sig +							
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90 (A)																	sig +	sig +												sig +
97 (A)																		nsig												

Table 10 (cont'd)

SIGNIFICANCE OF INDIVIDUAL INPUT VARIABLES IN EACH STUDY IN WHICH THEY WERE USED

Study Number & Type \ Input Variables	School Inputs Uniquely 32	Community Uniquely 33	School & Community in Common 34	SE (Father's Education) 35	Teacher Perception of School Climate 36	SE (Mother's Education) 37	Continuing Educ. (% to College) 38	Library Books Pupils 39	Location (Urban-Rural) or Region 40	Teacher Aspirations 41	Staff/Pupil 42	SE Teacher 43	Effort Index 44	Housing Types 45	Innovative Scale 46	Holding Power 47	Absentee Rate 48	Population Trend 49	Teacher View of Prof. Recognition 50	Retention Rate 51	Instruction 52	Attitude Toward Learning 53	School Building Age 54	Putting Low SE in Higher SE School 55	Principal Salary 56	Superintendent's Salary 57	Growing Edge 58	Teaching Emphasis on Subject Matter 59	Careful Classroom Preparation 60	Imaginative Class-room Practice 61
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Table 10 (cont'd)

SIGNIFICANCE OF INDIVIDUAL INPUT VARIABLES IN EACH STUDY IN WHICH THEY WERE USED

Study Number & Type \ Input Variables	62 Student Attitude Toward Life	63 Number of Laboratories	64 Presence of Extra-curricular Activ.	65 Availability of Col. Prep.& Accelr. Curr.	66 Comprehensive Curriculum Track	67 School's Explain Variance	68 Student Feeling of Control Over Destiny	69 SE (Family Background)	70 Race	71 Student Body Characteristics	72 Student Self-concept & Interest in School	73 Form of Variables in Equation(Linear,etc.)	74 Student Motivation	75 SE (Income)	76 Community Size	77 Comprehensive H.S.	78 Small Grade Span in School	79 % of Pop. Not Enrolled in Schools	80 Property Tax	81 Average of Professional Staff (Age)	82 Average Staff Salary	83 % Mature, Broadly Trained & Exp. Staff	84 % Young, Well Grounded Staff	85 Character of Tax & Budget Power of Dist.	86 State Aid to School District	87 Dist. working Arrang. Vis-à-Vis Decision Making	88 Legal Structure, etc Influen. Policy	89 Legal Structure, etc. Influen. Sch. Charac	90 Legal Structure, etc Influen. Ed. Process	91 District Wealth
73 (CR)																														
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24 (NCR)																														
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56 (CC)													sig +																	
44 (CR)														sig +	sig +	sig +	ambg													
36 (CR,NCR)																														
2 (CR)																														
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84 (CR)									sig +	sig +																				
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90 (A)																														sig +
97 (A)																														

Table 10 (cont'd)

SIGNIFICANCE OF INDIVIDUAL INPUT VARIABLES IN EACH STUDY IN WHICH THEY WERE USED

Input Variables / Study Number & Type	Process or (See 58) Growing Edge 92	% Of Labor Force in Manufacturing 93	Amount of Homework 94	Dropouts 95	Delinquency Problems 96	Existence of Guidance Program 97	Numerical Staff Adequacy 98	Number of Curriculum Units 99	Teacher Turnover 100	Total Number of Professional Staff 101	% of Staff From Outside District 102	% of Staff in 6 or More Prof. Groups 103	Staff Travel 104	Student Sex 105	Reading Ability of Student 106	Extent of Math Training 107	Value of District Property 108	District Growth Rate 109	Plant and Equipment Value 110	Textbook quality 111
73 (CR)																				
40 (CC)																				
19 (CR)																				sig +
24 (NCR)																				
3 (CR)																				
56 (CC)																				
44 (CR)		nsg	nsg	nsg	nsg	nsg														
63 (CR,NCR)																				
2 (CR)																				
20 (NCR)																				
84 (CR)																				
16 (CC)																				
11 (CR)																				
74 (CR)																				
79 (A)								sig +												
67 (A)																				
90 (A)																				
97 (A)																				

Table 10 (cont'd)

SIGNIFICANCE OF INDIVIDUAL INPUT VARIABLES IN EACH STUDY IN WHICH THEY WERE USED

Study Number & Type \ Input Variables	1 Programed Learning	2 Amount of Formal Education	3 Student Ability Score	4 General Quality of Students at School	5 College Type (State, L.A., Univ.)	6 Teaching Experience	7 Class Size or T/P	8 Formal Course in Subject	9 Quality of Course Materials	10 "Better" Trained Teachers in the Subject Taught	11 TV Teaching	12 Pretest Score	13 Student Major	14 Amount of Student Formal Training in the Subject	15 Teacher Verbal Score	17 IQ	18 School Size	19 Expenditure	20 S.E. (Father Occupation)	21 Instructional Material ($)/P	22 Teacher Salary	23 Administrative Salary or Expend.	24 Teacher Degree Status	25 Teacher Certification	26 Special Staff/P	27 # of Prin. & Supvr. Per Pupil	28 Teacher Age	29 Teacher Marital Status	30 Noncognitive Outputs	31 S.E. (Many or Other)
91 (CR, NCR)						nsig	sig											nsig			nsig				nsig					sig +
34 (CC)																														sig +
83 (A)							sig +										sig +	sig +												sig +
22 (CR)																sig +														
Gross Tally	2 sig+	2 sig+	2 sig+	1 sig+	2 sig+	13sg+ 2sg- 2amb 6nsg	7sg+ 1sg- 1amb 10nsg	3sg+ 1nsg	2sg+	1sg+	3sg+ 1sg-	2sg+	2sg+	1sg+	3sg+	25sg + 1nsg	3 sg + 7nsg	13sg+ 3amb 14nsg	16sg + 4nsg	1sg- 1amb 1nsg	12sg+ 4nsg	2sg+	9sg+ 1amb 1nsg	1sg+ 1nsg	5sg+ 1amb 5nsg	1sg+ 2sg- 2nsg	2sg+ 1sg-	2sg+	3sg+	14 sg+
Cog-Reg (CR)	1 sg+	2 sg+	2 sg+	1 sg+	1 sg+	5sg+ 2sg- 2amb 3nsg	5sg+ 1sg- 1amb 4nsg	2sg+ 1nsg	2sg+	1sg+		2sg+	2sg+	1sg+	3sg+	11sg+	1sg+ 6nsg	3sg+ 2amb 6nsg	7sg+ 1nsg	1sg- 1amb 1nsg	10sg+ 1nsg	2sg+	3sg+ 1 sg- 1amb	1nsg	1sg+ 2nsg	2sg- 2nsg	1sg-	2sg+		5 sg+
Noncog-Reg (NCR)					1 sg+	6sg+ 2nsg	4nsg									2sg+ 1nsg	1nsg	4sg+ 4nsg	6sg+ 3nsg		2sg+ 2nsg		3sg+	1sg+	4sg+ 2nsg	1sg+	2sg+			2sg+
Cog-Cor (CC)						1sg+ 1nsg	1nsg									4sg+		3sg+ 1amb 2nsg	2sg+		1nsg		2 sg+		1amb 1nsg				3sg+	4sg+
Adaptability (A)						1sg+	2sg+ 1nsg										2sg+	3sg+ 2nsg					1sg+							3sg+
Other (O)	1 sg+							1sg+			3sg+ 1sg-					1sg+			1sg+											

Table 10 (cont'd)

SIGNIFICANCE OF INDIVIDUAL INPUT VARIABLES IN
EACH STUDY IN WHICH THEY WERE USED

Study Number & Type \ Input Variables	32 School Inputs Uniquely	33 Community Uniquely	34 School & Community in Common	35 SE (Father's Education)	36 Teacher Perception of School Climate	37 SE (Mother's Education)	38 Continuing Education (% to College)	39 Library Books Pupils	40 Location (Urban-Rural) or Region	41 Teacher Aspirations	42 Staff/Pupil	43 SE Teacher	44 Effort Index	45 Housing Types	46 Innovative Scale
91 (CR, NCR)											nsg				
34 (CC)															
83 (A)															
22 (CR)															
Gross Tally	5 sig +	4 sig +	4 sig +	7 sig +	2 sig +	6sg + 2 nsg	3sg + 3 nsg	1sg+ 1amb 1nsg	6sg+ 2nsg	4 sig +	1 nsig	3 sig +	1sg+ 5nsg	3 sig +	1 sig +
Cog-Reg (CR)	3 sig +	2 sig +	2 sig +	2 sig +		5 sig +	1 sig +	1sg+ 1amb 1nsg	2sg+ 1nsg	1 sig +		1 sig +	1 sig +	1 sig +	
Noncog-Reg (NCR)	2 sig +	2 sig +	2 sig +	4 sig +	2 sig +	2 nsg	2sg + 3 nsg		4sg+ 1nsg	3 sig +		2 sig +	5 nsg	2 sig +	1 sig +
Cog-Cor (CC)				1 sig +		1 sig +					1 nsig				
Adaptability (A)															
Other (O)															

Study Number & Type \ Input Variables	47 Holding Power	48 Absentee Rate	49 Population Trend	50 Teacher View of Prof. Recognition	51 Retention Rate	52 Instruction	53 Attitude Toward Learning	54 School Building Age	55 Putting Low SE in Higher SE School	56 Principal Salary	57 Superintendent's Salary	58 Growing Edge	59 Teaching Emphasis on Subject Matter	60 Careful Classroom Preparation	61 Imaginative Classroom Practice
91 (CR, NCR)															
34 (CC)															
83 (A)															
22 (CR)															
Gross Tally	1 sig + 2nsg	4sg+ 2nsg	2nsg	1 sig +	1 nsg	1 sig +	1 sig +	2 sig +	1 sig +	2 sig +	1 nsg	1 sig +	1 sig +	1 sig -	1 sig -
Cog-Reg (CR)		1 sig +						2 sig +	1 sig +	2 sig +	1 nsg				
Noncog-Reg (NCR)	1sg+ 2nsg	3sg+ 2nsg	2nsg	1 sig +	1 nsg										
Cog-Cor (CC)						1 sig +	1 sig +					1 sig +	1 sig +	1 sig -	1 sig -
Adaptability (A)															
Other (O)															

Table 10 (cont'd)

SIGNIFICANCE OF INDIVIDUAL INPUT VARIABLES IN
EACH STUDY IN WHICH THEY WERE USED

Study Number & Type \ Input Variables	Student Attitude Toward Life 62	Number of Laboratories 63	Presence of Extra-curricular Activ. 64	Availability of Col Prep.& Accelr. Curr 65	Comprehensive Curriculum Track 66	School's Explain Variance 67	Student Feeling of Control over Destiny 68	SE (Family Back-ground) 69	Race 70	Student Body Characteristics 71	Student Self-concept & Interest in School 72	Form of Variables in Equation(Linear,etc. 73	Student Motivation 74	SE (Income) 75	Community Size 76
91 (CR,NCR)															
34 (CC)															
83 (A)															
22 (CR)												sig +			
Gross Tally	1 sig +	2 sig +	1 sig +	1 sig +	1 ambg	1 sig +	1 sig +	1 sig +	11 sig + 4nsg	2 sig +	1 sig +	2 sig +	1 sig +	2 sig +	1 sig +
Cog-Reg (CR)		2 sig +	1 sig +	1 sig +	1 ambg	1 sig +	1 sig +	1 sig +	5 sig +	2 sig +	1 sig +	2 sig +		2 sig +	1 sig +
Noncog-Reg (NCR)									6 sig + 4nsg						
Cog-Cor (CC)	1 sig +												1 sig +		
Adaptability (A)															
Other (O)															

Study Number & Type \ Input Variables	Comprehensive H.S. 77	Small Grade Span in School 78	% of Pop. Not En-rolled in Schools 79	Property Tax 80	Average of Profes-sional Staff(Age) 81	Average Staff Salary 82	% Mature,Broadly Trained & Exp.Staff 83	% Young, Well Grounded Staff 84	Character of Tax & Budget power of Dis 85	State Aid to School District 86	Dist. Working Arrang. Vis-A-Vis Decision Making 87	Legal Structure,etc. Influen. Policy 88	Legal Structure,etc Influen.Sch.Charac 89	Legal Structure,etc Influen. Ed.process 90	District Wealth 91	
91 (CR,NCR)																
34 (CC)																
83 (A)																
22 (CR)																
Gross Tally	1 sig +	1 ambg	1 sig -	1 sig -	1 sig +	1 sig +	1 sig +	1 sig +	1 sig +	1 sig +	1 sig +	1 sig +	1 sig +	1 sig +	1 sig +	
Cog-Reg (CR)	1 sig +	1 ambg		1 sig -												
Noncog-Reg (NCR)			1 sig -													
Cog-Cor (CC)																
Adaptability (A)					1 sig +	1 sig +	1 sig +	1 sig +	1 sig +	1 sig +	1 sig +	1 sig +	1 sig +	1 sig +	1 sig +	
Other (O)																

Table 10 (cont'd)

SIGNIFICANCE OF INDIVIDUAL INPUT VARIABLES IN
EACH STUDY IN WHICH THEY WERE USED

Input Variables / Study Number & Type	Process or (See 58) Growing Edge 92	% Of Labor Force in Manufacturing 93	Amount of Homework 94	Dropouts 95	Delinquency Problems 96	Existence of Guidance Program 97	Numerical Staff Adequacy 98	Number of Curriculum Units 99	Teacher Turnover 100	Total Number of Professional Staff 101	% of Staff From Outside District 102	% of Staff in 6 or More Prof. Groups 103	Staff Travel 104	Student Sex 105	Reading Ability of Student 106	Extent of Math Training 107	Value of District Property 108	District Growth Rate 109	Plant and Equipment Value 110	Textbook Quality 111
91 (CR,NCR)							nsg		nsg	nsg	nsg	nsg	nsg							
34 (CC)																				
83 (A)																				
22 (CR)																				
Gross Tally		1 nsg	1 nsg	1 nsg	1 nsg	1 nsg	1 nsg	1 sig +	1 nsg	1 nsg	1 nsg	1 nsg	1 nsg	1 sig +	1 sig +	1 nsg	1 nsg	1 ambg 1 nsg	1 ambg	1 sig +
Cog-Reg (CR)		1 nsg	1 nsg	1 nsg	1 nsg	1 nsg								1 sig +	1 sig +	1 nsg	1 nsg	1 ambg 1 nsg	1 ambg	1 sig +
Noncog-Reg (NCR)																				
Cog-Cor (CC)							1 nsg		1 nsg	1 nsg	1 nsg	1 nsg	1 nsg							
Adaptability (A)								1 sig +												
Other (O)																				

At the end of table 10 (pages 86-89),column tallies are presented showing the number of times each variable was found to be significant (sig+), perversely significant (sig-), ambiguous (ambg), and nonsignificant (nsig) in the studies reviewed. The gross tally shows totals for all studies together, while the last five rows show totals for each of the categories of studies: cognitive-regression (CR), noncognitive-regression (NCR), cognitive-correlation (CC), adaptability (A), and other (O).

Though somewhat arduous to read, table 10 allows the reader with special interest in one or more specific inputs to determine easily which studies dealt with those inputs and what the findings were. More important to the purposes of this review, the tallies in table 10 make it possible to compute for each input variable the proportion of significant occurrences in the studies reviewed.

The proportion of significant occurrences for each input variable was computed by dividing the number of times a variable was found to be significantly related (sig+) to the level of student performance by the total number of models in which the variable was used. While choosing the numerator for the computations was a straightforward task, the choice of an appropriate denominator presented some problems. Using the total number of models in which a variable was used would tend to underestimate the frequency with which a variable is found to affect the level of output. For example, numerous statistical and specification problems can result in the conclusion that a particular variable's relationship to the output measure is perverse, or at least ambiguous. Entering studies in which these types of results obtained into the "total" number used as denominator would bias downward the estimate of how consistently a given variable is found to influence the level of output.

However, minimizing the chances of identifying a variable as a significant determinant of the level of production, when in fact it may not be seems to be a real benefit. For this reason, ratios were computed as the number of times a variable was found significant (sig+) relative to the total number of times it was used and expressed as a percentage.

Table 11 presents significance percentages for the most frequently used variables in table 10. The columns in table 11 represent the different output-technique types of studies encountered in this review. Each row represents a specific variable and the percent in each cell represents the proportion of the number of times the variable was tested that it was found significantly related to student performance. The number in parentheses represents the total number of studies upon which the percent determination was based.

Variables from this table can be classified as fixed inputs, variable inputs, or financial inputs. Their relative significance will be discussed in the four remaining sectionsof this chapter.

One remaining question is what percent of the time a variable must appear significantly related to individual student or school average performance in order to warrant being classed as an output determinant. One does not expect perfect consistency in the findings of research efforts. Inconsistency could result from imperfections in the application of statistical techniques, unrepresentative samples, or ambiguously stated hypotheses. Such problems are especially likely in investigating very complex interrelationships and in those areas where the tradition of rigorous investigation is still in its infancy. The investigation of production interrelationships in education fits both these conditions. Therefore, there

Table 11

PERCENT OF STUDIES IN WHICH CERTAIN INPUTS WERE FOUND SIGNIFICANT AND THE NUMBER OF STUDIES IN WHICH THEY WERE USED

VARIABLE	VARIABLE NUMBERS*	TYPE OF STUDY					
		All Studies	Cognitive Output Regression Studies	Noncognitive Output Regression Studies	Cognitive Output Correlation Studies	Adaptability Studies	Other Studies
Student's IQ	3, 17	98% (28)	100% (13)	90% (10)	100% (4)		100% (1)
Student's Socio-economic Status (SE)	20, 31, 33, 35, 37, 40, 45, 69, 75	88% (67)	93% (29)	77% (26)	100% (8)	100% (3)	100% (1)
Student's Race	70	73% (15)	100% (5)	60% (10)			
Formal Schooling	2, 8, 14, 32, 67	92% (13)	90% (10)	100% (2)			100% (1)
Programed Learning	1	100% (2)	100% (1)				100% (1)
T.V. Teaching	11	75% (4)					75% (4)
Student Body Quality	4, 55, 71	100% (4)	100% (4)				
Instruct. Materials Quality	9	100% (2)	100% (2)				
Instruct. Materials ($)/P	21	0% (3)	0% (3)				
Teacher D.S.	10, 24	83% (12)	67% (6)	100% (3)	100% (2)	100% (1)	
Teacher Experience	6	57% (23)	42% (12)	75% (8)	50% (2)	100% (1)	
Special Staff/Pupil	26, 97	45% (11)	25% (4)	67% (6)	0% (1)		
Prin. & Suprv./Pupil	27	20% (5)	0% (4)	100% (1)			
Administrative Salaries	23, 56, 57	80% (5)	80% (5)				
Class Size or T/P	7	37% (19)	45% (11)	0% (4)	0% (1)	67% (3)	
School District Educational Expend. Levels	19	43% (30)	27% (11)	50% (8)	50% (6)	60% (5)	
Teacher Salary	22	75% (16)	91% (11)	50% (4)	0% (1)		
Library Size or Size/P	39	33% (3)	33% (3)				
Teacher SE or Verbal Ability	15, 43	100% (6)	100% (4)	100% (2)			
School Size	18	30% (10)	14% (7)	0% (1)		100% (2)	
Effort Index (Taxes / Wealth)	44	17% (6)	100% (1)	0% (5)			
Growing Edge	58	100% (1)			100% (1)		
Absentee Rate	48	67% (6)	100% (1)	60% (5)			
Number of Laboratories	63	100% (2)	100% (2)				
Teacher Aspirations	41	100% (4)	100% (1)	100% (3)			

*Refers to the column numbers in table 10.

Table 11 (Cont'd)

PERCENT OF STUDIES IN WHICH CERTAIN INPUTS WERE FOUND SIGNIFICANT AND THE NUMBER OF STUDIES IN WHICH THEY WERE USED

VARIABLE	VARIABLE NUMBERS*	TYPE OF STUDY					
		All Studies	Cognitive Output Regression Studies	Noncognitive Output Regression Studies	Cognitive Output Correlation Studies	Adaptability Studies	Other Studies
Holding Power	51, 47	25%(4)		25%(4)			
Percent to College	38	50%(6)	100%(1)	40%(5)			
Teacher Perception of School Climate	36	100%(2)		100%(2)			
Teacher Marital Status	29	100%(2)	100%(2)				
Teacher Age	28	67%(3)	0%(1)	100%(2)			
Teacher Certification	25	50%(2)	0%(1)	100%(1)			
Student Major	13	100%(2)	100%(2)				
Pretest Score	12	100%(2)	100%(2)				
College Type	5	100%(2)	100%(1)	100%(1)			
Value of District-Owned Property	91, 108, 110	33%(3)	0%(2)			100%(1)	
Student Self-concept and Attitude Toward Learning	53, 62, 68, 72, 74, 30	100%(8)	100%(2)		100%(6)		
All Staff/P Variables	7, 26, 27, 42	36%(35)	33%(18)	45%(11)	0%(3)	67%(3)	

*Refers to the column numbers in table 10.

may be good reason to designate a variable as a determinant of educational output even though there is less than unanimity among the findings of various researchers.

Fixed Inputs and School Outputs

Variables affecting school or student performance can be considered as either fixed inputs or controllable inputs. Fixed inputs are variables which cannot be altered by the policy maker or manager over a short period of time. Policy controllable inputs are variables which the policy maker can manipulate. Controllable inputs will be discussed in the next section; the remainder of this section will be devoted to a discussion of fixed inputs.

The four variables generally theorized to influence school performance which can be classified as fixed inputs are school (or school district) size, student IQ, socioeconomic status, and race.[20] Table 12 shows the percent of different types of studies in which specific fixed inputs were found significant as well as the total number of studies of each type in which the variable was used.

Student IQ. Student IQ was found to be significantly related to school output in 96 percent of the 28 studies in which its effect was tested. This is strong evidence that theorists are correct in postulating that variance in school performance is associated with variance in the IQ level of students. Only one study failed to show student IQ as a significant determinant of student performance. This was a study of student health habits. Otherwise, whether the study dealt with cognitive or noncognitive

[20] See table 7, p. 39.

Table 12

PERCENT OF STUDIES IN WHICH FIXED INPUTS WERE FOUND SIGNIFICANT AND THE NUMBER OF STUDIES IN WHICH THEY WERE USED

Input Variable	Type of Study					
	All Studies	Cognitive Output Regression Studies	Noncognitive Output Regression Studies	Cognitive Output Correlation Studies	Adaptability Studies	Other Studies
IQ	96% (28)	100% (13)	90% (10)	100% (4)		100% (1)
SE	88% (67)	93% (29)	77% (26)	100% (8)	100% (3)	100% (1)
Race	73% (15)	100% (5)	60% (10)			
School Size	30% (10)	14% (7)	0% (1)		100% (2)	
Formal Schooling	92% (13)	90% (10)	100% (2)			100% (1)

outcomes, IQ appeared to be highly important. Hence, it appears that the performance of the students, in cognitive areas and in many noncognitive areas, is determined in part by student IQ.

Socioeconomic status. Socioeconomic status of students also seems to be a consistent affector of school output. Overall, socioeconomic status was found to be a significant variable in 88 percent of the 67 studies in which it was used. It appears to be a more consistent determinant of cognitive achievement (significant in 93 percent of 29 studies) than of noncognitive outputs (significant in 77 percent of 26 studies).

Race. Student race was found significantly related to school output in 73 percent of the studies in which it was used. The larger the proportion of white students in the school, the higher the level of school output. Race was a significant variable in all of the cognitive output studies in which it was used, while among the 10 noncognitive output studies it was significant 60 percent of the time. It is doubtful that significance 60 percent of the time is sufficient to warrant describing a variable as "determinant of educational performance." At present levels of understanding of educational input-output relationships, such inconsistency of findings relative to a complex variable such as race raises questions about its relation to school output.

Little has been said about interrelationships among fixed input variables. Without pursuing the issue at length here, the question should be raised: Is race a proxy variable picking up variation in student performance due primarily to other factors such as socioeconomic status, intelligence, or subtle effects of discrimination?

School size. School size is one of the most commonly postulated determinants of school quality, yet it was only found to be significantly related to student performance in 30 percent of the studies in which it was used. It was found to be a determinant of noncognitive output in the one study of this type in which it was used and in only one of the seven cognitive studies reviewed. It did appear significant in two adaptability studies. In these latter studies, a proxy for output was used which involved judging the quality of a school by whether or not the school was "sloughing off outmoded purposes and practices and taking on new ones to meet new needs."[21] In all studies using school size, variation in school size was found to be positively and significantly associated with the presence in a school of the most modern pedagogical techniques, but generally not with measures of cognitive or noncognitive output. It would seem that school size (either school district or individual school) is neither an asset nor handicap affecting student performance, though larger schools are probably better able to meet the criterion of offering more course choices to students. This generalization is most likely to apply within the most commonly found range of school

[21]Study 55, vol. II, p. 2.

district size; extremely large or small districts may not have been studied in sufficient numbers to warrant such firm conclusions.

To summarize, fixed inputs in the education production process do seem to have an effect on school outputs in both the cognitive and the non-cognitive areas. Schools whose students are predominantly low in socioeconomic status, low in IQ, and/or high in nonwhite enrollment will require greater allocations of resources (controllable inputs) than other schools in order to produce the minimal levels of various educational outputs society requires.

The important question: does schooling matter?

The most general question one can ask about schools and school output is whether formal schooling affects student performance. Thirteen studies were reviewed which investigated this question in one way or another. Most often the investigations centered around determining whether different amounts of previous schooling affected the test performance of students. A second approach, taken less frequently, was to determine whether schools explain variation in student performance that can not be explained by nonschool factors. In 12 of the 13 investigations reviewed, formal schooling was found either to result in higher levels of student achievement than would have resulted if no formal schooling was available or to explain variation in student performance which could not be explained in any other way.

One study examined the performance of students on tests given at the beginning and end of a particular course of study. Pretest scores were found to be higher for students who previously had taken a course in the subject. However, on the posttest, both those students who had and those who had not had the course previously were found to perform equally well. Hence, the question resolved by the study seems to be whether somewhat redundant formal education affects student performance, rather than whether formal education itself affects the development of academic skills.

Overall, then, the evidence supports the contention that schools are doing a job that would not otherwise get done, or in more production oriented language: Schools are in fact producing some output. Given this, the next problem in understanding the production of educational outcomes involves determining what the relevant school inputs are whose variation explains the level of school or student performance.

Controllable inputs and school performance

Controllable inputs are those whose level of usage the policy maker can increase or decrease to affect the output of the schools. Certain variables which fall into this class are teacher degree status, teacher experience, class size, the level of usage of guidance counselors and other special staff, and the availability of books and other instructional supplies for use in the educational process. Two other variables, teacher salary and level of educational expenditure, are also commonly thought to affect student performance and are probably most accurately viewed as representative of controllable inputs. Since these are monetary rather than real variables, they will be discussed in the next part of this report along with other financial variables.

Table 13 presents overall and by study type the frequency with which certain controllable variables were found to be significantly related to school output. The variables and data were taken from table 11 and represent those variables in table 11 which most unambiguously could be considered as controllable inputs.

Table 13

PERCENT OF STUDIES IN WHICH VARIABLE INPUTS WERE FOUND SIGNIFICANT AND THE NUMBER OF STUDIES IN WHICH THEY WERE USED

Variable	Study Type					
	All Studies	Cognitive Output Regression Studies	Noncognitive Output Regression Studies	Cognitive Output Correlation Studies	Adaptability Studies	Other Studies
Teacher Degree Status	83% (12)	67% (6)	100% (3)	100% (2)	100% (1)	
Teacher Experience	57% (23)	42% (12)	75% (8)	50% (2)	100% (1)	
Student Self-concept & Attitude Toward Learning	100% (8)	100% (2)		100% (6)		
Class Size or T/P Ratio	37% (19)	45% (11)	0% (4)	0% (1)	67% (3)	
Special Staff Per Pupil	45% (11)	25% (4)	67% (6)	0% (1)		
Instructional Materials Quality	100% (2)	100% (2)				
TV Teaching	75% (4)					75% (4)
Programed Learning	100% (2)	100% (1)				100% (1)
Teacher SE or Verbal Ability	100% (6)	100% (4)	100% (2)			
Student Body Quality	100% (4)	100% (4)				
Principals and Supervisors Per Pupil	20% (5)	0% (4)	100% (1)			
Library Size or L.S. Per Pupil	33% (3)	33% (3)				
Absentee Rate	67% (6)	100% (1)	60% (5)			

The five variables in table 13 which were most frequently subjected to testing will be discussed first, emphasizing how convincing the evidence is that they are related to overall student performance.

Teacher degree status. The evidence on teacher degree status seems appreciable in this respect. In 83 percent of the studies reviewed, it was found that the more highly educated the teacher was, or the higher the average level of teacher education in a school, the more impressive was student performance. All of the noncognitive output and correlational-cognitive output study conclusions support this finding. In the cognitive output regression studies this conclusion was not unanimously reached, though it was found 67 percent of the time. Hence, even in this group of studies the general conclusion that higher teacher educational levels are related to higher levels of student performance seems to hold. Although policy makers and managers can probably exert only minimal, if any, control over the formal education level of any one teacher, they can control to some extent the overall level of teacher degree status in their schools. This control can be exercised by selecting the most highly educated applicants to fill new teaching positions (assuming that their other qualifications are comparable), by developing salary schedules which provide greater monetary rewards to teachers holding advanced degrees, and by providing encouragement to teachers who are working toward advanced degrees.

Teacher experience. Teacher experience is also commonly thought to influence student performance. However, the evidence is substantially less conclusive on whether a policy decision to increase the average experience level of teachers in a school is likely to result in better student performance. In the 23 studies reviewed, teacher experience was found to be significantly related to student performance only 57 percent of the time.

Examination of results of studies by the type of output, however, suggests that while teacher experience may not be related to student achievement in the cognitive domain, there is more evidence that it is related to student performance in the noncognitive area. In the former case it was found significant in 42 percent of the regression technique studies and in 50 percent of the correlational technique studies; in the noncognitive output studies it was found significant 75 percent of the time. Thus,manipulating the level of teacher experience in a district (by hiring more experienced teachers, for example) as a means of improving school output appears to be of dubious value in relation to cognitive performance; the prospects of influencing noncognitive performance in this way appear somewhat better.

Interaction of cognitive and noncognitive domains. Initiation of a policy to improve student noncognitive development can have a positive effect on student academic achievement. Rather persuasive evidence was reviewed which indicates that, in part, student achievement in the intellectual skills area is related to the level of a student's development in the noncognitive domain. The findings of eight studies unanimously support this contention. The noncognitive output variables found related to cognitive achievement levels are collectively referred to in tables 11 and 13 as student self-concept and attitude toward learning, and they are fairly typical of the noncognitive output measures reviewed in this study.

Class size and teacher-pupil ratios. Class size is frequently considered to have an effect on the ability of the school to educate students. However, there seems to be little evidence to suggest that, within fairly broad limits, class size (or its often used proxy, teacher-pupil ratio) has any general effect upon cognitive and noncognitive school outputs. Overall, class size was found to be significantly related to student performance in

37 percent of the 19 studies in which it was used. In the cognitive skills studies, class size was found to be significant less than half the time it was subjected to testing. In the noncognitive area, four models were reviewed. In none of these studies was a significant relationship found between class size and noncognitive achievement.

The complete lack of evidence of a relationship between class size and noncognitive achievement is somewhat surprising. The additional personal contact possible in smaller classes would seem at least as likely to affect attitudinal and self-concept development as intellectual development. However, this does not seem to be the case, if these four studies are sufficient evidence. Improving teacher _quality_ (as indicated by degree status and experience) rather than teacher _quantity_ seems to be the administrative strategy most likely to result in gains in student achievement.

Special staff. The term special staff refers primarily to the school's use of guidance counselors, though in four of the 11 studies reviewed, it also includes certain other specialist groups such as psychologists and social workers. Overall, the amount of special staff per pupil used was found to have a significant effect on student achievement in fewer than half (45 percent) of the studies in which its effect was tested. However, there are substantial differences between results of cognitive output and noncognitive output studies. The studies reviewed indicate that use of special staff has little direct effect on student cognitive achievement. It was found unrelated to cognitive achievement in four of the five studies in which it was used. However, in the studies of noncognitive output, special staff was found significantly associated with student performance 67 percent of the time, which gives a fairly strong indication that manipulating the number of special staff may provide administrators a means of influencing school objectives in the noncognitive domain.

Instructional materials and technology. The last of the more commonly postulated determinants of school performance to be examined is the usage of instructional materials and technology.

Two studies were reviewed which investigated the effect of textual materials on student performance. Both studies dealt with the quality of textual materials by examining different effects of a variety of textbooks on cognitive achievement of students. In both cases achievement levels were found to vary with the choice of textbooks used. Selecting textbooks is obviously a function of school personnel although, as a practical matter, their choice of the best materials may be hampered by a lack of information about the relationship of specific materials to achievement.

Four studies of the effects of television instruction were reviewed.[22] In three of the four studies, the use of television for instruction at the college level was found to result in as good or better achievement as did the normal classroom approach.

Another alternative to traditional methods of instruction is programed learning. In two college-level studies reviewed, students using only programed learning texts and with no teacher exposure at all were found to perform as well on achievement tests as did students who had been instructed in the usual classroom manner. Both of these studies also found that the amount of effort (hours of study) required to produce equivalent test results was much smaller for the programed-learning groups of students.

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[22] See study 5.

Since both the television and the programed-learning studies were carried on exclusively at the college level, the question arises of their applicability to elementary and secondary education. One might reasonably expect similar results among college-oriented secondary school students, but extending the inference much farther would be risky on the evidence provided by these studies.

Several other controllable inputs warrant discussion. Generally speaking, they were not nearly so often postulated as determinants of school performance in the literature reviewed as were the variables discussed above. However, to the extent that they were tested, they generated rather interesting results.

Teacher socioeconomic status and verbal ability. One such set of variables is defined in table 13 as teacher socioeconomic status or verbal ability. Teacher socioeconomic status refers primarily to the educational level of the teachers' parents; verbal ability may be a proxy for a combination of the teachers' socioeconomic background and intelligence.

Six studies used one or both of the socioeconomic or verbal ability variables and found that these variables were significantly related to student performance levels, both cognitive and noncognitive. Hence, they may serve, as do teacher degree status and experience, as indicators of teacher quality. In situations where there are several applicants for teaching positions, this provides another dimension along which decisions can be made by the school administrator as he attempts to increase the use of inputs associated with better student performance. In this particular case, the evidence suggests that increases in the average socioeconomic status or verbal ability of a school's teachers may have a positive effect on both cognitive and noncognitive performance of students.

The general socioeconomic level in a school. The average socioeconomic level of all students was related to cognitive performance levels of individual students in all the studies in which it was used. The findings indicate that, given the other characteristics of the school and student (including his own socioeconomic level), a student's performance will tend to be greater the higher the average socioeconomic status of students at his school. From a policy point of view, it suggests that concentrations of low socioeconomic students in a school mitigate against high achievement. Equalizing the socioeconomic level of the various schools in a district may be a means of stimulating a higher level of performance among low socioeconomic level students.

Principals and other supervisory personnel. The effect of principals and other supervisory personnel on student performance was investigated in five of the studies reviewed. Since the amount of resources allocated to the supervisory function is largely within the control of school officials, its value as a means of facilitating student achievement is of interest. On the basis of the limited evidence provided by the five studies reviewed, the results are not too encouraging. In none of the four studies dealing with cognitive achievement was the intensity of supervision found to be related to variation in the level of student performance. The other study indicated that intensity of supervision was associated with student development in the noncognitive domain, specifically in the development of habits and attitudes indicative of responsible citizenship.

Library size. Three studies were reviewed which examined the relation of library size to student cognitive development. Only one showed a significant relationship between these two variables.

The fact that only three studies were found dealing specifically with the relationship of library size to student achievement indicates the need for additional research in this area. More appropriately defined dimensions of the school library such as types of holdings and rate of circulation--that is, dimensions which describe the library's function in the educational process rather than merely size--may be more likely to produce a realistic picture of the library's contribution to student achievement. The library as a multimedia resource center could prove to be a fruitful area of study.

Student absenteeism. The negative effect of student absenteeism on student performance was verified in four of the six studies in which it was examined. Student absenteeism is only partially controllable by the school since it probably reflects a number of community factors including socioeconomic status. Since the studies reviewed did attempt to control for the socioeconomic status of the student, it appears that the relationships found between absenteeism and student achievement at least partially result from variation in the strictness of school policy toward absenteeism. Hence, the evidence provided by these studies, though limited and mixed, suggests that the school's efforts to discourage unnecessary student absence have a good likelihood of yielding better student performance.

Financial Variables and School Performance

Most school input variables can be expressed in either the descriptive units of the variable or in terms of its cost. Examples of variables expressed in descriptive units are number of years of teacher experience, number of pupils per class, and number of special staff per pupil. Variables expressed in monetary terms include instructional expenditures, teacher salary, and expenditures for materials. The choice of whether to use a monetary definition or to express the variable in its descriptive units is usually one of convenience.

It is not necessary to test the relationship between some measure of school performance and financial variables to determine whether educational quality is related to educational expenditure; it is only necessary to show that some resources which have to be purchased in the market place are related to performance. For example, it was shown earlier in this chapter that school performance levels were higher when the average degree status of teachers, number of years of experience of teachers, and the number of special staff per pupil were higher. Since it costs more money to obtain teachers with higher degrees and more experience than it does to obtain relatively untrained and inexperienced teachers, school quality will vary with variations in school expenditure. Similarly, larger numbers of special staff cost more than smaller numbers. In order to optimize the results obtained by the money available, the school administrator needs to know the relationships between the resources he can buy and student performance. To the extent that these relationships can be known and he can act accordingly, additional expenditure can result in better performance.

The effect of school district expenditure on the level of educational output is indirect. Money does not influence school quality directly; it buys resources which can influence the level of output. However, this should not be interpreted to mean that high levels of expenditure automatically result in satisfactory achievement levels. Fixed inputs, discussed earlier in this chapter, may cause variations in achievement levels from school to school even if school expenditure levels are similar. Further, if money is spent to buy resources which are unrelated to student performance, obviously it is not realistic to expect the expenditure to affect student achievement. This may be done intentionally, as when a district decides to absorb typing or laboratory fees formerly paid by the students, or unintentionally through lack of knowledge. Finally, variation in cost structure from community to community can result in differences in school expenditure levels not associated with variation in student performance.

Table 14 presents the six financial variables whose relationships to school performance levels were most often investigated in the studies reviewed.

Administrators' salaries. In four of the five studies in which they were tested, administrators' salaries were found significantly related to student cognitive performance. The result requires some interpretation. Two of the four studies in which the variable was found significant used a salary-per-pupil figure, which can vary either because of varying numbers of administrative staff per pupil or varying levels of remuneration of a constant number of administrative staff per pupil. Since the results cited in an early part of this chapter (page 105) strongly suggested that the numbers of administrators per pupil had little impact on student performance, it seems more reasonable to conclude that the level of remuneration of administrators is the important factor. The other studies in which this variable was found significant also used the level of remuneration (e.g., average principal's salary in a school district).

Attempts were made in all these studies to control for community socioeconomic levels. Therefore, the probability seems minimal that the findings merely indicate the wealthier districts' ability to pay higher

Table 14

PERCENT OF STUDIES IN WHICH FINANCIAL VARIABLES
WERE FOUND SIGNIFICANT AND THE NUMBER OF
STUDIES IN WHICH THEY WERE USED

Financial Variable	Study Type				
	All Studies	Cognitive Output Regression Studies	Noncognitive Output Regression Studies	Cognitive Output Correlation Studies	Adaptability Studies
Administrators' Salaries	80% (5)	80% (5)			
Teachers' Salaries	75% (16)	91% (11)	50% (4)	0% (1)	
Gross Expenditure Level	43% (30)	27% (11)	50% (8)	50% (6)	60% (5)
Value of School-Owned Property	33% (3)	0% (2)			100% (1)
Effort Index	17% (6)	100% (1)	0% (5)		
Instructional Materials Cost Per Pupil	0% (3)	0% (3)			

salaries. One other factor, beside variation in numbers of administrators and the community's ability to pay, may be likely to result in variation in administrative salary levels: administrative quality. By process of elimination, this seems to be the most likely cause of the positive relationship between administrators' salaries and student achievement. Since little data is available on quality of administrators, the salary measure provides a convenient, but admittedly less precise, means of examining the importance of this variable.

Teachers' salaries. Teachers' salaries were found to be positively related to student performance in 75 percent of the studies in which the variable was examined. Since it was found that the major characteristics which determine teacher salary (degree status and experience) were strongly related to student performance, this result should not be surprising. The relationship between teachers' salaries and achievement is especially strong for cognitive types of achievement. The ambiguous findings concerning the relationship between teachers' salaries and noncognitive output (two of four studies showed significant results) are inconsistent with findings discussed earlier (pages 100-101) which showed degree status and experience of teachers to be positively related to noncognitive output.

Gross expenditure level. A major concern of educators is determining the relationship of school expenditures to student performance. Thirty studies reviewed here examined this relationship and over half of them reported that no obvious relationship between performance and expenditure could be found. Such results have led many observers to question whether the money spent on education influences the quality of that education. A more constructive interpretation would point out the difficulty of obtaining meaningful information from gross expenditure figures.

Highly aggregated expenditure data tend to obscure the impact of any specific expenditure. In addition, gross expenditure figures usually include a number of expenditures not necessarily intended to affect achievement, such as expenditures for transporting students to and from school.

Many of the studies reviewed used instructional expenditures to examine the cost-quality relationship. This type of variable eliminates nonachievement-related items but--because it reflects such factors as class size, teacher experience, and quantities of instructional materials--does not eliminate the problem of relating specific expenditures to specific outcomes. If, for example, a study shows instructional costs to be significantly related to student performance, does it mean that all instructional items purchased affect student performance, or only some of them? Conversely, if a study finds no relationship between instructional costs and achievement, does that indicate that none of the purchased inputs affected achievement?

Such general findings are of little value to the school administrator as he allocates available funds among a variety of goods and services.

These problems can be dealt with in part by implementing record-keeping systems which relate expenditures to specific programs or purposes. Such cost accounting procedures are feasible but not yet widely employed. Lacking such systems, other strategies must be sought. One would be to examine those variables whose relationships to student performance have been established. If greater use of these variables requires more money, then the relationship between cost and quality is logically established.

This approach can be illustrated by applying it to results of the previous section. Some of the inputs most frequently found related to student performance were teacher degree status, teacher experience, administrator quality, and the number of special staff. In all of these, the greater the amounts used in the educational process, the higher the level of student performance observed. Similarly, the greater the amounts of these variables used, the greater the cost to the school district. Thus, to attain higher levels of student performance by manipulating these variables, the greater the expenditure must be.

How can knowledge of cost-quality relationships in education be used to improve the efficiency with which monetary resources are used? As has been pointed out, this knowledge is still rather sketchy. As more specific data become available and researchers are able to examine possible relationships more closely, knowledge will increase. Still, the results discussed here provide a basis for some tentative comments.

Findings cited in the previous section indicated that the relationship of class size to student performance appears much more tenuous than the relationship of degree status of teachers to student performance. Thus investing in teachers with higher degree status appears to be a more efficient use of funds than reducing class size.

The problem becomes more difficult when the administrator must allocate funds between two variables, both of which are positively related to student performance. What investment would be most cost-effective, that is, have the most impact on student performance per dollar of expenditure? Two examples may illustrate this problem.

The findings of two of the studies reviewed indicate that a given additional expenditure on principals' salaries (in order to upgrade the quality of school principals) results in larger gains in student performance than the same expenditure used to increase teachers' salary levels. In another study the findings indicated that using financial resources to employ teachers with superior verbal ability was five to ten times as effective per dollar of expenditure as employing highly experienced teachers as a means of increasing student performance levels.

Although these findings are necessarily tentative, they may illustrate the problems involved in allocating funds efficiently.

Value of school property. The relationship of the value of school-owned property to school output was investigated in three studies. The rationale upon which this variable was based is not clear from the studies. It was found to be unrelated to cognitive output in two studies but related to measures of school adaptability in the third study.

Educational effort index. One of the more interesting financial variables examined is referred to in tables 11 and 14 as the effort index. This variable represents the ratio of school tax levels to a measure of the wealth of the community. A higher ratio indicates that a greater educational "effort" is being made by the community. In the one cognitive output study in which it was used, it was found to be significantly related to the level of student performance. However, in five noncognitive studies, it was not found to be related to the level of student performance.

There are at least two reasons why variation in community effort may not be associated with variation in school quality. One reason is that the wealth base of some communities may be too small to result in a significant level of educational expenditure regardless of the (tax level) effort made. The other is that inefficiencies in the use of educational moneys occur frequently enough in high effort districts and infrequently enough in low effort districts to neutralize any effect on student performance that variation in community effort may potentially have. This would seem to support the contention that strong community support for education is not in itself sufficient to guarantee that quality education will result. It would seem at least as important that educational resources be used efficiently and that the community have an adequate wealth base (or sufficient outside aid) to support an adequate educational system.

Instructional materials cost. The last financial variable in table 14 is instructional materials (textbooks and other instructional supplies) cost per pupil. This variable was used in three studies. None of the studies showed a positive relationship between expenditures for instructional materials and cognitive achievement. Expenditures for textbooks and supplies represent both the replacement of worn out and obsolete materials as well as an attempt to increase the variety and quantity of instructional materials available for use in the educational process. Hence, expenditures could vary for either of these reasons. Since socioeconomic status was controlled for in these studies, it does not seem likely that the lack of significance is due merely to different reasons for purchasing instructional materials in different kinds of communities.

One other study, not included among the three mentioned in table 14, found the number of textbooks used in a school positively related to performance (study 28). To the extent that per-pupil expenditure on instructional materials represents a measure of the quantity of such materials used in the instructional process, the findings of study 28 could be inferred as partial substantiation of the hypothesis that expenditures for instructional materials positively affect student performance. Such indirect results must still be balanced against the complete lack of significance found in the other three studies.

Another group of studies, previously discussed, indicated that differences in textbook quality were related to school output. The pattern of differences in quantity and quality findings was also characteristic of the findings on the importance of teachers and administrative personnel reviewed earlier. It appears that one of the most notable characteristics of educational input-output relationships is the substantial effect on student performance of differences in input quality and the insensitivity of student performance levels to differences in the quantity of inputs used. The only real exception to this which was found in this survey is special staff usage.

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