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ABSTRACT

The effect of school expenditures on student performance has been a subject of much study and controversy. This paper provides additional empirical evidence about the effects of various categories of school spending on student performance. An educational production function is estimated using achievement test scores to proxy school output, with socioeconomic characteristics and expenditures in various categories as inputs. The data are school-district-level expenditures from Oklahoma. Unlike most past research, a correction is made for heteroskedasticity created by differences in school district size. The correction for heteroskedasticity leads to statistical tests with greater power. Test scores were positively related to expenditures on instruction and instructional support, and are negatively related to expenditures on student support, such as counseling and school administration. The negative effect of counseling and administration could be due to counselors taking up classroom time or administrators using classroom time with announcements or assemblies. Alternatively, the causality could go the other way. It could be that schools with problems hire more administrators and counselors. The socioeconomic variables included may not fully capture the problems that a school faces. The results do show that spending is useful when targeted toward instruction. The effect, though statistically significant, is not large. Thus, the research finds that money can matter if it is spent on instruction. (Contains 16 references and 3 tables.) (Author)

Relationship between School District Expenditures in Various Categories and Student Performance

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Abstract

The effect of school expenditures on student performance has been a subject of much study and controversy. This paper provides additional empirical evidence about the effects of various categories of school spending on student performance.

An educational production function is estimated using achievement test scores to proxy school output, with socio-economic characteristics and expenditures in various categories as inputs. The data are school district level expenditures from Oklahoma. Unlike most past research, a correction is made for heteroskedasticity created by differences in school district size. The correction for heteroskedasticity leads to statistical tests with greater power.

Test scores were positively related to expenditures on instruction and instructional support, and are negatively related to expenditures on student support, such as counseling and school administration. The negative effect of counseling and administration could be due to counselors taking up classroom time or administrators using classroom time with announcements or assemblies. Alternatively, the causality could go the other way. It could be that schools with problems hire more administrators and counselors. The socioeconomic variables included may not fully capture the problems that a school faces.

The results do show that spending is useful when targeted toward instruction. The effect, although statistically significant, is not large. Thus, the research finds that money can matter if it is spent on instruction.

Introduction

> *The central issue in all policy discussions is usually not whether to spend more or less on school resources but how to get the most out of marginal expenditures. Nobody would advocate zero spending on schooling, as nobody would argue for infinite spending on schooling. The issue is getting productive uses from current and added spending.* (Hanushek, 1996).

Studies have shown that nationally, school expenditures are not related to student performance (Hanushek 1996), or are only marginally related to school performance and marginally significant (Borland and Howsen, 1996). A meta-analysis performed by Hedges, Laine, and Greenwald (1994) shows that increasing per student expenditures improves test scores. However, Hanushek (1994) points out that their meta-analysis is flawed because they omitted many studies which show that increasing expenditures have no effect. These studies used aggregate expenditures as the explanatory variable.

But different categories of expenditures may have different influences on test scores. For example, Brewer (1996) suggests that increased expenditures on administration might even reduce test scores. Ferguson and Ladd (1996), using a high-quality dataset from Alabama (which has low spending levels) found that instructional spending had a large effect on test scores, but did not report effects of noninstructional spending.

Results from a desegregation settlement in Austin, Texas show that it matters where money is spent. Of fifteen disadvantaged schools that received $300,000 per year for five consecutive years from the settlement, only two showed a significant improvement in test scores. The two successful schools used innovative ways to teach children and involve parents. Their unsuccessful counterparts spent all the money hiring teachers to reduce class size, and used the

same instructional methods (Murnane and Levy, 1996). So our interest is whether specific types of expenditures result in test score improvement.

The objective of this research is to determine the influence on student achievement of various types of school expenditures in order to find areas where additional investment in education would give the greatest results. The important problem is finding the right combination of educational investment, which under the constraint of limited resources, produces the maximum possible results.

We go beyond previous research by estimating a production function with achievement test scores as output and various types of school expenditures as inputs. Results show how various categories of expenditures, such as instruction and administration affect achievement test scores. Various demographic and school related variables are also included in the production function. Our model isolates expenditure effects by including demographic and other school related variables as explanatory variables.

Methods

The model uses school district averages of achievement scores on standardized tests as the dependent variable and eleven expense categories by school district as independent variables. Disaggregate data was not available. Various socio-economic and school factors are also included to correct for other factors that influence test scores. The data are cross-sectional. Because the school district averages are averages across differing number of students, and there are many more small school districts than large ones, heteroskedastic disturbances are expected. Therefore, maximum likelihood estimation (MLE) is used instead of ordinary least squares. MLE is needed to gain asymptotically efficient parameter estimates and valid hypothesis tests (Greene, 1993).

The following equation was estimated using maximum likelihood estimation:

$$\mathbf{Y} = \mathbf{S}\beta + \mathbf{X}\phi + \mathbf{G}\delta + \mathbf{E}\Psi + \mathbf{u} + \epsilon \qquad (1)$$

where **Y** is a vector of average test scores for each school district/grade/test combination, **S** is a matrix that contains student effects which vary by school district and grade. Student effects are proportions for each grade by race and gender, and the percent of students taking the tests. Since the proportions by race and gender sum to one, this procedure required leaving one variable in the intercept, which was white males.

The socioeconomic effects matrix, **X**, varies only by school district. It includes the percent of students in special education, the percent of students receiving free or reduced-price lunches, and four levels of education attainment of the parents. The proportion without a high school education was left in the intercept, since the total summed to one. A matrix of dummy variables **G** includes the type of test (NRT or CRT), the kind of test (math, reading, or science), and grade level of the test (third and seventh for the NRT, and fifth, eighth, and eleventh for the CRT). The variable for CRT, grade 11, math test was included as part of the intercept.

E is a matrix of eleven expense variables for each school district, each as a per student expenditure; **u** is a random school/grade effect, and ϵ is a heteroskedastic error vector. The elements in **u** are $u_i \sim N(0,\sigma_u^2)$, and the elements in ϵ are $\epsilon_{ij} \sim N(0,\sigma^2/n_i)$; i being the index for school/grade and j for test. This structure of the error term originates by aggregating test scores of students within each grade within each school district. Disaggregate data would have been used had it been available. However, the gains from using disaggregate data are not expected to be high since the relevant variables in the model, namely expense categories, are themselves aggregated at the classroom level.

Family background is one of the major factors determining performance on achievement tests (Chubb and Moe, 1990). By including these effects in the model, we are better able to measure the effects of various types of school expenditures on achievement test scores.

Brewer (1996) argues that test scores and expenditures are simultaneously related and uses a simultaneous equations estimator. However, he finds little significance with his simultaneous-equations-estimator, which may suggest that he was unable to find adequate instruments to identify his parameters. See Staiger and Stock (1997) for a discussion of the problems created when instruments are weak. Ferguson and Ladd (1996) also argued for endogeneity of expenditures in Alabama because poorer performing schools were given additional money. Oklahoma does not allocate expenditures based on test scores as thus there should be little or no simultaneity here. There can still be bias due to missing explanatory variables. The parental, student, and school variables may not adequately capture all the cultural differences between communities.

Data

Data for this research were obtained from the Oklahoma Department of Education (1996). Test results were from the Criterion Referenced Test (CRT) and the Iowa Test of Basic Skills (ITBS), which is also known as the Norm Referenced Test (NRT). Test scores by school district and grade were available for each school district for the school year 1994-1995. The CRT is given to grades 5, 8, and 11, and is a test to ascertain whether or not students are at grade level. The NRT is given to grades 3 and 7, and is a test of knowledge level, not a test of grade level. Both the CRT and NRT have three tests, reading, science, and math. Our approach weights all tests equally, though Blackburn and Newmark (1995) found that math scores alone were the best predictor of salary after graduation and thus math scores should perhaps be given a higher

weight. No test scores were provided when less than six students took the tests due to concerns about confidentiality.

Much of the effects of social class alluded to by Chubb and Moe (1990) are alleviated by using parental influences and student influences as explanatory variables. Student data includes number of students for each gender and each race by grade for each school district. Race data includes Asian, Black, Hispanic, Native American, and White.

Parental data for parents with school age children were derived from 1990 school district census data (U.S. Department of Education, 1995). Educational attainment of the parents was divided into four categories; proportion with at least a bachelor's degree, with some college, with a high school diploma, and no high school diploma. The disadvantage of the Census data is that it is five years old and may not precisely reflect the current population.

Schools can and do achieve higher test scores by restricting who can take the test. Therefore, we include percentage of students in the given grade who took the test. School information used was proportion of special education students by district and proportion of students obtaining a free or reduced-price lunch by district (Oklahoma Dept. of Education, 1996). The free-lunch variable is especially important because it is a function of family size as well as family income.

Average daily attendance (ADA) and average daily membership (ADM) by district were also available. We chose to use ADM, the average daily membership (enrollment). When calculating average expenditures per category, ADM gives an exact calculation of costs per student enrolled. The State of Oklahoma requires each district to use the same accounting procedure. Means and standard errors for each of the eleven expenditure categories are in Table 1. These categories are defined below:

(1) Instructional expenditures include those activities dealing directly with teacher-student interaction. This includes any teacher-student interaction. Included here are salaries and benefits for teachers, teacher's aides, clerks, tutors, translators, and interpreters.

(2) Instructional staff support services include activities associated with assisting instructional staff with content and provide teachers with concepts and tools that enhance the learning process. This includes "in service" training such as workshops, demonstrations, school visits, and courses for college credit. Help in developing curriculum and instruction techniques are included here as well as media services such as library, audiovisual, educational television, and computer assisted instruction services.

(3) Student support services includes attendance and social work services, guidance services, health services, individual psychological services, speech pathology, and audiological services. This includes individual counseling, identification of problems arising from the home, school, or community, identification of attendance problems, identification of health problems such as visual or auditory, and testing (SAT etc.). We wish that we could separate expenditures on school counselors, but further disaggregation with the available data was impossible.

(4) School Administration includes activities of the school principals and their office subordinates such as assistant principals, secretaries, clerks, and other assistants in general supervision of all operations of a particular school or group of schools.

(5) General Administration and Business activities include those of the Superintendent's office and school business including, the fiscal and budgeting process for schools at the district level.

(6) Student transportation services are those transportation services mandated by state law such as transportation from home to school, and nonmandated services, such as school activity transportation.

(7) Operations, maintenance, child nutrition, and community service operations are in this category.

(8) Facilities acquisition and construction includes acquisition of buildings, remodeling, construction of buildings, additions to buildings, installing built-in equipment, and site improvement.

(9) Classified by the state's accounting system as "other outlays", this includes debt service, a clearing account, and funds transfer.

(10) Included in this category are scholarships given to students, student aid, and staff awards, all supported by outside revenue sources. In addition, worker's compensation claims, tort claims, and medical care claims and reimbursements are included here.

(11) The accounting system classifies this activity as "repayment".

Using MLE, these expenditure categories are tested for economic and statistical significance in regard to their effect on achievement test scores.

Results

Instructional expenditures, student support, and student transportation were significant at the 0.10 level (Table 2). The other expense variables in the model were insignificant.

Instruction

The instructional expenditures coefficient was 0.82, indicating that for another $1000 per student in instructional expenditures, there should be almost a point increase in test scores. Thus teachers, textbooks, and supplies are a productive place to spend money.

Instructional support

Instructional support is positive but insignificant with a parameter value of 0.63. Instructional support such as workshops, seminars, and computers, *may* increase teacher productivity, and therefore achievement test scores *may* increase.

Student support

Student support had a value of – 1.64, suggesting that spending in this category is unproductive. Expenditures in this area tend to take students out of the classroom, so a negative effect is reasonable. This could be a causality problem. Schools with serious problems may have more need to spend money in this category. Our socio-economic variables may not fully capture factors causing schools to have more needs in this area. Unfortunately, the expenditure data were not disaggregated enough to capture the separate effects of truancy enforcement, counseling, or health services such as audio and visual testing.

School Administration

The parameter value for school administration (Principal's office) was – 1.06. Brewer (1996) hypothesized two possible effects of administration expenditures on student performance. One is that more administration actually lowers output by reducing teacher productivity, and has a negative marginal product at current expenditure levels. The other hypothesis is a less severe indictment of administration. It states that increased administration does not actually lower educational output, but displaces funds that could be used in a more productive manner. Our results support his first hypothesis for the Principal's office and the second for the Superintendent's office. We would also offer a third hypothesis. Principals that cannot manage their own office efficiently may also provide poor leadership for the school.

Transportation

The coefficient of transportation expenses was positive and significant. This is likely a missing variable problem. Those school districts that have large land areas and few students require larger expenditures per student on transportation. Most such schools are located in western Oklahoma. Eastern Oklahoma has historically been behind Western Oklahoma in terms of education level and job salaries (Warner,1995). This variable may capture some regional differences that the other variables failed to measure.

Insignificant Expense Variables

Superintendent's office and business expenses were insignificant both statistically and economically, as were operating expenses and lunch programs. Construction and acquisition shows little relationship to test scores; however, this data was for a single year, and it is not surprising that construction in a particular year would not affect achievement test scores in that year. The other three categories, classified as "other" by the accounting system were also insignificant.

Other Variables in the Model

Regarding the parent's education variables, only 'Parents with a Bachelor's degree' was significant. But as educational level increased, so did both the level of statistical significance and the parameter level. Increasing the percentage of parents with at least a bachelor's degree by 11%, holding the other education variables constant, has about the same effect as increasing per student expenditures on instruction by $1000 per student. Educational level of the parents is important to achievement test scores for the district.

The race and gender variable were insignificant with the exception of black and white females, and Indian males. Proportion of students receiving free or reduced-price lunches was

significant and negative. Increasing the number of students receiving free or reduced-price lunches by 10% decreases test scores by about one half of a point. The special education variable was also significant and negative, as was the percent of students per class allowed to take tests. Increasing either of these variables decreases test scores.

Conclusion

Schools that spend more on instruction have higher test scores than those that spend less in those areas. However, schools that spend more on school administration (Principal's office) and student support have lower test scores than schools that spend less. Since school districts have limited funds, increased spending on any category whose parameter estimate is statistically insignificant results in a misallocation of resources away from more productive areas such as instruction.

Research with state level data found school expenditures have an insignificant effect on performance, with test scores as a proxy for school quality. On a national level using statewide data, spending per student ranged from over $9000 in New Jersey to just over $3000 in Utah in 1993-1994. Oklahoma ranked 46th in spending per student, in 1993-1994 (Hanushek, 1996). Because of Oklahoma's low expenditures, the marginal return to education expenditures may be positive in Oklahoma, but not in other states.

The methods here may yield more powerful tests than previous research due to the larger variations in expenditures, larger number of observations, and the correction for heteroscedasticity when using aggregate data. Also, Hanushek (1986, 1996) used aggregate expenditures while our results show that expenditures in some categories have negative effects. Further, Hanushek's data is from the time mainstreaming of special education students was not yet popular. Reducing class size may now have a greater benefit.

The results show that money spent on instruction leads to a small increase in student performance. If spending is to be increased and the goal is to increase the average test score, then money appears to be best spent on teachers, teacher supplies, and teacher training.

Table 1. Oklahoma school district average achievement test scores

variable	min.	mean	std. dev.	max.
Grade 3 math[a]	15.2	25.7	2.461	32.2
Grade 3 reading[a]	11.3	17.7	1.856	25.2
Grade 3 science[a]	11.7	18.2	1.727	25.1
Grade 5 math[b]	52.0	72.3	5.557	89.0
Grade 5 reading[b]	55.0	80.9	4.903	94.0
Grade 7 math[a]	16.9	25.9	3.314	36.9
Grade 7 reading[a]	16.8	22.6	2.351	30.7
Grade 7 science[a]	17.7	25.5	2.391	37.1
Grade 8 math[b]	55.0	74.5	6.092	91.0
Grade 8 reading[b]	52.0	76.1	5.257	91.0
Grade 8 science[b]	52.0	73.0	4.731	84.0
Grade 11 reading[b]	36.0	67.1	7.495	92.0
Grade 11 math[b]	44.0	75.2	5.169	87.0

[a] Norm Referenced Test Scores

[b] Criterion Referenced Test Scores

Note: The means are unweighted averages of each district's proportion and therefore they will not match state averages.

Table 2. School district per student averages for Oklahoma school district variables

Variable	min.	mean	std.dev	max.
Parents without hs education	0.00	0.20	0.091	0.68
Parents with hs education	0.00	0.39	0.098	0.69
Parents with some college	0.00	0.28	0.087	1.00
Parents with Bachelor's degree	0.00	0.14	0.084	0.58
Proportion Black males	0.00	0.02	0.056	0.80
Proportion Black females	0.00	0.02	0.055	0.92
Proportion Indian males	0.00	0.11	0.119	0.78
Proportion Indian females	0.00	0.11	0.113	0.73
Proportion Spanish males	0.00	0.01	0.033	0.35
Proportion Spanish females	0.00	0.01	0.035	0.47
Proportion Asian males	0.00	0.002	0.008	0.17
Proportion Asian females	0.00	0.002	0.007	0.08
Proportion White males	0.00	0.38	0.141	1.00
Proportion White females	0.00	0.35	0.132	0.86
Proportion free or reduced lunch	0.00	0.54	0.185	1.00
Proportion special education	0.00	0.12	0.040	0.52
Proportion taking tests	0.28	0.89	0.097	1.00
Instructional expenditures[a]	1,582.00	2,740.00	558.137	9,870.00
Instructional support[a]	0.00	120.00	97.520	1,360.00
Student support[a]	0.00	160.00	113.233	690.00
Principal's office[a]	0.00	220.00	112.694	720.00
Superintendent's office[a]	130.00	400.00	220.155	2,640.00
Student transportation[a]	5.00	240.00	136.757	1,700.00
Operations, child nutrition[a]	420.00	880.00	283.420	3,990.00
Facilities, construction[a]	0.00	157.00	372.940	4,207.00
Other: debt service[a]	0.00	10.00	152.998	1,050.00
Other expenses[a]	0.00	2.00	11.561	151.00
Repayment[a]	0.00	1.00	10.003	220.00

[a] These are per student expenditures.

Note:The means are unweighted averages of each district's proportion and therefore they will not match state averages.

Table 3. Parameter estimates of the effects of various factors on Oklahoma public school achievement test scores

variable	parameter est.	std. error	p-value
Intercept	78.41	1.306	0.0001
Grade 3 math[a]	-49.40	0.224	0.0001
Grade 3 reading[a]	-57.45	0.224	0.0001
Grade 3 science[a]	-56.87	0.224	0.0001
Grade 5 math[a]	-2.68	0.223	0.0001
Grade 5 reading[a]	5.94	0.223	0.0001
Grade 7 math[a]	-49.50	0.222	0.0001
Grade 7 reading[a]	-52.65	0.222	0.0001
Grade 7 science[a]	-49.77	0.222	0.0001
Grade 8 math[a]	-0.67	0.224	0.0029
Grade 8 reading[a]	1.07	0.224	0.0001
Grade 8 science[a]	-1.99	0.224	0.0001
Grade 11 reading[a]	-7.97	0.230	0.0001
Parents w/Bachelor's degree	7.35	1.355	0.0001
Parents w/some college	1.94	1.299	0.1366
Parents w/ high school education	1.00	1.297	0.4390
Proportion White female	1.26	0.612	0.0390
Proportion Black female	-13.16	1.692	0.0001
Proportion Indian female	-0.97	0.771	0.2065
Proportion Hispanic female	-0.32	2.023	0.8759
Proportion Asian female	8.11	7.393	0.2728
Proportion Black male	-0.15	1.720	0.9304
Proportion Indian male	-2.28	0.733	0.0019
Proportion Spanish male	-3.56	1.945	0.0671
Proportion Asian male	-4.69	6.156	0.4458
Percent subsidized lunch	-5.23	0.697	0.0001
Percent special education	-4.20	2.380	0.0780
Percent taking test	-4.43	0.583	0.0001
Instructional exp[b]	0.82	0.239	0.0006
Instructional support exp[b]	0.63	1.034	0.5404
Student support exp[b]	-1.64	0.811	0.0439
Principal's office[b]	-1.06	0.887	0.2312
Superintendent's office[b]	-0.61	0.594	0.3080
Student transportation[b]	1.45	0.791	0.0669
Operations, nutrition, etc.[b]	0.22	0.495	0.6551
Facilities construction[b]	0.18	0.223	0.4182
Other: debt payment, etc.[b]	0.60	0.554	0.2797
Other[b]	0.97	6.567	0.8826
Repayments[b]	-2.41	7.512	0.7488

[a] These are intercept-shifting dummy variables.

[b] These are average per student expenditures in thousands of dollars.

Note: A random effects model was estimated with MLE correcting for heteroskedasticity due to aggregation. There were 6,602 observations.

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