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Monitoring Inefficiency in Public Education

Yoshie Saito and Christopher S. McIntosh

The efficiency of public education is examined using a cost indirect output distance function. Efficiency estimates are obtained using data envelopment analysis applied to data from Georgia public schools. Georgia school districts utilize educational budgets with reasonable efficiency, achieving an overall efficiency of 98% with a range of 93%–100%. If all school districts were 100% efficient, outputs could be expanded 2%. This could be achieved by increasing funding $75.46 million state-wide in total for each of the 3 years. From the consumers' (voters') point of view, this result suggests that inefficiency costs Georgia, on average, a total of $226.38 million from 1994 to 1996.

Key Words: cost-indirect output distance function, data envelopment analysis, education, efficiency

JEL Classifications: H72, I21, I28, C60

The perceived decline in the quality and efficiency of American education has been the focus of much attention from the media, politicians, and researchers. Starting in 1963, performance on standardized tests began a steady decline in America, whereas graduation rates changed little. One can argue that school performance has contributed to lower the quality of high school graduates. Although the quality of graduates has declined, the costs of education and the quality of educational inputs has increased steadily. Both the amount of teachers' experience and expenditures per pupil have increased, and student-to-teacher ratios have declined. These phenomena foster a public opinion that educational inputs explain little about educational quality. Indeed, this issue has captured attention at the highest levels of political discourse with the passage of George W. Bush's No Child Left Behind Act (White House).

This study analyzes the cross-sectional variability of school district performance. The analysis evaluates relative school district performance based on how well educational resources are used to provide quality of education according to some uniform measures. The focus of this study is public education in the state of Georgia at the school district level, as opposed to the single school level. An efficiency study of Georgia counties' elementary and secondary education will provide a relative assessment of how well school districts achieve educational objectives. The school districts' performance has a direct impact on the quality of life and economic development for a city/county. Thus an efficiency evaluation based on performance provides information about how adequately school districts utilize tax spending for education.

The Georgia Quality Basic Education Act (QBE) was signed in April 1985 with a stated purpose of equipping "students to lead productive and satisfying lives" (Harris, p. 36).

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Further, "QBE identifies the basic competencies that students are expected to master by the end of high school" (Harris, p. 36). The accountability policy in QBE makes performance information available to the public. Some of the information about school districts and individual schools are now available through the Internet at the Georgia Department of Education web site. Despite the availability of this information, the data describe little about a school district's performance relative to other school districts or its performance over time.

The goal of public education is defined by Hanushek as providing students with the ability "to perform in and cope with society after they leave school" (p. 1150). This definition is very similar to the concept in QBE with a stated goal "to equip students to lead productive and satisfying lives" (Harris, p. 36). Although identifying appropriate measurable outputs is difficult, Hanushek concludes that test scores are reasonable measures to quantify educational outputs especially in early grades. The use of standardized test scores represents the broad consensus of opinion on reasonable measures of educational outputs. Thus, based on this consensus, a goal of public education (for the purposes of this study) is defined as maximizing educational value-added to students as measured by student test scores given budget constraints.[1] Voters in a school district have a strong influence on how much government revenue is allocated to public education. In such circumstances, the revenue allocated to public education should equal the voters' utility maximizing level of value-added to education. This price should correspond to the price that maximizes revenue for educational suppliers in a competitive market. Both goal maximizing school districts and utility maximizing voters face resource constraints. Better utilized resources lead to fewer tax dollars being spent for nonproductive purposes and more available to improve teaching and learning. Thus a measure of relative resource utilization can be used to evaluate how well school districts allocate their budgets to provide quality education. The relative performance evaluation of public education provides critical information for taxpayers and educators.

Methods

As mentioned above, there is some controversy over what is an appropriate proxy for educational outputs. The fact is that none of the measurable educational output candidates is perfect. Test scores are one of the school outputs that voters are concerned about and the most common measure of school output. Test scores may not accurately reflect student learning potential for a variety of reasons; however, no other measure of student ability is available in a standardized form. Thus this analysis will model efficiency by assuming the value-added portion of test scores is a primary educational objective of school districts. A value-added estimation model controls student-related factors, and school performance is evaluated according to increase in test scores given a budget.

School's resources used to supply education are support staff salaries, teachers' salaries, and material costs associated with teaching and students activities. Since each school district faces a unique combination of educational inputs and multiple output choices, the cost indirect output distance function is an appropriate model to employ for measuring budget constrained efficiency. The cost indirect output distance function, proposed by Färe, Grosskopf, and Lovell, is suitable "when resource usage can be reliably compared on the basis of cost, but benefits (outputs produced or services provided) cannot be priced reliably enough to allow revenue comparison" (p. 73). This approach can also accommodate a situation in which each school district faces a budget constraint but is allowed to choose input combinations according the needs of the district. Despite these advantages, few studies

[1] Employment, earnings, and contributions to the tax base are among the final outputs from public education. Unfortunately, there is no way to correlate data on these outputs to the individual school systems from which they were generated. Our use of standardized test scores as a measure of education output is consistent with the literature.

have employed the cost indirect output distance function.

Efficiency estimation can be conducted using two different approaches: data envelopment analysis (DEA) or stochastic frontier estimation. DEA, which was first introduced by Charnes, Cooper, and Rhodes, is employed in this study assuming variable returns to scale (VRS). The choice of VRS is due to two reasons. First, it is more difficult for a student who is at a higher achievement level (as measured by the test scores) to increase one point than it is for a student who is at lower achievement level. For example, a five-point incremental increase on a 100-point scale is more difficult for students who started at 95 points than those whose scores were at 50 points. Second, students with higher test scores tend to learn faster than students with lower test scores. Students with prior knowledge in subjects can often comprehend the subject matter faster than those who have no experience in the area.

Previous Research

Most prior studies of technical efficiency in education have employed DEA or a combination of DEA and regression analysis. Färe, Grosskopf, and Weber employed DEA with jack-knifing techniques (which drops one observation at a time and recalculates efficiency). They assumed a VRS technology, and their results from 40 Missouri school districts (1985–1986) show that more than half of the school districts were at the 100% efficiency level. The average efficiency score by school district was 96.9%. Ruggiero also employed VRS technology and analyzed 556 school districts in New York state for the 1990–1991 year. He found that 80% of school districts were inefficient and that half of these districts were only 71% efficient.

Lovell, Walters, and Wood combined a modified form of DEA with regression analysis. Utilizing their microlevel data (high school) characteristics, they took a three-step approach to account for short-term, intermediate-term, and a long-term goals. The mean efficiency scores were 73.5% for the first stage, 86.2% for the second stage, and 79.7% in the third stage, and a strong positive correlation between intermediate and long-term performance was found in their analysis.

McCarty and Yaisawarng and Ruggiero combined DEA with Tobit analysis. McCarty and Yaisawarng selected school districts in New Jersey and found that lower socioeconomic-factor school districts have lower efficiency scores. This was a result also found by Ray in an examination of 122 high school districts in Connecticut during 1980–1981. Many studies (Lovell, Walters, and Wood; McCarty and Yaisawarng; Ruggiero; Thanassoulis; Grosskopf et al.) consistently find a significant influence of environmental factors, such as the location of school districts and parents' economic and ethnic background, on test scores.

Although DEA is often criticized because it is deterministic (e.g., Chakraborty, Biswas, and Lewis), it estimates relative efficiency scores reasonable well. This is especially true when students' socioeconomic factors are controlled prior to frontier estimation and school districts face relatively similar environmental factors (as in the case of a statewide study). The application of an indirect output distance function in educational evaluation was first introduced by Grosskopf et al. who combined DEA with regression analysis. Their analysis also measured the allocative efficiency using direct and indirect output distance functions. Their approach is followed here with a higher efficiency score interpreted as the school district making better use of its budget in producing the highest educational value-added to students.

Value-added Model and Variables for Efficiency Evaluation

An objective of school district operations is to improve students' cognitive skills without increasing dropout rates. The dropout rate is, in effect, a "bad" output to society. Cognitive skills are measured using scores from the Iowa Test of Basic Skills (ITBS) and Test of Achievement and Proficiency (TAP). These test scores were chosen because both ITBS and TAP are norm-referenced tests, which makes interstate comparisons possible.

Since education is a cumulative process and elementary and secondary schools give academic education that is technically different from an education at home, the performance on standardized tests in grades 5, 8, and 11, and the dropout rate for grades 9–12 (the ratio of students leaving school in grades 9–12 to the total enrollment in grades 9–12) are used in the analysis.

Outputs in the Value-added Residual Approach

Family effects on schooling outcomes have been shown to be significant (Hanushek; Hanushek, Rivkin, and Taylor; Loeb and Bound). These effects include residential choices by parents, students' study habits, preferences for future careers, and parents' perception of education. To control for students' socioeconomic factors that are exogenous to school districts, this analysis employs the value-added residual technique as used by Hanushek and Taylor, Meyer, and Grosskopf et al. Four socioeconomic-related factors are included in this analysis. Racial composition (ETHNICITY) is used to control for socioeconomic factors,[2] percentage of free/reduced lunch program participants (LUNCH) is used to control for income level of families, and population density (POPD) is used to control for rural characteristics. The previous test scores ($TEST_{t-2}$) for the cohort test are included to extract specific cohorts' marginal effect on test scores. Dummy variables (DUMY) for each year are included to capture specific year effects in the model.

The model for estimating the value-added residual is

$$(1)\quad TEST_{t,d,s} = \delta_{1,t,d} + \sum \delta_{2,t,d}ETHNICITY_{t,d} + \delta_{3,t,d}LUNCH_{t,d} + \delta_{4,t,d}POPD_{t,d} + \delta_{5,t,d}TEST_{t-2,d,s} + \sum \delta_{6,t}DUMY + \varepsilon_{t,d,s},$$

where t indicates year, d indicates school district, and s indicates test subjects. Since previous researchers have reported that mathematical skills are more closely related to higher future salary (Bryk, Lee, and Holland; Murnane, Willett, and Levy; Sander), reading and mathematics test score are used separately to extract residuals. A similar equation is estimated to account for undesirable educational output, the dropout rate:

$$(2)\quad (1 - DROP_{t,d}) = \delta_{1,t,d} + \sum \delta_{2,t,d}ETHNICITY_{t,d} + \delta_{3,t,d}LUNCH_{t,d} + \delta_{4,t,d}POPD_{t,d} + \sum \delta_{5,t,d}TEST_{11,d,s} + \sum \delta_{6,t}DUMY + \varepsilon_{t,d,s}.$$

DROP is a proportion of students (grade 9–12) who drop out of school during a year.

The residuals estimated from Equations (1) and (2) represent the deviation of value-added in school district d from the state mean. Since half of the districts will have negative residuals and the distance function employed in this analysis cannot handle negative outputs, the average intercept for the above equations is added to the residuals as suggested by Grosskopf et al. Thus a final output in the efficiency estimation model is

$$(3)\quad Output_s = INTER_{s,t} + \varepsilon_{t,d,s},$$

where $INTER_{s,t}$ is the average intercept of each of value-added equation s for year t.

The costs directly related to students and teaching activities are defined as educational production costs. The value-added residual estimated from Equations (1) and (2) are defined as the output quantities in this distance function analysis. Since each school district has a

[2] Characteristics of peers or the effects of other students have received attention from several researchers as a part of socioeconomic characteristics. Racial composition is one of these variables that also include ethnic tradition and religion (Benabou, 1991, 1996; Borjas, 1992, 1995; Hanushek; and Johnson and Stafford).

unique combination of educational inputs, and public education must be provided within a limited budget, the cost indirect output distance function is the appropriate analysis tool. An evaluation of technical efficiency is based on the school districts' abilities of converting budget-constrained teaching resources into students' cognitive skills without creating student dropouts.

Empirical Model and Analysis

The evaluation technique used in this analysis is the estimation of an educational efficiency frontier employing DEA. This estimation relies on observed practices that must be collected from aggregated information. The estimation of a frontier is sensitive to observations that the analyst decides to include in the educational production function.[3] Consistency of data across years and school districts is imperative, and care must be taken in the data collection process. In this analysis, goal-oriented behavior is assumed to connect the technical structure of educational production and economic behavior of policy makers. The cost indirect output distance function can be defined as follows:

$$\text{(4)} \quad ID_0(w/c,\ y) = \min_{\theta}\ \{\theta\text{: } y/\theta, \in IP(w/c)\},$$

where w/c is a vector of budget deflated input price, y is a vector of output, $IP(\cdot)$ is a cost indirect output set, and θ is a scale factor. The output distance function (4) is homogeneous of degree one (HOD[1]) in outputs and can be rewritten as

$$\text{(5)} \quad ID_0(w/c,\ \alpha y) = \min_{\theta/\alpha}\ [\theta/\alpha\text{: } y/(\theta/\alpha) \le IP(w/c)]$$
$$= \alpha ID_0(w/c,\ y).$$

The output-oriented distance function is a radial measure of distance ratios written as

$$\text{(6)} \quad ID_0\left(\frac{w}{c},\ y\right) = \frac{y^0}{y^*},$$

[3] If a parametric method is used, it also depends on assumed functional form and the assumptions coincidental with statistical estimation.

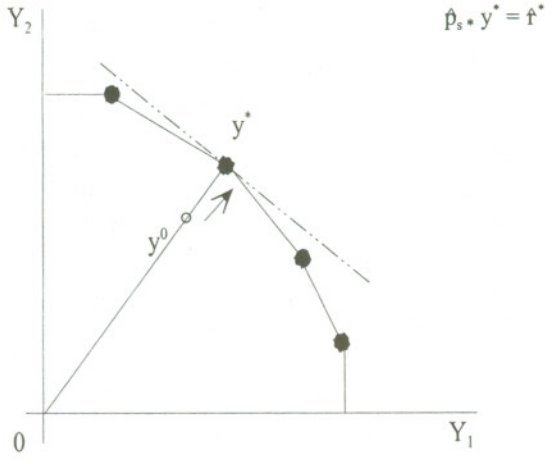

Figure 1. Efficiency Frontier and Radial Expansion (y^0 is the observed level of output; y^* is the optimal level of output, and the dotted line is the projected price line; Y_1 and Y^2 are two desired outputs such as test scores for math and reading; $\hat{p}_s$ is the projected output price; and $\hat{r}$ is the projected revenue to school districts.)

where y^0 is an observed level of output and y^* is optimal level of output. Inefficiency is measured by a ratio of an observation to an efficient operation and $y^0/[ID_0(w/c,\ y)]$ brings the observation to an efficient frontier. In other words, inefficiency is radially measured by how far realized output is from the estimated efficient frontier given a budget constraint as shown in Figure 1. In our application, y^0 is the current level of school districts' value-added to students measured by improvement in test scores, and y^* is the estimated best practice.

An indirect distance function lies between 0 and 1, $0 \le ID_0(w/c) \le 1$. A score close to 1 indicates the school district utilizes their budgets effectively in meeting students' needs and improvement in students' test scores is high relative to school districts that receive similar budgets. On the other hand, a score closer to 0 indicates that school district performance is low relative to other school districts that receive similar budgets.

The cost indirect output distance function directly measures how much a school district can expand its output radially, if school districts were to utilize their current budgets efficiently. The presentation of inefficiency and expansion shown in Figure 1 describes point y^0 representing an observation that does not use the budget efficiently.[4] Output prices might be unknown or may not be generated in a purely competitive market, so producers have to estimate or project ($\hat{p}_s$) when they select their output level. As shown in Figure 1, the estimated frontier y^* is assumed to be at the revenue maximizing level defined as $\hat{p}_s \times y^* = \hat{r}^*$.

Data Collection

The educational data were collected from the Georgia Department of Education, Georgia Public Education Report Cards. New precise educational data are available at the school district level, beginning with the 1994/1995 academic year. Unfortunately, changes in definitions and classification of variables have occurred, making cross-year comparison difficult. Reconstruction of a consistent data set was undertaken using the most recent definitions provided by the Department of Education (1996/1997 academic year Georgia Public Education Report Cards).

As opposed to the state school district data, many environmental variables such as the unemployment rate, the crime rate, and the poverty level are available only at the county level. When data on these environmental variables were not available for a city, they are replaced by data for the county in which the city is located. Seven counties do not have a high school, and six of these seven do not have a junior high school. The students of these counties attend junior high or high schools in nearby counties. Since insufficient data are available for these merged counties, these 13 counties have been excluded from the analysis.[5]

Output Data

The variables used as a proxy for cognitive skills (output measures) are the ITBS and the TAP, both of which are Norm-Referenced Tests (NRT). Since the ITBS has a long history and makes interstate comparison possible, these test scores are used (in grades 3, 5, 8, and 11), rather than the Georgia High School Graduation Tests (GHSGT). The GHSGT test is taken only by students within the state, meaning the results are not easily compared with other states and regions. In a diversified economy, students from Georgia must compete with students from other states. In the long run, the NRT provides a more relevant measure to assess students abilities.

Since TAP data is only available for 1994/1995 and 1995/1996, the 1996/1997 TAP score was approximated using the GHSGT. To do this, a ratio of TAP to GHSGT was calculated for every county using the average of the data for 1994/1995 and 1995/1996. An approximation of the county TAP score for 1994/1995 was computed as the product of the county GHSGT score and the ratio estimated above. The ratio of the 1994/1995 TAP scores to these estimated TAP scores was reasonably close to 1. This suggests that the county GHSGT scores, scaled by their ratio to TAP score, is a reasonable estimate of TAP scores for the county. The same method was employed to estimate the TAP score for the Thomasville city system in 1994/1995.[6]

The dropout rate is the ratio of students leaving school in grades 9 to 12 to the total enrollment in grades 9 to 12.[7] Data on socioeconomic factors, the proportion of the student body in various racial groups, and the proportion of free/reduced lunch program participants were obtained from the Department of Education.

[4] All points on the frontier are efficient operations, and inefficiency is radially measured by a ratio of a point on the frontier y^* to an observation y^0, as in Equation (6).

[5] Hancock county was also dropped from the sample because four methods (Cook's D-test, hat matrix, and influence analysis) suggest that this county is an outlier.

[6] The mean ratio of the 1994/1995 TAP scores to the estimated TAP scores were 1.0244 for reading and 1.0099 for mathematics. TAP scores were not available for the Thomasville city school system in 1994/1995.

[7] The dropout rate was not adjusted for retained students due to data availability.

Table 1. Descriptive Statistics for the Value-added Outputs, Test Scores, Dropout Rate, and Total Enrollment

Variable[a]	*M*	SD
ITR5	49.217	8.292
ITM5	51.867	10.104
ITR8	47.398	9.563
ITM8	50.779	8.748
ITR11	44.094	11.194
ITM11	53.902	10.472
DROPR	0.091	0.034
TENR	7,602.030	13,459.910

[a] ITR5 are Iowa Test of Basic Skills for reading grades 5, 8, and 11 (Test of Achievement and Proficiency), respectively; ITM5 are the corresponding test scores for mathematics; DROPR is the proportion of students who drop out; and TENR is the total enrollment. The total number of observations is 498.

Input and Environmental Variables

The input price variables are the average teacher salary,[8] the average support personnel salary,[9] and the adjusted Consumer Price Index for materials. These materials costs are nonlabor expenditures that are directly related to teaching and student activities such as books, food services, library and media services, and student transportation costs. Since no specific price is available for these expenditures, price indices are used. The figures for annual Consumer Price Index, computed by the Bureau of Labor Statistics, are average figures from January to December, and it is therefore necessary to adjust the index so that it corresponds to an academic year (from July to June).

Three categories—total teacher salary, support staff salary, and material expenses—typically make up about 75% of total district expenditures on education. The Department of Education provides the number of students, teachers, support service staff, specialized staff, and policy makers for each county. Using these data, a proxy for school district quality, the student/teacher ratio, is calculated. This serves as the environmental variable for frontier estimation. Summary statistics for the outputs, inputs, revenue, a quality proxy, and student characteristic variables are shown in Tables 1–4.

[8] Full-time teachers as well as part-time teachers.

[9] Support personnel includes students service personnel, information services personnel, librarian/media specialists, special education specialists, and recreational therapists.

Table 2. Descriptive Statistics for Student Characteristics

Variable[a]	*M*	SD
ASIS	0.0054	0.0089
HISP	0.0171	0.0324
BLACK	0.3382	0.2354
LUNP	0.4869	0.1631

[a] ASIS is the proportion of Asian students; HISP is the proportion of Hispanic students; BLACK is the proportion of black students; and LUNP is the proportion of students who participate in the free lunch program.

Value-Added Output Analysis

For educational analysis, value-added residual techniques are suggested by Hanushek and Taylor; Meyer; Loeb and Bound; and Grosskopf et al. These techniques control socioeconomic factors for all students and allow us to extract the school districts factors on educa-

Table 3. Descriptive Statistics for Expenses, Price, Student/Teacher Ratio, and Share Proportions

Variable[a]	*M*	SD
TOT-EXP ($)	5,361.40	928.315
TEXP-STD ($)	4,064.81	426.948
SPSAL ($)	38,265.03	3,343.23
TEASAL ($)	32,300.59	2,426.81
CPI ($)	154.61	3.47
SPSHA	0.033	0.010
TEASHA	0.381	0.050
MATSHA	0.359	0.049
STUTEA	16.150	1.253

[a] TOT-EXP is total teaching and student-related expenses in million dollars; TEP-STD is teaching and student-related expenses per student; SPSAL is the average support staff's salary; TEASAL is the teacher's salary; CPI is the price for material relating to teaching and student activities; SPSHA is the share for support staff salary; TEASHA is the share for teachers' salary; MATSHA is the share for materials costs; and STUTEA is the student/teacher ratio.

Table 4. The Budget Constraints, Descriptive Statistics

Variable[a]	*M* ($)	SD ($)
TSPSAL	1,549,729.32	3,609,499.20
TTEASAL	15,800,631.56	29,880,921.39
TMAT	14,759,036.55	28,692,093.75

[a] TSPSAL is the budget constraint for support staff; TTEASAL is the budget constraint for teaching staff; and TMAT is the budget constraint for materials costs.

tion. Using this method, the final empirical models for school districts outputs (the value-added by education) are as follows:

$$(7)\quad \varepsilon_{t,d,s} = \Big\{\text{TEST}_{t,d,s} - \Big[\delta_{1,t,d} + \sum \delta_{2,t,d}\text{ETHNICITY}_{t,d} + \delta_{3,t,d}\text{LUNCH}_{t,d} + \delta_{4,t,d}\text{POPD}_{t,d} + \delta_{5,t,d}\text{TEST}_{t-2,d,s} + \sum \delta_{6,y}\text{DUMY}_{s}\Big]\Big\}, \quad \text{and}$$

$$(8)\quad \varepsilon_{t,d} = \Big\{(1 - \text{DROP}_{t,d}) - \Big[\delta_{1,t,d} + \sum \delta_{2,t,d}\text{ETHNICITY}_{t,d} + \delta_{3,t,d}\text{LUNCH}_{t,d} + \delta_{4,t,d}\text{POPD}_{t,d} + \sum \delta_{5,t,d}\text{TEST}_{11,d,s} + \sum \delta_{6,y}\text{DUMY}_{s}\Big]\Big\},$$

where ε is the residuals from the regression model inside of the bracket, variables are as previously defined, t represents the year (t = 1, 2, 3), d indicates the school district (d = 1, . . . , 166), and s indicates test subjects (s = 1, . . . , 6). An F-test is conducted for a test of the restrictions and select the educational value-added models defined by Equations (7) and (8). Since all test scores (grades 5, 8, and 11 for both reading and math) and the complement of dropout rate share common regressors and contemporaneous correlation in the error term is expected, seemingly unrelated regressions were used to estimate these models. Since distance function methods cannot accommodate negative outputs, the average intercept from the above equation is added to obtain estimates of the final outputs,

$$(9)\quad \text{Output}_{s+1} = \text{INTER}_{s+1,t} + \varepsilon_{t,d,s},$$

Table 5. Parameter Estimates from the Seemingly Unrelated Regression

	Dependent Variable = Educational Outputs		
Variable[a]	Parameter Estimate	Standard Error	t-value[b]
INT5R	43.787	1.609	27.209*
NAS5R	−11.728	14.570	−0.805
NHI5R	10.028	5.774	1.737***
NBL5R	−4.731	1.372	−3.448*
NLU5R	−19.447	2.047	−9.502*
NPO5R	0.001	0.001	2.551**
NPR5R	0.337	0.022	15.277*
N955R	0.421	0.404	1.043
N965R	−0.854	0.400	−2.138**

[a] INT5R is the intercept; NAS5R is the proportion of Asian students; NHI5R is the proportion of Hispanic students; NBL5R is the proportion of Black students; NLU5R is the proportion of students who participate in the free lunch program; NPO5R is the population density; NPR5R is the test score of previous cohort; N955R is the year 95; and N965R is the year 96.

[b] The t-value * is significantly different from zero at α = 0.01, ** α = 0.05, and *** α = 0.10.

where INTER is the average intercept of each value-added equation s for a separate year t. The resulting parameter estimates are shown in Table 5.

When the estimated residuals were plotted against the independent variables, some systematic patterns were found with some of the regressors. Tests for heteroscedasticity were conducted using the White test (regressing the square residual against the individual independent variables), Glejser test, and Breusch and Pagan test. The null hypothesis of homoscedasticity was rejected for all models, except for a reciprocal of dropout rate at a α = 0.01 level using the Breusch and Pagan test. Since the sum of squared errors for the individual years are different, a test for significant difference between errors from each year was conducted. The results indicated a significant difference between the year of 1994/1995 and the other 2 years in student-related factors. The heteroscedasticity correction was conducted using predicted values (absolute value of estimated ordinary least squares residual regressed on regressors of the value-added model) as the weight factor, following a two-step weighted least square procedure proposed by Prais and Houthakker.

Results of the DEA Analysis

The presence of technical change was tested over the years included in this study. The data do not support the presence of technical changes over the 3 years. Thus the estimation is a single, large frontier over 3 years which reflects the best practicing performance of all counties. The results show an overall mean efficiency of 97.95%.

Roughly 15% of the samples are on the frontier. Efficiency estimates of 97.95% indicate that total educational production can be increased 2.1% (1/0.9795) if all school districts operated at a 100% level of efficiency. This inefficiency, in terms of tax spending, provides more intuitive understanding of these scores. Given a budget, when efficiency of education is evaluated using student test scores, the inefficiency can be interpreted as a misallocation of tax dollars of $90 per student per year. In other words, if all schools operated at the level of the most efficient schools, the observed test score results could theoretically be achieved at a lower cost (equal to $90 per student per year). For 3 years, this would equal a total of $226.38 million misallocation resulting from school districts not operating on the frontier level of efficiency (Table 6).

Following the above findings, a ranking analysis was conducted over the 3 years' observations and revealed other insights into Georgia public education. The panel data results show that the city school systems better utilize their budgets and produce educational value-added with higher efficiency. The test of mean difference shows that there is a significant difference ($\alpha = 0.0001$) in the mean efficiency score between city and county school systems. Many counties containing city school systems have efficiency scores of 1. Those school districts include Cobb (633), Fayette (656), Fulton (660), Dekalb (644), Gwinnet (667), Atlanta (761), and Rome (785),[10] mostly suburban counties. About 28% of the school districts have an efficiency score less than 97%. Those school districts include Bacon (603), Branlly (613), Brooks (614), Polk (715), and Pierce (713).

Table 6. Estimates of Efficiency Scores and Their Tax Dollar Equivalents[a]

Variable	*M*	SD
Efficiency Score 1[b]	0.9795	0.0151
Efficiency Score 2[c]	0.9778	0.0153
Revenue per student[d] ($)	4,281.92	893.95
Optimal revenue level ($)	4,371.6	908.996
Potential increases[e] ($)	89.678	70.768

[a] Total number of observations is 498.
[b] Efficiency Score 1 is the efficiency score estimation with the environmental variable.
[c] Efficiency Score 2 is the efficiency score estimation without the environmental variable.
[d] Revenue per student is the current level of revenue collection.
[e] Potential increase for an average school district is $89.678 for each year. In state-wide terms for 3 years, this result is $454,576 × 498 = $226,378,848.

These results indicate that there are some differences in school operation between city and county school systems. To further analyze this issue, a comparison using environmental variables was conducted. City school districts, on average, are located in highly populated and growing areas. Although the size of enrollment does not show any differences between county and city school districts, greater ethnic diversity is found in the city school districts. These results are shown in Table 7.[11]

There is evidence that city school systems incurred higher teaching and student-related labor expenditures per student and had higher than average teachers' salaries. Moreover, city school districts, including suburban county districts, tend to have greater ethnic diversity. These characteristics are not observed for school districts with lower efficiency scores. These results together suggest that different characteristics of students and special pro-

[10] Numbers in parentheses are the codes corresponding to the city/county.

[11] School district rankings of the first-top and last-bottom 50 are available from the authors by request.

Table 7. Comparison of County and City School Districts

Variable[a]	*M*	SD	t-value[b]
Efficiency score 1			
County	0.978	0.0152	
City	0.988	0.0117	−4.897*
LUNP			
County	0.494	0.1614	
City	0.440	0.1684	2.436*
STUTEA			
County	16.149	1.1922	
City	16.159	1.6252	−0.059
ADMSAL			
County ($)	52,732.16	4,395.62	
City ($)	55,536.39	5,441.72	−4.580*
TEASAL			
County ($)	32,053.03	2,231.25	
City ($)	34,009.93	2,993.68	−6.203*
QBE			
County ($)	2,890.41	354.0454	
City ($)	2,771.70	405.7392	2.440*

[a] Efficiency Score 1 is the efficiency score estimated with the environmental variable; LUNP is the proportion of students who participate in the free lunch program; STUTEA is the number of students per teacher; ADMSAL is the average administrator salary; TEASAL is the average teacher's salary; and QBE is the support from the QBE funds.
[b] The *t*-value * is significantly different from zero at $\alpha = 0.01$, ** $\alpha = 0.05$, and *** $\alpha = 0.10$. The *t*-statistic compares the means under the assumption of unequal variances. The total number of observations for counties is 435 and observations for cities is 63.

grams that support those students might contribute to increased efficiency scores. For example, if a city school district has a higher number of a particular type of student who receives a higher proportion of expenditure per student and more experienced teachers are allocated for these students, the results suggest programs supporting these students efficiently utilize budgets. Given the data limitations, specific program impacts cannot be evaluated. This result is, however, consistent with anecdotal evidence received from public school teachers in Georgia. These implications should provide useful information for Georgia educators to further investigate issues related to the QBE program.

The effect of input quality on education can be examined using the cross-sectional results on efficiency scores. Since efficiency scores fall between 0 and 1, and several observations are at the efficiency level of 1 (i.e., the variable has a limited range), a Tobit model can be used (assuming a normal distribution of errors) to estimate how school quality affects educational efficiency. To estimate quality affects on efficiency scores, the student/teacher ratio is regressed on efficiency scores. If the quality has a positive impact on efficiency scores, the estimated coefficient should be negative and significant (i.e., the lower the ratio, the higher the efficiency score). The Tobit regression shows that a smaller class size increases efficiency and supports Card and Krueger's (1992, 1996) and Finn and Achilles' argument that input quality matters and significantly affects the efficiency with which education is achieved (Table 8).

Summary and Conclusions

Researchers have found a positive relationship between the amount spent on education and

Table 8. Results of the Tobit Regression[a]

Variable	Estimate	Standard Errors	χ^2	*p*-value
Intercept	1.020	0.0102	9,925.977	0.0001
STUTEA	−0.003	0.0006	15.132	0.0001
Scale	0.017	0.0006		

[a] The dependent variable is efficiency scores; STUTEA is the number of students per a teacher; and the number of right censored values is 75.

educational outcomes, although others claim the impact is insignificant. Much of the previous research has employed regression analysis to estimate an average educational production function. In this analysis, an efficiency frontier was estimated to evaluate the relative performance of school districts' operation.

Difficulties faced in the analysis arose from inconsistency in educational data. Data descriptions have changed during the last several years, which made a yearly comparison difficult. The consolidation of data over years and across school districts was an obstacle. According to the Council for School Performance information, the cross-sectional comparisons or school district performance should be possible. Since the accountability of schools' performance is of interest to many voters, information on the relative performance of school districts should be available to the public. Furthermore, empirical studies rely on this data. Consistent data collection over time and across school districts and measurement of relative performance, rather than the absolute performance, should be areas of emphasis for all state departments of education. The political climate now demands accountability from public schools, and no comparable assessment can be made without consistent data.

In terms of school evaluation, a norm referenced test is the preferable proxy for educational performance. Although it can be argued that test scores are an intermediate output from the educational process, final outputs such as earnings potential and contributions to society are impossible to measure and link back to specific school districts. This study relied on a NRT as opposed to the GHSGTs, which are not readily comparable to other states. True accountability for each state (as suggested in the No Child Left Behind Act) and comparability between states would require NRTs applied across geographically or socially similar areas. Since Georgia students must compete against students from other states in the long run, a comparative measurement of student achievement would prove beneficial.

The results suggest that the quality of school inputs (as measured by student/teacher ratios) impacts the efficiency of school operation. Smaller class size has a positive impact on efficiency. It is also apparent that educational efficiency faces diminishing marginal returns. The school districts with the higher test scores increase efficiency at lower rates than school districts with lower test scores. However, the school districts with better students (as measured by the test scores) are still more efficient than the lower test score school districts. Since the initial test scores are an uncontrollable factor in school operations, this result suggests that the higher test score counties better utilized expenses to produce higher educational value-added.

Overall, the city school systems were found to produce higher educational value-added than the county school systems given their budget constraints. Further analysis of environmental factors might help identify a systematic pattern for efficient and inefficient counties. This result is of importance to rural counties who must compete directly with urban areas in attracting economic growth. Businesses tend to locate in areas where school districts are perceived to be succeeding and the quality of education is deemed "good." State agencies concerned with economic development should carefully study results such as those found here when finding ways to improve efficiency of local schools and to develop plans for recruiting and retaining of businesses.

In the end, accountability for schools should be based not solely on achievement levels as measured against national standards or by standardized test scores, but also on the efficiency with which these scores or standards are achieved. To penalize a lower achieving but higher efficiency school would send the wrong message to education administrators. Georgia school districts appear to utilize educational budgets with reasonable efficiency. Overall school efficiency is 98%, and the lowest district achieves a score of 93%. The average inefficiency is equivalent to a 2% increase in educational outputs. Although these scores seem impressive, the interpretation is not quite so positive when the cost of the inefficiency is considered. An interpretation of the average efficiency of 98% (or inefficiency of 2%) is that if all school districts were 100% efficient, outputs could be expanded 2%, or, at current efficiency levels, this could be achieved by increasing funding $75.46 million state-wide in total for each of the 3 years. From the consumers' (voters') point of view, this result suggests that inefficiency in school districts cost Georgia a total of $226.38 million,[12] on average, between the 1994 and 1996 academic years. Individual school districts achieving lower than average efficiency scores should be targets for more careful scrutiny in the use of tax dollars.

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[12] The amount $75.46 times 3 years.

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