The Economics of Elementary and Secondary Schooling in Oklahoma

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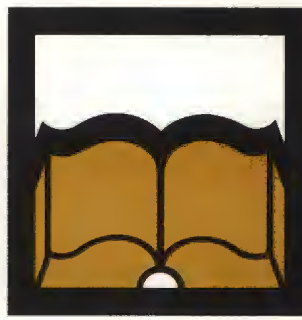

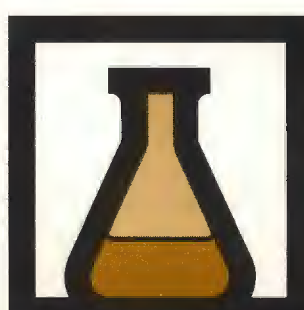

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THE ECONOMICS OF ELEMENTARY AND SECONDARY SCHOOLING IN OKLAHOMA

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Introduction

Resistance of taxpayers to bond issues and higher taxes coupled with pressures by parents and others for better schooling in the face of rising costs generate a real need to use schooling resources more efficiently. Applied economic principles, which show how to allocate scarce means among competing ends to satisfy those ends as fully as possible, can help schooling administrators and voters to make decisions that result in more efficient and equitable schooling.

One objective of this study is to show the efficient organization of schooling resources to raise achievement scores, reduce dropout rates and/or reduce absentee rates. The authors by no means wish to imply that high achievement scores, and low absentee or dropout rates *should* be the only objectives of schooling. Rather the position is that if these outcomes are desired, then changes outlined in this study can help to achieve these objectives in a cost-effective manner. Of course, efficiency is also not an ultimate end, but economic analysis showing the savings from operating a larger school can help communities with small schools decide for themselves what course of action they wish to pursue given greater understanding of the costs and benefits of alternatives.

The study examines interrelationships among the educational process, student achievement, and environment. Student achievement is defined as the level of attainment of students in an educational program. The educational process is defined as activities in a school designed to raise students' levels of attainment. Environment is all the circumstances in the community and home that may facilitate or impede the educational effort.

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Since controlled experimental efforts and secondary data were unavailable to establish the interrelationships of the large number of variables that determine output or student achievement, data from a random sample of Oklahoma elementary and secondary schools were used herein. From these data, the achievement test scores of the sample of Oklahoma students are compared to national norms. The results indicate the average achievement level of Oklahoma students, but there are many characteristics of students and their environment that are associated with deviation from the average test scores. A number of these characteristics are examined in this report.

This study is the product of interdisciplinary research between educators and economists. The Oklahoma State Department of Education and the Title III, ESEA State Advisory Council coordinated the entire program to assess learner needs. A Task Force within the State Department of Education in conjunction with Professors Tweeten and Lu formulated the research design and the development of instruments to be used in data collection.

The Guidance Division of the State Department of Education was primarily responsible for administering the standardized tests and the questionnaires. Without the cooperation of school administrators, parents, teachers, and students, a study of this magnitude would not have been possible.

Objectives

The objectives of this study of Oklahoma elementary and secondary schooling are to determine:

(1) Achievement levels of Oklahoma students in relation to national norms;

(2) The rate of return on private and social investment in schooling;

(3) Relative achievement of components of the student population including racial minorities, farm, and small town youth;

(4) The contribution of student background, school organization, and teacher characteristics to student achievement;

(5) Least-cost school size, accounting for transportation costs, achievement scores, student density per square mile as well as other factors;

(6) Overall optimal school organization;

(7) The distribution of common school benefits and costs among income classes; and,

(8) School funding procedures that account for ability to pay as well as compensation for net spillout of local public investment in schooling.

Sampling Procedures

To obtain in the sample the wide differences in characteristics, such as geographic regions, school size, and minority groups, that are known to exist in Oklahoma schools, stratified random sampling was used. The sampling unit is the school district, and all school districts comprise the whole of the population. The population of school districts in Oklahoma was first divided into five subpopulations according to geographic location: northwest, northeast, southwest, southeast, and Oklahoma City and Tulsa. Each region, except the Oklahoma City and Tulsa area, was then divided into three strata according to school district sizes: under 500 students, between 501 and 2,000 students, and over 2,000 students. The Oklahoma City and Tulsa area was divided into two strata: regular school districts and Title I school districts. Thus there was a total of fourteen strata.

A sample was then drawn randomly and independently from each stratum. The sample size in each stratum was proportional to the size of the stratum, i.e., approximately five percent of the students in each stratum. 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 changes the sampling rate considerably.

A total of 27 independent Oklahoma school districts was drawn. 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, school size, and minority group was represented in the sample. After the schools were randomly drawn, students in the eleventh grade of the high schools, and 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 dealt with their socio-economic background, activities, educational preparation, post high school plans, etc. The parents of the students also filled out a questionnaire on their education, occupation, income and residence. In addition, data were acquired from school administrators concerning finances, program, organization, facilities, equipment, teacher qualifications, and community characteristics.

The number of students surveyed in the fourth, eighth, and eleventh grades was 2,240, 1,935, and 1,771, respectively. However, the number of students reported in the following tables is somewhat less due to missing data in student information, parent information, or school administrator information.

The Test Batteries

The SRA achievement tests were administered in March, 1970, to students in the fourth and eighth grades. The test battery consists of five tests: social studies, sciences, language arts, arithmetic and reading; and a composite score was computed from the above five test scores. For students in the eleventh grade, the Iowa Tests of Educational Development (ITED) were administered. The ITED also consist of five tests: social studies, natural science, correctness of expression, quantitative thinking, and reading. A composite score was obtained by the arithmetic sum of the five tests.

Comparison of Oklahoma Student Achievement Scores with National Norms

Table 1 shows average test scores in Oklahoma and national norms. The national norms are averages for the nation, and can be used as one basis for comparing achievement of Oklahoma students with students in the nation.

Several conclusions are apparent from the data in Table 1.

1. Oklahoma students' average achievement as measured by achievement test scores from the sample described earlier is very near the national norm. Disregarding the math score (which is probably the least reliable of the scores because of nationwide differences in interpretations of what constitutes the subject area), all of the Oklahoma average scores are within five percentage points of the national norms.

2. Oklahoma students consistently rank slightly above the national norms in grade four.

Table 1. Comparison of Average Test Scores in Oklahoma with the National Norm[1]

	Grade 4			Grade 8			Grade 11		
	Okla.	Norm	Okla. as % of norm	Okla.	Norm	Okla. as % of norm	Okla.	Norm	Okla. as % of norm
Social Studies	277.0	275.0	100.7	386.2	406.0	95.1	468.5	465.0	100.8
Science	271.3	268.0	101.2	355.5	369.0	96.3	400.0	420.0	95.2
Language Art	280.1	271.0	103.4	360.6	361.0	99.9	424.4	431.0	98.5
Math	288.2	287.0	100.4	449.9	506.0	88.9	617.0	661.0	93.3
Reading	275.3	272.0	101.2	361.2	372.0	97.1	427.9	439.0	97.5

[1]Growth scale values were used for the measurement of student achievement in grades 4 and 8. Since the tests were administered in March, 1970, the average growth scale values in our sample were compared with those of the average student in the nation in the seventh month of the same grade.

3. With few exceptions, Oklahoma students rank slightly below the national norms in grades eight and eleven.

4. The decline in average scores of Oklahoma students in relation to the national average occurs between grades four and eight. In some instances such as social studies, the poor showing may be explained by delayed emphasis on the subject until high school. In the case of science, language arts and reading, this explanation is inadequate, and the quality of schooling in grades five through eight is of concern.

Relating Characteristics of Schools and Students to Achievement

Achievement test scores vary among individuals, and test results show that the variation in Oklahoma is similar to that in the nation. Although much of the variation is explained by characteristics unique to each individual student, some of the variation is explained by general characteristics such as race, place of residence, teacher salaries, class size, school size, and region of state. Tables 2 through 8 show how each of these characteristics is related to achievement scores for reading and for a composite of all individual tests. These scores are called "raw" scores—they cannot be compared directly with national norms or with scores for other grades. They are useful in comparing achievement only within a specific grade in Oklahoma. With the exception of expenditures per student, the hypothesis that characteristics examined are independent of achievement scores was rejected at the 1 percent probability level based on a chi-square test. More refined statistical tests based on multiple regression are shown later in this report.

Race. Of the grade four students in the sample, eighty-four percent were white, seven percent were American Indian, and five percent were black. Percentages increased slightly for whites and decreased slightly for the other two groups for grades eight and eleven. Test scores in Table 2 show that blacks scored consistently lowest while whites scored consistently highest in all grades for the reading test and for a composite of all

Table 2. State Average Raw Test Scores By Race

	Grade 4			Grade 8			Grade 11		
Race	No. of students	Reading score	Composite score	No. of students	Reading score	Composite score	No. of students	Reading score	Composite score
White	1649	279	164	1445	366	197	1487	17	83
Black	90	244	127	80	318	154	87	12	61
Other	214	259	138	118	335	168	128	13	69

tests. Indians (included in the "other" category in Table 2) ranked intermediate between whites and blacks in all grades. (Composite achievement scores shown separately for the components of the "other" category as well as additional detail for other characteristics examined in this section are available from the authors.)

The low scores for blacks are of special interest. Multiple regression analysis indicates that socio-economic background and IQ scores, rather than color as such, explain the low scores for blacks. In other words, whites with similar socio-economic backgrounds and IQ scored as low on the achievement test as blacks. Special efforts are needed to raise achievement scores of black students.

Student Residence. Students from the farm, ranch, and small town rank below students from the middle and large city in reading and comprehensive achievement scores (Table 3). One exception is the eleventh grade reading score, where students from small and middle sized cities have the same average scores.

Nearly the same number of the eighth grade sample students listed farm (and ranch) residence as listed cities of 10,000-30,000 population as residence. Comparing these two places of residence, 84 of the farm youth and 30 of the city youth had composite scores under 120. Sixty-two of the farm youth and 130 of the city youth had composite scores over 240.

Teacher Salary. Higher salary scales are associated with higher student achievement except for the highest salary level in Table 4. Further statistical analysis revealed that the relationship between salaries and achievement is not as strong as depicted in Table 4 because teachers receive high salaries in districts with high socio-economic status; the latter variable is a powerful predictor of achievement and accounts for

Table 3. Average Raw Test Scores in Oklahoma By Place of Student Residence

	Grade 4			Grade 8			Grade 11		
Place of student residence	No. of students	Reading score	Composite score	No. of students	Reading score	Composite score	No. of students	Reading score	Composite score
Farm or ranch	529	264	148	479	349	181	497	15	77
Small-town (0-2,500)	228	267	149	206	344	176	165	16	76
Mid-City (2,500-10,000)	469	282	165	351	362	199	419	16	83
Large City (over 10,000)	727	282	167	607	376	205	621	17	84

Table 4. Average Raw Test Scores in Oklahoma By Beginning Teacher Salaries

	Grade 4			Grade 8			Grade 11		
Beginning Salary	No. of students	Reading score	Composite score	No. of students	Reading score	Composite score	No. of students	Reading score	Composite score
Less than $5,299	114	256	138	107	332	163	249	15	76
$5,300 - 5,599	229	267	149	251	347	182	172	16	76
$5,600 - 5,899	734	281	165	764	369	199	576	16	82
$5,900 and over	876	275	160	521	362	196	705	16	83

much of the observed relation of achievement to salaries in Table 4. Although salaries have some influence on students' outcomes, raising salary schedules to a beginning level of at least $5,600 will by no means immediately raise the reading score to 199 for grade eight. But higher salaries will through time encourage professional improvement by existing teachers and will entice qualified entrants who will over time raise student achievement.

Other measures of salary scales could be used, but all are closely related to salaries of beginning teachers with a Bachelor degree, the measure used in Table 4.

Expenditures Per Student. There is a weak though positive relationship between expenditures for all functions per student in average daily attendance (ADA) and achievement scores (Table 5). In all instances, achievement scores were higher for expenditures of $570 and over than for expenditures of less than $449. The pattern is inconsistent between these extreme values, however. One reason may be the influence of other factors such as population density. More time spent on the bus lowers

Table 5. Average Raw Test Scores in Oklahoma By Expenditures

	Grade 4			Grade 8			Grade 11		
Expenditure/ADA	No. of students	Reading score	Composite score	No. of students	Reading score	Composite score	No. of students	Reading score	Composite score
Less than $449	210	270	152	241	350	181	195	15	76
$450-489	364	282	160	228	361	198	348	16	79
$490-529	848	275	162	826	369	198	773	16	83
$530-569	263	272	156	149	349	178	174	16	81
$570 and over	268	273	156	199	353	191	212	17	81

achievement scores based on a study by Lu and Tweeten (1973). Adjustments in the data need to be made for these outside influences to show the net relationship between expenditures for instructional purposes and achievement scores.

Pupil-Teacher Ratio. The pupil-teacher ratio shows little apparent relationship to achievement scores (Table 6). One reason is because the range of average class size is not large among the sample schools. For example, 82 percent of the students in grade four attended schools with average pupil-teacher ratios of 25 to 32. And 65 percent of the students in grade 11 attended schools with average pupil-teacher ratios of 17 to 24. Within a range of 20 to 30 students per class, other factors overshadow the pupil-teacher ratio in explaining student achievement.

Region. The northwest region of the state and Oklahoma City and Tulsa generally ranked above other regions of the state in the achievement scores reported in Table 7. An exception is the grade 3 reading score, which is higher for the northeast and southwest than for the northwest. The average performance on the tests was very similar for the north-

Table 6. Average Raw Test Scores in Oklahoma By Pupil-Teacher Ratio

	Grade 4			Grade 8			Grade 11		
Pupil-teacher ratio	No. of students	Reading score	Composite score	No. of students	Reading score	Composite score	No. of students	Reading score	Composite score
0-19	118	276	155	174	347	187	350	15	78
20-24 (20-21)[1]	302	251	135	225	350	179	416	17	83
25-27 (22-23)	879	285	167	416	361	195	378	17	84
28-30 (24-25)	520	270	159	771	368	198	385	16	79
31 & over (25 & over)	134	283	168	57	358	185	173	16	81

[1]The pupil-teacher ratio in the parenthesis applies to grade 11.

Table 7. Average Raw Test Scores in Oklahoma By Region of the State

	Grade 4			Grade 8			Grade 11		
Region of state	No. of students	Reading score	Composite score	No. of students	Reading score	Composite score	No. of students	Reading score	Composite score
Northwest	263	284	166	240	356	203	255	18	88
Southwest	424	274	159	364	366	193	325	16	79
Northeast	512	277	158	561	364	194	495	16	80
Southeast	448	271	153	348	349	179	450	15	77
Okla. City & Tulsa	306	274	164	130	378	208	177	17	89

east and southwest. The southeast region consistently ranked below the other regions.

Total Student ADA by Grade. Student achievement is associated with school size measured by student ADA per grade (Table 8). Achievement scores are without exception higher for schools with 80 or more ADA per grade than for schools with less than 20 ADA per grade. The relationship between grade size and scores appears to be weakest for grade 4 and strongest for grade 8. It should be recognized that socio-economic background of the student may explain some of the difference in scores among size groups. Students with a lower socio-economic background tend to have lower achievement test scores, and these students are frequently overrepresented in small schools. Further statistical analysis reveals that after correcting for all other variables, increasing school size actually reduced achievement though by a small amount.

Educational Production Functions

Substantial knowledge of the relationship between educational inputs and educational output is required to measure the effectiveness of alternative policy actions. An educational input is defined as a resource (e.g. labor, capital, time) which is used in providing education services or a factor which affects a student's ability to learn. The output of a school's program is measured by the number of students in the program and the quality of schooling. The production function, a conceptual tool used herein to analyze efficiency problems in the education industry, expresses the physical relationship between inputs and output.

An essential step in the allocative procedure is to quantify the effect of various inputs in the quality of elementary and secondary education. The educational output variables were regressed on the educational process, student input, and environmental variables. This procedure yields the net effect of the educational process variables on educational

Table 8. State Average Raw Test Scores By Grade Size

	Grade 4			Grade 8			Grade 11		
ADA per Grade	No. of students	Reading score	Composite score	No. of students	Reading score	Composite score	No. of students	Reading score	Composite score
0-19	231	260	144	300	338	175	188	16	76
20-39	589	275	157	216	353	178	202	15	75
40-59	398	275	160	160	355	197	162	17	85
60-79	86	260	151	215	369	201	82	17	88
80 & over	649	283	168	752	372	201	1068	16	82

output, while holding student input and environmental variables constant. Regression equations explaining average language arts, math and composite achievement scores and attendance rates were estimated for grades 4, 8, and 11. A regression equation explaining retention rates (opposite of dropout rates) in grade 11 was also estimated. These equations are shown in Tables 9-11.

Students' ability, educational effort and family background significantly influenced educational outcomes. Achievement test scores in earlier grades and IQ, representing students' ability, were positively related to educational output in elementary, junior high and high schools. 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.

Among the educational process variables which affected student attainment, those factors that were associated with teacher performance appeared particularly important. Teacher performance as measured by students' achievement tended to reach a peak between 3 and 10 years of experience. Teachers with more than 10 years of experience appeared

Table 9. Equations Expressing Fourth Grade Educational Outputs as a Function of Educational Inputs[1]

Variables	Attendance rate	Language arts	Math	Composite achievement
Constant	77.18	80.16	249.61	—25.93
Educational process variables				
Teacher-related variables				
with 3-9 yr. of experience (%)	0.04*	0.40*		
With GT 9 yr. of experience (%)			0.22**	
Average experience (yr.)	0.30**	1.82**		0.96**
Beginning salary with B.A. degree (1000)	3.21**	10.88		
With planning period (%)	0.02**			0.10*
Pupil-teacher ratio	—0.25**		—1.38**	
Adequate kindergarten		6.69		
Number of periodicals		0.35	0.59**	
Audiovisual material per student ($100)		2.02*	2.28**	0.95
SQRT (ADA in thousands)		—2.11	—2.19	
Student input variables				
Student intelligence quotient (IQ)		0.75		1.54**
Study GT 2 hr. per day (%)		0.19**		
From rural areas (%)	0.03**			—0.17*
Environmental variables				
Average family net income ($1000)			1.16*	
Families with GT $10,000 net income (%)		0.58*		
Mothers with professional occupation (%)			1.16	1.19**
R^2	0.81	0.83	0.74	0.76

[1]All coefficients included in these stepwise regression equations were significant at the 0.10 level. GT means greater than, SQRT means square root.
*Coefficients were significant at 0.05 level
**Coefficients were significant at 0.01 level

to be more successful than other teachers in increasing attendance and retention rates. A smaller pupil-teacher ratio was more important in elementary than in secondary education. Student performance increased in elementary grades when teachers had lighter workloads. 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 included instructional materials, school district size, facilities and the number of academic units offered. Additional library volumes, audio-visual material, and periodicals increased student performance. Those schools offering more academic units had higher secondary composite scores. Other things equal, student performance declines slightly with increases in school district size. But other things are not equal when considering optimal size, and school districts up to the least-cost sizes indicated later can save enough money through size economies of input use to pay for additional inputs that maintain student performance.

Table 10. Equations Expressing Eighth Grade Educational Outputs as a Function of Educational Inputs[1]

Variables	Attendance rate	Language arts	Math	Composite achievement
Constant	76.96	86.50	403.96	41.90
Educational process variables				
Teacher-related variables				
With 3-9 yr. of experience (%)		0.19	0.34**	
With GT 9 yr. of experience (%)				—0.10
Average experience (yr.)	0.20**			
With a planning period (%)	0.01**			
Pupil-teacher ratio	—0.15**	—0.70	—0.64*	
Beginning salary with B.A. degree ($1000)	2.98**			
Library volumes per student			0.62*	0.55*
Number of periodicals				0.19*
SQRT (ADA in thousands)		—7.33**	—7.92**	—4.00**
Student input variables				
Fourth Grade Composite Score				0.25*
Student intelligence quotient (IQ)		2.18**		0.51
Study GT 1 hr. per day (%)	0.03			
Average number of hours studied		15.28		12.25*
Average number of books read last summer			5.97*	
From rural areas (%)	0.06**			
Environmental variables				
Fathers with college education (%)		0.56*	0.55**	0.54*
Families with GT $10,000 net income (%)		0.63**	0.92**	
Fathers with professional occupation (%)			0.71*	
Parents plan for children to attend college (%)				0.44**
R^2	0.74	0.85	0.90	0.92

[1]All coefficients included in these stepwise regression equations were significant at the 0.10 level. GT means greater than, SQRT means square root.
*Coefficients were significant at 0.05 level
**Coefficients were significant at 0.01 level

Cost Relationships

Larger school districts offer substantial economies through bigger classes and spreading overhead costs of specialized equipment, administration and other items over more students. But larger school districts also entail diseconomies particularly from increasing transportation costs per student. Trade-offs between internal schooling economies and transportation diseconomies determine the shape of the long-run average cost curve and hence determine the optimal school district size.

By ignoring transportation cost, past studies have provided misleading guidelines for optimal school district size, especially for rural areas. This study, which shows long-run average costs for a given quality of elementary and secondary schooling for various student densities, provides methodology and empirical estimates to guide school district consolidation. In specifying cost relationships, quality measures used in this study are average eleventh grade composite achievement scores and the number and type of credit units offered. The data are for Oklahoma, but the structure of schooling is similar in other states. Thus, with some modifications the results could be applied more generally.

Instruction

The major component of educational costs is instruction, those activities dealing directly with the teaching of students. Instructional expenses include the salaries of teachers, principals, and guidance personnel. These costs also include salaries of secretarial and clerical assistants and expenditures for textbooks, school libraries, audiovisual material, 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.

Optimal pupil-teacher ratios and average teacher salaries based on degree and experience were used in calculating cost of teachers. Average teacher salaries were $7,137 for high school teachers and $6,834 for elementary and junior high teachers. Cost calculations were based on the assumption that two courses can be combined in a single classroom under one teacher until the number of students in combined courses exceeds the maximum class size.

Costs of principals, guidance counselors, and secretaries were based on average salaries and adequate personnel-to-ADA ratios. The average full-time equivalent principal-to-ADA ratio was 3:1000. Adequate full-time equivalent guidance counselors and secretarial personnel-to-ADA ratios were 4:1000 and 3:1000, respectively. Average salaries for principals, guidance counselors, and secretaries were $9,028, $8,657 and $4,000, respectively. Using average pupil-teacher ratios and teacher salaries, average instructional cost curves for elementary and secondary education are shown in Figure 1.

Attendant costs can be broken down into a fixed component, embodied in plant and equipment, and a second component termed overhead. Major overhead costs include administration and plant operation and maintenance. Administration consists of those activities which regulate and control the affairs of the school districts. Plant operation and maintenance include all current expenditures for keeping the grounds, buildings, and equipment in good condition. Equations depicting educational costs discussed below are shown in Table 12 (see also White and Tweeten, Feb., 1973).

Overhead

Long-run average cost curves for overhead were estimated using data from the 27 sampled school districts in regression analysis. Overhead costs per pupil varied by class size, school district size, and quality of the education program (Table 12). Class size and school district size were represented by pupil-teacher ratio and average daily attendance (ADA), respec-

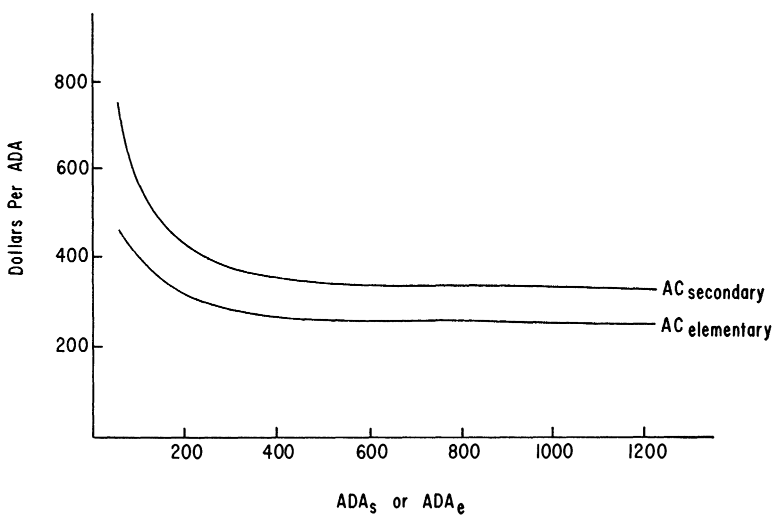

Figure 1. Average Cost Per ADA of Instruction

Table 12. Equations Explaining Average Cost of All School District Operations Except Instruction[1]

Department variables	Constant	In thousand units ADA	In thousand units 1/ADA	Transported ADA squared	Composite achievement grade 11	Pupil-teacher ratio (PTR)	PTR squared
Administrative cost per ADA	311.74		6.69		0.53	—26.39	0.51
Plant operation and maintenance cost per ADA	133.10	0.34	12.89		1.61	—12.52	0.30
Annual cost of buildings per ADA	131.42	—4.15	2.04				
Annual cost of equipment per ADA[2]	47.46	2.04					
Transportation cost per transported ADA for density equal to:[3]							
0.6 transported ADA per square mile	305.06			0.24E-2			
1.2 transported ADA per square mile	218.76			0.38E-4			
1.8 transported ADA per square mile	149.99			0.13E-4			
2.4 transported ADA per square mile	123.73			0.65E-5			
3.0 transported ADA per square mile	106.81			0.35E-5			

[1]All coefficients were significant at least at the 0.10 level.
[2]Excluded vocational equipment which varied by curriculum.
[3]Assumes that students were uniformly distributed, and 265 nontransported students. E-i means i zeroes preceed number to right of decimal.

tively. Examination of the data revealed overhead costs declined rapidly with initial increases in ADA and the pupil-teacher ratio. After achieving these substantial economies in size, administrative costs remained relatively constant over a large range of ADA, but plant operation and maintenance costs exhibited slight diseconomies when ADA was very large.

Forms of the variables which best reflected these relationships were (1) pupil-teacher ratio and the square of that ratio to represent cost economies accruing from increases in class size, (2) inverse of ADA to represent cost economies accruing from increases in school district size, and (3) ADA to represent diseconomies accruing from increases in school district size. Since differences in per pupil costs may reflect differences in program quality, the average achievement score was included in the cost function to represent quality. These equations indicate substantial economies of size to approximately 1500 ADA.

Facilities

Educational facilities consist of school buildings and equipment. Construction costs for buildings include expenditures for general construction, installation of fixtures, architectural services, paint, and cost of planning. Equipment costs consist of all expenditures for items of furniture, furnishings, and machinery that are not integral parts of the buildings.

Since this long-term analysis allows organization of school districts to change, building and equipment investment must also be allowed to change. Data on recently built schools were used to determine the size-cost relationship in buildings and equipment. Equations explaining annual costs per ADA of buildings and equipment, including depreciation, insurance and interest on investment, are presented in Table 12. In addition to the basic equipment included in the cost equation, costs of equipment varied by curriculum. Annual costs of buildings and equipment were linked directly to ADA in elementary and secondary education. Major economies of size accrued to approximately 800 ADA in providing buildings and equipment.

The average cost per ADA of Facilities was based on the number of elementary students, secondary students, and secondary vocational students by courses. Facility costs were converted to annual costs of depreciation, insurance, and interest on investment. The facilities' operating life was assumed to be 25 years for nonvocational equipment, 10 years for vocational equipment, and 50 years for buildings. It was also assumed that school buildings would be salvaged at 20 percent of original cost, while equipment would have no salvage value at the end of its operating life. In all cases, a 6 percent interest rate was used.

Transportation

Public transportation is generally provided for students whose residence is not within walking distance of school. Insofar as possible, buses are approved to go at least within one-half mile of each pupil's home. Transportation costs in rural areas are particularly important since students are so dispersed.

In most districts the most expensive transportation item was drivers' salaries. The sampled school districts' average salary per mile of bus route was \$75.94 with a standard deviation of \$38.13. There was no stable relationship between bus drivers' salaries and either total miles or total miles adjusted for the number of students. District salary schedules were typically based on a school district's wealth and local wage rates rather than a uniform state salary schedule. Therefore, the salary used in computing transportation costs was the sample average.

The least expensive combination of body and chassis were selected for each size of bus. List prices by size of bus are presented in Table 13. 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 was covered.

Cost of fuel, lubricants, and maintenance is a large component of transportation costs. School buses make many starts and stops and gas mileage is low. A 30-passenger bus in rural areas typically gets 6.5 miles per gallon. The cost of lubricants was assumed to be 15 percent of the fuel cost. Maintenance includes cost of material and labor for repairs, equipment replacement such as tires, as well as the cost of overhauls. The costs of operation and maintenance are also presented in Table 13.

Insurance and interest on investment are the last components of transportation costs. The charge for interest was based on the average annual investment and a 6 percent interest rate. The cost of insurance was based on a typical package of comprehensive, collision, and liability insurance. The liability coverage had 100, 300, and 25 in thousands dollars of individual bodily injury, total bodily injury, and property damage, respectively.

A simulation program was used 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 considered both the size of district and density of transported students. It was assumed that the students transported by bus were evenly dispersed and were transported to a central location. This formulation characterizes many rural areas in which there is only one elementary and high school, centrally located.

Since time spent in busing involves an increasingly important disutility to students and parents, the program took into account the time that students were in transit. It appears feasible but unrealistic from a school administrator's point of view to assign a monetary cost to student's time lost in busing. Imposing a limit on the time that students can spend

Table 13. 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	$6,577	$36.43	$216.38	$16.64	$12.44	$218.95
36	6,695	37.20	220.94	18.76	12.73	226.52
42	7,172	39.85	236.68	20.07	13.97	237.11
48	7,328	40.72	241.82	21.18	14.12	244.84
54	7,719	42.89	254.73	22.09	14.93	254.65
60	8,491	47.18	280.20	23.00	16.81	267.88
66	8,851	49.18	292.08	23.70	17.48	277.42

in transit appears to be a more useful method for reflecting this disutility of busing. This study assumes that no student can be in transit for more than one hour, a maximum limit in effect in several sparsely populated areas.

All costs of operating school buses in Table 13 were combined with the information on routing provided by the simulation program to derive the average cost of transporting students by various student densities and district sizes (Figure 2). Curves for the low-density areas show that it is economically infeasible to transport large numbers of students in these sparsely populated areas.

Cost Effectiveness Model

This section uses information on input-output and cost relationships developed in the foregoing analyses to determine optimal organization of education inputs and school district size. The procedure used herein provides for internal reorganization of schools allowing class size, teacher characteristics, other educational process variables as well as school district size to change in a manner to minimize costs of reaching specified objectives.

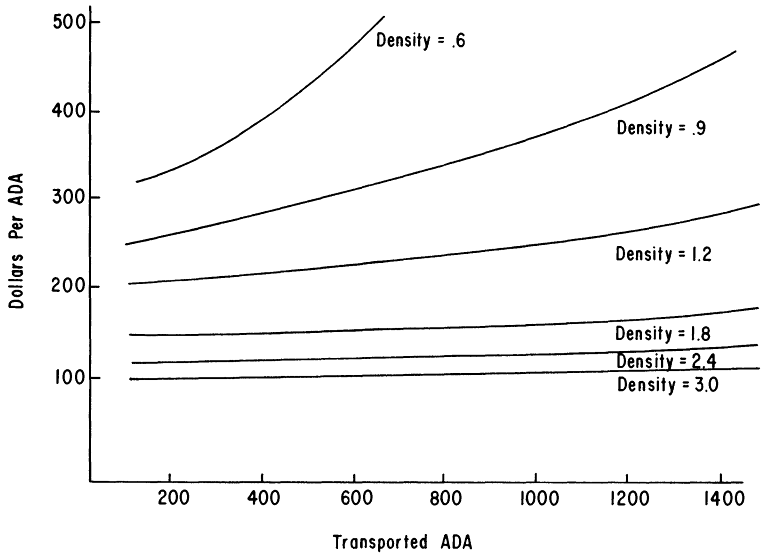

Figure 2. Average Cost of Transportation Per ADA by Student Density Per Square Mile.

Knowledge of the productivity and cost of schooling inputs can be used to improve internal schooling efficiency. Because there is no objective basis to determine what is an optimal level of achievement, absentee rate or dropout rate, such output measures are merely held at various levels and schooling inputs are reorganized to achieve these set objectives in the most cost-effective manner. It is cautioned that the production functions are not measured with great reliability; the results must be interpreted accordingly.

Optimization Procedure

To determine the optimal resource mix and size of school district, the average cost curve was minimized subject to characteristics of the geographic area and constraints on schooling quality. A separable programming technique, an extension of linear programming, was used to select the optimal alternative (see White and Tweeten, 1973).

Input-output estimates for elementary, junior high, and high school education are based on the production functions discussed previously. 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 selected output levels and 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 also discussed previously. 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 optimal district size or ADA is determined, these costs are also determined.

Analysis

A cost-effectiveness model was used to evaluate the effect of educational output, teacher salary, student background, student density and high school curriculum on optimal resource combination and average cost of instruction, attendant services and transportation. While one of these factors was allowed to vary, all others were held constant at their respective sample averages. These situations selected 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 provide additional information on the consequences of changing a given school district's organization.

The basic separable programming model was made up of sample averages and an average high school program with thirty academic units and eight vocational units. Educational output and student background variables for grades 4, 8, and 11 were specified at their respective sample averages. The salary used for a beginning teacher with a bachelor's degree was $5,750. The school district was assumed to have 260 nontransported ADA and a student density of 1.8 transported ADA per square mile.

Educational Output. Educational output measures used in the model are composite achievement scores, math scores, language arts scores, attendance rates, and retention rates. Three levels of output—low, average and high—were included in the analysis to represent differences in goals among school districts. Achievement scores and attendance and retention rates were lowered 5 percent to develop a measure of "low" educational output. On the other hand, the measures of output were increased 5 percent to represent "high" educational output. Five percent of the achievement scores represents about one standard deviation.

Table 14 presents results of the separable programming model with these three levels of educational output used as constraints. Average cost per ADA ranged from $662 for the low level of output to $768 for the high level of output. To attain the high level of output, the school district size was reduced from 675 to 377 ADA, reflecting the inverse relationship between size and student performance.

Differences in optimal teacher workloads account for most of the variation in average cost among output levels. Lower workloads improved student performance, but these adjustments were costly. Under the low output situation, pupil-teacher ratios were 30:1 for elementary and junior high and 28:1 for high school. Lower pupil-teacher ratios (22:1) were required in elementary and junior high to achieve the high output level. Also, giving a greater percentage of junior high teachers a planning period was necessary to attain the high output level.

Definite trends in adjustment of teacher experience to changes in the level of output are apparent. At the low output levels, greater experience is more desirable in the lower grades. The level of teacher experience remains relatively stable in high school but changes markedly in the lower grades as educational output is improved. But at the high output levels, teacher experience remains highest in the lower grades.

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 asterisks in the table. Elementary education required increases in the value of audiovisual material in order to achieve higher levels of output.

Table 14. Optimal Resource Combination By Educational Output and Student Background

Resources	Educational output levels Low	Average	High	Student background levels Low	Average	High
Elementary and secondary ADA	675.00	675.00	377.00	370.00	675.00	675.00
Pupil-teacher ratio						
High school	28.00	28.00	28.00	28.00	28.00	28.00
Junior high	30.00	30.00	22.00	22.00	30.00	30.00
Elementary	30.00	26.00	22.00	22.00	26.00	28.00
Percentage of teachers with 3-9 yr. exp.						
High school	67.03	65.48	63.86	64.41	65.48	66.60
Junior high	25.25	33.10	75.00	45.00	33.10	24.98
Elementary	50.24	20.56	21.35	20.56	20.56	20.56
Percentage of teachers with 10 yr. or more exp.						
High school	32.97	34.51	36.14	35.59	34.51	33.40
Junior high	74.75	66.89	25.00	25.00	66.89	75.02
Elementary	49.76	79.44	78.65	79.44	79.44	79.44
Average teacher experience						
High school	9.16	9.51	9.87	9.75	9.51	9.26
Junior high	18.58	16.81	7.36	7.36	16.81	18.64
Elementary	12.95	19.64	19.46	19.64	19.64	19.64
Percentage of teachers with a planning period						
Junior	0	25.88	93.63	92.75	25.88	0
Elementary	64.12	0	0	100.00	0	0
Value of audiovisual material per ADA						
High school	8.70*	8.70*	8.70*	8.70*	8.70*	8.70*
Junior high	8.70*	8.70*	8.70*	8.70*	8.70*	8.70*
Elementary	8.70*	99.90	241.57	212.00	99.90	14.00
Printed volumes per ADA						
High school	5.30*	5.30*	5.30*	5.30*	5.30*	5.30*
Junior high	5.30*	5.30*	7.80	10.30	5.30*	5.30*
Elementary	5.30*	5.30*	5.30*	5.30*	5.30*	5.30*
Average cost per ADA (dollars)	661.67	691.85	767.62	794.93	691.85	672.60

*Values have entered the solution at their lower limit.

Junior high education required an increase in the printed volumes per pupil to attain the high level of output.

Student Background. Student background encompasses home influences such as parents' education and occupation, as well as students' activities, educational preparation and high school plans. The three student background levels used in this analysis are 10 percent below average, average and 10 percent above average. In other words, all variables relating to student background were held constant at their average values in the average student background model. These variables were then increased 10 percent for the high student background model and reduced 10 percent for the low student background model.

The cost-minimizing internal schooling organization and school district size for the three specified levels of student background are presented in Table 14. A given level of output is more costly to attain with a lower student background. Average cost of attaining the average level of output was $673 for a district with students from a high background versus $795 for a district with students from a low background. For the students with low backgrounds to attain the average level of educational output, district size was restricted to 370 ADA.

Although student performance in high school was not affected by teacher workloads, optimal workloads in lower grades varied by student backgrounds. Pupil-teacher ratios were 22:1 in both elementary and junior high with the low student background. These ratios were higher with both average and high student backgrounds. Percentage of teachers with a planning period declined in both elementary and junior high as student background improved.

High School Program. Three school curriculums were considered in this analysis. The first program (typical for many small rural high schools) included 38 academic units – the "minimum" for accreditation. However, this program does not meet the needs of all students. The second program was designed to be "adequate" for even vocation-oriented students. This program, containing 30 academic units and 8 vocational units, was developed from courses offered by accredited districts which provided both academic and vocational courses. The third program, a more extensive or "desirable" program of 38 academic units and 8 vocational units, offered the same courses as the other two programs combined.

The most efficient schooling organization under each of these programs is shown in Table 15. It is more expensive to provide an extensive curriculum which includes vocational courses. Average costs for the three programs ranged from $665 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 required 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 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 15. Optimal Resource Combination By High School Program and Teacher Salary Schedule

Resources	High school program Minimum	High school program Adequate	High school program Desirable	Teacher salary schedule Low	Teacher salary schedule Average	Teacher salary schedule High
Elementary and secondary ADA	550.00	675.00	900.00	675.00	675.00	675.00
Pupil-teacher ratio						
High school	30.00	28.00	28.00	28.00	28.00	28.00
Junior high	30.00	30.00	30.00	30.00	30.00	30.00
Elementary	26.00	26.00	26.00	24.00	26.00	28.00
Percentage of teachers with 3-9 yr. exp.						
High school	66.33	65.48	64.14	50.63	65.48	62.42
Junior high	31.23	33.10	36.07	26.76	33.10	60.15
Elementary	20.56	20.56	20.56	23.63	20.56	20.56
Percentage of teachers with 10 or more yr. exp.						
High school	33.67	34.51	35.85	49.37	34.51	25.00
Junior high	68.76	66.89	63.93	73.23	66.89	39.85
Elementary	79.44	79.44	79.44	76.37	79.44	79.44
Average teacher experience						
High school	9.23	9.51	9.81	12.86	9.51	7.14
Junior high	17.23	16.81	16.14	18.24	16.81	10.71
Elementary	19.64	19.64	19.64	18.95	19.64	19.64
Percentage of teachers with a planning period						
Junior high	21.52	25.88	32.79	100.00	25.88	0
Elementary	0	0	0	52.19	0	0
Value of audiovisual material						
High school	8.70*	8.70*	8.70*	101.43	8.70*	8.70*
Junior high	8.70*	8.70*	8.70*	8.70*	8.70*	8.70*
Elementary	92.23	99.90	112.11	8.70*	99.90	221.39
Printed volumes per ADA						
High school	5.30*	5.30*	5.30*	5.30*	5.30*	5.30*
Junior high	5.30*	5.30*	5.30*	8.77	5.30*	5.30*
Elementary	5.30*	5.30*	5.30*	5.30*	5.30*	5.30*
Percentage of high school teachers with a master's degree	0	0	55.42	0	0	0
Average cost per ADA (dollars)	665.48	691.85	700.00	690.38	691.85	709.93

*Values have entered the solution at their lower limit.

Teacher Salary. The average salary for a beginning teacher with a bachelor's degree was $5,750. The three salary levels considered were 10 percent below average, average and 10 percent above average. In all three cases, teachers were assumed to receive $100 for each additional year of experience. The long-term nature of these adjustments is particularly apparent in this section, since the influence of salary on teacher performance takes several years to be fully realized. Increasing the salary level approximately $500 a year will not materially improve present teachers' 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 15. From the estimated production functions, teacher performance was positively related to salary. Thus under the low-salary situation, the specified output was maintained through increased expenditures on other educational process variables. For example, the low-salary situation resulted in a smaller pupil-teacher ratio in the elementary grades. As salaries increased, or in other words, as the cost of teachers increased, the elementary pupil-teacher ratio rose 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 junior high teachers and more than half of the elementary teachers were given planning periods under the low-salary situation. Also, expenditures on audiovisual material in high school and printed volumes in junior high had to be increased with lower salaries.

Student Density and Optimal School District Size. The high transportation cost in rural areas which is based on student density strongly influences optimal school district organization. The production functions showed that student performance deteriorated slightly with increases in district size, requiring minor adjustments in other educational process variables to maintain a given level of educational output.

More importantly, differences in student densities cause significant differences in optimal school district size and average cost as shown in Table 16 and Figure 3. Average cost with optimal organization was $744 for a student density of 0.6 transported ADA per square mile and $661 for a 3.0 student density. The optimal school district size ranged from 300 ADA with low density to 1075 ADA with high density. Thus the optimal school district size is smaller in sparsely populated rural areas.

For a student density of 1.8 students per square mile, minimum cost occurs at 675 ADA. However, the cost curve is very flat between 400 and 1,100 ADA (Figure 3). School districts can operate anywhere within this range without significant differences in per-unit costs. School districts operating outside this range face higher per-unit costs. Figure 2 also shows that school districts located in more sparsely populated areas have a much smaller range of ADA within which they can operate efficiently. Such districts face substantially higher per-unit cost if they operate outside this low-cost range.

Other Cases. In the basic model, teacher salaries were incremented $100 for each year of experience. Lowering the cost of experience 20 percent resulted in no change in the optimal resource combination. With a 20 percent increase in the cost of experience, other educational process

Table 16. Optimal Resource Combination By Student Density

Resources	Student Densities in Transported ADA per square mile 0.6	1.2	1.8	2.4	3.0
Elementary and secondary 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 3-9 yr. exp.					
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 10 yr. or more exp.					
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
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
Average cost per ADA (dollars)	744.27	728.83	691.85	674.82	660.68

*Values have entered the solution at their lower limit.

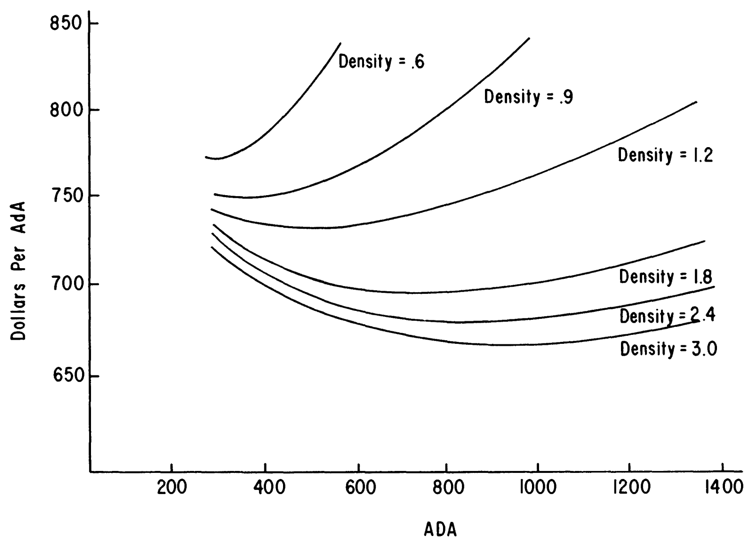

Figure 3. Average Cost of Education and Transportation Per ADA by Student Density

variables, such as percentage of teachers with a planning period, were substituted to reduce the use of high cost experience.

The number of nontransported students can affect the optimal school district size. The 265 nontransported students in the basic model resulted in an optimal school district size of 675 ADA. An increase of twenty-five nontransported ADA increased optimal school district size fifteen ADA. In general, a large number of nontransported ADA resulted in a larger optimal school district size but a 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 optimal school district size. In this analysis, minimum average *current* cost occurred at 550 ADA while minimum average *total* cost occurred at 675 ADA.

Conclusions

It is apparent that the optimal resource organization in schooling 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. Efficient attainment of higher levels of educational output requires a reduction in elementary and junior high teacher workloads and increased expenditures on instructional materials.
2. Abilities and socioeconomic backgrounds of students place formidable constraints on educational output. Performance of below-average students can be improved, although within fairly narrowly circumscribed limits, with properly allocated high expeditures.
3. Allowing for long-run adjustments to changes in teacher salaries, student performance was positively related to salary. An increase in teacher salaries can substitute for a reduction in expenditures on other educational process variables and leave student attainment unchanged.
4. A more extensive curriculum requires larger school districts to efficiently utilize the program. The optimal school district size for a school offering only a minimum program is 550 ADA compared to 900 ADA for a school offering the "desirable" program as defined herein.

5. Optimal school district size and the cost per student was affected by student density. The optimal school district size (and minimum attainable average cost per ADA) was 300 students ($744) for a densiy of 0.6 transported students per square mile and was 1075 students ($661) for a student density of 3 per square mile. In sparsely populated areas, school districts could not expand in size to take full advantage of economies in instruction and attendant services because transportation diseconomies were an overriding factor. Transportation costs are not nearly as important in heavily populated districts. In these areas the optimal school district size is much greater.

Economic Payoff From Schooling

The foregoing analysis showed least-cost schooling methods but did not indicate whether schooling has a favorable economic payoff. The following estimates are computed from U. S. data, but are very similar to results for Kansas (Sjo, Trapp and Munson, 1972). Estimates by region are found elsewhere (Hines, Tweeten and Redfern, 1970).

Traditionally, economists have concerned themselves with optimal allocation and accumulation of conventional production capital, land, and labor inputs. In a total sense, however, the optimal allocation of inputs cannot be judged without including education as production inputs. Just as managers decide to invest in operating capital, machinery, or plants based on expected returns, so managers—or in the case of public funds, society as a whole—can do the same with the cost-returns approach for investments in education.

Investment to raise the productivity of conventional resources through research and education tends to be a more roundabout process than typical capital investment. But the basic principles of investment still apply. In competitive equilibrium—the point of optimal allocation of inputs—the return on investment equals the discount rate people place on future versus present consumption. Investments that yield, say, over 8 percent are exploited, and those that yield less are shunned. This process among many individuals in the market leads to the determination of the interest rate which is a measure of investment yield opportunities and time preference for consumption. Institutional restrictions, indivisibilities, and uncertainties distort the process, however.

The cost of education can be subdivided into private cost, borne by the individual, and public cost, borne by taxpayers. Private costs include opportunity costs incurred by individuals (due to earnings foregone while attending school), and costs of books, transportation, and clothing over and above what would have been purchased if the student had not been attending school. Education through the secondary schools is widely regarded as "free" to the individual student. Yet, because of earnings foregone, individuals paid 62 percent of total costs for high school, the same percent as for college, in 1959.

Public costs include repairs, interest on and depreciation of capital items, and salaries and operating costs paid out of taxes. Adding these public costs to private costs, total resource costs in 1959 for U. S. white males were estimated to be $613 per elementary student, $1,782 per high school student, and $5,820 per college student (Hines, et al., 1970, p. 339).

Census data on earnings provide the foundation for computing rates of return on schooling for various race, sex and sector groups (Table 17). The rural farm sector includes farm operators, hired farm workers, and unemployed persons. The rate of return may be interpreted as an interest rate that could be paid on outlays for education to make such investment a break-even opportunity—in which case it would be just as profitable to forego the schooling as to obtain it.

The private rate of return is the decision variable most applicable to the individual, since it includes only costs (mainly foregone earnings) incurred by individuals for schooling. The private rates of return for white males for all sectors were considerably above typical interest rates or returns on nonschooling investment alternatives. Hence, on the average, returns should provide economic incentives for schooling irrespective of the benefits from schooling as a consumption good. Four years of college appeared to be only a marginally attractive economic investment for nonwhite males in 1959. Although earnings generated by schooling were lower for farm than urban residents, costs were also lower. Thus rates of return from high school and college were of somewhat comparable magnitudes for farm and urban residents. At the high school level, rural nonfarm residents appear to combine some of the high earnings of urban residents with the low education costs of farm residents; the result is a favorable rate of return for white male rural nonfarm residents.

Social rates of return are computed from the costs of schooling paid by the public as well as the individual. It is a better measure than private rates of the value of schooling from society's viewpoint.

The social rate of return, like the private rate, trends downward with higher levels of schooling. Social rates of return to white males for college completion in all sectors shown in Table 17 tend to be near typical rates of return on business investments and exceed the rate of return on numerous alternative public investments. White females, because their earnings are frequently cut short by marriage, and non-white males, because of job discrimination and other factors, experienced a low social rate of return on investment in schooling in 1959. However, returns to schooling of females are underestimated in Table 17 because economic

Table 17. Estimated Private and Social Rates of Return on Investment in Schooling, in Percent, United States, 1959[1]

	Elementary School (8 yrs. over no schooling)	High School Dropout (9-11 yrs. over 8 yrs.)	High School Graduate (12 yrs. over 8 yrs.)	College Dropout (13-15 yrs. over 12 yrs.)	College Graduate (16 yrs. over 12 yrs.)
			(White males, U.S.)		
Private rate	155.1	20.6	15.8	12.1	13.6
Social rate	17.8	11.9	9.9	8.3	9.7
			(White females, U. S.)		
Private rate	37.8	22.7	32.2	6.9	9.9
Social rate	5.6	6.2	9.2	2.3	4.2
			(Nonwhite males, U. S.)		
Private rate	78.8	24.9	22.1	2.2	6.0
Social rate	9.7	11.0	11.8	.6	3.0
			(White males, urban)		
Private rate	155.9	11.7	11.6	12.9	12.8
Social rate	21.2	7.8	7.9	8.0	9.7
			(White males, rural nonfarm)		
Private rate	179.3	--	21.5	--	11.8
Social rate	24.8	--	13.8	--	8.5
			(White males, rural farm)		
Private rate	87.9	--	12.2	--	16.0
Social rate	20.7	--	8.4	--	10.2

Source: From Redfern (1970) and Hines, et al. (1970); earnings data from U. S. Census.
[1]Private rates of return are estimated from added earnings from education and from costs based on earnings foregone by continuing in school; the internal rate of return makes the present value of benefits and costs equal to zero. Social rates of return are estimated in the same way but also include costs of instruction, facilities, etc., borne by the public. Rates not calculated are indicated by dashes. Rates of return are adjusted for ability and other variables.

contributions of schooling to making one a better housewife and mother are not included. For women who enter the labor force, schooling undoubtedly is economically justified.

The estimated rates of return computed for 1950 are very similar to those for 1959 in Table 17, and suggest that the demand for persons with various schooling levels kept pace with the sharply rising supply. The excess supply of teachers, aerospace scientists and other white collar workers in the early 1970' at least temporarily reduced the rate of return for many below the figures reported above.

Distribution of Common School Benefits and Taxes Among Families By Income

The rate of return on investment in elementary and secondary schooling is positive according to Table 17 and benefits exceed costs. It is of interest to learn how the benefits and costs of education are shared by families of different income levels. To determine how taxes which finance Oklahoma common schools are distributed, school taxes were allocated according to Bureau of Labor Statistics data on consumer expenditure patterns. Expenditure "benefits" just equal in dollar value to total taxes for common schools were distributed among families according to the quantity of schooling (based on number of children and years in school) received by children under eighteen in families of various income levels. Assumptions are discussed in greater detail below.

The Distribution of Local, State and Federal Taxes in Support of Common Schools

The ad valorem tax falling on the residential portion of town lots and improvements was assumed to have an incidence proportional to the distribution of housing expenditure. Taxes on the non-residential portion of the same property class were assumed to be shifted forward to the consumer and were allocated proportionally to total consumption expenditures.

Taxes on public service companies were assumed to be largely shifted forward to consumers but also partially paid by stock holders of the corporation in the form of lower dividends.

Automobile license fees were allocated in proportion to expenditures on automobiles. The gross production tax was assumed partially shifted forward to consumers and partially shifted to owners of the factors of production in the form of reduced dividends.

The burden of most of state taxes which constitute the category "All Other Revenues From State Sources" was assumed shifted forward to consumers. This assumption is most easily justified when the tax in question applies to a narrow range of products such as tobacco or liquor. For more general taxes such as the state sales tax, the issue is in more doubt. Some economists have argued that general sales taxes are partially shifted backward to the owners of the factors of production—reducing the estimated burden on lower income groups and increasing the burden on higher income groups. To account for this possibility and for the fact that certain state taxes are distributed progressively with respect to income, one quarter of "All Other Revenues" was assumed shifted backward to factor owners in proportion to dividends.

Federal revenues for elementary and secondary education in Oklahoma were assumed to be derived from federal taxes less social insurance contributions. The incidence of federal taxes by income class for the United States was then adjusted to the southern regional income distribution.

Expenditure Benefits

The expenditure benefit of spending in Oklahoma for public elementary and secondary education was allocated by income class as a function of the number of children under eighteen estimated to be enrolled in school. School enrollment is sensitive to both parental income and educational level. Enrollment percentages representing the median years of education for Oklahoma residents over twenty-five were used for each income group.

Findings

The incidence of educational benefits and costs per family is presented in Table 18. Up to $5,000 annual family income, benefits of education per family exceed costs per family. Net common school benefits average $81 per family below $3,000 income and decline to a net tax burden of $1,338 for families with income in excess of $15,000 per year. The ratio of benefits to taxes for common schools ranges from 2.0 for low income families to .2 for high income families. The evidence indicates that a considerable public subsidy is being provided to low income families through public elementary and secondary education. In other words, public elementary and secondary schooling is characterized by larger benefit-tax ratios for low income families than for high income families and redistributes wealth from high income to low income families in Oklahoma. Geographic disassociation of benefits and costs remains a serious problem, however.

The preponderence in Table 18 of large net losses to high income groups may appear inconsistent. Since *total* benefits were assumed to be equal to *total* taxes, the large negative values in the redistribution of income is explained by the fact that the number of families in low income groups greatly exceeds the number in high income groups.

Table 18. Incidence of Federal, State, and Local Taxes and Expenditures for Common Schools in Oklahoma in 1961

	Income Class (Money income after personal taxes)							
	Under $2,999	$3,000 to $3,999	$4,000 to $4,999	$5,000 to $5,999	$6,000 to $7,499	$7,500 to $9,999	$10,000 to $14,999	$15,000 and Over
	(Dollars per family)							
Local Taxes	44	85	117	163	171	204	276	733
State Taxes	33	79	83	111	123	150	231	669
Federal Taxes	3	9	12	15	19	26	44	169
Total Taxes	80	173	212	289	313	380	551	1,571
Total Expenditure Benefit	161	232	240	287	279	283	281	233
Redistribution (Benefit-taxes)	81	59	28	—2	—34	—97	—270	—1,338
	(Ratio)							
Benefit-Tax Ratio	2.0	1.3	1.1	1.0	.9	.7	.5	.2

Source: Holland (1973)

The benefit-tax ratios for common schools are very similar among income groups to those for all local and state taxes spent for all purposes, but are considerably less for families with low income than the benefit-tax ratios for all federal benefits for all purposes divided by all federal taxes (see Tweeten, 1973 for other ratios).

The Geographic Distribution of Schooling Benefits: Implications for Public School Finance

The previous section showed distributional patterns among income levels, but such patterns neglect important spatial considerations which are examined in this section.

Partially in response to increased human capital mobility, an inadequate human capital accounting system, and increased economic and community interdependency, the mix of local, state, and federal revenues for public schooling has become increasingly weighted toward non-local revenue sources. The increased reliance upon larger units of government, while not solely a response to human capital migration, is consistent with the notion of internalization of benefit spillovers, and raises the central question to which this section is addressed. That is, how much of the cost of common school education should be financed at local, state, and federal levels? And how much difference would it make in the present scheme of local, state, and federal public school funding if revenue sources were aligned with the expected geographic distribution of public schooling benefits? To answer these questions, a school funding model accounting for geographic spillovers was developed.

In our belief, spillover compensation must be predicated upon satisfaction of the "ability to pay" and "equality of opportunity" aspects of the school finance question. Briefly summarized, the ability-spillover model was implemented under the assumption that school funding effort at the local level should be first equalized for all areas. As a step toward providing equality of opportunity, per student expenditures were also equalized for all areas. Each area was then compensated for the net schooling benefit spillover associated with its schooling investment. Although the necessary model coefficients were derived from Oklahoma data, the general issue and answers are believed to be of wide interest and application.

The Ability-Spillover Model

A number of studies have examined the relationship between various socio-economic variables and expenditures on education. Measures of property valuation, income, percent of owner-occupied housing, rurality, and percent enrollment in public schools have usually been the most important variables explaining variation in education expenditures. Research directed specifically at fiscal capacity and tax effort has often foundered upon the lack of an operational definition of "ability to pay". Although present thinking seems to be more inclined to a mixture of property and income measures, there is very little agreement on correct proportions in the mixture.

The two ability measures examined in the present study were per capita income and per capita assessed valuation. Data for the 1960-61 school year were assembled for Oklahoma State Economic Areas. Per capita income and per capita assessed valuation were regressed on local revenues divided by number of students in Average Daily Attendance (ADA). By comparing the actual level of local spending with the level predicted by the equation, an estimate of the area's effort with respect to each ability measure is obtained. The predicted level of local spending, $\hat{Y}$, may be interpreted as the state norm. State economic areas whose actual spending was less than that predicted by the equation are defined as "under-achievers". Areas that exceed the norm as indicated by the equation are termed "over-achievers". Use of the predicted value from the regression equation is an admittedly arbitrary norm, but has the advantage $\Sigma(\hat{Y}-Y) = 0$. The marginal propensity to finance schooling out of income or wealth is the same for each geographic entity and the results can be reproduced by analysts working independently of each other.

Equation (1) relates the level of local revenues to income, X_1, per capita. The independent variable in equation (2) is per capita assessed valuation, X_2. In equation (3) the effect of both income and property is examined. The t values are in parentheses; all coefficients of X_1 and X_2 are significantly different from zero at .05 probability level.

$$(1) \quad \hat{Y} = -63.160 + \underset{(3.545)}{0.172X_1}$$

$$R^2 = .51$$

$$(2) \quad \hat{Y} = 27.547 + \underset{(6.024)}{0.126X_2}$$

$$R^2 = .75$$

$$(3) \quad \hat{Y} = 75.500 + \underset{(3.226)}{0.095X_1} + \underset{(5.574)}{.099X_2}$$

$$R^2 = .87$$

$$N = 14$$

As expected, a greater percent of variation in local revenues is explained by the property variable than the income variable. However, income is statistically significant when tested only by itself, and continues to retain its significance when combined with property. The two variables account for 87 percent of the variation in local revenues in equation (3).

In general, the more highly urban areas undergo a change in achievement classification as the ability measure is changed from income to property. Relative to income per capita, the large urban areas were under-achievers; relative to property per capita, they were over-achievers. The more highly rural areas would contribute a higher level of local revenues under the property measure than under the income measure.

There are advantages in basing the measure of "ability to pay" for schooling on property as well as income per capita. Property per capita tends to be lower and income per capita tends to be higher in urban than in rural areas. And income means not only more money for private individuals but also potentially more money for the public sector. On the other hand, in some rural areas where income per capita is relatively low, property per capita and attendant capital gains are relatively high. Property is an important component of individual wealth, and, in general, individuals with greater property do have, ceteris paribus, a greater ability to pay. If per capita income and property are both low in a particular area, given that both measures are important components of individual wealth, it is likely that individual wealth is low. Hence, the area ought not to be expected to bear a heavy financial burden. The drawback, as mentioned before, to using both income and property is that no well established procedure is available for assigning the "correct" weights to each measure.

To provide at least a first step in equality of opportunity, the state contribution to public schooling revenues for each state economic area was determined as the difference between (a) the equal effort level of local expenditures as defined by equation (3), and (b) the statewide average level of state and local spending in the 1960-61 school year. This formula results in each SEA receiving the same total of state and local revenues and additionally guarantees that all areas will be bearing equitable tax burdens.

The estimates were not adjusted to compensate for schooling quality differences. It could be argued that the rural areas must spend more to achieve the same quality level because of higher transportation costs and greater difficulty in obtaining scale economies. On the other hand, some authorities would contend that the urban ghetto, due to greater site and salary costs, not the rural area, is disadvantaged in providing the same quality of education. We recognize that there is an expenditure-quality problem. We have ignored it due to the lack of a good adjustment criteria, and because it is not central to our main line of inquiry.

Since the focus of this study was on common schooling, the benefits of schooling were measured as the increased earnings associated with a high school education versus no formal education. It is realized that the benefits from education consist presumably of a good deal more than just increased earnings. We adopted the earnings approach because, in combination with primary and secondary data on migration patterns, we were able to develop a human capital accounting framework by geographic region and because, in our spillover adjustment procedure, it is necessary to know only the percentage distribution rather than absolute level of spillovers. The critical and seemingly plausible assumption, therefore, is that the benefits from education are distributed in proportion to educationally developed increases in earnings. The estimate of schooling benefit accruing to a particular area was computed as the product of the appropriate earnings increase and the probability of residence in that area.

According to our calculations, the gross spillout of schooling benefits for the 1960-61 school enrollment in the respective SEA's ranged from a high of 88.91 percent to a low of 71.60 percent. However, when benefit spillins were taken into account, quite a different picture emerged. Several of the SEA's experienced a net spillin of benefits. Net spillins for the respective SEA's ranged from a high of 6.43 percent to a low of −30.19 percent—the latter figure means that the SEA in question was estimated to experience a net spillout of schooling benefits equal to 30.19 percent of the total benefits developed in the area.

Model Funding Versus Actual Funding

The location of Oklahoma State Economic Areas is identified in Figure 4. Areas A and B contain Tulsa and Oklahoma City, respectively, and are the major metropolitan areas of the state. Areas C and D are the major suburban counties for Tulsa and Oklahoma City. The SEA's on the

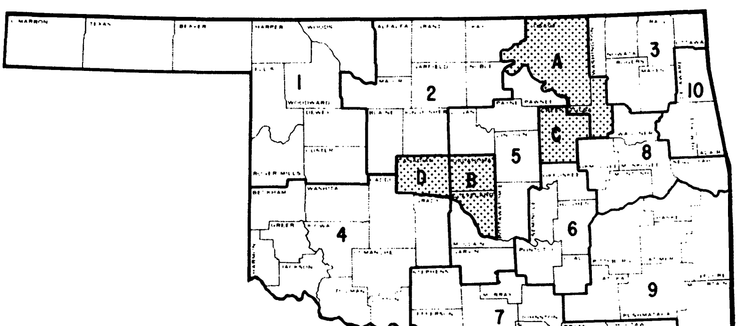

Figure 4. Oklahoma State Economic Areas, 1960

eastern edge of the state represent the Ozark region and have been disadvantaged by high rates of out-migration among the young and generally low income. The changes in local, state, and federal funding that would result with implementation of ability-spillover model are presented in Table 19.

The ability-effort implications of the model, represented in the Ability columns in Table 19, are that the northwest and northcentral SEA's—1,2,5,6—"over-invest" relative to income and property per capita. In contrast, the southeastern areas of the state—10,9,8,7—while lower in wealth, apparently do not make an equal effort even relative to their wealth. The urban and semi-urban areas—A,B,C,D—all under-invest in education at the local level relative to their ability.

Conditioned upon satisfaction of equal effort and equal opportunity, the change in the local, state, and federal mix of revenues is substantial when spillover compensation is made. Net rather than gross spillovers were selected as the criterion upon which compensation should be based. Each state economic area was compensated for net spillovers to the rest of Oklahoma and outside of Oklahoma in direct proportion to percentage of net spillovers estimated to accrue to these respective categories.

When the ability model is adjusted for spillovers, only areas 4,B, and D experience an increase in required local revenues. They were the only areas to experience a net spillin of schooling benefits. In general, the local share of schooling revenues is decreased while the federal share is increased. The only area not receiving increased federal revenue is Area D which received a net benefit spillin from outside the state. The areas receiving less state support are the urban areas, the Lawton area, and the Panhandle area, which were all estimated to experience net spillins from the rest of Oklahoma.

The ability-opportunity changes in local, state, and federal schooling revenues can be compared to the changes necessary for geographical alignment of costs with benefits. The magnitude of the change in funding associated with spillover compensation in many areas involved greater dollar changes than the more frequently discussed "ability to pay" and "equality of opportunity" aspects of the school finance problem.

Among the more interesting findings of the spillover component of the model was that when the results of the ability model were adjusted for educational spillovers, we found that many of the low-income eastern Oklahoma areas, rather than investing too little at the local level, have been investing too much. The increase in required state and federal support in eastern Oklahoma is quite large. In SEA 9, for example, the local schooling contribution should be zero. Likewise, in Areas 3,6,7,8, and 10—the central eastern portions of Oklahoma—local schooling effort should be dramatically reduced while state and federal effort is increased

Table 19. The Ability-Spillover Model with Property and Income as Ability Measures—Implications for Local, State and Federal School Spending

State Economic Area	Local			State			Federal		
	Actual	Ability	Spillover Ability	Actual	Ability	Spillover Ability	Actual	Ability[1]	Spillover Ability
Area 1	337	307	290	145	36	23	18	23	53
Area 2	296	267	214	119	76	79	17	23	73
Area 3	190	127	72	159	216	219	12	23	75
Area 4	153	167	183	178	179	151	49	23	32
Area 5	183	171	164	171	172	130	17	23	72
Area 6	157	141	54	198	202	232	19	23	80
Area 7	152	196	115	188	147	150	9	23	101
Area 8	112	132	55	196	211	233	17	23	78
Area 9	90	91	0	228	252	292	20	23	74
Area 10	70	78	29	235	265	263	42	23	74
Area A	252	275	267	95	68	50	12	23	49
Area B	197	224	236	119	119	66	32	23	64
Area C	144	153	102	170	190	193	10	23	71
Area D	259	266	290	125	77	61	24	23	15

[1]Federal revenues are equalized for each SEA in order to provide equal total revenues per ADA.

if equity relative to geographic distribution of schooling benefits is to be maintained.

Conclusions

According to our estimates for state economic areas in Oklahoma the gross spillout of educational benefits ranged between 89 and 72 percent of the initial stock. On a school district basis, spillouts would be even larger. However, in several areas spillins were sufficiently large to result in a net estimated gain in transferred benefits. After adjustments for "ability to pay," the geographical alignment of costs with benefits substantially altered the pattern of local, state, and federal spending. In several areas the needed compensation in local spending was on the order of $75.00 to $90.00 per ADA, a rather substantial amount relative to the state average of $366.00 from all levels of government for the 1960-61 school year. In general, spillover compensation resulted in the urban areas receiving less state but more federal funds for education, while the low-income areas of southern and eastern Oklahoma received more of both state and federal revenues.

The reports to President Nixon's Commission on School Finance called for the states to gradually take over most public school costs currently borne by local governments. To ease the transition the federal government would provide an extra 4 to 5 billion dollars over a five-year period. Although total state funding is one solution to the problems of equal opportunity and the cost-revenue squeeze, the reports have apparently neglected consideration of the geographical disassociation of schooling costs and benefits. Spillover magnitudes, particularly in the case of low income rural areas, are sufficiently large to be important. If there is to be equity in these areas relative to the distribution of costs and benefits, both the federal and state governments must play a large and important compensatory role.

Summary and Conclusions

Achievement scores of Oklahoma public school students are near national norms for grades 4, 8, and 11. Performance appears to lag slightly in middle schools and junior high schools, however. Of special concern is low achievement scores of minorities. While numerous special programs are underway to alleviate deficiencies, lagging achievement of minorities is a nationwide phenomena with no easy solution. The school exerts far less influence on achievement than the home, neighborhood and genes. Substantive improvements in minority achievement scores appear to await raising the socio-economic status of the groups themselves through income maintenance programs, integrated housing and other efforts.

A linear programming analysis revealed opportunities for costs savings under internal schooling organization, as well as school size changes. The least cost per student in sparsely populated areas of western Oklahoma (student density .6 per square mile) was approximately 300 elementary and secondary students and, for more densily populated urban areas, over 1,000 students. Even with these optimal school sizes, costs per student—for a given level of output—were approximately $100 higher per ADA in sparsely populated rural areas than in urban areas.

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 now are too small to meet the needs of their students. Reorganization and consolidation based on efficient resource organization offers these small school districts great potential for cost reductions. This study shows that optimal school district size is a function of student density as well as other variables.

Data indicate that elementary and secondary schooling has a favorable economic payoff for all race-sex groups examined. The rates of return on investment in human capital, frequently about 10 percent, are very similar to rates of return on more conventional investments.

The benefits of common schooling in Oklahoma were distributed inversely to family income. The cost of supporting common schools was proportionate to income. Thus the net effect of common schooling in Oklahoma was to redistribute wealth from high income to low income families.

Unfortunately, some geographic areas not only are economically depressed but also have substantial net loss of local capital (property taxes) through net outmigration of residents. Earnings from the investment accrue elsewhere. Changes in school funding procedures are required to compensate this out-movement of capital. According to the Ability-Spillover model, both federal and state support of public schooling should be dramatically increased in eastern Oklahoma if equity is to be maintained. This topic is being studied in more detail.

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