A QUANTITATIVE ANALYSIS OF FACTORS AFFECTING ELEMENTARY AND SECONDARY SCHOOLING QUALITY IN OKLAHOMA, WITH ECONOMIC APPLICATION FOR RURAL AREAS

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PREFACE

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CHAPTER I

INTRODUCTION

The Problem

Pressures of tight budgets and resistance of taxpayers to higher taxes on one hand and, on the other hand, pressures of parents for better schooling for their children have placed school administrators in a difficult position. Whereas, administrators once may have been able to improve schooling quality by obtaining more funds, emphasis now is turning to improving quality with given resources - hence increasing efficiency. In some instances, school boards have contracted with private consultants to take over school operations and improve student performance. Use of private consultants and performance contracts highlights public concern with the jobs schools are doing. Such drastic action will not be necessary if current administrators make needed adjustments to improve the efficiency of schools. This study shows opportunities to improve efficiency.

Quality schooling is essential to the well being of youth who must compete for jobs or for a university degree. The close interaction between rural and urban areas provided by migration requires that the quality of education offered in rural areas not lag behind that of urban areas. However, major differences in educational opportunities between urban and rural areas exist. A task force on rural development and family living reported:

> Vocational education in rural areas too often stresses agricultural production where relatively little employment opportunity exists. Other aspects of rural education that still lag behind urban standards are illustrated by: lack of preschool and kindergarten experience; inadequate curriculum offerings and vocational guidance; dearth of special teaching aids, laboratories, libraries, and other educational facilities deemed necessary in modern schools.[1]

These inequalities in educational opportunities are of special concern since many rural residents are faced with the prospect of migration. It is widely believed that the mass migration of poorly educated rural residents into urban areas has contributed to urban problems. This migration has also weakened the economic base of many rural communities and raised dependence rates, making it difficult to adequately finance schooling and maintain the quality of education offered. The need for efficient use of available resources is clear.

Economics of Education

Economic analysis is applied to education in a manner similar to any other activity which uses scarce resources. This analysis encompasses the allocation of a community's scarce resources so as to satisfy wants as fully as possible. It requires adequate information on (1) educational objectives, (2) performance of various educational methods or inputs in attaining these objectives, and (3) costs associated with these educational methods or inputs.

Economic analysis of education can be divided into two separate but related components, external and internal economics. External economics of education deals with the economic value of education. Encompassing issues of economic payoff, equity and financing of education, the external economics of education helps guide public policy. Internal economics of education, concerned with the efficient operation of a school district or system, applies theory of the firm on a school-district basis. It can be used to determine (1) how to apply given funds most efficiently, and (2) what level of funds are needed to attain a given level of output.

External Economics of Education

The bulk of previous economic analyses on education have focused on concepts of human capital, social benefit-cost analysis, and educational policy. Although research on external economics of education had begun earlier, T. W. Schultz revived this branch of economics emphasizing the idea of human capital formation.[2] The amount of educational capital embodied in the population helps to explain past economic growth and to prescribe needed changes for future growth.

The benefits from investing in education, however, must be weighed against its costs. Beginning with Hansen's[3] and Weisbrod's[4] work, almost all benefit-cost studies have shown a favorable rate of return on investment in education and have documented the importance of education's contribution to economic growth. Favorable rates of return on investment indicated a capacity for the educational system to absorb greater investments profitably.

These measurements of the benefits and costs of education provide a basis for educational planning on a state or national level. This approach guides investment in education among rural-urban-suburban sectors and among regions. The optimum level of investment may be based on ability to invest, equity, or profitability of investment. Equity deals with issues of who pays for and who benefits from schooling and examines the disassociation of schooling costs and benefits. An analysis of schooling investments among regions within the United States showed investment in formal schooling yielded a favorable but unequal rate of return on investment among regions.[5] Another study showed the rate of return on investment in elementary and secondary education differs among rural and urban residents.[6] These differences in rates of return among rural-urban sectors and among regions indicate an imbalance in resource allocation.

Initial analyses of the economic value of education concentrated on those aspects of education which were most easily quantifiable. Measuring outputs in dollar values was a logical starting point. Economic analysis of education focused on state, regional, and national schooling problems since data on lifetime earnings, as a measure of educational output, are readily available at this level of aggregation. Lack of output data helps explain the relative neglect by economists of internal economics of schooling.

Internal Economics of Education

Income data to measure schooling output are usually not available on a school-district basis. Even if they were available, earnings may only partially measure the productivity of education since all of the output of the educational system does not enter the market. Moreover, an analysis emphasizing economic benefits fails to address many relevant questions for a school system. A school system is concerned with internal efficiency - the allocation of its resources in an efficient manner to reduce costs of achieving schooling objectives.

Analysis to improve educational quality requires substantial knowledge of the relationship between educational inputs and educational output, as well as the relationship between educational inputs and educational costs. An educational input is defined as a resource (e.g., labor, capital, time) which is used in providing educational services. The output of a school's program is measured by the number of students in the program and the quality of schooling. Quality of the schooling program is ultimately measured by the behavior it produces in the students who pass through it. Since the many dimensions of lifetime behavior are difficult to assess, variables such as achievement test scores, dropout rates, and absentee rates (which are known to be related to subsequent behavior) are used to measure school quality. These measures of quality are subsequently used as measures of output for a given number of students educated in the program. Internal economics of education focuses on combining schooling inputs in a least-cost manner to achieve a given level of output. The review of literature in the next chapter reveals that economists have given little attention to this important field of human economic development.

Objectives

This study is concerned with the internal economics of education in Oklahoma elementary and secondary public schools. The major objective is to determine optimum resource allocations and school district size for rural areas. Specific objectives are to:

(1) Quantify the effect that the various factor inputs have on the output of elementary and secondary schooling in Oklahoma.

(2) Measure the costs of factor inputs.

(3) Determine the allocation of schooling inputs that minimizes the cost of a given quality of education for a given

population density and other characteristics of a geographic area.

(4) Measure the economic payoff from changes in use of inputs in achieving a given level of output.

Organization of the Study

Published studies relating to the internal economics of education are reviewed in the next chapter. Chapter III identifies relevant educational outputs and inputs and provides a theoretical framework applicable to the internal economics of education. Data sources and characteristics are presented in Chapter IV. The educational production functions and cost relationships are presented in Chapters V and VI. respectively. The procedure for optimizing the resource mix is presented in Chapter VII. The major empirical chapter, Chapter VIII, describes the long-run optimum allocation of educational resources for a given school district. Summary, conclusions and implications are presented in Chapter IX.

FOOTNOTES

[1]A Joint Task Force of the U. S. Department of Agriculture and the State Universities and Land Grant Colleges, Rural Development and Family Living (November, 1968), p. 11.

[2]T. W. Schultz, "Investment in Human Capital," American Economic Review, Vol. 51 (1961), pp. 1-17.

[3]W. Lee Hansen, "Total and Private Rates of Return to Investment in Schooling," Journal of Political Economy, Vol. 81, No. 2 (1963), pp. 128-41.

[4]B. A. Weisbrod, "Education and Investment in Human Capital," Journal of Political Economy, Vol. 70, No. 5, Part 2 (Supplement) (1962), pp. 106-23.

[5]Freddy Kent Hines, "Optimal Allocation of Funds for Schooling Among Geographic Divisions Within the United States" (unpub. Ph.D. dissertation, Oklahoma State University, 1970), pp. 77-84.

[6]James Martin Redfern, "Social and Private Returns to Investment in Schooling, By Race-Sex Groups and Urban-Rural Residence" (unpub. Ph.D. dissertation, Oklahoma State University, 1970), p. 135.

CHAPTER II

REVIEW OF LITERATURE

This chapter examines past research dealing with inputs and outputs of the educational system. Research reveals that numerous variables conceivably affect both the performance and cost of educational systems. Since controlled experiments to establish the interrelationships of a large number of variables in education are costly, research surveys have been used to ascertain the contribution of inputs to output. These surveys measure inputs such as pupil-teacher ratios and instructional materials that influence educational output and that are under the control of school administrators. However, administrators should also take into account other variables or inputs such as student background which must be considered as given in the short run. A few studies have recognized this relationship between instrumental and background variables.

Educational Output and Its Measurement

Although economists have long been concerned with output and its measurement, only recently have they tried to define and measure the output of an educational system. The many quality dimensions of educational output make its measurement particularly difficult, because there is no system of weighting outputs to get a single measure of output.

Lacking measures of output, researchers frequently use inputs such as expenditures per pupil to measure schooling output. Readily observable physical inputs were first used to approximate educational quality. Using the Metropolitan St. Louis survey, Hirsch quantified inputs which were assumed to indirectly measure educational output.[1] For comparison, the school districts were ranked according to each input and ranks were summed by school districts on all factors to form a composite rank. Those districts which were generally recognized as "being among the best" in the area had the highest index scores.

Hirsch's index of educational inputs consisted mainly of factors used in educating students. Schmandt and Stephens thought schooling subfunctions or activities were more closely related to schooling quality.[2] Activities were measured in terms of the number of school services offered. While these items influence output, they are the ingredients and not the measure of production.

Dollar inputs are frequently used to measure educational quality. Zimmer used current operating expenditures per student in average daily attendance to measure educational quality.[3] Total expenditures make no distinction between those expenditures which directly affect educational output and other expenditures such as transportation. Instructional costs, on the other hand, would be more closely correlated with educational output. However, an expenditures approach is justifiable only under conditions of linear homogeneity in production and equal efficiency among schools in resource allocation.[4] If there are economies or diseconomies of size, school systems of different size have different outputs for the same expenditure per pupil.

Standardized achievement tests have been used as one measure of educational output. These tests have shortcomings such as middle-class orientation but avoid some of the limitations inherent in the use of educational inputs as measures of educational output. Standardized tests of achievement have been used by two national research surveys to assess over-all performance in subject areas as a measure of educational output. Project TALENT involved over 4,000,000 high school students in a representative sample of the country's high schools.[5] Data were obtained on student achievement scores, as well as outcomes such as college attendance, dropout, absentee, and delinquency rates. The Equal Educational Opportunity Survey, as presented by the Coleman Report, examined data from 5,000 schools on student achievement and its relationship to the school.[6] Both studies obtained measures of the student's socioeconomic background which were held constant so that realistic comparisons of schools operating under different conditions could be made.

Educational Production Function

The production function, a conceptual tool which can be used to analyze efficiency problems in the education industry, expresses the physical relationship between inputs and outputs. The production function for education describes a multitude of choices open to school administrators.[7] It shows the output that various levels and combinations of inputs will produce for a given state of technology and environmental conditions. Knowledge of these production possibilities allows economic principles to be applied to factor substitution.

The estimation of production functions has been limited by the availability of quantifiable outputs and meaningful measures of inputs. To estimate input-output relationships within school systems, it is essential to control for the effect of family and community on educational outputs.[8] Economic analyses must be different from benefit-cost studies of general education which have not separated in-school from out-of-school influence on educational outputs.

The Project TALENT data indicated that the most important factors associated with school outcomes - achievement, going to college and staying in school - were teacher salaries, teacher experience, number of books in school library, and per-pupil expenditure.[9] These four factors remained important even after region, rural-urban status, and such socioeconomic factors as median family income and quality of family housing were held constant. Many other factors appeared unlikely to have much influence on school outcomes considered in this study. Among these factors were school size, average size of classes, age of building, and suburban location.

The Coleman Report regressed student performance on student-body composition, facilities, curriculums, and teacher characteristics. Student achievement was related to factors within the school, as well as family background and student attitudes. Background variables - parent's education, living pattern, and interest in students schoolwork - were highly correlated with student achievement. The schools showed little statistical effect on student achievement when the socioeconomic background of the students was taken into account. Teacher characteristics showed a stronger relationship to achievement than other school factors. Little variation in student achievement was accounted for by variation in school facilities and curriculum.

Size-Performance Relationships

Student performance may vary systematically with the size of school. A broader curriculum and teacher specialization made possible through larger enrollments are major factors in improving performance. The introduction of ability groupings and specialized inputs such as guidance and reading specialists generally associated with larger enrollments are also designed to increase student performance. One possible source of diseconomies in education may result from crowding and from less contact by teachers with students on an individual basis.

Jackson used schooling input data on all southern high schools to study the relationship between high school size and program quality.[10] The adequacy of the instructional program was influenced by factors such as training and certification of teachers, teaching load, and scope of the curriculum. The relative effectiveness of schools of various sizes were evaluated by separating the schools into categories of size. These results showed that small schools were unable to provide a satisfactory educational program. Course offerings were particularly limited in small schools. Teacher qualifications - certification and advanced degrees - improved with increases in enrollment. Although informative, this study measured the relationship between school size and schooling inputs rather than outputs.

Street, Powell, and Hamblen examined the relationship between performance of elementary students on standardized achievement tests and school size in eastern Kentucky.[11] Within a district, large schools had significantly higher mean achievement scores than small schools. Further, they found larger schools tend to have more facilities, attract better-prepared teachers, and be located in areas where there are more educational opportunities for students. Although these factors were not controlled for, it was felt that they were actually responsible for the relationship of school size to achievement.

Kiesling's study of school districts in New York used data from the Quality Measurement Project.[12] This analysis related student performance to school district size while correcting for the influences of pupil intelligence and socioeconomic background. After school districts were stratified by socioeconomic background, average achievement scores were regressed against size, expenditures, and pupil intelligence. Holding socioeconomic background and pupil intelligence constant, achievement decreased at a decreasing rate with increases in district size.

Data from the Project TALENT Sample were used to establish a relationship between school size and student performance.[13] In general, the size-performance relationship is not very well defined until the effects of other factors are controlled. With the introduction of intelligence, socioeconomic index, and high school expenditures into the multiple regression equation, however, the size-performance relationship becomes consistently negative. School size per se is somehow detrimental to better school performance. Uncorrected student performance seems to attain a maximum between 1200 and 1600 pupils in ADA and then to decline. After the three control variables have been introduced, student performance declines with each successive increase in size.

Expenditure-Performance Relationships

Communities hope that increased expenditures will improve the quality of their school systems. A number of studies have analyzed the output of schools with different expenditure levels. In these early studies, all inputs were usually aggregated under the heading of "total expenditures per pupil."

Kiesling's Project TALENT study found a positive relationship between achievement scores and expenditures levels.[14] The relationship was quite strong when the intelligence, size, and socioeconomic variables were not in the equation. The effect of expenditures on performance net of the three other variables, however, was small and in some cases not significant. This approach makes no distinction between rural and city school districts which may have the same expenditures but different programs.

To determine which measures of expenditures were related to educational quality, Stinson and Krahmer analyzed the correlation between 24 separate expenditure variables and student achievement tests in 80 per cent of North Dakota's school districts.[15] A statistically significant correlation existed between some measures of per-teacher expenditure and achievement test scores. The three most useful expenditure measures were instructional cost, operating cost less transportation, and total cost less transportation. This correlation appeared consistent among grades and among different high school sizes. No statistically significant relationships existed between any measure of per-pupil expenditure and achievement test scores.

Educational Costs and Cost Functions

This section examines the cost concepts and empirical studies of educational costs. The large variation in educational programs of different schools requires that quality of the educational program be held constant in making valid comparisons among schools.

Much of the interest in school size is focused on per-unit costs associated with schools of different sizes. For a given program, large schools may have cost advantages over smaller ones. These decreases in unit costs associated with increases in size are called economies of size. This cost reduction arises in education mainly through declining average fixed costs achieved by better utilization of administration, teachers, plant and equipment.

Using school-input variables, Katzman derived two short-run input-cost relationships - current costs per ADM (average daily membership) and instructional costs per ADM.[16] The percentage of teachers with one to ten years experience had little effect on costs. Increases in median class size, crowding, and student-staff ratios tended to reduce expenditures per student. Both instructional costs and current costs showed significant diseconomies of size at all levels of utilization in the Boston area.

Wright and Pine analyzed factors affecting costs per pupil for 108 rural high school districts in central Kansas.[17] Although measures of the quality of education are important, they were not included. The teacher-pupil ratio explained more than 90 percent of all the variations in instructional costs per pupil. Other factors which significantly affected costs were curriculum, district assessed valuation, value of plant and equipment, and average daily attendance. School size accounted for most of the variations in plant operation costs per pupil. Significant cost reductions could have been achieved by enlarging the district size. Consolidation depends in part on time and cost of transporting pupils; however, transportation was not included in this study.

In Hanson's study of 577 districts located in nine states, the unit costs corrected for population characteristics consistently declined as district size increased from 1,500 to 20,000 pupils.[18] He also found substantial but less consistent support for diseconomies of size beyond the optimum size. However, three states did not reveal any tendency for costs to rise in extremely large school districts.

Although early analyses of economies of size in school operation used a school district as the unit of observation, Riew utilized data on individual public high schools located in Wisconsin.[19] Variations in educational programs and qualities among schools were reduced by considering only accredited schools with typical teacher salaries. More than one-half of the variation in average operating expenditures among the 109 high schools was accounted for by six independent variables of which average teacher's salary, enrollment and changes in enrollment were statistically significant. Almost 20 percent of the variation in per-pupil operating expenditures was explained by variation in enrollment. An increase in enrollment with other variables held constant decreased average per-pupil operating expenditures until enrollment reached 1,675.

Cohn evaluated the per-pupil cost function for a sample of 377 Iowa high school districts.[20] To examine economies of size in high school operations, he estimated the long-run average cost curve. A long-run period is a time interval in which the school district size can be changed. The long-run average cost curve is a function of schooling outputs and inputs. Incremental test scores were used as a proxy for educational quality. The study of per-pupil costs indicated the existence of significant economies of size for Iowa high schools.

Cost-Effectiveness Analysis

In one of the few studies to deal with efficiency problems, Levin applied cost-effectiveness analytic techniques to decisions on teacher recruitment.[21] Teacher characteristics were related to student achievement and average costs. Recruiting teachers with verbal scores was five to ten times as effective per dollar in raising achievement scores as obtaining teachers with more experience. His analysis was only designed to be illustrative. School administrators need this type of information on many more educational inputs.

Summary

Useful measures of educational inputs and outputs have evolved from previous studies on educational production functions. These studies have narrowed the number of variables which conceivably affect educational output. By quantifying the effect various inputs have on educational output, they provide some insight into resource allocation. Policy guidelines as a result of these studies must of necessity be limited because they were not related to efficiency problems.

Most educational cost studies relied entirely on regression techniques, which made little allowance for changes in factor proportions. Also, these studies made little attempt to control for educational quality. In many cases, factors affecting a district's ability to support education were found to affect the cost of an educational program.

No study has successfully combined production functions and cost functions to provide insights on efficient resource allocation in an educational system. Even the discussion of a theoretical framework for such analysis has been limited. The present study provides a theoretical discussion and an empirical application of the theory of the firm to the problem of efficient resource organization in an educational system.

Economists offered few guidelines to help direct the school district consolidation that has been occurring. Even those studies that were applied in rural areas have ignored transportation costs, an important component of educational costs in sparsely populated areas. These previous studies have provided many misconceptions for policy purposes on school district organization by not taking student density into consideration. The present study relates minimum size of school district to student density and other characteristics of the geographic area.

This study will estimate production functions for achievement scores, absentee and dropout rates. Cost relationships which allow for factor substitution and control for quality will also be developed. The production functions and cost functions will be combined to find the most efficient method of producing a given output. The study will simultaneously determine the optimum organization of resources within a school district, as well as the optimum school district size.

FOOTNOTES

[1]Werner Z. Hirsch, "Measuring Local Services," Exploring the Metropolitan Community, ed. John C. Bollens (Berkeley, 1961), pp. 360-364.

[2]Henry J. Schmandt and G. Ross Stephens, "Measuring Municipal Output," National Tax Journal, Vol. 13, No. 1 (December, 1960), pp. 369-375.

[3]John M. Zimmer, "Expenditures for Public Elementary and Secondary Education in Counties Classified by the Relative Poverty Status of Their Rural Populations," Journal of Farm Economics, Vol. 49, Part 2, (December, 1967), pp. 1204-1208.

[4]Martin T. Katzman, "Distribution and Production in a Big City Elementary School System," Yale Economic Essays, Vol. 8, No. 1 (Spring 1968), p. 206.

[5]John C. Flanagan et al., Project TALENT: Studies of the American High School, Cooperative Research Project No. 226 (Pittsburg, 1962), pp. 11.1-11.11.

[6]James S. Coleman et al., Equality of Educational Opportunity, (Washington, 1966), pp. 290-325.

[7]Werner Z. Hirsch, "The Supply of Urban Public Services," Issues in Urban Economics, ed. Harvey S. Perloff and Lowdon Wingo, Jr. (Baltimore, Maryland, 1968), p. 485.

[8]Jesse Burkhead, Thomas G. Fox, and John W. Holland, Input and Output in Large-City High Schools (New York, 1967), pp. 18-38.

[9]Flanagan, pp. 11.1-11.11.

[10]Joe L. Jackson, School Size and Program Quality in Southern High Schools (Nashville, 1966), pp. 1-42.

[11]Paul Street, James H. Powell, and John W. Hamblen, "Achievement of Students and Size of School," The Journal of Educational Research, Vol. 55, No. 6 (March, 1962), pp. 261-266.

[12]Herbert J. Kiesling, "Measuring a Local Government Service: A Study of School Districts in New York State," Review of Economics and Statistics, Vol. 49, No. 3 (August, 1967), pp. 356-376.

[13] Herbert J. Kiesling, "High School Size and Cost Factors," Technical Report to the Office of Education," U. S. Department of Health, Education and Welfare (Indiana, 1968), pp. 1-134.

[14] Kiesling, 1968, pp. 43-63.

[15] Thomas F. Stinson and Edward F. Krahmer, "Local School Expenditures and Educational Quality: A Correlation Analysis," American Journal of Agricultural Economics, Vol. 51, No. 5 (December, 1969), pp. 1553-1556.

[16] Katzman, pp. 215-224.

[17] Willard A. Wright and Wilfred H. Pine, Costs and Rural High Schools in Central Kansas, 1956-57, Kansas State University Agricultural Experiment Station, Bulletin 429 (Manhattan, 1961), pp. 3-18.

[18] Nels W. Hanson, "Economy of Scale as a Cost Factor in Financing Public Schools," National Tax Journal, Vol. 17, No. 1 (March, 1964), pp. 92-95.

[19] John Riew, "Economies of Scale in High School Operations," Review of Economics and Statistics, Vol. 48 (August, 1966), pp. 280-287.

[20] Elchanan Cohn, "Economies of Scale in Iowa High School Operation," The Journal of Human Resources, Vol. 3, No. 4 (Fall, 1968), pp. 422-434.

[21] Henry M. Levin, "A Cost-Effectiveness Analysis of Teacher Selection," Journal of Human Resources, Vol. 5, No. 1 (Winter, 1970), pp. 24-31.

CHAPTER III

INTERNAL ECONOMICS OF EDUCATION

An efficient educational system is defined here as one which combines inputs to produce a given quality of schooling at minimum cost.[1] A school district can be visualized as a firm utilizing capital and labor to produce its output. It must compete with other firms in purchasing its inputs. It is broadly concerned with efficient use of resources to produce its product. However, there is no well-defined product nor a price that can be attached to its product, and most of its product is not directly sold. Users (students) exert little pressure to increase efficiency, not only because they lack mature judgment and are unaware of input-output relationships (often inputs as well as outputs are ill-defined and uncertain) but also because efficiency gains are not passed to users. Furthermore, factors outside the school system influence output throughout the long production process. Even if the price mechanism does not work, economic principles can still be used in education to allocate resources efficiently. This chapter identifies educational inputs and outputs and relates their use to relevant economic principles which can be followed to improve a school system's efficiency of operation.

Educational Production Functions

Input-output relationships can be used to determine the consequences of changing input combinations. Output variables ideally should represent what the school system is attempting to produce. Input variables ideally should include all factors which influence output of the school system. However, the variables included in the subsequent model are restricted to those having a measurable and significant effect on the performance of the system. Performance is not measurably sensitive to a great number of variables.

The characteristics of a production function are: (1) the law of diminishing returns and (2) economies of size. The law of diminishing returns states that successive increments of equal size in the use of one resource per unit of time, holding other resources constant, will produce smaller increases in output beyond some point.[2] This law may be illustrated in education by the fact that doubling the number of teachers per class is not likely to result in a doubling of the class achievement scores. A statistical estimate of the production function may not exhibit diminishing returns because diminishing returns may not have been observed in the sample used in the estimation procedure. However, one must be aware that diminishing returns do exist somewhere beyond the range of input levels observed in the sample.

Scale factors are not readily observable in education because the quality of output is not constant as the size of the school increases.[3] Since questions of school size and efficiency are important, however, size of school should be included in the model explaining educational output. Physical economies of size may result from division and specialization of labor, while diseconomies may result from crowding, lack of supervision, and other sources.

Educational Output

While the quality of a school's program is ultimately measured by the behavior it produces in the students who pass through it, this study measured output by achievement test scores, dropout rates, and absentee rates. Omission of less easily quantified outputs, such as personality and citizenship, is in no way meant to slight their importance but rather stems from the fact that inadequate data preclude their use in the analysis. Even though the variables used to measure output have imperfections, and other measures of output exist, these variables are believed to be important. Schools characterized by high achievement scores, low absentee rates, and low dropout rates are assumed to have a higher "output" than schools with the opposite characteristics.

Educational Input

Three general factors determine the output of an educational system - student input, educational process, and environment. Student input variables are defined as the characteristics and level of attainment of students at the beginning of an educational program. Educational process variables are all the activities in a school that are designed to raise students' level of attainment. Environmental variables are circumstances in the community and the home that facilitate or impede the educational process.

Many more factors affect output in elementary and secondary education than can be included in a statistical model. The specific variables included in the study were thought to have a causal relationship with educational output. To preserve structural validity, the model explaining educational output was specified as a hierarchy of admissible hypotheses (variables). There are two echelons of inputs into the educational system similar to Tinbergen's conceptualization of factors affecting economic policies.[4] First, the school board has at its disposal an array of policy instruments or instrumental variables which it can use to reach certain objectives. There are, however, a large number of factors whose values are determined outside the school system; these factors are control variables. All the input variables are listed in Table I.

Instrumental Variables. The educational process variables are the focal point of the allocative analysis and are placed in the first echelon. The importance of the ranking will be apparent in subsequent statistical analysis. These educational process variables include program offerings, teaching innovations, instructional materials, and teacher characteristics.

Teacher characteristics which affect student performance include workloads, qualifications, and salaries. Average teacher experience, percentage of teachers by years of experience, standard salary[5], and percentage of teachers with a master's degree were the variables used to reflect teacher qualifications. Pupil-teacher ratios and percentage of teachers with a planning period were used to measure teacher workload.

The scope of an educational program is defined as the number and type of course offerings and special services provided by the school. The existence of an adequate kindergarten may improve student performance in elementary education. Team teaching, ability groupings, special education classes, remedial classes, and accelerated classes reflect teaching innovations and special efforts of the school to meet individual student needs.

TABLE I

VARIABLES INCLUDED IN THE ANALYSIS

OUTPUT VARIABLES

Achievement test scores
Absentee rates
Dropout rates

INPUT VARIABLES

<u>Educational Process Variables</u>

Use of team teaching
Use of ability groupings
Percentage of students in special education classes
Percentage of students in accelerated classes
Availability of adequate kindergarten
Availability of adequate science laboratory
Availability of adequate language laboratory
Availability of adequate industrial shop
Number of printed volumes per pupil
Number of periodicals
Value of audiovisual material
Classroom teachers' education
Classroom teachers' experience
Average district classroom teacher salary
Standard district classroom teacher salary
Pupil-teacher ratio
Percentage of teachers with a planning period
Number of nonvocational units offered
Number of vocational units offered

<u>Student Input Variables</u>

Race
Student scores on Otis-Lennon Mental Ability Test
Time students spent studying outside of school
Type of community in which students have spent most of their lives
Student workloads outside of school
Post high school educational plans
Number of books read during the last summer
Number of times students changed schools

<u>Environmental Variables</u>

Parents' education
Parents' occupation
Parents' net income
Plans for children's education
Number of times parents talk with children about school work

Capital services - plant, grounds, equipment, and instructional materials - are an important factor in an educational system. The volume of capital services actually used is difficult to measure, but the inclusion of approximate measures of capital services in the model appears desirable. Some measures of facilities such as current value of plant and grounds[6] and crowding[7] show little impact on educational output. More appropriate measures may be critical facilities: (a) science laboratory, (b) language laboratory, and (c) industrial, vocational, or technical shop. These measures are expected to correlate positively with other measures of the over-all adequacy of facilities.

The number of periodicals, printed volumes per pupil, and value of audiovisual material per pupil measure an important part of the capital stock of a school. Again, the existence of these items does not insure that they are used extensively in the educational program. However, their existence and use are positively related. Since the number and value of these items has no quality dimensions, their usefulness in statistical analysis is further reduced. In any case, an attempt will be made to measure the impact of these capital items on educational output.

Control Variables. The second echelon of inputs into the educational system include those control variables - student input and environmental variables - which at least in the short run must be considered fixed. The student input and environmental variables are interrelated, making it difficult to distinguish their separate effects on output. For this reason, the two types of variables are grouped under one category. The school board and administration must take into account the effect of these control variables on educational output when determining the levels of instrumental variables.

The output of the educational program depends heavily on the quality of students that enter the program. Student aptitude, measured in the study by scores on the Otis-Lennon Mental Ability Test, indicates the student's potential for academic performance. Given the academic potential, motivation is important to realize high levels of achievement, but motivation is difficult to assess. It is hypothesized that there is a direct relationship between a student's commitment to education and his performance. Variables used to measure this commitment are (1) time spent studying outside of school, (2) the number of books the student read the previous summer, and (3) his post high school educational plans. Admittedly, the school has an influence on homework through assignments and post high school plans through counseling.

Time allocated to work decreases time which would otherwise be available for studying and other educational activities. Therefore, it is hypothesized that time spent working outside of school is inversely related to student performance.

The quality of a school's program is influenced by the continuity of students in the school system. Thus, another student input variable considered is residence patterns - type of community in which a student has spent most of his life and number of times he has changed schools. Student performance may suffer from changing schools several times.

Home environment is expected to influence student performance. Environmental variables included in the analysis are parents' education, occupation, income, and interest in their children's education. It is hypothesized that a direct relationship exists between student performance and family status variables - parents' education, occupation, and income. Parents' education serves as a proxy for informal education provided in the home, and average income reflects the family's ability to support the student's education. The interest that parents show in their children's education may influence student performance. Variables used to reflect this interest are the number of times each week that a student talks to his parents about schoolwork and parents' plans for their children's future education.

Educational Cost Functions

The costs of production incurred by a school district were broken into (1) costs of education (instruction and attendant activities) and (2) transportation. Educational costs include expenditures on teachers, textbooks, supplies, administration, plant operation and maintenance, buildings, and equipment. The cost function expresses the functional relationship between output and cost.

The cost function depends on the production function which underlies it. This analysis contains school district's cost of production at various output levels. Cost of each output level is based upon (1) resource price and (2) efficiency with which school districts use the resources.[8] The resource prices are assumed to be fixed for each individual school district. For example, the school district can hire additional teachers as needed at its current salary schedule.

Changes in cost of production associated with changes in output depend on the period of time under consideration. The short run is a time interval long enough to permit changes in output without altering the scale of plant.[9] The long run, to which most estimates in this study apply, is a period of sufficient duration to allow a school to vary output by changing either the resource combination, district size, or the scale of plant.

The long-run average cost curve shows the minimum cost of producing various outputs. In other words, a school district can operate on the long-run average cost curve only if resources are combined efficiently for each level of output.[10] Much concern over school district size relates to per-unit costs associated with educating students in school districts of different sizes. The long-run average cost curve for school districts is thought to exhibit both economies and diseconomies of size.

Internal economies of large-scale production are primarily a long-run phenomenon, dependent upon appropriate adjustment of plant scale to each successive output.[11] When the size of school district is large, greater teacher specialization may occur with each teacher instructing those classes in which he is most qualified. An illustration of technical internal economies would be the savings in teacher requirements per student made possible by a larger scale of operations. Figure 1 depicts economies of size in educational costs.

On the other hand, increases in the size of school district can involve less efficient operation and, consequently, higher unit costs. These diseconomies are not likely to be very important in elementary and secondary education. The major diseconomies accrue from transportation costs. School districts must provide transportation for all students in the district who live more than 1.5 miles from school. Such costs are particularly prominent in sparsely populated areas. The average cost of transportation for a given population density is also shown in Figure 1.

An examination of a school district's long-run cost curve provides

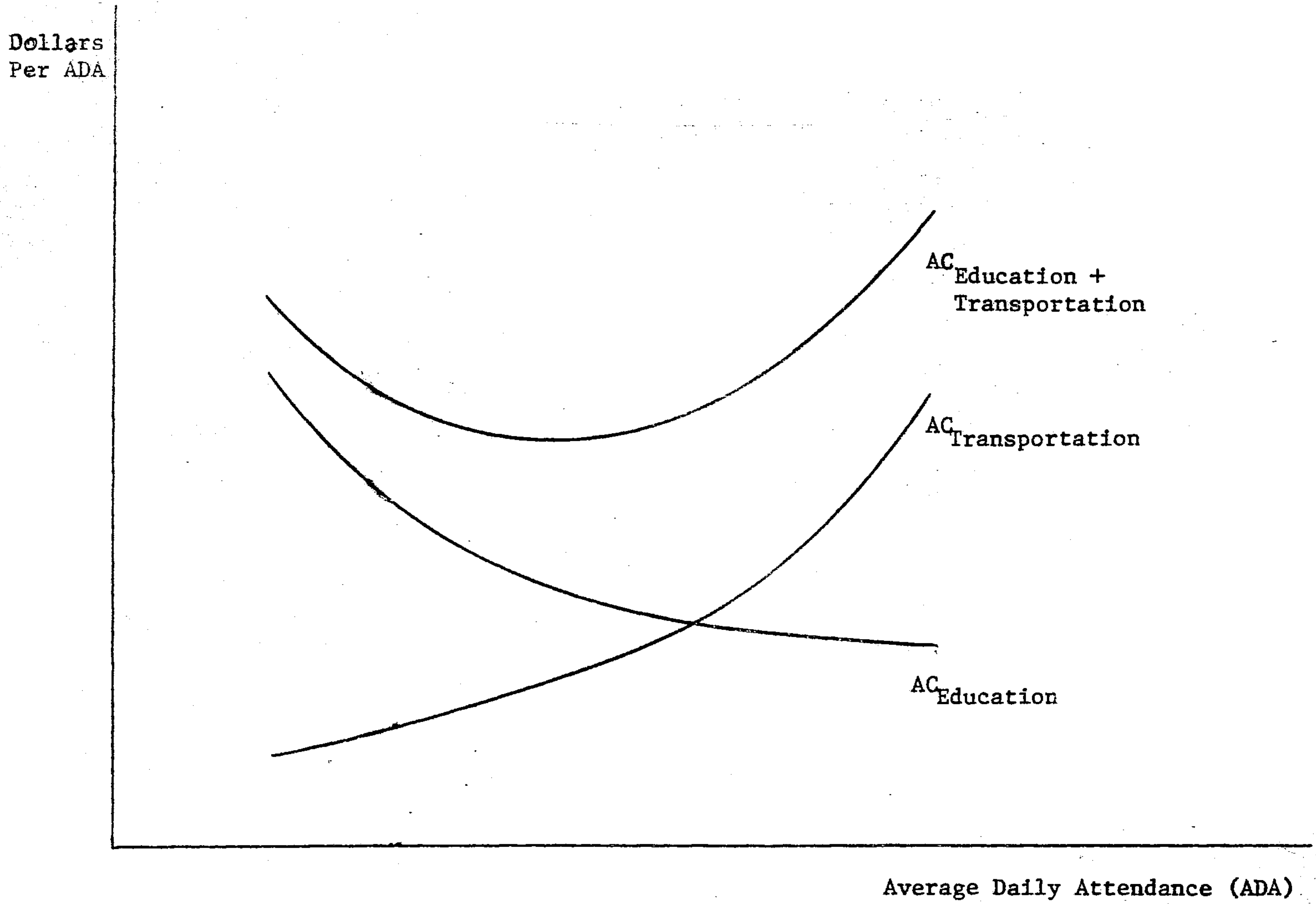


Figure 1. Average Cost of Education and Transportation Per ADA

some insight into how large the school district should be. The optimum size of school district is defined as that which has minimum long-run average costs with resources combined in a least-cost manner.[12]

Least-Cost Combination

The school district can combine factor inputs in varying proportions to produce its output. The problem facing the school district is to use factor inputs in such a way that, whatever the output produced, the cost will be a minimum. In mathematical terms, the problem is one of constrained cost minimization in which the restrictions on output are the constraints. The economic principles derived are also applicable to maximizing the level of output for a given cost outlay.

Let the school district's cost function and production function be represented, respectively, by:

$$C = f(X_1, X_2, \ldots, X_n)$$

$$Q = g(X_1, X_2, \ldots, X_n)$$

where X_i is the quantity of the i^{th} input, C is cost, and Q is output. The school district will try to produce a given output Q* at lowest possible cost. The Lagrangian expression for this constrained minimization problem is:

$$V = f(X_1, X_2, \ldots, X_n) + \lambda(Q^* - g(X_1, X_2 \ldots, X_n)).$$

This expression is minimized by setting each of the partial derivatives equal to zero as follows:

$$\frac{\partial V}{\partial X_1} = \frac{\partial f}{\partial X_1} - \lambda \frac{\partial g}{\partial X_1} = 0$$

$$\frac{\partial V}{\partial X_2} = \frac{\partial f}{\partial X_2} - \lambda \frac{\partial g}{\partial X_2} = 0$$

$$\vdots$$

$$\frac{\partial V}{\partial X_n} = \frac{\partial f}{\partial X_n} - \lambda \frac{\partial g}{\partial X_n} = 0$$

$$\frac{\partial V}{\partial \lambda} = Q^* - g(X_1, X_2, \ldots, X_n) = 0 .$$

The marginal physical product of input X_i and the marginal cost of input X_i are represented by $\partial g/\partial X_i$ and $\partial f/\partial X_i$, respectively. These simultaneous equations can be solved for the optimum values of the n inputs and λ.

Factor-Product Conditions

If a dollar value can be assigned to output, then the optimum schooling plan calls for expansion of factor use until marginal cost is just equal to the marginal value of output. Even though educators are unwilling to assign dollar values to output in determining its level, information on the cost of an additional unit of output may be useful to compare with other marginal costs. The simultaneous equations can be solved for λ so that:

$$\lambda = \frac{\partial f/\partial X_i}{\partial g/\partial X_i} .$$

This ratio of marginal cost of input X_i to marginal physical product of input X_i represents the change in cost brought about by a one-unit change in output, and is the marginal cost of another unit of output.

Factor-Factor Conditions

Given the desired level of output, the problem faced by the school administrators is how to allocate all resources in producing that level of output. Solving the above simultaneous equations yield:

$$\frac{\partial g/\partial X_1}{\partial f/\partial X_1} = \frac{\partial g/\partial X_2}{\partial f/\partial X_2} = \cdots \frac{\partial g/\partial X_n}{\partial f/\partial X_n} .$$

The cost of production is minimized by combining factor inputs in such a way that the marginal physical product of a dollar's worth of one input is equal to the marginal physical product of a dollar's worth of every other input used.

Product-Product Conditions

The educational production process yields more than one output. The case of joint products exists whenever the quantities of two or more outputs, such as achievement scores, absentee rates, and dropout rates, are technically interrelated. Restrictions on the levels of these additional outputs can be incorporated into the above model by imposing additional constraints. The added equimarginal principles that must be met to minimize costs are:

$$\frac{\partial g_1/\partial X_i}{\partial f/\partial X_i} = \frac{\partial g_2/\partial X_i}{\partial f/\partial X_i} = \cdots \frac{\partial g_m/\partial X_i}{\partial f/\partial X_i} .$$

The input X_i should be used in the production of each of the m outputs to the point that the marginal physical product of X_i in the production of output Q_j per dollar's worth of input X_i is the same for all outputs.

Theoretical Applications

This study will apply the economic principles derived above to select the least-cost combination of inputs for a given quality of education. The possible range of substitution among outputs will also be estimated. Assuming that the number of students is variable, the minimum point on the long-run average cost curve, such as point A_1 in Figure 2, shows the optimum size of school district. Each long-run average cost curve in Figure 2 is based on a different student density. The less densely populated areas have greater transportation costs associated with busing a given number of students over large distances. Thus, the three curves are long-run average cost curves for the same quality of education, but different student densities. The curve showing the optimum school district size for the different student densities, which is presented in Figure 3, can be derived from Figure 2. Before applying these principles, sources and profiles of data used in the analysis are presented in the following chapter.

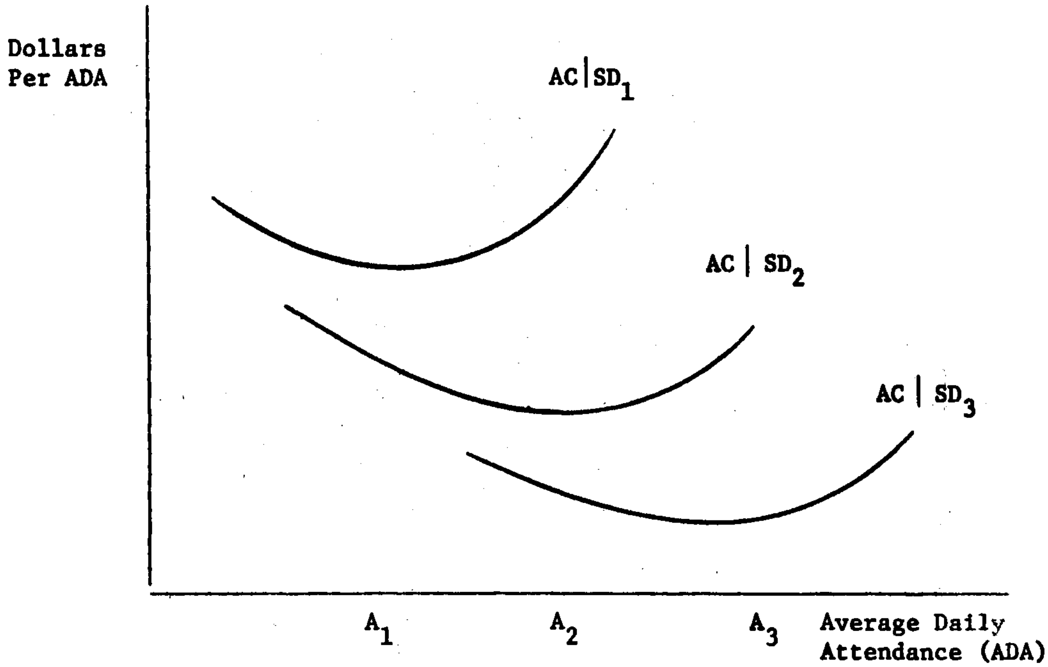


Figure 2. Long-run Average Cost Curves for Alternative Student Densities (SD_i)

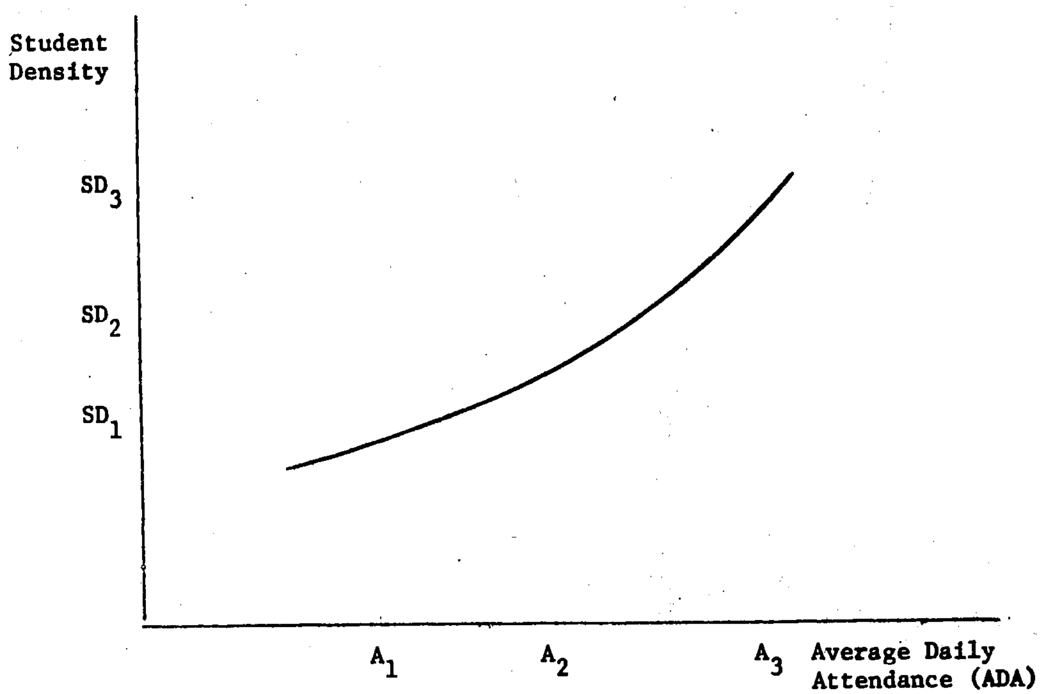


Figure 3. Optimum Size of School District for Alternative Student Densities

FOOTNOTES

[1]Output is also a dimension of efficiency. Although this study did not determine efficient levels of output, it did examine the impact of changes in educational output.

[2]Richard H. Leftwich, _The Price System and Resource Allocation_, 4th ed. (Hinsdale, Illinois, 1970), p. 117.

[3]Jesse Burkhead, Thomas G. Fox, and John W. Holland, _Input and Output in Large-City High Schools_ (New York, 1967), p. 20.

[4]Jan Tinbergen, _On the Theory of Economic Policy_ (Amsterdam, 1952), pp. 6-7.

[5]Salaries of teachers were standardized to the same experience and degree level.

[6]Burkhead, Fox, and Holland, pp. 39-76.

[7]Martin T. Katzman, "Distribution and Production in a Big City Elementary School System," _Yale Economic Essays_, Vol. 8, No. 1 (Spring, 1968), pp. 218-220.

[8]Leftwich, p. 146.

[9]Jacob Viner, "Cost Curves and Supply Curves," _Readings in Price Theory_, ed. George J. Stigler and Kenneth E. Boulding, American Economics Association (Homewood, Illinois, 1952), p. 201.

[10]Leftwich, pp. 160-162.

[11]Viner, p. 213.

[12]George J. Stigler, _The Theory of Price_, 3rd ed. (New York, 1966), p. 159.

CHAPTER IV

DATA

The data used herein were obtained by the Oklahoma State Department of Education which evaluated student needs in Oklahoma schools. The statewide study assessed school programs, student backgrounds, and student attainment. The data were collected to determine the relationship of student performance to educational process, student input, and environmental variables. Broad categories of variables were included in the study to assess general effectiveness of educational programs irrespective of individual school district goals.

Sampling Procedure

To capture the wide differences in characteristics that are known to exist in Oklahoma's public elementary and secondary schools, a stratified random sample of the state's school districts was used. The population of school districts was first divided into 16 populations or strata according to geographic location: the Tulsa area and Oklahoma City area, northwestern, northeastern, southwestern, and southeastern Oklahoma. Figure 4 shows these geographic regions. Each region, except the Oklahoma City and Tulsa areas, was then divided into three strata according to school district sizes: under 500 students, between 500 and 2,000 students, and over 2,000 students. The Oklahoma City and Tulsa areas were divided into two strata: regular districts and Title I

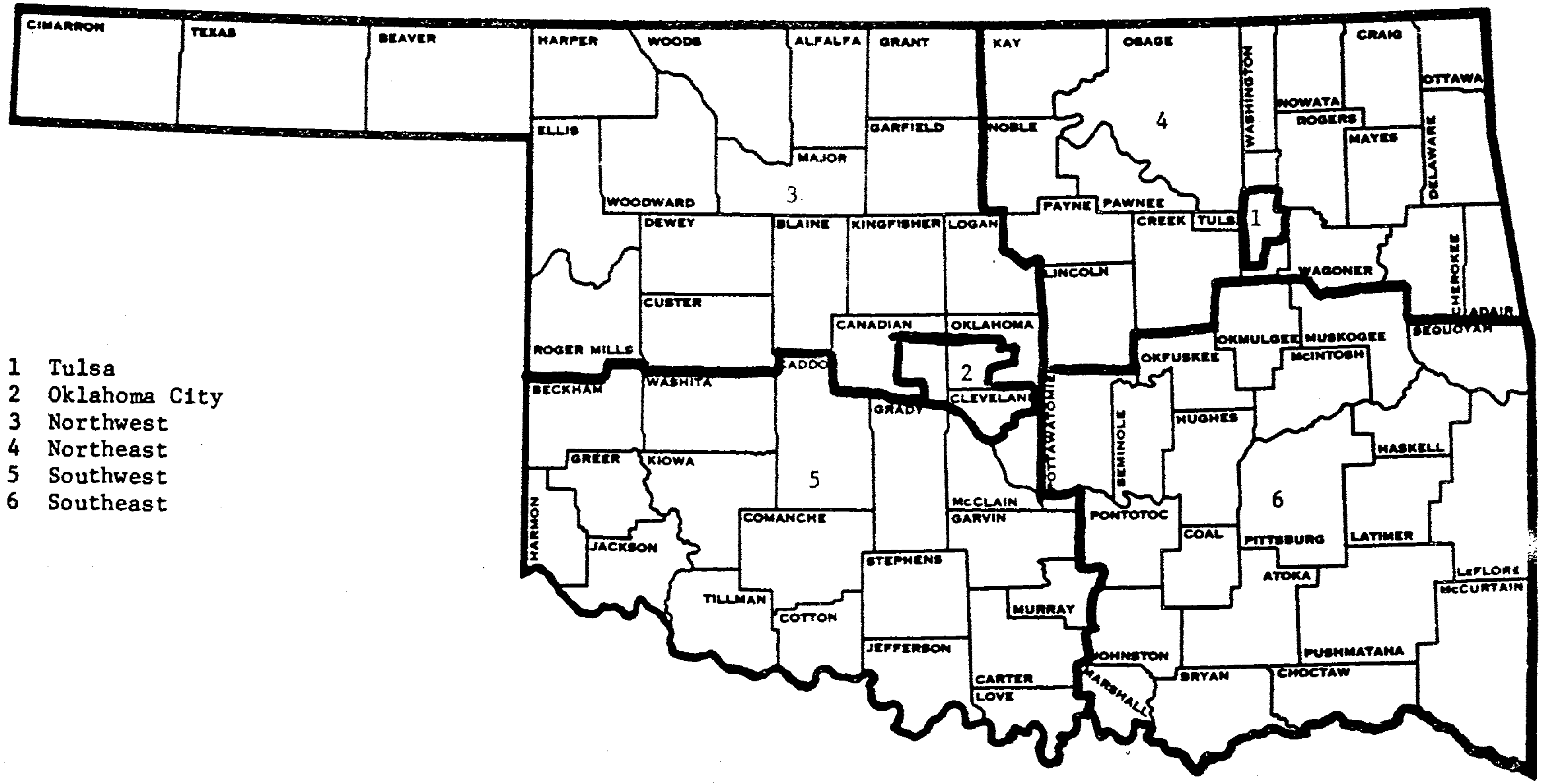


Figure 4. The Geographic Regions From Which the Sample Was Drawn

school districts.

The sample was designed to be proportional - sampling all students in each district until the number of districts included five percent of all students in each stratum. As shown in Table II, the actual sampling rate varied slightly among strata because of the "lumpiness" of school districts. For example, in the stratum containing large schools, adding or subtracting one school would change the sampling rate considerably. A sample of districts was drawn independently and randomly in each stratum.

Data Gathering

After the schools were randomly drawn, counselors from the Oklahoma State Department of Education visited the schools in March, 1970, to supervise the administering of tests and questionnaires. Students in the eleventh grade of sampled high schools, and the students in the fourth and eighth grades of schools that "feed" into these high schools completed standardized achievement and IQ instruments and filled out a questionnaire. The questions, as shown in Appendix A, included socio-economic background, activities, educational preparation, and post high school plans. The numbers of students surveyed in the fourth, eighth, and eleventh grades were 2,255, 1,993, and 1,903, respectively. The parents of the students also filled out a questionnaire on their education, occupation, income, and residence. This questionnaire is shown in Appendix B. In addition, data were acquired from school administrators concerning finances, program, organization, facilities, equipment, teacher qualifications, and community characteristics. The administrators' questionnaire is shown in Appendix C.

TABLE II

DESCRIPTION OF POPULATION AND SAMPLE BY STRATA

Strata	ADA in Strata	ADA of Districts Sampled	ADA of Districts Sampled as % of Stratum ADA	Percentage of Students Sampled in the Fourth Grade	Eighth Grade	Eleventh Grade
Metropolitan Areas	136,897	---	---	3.102	1.261	2.181
Southeast						
Greater than 2000 students	18,312	4,739	25.879	16.943	20.844	22.874
501 - 2000 students	40,431	2,664	6.589	5.339	5.926	6.144
0 - 500 students	41,042	1,801	4.388	3.895	4.206	3.896
Southwest						
Greater than 2000 students	49,695	3,569	7.182	6.457	4.975	5.557
501 - 2000 students	31,677	1,386	4.375	3.978	3.782	3.838
0 - 500 students	24,428	1,034	4.233	3.094	3.462	4.003
Northeast						
Greater than 2000 students	42,089	2,634	6.258	4.713	4.799	6.310
501 - 2000 students	40,155	1,881	4.684	3.894	4.183	4.574
0 - 500 students	25,392	1,237	4.872	3.676	4.857	4.371
Northwest						
Greater than 2000 students	68,257	2,857	4.186	3.487	3.028	2.419
501 - 2000 students	13,006	1,003	7.712	7.092	5.420	5.793
0 - 500 students	21,739	593	2.728	2.308	1.837	4.255

Additional information on transportation, course enrollment, and costs by functions for the sampled school districts was obtained from the State Department of Education's files. Most of this data were from school district annual reports.

Complete data were acquired from 27 independent Oklahoma school districts. The size of the school districts sampled ranged from under 100 pupils to more than 70,000 pupils. The stratification insured that every geographic region in the state and school district size was represented in the sample.

Biases

Even though 91.8 percent of the students who took achievement tests returned both parent and student questionnaires, there may have been some biases introduced into the data from missing observations associated with the unreturned questionnaires. It is useful to examine how the results may be affected by missing information. The first issue is whether real differences exist between the performance of those students with complete information and those with missing information. Secondly, it is important to decide if any observed differences are likely to bias the results.

The mean composite score of students with complete information was compared to the mean composite scores of students with incomplete student questionnaires and incomplete parent questionnaires. The summary information is shown in Table III. In all three grades, students with complete information had higher average composite achievement scores than students with missing questionnaires. The means of these groups were significantly different at the .01 level in every instance. The

TABLE III

SELECTED INFORMATION RELATED TO DATA BIAS

Subpopulations	Number of Observations	Average Composite Score	Standard Deviation of Composite Score
Fourth Grade			
Complete Information	2019	157.506	46.629
Missing Student Questionnaire	6	97.833	47.998
Missing Parent Questionnaire	230	140.917	46.041
Eighth Grade			
Complete Information	1854	175.553	72.152
Missing Student Questionnaire	10	133.200	50.907
Missing Parent Questionnaire	129	142.481	81.186
Eleventh Grade			
Complete Information	1776	80.676	24.280
Missing Student Questionnaire	9	64.778	25.464
Missing Parent Questionnaire	118	72.373	22.124

greatest difference was between students with complete information and students with missing student questionnaires. However, there were only 25 such students in the entire sample.

Without complete information on these students, it is difficult to know what characteristics are responsible for the lower achievement scores. It seems likely that the results will be slightly biased. However, the number of incomplete questionnaires is so small that the conclusions of the study are not likely to be significantly affected.

Profile of Sample

The educational output variables used in this study are each district's average absentee rate, dropout rate, and average achievement scores. The absentee and dropout rates are averages for the schools included in the sample rather than for the students sampled. The achievement scores are average school district scores made on Science Research Associates' standardized achievement tests. The tests were administered to students in the fourth, eighth, and eleventh grades. The modern math and language arts scores in all three grades are district averages. The fourth and eighth grade composite scores are made up of test scores on social studies, science, language arts, math, and reading. The eleventh grade composite score is the average district score on social concepts, natural science, expression, quantitative thinking, and reading.

Even though observations were made at the individual student level, the school district is used as the unit of observation to provide guidelines for school district resource organization. Since this study is concerned with school characteristics, using the school district as the unit of observation has a major advantage - that of weighting all districts equally so that a school district with many pupils cannot bias the results in comparison to using the pupil as the unit of observation. This procedure also has a disadvantage, however, in that a great deal of information is lost through aggregation. For example, the effect of IQ is very important at the individual level, but the averages "wash out" individual student differences and decrease its importance at the district level.

It is useful to compare results of regression equations with the pupil and the school district as units of observation. In the former case, individual pupil achievement scores were regressed on individual pupil characteristics. The resulting relationship provides information to predict each pupil's achievement score given his characteristics of background and schooling. With the school district as the unit of observation, average school district scores were regressed on district averages for educational process and background variables. The equation can be used to predict a given school district's average achievement score, making use of information on its schooling variables and average student characteristics. Almost all of the explained variation in the first equation was attributable to student IQ. All other variables included in this equation explained a very small percentage of the variation in achievement scores. With the school district as the unit of observation, the estimated equation indicated schooling inputs had a much greater impact on average achievement scores.

Tables IV, V, and VI present data which describe the educational outputs by strata for each of the three grades. In general, absentee and dropout rates are higher in the smaller school districts. Northwestern Oklahoma and the Tulsa and Oklahoma City areas consistently had

TABLE IV

FOURTH GRADE EDUCATIONAL OUTPUTS BY SAMPLING STRATA

Strata	Number of Students Sampled	School Average Absentee Rate	Sample Average Language Arts Score	Sample Average Modern Math Score	Sample Average Composite Score
Metropolitan Areas	364	5.00	283.11	284.74	157.91
Southeast					
0-500 students	266	3.96	277.93	279.51	158.38
501-2000 students	185	1.20	282.65	292.30	164.51
Greater than 2000 students	137	2.39	252.85	270.28	133.52
Southwest					
0-500 students	275	4.10	281.77	291.32	161.09
501-2000 students	108	3.63	279.44	289.06	153.75
Greater than 2000 students	84	4.63	268.60	275.71	146.20
Northeast					
0-500 students	170	5.00	274.72	288.48	159.63
501-2000 students	134	5.71	281.74	296.99	167.31
Greater than 2000 students	80	0.00[a]	264.96	278.60	142.39
Northwest					
0-500 students	204	4.37	271.36	280.32	152.18
501-2000 students	79	3.00	273.73	299.76	158.58
Greater than 2000 students	43	1.89	280.58	304.14	167.37

[a]Absentee rates for schools were recorded to the nearest percent.

TABLE V

EIGHTH GRADE EDUCATIONAL OUTPUTS BY SAMPLING STRATA

Strata	Number of Students Sampled	School Average Absentee Rate	Sample Average Language Arts Score	Sample Average Modern Math Score	Sample Average Composite Score
Metropolitan Areas	147	5.00	365.68	472.76	203.39
Southeast					
0-500 students	325	3.00	356.45	443.44	192.52
501-2000 students	204	2.26	353.67	438.73	184.50
Greater than 2000 students	147	2.22	326.41	417.80	163.19
Southwest					
0-500 students	215	4.00	359.76	463.66	200.71
501-2000 students	102	4.25	360.70	439.86	190.86
Greater than 2000 students	72	4.74	348.93	429.50	175.50
Northeast					
0-500 students	172	5.00	356.69	450.53	191.00
501-2000 students	143	5.67	378.26	467.27	208.47
Greater than 2000 students	105	0.70	321.53	427.09	163.37
Northwest					
0-500 students	176	5.00	366.04	458.82	201.30
501-2000 students	60	0.00	380.90	460.45	190.02
Greater than 2000 students	34	1.89	365.62	446.91	198.21

TABLE VI

ELEVENTH GRADE EDUCATIONAL OUTPUTS BY SAMPLING STRATA

Strata	Number of Students Sampled	School Average Absentee Rate	School Average Dropout Rate	Sample Average Language Arts Score	Sample Average Modern Math Score	Sample Average Composite Score
Metropolitan Areas	226	5.97	5.13	428.26	442.33	87.60
Southeast						
0-500 students	317	5.00	4.00	428.10	414.52	80.95
501-2000 students	188	2.64	6.27	414.95	416.22	80.41
Greater than 2000 students	121	3.01	3.54	383.72	386.15	62.58
Southwest						
0-500 students	209	5.00	5.00	421.40	407.80	79.24
501-2000 students	92	2.80	4.44	428.83	427.69	81.92
Greater than 2000 students	74	3.71	4.54	402.29	392.73	72.62
Northeast						
0-500 students	201	5.00	5.00	419.84	419.09	78.57
501-2000 students	139	5.16	4.23	436.00	431.74	87.89
Greater than 2000 students	84	1.07	1.13	406.26	407.38	73.14
Northwest						
0-500 students	125	2.00	3.00	417.45	413.38	77.21
501-2000 students	57	0.00	3.00	429.23	432.37	85.11
Greater than 2000 students	70	0.75	0.00	441.33	427.64	87.57

the highest achievement test scores. However, it is difficult to detect any substantial trends among school district sizes, geographic regions, or grades. The achievement scores are not standardized among grades, and cannot be used directly to compare progress among grades 4, 8, and 11.

Table VII presents simple correlation coefficients between educational outputs. The first number in the second column shows that the correlation between fourth grade absentee rate and language arts score is .096. In general, the correlations between absentee rates and achievement scores are low in absolute value but statistically significant. The correlations show that composite scores in all grades are closely related. In the eleventh grade, dropout rates are negatively related to all achievement scores.

Simple correlation analysis gives some insight into which variables are associated with higher educational output. A list of selected variables with their means and standard deviations are shown in Table XXXVII of Appendix D. Tables XXXVIII and XXXIX show the correlation coefficients associated with these variables. However, correlation analysis does not take into account the interrelationships among all the variables. Subsequent chapters will address this problem.

TABLE VII

CORRELATION COEFFICIENTS OF EDUCATIONAL OUTPUTS

Variable	Absentee $Rate_4$	Language $Arts_4$	Modern $Math_4$	Composite $Score_4$	Absentee $Rate_8$	Language $Arts_8$	Modern $Math_8$
Absentee $Rate_4$	1.000	0.096	0.043	0.163	0.859	0.607	0.566
Language $Arts_4$		1.000	0.595	0.865	0.089	0.461	0.580
Modern $Math_4$			1.000	0.798	-0.053	0.471	0.509
Composite $Score_4$				1.000	0.099	0.588	0.707
Absentee $Rate_8$					1.000	0.465	0.439
Language $Arts_8$						1.000	0.812
Modern $Math_8$							1.000

TABLE VII (Continued)

Variable	Composite Score$_8$	Absentee Rate$_{11}$	Dropout Rate$_{11}$	Language Arts$_{11}$	Modern Math$_{11}$	Composite Score$_{11}$
Absentee Rate$_4$	0.610	0.668	0.439	0.262	0.285	0.403
Language Arts$_4$	0.583	-0.165	0.076	0.359	0.406	0.459
Modern Math$_4$	0.564	-0.156	-0.077	0.631	0.577	0.647
Composite Score$_4$	0.725	-0.126	0.112	0.567	0.582	0.685
Absentee Rate$_8$	0.514	0.741	0.486	0.166	0.207	0.314
Language Arts$_8$	0.896	0.170	0.108	0.699	0.723	0.809
Modern Math$_8$	0.925	0.209	0.117	0.680	0.794	0.829
Composite Score$_8$	1.000	0.180	0.069	0.770	0.797	0.871
Absentee Rate$_{11}$		1.000	0.592	0.057	0.076	0.156
Dropout Rate$_{11}$			1.000	-0.217	-0.073	-0.004
Language Arts$_{11}$				1.000	0.881	0.920
Modern Math$_{11}$					1.000	0.939
Composite Score$_{11}$						1.000

CHAPTER V

EDUCATIONAL PRODUCTION FUNCTIONS

The main objective of this chapter is to quantify the effect of various inputs on the quality of elementary and secondary education. The educational output variables - absentee rates, dropout rates, and achievement scores - were regressed on the educational process, student input, and environmental variables. This procedure yields the net effect of the educational process variables on educational output, while holding the control variables constant.

Hierarchical Regression

Simple correlation analysis fails to account for the interrelationships of educational process variables and student input and environmental variables. Regression analysis is one technique that can be used to estimate the net relationship between educational process variables and educational output while holding the control variables constant.

In the regression analysis, the achievement scores, absentee rates, and dropout rates which measure the quality of educational output are termed the dependent variables. The educational process variables, student input variables, and environmental variables are the independent or explanatory variables. The regression equation is essentially a formula for predicting the value of the dependent variable.

Since there are more admissible hypotheses (variables) explaining any dependent variable than can be included in the regression equation, stepwise regression is used to select a subset of variables for the final equation. The stepwise linear regression procedure computes successive multiple linear regression equations. At each successive step, the variable which makes the greatest reduction in the error sum of squares is added to the regression equation. The variable added consequently has the highest partial correlation with the dependent variable partialled on the variables which have already been included. Although this procedure does not insure the "best" regression equation, it is considered to be the best of the variable selection procedures.[1]

Just as the model of the inputs' relationship to output was specified as a hierarchy of admissible hypotheses, the regression procedure was formulated to take this hierarchy into account. Interest centered on the educational process variables, and these comprised the first echelon. Thus, if either educational process or control variables can account for the variation in educational output, the former variables are favored and selected to be included in the equation. This procedure is similar to the one used by Heady and Tweeten.[2] The most significant variables of the higher echelon (educational process variables) were the first variables allowed to enter the equation by the stepwise regression procedure. Then, the significant variables of the second echelon (control variables) were allowed to enter the equation. As additional variables were introduced, educational process variables were removed from the equation if they became insignificant. This regression procedure may slightly bias the t-test of significance.

Fourth Grade

The equations showing the effect of various factors on fourth grade absentee rates, language arts, modern math, and composite achievement scores are shown in Tables VIII, IX, X, and XI, respectively. The coefficients of all the variables included in these equations were significant at the .10 level. These equations explained from 74 to 82 percent of the variation in the sample data on educational output.

Educational Process Variables

The influence of teachers on student performance was especially apparent in the fourth grade. Lighter workloads and higher salaries were associated with improved student performance. Every one percent increase in the number of teachers with a planning period was associated with .10 unit increase in the composite achievement score and .02 percent reduction in the absentee rate. Large pupil-teacher ratios were detrimental to absentee rates and modern math scores. The absentee rate increased by .25 percent and the average modern math score declined by 1.38 units for every additional student per teacher. Those school districts offering higher standard salaries attained higher achievement scores and lower absentee rates by attracting better teachers.

Educational output was also linked to teacher experience. Each year of average teacher experience was associated with a reduction of .30 percent in the absentee rate and an increase of 1.82 units in average language arts score, and .96 units in average composite score. Students tended to have lower absentee rates and higher language arts scores if a greater percentage of their teachers had between three and nine years of experience. On the other hand, students had higher modern

TABLE VIII

EQUATION EXPLAINING FOURTH GRADE ABSENTEE RATE

Variable	Regression Coefficient	Standard Error
Constant	22.8199	
Educational Process Variables		
Percentage of teachers with three to nine years of experience	-0.0394	0.0228
Percentage of teachers with a planning period	-0.0190	0.0061
Pupil-teacher ratio	0.2460	0.0511
Average teacher experience	-0.2972	0.0690
Salary in thousand dollars for beginning teachers with bachelor's degree	-3.2050	0.9250
Student-Input Variables		
Percentage of students who study three or more hours a day	-0.1903	0.0482
Percentage of students who have spent most of their lives in rural areas	-0.0285	0.0105
R^2	0.8056	

TABLE IX

EQUATION EXPLAINING FOURTH GRADE LANGUAGE ARTS SCORES

Variable	Regression Coefficient	Standard Error
Constant	80.1583	
Educational Process Variables		
Percentage of teachers with five to nine years of experience	0.6479	0.2718
Adequate kindergarten	6.6886	4.0334
Number of different periodicals	0.3476	0.2126
Value of audiovisual material in hundred dollars per student	2.0176	0.7003
Average teacher experience	1.8205	0.4238
Salary in thousand dollars for beginning teachers with bachelor's degree	10.1777	5.8997
SQRT (Average daily attendance in thousands)	-2.1119	1.5367
Student-Input Variable		
IQ	0.7516	0.4819
Environmental Variable		
Percentage of students whose parents' net income is greater than $10,000	0.5813	0.2788
R^2	0.8289	

TABLE X

EQUATION EXPLAINING FOURTH GRADE MODERN MATH SCORES

Variable	Regression Coefficient	Standard Error
Constant	249.6048	
Educational Process Variables		
Percentage of teachers with ten or more years of experience	0.2242	0.1104
Number of different periodicals	0.5861	0.2290
Pupil-teacher ratio	-1.3820	0.5610
Value of audiovisual material in hundred dollars per student	2.2752	0.7097
SQRT (Average daily attendance in thousands)	-2.1854	1.2708
Environmental Variables		
Percentage of students whose mother's occupation is professional or executive	1.1563	0.6066
Parents' average net income	4.7960	1.2873
R^2	0.7414	

TABLE XI

EQUATION EXPLAINING FOURTH GRADE COMPOSITE SCORES

Variable	Regression Coefficient	Standard Error
Constant	-25.9263	
Educational Process Variables		
Percentage of teachers who have a planning period	0.0977	0.0488
Value of audiovisual material in hundred dollars per student	0.9503	0.5953
Average teacher experience	0.9591	0.3571
Student-Input Variables		
IQ	1.5406	0.4052
Percentage of students who have spent most of their lives in rural areas	-0.1648	0.0810
Environmental Variable		
Percentage of students whose mother's occupation is professional or executive	1.1944	0.4400
R^2	0.7630	

math scores if a greater percentage of their teachers had ten or more years of experience.

Instructional materials also had an important effect on student performance. Value of audiovisual material per pupil was positively associated with all three achievement scores. The number of periodicals available in a school was positively related to language arts and modern math scores. These measures may actually reflect the impact of a full complement of instructional materials. Student performance was significantly influenced by two additional educational process variables - the availability of an adequate kindergarten and the size of the school district. Fourth grade students had higher language arts scores if the district had an adequate kindergarten. Evidently, kindergarten had a positive effect on learning and helped to build a foundation for elementary education. Those school districts with larger enrollments had lower language arts and modern math scores, other things equal.

Control Variables

As expected, student characteristics were also important in explaining student performance. Each unit of IQ was associated with an increase in the language arts score of .75 units and in the composite achievement score of 1.54 units. Schools had lower absentee rates if a greater percentage of students studied three or more hours a day, other things equal. Time spent studying probably revealed students' interest in education. Those schools with a greater percentage of students who have spent most of their lives in rural areas had lower absentee rates but also lower composite achievement scores. Every one percent of students who have spent most of their lives in rural areas reduced absentee rates by .03 percent and composite achievement scores by .16 units.

Parents' income and occupation accounted for a large portion of the variation in student achievement. Every one percent of the mothers whose occupation is professional or executive was associated with an increase of 1.16 units in the modern math score and 1.19 units in the composite achievement score. Each thousand dollar increase in parents' average net income was associated with an increase of 4.80 units in the modern math score. Each additional percentage point gain in the proportion of parents with a net income of more than $10,000 was associated with an increase of .58 units in the language arts score.

Nonsignificant Variables

Identification of variables which did not have a significant effect on student attainment can also be an important part of evaluation. Ability groupings, special education, and accelerated classes appeared to have little effect on fourth grade student performance. Teacher education showed no significant effect on student attainment. Of course, it is possible that some of these omitted variables may have been important but did not show significance because of limited data in the sample or because they are closely correlated with other variables which were included in the equation.

Eighth Grade

Variables affecting eighth grade student performance are shown in Tables XII, XIII, XIV, and XV. These equations reveal as did those for grade 4 that educational process, student input, and environmental

TABLE XII

EQUATION EXPLAINING EIGHTH GRADE ABSENTEE RATE

Variable	Regression Coefficient	Standard Error
Constant	23.0438	
Educational Process Variables		
Percentage of teachers with a planning period	-0.0137	0.0061
Pupil-teacher ratio	0.1535	0.0472
Average teacher experience	-0.1993	0.0532
Salary in thousand dollars for beginning teachers with bachelor's degree	-2.9833	1.0619
Student-Input Variables		
Percentage of students who study one or more hours a day	-0.0258	0.0188
Percentage of students who spent most of their lives in rural areas	-0.0634	0.0141
R^2	0.7569	

TABLE XIII

EQUATION EXPLAINING EIGHTH GRADE LANGUAGE ARTS SCORES

Variable	Regression Coefficient	Standard Error
Constant	86.5020	
Educational Process Variables		
Percentage of teachers with five to nine years of experience	0.3016	0.2275
Pupil-teacher ratio	-0.6994	0.4528
SQRT (Average daily attendance in thousands)	-7.3332	1.8858
Student-Input Variables		
IQ	2.1791	0.5472
Average number of hours students studied	15.2785	9.7660
Average number of books students read during last summer	5.9697	2.3514
Environmental Variables		
Percentage of students whose fathers attended college	0.5568	0.2520
Percentage of students whose parents' net income is greater than $10,000	0.6263	0.2600
R^2	0.8531	

TABLE XIV

EQUATION EXPLAINING EIGHTH GRADE MODERN MATH SCORES

Variable	Regression Coefficient	Standard Error
Constant	403.9570	
Educational Process Variables		
Percentage of teachers with three to nine years of experience	0.3391	0.1040
Number of printed volumes per pupil	0.6193	0.2906
Pupil-teacher ratio	-0.6425	0.3017
SQRT (Average daily attendance in thousands)	-7.9208	1.6008
Environmental Variables		
Percentage of students whose fathers attended college	0.5494	0.1706
Percentage of students whose father's occupation is professional or executive	0.7084	0.2651
Percentage of students whose parents' net income is greater than $10,000	0.9200	0.1628
R^2	0.9044	

TABLE XV

EQUATION EXPLAINING EIGHTH GRADE COMPOSITE SCORES

Variable	Regression Coefficient	Standard Error
Constant	41.9040	
Educational Process Variables		
Percentage of teachers with ten or more years of experience	-0.1019	0.0739
Number of printed volumes per pupil	0.5505	0.2358
Number of different periodicals	0.1860	0.0894
SQRT (Average daily attendance in thousands)	-3.9975	1.1644
Student-Input Variables		
Fourth grade composite score	0.2508	0.1160
IQ	0.5070	0.3749
Average number of hours students studied	12.2533	5.1364
Environmental Variables		
Percentage of students whose fathers attended college	0.5440	0.1388
Percentage of students whose parents plan for their children to attend college	0.4419	0.1727
R^2	0.9212	

variables account for a sizable proportion of the variation among districts in student performance. The school that seeks to change educational process variables to improve student performance must recognize constraints imposed by student background.

Educational Process Variables

Major educational process variables affecting eighth grade student performance include instructional materials, school district size, and factors associated with classroom teachers. Every printed volume per pupil was associated with increased modern math and composite achievement scores of .62 and .55 units, respectively. The number of periodicals available also increased composite achievement scores. Larger school districts had lower achievement scores, other things equal.

Significant factors associated with teachers include their workload, salary, and experience. Giving teachers planning periods improved their performance and, consequently, reduced absentee rates. Increasing pupil-teacher ratios reduced the effectiveness of teachers. Every one-unit increase in the pupil-teacher ratio was associated with .15 percent increase in the absentee rate, .70 unit decline in the language arts score, and .64 unit decline in the modern math score. Those districts with the highest standard teacher salaries had the lowest absentee rates, other things equal. Each thousand dollar increment in salary for beginning teachers with bachelor's degree was associated with a reduction in the absentee rate of 2.98 percent.

Again, teacher experience played a major role in determining student performance. The absentee rate was reduced .20 units on the average for each year of teacher experience. Percentage of teachers with three to nine years of experience was positively related to language arts and modern math scores. A high percentage of teachers with ten or more years experience was detrimental to composite achievement scores. Thus, teachers with several years of experience are very important in some aspects of education, such as motivating students to stay in school. On the other hand, the skills that older teachers obtained in college may have been of lower quality than currently obtained.

Control Variables

Aptitudes and educational efforts are the most important student characteristics affecting student performance. Time spent studying was positively related to language arts and composite achievement scores. Also, percentage of students who study one or more hours a day was negatively related to the absentee rate. Each unit increase in the average number of books read was associated with an increase in language arts score of 5.97 units. Student IQ was positively related to language arts and composite achievement scores. Average fourth grade achievement scores were used as a characteristic of students entering the junior high educational program. Each additional unit of fourth grade composite achievement score was associated with an increase in eighth grade composite achievement score of .25 units, other things equal. Those schools with a greater percentage of students who spent most of their lives in a rural area had a lower absentee rate.

Parents' education, occupation, income, and interest in their children's education were very strongly related to eighth grade student performance. The percentage of fathers who attended college was positively related to all achievement scores. Language arts and modern math scores improved with an increase in the percentage of students whose parents' net income is greater than $10,000. The percentage of students whose father's occupation is professional or executive was positively related to modern math scores. A greater percentage of parents who plan for their children to attend college was associated with a higher average composite achievement score.

Nonsignificant Variables

A pattern of omitted variables in explaining student performance was not as evident for the eighth grade as for the fourth grade. Facilities did not have a significant effect on student performance, and again the teacher's education did not appear significant. All other major categories of educational process variables were important in explaining some aspect of student performance.

Eleventh Grade

The equations explaining eleventh grade student performance are shown in Tables XVI, XVII, XVIII, XIX, and XX. Besides absentee rates, language arts, modern math, and composite achievement scores, student performance is expanded in the eleventh grade to include dropout rates. Additional educational process and student input variables which reflect high school education and high school students were included for the eleventh grade. The last part of this section examines the tradeoff between educational outputs.

Educational Process Variables

Factors associated with teachers were again the most important

TABLE XVI

EQUATION EXPLAINING ELEVENTH GRADE DROPOUT RATE

Variable	Regression Coefficient	Standard Error
Constant	20.5431	
Educational Process Variables		
Percentage of teachers with five to nine years of experience	-0.0588	0.0194
Percentage of teachers with ten or more years of experience	-0.0893	0.0198
Value of audiovisual material in hundred dollars per student	-0.3764	0.0746
Salary in thousand dollars for beginning teachers with bachelor's degree	-1.8264	1.0377
SQRT (Average daily attendance in thousands)	0.5615	0.1922
Environmental Variable		
Percentage of students whose parents net income is greater than $10,000	-0.0531	0.0299
R^2	0.7856	

TABLE XVII

EQUATION EXPLAINING ELEVENTH GRADE ABSENTEE RATE

Variable	Regression Coefficient	Standard Error
Constant	23.0678	
Educational Process Variables		
Percentage of teachers with five to nine years of experience	-0.1008	0.0220
Value of audiovisual material in hundred dollars per student	-0.1922	0.1000
Average teacher experience	-0.1822	0.1172
Salary in thousand dollars for beginning teachers with a bachelor's degree	-2.6920	1.0924
Adequate language laboratory	-0.9120	0.6691
SQRT (Average daily attendance in thousands)	0.5572	0.1881
Student-Input Variables		
Percentage of students who have changed schools three or more times	0.0487	0.0254
Percentage of students who have spent most of their lives in rural areas or towns with less than 2,500 population	-0.0256	0.0150
R^2	0.7373	

TABLE XVIII

EQUATION EXPLAINING ELEVENTH GRADE LANGUAGE ARTS SCORES

Variable	Regression Coefficient	Standard Error
Constant	372.8147	
Educational Process Variables		
Percentage of teachers with three to nine years of experience	0.2938	0.1966
Adequate industrial, vocational or technical shop	14.4273	5.2503
SQRT (Average daily attendance in thousands)	-9.1054	2.8113
Student-Input Variable		
Percentage of students who plan to continue going to school after graduation	0.5226	0.1794
Environmental Variables		
Percentage of students whose father's occupation is professional or executive	1.4695	0.5047
Percentage of students whose parents' net income is less than $3,000	-0.7439	0.1882
R^2	0.7676	

TABLE XIX

EQUATION EXPLAINING ELEVENTH GRADE
MODERN MATH SCORES

Variable	Regression Coefficient	Standard Error
Constant	77.0076	
Educational Process Variables		
Percentage of teachers with ten or more years of experience	-0.2191	0.1483
Salary in thousand dollars for beginning teachers with a bachelor's degree	12.8106	7.9707
Adequate industrial, vocational or technical shop	7.4269	4.5102
Student-Input Variables		
Eighth grade modern math score	0.5652	0.1442
Average number of hours students studied	14.8942	8.2821
Average number of books students read during last summer	4.7528	2.3086
Average number of hours worked per week outside of school	-2.7796	1.3291
R^2	0.8372	

TABLE XX

EQUATION EXPLAINING ELEVENTH GRADE COMPOSITE SCORES

Variable	Regression Coefficient	Standard Error
Constant	28.0791	
Educational Process Variables		
Percentage of teachers with master's degree	0.2058	0.1018
Percentage of teachers with ten or more years of experience	-0.2546	0.1019
SQRT (number of nonvocational units offered)	4.1382	1.9831
Adequate industrial, vocational or technical shop	7.8974	2.2111
SQRT (Average daily attendance in thousands)	-3.8311	1.1549
Student-Input Variables		
Eighth grade composite score	0.0872	0.0304
Percentage of students who have changed schools three or more times	-0.1345	0.0966
Percentage of students who plan to continue going to school after graduation	0.1415	0.0769
Environmental Variables		
Percentage of students whose fathers attended college	0.2281	0.1473
R^2	0.8474	

educational process variables. Standard salary had its major impact in the eleventh grade. Those districts offering higher standard salaries had lower dropout and absentee rates and higher modern math scores. Percentage of teachers with a master's degree was positively related to composite achievement scores. These two variables indicate that highly qualified teachers are especially important in high school education. Teacher experience was important in determining every dimension of student performance. Having high percentage of teachers with five to nine years of experience reduced both absentee and dropout rates and increased language arts scores. However, the percentage of teachers with ten or more years of experience had a greater impact on reducing dropout rates. Teachers with this much experience were detrimental to modern math and composite achievement scores.

Other educational process variables which affected student performance were audiovisual materials, program offerings, facilities, and district size. Absentee and dropout rates declined with increases in the value of audiovisual material available. Those schools with a greater number of nonvocational units had higher composite achievement scores. Schools with an adequate industrial, vocational or technical shop, a proxy for facilities in general, had higher achievement scores. Schools with an adequate language laboratory had lower absentee rates. School district size per se again was negatively related to student performance.

Control Variables

Student effort was apparent in performance. The average number of hours studied was positively related to modern math scores. An increase in the average number of books read last summer was associated with an increase in the modern math scores. Those schools whose students scored higher on eighth grade modern math and composite achievement tests had higher eleventh grade modern math and composite achievement scores.

Other significant student input variables include work outside of school, post high school plans, number of times students have changed schools, and residence patterns. Modern math scores were lower in those schools which had many students working outside of school. Students who have changed schools three or more times had higher absentee rates and lower composite achievement scores. Percentage of students who plan to continue going to school after graduation was positively related to language arts and composite achievement scores. Schools with a greater percentage of students who had spent most of their lives in rural areas or towns with less than 2,500 population had lower absentee rates.

Environmental variables were not directly as important in determining eleventh grade student performance as they were in earlier grades. Parents' income affected dropout rates and language arts scores. Students were less likely to drop out if their parents had high incomes (over $10,000) and more likely to have low language arts scores if their parents had very low incomes (under $3,000). Those students whose fathers attended college had higher composite achievement scores. Also, those students whose father's occupation is professional or executive had higher language arts scores.

<u>Nonsignificant Variables</u>

One of the most striking results of the eleventh grade equations was the absence of variables related to teaching workload. Although the coefficients of these variables (pupil-teacher ratio and percentage of teachers with a planning period) were statistically significant in earlier grades, they were not in the eleventh grade. Teacher qualifications appeared to be just as important as in earlier grades, but instructional materials appeared to be less important. After correcting for parents' education, occupation, and income, race appeared to have no significant effect on student performance in any grade.

Simultaneous Equations

A system of equations was specified in the eleventh grade to measure the possible substitution effect between dropouts and achievement test scores. Each of the three eleventh grade achievement scores - language arts, modern math, and composite achievement scores - were specified as a function of the dropout rate and the same independent variables as presented in Tables XVIII, XIX, and XX, respectively. Eleventh grade dropout rate was specified as a function of eleventh grade composite achievement score and the same independent variables as presented in Table XVI. Two-stage least squares was used to estimate the four equations, which were all over identified. The results of these regressions are shown in Tables XL, XLI, XLII, and XLIII of Appendix E.

In all cases, the regression coefficients in the simultaneous equations were very close to the ones in the previous single equation models. Each one-unit increase in eleventh grade composite achievement score is associated with .015 percent increase in the dropout rate. Since composite achievement score has a mean of 77 and a standard deviation of 9.9, it has little impact on the dropout rate. In the achievement score simultaneous equations, the dropout rate regression coefficient is -2.38 for language arts, -1.10 for modern math, and 0.11 for composite achievement score. Average dropout rate is 3.4 percent with a standard deviation of 2.3. In absolute terms, dropout rate has little effect on achievement scores. These equations show little improvement over the single equation models. Moreover, school programs for reducing dropout rates had no apparent effect on achievement test scores.

Summary and Conclusions

The major task of this chapter has been to quantify the relationship between educational inputs and outputs as measured by achievement scores, absentee rates, and dropout rates. Among the educational process variables which affect achievement, those factors that are associated with teacher performance appeared particularly important. Teacher performance as measured by students' achievement tended to reach a peak between three and ten years of experience. Teachers with more than ten years of experience appeared to be more successful than other teachers in reducing absentee and dropout rates. A smaller pupil-teacher ratio was more important in elementary than in secondary education. Student performance increased in elementary grades when teachers had a lighter workload. Students in secondary schools attained higher levels of performance if they had better trained and better paid teachers.

Other educational process variables that significantly affected student performance include instructional materials, school district size, facilities, and the number of nonvocational units offered. Printed volumes per pupil, value of audiovisual material, and the number of periodicals positively affected student performance. Those schools offering a higher number of nonvocational units had higher secondary composite scores. Other things equal, student performance declined with increases in school district size.

The types of educational input-output relationships presented in this chapter can be used to improve the quality of educational output by changing factor inputs. However, policy decisions should not be based solely on the significance of a factor's effect on educational output, but should also be based on its impact on output in relation to its cost relative to other factors. Subsequent analysis will determine efficient ways to improve the quality of elementary and secondary education based on the input-output coefficients estimated in this chapter. The simultaneous equations in Appendix E suggest that the educational outputs considered in this study can be viewed as independent of each other. This finding greatly simplified the subsequent analysis of an efficient schooling organization to meet specific output targets.

FOOTNOTES

[1] N. R. Draper and H. Smith, Applied Regression Analysis (New York, 1966), pp. 171-172.

[2] Earl O. Heady and Luther G. Tweeten, Resource Demand and Structure of the Agricultural Industry (Ames, 1963), pp. 405-417.

CHAPTER VI

EDUCATIONAL COSTS

This chapter shows costs of elementary (grades 1-8) and secondary (grades 9-12) education applicable to rural areas. A thorough analysis of a school district's operation requires cost data on transportation as well as education. The problem of providing high quality education at a reasonable cost in rural areas is intensified by the high cost of transportation. Educational costs can be divided into a fixed component, embodied in plant and equipment, and a variable component. Major variable costs include administration, instruction, and operation and maintenance of plant.

In planning for educational services, it is useful to know how costs of education vary with the number of students in a district. This study is concerned with a long-run period, a time interval long enough to allow a school district to vary in size. The long-run average cost curve shows the minimum cost per student of educating various numbers of students. The purpose of this chapter is to estimate these cost curves.

The large variation among schools in the quality of educational programs must be accounted for in estimating the size-cost relationship. Measures used herein of quality are average eleventh grade composite achievement scores (the school district's final product), and the number and type of credit units offered.

Administration

Administration consists of those activities which regulate and control the affairs of the school district. Three major items were included in administrative expenditures - salaries, contractual services, and other expenses. The variables which were considered to affect administrative costs include average pupil-teacher ratio, average daily attendance (ADA), and average achievement score. An examination of the data showed that, with increases in ADA, administrative costs per ADA declined rapidly at first and then remained relatively constant over a large range of school district sizes. Also, administrative costs declined at a decreasing rate with increases in the pupil-teacher ratio.

A long-run average cost curve was estimated for administrative services using multiple regression. Standard errors are shown in parentheses below the regression coefficients. Each regression coefficient is significant at least at the .05 level.

$$AD = 311.743 + \underset{(.312)}{.528}\ ACH - \underset{(4.730)}{26.391}\ PTR + \underset{(.097)}{.513}\ (PTR)^2 + \underset{(2.679)}{6.694}\ (1/ADA)$$

$$R^2 = .937. \qquad (1)$$

The variables are as follows:

AD is administrative costs per student in average daily attendance,

ACH is average eleventh grade composite achievement score,

PTR is pupil-teacher ratio, and

ADA is average daily attendance in 1,000 units.

The long-run average administrative cost curve for a given level of achievement is derived by finding the minimum cost with respect to the pupil-teacher ratio for each level of ADA. The average cost curve for achievement held at the Oklahoma average is shown in Figure 5 by the curve LR. Under actual conditions, a school district may operate on a short-term cost curve above the level that is achieved under a full long-term adjustment. The short-run curves are based on a given size plant. In the case illustrated, short-run curves SR_1 and SR_2 are derived by holding the number of teachers constant at 50 and 100, respectively. These curves show that average administrative costs per pupil in ADA can be high with too many teachers.

School Plant Operation and Maintenance

Accounts for operation and maintenance of plant for the school system record all current expenditures for keeping the grounds, buildings, and equipment in good condition. Operation of plant includes cleaning, lighting, heating, communications, power, and other such activities required on a regular basis. Maintenance consists of repairs or replacements needed to keep the physical plant in good condition.

Cost of operation and maintenance of plant are related to student achievement, pupil-teacher ratio and ADA in Equation (2). The regression coefficients are significant at the .05 level.

$$POM = 32.073 + \underset{(.380)}{1.612}\, ACH - \underset{(8.591)}{16.516}\, PTR + \underset{(.179)}{.298}\, (PTR)^2 + \underset{(.193)}{.338}\, ADA + \underset{(3.617)}{12.839}\, (1/ADA)$$

$$R^2 = .852. \qquad (2)$$

POM is average cost of plant operation and maintenance per pupil in ADA.

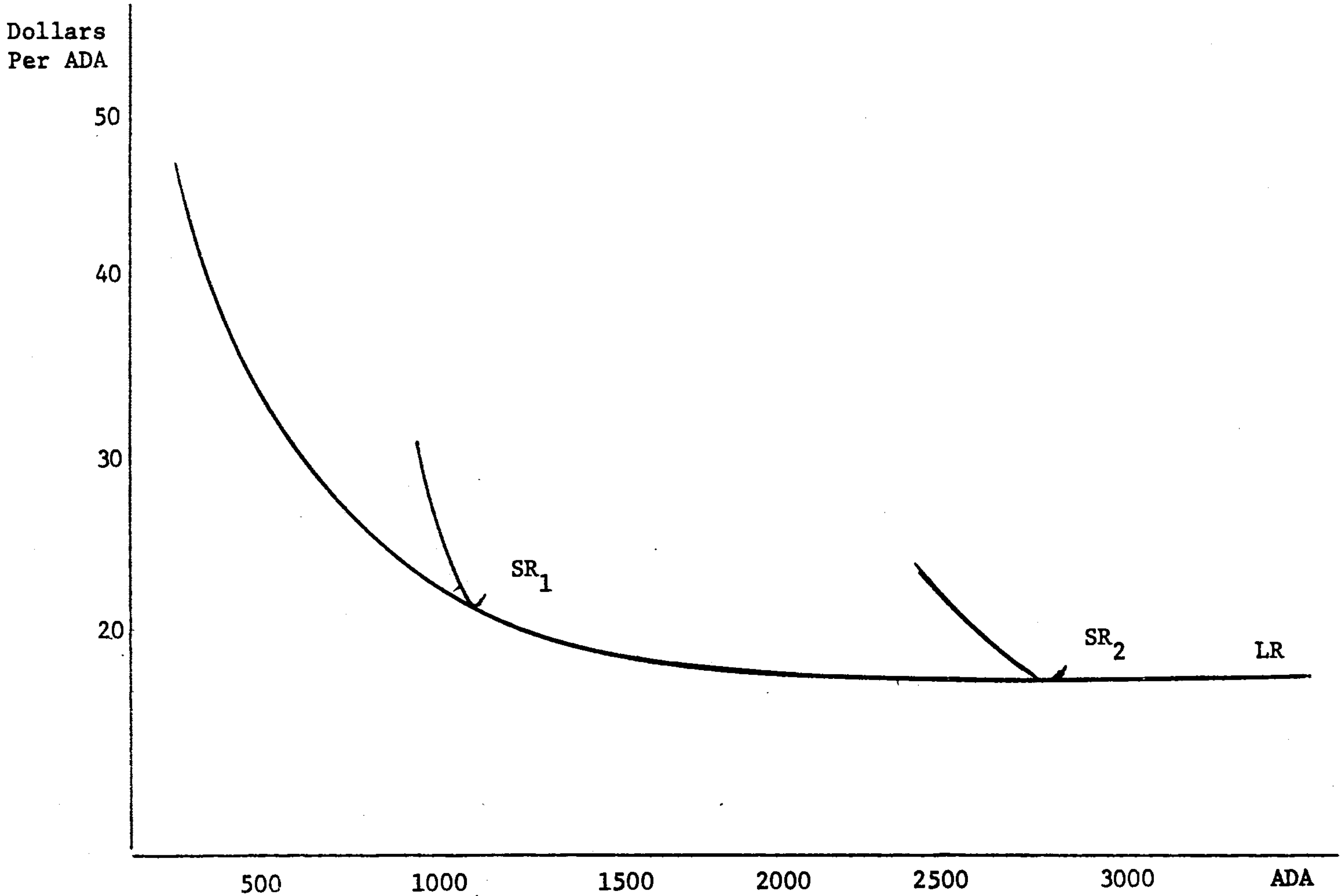


Figure 5. Average Cost of Administrative Services Per ADA

Results indicate initial economies and then slight diseconomies as school district size (ADA) is increased. Initial economies accrue from more intensive utilization of plant, while diseconomies accrue from servicing a large number of school plants within a given district. POM declines at a decreasing rate with increases in the class size.

Figure 6 shows the average cost per pupil of plant operation and maintenance when achievement is held constant at the Oklahoma average. Long-term adjustments in ADA produce significant economies of size up to 2,000 ADA as shown by LR. The short-run cost curves SR_1 and SR_2 were derived by holding the number of teachers constant, which causes more than the optimum number of classes to be in operation at smaller enrollments. These short-run curves illustrate that only minor deviations in plant operation may cause major deviations from minimum attainable costs.

Instruction

Instruction consists of those activities dealing directly with the teaching of students. These are the activities of teachers, principals, and guidance personnel. Attendant costs include salaries of secretarial and clerical assistants, textbooks, school libraries, audiovisual materials, and teaching supplies.

Instructional costs vary because of differences in the quality of program offerings. To make a valid comparison of costs among schools of different sizes, the program quality must be held constant. For this analysis, the high school course offerings were standardized according to number and type of vocational and nonvocational courses offered.

Three high school curriculums - the first designed to be minimum

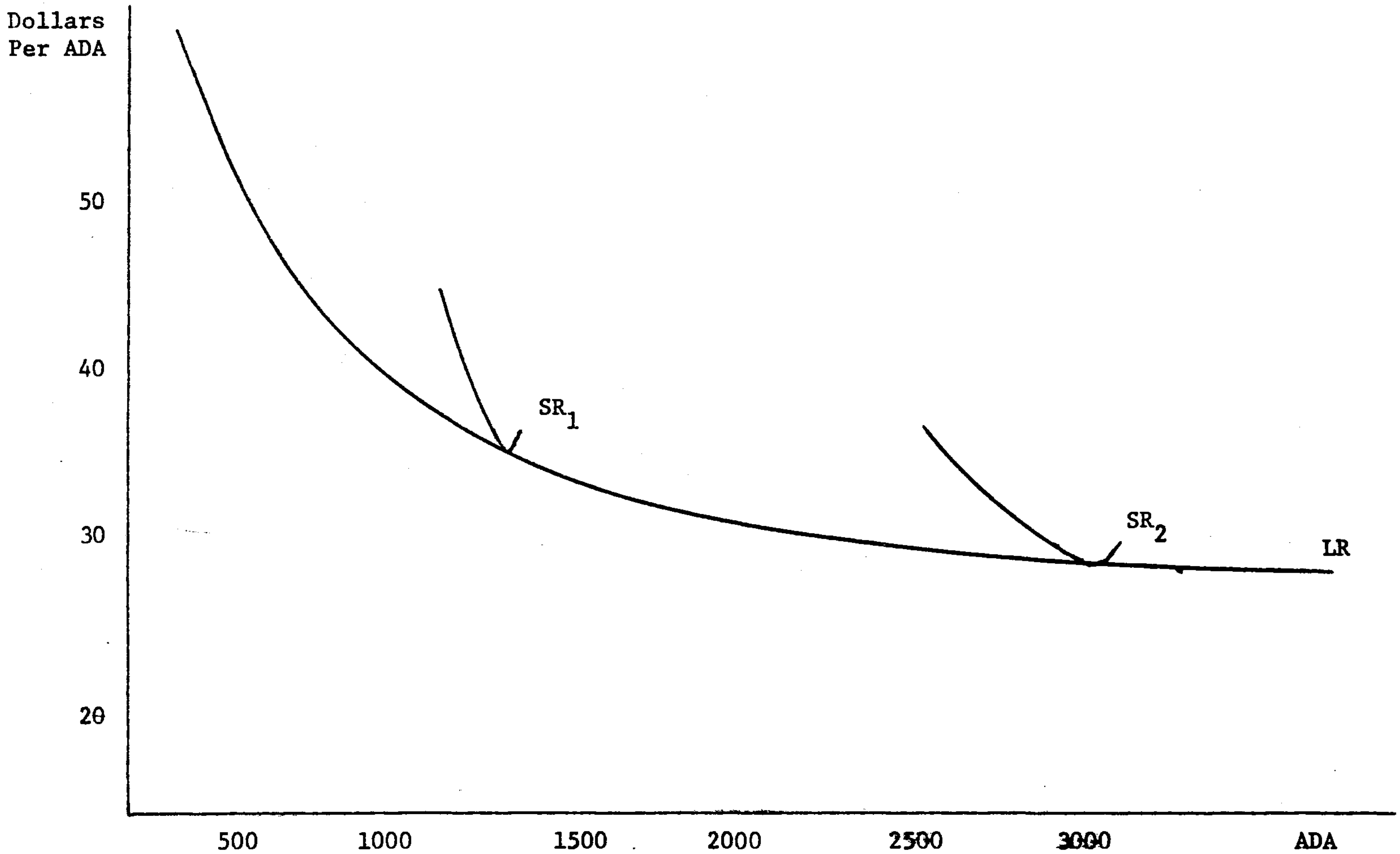


Figure 6. Average Cost of Plant Operation and Maintenance Per ADA

for accreditation, the second designed to be adequate, and the third designed to be desirable - are presented in Tables XXI, XXII, and XXIII. The most frequently offered courses within each subject area are also presented in the tables. The first program, typical for many small, rural high schools, offers only nonvocational courses. However, this type of program may not meet the needs of all students. Percentages of students by subject area were computed from actual enrollments in the sampled districts. The "adequate" program was developed from the courses offered by the districts in the sample which provided (1) both vocational and nonvocational courses and (2) enough units to be accredited. This program was designed as a minimum standard of broad exposure to the general subject areas, including vocational education. The "desirable" program offered the same courses as the other two programs combined. Percentages of students enrolled in each subject area for the adequate and desirable programs were computed from those districts providing both vocational and nonvocational courses. The course offerings may be expanded as the initial classes of a subject area reach optimum size and new classes are added. High school instructional costs were calculated by incrementing ADA and distributing high school students among courses as prescribed by the program under consideration.

The number of high school teachers was calculated from the number of classes required for the given program. The number of elementary and junior high school teachers was based on ADA and the optimum student-teacher ratio. Cost calculations were based on the generous assumption that two courses could be combined in a single classroom under one teacher until the number of students in combined courses exceed the maximum class size.

TABLE XXI

MINIMUM PROGRAM OF COURSE OFFERINGS

Courses	Credit Units	Credit Units By Subject Area	Maximum No. Of Students Per Class	Percentage Enrolled in Subject Area
Language Arts		8	35	25.305
English I-IV	4			
Speech	1			
Library Science	1			
Creative Writing	1			
Yearbook	1			
Mathematics		5	28	10.668
General Math	1			
Algebra I-II	2			
Plane Geometry	½			
Trigonometry	½			
Math Analysis	1			
Social Studies		5	35	16.726
American History	1			
World History	1			
Government	½			
Oklahoma History	½			
Sociology	1			
Psychology	1			
Science		5	22	11.373
Biology	1			
Chemistry	1			
General Science	1			
Physics	1			
Physical Science	1			
Business Education		5	30	10.397
Accounting	1			
Business Law	1			
General Business	1			
Shorthand	1			
Typing	1			
Fine Arts		4	32	10.335
Arts	1			
Crafts	1			
Vocal Music	1			
Instrumental Music	1			
Health and Safety		3	35	11.460
Driver Education	½			
Health Education	1			
Physical Education	1			
Safety Education	½			

TABLE XXI (Continued)

Courses	Credit Units	Credit Units By Subject Area	Maximum No. Of Students Per Class	Percentage Enrolled in Subject Area
Foreign Language		3	30	3.733
French	1			
Spanish	1			
Latin	1			
TOTAL CREDIT UNITS		38		

TABLE XXII

ADEQUATE PROGRAM OF COURSE OFFERINGS

Courses	Credit Units	Credit Units By Subject Area	Maximum No. Of Students Per Class	Percentage Enrolled in Subject Area
Language Arts		6	35	31.428
Enlgish I-IV	4			
Speech	1			
Library Science	1			
Mathematics		4	28	14.663
General Math	1			
Algebra I-II	2			
Plane Geometry	½			
Trigonometry	½			
Social Studies		4	35	5.986
American History	1			
World History	1			
Government	½			
Oklahoma History	½			
Sociology	½			
Psychology	½			
Science		4	22	10.767
Biology	1			
Chemistry	1			
General Science	1			
Physics	1			
Business Education		5	30	7.916
Accounting	1			
Business Law	1			
General Business	1			
Shorthand	1			
Typing	1			
Fine Arts		3	32	12.336
Arts	1			
Crafts	1			
Music	1			
Health and Safety		2	35	7.792
Driver Education	½			
Health Education	½			
Physical Education	1			
Foreign Language		2	30	2.108
French	1			
Latin	1			

TABLE XXII (Continued)

Courses	Credit Units	Credit Units By Subject Area	Maximum No. Of Students Per Class	Percentage Enrolled In Subject Area
Vocational Education		8	22	16.631
Vocational Agric.	2			
Home Economics	2			
Auto Mechanics	2			
Cosmetology	1			
Drafting	1			
TOTAL CREDIT UNITS		38		

TABLE XXIII

DESIRABLE PROGRAM OF COURSE OFFERINGS

Courses	Credit Units	Credit Units By Subject Area	Maximum No. Of Students Per Class	Percentage Enrolled In Subject Area
Language Arts		8	35	31.428
English I-IV	4			
Speech	1			
Library Science	1			
Creative Writing	1			
Yearbook	1			
Mathematics		5	28	14.663
General Math	1			
Algebra I-II	2			
Plane Geometry	½			
Trigonometry	½			
Math Analysis	1			
Social Studies		5	35	5.986
American History	1			
World History	1			
Government	½			
Oklahoma History	½			
Sociology	1			
Psychology	1			
Science		5	22	10.767
Biology	1			
Chemistry	1			
General Science	1			
Physics	1			
Physical Science	1			
Business Education		5	30	7.916
Accounting	1			
Business Law	1			
General Business	1			
Shorthand	1			
Typing	1			
Fine Arts		4	32	12.336
Arts	1			
Crafts	1			
Vocal Music	1			
Instrumental Music	1			
Health and Safety		3	35	7.792
Driver Education	½			
Health Education	1			
Physical Education	1			
Safety Education	½			

TABLE XXIII (Continued)

Courses	Credit Units	Credit Units By Subject Area	Maximum No. Of Students Per Class	Percentage Enrolled In Subject Area
Foreign Language		3	30	2.108
French	1			
Spanish	1			
Latin	1			
Vocational Education		8	22	16.631
Vocational Agric.	2			
Home Economics	2			
Auto Mechanics	2			
Cosmetology	1			
Drafting	1			
TOTAL CREDIT UNITS		46		

The State's average salaries were \$9,028 for principals, \$8,657 for guidance counselors, and \$4,000 for secretaries. The Oklahoma full-time equivalent principal-to-ADA ratio is 3:1000. This ratio includes both principals and assistant principals. Adequate full-time equivalent guidance counselors and secretarial personnel-to-ADA ratios are 4:1000 and 3:1000, respectively.

Buildings

Construction costs for buildings consist of all expenditures for general construction; installation of plumbing, heating, lighting, architectural services; paint; and any other costs connected with the planning of buildings. Data on recently built schools, reported in School Management, give the general cost of construction by size of school district and state.[1] Equations (3) and (4) derived from these data give a representative picture of the size-cost relationship in building construction in Oklahoma.

$$CON_E = 1,428.944 - .057\ (ADA_E) + 22,488.895\ (1/ADA_E) \qquad (3)$$

$$CON_S = 1,909.770 - .234\ (ADA_S) + 1,845.033\ (1/ADA_S). \qquad (4)$$

The variables are as follows:

CON is construction cost per ADA,

E is elementary school, and

S is secondary school.

Average costs of building construction for high schools and elementary schools are shown in Figures 7 and 8. In computing annual investment and depreciation, it was estimated that a school building loses

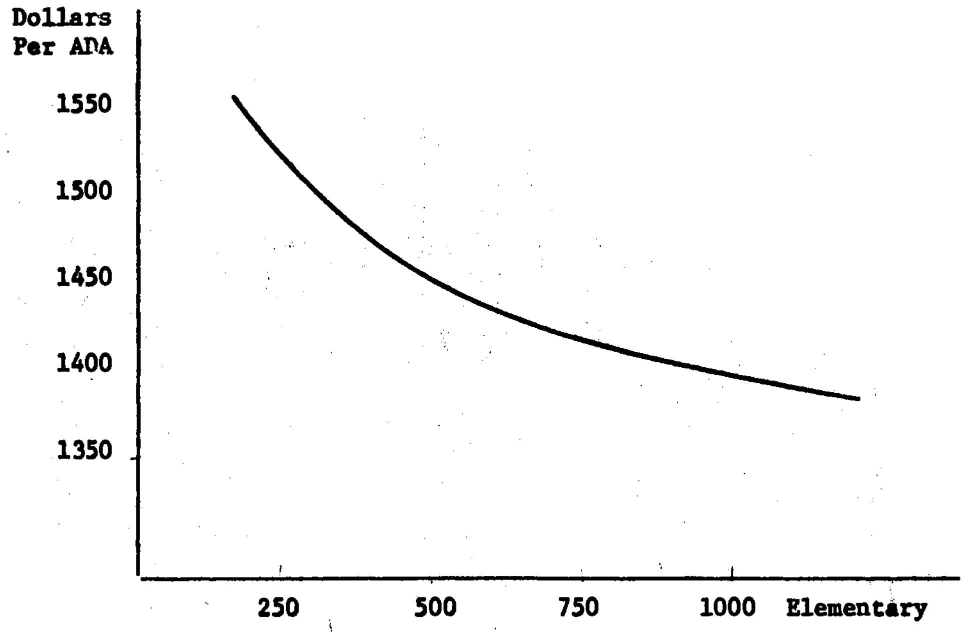


Figure 7. Average Cost Per ADA of Buildings for Elementary School

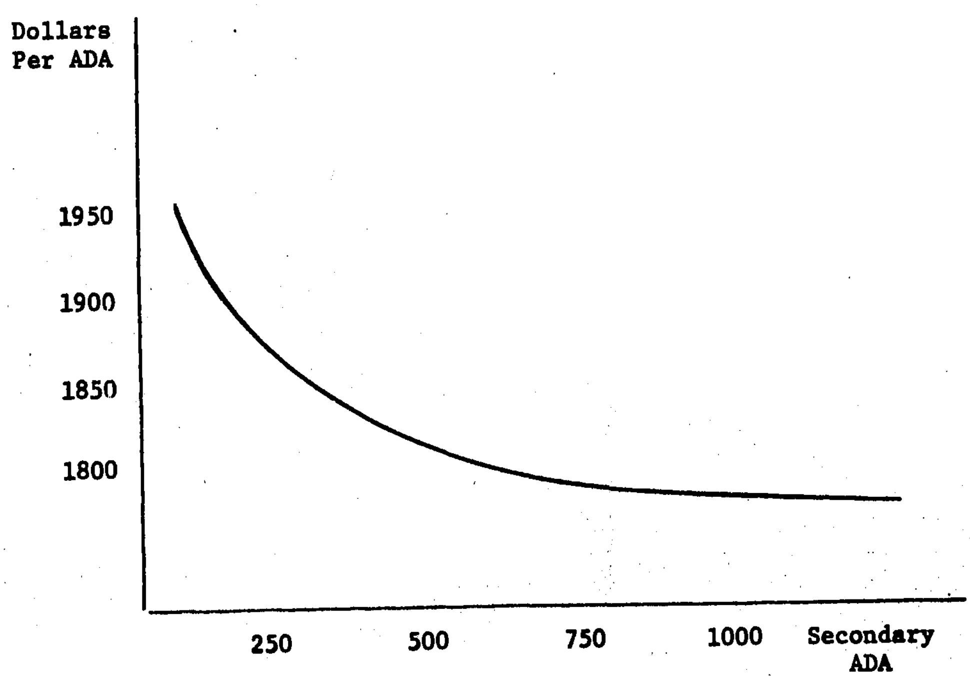


Figure 8. Average Cost Per ADA of Buildings for Secondary School

only 80 percent of its value in 50 years. The average cost of construction was put on an annual basis by considering depreciation, insurance, and interest on investment.

Equipment

Cost of equipment includes expenditures for items of furniture, furnishings, and machinery that are not integral parts of the building. Some examples of equipment include desks, chairs, tables, bookcases, musical instruments, shop machinery and tools, and typewriters. Some economies of size in providing equipment are realized, given constant quality of equipment. Equations (5) and (6) depict the average cost of equipment for elementary and secondary education, excluding vocational equipment.[2] These equations were adjusted to 1969-70 price levels by the Bureau of Labor Statistics commercial furniture price index.

$$EQP_E = 238.520 + 4404.357\ (1/ADA_E) \tag{5}$$

$$EQP_S = 406.735 + 7919.032\ (1/ADA_S). \tag{6}$$

EQP is equipment cost per ADA. The average cost curves of equipment for elementary and secondary schools (excluding vocational equipment) are shown in Figures 9 and 10.

The cost of vocational equipment varies by the curriculum offered, as shown in Table XXIV. Equipment for an auto mechanics course with 30 students would cost $25,040 or [1 x 18,270 + (30/3) x 500 + (30/10) x 590]. These programs show significant economies associated with large classes. For example, the cost per student in an auto mechanics class is $208.60 for only 10 students compared to $83.47 for 30 students.

The cost of equipment per ADA was based on the number of elementary

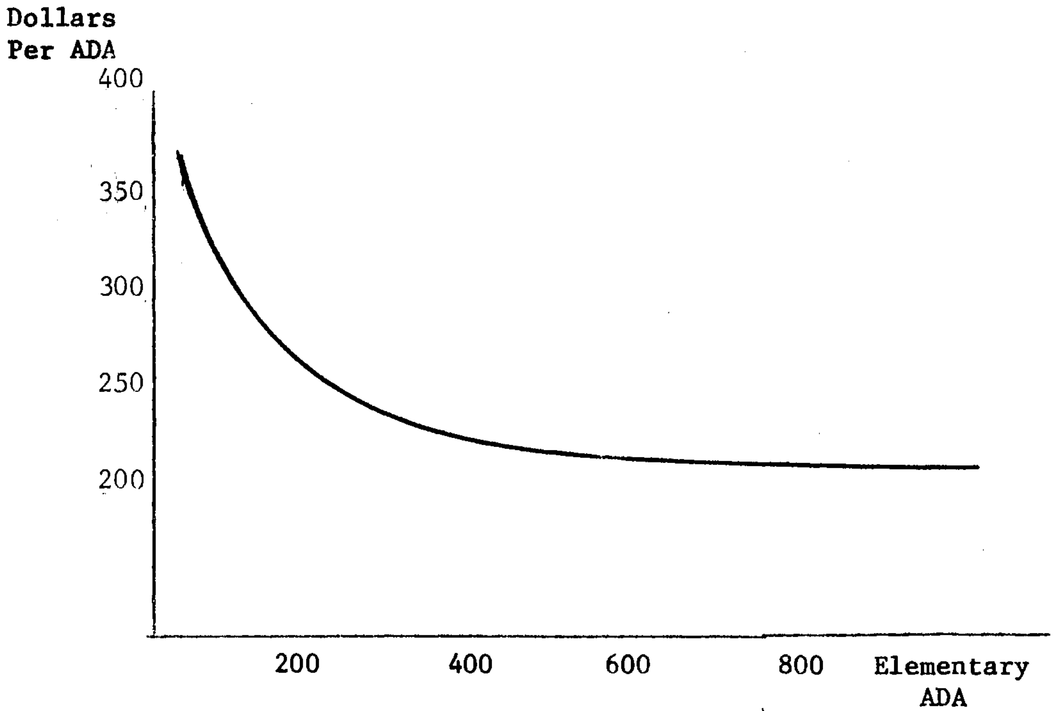


Figure 9. Average Cost Per ADA of Equipment for Elementary Education

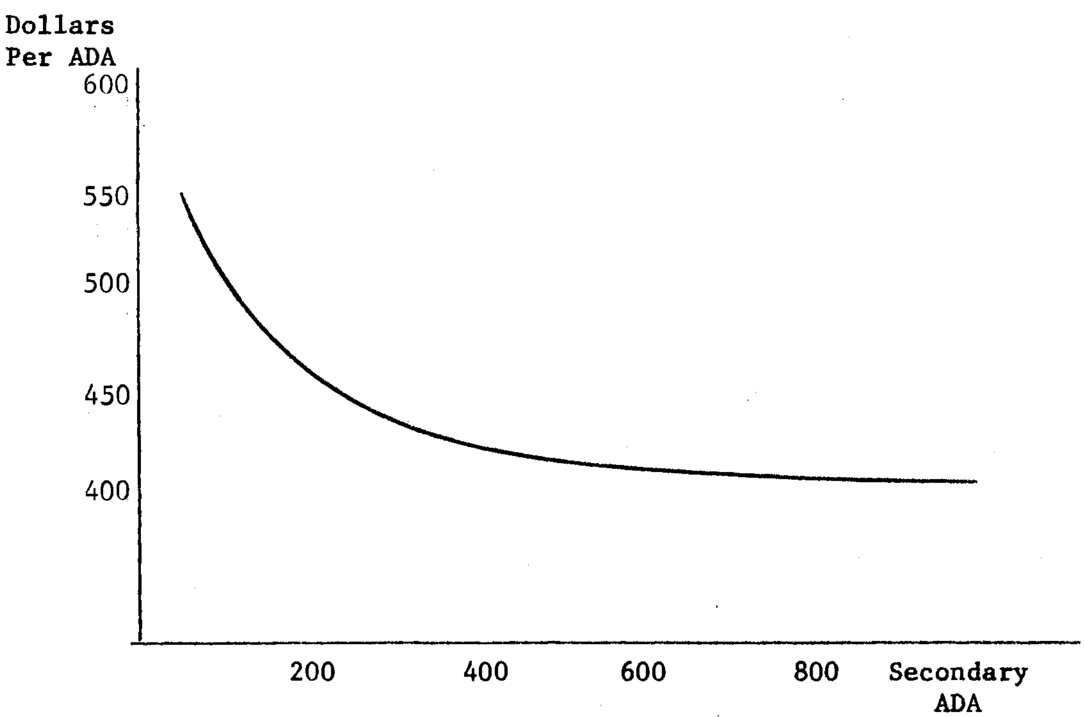


Figure 10. Average Cost Per ADA of Equipment for Secondary Education

TABLE XXIV

COST OF EQUIPMENT AND SUPPLIES BY VOCATIONAL PROGRAM

Course	Required for Every	Cost of Equipment	Cost of Supplies Per Person
Auto Mechanics			30.09
	Class	$18,270	
	3 Persons	500	
	10 Persons	590	
Cosmetology			24.08
	Class	2,830	
	3 Persons	1,200	
	8 Persons	200	
Drafting			8.98
	Class	7,930	
	1 Person	490	
Air-Conditioning and Refrigeration			34.04
	Class	6,185	
	1 Person	160	
	3 Persons	140	
Welding			35.66
	Class	15,288	
	5 Persons	860	
	8 Persons	2,410	
Home Economics			15.00
	Class	1,716	
	2 Persons	300	
	6 Persons	1,215	
Vocational Agriculture			30.00
	Class	5,000	
	6 Persons	1,500	

students, secondary students, and secondary vocational students by courses. These costs were converted to annual costs by taking into consideration depreciation, insurance, and interest on investment. The equipment's operating life was assumed to be 25 years for nonvocational equipment and 10 years for vocational equipment.

Transportation

In Oklahoma school districts, public transportation generally is provided for students whose residence is not within 1.5 miles of the school attended. Thus, the school districts are not responsible for transporting the students who live near their schools. Insofar as possible, buses are approved to go at least within one-half mile of each student's home. Transportation costs in rural areas are particularly important because students frequently are dispersed over many square miles. This section examines costs of transporting students.

Costs Per Bus

In many districts, the major transportation expense is the drivers' salaries. The average salary per mile of bus route is 75.94 dollars with a standard deviation of 38.139 dollars. There is no stable relationship in the state between bus drivers' salaries and either total miles or total miles adjusted for the number of students. District salary schedules are typically based on a school district's wealth and local wage rates rather than a uniform state salary schedule. In computing transportation cost, the state's average salary was used.

The least expensive combination of body and chassis was selected for each size of bus. The list prices of buses by size are presented in

Table XXV. Depreciation costs were computed from these list prices and a seven-year operating life, the state average. The approximate cost per mile traveled was derived from the cost per mile of bus route using the number of days traveled (180) and the number of times per day the bus route is covered.

Combined cost of fuel and lubricants is one of the largest items of transportation costs, ranking third among all items. With the many starts and stops that school buses must make, their gas mileage is particularly low. A 30-passenger bus in rural Oklahoma typically gets 6.5 miles per gallon. The typical fuel consumption is .000937 gallons per mile per horsepower. Since the engines for those bus sizes considered in Table XXV only ranged from 165 to 235 horsepower, it was assumed that the above coefficient of fuel consumption per mile per horsepower was applicable in all cases. The cost per gallon of gasoline was assumed to be 26 cents since public schools are exempted from gasoline taxes. The cost of lubricants - oil and grease - was assumed to be 15 percent of the fuel cost. The combined cost of fuel and lubricants are also presented in Table XXV.

Maintenance, the fourth largest bus-operating cost, includes cost of materials and labor for repairs, overhauls, and equipment replacement such as tires. Equation (7), an engineering relationship for calculating the cost of school bus maintenance, was adopted from Bowers' research on truck replacements.[3] This equation gives the cumulative maintenance cost. An average school bus was assumed to operate 2520 hours in its seven year life. Average maintenance cost per year is found by dividing the cumulative maintenance cost for its life by the number of years of useful life, seven years. This annual cost is

TABLE XXV

FIXED AND VARIABLE COST OF OPERATING SCHOOL BUSES,
BY SIZE OF BUS

Seating Capacity	List Price	Depreciation Per Mile of Bus Route	Interest on Average Annual Investment	Cost of Fuel and Lubricants Per Mile of Bus Route	Cost of Maintenance Per Mile of Bus Route	Annual Cost of Insurance
30	$6,557	$36.4323	$216.38	$16.6422	$12.4409	$218.95
36	6,695	37.1990	220.94	18.7603	12.7266	226.52
42	7,172	39.8494	236.68	20.0715	13.9707	237.11
48	7,328	40.7162	241.82	21.1810	14.1220	244.84
54	7,719	42.8886	254.73	22.0888	14.9291	254.65
60	8,491	47.1780	280.20	22.9965	16.8120	267.88
66	8,851	49.1783	292.08	23.7026	17.4845	277.42

converted to maintenance cost per mile by dividing by the average length of bus route.

$$MC_i = \frac{0.585}{(4{,}000)^{1.4}} \times (TH_i)^{1.4} \times LP. \qquad (7)$$

The variables are as follows:

MC_i is maintenance costs through year i,

TH_i is total hours used through year i, and

LP is list price.

Since fuel, lubricant, and maintenance costs have been derived from engineers, the accuracy of these costs must be verified before confidence can be placed in their use. Combined fuel, lubricant, and maintenance expenditures, available from the sampled school districts, were compared with the derived costs shown in Table XXV. The observed number of students per bus was assumed to be the bus size in use. Using derived costs as predictions of actual costs, over 79 percent of the variation in actual costs was explained. For the sampled school districts, average cost of fuel, lubricants, and maintenance per mile of bus route was $39 compared to $35 for average predicted cost. Actual costs, however, included mileage other than transporting students between home and school.

Insurance and interest on investment are the last components of transportation costs. The charge for interest was computed from average annual investment and a six percent interest rate. The cost of full-coverage insurance was based on a typical package of comprehensive, collision, and liability insurance. The liability coverage had 100-300-25 in thousand dollars of individual bodily injury, total bodily injury, and property damage, respectively.

Organization of District Transportation

The cost of transporting students between home and school varies by size of school district and student density. Analysis of the relationship of cost to size and density requires accurate estimates of the number and size of buses used, as well as the distance traveled. The following discussion outlines the procedure used to design an efficient bus route and presents the program used to calculate the number and size of buses needed to service this route. The bus routes in actual use may be slightly shorter than the ones derived here because of clustering of students. For this reason, an "efficient" bus route used here probably underestimates actual mileage typically used to reach a given population but underestimates mileage saved by clustering of students. These biases may be offsetting.

Designing a Bus Route. In general, bus routes should be designed to minimize the total distance covered by all buses in transporting students from given locations to school. Achieving this objective insures that the minimum number of buses will be used. The problem is to determine the exact sequence in which stops will be made. In most cases, it is impossible to examine every possible route. The lockset method is one procedure for establishing a route of relatively low cost.[4] Although this method does not insure an optimum route, it provides an organized and efficient procedure for reducing distance covered. Solutions derived from this method have been tested against results of dispatching methods used by many firms. The actual routes in use were never shorter than the routes prescribed by the lockset method.

Typically, the new route was eight to twelve percent shorter than the actual route.

An example for one route illustrates the steps used in the procedure. A bus begins its route at the school, makes stops at four locations, and then returns to the school. The problem is to sequence the stops at the various student locations so that the distance traveled is as short as possible. The student locations are given and only the sequence of stops remains to be determined.

The first step in minimizing the distance traveled is to obtain a distance matrix. This matrix shows the number of miles between every possible stop, including the school. The distance matrix for a bus route with four stops and the school is shown in Table XXVI. The second number in the first row shows that there are ten miles between the school S_0 and student location S_1. There are seven miles between student location S_1 and student location S_2.

TABLE XXVI

DISTANCE MATRIX EXAMPLE

Origin	Destination				
	S_0	S_1	S_2	S_3	S_4
S_0	0	10	8	7	3
S_1	10	0	7	4	7
S_2	8	7	0	8	6
S_3	7	4	8	0	4
S_4	3	7	6	4	0

The initial basis assumes that every student location is on a one-stop route. This basis is shown in Part A of Figure 11. The coefficients depict the maximum distance that can be traveled to transport these students. The distance is reduced by successive modifications of the route. The first step involves every pair of student locations as shown in Table XXVII. Information shown in this table gives the distance between each pair of stops (S_i S_j), as well as each stop and the school (S_0 S_i and S_0 S_j).

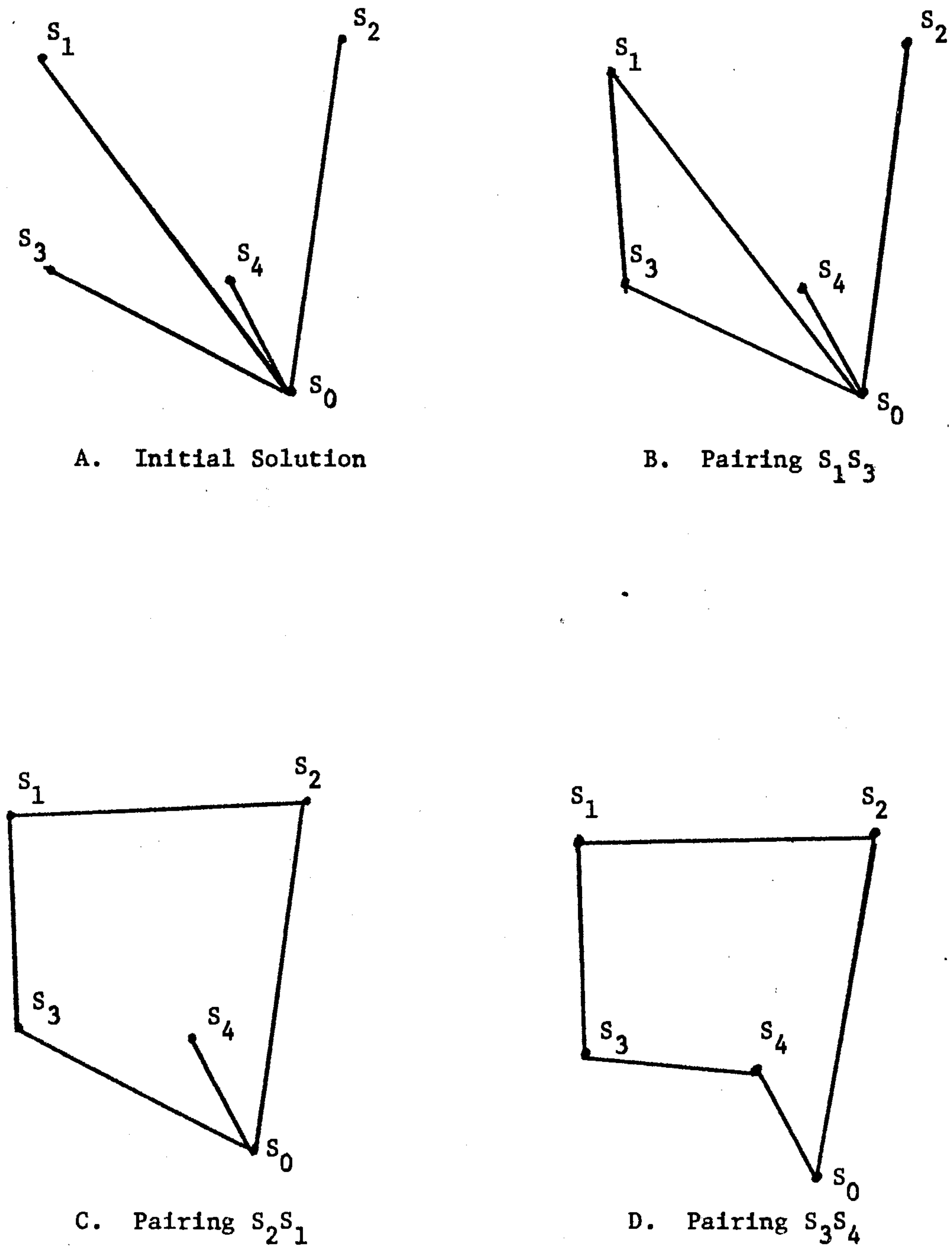
TABLE XXVII

PAIRING LIST AND DISTANCE-SAVED COEFFICIENT EXAMPLE

Pairing	Distance-Saved Coefficients			
	$S_0 S_i$	$S_0 S_j$	$S_i S_j$	DSC
S_1 with S_2	10	8	7	11
S_1 with S_3	10	7	4	13
S_1 with S_4	10	3	7	6
S_2 with S_3	8	7	8	7
S_2 with S_4	8	3	6	5
S_3 with S_4	7	3	4	6

The second step determines how many miles can be saved by combining S_i and S_j on the same route. This savings, termed the distance-saved coefficient (DSC), is computed as follows:

$$DSC = S_0 S_i + S_0 S_j - S_{ij}$$



A. Initial Solution

B. Pairing S_1S_3

C. Pairing S_2S_1

D. Pairing S_3S_4

Figure 11. Successive Pairing in Selecting
Route by Lockset Method

where:

S_0 is the school,

S_i is student location i,

S_j is student location j, and

S_iS_j represents the distance between S_i and S_j.

The distance-saved coefficients are presented in Table XXVII.

The third step combines the pair of student locations that result in the largest DSC. This pair is S_1 and S_3 which has a DSC of 13 miles. Part B of Figure 11 shows the route, $S_0S_1S_3S_0$, which combines this pair. Before accepting this pairing, two restrictions must be met:

(a) Each stop must have at least one leg connected with the origin.

(b) Each stop has not previously been selected.

The pair S_1 and S_3 can be joined because the pairing meets both restrictions.

Now consider pairing the two student locations with the next largest DSC. Student locations S_1 and S_2 have the second largest DSC, 11 miles. This pairing meets the two restrictions above, so it becomes part of the revised route, $S_0S_2S_1S_3S_0$, as shown in Part C of Figure 11. This procedure is repeated until all stops are included in the route. The pair with the next largest DSC is S_2 and S_3. These two stops are already included in the route. Pairs S_1S_4 and S_3S_4 each have a DSC of six miles. However, S_1 does not have a leg connected with the origin. The pairing of S_3 and S_4 meets both restrictions so it can be incorporated into the route. As shown in Part D of Figure 11, all stops have been incorporated into the final route, $S_0S_2S_1S_3S_4S_0$.

To apply this method to an actual school district, two additional restrictions must be met in considering possible pairings:

(c) The bus must be of sufficient size.

(d) The bus must be capable of traveling the distance in the allotted time.

The procedure incorporating these additional restrictions follows the description used in the preceding example. As each pair is accepted or rejected, the remaining pair with the largest DSC on the same route under consideration is tested to see if it meets all four restrictions. After all pairs have been considered, the final solution of the lockset method is identified.

In calculating transportation costs for a given school district, the bus routes had to be specified. The routes used in the following analysis conformed to the lockset method to insure an efficient and feasible routing.

Determining Distance Traveled, Size of Buses, and Number of Buses. A computer program was written to determine the size and number of buses used, as well as the distance traveled in transporting students from their homes to school. This program considers both the size of district and density of transported students.

Student locations and size of district are assumed to be known. District size is based on the concept of area served - the area through which buses must travel to transfer students. Actual district size can differ from the area served if there are no students in an outer portion of the district. Following Oklahoma laws, the bus routes are designed to go at least within one-half mile of each student's home. For a generalized discussion of student transportation costs, it is assumed that the students are evenly dispersed. Even if there is some clustering, the results will not vary markedly since the bus has to travel the road to pick up any lone student anyway. Also, the roads are assumed to be built in a grid one mile apart. This type of road system is common in rural Oklahoma counties.

Based on the size of district, the program makes a preliminary estimate of distance to be covered by bus routes. The estimated distance and student density are used to compute the bus size needed. Since buses in Oklahoma are stationed at the beginning of their respective routes, the route outlined in Figure 12 in general represents the minimum distance route. This route covers one-half the district and can be doubled to get information for the entire district.

To illustrate the procedure used in determining the distance covered, suppose a bus has already traveled from A to D. Before the bus leaves Point D, the program tests to see if the bus

(a) has the capacity to pick up the students along road segment DE, and

(b) can pick up all the students along road segment DE and still get to school in the allotted time.

If both restrictions are met, the route of the current bus extends through this segment, in this case segment DE. If either of these restrictions is not met, the bus will pick up only as many students as it can and still meet the restrictions. Then a new bus starts its route where the last route ended. The entire procedure is outlined by the block diagram of Figure 13.

Determining Average Transportation Costs by Student Density. All costs of owning and operating school buses presented in Table XXV were combined with the information on routing to determine the average cost

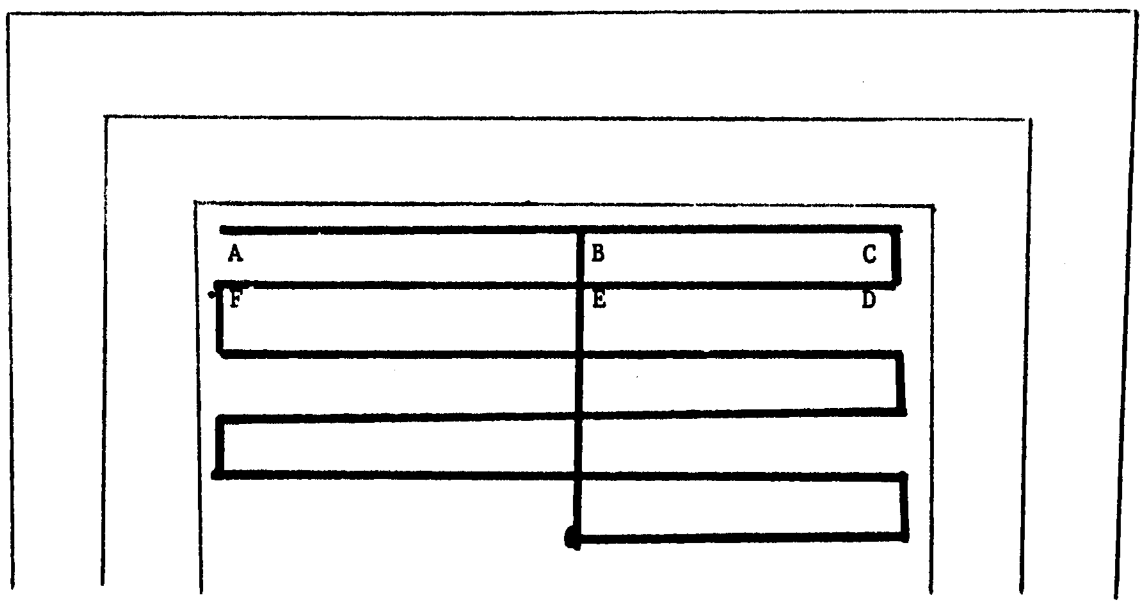


Figure 12. Generalized Routes For One Size District and Successive Expansions of District Size

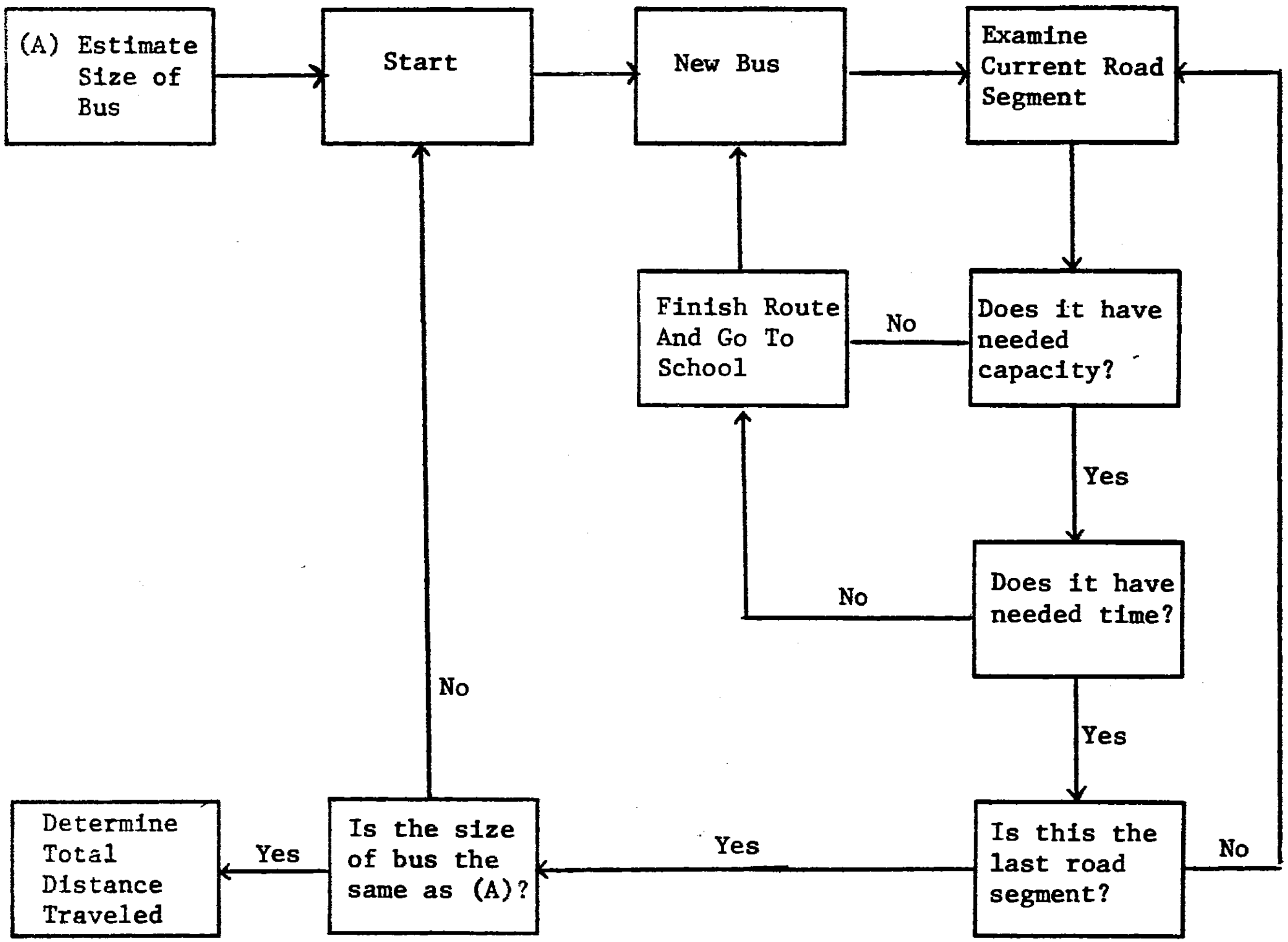


Figure 13. Diagram Showing How to Determine Total Distance Traveled in Transporting Students

of transporting students by student density and district size. Average cost curves for different student densities are presented in Figure 14. The curves for the low density districts show that it is economically infeasible to transport large numbers of students in these sparsely populated areas.

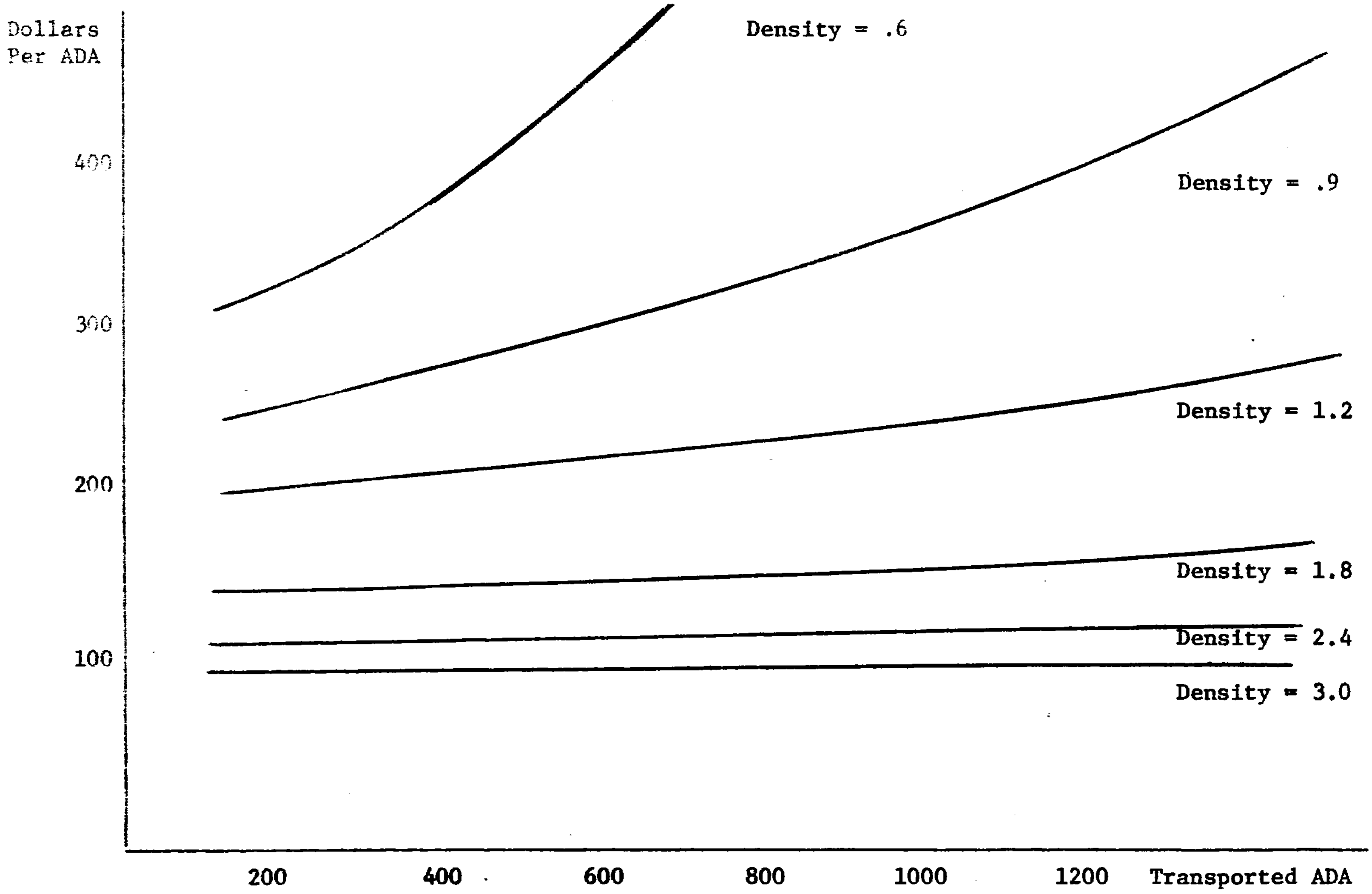


Figure 14. Average Cost Per ADA of Transportation by Student Density

FOOTNOTES

[1]"Cost of Construction," School Management, Vol. 14 (July, 1970), pp. 15-35.

[2]Walter Isard and Robert E. Couglin, Municipal Costs and Revenues Resulting from Community Growth (Wellesley, Mass., 1957), pp. 71-74.

[3]Wendell Bowers, Modern Concepts of Farm Machinery Management, Oklahoma State University (Champaign, Ill., 1970), pp. 30-37.

[4]Leonard W. Schruben and Ruth E. Clifton, "The Lockset Method of Sequential Programming Applied to Routing Delivery and Pickup Trucks," American Journal of Agricultural Economics, Vol. 50, No. 4 (November, 1968), pp. 854-867.

CHAPTER VII

OPTIMIZATION PROCEDURE

The major objective of this study is to determine the optimum resource mix and size of school district. To meet this objective, the average cost curve is minimized subject to constraints on schooling quality and characteristics of the geographic area. This chapter describes the mathematical programming procedure used to optimize the resource mix.

Linear programming, a mathematical programming technique which allows for the substitution of inputs, is used here to select the optimum alternative. It optimizes a linear function subject to linear constraints. The general linear programming problem can be stated as:

$$\text{optimize } Q = C'X$$
$$\text{subject to } AX \geq B$$
$$X \geq 0$$

where X is a (N X 1) vector of activities, A is a (M X N) matrix of input-output coefficients, B is a (M X 1) vector of constraints, C is a (N X 1) vector of costs per unit of each activity and Q is the value to be optimized.

Even though linear programming can minimize average cost subject to the constraints, the model to be used in this study must also consider the economies and diseconomies of size which may exist in education.

Modified linear programming procedures can be used in the case of non-linear, convex objective functions. Solutions to these problems are based on the assumption of a convex feasible solution, which can arise from increasing returns to size or decreasing average costs.

Consider the problem of minimizing the average cost of transportation and instruction similar to the average cost curve shown in Figure 15. The average cost of transportation and instruction is convex within the range of values being considered. Normal linear programming procedures cannot be used to solve the model which includes both economies and diseconomies of size. Separable programming may be used to solve the nonlinear problem if the nonlinear function is a function of a single variable. In the present study, the nonlinear function is determined by the number of students transported and educated.

The method for solving these problems containing nonlinear functions was developed by Miller.[1] The method assumes each nonlinear function can be represented by linear equations coupled with logical restrictions. The simplex method has been modified to enforce these logical restrictions.

Suppose that a variable of interest is in the functional form f(Z) as represented in Figure 15. This function can be replaced by a piece-wise linear approximation based on a finite number of points. Let the coordinates of the points be (a_i, b_i), and certain special variables $S_1, S_2, \ldots, S_n$ be defined so that:

$$S_1 + S_2 + \ldots + S_n = 1, \tag{1}$$

$$a_1 S_1 + \ldots + a_n S_n = Z, \tag{2}$$

and

$$b_1 S_1 + \ldots + b_n S_n = f(Z). \tag{3}$$

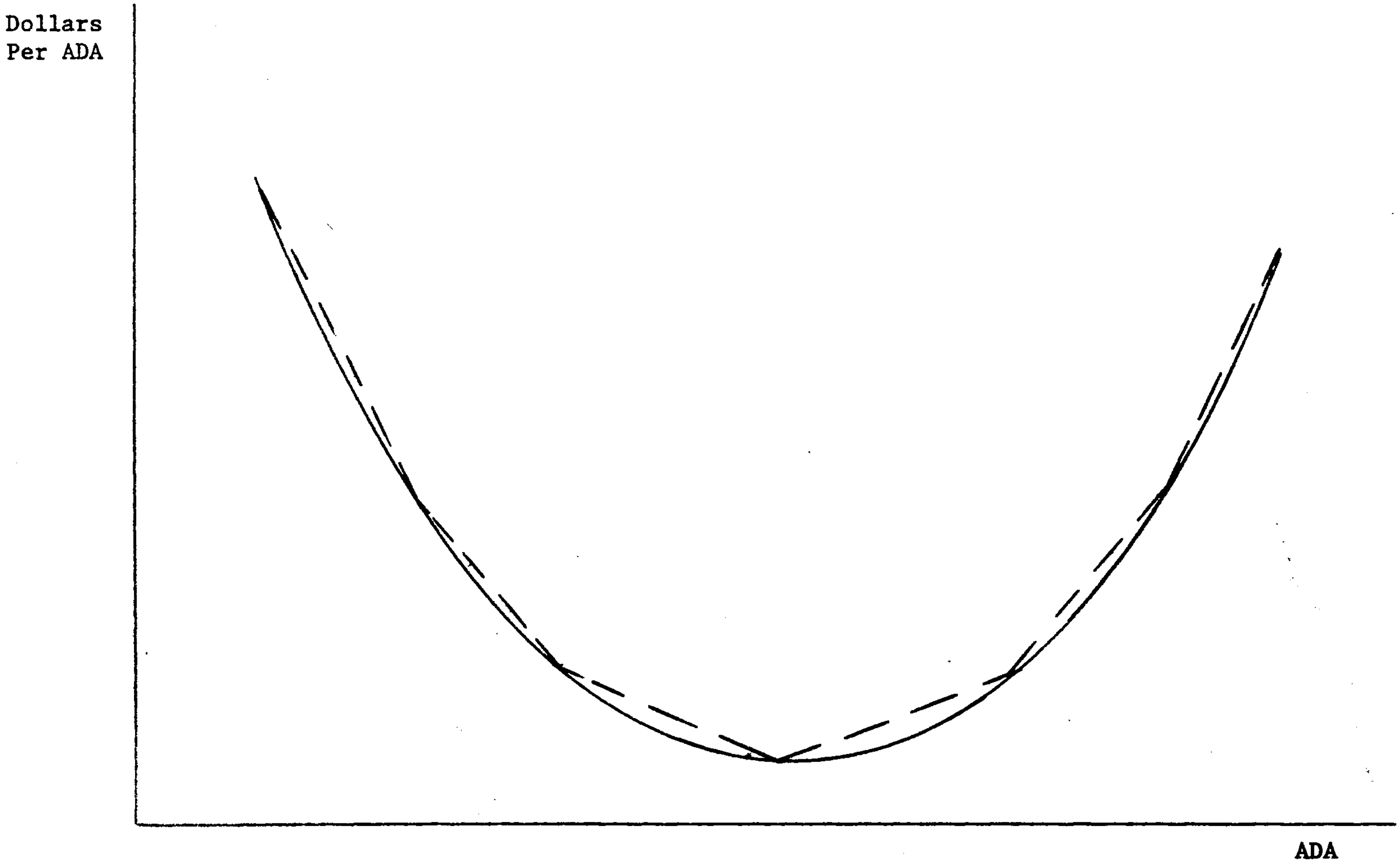


Figure 15. Average Cost of Instruction and Transportation and Its
Representation by Piecewise Linear Segments

If $S_1 = 1$, $S_2 = \ldots = S_n = 0$, then $Z = a_1$ and $f(Z) = b_1$. In the separable programming problem, the special variables enter the analysis in sequence. For instance, S_2 is the second variable to enter the analysis but can do so only after S_1 has reached its upper limit.

For purposes of illustration, a simplified tableau for a separable programming model is presented in Table XXVIII. This matrix contains many relationships that will be used in later analysis. Variables listed are:

PTR_j^i = pupil-teacher ratio where i is the class size and j is the educational program (1 = elementary and 2 = secondary),

EXP_j = average teacher experience,

TR = accounting transfer column,

ADA = number of pupils in average daily attendance,

COST = cost associated with transporting students,

M_{ij}, N_{ij}, P_{ij}, Q_{ij}, R_{ij}, and S_{ij} = regression coefficients

S_i = special variables,

a_i and b_i = coordinates of special variables,

ACH_j = specified achievement level, and

ABS_j = specified absentee rate.

Row (1) shows the costs associated with each variable. The cost per ADA associated with teacher experience varies by pupil-teacher ratio. For example, C_{12}, the cost of an average year of experience when the pupil-teacher ratio is 25, is greater than C_{14}, the cost of an average year of experience when the pupil-teacher ratio is 30. In elementary education, the relationship of experience to pupil-teacher ratio is insured by rows (7), (8), and (9). Row (7) insures that only one pupil-teacher ratio exists at a time. Rows (8) and (9) link the experience

TABLE XXVIII

MATRIX FOR THE SEPARABLE MODEL: ELEMENTARY AND SECONDARY EDUCATION WITH CONSTRAINTS ON ACHIEVEMENT SCORES AND ABSENTEE RATES

	PTR_1^{25}	EXP_1	PTR_1^{30}	EXP_1	TR	PTR_2^{25}	EXP_2	PTR_2^{30}	EXP_2	ADA	COST	Special Variables S_1	S_2	...	S_n	Type of Restriction	Right Hand Side
1	C_{11}	C_{12}	C_{13}	C_{14}		C_{21}	C_{22}	C_{23}	C_{24}		1					N	OBJ
2	M_{11}	M_{12}	M_{13}	M_{14}	-1											=	0
3					1											$\geq$	ACH_1
4	N_{11}	N_{12}	N_{13}	N_{14}												$\leq$	ABS_1
5					P_{20}		P_{22}		P_{24}							$\geq$	ACH_2
6						Q_{21}	Q_{22}	Q_{23}	Q_{24}	Q_{25}						$\leq$	ABS_2
7	1		1													=	1
8	R_{11}	-1														$\geq$	0
9			R_{13}	-1												$\geq$	0
10						1		1								=	1
11						S_{21}	-1									$\geq$	0
12								S_{23}	-1							$\geq$	0
13										-1		a_1	a_2	...	a_n	=	0
14											-1	b_1	b_2	...	b_n	=	0
15												-	-	...	-	Lower	Bound
16												1	1	...	1	Upper	Bound

variables to the appropriate pupil-teacher ratio.

Rows (3) and (4) are constraints on elementary achievement scores and absentee rates. Each year of average teacher experience adds M_{12} units to the average achievement score. Row (4) insures a given level of elementary achievement. The elementary achievement score is transferred by column TR to the secondary achievement constraint row. Each unit of elementary achievement adds P_{20} units to the average secondary achievement score. Each unit of ADA adds Q_{25} units to the secondary absentee rate. The absence of a coefficient in Row (5) under the secondary pupil-teacher ratio variable indicates that all variables do not have to affect all constraints.

FOOTNOTES

[1]Clair E. Miller, "The Simplex Method for Local Separable Programming," Recent Advances in Mathematical Programming, ed. R. L. Graves (New York, 1963), pp. 80-100.

CHAPTER VIII

ANALYSIS

An understanding of a school district's optimum resource combination to meet specified objectives is essential for efficient operation. The school district must take into account those factors outside its control, such as student background and student density, which affect either productivity or cost. Optimum school district organization is evaluated herein for various alternatives - curriculum, level of educational output, salary schedule, student background, and student density. Several levels of each alternative are presented so that trends in resource adjustments for that alternative can be identified.

Model Formulation

The models of this chapter are formulated to determine the minimum average cost of educating and transporting students within a school district to meet specified levels of educational output. The model is specified in a separable programming format in which the objective function average cost is minimized subject to the production constraints.

Production estimates for elementary, junior high, and high school education are based on the production functions discussed in Chapter V. Minimum output levels are specified for each of the production functions. Student input and environmental variables are held constant, while the educational process variables are allowed to adjust to meet these restrictions at minimum cost. These educational process variables include teacher experience, percentage of teachers with a master's degree, percentage of teachers with a planning period, pupil-teacher ratio, value of audiovisual material, printed volumes per pupil, school district size, and other variables.

These educational process variables have costs associated with them, which must be included in the cost function. Cost estimates used herein were discussed in Chapter VI. There are certain costs such as current expenditures for buildings, equipment, administration, guidance counselors, secretaries, instructional supplies, and transportation that are directly connected to ADA. Once the optimum district size or ADA is determined, these costs are also determined.

Resource Situation

The basic model was made up of sample averages, and the high school was assumed to offer the standard adequate program. Educational outputs for all three grades - composite scores, modern math scores, language arts scores, absentee rates, and dropout rates - were specified at the sample averages. All student background variables were set at their averages. The salary used for a beginning teacher with a bachelor's degree was $5,750.70. The school district was assumed to have 265 non-transported ADA and a student density of 1.8 transported ADA per square mile.

Among other results, the basic separable programming problem solution shows the change in average cost associated with a one-unit change in each educational output. The cost of changing the level of these educational output variables is of interest since it indicates the cost of alternative strategies used in improving schooling quality. These costs are presented in Table XXIX. The change in average cost of lowering the fourth grade absentee rate one percent below its level in equilibrium was $4.29. In general, the costs associated with a one percent decrease in absentee and dropout rates were high, because one percentage unit change of these rates was more than one-fourth of their mean values. The largest change in average cost for increasing achievement scores was eighth grade modern math.

Cost-Effectiveness Evaluation

A cost-effectiveness model was used to evaluate the effect of educational output, salary, student background, student density, and high school curriculum on average cost and optimum resource combination. While any one situation was varying, all other characteristics were held constant at their respective averages. These situations include the main kinds of operations facing school districts. However, a mixture of these pure cases would occur in any given school district. In effect, they represent patterns which can improve judgments about the consequences of a given school district's organization.

Educational Output

Educational output measures used in the model are composite achievement scores, modern math scores, language arts scores, absentee rates, and dropout rates. Oklahoma school district averages for these outputs are shown in Table XXX. Three levels of output - low, average, and high - were included in the analysis to represent differences in goals among school districts. Achievement scores were lowered five

TABLE XXIX

CHANGES IN AVERAGE COST PER ADA ASSOCIATED WITH ONE UNIT IMPROVEMENT IN EDUCATIONAL OUTPUT FROM EQUILIBRIUM

Variable	Equilibrium Value	Increase in Average Cost For One Unit Increase	Variable	Equilibrium Value	Increase in Average Cost For One Unit Decrease
Fourth Grade			Fourth Grade		
Language Arts	281.57	$1.19	Absentee Rate	2.39	$4.29
Modern Math	285.15	3.16			
Composite	152.01	2.36			
Eighth Grade			Eighth Grade		
Language Arts	351.96	0.07	Absentee Rate	2.93	2.92
Modern Math	440.26	0.03			
Composite	183.92	0.14			
Eleventh Grade			Eleventh Grade		
Language Arts	438.03	0.96	Absentee Rate	1.30	5.92
Modern Math	424.90	1.12	Dropout Rate	3.44	4.26
Composite	90.84	0.29			

percent and absentee and dropout rates were raised five percent to develop a measure of "low" educational output. On the other hand, the measures of output were improved five percent to represent "high" educational output. Five percent of the achievement scores represents about one standard deviation. This was the largest uniform variation that could be made and still get an optimum solution with average characteristics of student background.

TABLE XXX

AVERAGES OF SELECTED MEASURES OF EDUCATIONAL OUTPUTS

	Fourth Grade	Eighth Grade	Eleventh Grade
Composite Achievement Score	151.48	183.50	77.03
Modern Math Score	285.15	440.26	412.12
Language Arts Score	271.50	350.09	414.67
Absentee Rate	2.83	2.93	2.98
Dropout Rate	--	--	3.44

Table XXXI presents results of the separable programming model with these three levels of educational output used as constraints. Average cost per ADA ranged from $661.67 for the low level of output to $767.62 for the high level of output. To attain the high level of output, the school district size was reduced from 675 to 377 ADA. Under the low output situation, all pupil-teacher ratios were at their maximum

TABLE XXXI

OPTIMUM RESOURCE COMBINATION BY EDUCATIONAL OUTPUT

	Low Output	Average Output	High Output
Average cost per ADA (dollars)	661.67	691.85	767.62
ADA	675.00	675.00	377.00
Pupil-teacher ratio			
High School	28.00	28.00	28.00
Junior High	30.00	30.00	22.00
Elementary	30.00	26.00	22.00
Percentage of teachers with three to nine years experience			
High School	67.03	65.48	63.86
Junior High	25.25	33.10	75.00
Elementary	50.24	20.56	21.35
Percentage of teachers with ten or more years experience			
High School	32.97	34.51	36.14
Junior High	74.75	66.89	25.00
Elementary	49.76	79.44	78.65
Average teacher experience			
High School	9.16	9.51	9.87
Junior High	18.58	16.81	7.36
Elementary	12.95	19.64	19.46
Percentage of teachers with a planning period			
Junior High	-0-	25.88	93.63
Elementary	64.12	-0-	-0-
Value of audiovisual material per ADA			
High School	8.70[a]	8.70	8.70
Junior High	8.70	8.70	8.70
Elementary	8.70	99.90	241.57

TABLE XXXI (Continued)

	Low Output	Average Output	High Output
Printed volumes per ADA			
High School	5.30	5.30	5.30
Junior High	5.30	5.30	7.80
Elementary	5.30	5.30	5.30

[a]All underlined values have entered the solution at their lower limit.

allowable levels (30:1 for elementary and junior high and 28:1 for high school). Pupil-teacher ratios were 22:1 in elementary and junior high to achieve high output.

Definite trends in adjustment of teacher experience to higher levels of output are apparent. At low output levels, the percentage of teachers with three to nine years of experience was greater in elementary and high school and smaller in junior high. Greater teacher experience appears to be more important in elementary and high school at high output levels.

Since the percentage of teachers with a planning period had no effect on eleventh grade output, it never entered the solution in high school. A greater percentage of junior high teachers with a planning period was required in order to attain the high output level. Percentage of elementary teachers with a planning period appeared to be redundant at the high output level since it was zero at this level but positive at the low output level.

Other factors included in the analysis were value of audiovisual material and printed volumes per pupil. In most cases these variables entered the solution at their lowest allowable level, as represented by the line under the value in the table. Elementary education required increases in the value of audiovisual material in order to achieve higher levels of output. High school education required an increase in the printed volumes per pupil to attain the high level of output.

Student Background

In this instance student background encompasses home influences such as parents' education and occupation, as well as students' study habits and attitudes toward education. The three student background levels included in this analysis are ten percent below average, average, and ten percent above average. For example, 78 percent of the fourth graders talked to their parents about schoolwork at least once a week. This figure (78 percent) was used in the average student background model. Ninety percent of this figure was used in the low student background model. All other variables relating to student background were similarly adjusted for the different models.

A given level of output with a lower student background is more costly to attain. The results of these three models are presented in Table XXXII. For the students with low backgrounds to attain the average level of educational output, district size was 370 ADA. Average cost of attaining the average level of output was $794.93 for a district with students from a low background versus $672.60 for a district with students from a high background.

Since eleventh grade output was never affected by the pupil-teacher ratio, the high school pupil-teacher ratio always entered the solution at 28:1. On the other hand, the pupil-teacher ratio was 22:1 in both elementary and junior high with the low student background. These ratios were higher with both average and high student backgrounds.

With increases in student background, teacher experience tended to go down in high school and up in junior high. There was no change in fourth grade teacher experience associated with these levels of student background. Percentage of teachers with a planning period declined in both elementary and junior high as student background improved. Elementary education required a much greater investment in audiovisual material to achieve average output as student background declined.

TABLE XXXII

OPTIMUM RESOURCE COMBINATION BY STUDENT BACKGROUND

	Low Student Background	Average Student Background	High Student Background
Average cost per ADA (dollars)	794.93	691.85	672.60
ADA	370.00	675.00	675.00
Pupil-teacher ratio			
High School	28.00	28.00	28.00
Junior High	22.00	30.00	30.00
Elementary	22.00	26.00	28.00
Percentage of teachers with three to nine years experience			
High School	64.41	65.48	66.60
Junior High	45.00	33.10	24.98
Elementary	20.56	20.56	20.56
Percentage of teachers with ten or more years experience			
High School	35.59	34.51	33.40
Junior High	25.00	66.89	75.02
Elementary	79.44	79.44	79.44
Average teacher experience			
High School	9.75	9.51	9.26
Junior High	7.36	16.81	18.64
Elementary	19.84	19.64	19.64
Percentage of teachers with a planning period			
Junior High	92.75	25.88	-0-
Elementary	100.00	-0-	-0-
Value of audiovisual material per ADA			
High School	8.70	8.70	8.70
Junior High	8.70	8.70	8.70
Elementary	212.00	99.90	14.00

TABLE XXXII (Continued)

	Low Student Background	Average Student Background	High Student Background
Printed volumes per ADA			
High School	5.30	5.30	5.30
Junior High	10.30	5.30	5.30
Elementary	5.30	5.30	5.30

High School Curriculum

The three high school curriculums, which were discussed previously, are as follows:

(1) minimum program (38 academic units and no vocational units),

(2) adequate program (30 academic units and 8 vocational units), and

(3) desirable program (38 academic units and 8 vocational units).

These programs are listed in ascending order with respect to their ability to meet student needs.

Table XXXIII shows that it is much more expensive to provide an extensive curriculum which includes vocational courses. Average costs for the three programs ranged from $665.48 without vocational courses to $700 for the desirable program. To achieve minimum average cost, the school district size increased from 550 ADA for the minimum program to 900 ADA for the desirable program.

Among the three programs, there were only minor differences in other policy variables. The high school pupil-teacher ratio with the minimum program was 30:1. Since vocational courses require smaller classes, the adequate and desirable programs had smaller high school pupil-teacher ratios; both were approximately 28:1. There were slight changes in teacher experience in high school and junior high to adjust for potential declines in performance associated with increased school district size. Likewise, 55.42 percent of high school teachers had to have a master's degree to maintain output in the larger district required by the desirable program.

TABLE XXXIII

OPTIMUM RESOURCE COMBINATION BY HIGH SCHOOL CURRICULUM

	Minimum Program	Adequate Program	Desirable Program
Average cost per ADA (dollars)	665.48	691.85	700.00
ADA	550.00	675.00	900.00
Pupil-teacher ratio			
High School	30.00	28.00	28.00
Junior High	30.00	30.00	30.00
Elementary	26.00	26.00	26.00
Percentage of teachers with three to nine years experience			
High School	66.33	65.48	64.14
Junior High	31.23	33.10	36.07
Elementary	20.56	20.56	20.56
Percentage of teachers with ten or more years experience			
High School	33.67	34.51	35.85
Junior High	68.76	66.89	63.93
Elementary	79.44	79.44	79.44
Average teacher experience			
High School	9.32	9.51	9.81
Junior High	17.23	16.81	16.14
Elementary	19.64	19.64	19.64
Percentage of teachers with a planning period			
Junior High	21.52	25.88	32.79
Elementary	-0-	-0-	-0-
Value of audiovisual material per ADA			
High School	8.70	8.70	8.70
Junior High	8.70	8.70	8.70
Elementary	92.23	99.90	112.11

TABLE XXXIII (Continued)

	Minimum Program	Adequate Program	Desirable Program
Printed volumes per ADA			
High School	5.30	5.30	5.30
Junior High	5.30	5.30	5.30
Elementary	5.30	5.30	5.30
Percentage of high school teachers with a masters degree	-0-	-0-	55.42

Teacher Salary

The average salary for a beginning teacher with a bachelor's degree was $5,750.70. The three salary levels considered were ten percent below average, average, and ten percent above average. In all three cases, teachers were assumed to receive $100 for each additional year of experience. The adjustments, particularly in this section, are assumed to be long-run adjustments, since the influence of salary on teacher performance takes several years to be fully realized. In other words, increasing the salary level approximately $500 a year will not materially improve present teacher's performance immediately; but in the long run, it will encourage teachers to upgrade their skills through continuing higher education and at the same time attract better-qualified teachers.

Even though the range in teacher salary was greater than $1,000, the range in average cost per ADA was less than $20 - as shown in Table XXXIV. Under the low-salary situation, teacher performance was assumed to have deteriorated. Only by increasing expenditures on other educational process variables could the same level of educational output be attained. With the low salary level, the pupil-teacher ratio had to be lowered in the elementary grades. As the cost of teachers increased, the elementary pupil-teacher ratio increased to substitute less expensive inputs for teachers.

In general, teacher experience had to be increased under the low salary situation to maintain the average level of educational output. All eighth grade teachers and more than one-half of the elementary teachers were given planning periods under the low-salary situation.

TABLE XXXIV

OPTIMUM RESOURCE COMBINATION BY TEACHER SALARY LEVELS

	Low Salary	Average Salary	High Salary
Average cost per ADA (dollars)	690.38	691.85	709.93
ADA	675.00	675.00	675.00
Pupil-teacher ratio			
High School	28.00	28.00	28.00
Junior High	30.00	30.00	30.00
Elementary	24.00	26.00	28.00
Percentage of teachers with three to nine years experience			
High School	50.63	65.48	62.42
Junior High	26.76	33.10	60.15
Elementary	23.63	20.56	20.56
Percentage of teachers with ten or more years experience			
High School	49.37	34.51	25.00
Junior High	73.23	66.89	39.85
Elementary	76.37	79.44	79.44
Average teacher experience			
High School	12.86	9.51	7.14
Junior High	18.24	16.81	10.71
Elementary	18.95	19.64	19.64
Percentage of teachers with a planning period			
Junior High	100.00	25.88	-0-
Elementary	52.19	-0-	-0-
Value of audiovisual material per ADA			
High School	101.43	8.70	8.70
Junior High	8.70	8.70	8.70
Elementary	8.70	99.90	221.39

TABLE XXXIV (Continued)

	Low Salary	Average Salary	High Salary
Printed volumes per ADA			
High School	5.30	5.30	5.30
Junior High	8.77	5.30	5.30
Elementary	5.30	5.30	5.30

Also, expenditures on audiovisual material in high school and printed volumes in junior high had to be increased with lower salaries.

Student Density

The high level of transportation cost in rural areas makes its influence on school district organization especially important. The average transportation cost which is based on student density is a major determinant of school district size. Student performance is assumed to deteriorate slightly with increases in district size, causing minor adjustments in other educational process variables to maintain the level of educational output.

On the other hand, differences in student densities cause significant differences in optimum school district size and average cost as shown in Table XXXV. Average cost with optimum organization was $744.27 for a student density of 0.6 transported ADA per square mile and $660.68 for a 3.0 student density. Figure 16 shows that, in the heavily populated areas, school districts can operate anywhere within a wide range of ADA without significant differences in per-unit costs. School districts operating outside this low cost range, particularly in sparsely populated areas, face substantially higher per-unit costs. The optimum school district size ranged from 300 ADA with the light density to 1,075 with the heavy density. The relationship between student density and optimum school district size is shown in Figure 17. This figure shows a positive relationship between student density and optimum school district size; i.e., the optimum school district size is smaller in sparsely populated rural areas.

TABLE XXXV

OPTIMUM RESOURCE COMBINATION BY STUDENT DENSITY

	Student Densities in Transported ADA per Square Mile				
	.6	1.2	1.8	2.4	3.0
Average cost per ADA (dollars)	744.27	728.83	691.85	674.82	660.68
ADA	300.00	550.00	675.00	900.00	1075.00
Pupil-teacher ratio					
High School	28.00	28.00	28.00	28.00	28.00
Junior High	30.00	30.00	30.00	30.00	30.00
Elementary	26.00	26.00	26.00	26.00	26.00
Percentage of teachers with three to nine years of experience					
High School	69.88	66.33	65.48	64.14	63.21
Junior High	23.36	31.24	33.10	36.07	38.13
Elementary	20.56	20.56	20.56	20.56	20.56
Percentage of teachers with ten or more years of experience					
High School	30.12	33.67	34.51	35.86	36.79
Junior High	76.64	68.76	66.89	63.93	61.87
Elementary	79.44	79.44	79.44	79.44	79.44
Average teacher experience					
High School	8.51	9.32	9.51	9.81	10.02
Junior High	19.01	17.23	16.81	16.14	15.68
Elementary	19.64	19.64	19.64	19.64	19.64
Percentage of teachers with a planning period					
Junior High	3.18	21.52	25.88	32.79	37.59
Elementary	-0-	-0-	-0-	-0-	-0-

TABLE XXXV (Continued)

	Student Densities in Transported ADA per Square Mile				
	.6	1.2	1.8	2.4	3.0
Value of audiovisual material per ADA					
High School	8.70	8.70	8.70	8.70	8.70
Junior High	8.70	8.70	8.70	8.70	8.70
Elementary	59.85	92.23	99.70	112.11	120.58

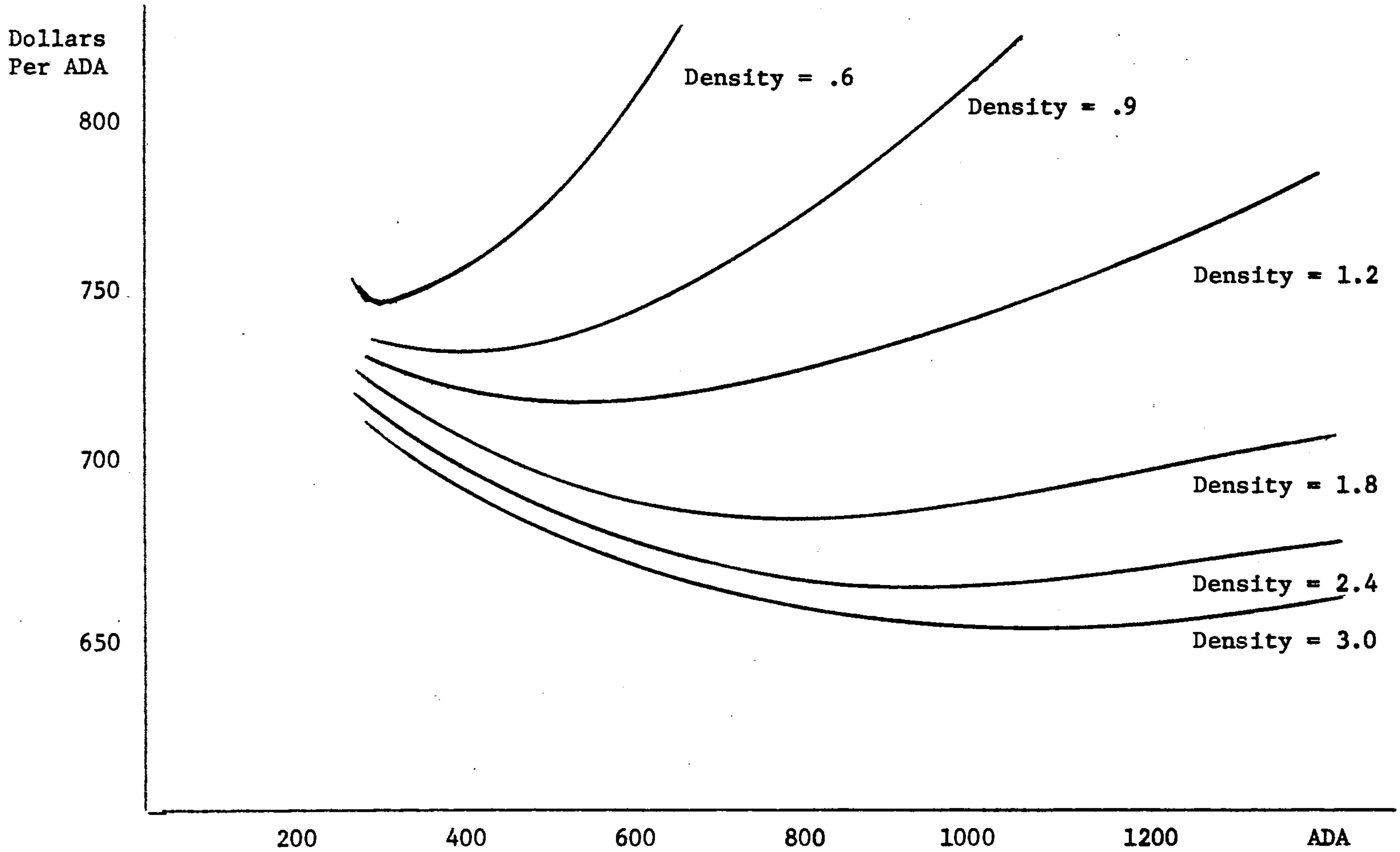


Figure 16. Average Cost of Education and Transportation Per ADA by Student Density

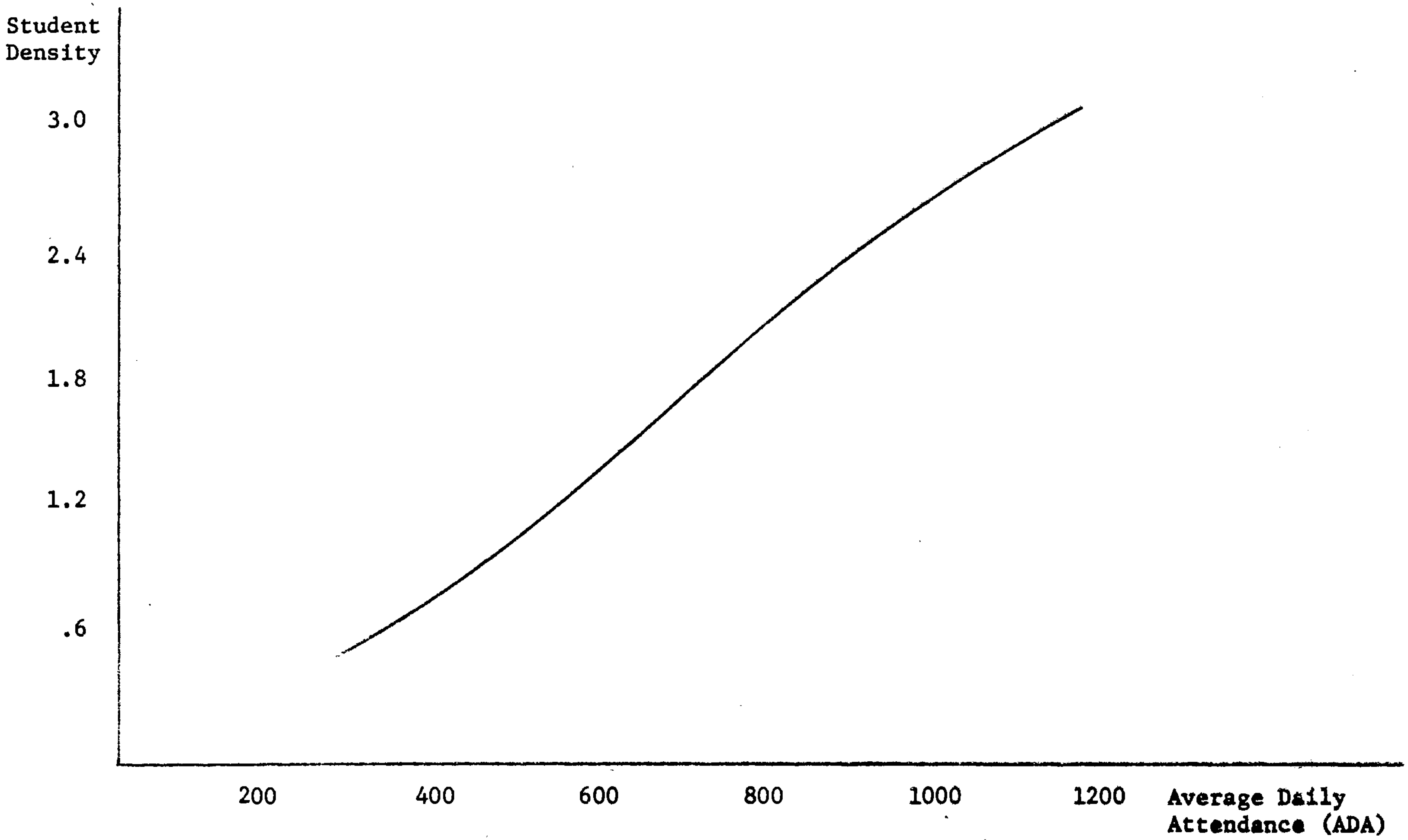


Figure 17. Relationship Between Student Density and Optimum School District Size

Other Cases

Since the modern math and composite scores of the lower grades were linked statistically with achievement in the upper grades, they were also linked in the separable programming model. By removing the restrictions on these scores in the lower grades, it was possible to determine where expenditures should be made in the different phases of education to obtain the highest level of eleventh grade achievement. The two alternatives were to increase expenditures in the lower grades or in the upper grades. The results showed that without these restrictions, there was more flexibility in the lower grades with respect to resource combination. Less effort was directed into elementary and junior high education and more into high school education to attain the highest level of high school achievement.

In the basic model, the cost of a year's experience was assumed to be $100. Lowering this cost 20 percent resulted in no change in the optimum resource combination. With a 20 percent increase in the cost of experience, other educational process variables, such as percentage of teachers with a planning period, were substituted to reduce the use of the higher cost experience.

The number of nontransported students can affect the optimum school district size. The 265 nontransported students in the basic model resulted in an optimum school district size of 675 ADA. An increase of 25 nontransported ADA increased optimum school district size 15 ADA. In general, a larger number of nontransported ADA resulted in a larger optimum school district size but smaller number of transported ADA.

Costs considered so far have included charges for buildings and equipment. However, most information available and, consequently, most previous research included only current costs. Since there are some economies of size associated with providing buildings and equipment, research considering only current cost understates optimum school district size. In this analysis, minimum average current cost of $556.75 per student occurred at 550 ADA compared to minimum average cost of $691.85 per student at 675 ADA.

Sensitivity Analysis

In evaluating the results of a model, it is important to know how sensitive the results are to changes in the basic parameters of the model. The eleventh grade dropout rate, eighth grade absentee rate and average modern math score, and fourth grade average modern math score were all at their limits in the equilibrium model. The dropout rate could have varied three percentage points with no change in the optimum set of activities. This change is relatively large, since the average dropout rate was 3.4 percent. In the eighth grade, the absentee rate could have varied .6 percentage points and the modern math score could have varied 12 units with no change in activities. Fourth grade modern math score could have varied four units with no change in activities. Looking at the regression coefficients of the production functions, coefficients of the pupil-teacher ratio could have varied five percent in the fourth grade and ten percent in the eighth grade with no change in the optimum pupil-teacher ratio.

Benefit-Cost Analysis

Any policy alternative, such as a change in the pupil-teacher ratio, may affect more than one dimension of educational output.

Therefore, it is desirable to have a meaningful aggregation of the output variables. One such aggregation can be accomplished by converting the achievement test scores to yearly equivalent changes in test scores. A comparison of benefits to costs for a particular policy can then be made.

Benefits

To measure the benefits of a particular policy alternative, changes in average achievement test scores were estimated from the production functions of Chapter V. The change in yearly equivalents of language arts, modern math, and composite achievement scores were averaged together to obtain an over-all measure of change in yearly equivalents. Assuming that the yearly equivalent change in average test scores is sustained and can be used as a measure of the change in years of schooling, dollar values can be assigned to the benefits. The results will be biased to the extent that improved achievement is lost over time.

Redfern estimated the discounted value of the extra earnings that an individual would expect to receive by obtaining extra schooling.[1] Adjusting his figures for sex and race of students according to the sampled school districts, the average present value for an additional year of schooling was $4,478.66 in 1969-70 for students finishing their twelfth year of schooling. Similar to Becker's work, the average income was assumed to increase two percent a year.[2] Although lower classmen could expect a greater income upon completion of their schooling, its present value would be smaller since it had to be discounted to the year under consideration. Using a six percent discount rate, the present value of a year's schooling was $2,809.96 for fourth graders, $3,547.51 for eighth graders, and $4,306.40 for eleventh graders.

Costs

To make a valid comparison between costs and benefits, costs had to be accumulated by compounding (or discounting) to the same period in which the benefits were being considered. Since fourth grade achievement was considered in elementary education, the costs of a policy alternative (e.g., increasing teacher experience) for the first four grades were associated with the benefits of that alternative. Likewise, costs of policy alternatives for the seventh and eighth grades were associated with eighth grade achievement, and costs of policy alternatives for the ninth through eleventh grades were associated with eleventh grade achievement.

Benefit-Cost Ratio

The equilibrium values of the educational process variables from the basic model were used to compute benefit-cost ratios as shown in Table XXXVI. The benefit-cost ratio for average teacher experience ranges from 6:1 in the fourth grade to 16:1 in the eleventh grade. As expected, pupil-teacher ratios, audiovisual material, and printed volumes had a positive benefit in the lower grades, and teacher education had a positive benefit in the eleventh grade.

Surprisingly, the benefit-cost ratio of the pupil-teacher ratio in the fourth grade was very low - .28:1. Other important variables may have failed to show a positive benefit because all schools had a sufficient level of these variables. For example, just because printed

TABLE XXXVI

AVERAGE BENEFITS AND COSTS ASSOCIATED WITH VARIOUS EDUCATIONAL PROCESS VARIABLES

Variable	Increment	Change in Yearly Equivalent of Mean Test Score	Present Value of Benefits	Present Value of Costs	Benefit-Cost Ratio
Fourth Grade			($)	($)	
Percentage of teachers with three to nine years of experience	10 percent	.0883	248.12	10.05	24.69
Percentage of teachers with ten or more years of experience	10 percent	.0687	193.04	23.56	8.19
Average teacher experience	1 year	.0379	106.50	16.82	6.33
Percentage of teachers with a planning period	10 percent	.0074	20.79	17.93	1.16
Pupil-teacher ratio	from 26:1 to 24:1	.0079	22.20	80.63	.28
Value of audiovisual material per pupil	10 dollars	.0044	12.36	5.60	2.21
Eighth Grade					
Percentage of teachers with three to nine years of experience	10 percent	.0645	228.81	4.12	55.54
Percentage of teachers with ten or more years of experience	10 percent	.0136	48.25	9.61	5.02
Average teacher experience	1 year	.0168	59.60	6.87	8.68
Pupil-teacher ratio	from 30:1 to 28:1	.0294	104.30	28.21	3.70
Printed volumes per pupil	1 volume	.0125	44.34	.90	49.27
Eleventh Grade					
Percentage of teachers with three to nine years of experience	10 percent	.0338	145.56	6.82	21.34

TABLE XXXVI (Continued)

Variable	Increment	Change in Yearly Equivalent of Mean Test Score	Present Value of Benefits	Present Value of Costs	Benefit-Cost Ratio
Percentage of teachers with ten or more years of experience	10 percent	.0746	321.26	15.92	20.18
Average teacher experience	1 year	.0427	183.88	11.37	16.17
Percentage of teachers with a master's degree	10 percent	.0046	19.81	2.27	8.73

volumes in the eleventh grade showed no positive benefit, it is still necessary to provide an adequate library.

Although these benefits and costs were based on averages of the optimum solution of the basic model, they are not necessarily appropriate for directing additional expenditures. The tradeoffs between policy alternatives, such as percentage of teachers with three to nine years of experience and ten or more years of experience, indicate that increases in the levels of some educational process variables cause deteriorations in some dimensions of output. For example, the benefit of an additional year of average teacher experience in elementary education is -.0555 yearly equivalents when all variables are allowed to adjust to equilibrium.

Benefits from an increase in an educational process variable may differ from benefits derived above as the level of other educational process variables adjust. Also, costs may increase as additional expenditures on other educational process variables are needed to maintain a given level of educational output. Allowing variables to adjust, the benefit-cost ratio of eighth grade pupil-teacher ratio is 4.72:1 compared to 3.70:1 when other variables are held constant. If a school district wishes to make small adjustments in its resource organization, it should be aware of these possible tradeoffs in ascertaining benefits and costs.

FOOTNOTES

[1]James Martin Redfern, "Social and Private Returns to Investment in Schooling, By Race-Sex Groups and Urban-Rural Residence" (unpub. dissertation, Oklahoma State University, 1970), pp. 74-78.

[2]Gary S. Becker, Human Capital (New York, 1964), p. 139.

CHAPTER IX

SUMMARY AND CONCLUSIONS

The problems concerning inequalities of educational opportunities and high cost of providing educational services, particularly in rural areas, are amenable to economic analysis. Through efficient resource allocation and school district organization, the cost of providing a given quality of schooling can be lowered. This chapter summarizes how economic analysis was used to address these problems. The first section gives a summary of objectives, procedures, and major empirical results. The second section discusses implications and limitations of this study, as well as the need for further research.

Summary

This analysis applied economic theory to the problems of school district organization in Oklahoma elementary and secondary education. A major objective was to develop and apply a model to efficiently organize a school district and allocate its scarce resources. This model required information on schooling inputs, output, costs, and, to a lesser extent, returns.

Past studies have measured the impact of inputs on educational output, but stopped short of a comprehensive analysis of an efficient allocation of schooling inputs. Previous studies helped identify relevant input-output variables. The present research used this knowledge of relevant variables to measure the effect of various inputs on selected educational outputs in Oklahoma. Data from a random sample of Oklahoma school districts were used to estimate functional relationships.

Measures of educational output included achievement scores, dropout rates, and absentee rates. Three broad categories of educational inputs - educational process, student input, and environmental variables - affected these measures of output. The educational process variables, which are under the control of the school board, can be manipulated to raise the level of student attainment. The student input and environmental variables, which must be considered as given in the short run, must be taken into account in any decisions relating to changes in students' level of attainment.

Major control variables (student input and environmental variables) relate to students' ability and educational effort and family background. IQ and achievement test scores in earlier grades, representing students' ability, significantly contributed to educational output in elementary, junior high, and high school. Time spent studying and number of books read outside of school, as measures of educational effort, were also important. Parents' education, occupation, income, and interest in their children's education were directly related to student attainment.

Educational process variables affecting educational output included teacher qualifications and workloads, teacher salaries, instructional materials, program, and school district size. Of the educational process variables, teacher performance had the greatest impact on educational output. Workloads, measured by pupil-teacher ratios and percentage of teachers with a planning period, were especially important in the lower grades. Teacher education (percentage of teachers with a master's degree) was more important in high school. Teacher salary, standardized for experience and education, affected all dimensions of educational output. The level of teacher experience was also important. Experience was more significant in lower grades than in high school and was more important in reducing absentee and dropout rates than in raising achievement.

As measures of the program, availability of kindergarten improved elementary achievement and number of nonvocational units were positively related to high school achievement. Instructional materials - periodicals, printed volumes, and audiovisual material - had major impact in lower grades. Availability of facilities affected high school achievement; school district size was negatively related to educational output, other variables held constant.

However, increasing school district size permitted internal changes that raised student attainment for a given level of expenditures. Existence of economies of size or cost reductions associated with increases in school district size allowed these savings to be reallocated to raise educational output. This apparent contradiction highlights the importance of knowing the physical relationship between inputs and outputs. Costs must also be taken into consideration, and it is necessary to know each input's contribution to output relative to its cost.

The cost of schooling was divided into transportation and educational costs. Educational costs included expenditures for instruction, administration, and plant operation and maintenance, as well as annual charges for buildings and equipment. All educational costs showed significant economies of size. Transportation costs, on the other hand, showed slight diseconomies in heavily populated areas and significant diseconomies in sparsely populated areas. Combining transportation and educational costs gives insight into school district organization that largely has been ignored in previous studies.

Using a separable programming model, this study related costs to production functions to find the minimum cost of a given quality of education. Activities affecting both cost and production included teacher qualifications and workloads and instructional materials. Costs of administration, buildings, and equipment were linked directly to ADA or school district size. This model provides information on efficient resource allocation and school district organization for given student and community characteristics, as well as school district goals.

The basic model was initially specified to reflect average levels of output, student background, salary, and student density. In turn, each of these situations was varied to identify its impact on the optimum resource combination.

Conclusions

Implications

It is apparent that the optimum resource organization in education depends on educational objectives, student backgrounds, high school curriculum, teacher salary, and student density.

1. For a given level of student background, higher levels of educational output were associated with substantial increases in per-unit costs. The most efficient way to attain higher levels of educational output requires a reduction in elementary

and junior high teacher workloads, increased teacher experience and increased expenditures on instructional materials.

2. Students with below average abilities and socioeconomic backgrounds place formidable constraints on attainable educational output. Their performance can be improved, however, with properly allocated higher expenditures.

3. Allowing for long-run adjustments to changes in teacher salaries, student performance was positively related to salary. Thus increases in teacher salaries can be accompanied by reductions in expenditures on other educational process variables.

4. A more extensive curriculum requires larger school districts to efficiently utilize the program. The optimum school district size for a school offering only a minimum program is substantially less than one offering a more comprehensive program.

5. Optimum school district size was also affected by student density. In sparsely populated areas, school districts could not expand in size to take full advantage of economies in instruction because transportation diseconomies were an overriding factor. Transportation costs are not nearly as important in heavily populated districts. In these areas, the optimum school district size is much greater, and the average cost curves for heavily populated districts are nearly flat over a very wide range. School districts can operate anywhere within this range without significant differences in per-unit costs. On the other hand, sparsely populated districts have

a very small range in which they can operate at minimum cost. Only minor deviations in this optimum size result in substantially higher costs.

Since this research has shown that it may be more important to know how funds are spent than the total level of funds, it follows that a general increase in expenditures will not necessarily result in any measurable increase in student performance. If funds are to be employed in a measure to strengthen education, careful attention must be given to productive investment opportunities.

Problems in financing local education stem partly from inappropriate school district organization. Since the structure of school district organization was established generations ago, many rural school districts are too small to meet the needs of their students. Reorganization and consolidation for these school districts offer much greater potential for cost reductions than efficiently organizing resources within the school districts. Reorganizations should be based on a minimum school district size to provide a specified quality of education at the least cost.

The major portion of this study examined costs for reaching some prescribed schooling output, but, for some purposes, measures of the dollar value of output need to be compared with costs. Dollar values were assigned to the yearly equivalent test scores to measure the present value of benefits. The present value of benefits and costs for various policy alternatives were then compared. Surprisingly, the benefit-cost ratio for reducing the pupil-teacher ratio was one of the lowest for any alternative considered. Several other changes in the allocation of schooling resources had very favorable benefit-cost ratios. The results were crude, however, and they must be interpreted cautiously.

Limitations

Conclusions relating to such things as pupil-teacher ratios and instructional materials may give insight into changes required to improve efficiency but may be inappropriate for some schools. To determine appropriate changes for any given school, it is necessary to measure input-output relationships for that school and make adjustments accordingly. Then these relationships may be used in cost-effectiveness analysis to determine optimum resource organization. The approach could be similar to the one used in this research in which broad categories of variables were used.

All costs of education such as discomfort of bus rides or loss of sports due to reorganization are nonquantifiable and are not included in this analysis. The analysis reported herein shows opportunity costs of misallocating resources. Such information on the cost of a school that is too small or inefficiently organized can be balanced against the nonquantifiable benefits of allowing these inefficiencies to persist.

A sample containing a larger number of schools would have been more informative. Insufficient variation among schools sampled may have veiled real influences of some factors on educational output. For example, the failure of printed volumes per student to show significant relationships to eleventh grade output may have been because all schools sampled had an adequate number of printed volumes. While a larger sample would allow more statistically significant variables to be detected, the results would not have revealed any variables with a large impact on the educational output variables.

Another problem relates to school district objectives. These objectives may vary by socioeconomic and other characteristics of the community. Many school districts may place heavy emphasis on scholarly achievement while others emphasize vocational, citizenship, and even sports activities. Lumping school districts with different objectives together is hazardous. However, the output variables selected in this research were considered to be sufficiently broad and basic to apply to most school districts and do not necessarily conflict with pursuit of local objectives such as a good sports program.

Some variables were not as completely specified as would be desired. The only measure of teacher education was percentage of teachers with a master's degree. Other measures of education could also be included. Also, measures of teacher qualifications obtained by testing of teachers in verbal and other skills would have been useful. The pupil-teacher ratio was the ratio of enrollment to total teachers. This variable might be improved by using average class size. A further modification would be to select only certain classes, ignoring classes which are unlikely to affect the dimension of quality currently under consideration.

Availability of science laboratory, language laboratory, and industrial, vocational, or technical shop were the measures of facilities considered in the analysis. While these measures are undoubtedly correlated with the quality of the entire physical plant, it is recognized that the measures are not fully adequate.

Much criticism has been directed at the use of linear regression input-output analysis. Linear equations imply that the next unit of an input has the same effect on student performance as did the last unit of that input and that the effect is independent of other inputs. However, interaction terms could have been used to show that the input's effect on output depends on the level of other inputs. While the linear and squared variables were used to express the pupil-teacher ratio, a larger sample would have permitted use of more squared variables.

The regression equations explained from 70 to 90 percent of variation in the educational output variables. Since all the variation was not explained, there may be some discrepancies between expected and actual values of an output. Also, the analysis was restricted to conventional teaching methods. These limitations must be considered in interpreting the results of the mathematical programming model.

Further Research

Continuation of this line of research using data gathered for more schools and students and for more years will provide further insight into schooling efficiency. More refinement is needed on estimates of the returns to be expected from variations in the inputs used in the educational system. The schools being considered could be categorized by similar characteristics. Although the school district appeared to be the obvious unit of analysis in rural areas, similar analysis could be applied to just elementary, junior high or high schools.

More dimensions of educational output need to be included in the analysis. One such possibility is job-oriented tests. Estimates of how well measures of student performance are maintained over time should be developed. Job-oriented tests should be related to post high school employment, and achievement tests should be related to success in higher education.

Further research linking school programs to individual students is needed. Average class size that an individual student actually attends and the qualifications of teachers that he is actually exposed to are the relevant variables in determining his performance. Since characteristics of schools in which students attended in earlier grades may be dissimilar to current school characteristics, longitudinal studies are necessary to link these characteristics in earlier grades to current student performance.

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APPENDIX A

SAMPLE QUESTIONNAIRE - STUDENT INFORMATION

SAMPLE QUESTIONNAIRE

STUDENT INFORMATION

County	District	Site	Grade	Student Number
☐☐	☐☐☐☐	☐☐☐	☐☐	☐☐☐

(Check appropriate blank.)

1. Sex: (1) Male_______ (2) Female_______

2. Race: (1) Indian_______ (2) Black_______ (3) White_______

   (4) Mexican American_______ (5) Oriental_______

   (6) Other_______

3. Did you go to kindergarten before you started the first grade?

   (1) Yes_______ (2) No_______

4. Did you go to Headstart or nursery school before you went to kindergarten?

   (1) Yes_______ (2) No_______

(Circle the correct answer.)

5. About how many times have you changed schools since you started the first grade? (Not counting promotions from one school to another.)

   1. Never
   2. Once
   3. Twice
   4. Three times
   5. Four times or more

6. On an average school day, how much time do you spend studying outside of school?

   1. None or almost none
   2. About ½ hour a day
   3. About 1 hour a day
   4. About 1½ hours a day
   5. About 2 hours a day
   6. About 3 hours a day
   7. About 4 or more hours a day

7. How often do you and your parents or guardians talk about your schoolwork?

    1. Just about every day

    2. Once or twice a week

    3. Once or twice a month

    4. Never or hardly ever

8. Did you read any books during the last summer?

    1. No

    2. Yes, 1 or 2

    3. Yes, about 5

    4. Yes, about 10

    5. Yes, more than 10

9. In what type of community have you spent most of your life? (Give your best estimate if you are not sure.)

    1. Rural (farm or ranch)

    2. Town or city (0-500)

    3. Town or city (500-2,500)

    4. Town or city (2,500-5,000)

    5. Town or city (5,000-10,000)

    6. Town or city (10,000-30,000)

    7. Town or city (30,000-above)

10. Do you feel that you can get to see a guidance counselor when you want to or need to?

    1. Yes

    2. No

    3. We have no guidance counselor.

11. How many times did you talk to a guidance counselor in an individual or group situation last year?

    1. Never
    2. Once
    3. Two or three times
    4. Four or five times
    5. Six or more times
    6. We had no guidance counselor.

12. With whom do you live?

    1. Both parents
    2. Father
    3. Mother
    4. Guardian
    5. Other

THE FOLLOWING QUESTIONS SHOULD BE ANSWERED BY EIGHTH (8th) AND ELEVENTH (11th) GRADERS <u>ONLY</u>.

13. Circle the activities below in which you participate.

    1. Athletic
    2. Band
    3. Chorus
    4. Subject-related clubs
    5. Social clubs
    6. Honor Society
    7. Others

14. Do you work after school (other than household duties)?

    1. No
    2. Less than 10 hours a week
    3. About 10 to 20 hours a week
    4. More than 20 hours a week

THE FOLLOWING QUESTIONS SHOULD BE ANSWERED BY ELEVENTH (11th) GRADERS ONLY.

15. I plan to make the following occupation my career:

1. Office work (cashier, clerk, bookkeeper, etc.)
2. Professional (doctor, teacher, lawyer, minister, nurse, etc.)
3. Executive (manage large business, industrial firm)
4. Semi-skilled work (janitor, farm hand, plumber's helper, waiter, truck driver, etc.)
5. Salesman (insurance, real estate, auto, store, etc.)
6. Skilled work (secretary, mechanic, welder, appliance service man, etc.)
7. Own, rent, manage small business (store, station, cafe, etc.)
8. Military
9. Own, rent, manage farm or ranch
10. Housewife

16. After graduation from high school, I plan:

1. To continue going to school
2. To get a job
3. To become an apprentice
4. To go into military service
5. To work at my home
6. I have no definite plans
7. Other____________________

APPENDIX B

SAMPLE QUESTIONNAIRE - PARENT INFORMATION

SAMPLE QUESTIONNAIRE

PARENT INFORMATION

County	District	Site	Grade	Student Number

(Circle correct answer.)

1. Father's education

    1. Less than high school
    2. Attended high school
    3. Graduated from high school
    4. Attended trade or business school
    5. Attended college
    6. Graduated from college
    7. Has a master's or doctor's degree

2. Father's occupation

    1. Office work (cashier, clerk, bookkeeper, etc.)
    2. Professional (doctor, teacher, lawyer, minister, etc.)
    3. Executive (manages large business, industrial firm)
    4. Semi-skilled work (janitor, farm hand, plumber's helper, waiter, truck driver, etc.)
    5. Salesman (insurance, real estate, auto, store, etc.)
    6. Skilled work (mechanic, welder, appliance service man, etc.)
    7. Owns, rents, manages small business (store, station, cafe, etc.)
    8. Military
    9. Owns, rents, manages farm or ranch
    10. Disabled, retired
    11. Deceased

3. Mother's education

    1. Less than high school
    2. Attended high school
    3. Graduated from high school
    4. Attended trade or business school
    5. Attended college
    6. Graduated from college
    7. Has master's or doctor's degree

4. Mother's occupation

    1. Housewife (does not work outside of home)
    2. Professional (teacher, doctor, lawyer, etc.)
    3. Executive (manages large business)
    4. Semi-skilled work (waitress, cleaning woman, etc.)
    5. Saleslady
    6. Skilled worker (secretary, lab technician, etc.)
    7. Owns, rents, manages small business
    8. Office work (clerk, filing, receptionist)
    9. Disabled, retired
    10. Deceased

5. Residence

    1. Rural (farm or ranch)
    2. Town or city (0-500)
    3. Town or city (500-2,500)
    4. Town or city (2,500-5,000)
    5. Town or city (5,000-10,000)
    6. Town or city (10,000-30,000)
    7. Town or city (30,000-above)

6. Number of miles from school

    1. 0-1 mile
    2. 1-3 miles
    3. 3-10 miles
    4. 10 or more miles

7. Parent's or guardian's net income

    1. Less than $1,500
    2. $1,500 to $3,000
    3. $3,000 to $5,000
    4. $5,000 to $10,000
    5. $10,000 to $20,000
    6. $20,000 and above

8. Our plan for our children's education

    1. Attend high school
    2. Complete high school
    3. Attend business college (secretarial, barber, cosmetology, etc.)
    4. Vocational-technical school
    5. Junior college
    6. Four-year college
    7. University

APPENDIX C

SAMPLE QUESTIONNAIRE - ADMINISTRATORS INFORMATION

SAMPLE QUESTIONNAIRE

ADMINISTRATORS INFORMATION

County	District	Site
☐☐	☐☐☐☐	☐☐☐

PROGRAM

1. Specific grade(s), at this school site, covered by this questionnaire.__________

> THE FOLLOWING INFORMATION SHOULD APPLY ONLY TO THE GRADES AT THIS SCHOOL SITE, BUT SEPARATE QUESTIONNAIRES SHOULD BE FILLED OUT FOR EACH OF THE SCHOOL GROUPINGS AT THIS SITE AS INDICATED IN QUESTION NUMBER ONE.

2. Is team teaching utilized to any extent? (a)Yes___(b)No___
3. Are students grouped by ability to any extent? (a)Yes___(b)No___
4. Total number of students in remedial classes. __________
5. Total number of special education students. __________
6. Total number of students in accelerated classes. __________
7. Is your elementary school instructional program
   - (a) Self-contained classrooms __________
   - (b) Departmentalized __________
   - (c) Combination of the above __________

> TO BE ANSWERED BY SENIOR HIGH SCHOOL ADMINISTRATORS ONLY

8. Total number units offered in this school site. __________
9. Total number of non-vocational units offered. __________
10. Total number of vocational units offered. __________
11. Total number of students in vocational subjects. __________

Instructional staff, fall 1969 (Total number of filled positions, full-time equivalent.)

Type of Personnel	Elementary	Secondary
Principals	12	13
Classroom teachers	14	15
Guidance and counseling personnel	16	17

Characteristics of Classroom Teachers by degree status and type of certificate, fall 1969.

Degrees. In the following table, report the number of teachers in each level of school organization by highest degree obtained and type of teaching certificate. Count each teacher once in each of the two sections of the table.

	Number of Teachers		
	Highest Degree Obtained		
Organizational Level	Bachelor's	Master's or higher	No Degree
Elementary	18	19	20
Secondary (including junior high)	21	22	23
Total number of teachers	24	25	26

<u>Salary</u>. Full-time classroom teachers by salary groups, fall 1969.

Include as salary all adjustments and increments such as additional sums for dependents, and for services as coach, librarian, etc.

	Salary Groups	Number of Teachers
27.	$5,000 to $5,499	
28.	$5,500 to $5,999	
29.	$6,000 to $6,999	
30.	$7,000 to $7,999	
31.	$8,000 to $8,999	
32.	$9,000 to $9,999	
33.	$10,000 and over	
34.	Total number of teachers	

Number of teachers with following years experience:

35. _____None

36. _____1 or 2

37. _____3 or 4

38. _____5 to 9

39. _____10 to 14

40. _____15 to 19

41. _____20 to 29

42. _____30 or longer

43. Number of instructional periods per day at this school site.

(a) 5_____ (b) 6_____ (c) 7_____ (d) Modular_____ (e) Other___

44. Number of teachers who have planning period. __________

45. Number of teachers who do not have planning period. __________

FACILITIES

If instructional rooms are needed to eliminate inadequate facilities, what type of special facilities are needed, if any? (Check as many as appropriate.)

46. Science Laboratory (a)Yes___ (b)No___

47. Language Laboratory (a)Yes___ (b)No___

48. Industrial, Vocational or Technical Shop (a)Yes___ (b)No___

49. Kindergarten (a)Yes___ (b)No___

50. What is the total number of printed volumes per pupil in this school? Count the total number of books, exclusive of textbooks, whether in a central media center or elsewhere in the building, and divide by the total number of students in membership. ________

51. What is the total number of different periodicals which are available regularly in this school? ________

Below is a partial list of audiovisual equipment which is frequently used in classroom instruction. List how many of each item of equipment you have in this school building.

52. 16mm projectors ____

53. 8mm projectors ____

54. Filmstrip projectors ____

55. Slide projectors ____

56. Record players ____

57. Tape recorders ____

58. Overhead projectors ____

59. Television receivers ____

In the chart below include all audiovisual materials available for use at this school site.

Types of Materials	Number of Titles Available Elementary	Secondary
Motion pictures	60	61
Filmstrips	62	63
Slides	64	65
Disc recordings	66	67
Tape recordings	68	69
Picture sets	70	71
Maps	72	73
Globes	74	75
Charts	76	77
Transparencies	78	79
Other types (list)	80	81
Totals	82	83

ORGANIZATION - ADMINISTRATION - MANAGEMENT

84. Total number of grades offered at this school site. ________

85. What is the pupil-teacher ratio at this school site? (classroom teachers only) ________

86. What is the retention rate at this school site? ________

87. What is the absentee rate (percent) of students at this school site for first semester 1969-70?

$$\frac{\text{Total days absent}}{\text{Total days on roll}} \times 100$$ ________

88. What percent of the student population comes from ranches, farms, or open country at this school site? ________

89. Total ADA of this school site at the end of 1968-69 school year. ________

ALL QUESTIONS APPLY TO THE ENTIRE SCHOOL DISTRICT

FINANCES

90. What is the assessed valuation per ADA? ________

91. Expenditures for instructional purposes per ADA? ________

92. Expenditures for school library purposes per ADA? ________

93. Expenditures for transportation purposes per ADA? ________

94. Expenditures for instructional supplies per ADA? ________

95. Expenditures for all functions per ADA? (Do not include capital outlay and building fund.) ________

SCHOOL DISTRICT INFORMATION

96. What is the student density figure (enrollment per square mile) for the school district?

$$\frac{\text{Total Enrollment}}{\text{Total Sq. Miles}}$$ ________

97. Total number of high school graduates. ________

98. Total ADA of this school district. ________

99. Typical salary for this school site.

(a) Beginning teacher with bachelor's degree ________

(b) Teacher with 10 years experience, bachelor's degree ________

(c) Teacher with 10 years experience, master's degree ________

APPENDIX D

MEANS, STANDARD DEVIATIONS, AND CORRELATION COEFFICIENTS OF SELECTED ELEVENTH GRADE VARIABLES

TABLE XXXVII

ELEVENTH GRADE VARIABLES

Variable	Description	Estimated Mean	Estimated Standard Deviation
	Educational Outputs		
X_1	Absentee rate	2.982	2.389
X_2	Dropout rate	3.444	2.313
X_3	Average language arts score	414.666	22.153
X_4	Average modern math score	412.122	21.065
X_5	Average composite achievement score	77.031	9.943
	Instrumental Variables		
Y_1	Percentage of teachers with 10 or more years of experience	47.293	16.351
Y_2	Percentage of teachers with a planning period	51.041	47.175
Y_3	Adequate science laboratory	0.555	0.506
Y_4	Printed volumes per pupil	12.549	7.642
Y_5	Pupil-teacher ratio	20.845	5.719
Y_6	Percentage of teachers with a master's degree	34.068	15.470
Y_7	Value of audiovisual material per pupil ($100)	2.105	3.319
Y_8	Average teacher salary ($1,000)	6.963	0.448
Y_9	Average teacher experience	11.617	3.420

TABLE XXXVII (Continued)

Variable	Description	Estimated Mean	Estimated Standard Deviation
Y_{10}	Salary for beginning teachers with bachelor's degree ($1000)	5.750	0.295
Y_{11}	Number of academic units offered	44.537	19.253
Y_{12}	Number of vocational units offered	13.685	12.242
Y_{13}	Adequate industrial, vocational or technical shop	0.518	0.509
Y_{14}	Expenditures for all functions except transportation per ADA	526.703	129.122
Y_{15}	Average daily attendance (1,000 units)	5.934	18.064
	Control Variables		
Z_1	Average IQ	95.962	8.652
Z_2	Percentage of students whose fathers attended college	22.798	15.728
Z_3	Percentage of students whose fathers' occupation is professional or executive	12.538	11.509
Z_4	Parents' average net income ($1,000)	8.672	2.634
Z_5	Percentage of students whose parents plan for their children to attend college	62.713	14.178
Z_6	Percentage of students who are Indian	8.961	14.904
Z_7	Percentage of students who are black	5.908	12.314
Z_8	Average number of times student has changed schools	1.732	0.425

TABLE XXXVII (Continued)

Variable	Description	Estimated Mean	Estimated Standard Deviation
Z_9	Average number of hours studied	0.895	0.285
Z_{10}	Percentage of students who talk to parents about schoolwork at least once a week	72.316	11.017
Z_{11}	Average number of books students read during the last summer	3.874	0.954
Z_{12}	Percentage of students who have spent most of their lives in rural areas	40.110	25.410
Z_{13}	Percentage of students who have spent most of their lives in a town or city with 0-2500 population	15.865	16.868
Z_{14}	Average number of hours worked outside of school per week	4.547	1.690
Z_{15}	Percentage of students who plan to go to college	61.014	13.456

TABLE XXXVIII

CORRELATION COEFFICIENTS OF EDUCATIONAL OUTPUTS AND SELECTED EDUCATIONAL PROCESS VARIABLES FOR THE ELEVENTH GRADE

Variable	X_1	X_2	X_3	X_4	X_5	Y_1	Y_2	Y_3	Y_4	Y_5
X_1	1.000	0.592	0.057	0.076	0.156	0.002	0.115	0.089	-0.317	0.567
X_2		1.000	-0.217	-0.073	-0.004	-0.294	0.213	0.044	-0.240	0.572
X_3			1.000	0.881	0.920	-0.324	0.262	0.053	0.174	-0.207
X_4				1.000	0.939	-0.274	0.358	0.049	0.230	0.030
X_5					1.000	-0.358	0.367	0.139	0.253	0.047
Y_1						1.000	0.037	-0.100	-0.169	-0.148
Y_2							1.000	-0.060	-0.196	-0.107
Y_3								1.000	0.244	0.188
Y_4									1.000	0.027
Y_5										1.000

TABLE XXXVIII (Continued)

Variable	Y_6	Y_7	Y_8	Y_9	Y_{10}	Y_{11}	Y_{12}	Y_{13}	Y_{14}	Y_{15}
X_1	0.017	-0.374	-0.266	-0.032	-0.194	0.472	0.433	-0.007	-0.454	0.350
X_2	-0.123	-0.555	-0.385	-0.198	-0.321	0.291	0.347	-0.203	-0.678	0.209
X_3	-0.009	0.230	0.104	-0.329	0.450	0.291	0.204	0.414	0.521	0.189
X_4	0.136	0.039	0.217	-0.242	0.476	0.493	0.204	0.418	0.302	0.423
X_5	0.019	0.078	0.137	-0.328	0.433	0.404	0.229	0.438	0.340	0.319
Y_1	0.571	-0.154	0.506	0.881	-0.025	-0.131	-0.030	0.190	-0.058	-0.225
Y_2	0.159	-0.075	0.201	0.087	0.053	0.411	0.243	0.553	-0.009	0.308
Y_3	-0.400	0.308	0.165	-0.050	0.054	0.162	-0.085	0.331	0.175	0.250
Y_4	-0.124	0.197	0.417	0.051	0.243	-0.181	-0.150	0.041	0.244	-0.100
Y_5	-0.011	-0.538	-0.168	-0.009	-0.016	0.351	0.310	-0.238	-0.716	0.310
Y_6	1.000	-0.478	0.452	0.546	0.371	0.162	0.251	0.029	-0.102	0.047
Y_7		1.000	0.003	-0.221	0.004	-0.153	-0.252	0.232	0.681	-0.021
Y_8			1.000	0.566	0.281	0.011	0.018	0.381	0.237	0.066
Y_9				1.000	0.019	-0.120	0.015	0.122	-0.177	-0.202
Y_{10}					1.000	0.293	0.247	0.138	0.293	0.270
Y_{11}						1.000	0.449	0.375	-0.145	0.867
Y_{12}							1.000	0.006	-0.240	0.298
Y_{13}								1.000	0.458	0.274
Y_{14}									1.000	-0.045
Y_{15}										1.000

TABLE XXXIX

CORRELATION COEFFICIENTS OF EDUCATIONAL OUTPUTS AND SELECTED STUDENT INPUT AND ENVIRONMENTAL VARIABLES FOR THE ELEVENTH GRADE

Variable	X_1	X_2	X_3	X_4	X_5	Z_1	Z_2	Z_3	Z_4	Z_5
X_1	1.000	0.592	0.057	0.076	0.156	-0.004	0.306	0.449	0.127	0.178
X_2		1.000	-0.217	-0.073	-0.004	-0.015	0.190	0.349	0.042	0.197
X_3			1.000	0.881	0.920	0.518	0.532	0.404	0.691	0.636
X_4				1.000	0.939	0.503	0.689	0.590	0.750	0.687
X_5					1.000	0.595	0.672	0.548	0.744	0.757
Z_1						1.000	0.344	0.146	0.256	0.447
Z_2							1.000	0.916	0.795	0.675
Z_3								1.000	0.739	0.527
Z_4									1.000	0.660
Z_5										1.000

TABLE XXXIX (Continued)

Variable	Z_6	Z_7	Z_8	Z_9	Z_{10}	Z_{11}	Z_{12}	Z_{13}	Z_{14}	Z_{15}
X_1	0.035	0.078	0.366	0.319	0.511	-0.079	-0.354	-0.060	0.051	0.049
X_2	-0.222	0.073	0.387	0.260	0.636	-0.246	-0.422	0.228	0.060	0.038
X_3	-0.503	-0.368	-0.534	0.246	0.067	0.479	-0.464	0.022	0.024	0.769
X_4	-0.555	-0.326	-0.310	0.415	0.182	0.436	-0.519	0.078	0.021	0.821
X_5	-0.601	-0.439	-0.367	0.360	0.205	0.436	-0.565	0.106	0.146	0.837
Z_1	-0.365	-0.366	-0.296	0.250	0.131	0.328	-0.209	0.231	0.294	0.417
Z_2	-0.489	-0.154	0.137	0.457	0.159	0.228	-0.658	0.048	0.342	0.687
Z_3	-0.338	-0.037	0.312	0.522	0.292	0.031	-0.673	0.054	0.260	0.540
Z_4	-0.630	-0.358	-0.041	0.231	0.111	0.321	-0.639	-0.066	0.280	0.640
Z_5	-0.692	-0.253	-0.077	0.223	0.378	0.503	-0.602	0.115	0.286	0.846
Z_6	1.000	0.242	0.262	-0.185	-0.341	-0.370	0.494	-0.135	-0.277	-0.606
Z_7		1.000	0.182	0.103	0.090	-0.525	0.094	0.020	-0.302	-0.279
Z_8			1.000	0.187	0.419	-0.151	-0.096	-0.089	0.132	-0.286
Z_9				1.000	0.431	0.004	-0.435	-0.101	-0.170	0.297
Z_{10}					1.000	0.204	-0.368	0.015	0.013	0.229
Z_{11}						1.000	-0.109	-0.045	0.051	0.436
Z_{12}							1.000	-0.217	-0.112	-0.467
Z_{13}								1.000	-0.119	-0.039
Z_{14}									1.000	0.216
Z_{15}										1.000

APPENDIX E

SIMULTANEOUS EQUATIONS EXPLAINING ELEVENTH GRADE EDUCATIONAL OUTPUT

TABLE XL

SIMULTANEOUS EQUATION EXPLAINING ELEVENTH GRADE DROPOUT RATE

Variable	Regression Coefficient	Standard Error
Constant	19.6590	
Endogenous Variable in Equation		
Eleventh Grade Composite Scores	0.0151	0.0003
Educational Process Variables		
Percentage of teachers with five to nine years experience	-0.0556	0.0002
Percentage of teachers with ten or more years experience	-0.0890	0.0002
Value of audiovisual material in hundred dollars per student	-0.3757	0.0006
Salary in thousand dollars for beginning teachers with bachelor's degree	-1.8503	0.0081
SQRT (Average daily attendance in thousands)	0.5888	0.0016
Environmental Variable		
Percentage of students whose parents' net income is greater than $10,000	-0.0617	0.0003
R^2	0.7874	

TABLE XLI

SIMULTANEOUS EQUATION EXPLAINING ELEVENTH GRADE LANGUAGE ARTS SCORES

Variable	Regression Coefficient	Standard Error
Constant	373.7004	
Endogenous Variable in Equation		
Eleventh Grade Dropout Rate	-2.3787	0.0083
Educational Process Variables		
Percentage of teachers with three to nine years of experience	0.3469	0.0014
Adequate industrial, vocational or technical shop	16.8045	0.0370
SQRT (Average daily attendance in thousands)	-9.4460	0.0210
Student Input Variable		
Percentage of students who plan to continue going to school after graduation	0.4843	0.0013
Environmental Variables		
Percentage of students whose father's occupation is professional or executive	1.8637	0.0042
Percentage of students whose parents' net income is less than $3,000	-0.2299	0.0011
R^2	0.6697	

TABLE XLII

SIMULTANEOUS EQUATION EXPLAINING ELEVENTH GRADE MODERN MATH SCORES

Variable	Regression Coefficient	Standard Error
Constant	93.6721	
<u>Endogenous Variable in Equation</u>		
Eleventh Grade Dropout Rate	-1.0966	0.0081
<u>Educational Process Variables</u>		
Percentage of teachers with ten or more years experience	-0.2621	0.0012
Salary in thousand dollars for beginning teachers with a bachelor's degree	10.1036	0.0662
Adequate industrial, vocational, or technical shop	6.8520	0.0359
<u>Student Input Variables</u>		
Eighth grade modern math score	0.5716	0.0011
Average number of hours students studied	17.5971	0.0685
Average number of books students read during last summer	4.5126	0.0184
Average number of hours worked per week outside of school	-2.6208	0.0106
R^2	0.8471	

TABLE XLIII

SIMULTANEOUS EQUATION EXPLAINING ELEVENTH GRADE COMPOSITE SCORES

Variable	Regression Coefficient	Standard Error
Constant	31.6542	
Endogenous Variable in Equation		
Eleventh Grade Dropout Rate	0.1055	0.0040
Educational Process Variables		
Percentage of teachers with master's degree	0.2054	0.0009
Percentage of teachers with ten or more years experience	-0.2878	0.0009
SQRT (Number of nonvocational units offered)	3.3243	0.0166
Adequate industrial, vocational or technical shop	8.4257	0.0204
SQRT (Average daily attendance in thousands)	-3.7579	0.0096
Student Input Variables		
Eighth grade composite score	0.0912	0.0002
Percentage of students who have changed schools three or more times	-0.0650	0.0016
Percentage of students who plan to continue going to school after graduation	0.1403	0.0007
Environmental Variable		
Percentage of students whose fathers attended college	0.3185	0.0011
R^2	0.8317	

VITA

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Candidate for the Degree of

Doctor of Philosophy

Thesis: A QUANTITATIVE ANALYSIS OF FACTORS AFFECTING ELEMENTARY AND SECONDARY SCHOOLING QUALITY IN OKLAHOMA, WITH ECONOMIC APPLICATION FOR RURAL AREAS

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