LET NO CHILD BE LEFT BEHIND: DETERMINING THE COST OF IMPROVING STUDENT PERFORMANCE

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The No Child Left Behind Act of 2001 and recent legislation in a number of states have raised the standards for accountability in schools, with the objective of closing achievement gaps and increasing student performance overall. These new education policies, however, rarely address the way in which schools are financed. They ignore the fact that characteristics of schools and students require that some schools spend more than others to achieve any given student performance standard. To determine the characteristics that lead to variations in the costs of achieving a specified improvement in student performance, the authors estimate an educational cost function using data from elementary and secondary school districts in Texas. Results indicate that cost differences across districts can be quite large. The cost function results are summarized into a cost index that can then be used in a simple formula to guarantee that every district has sufficient fiscal resources to achieve state-imposed performance goals.

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Improving the quality of primary and secondary education is a top priority of the Bush administration and of members of both parties in

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Congress. In introducing his education proposals to Congress, the president highlighted the "academic achievement gap" that exists between students from rich and poor families and between White and minority children (Bush 2001). As evidence of the failure of the current system, the president cited the fact that "nearly 70% of inner city fourth graders are unable to read at a basic level on national reading tests." The primary goal of the administration's education policy is to close this achievement gap and to ensure that, in President Bush's oft-repeated phrase, "no child should be left behind."

To that end, the Bush administration proposed, and after extensive debate, Congress enacted, the No Child Left Behind Act of 2001. The new legislation mandates annual testing of all students in Grades 3 through 8 and requires that schools make annual progress in meeting student performance goals for all students and for separate groups of students characterized by race, ethnicity, poverty, disability, and limited English proficiency (U.S. Department of Education 2002). The underlying premise of the legislation is that schools must be held accountable for the academic performance of their students. The legislation will reward schools that succeed in meeting state-imposed achievement goals and will sanction schools that fail. The intent is that all students, but especially students from disadvantaged backgrounds, show annual improvements in their academic performance as measured against state standards. Measuring student performance is thus a necessary component in a policy designed to improve the quality of education. We doubt it is a sufficient policy.

In this article, we present evidence suggesting that measuring student performance, setting performance standards, and threatening to sanction schools that fail to meet these standards are unlikely to close achievement gaps unless accompanied by a restructuring of the financing of public education. It should be noted that although the new federal legislation represents the first time that all states will be required to test students on an annual basis, some states have been administering such tests for a number of years. Despite this testing and the publication of the results on an individual school basis, the performance of students in many schools, especially those serving disadvantaged children, remains substantially below average.

We suggest that the amount of money necessary to meet student performance standards will vary across school districts. This variation in *costs* will be due primarily to factors over which local school officials have little control. For example, a school district with a high concentration of students from poor families or from families where English is not spoken in the home may have to use additional resources (in the form of smaller classes or specialized programs) to reach specified achievement goals. Also, some districts, given their location and the composition of their student bodies, will have to pay higher salaries than other districts to attract high-quality teachers.

Requiring that all schools increase the academic performance of their students is a potentially important step in improving the quality of education in the United States. However, if cost differences among school districts are substantial, then imposing statewide student performance standards without simultaneously allocating more state financial aid to school districts with high costs may result in a situation in which school districts with above-average costs will not have enough resources to educate their students to meet the new standards. These schools may fail, not necessarily because of their own inability to effectively educate children but because they have insufficient fiscal resources to do the job.

Although the new federal education legislation does not explicitly address the connection between the cost of education and student performance, over the past decade the courts in a number of states have explicitly recognized the link between educational finance and student performance. In several states, the courts have declared state school-financing systems unconstitutional because they have failed to provide all students, and especially those from economically disadvantaged families, with a sufficiently high-quality education; in the language favored by the courts, these systems have failed to provide an *adequate* education (Minorini and Sugarman 1999). Prior to these recent court cases, the focus of most school finance reform had been on resources alone. All states, to one degree or another, use state grants to school districts to partially equalize the fiscal resources districts have available at a given rate of property taxation. In most states, grant formulas distribute aid inversely to the size of each district's per-student property tax base but fail to account for differences in costs among school districts, differences that may contribute to varying student performance.

It should be emphasized that providing schools with enough resources to achieve state-imposed student performance goals will not guarantee that schools will actually use those resources effectively to improve student performance. However, once state governments have guaranteed that all school districts have sufficient financial resources to achieve state education goals, then the states can be aggressive in taking steps to intervene in those districts that fail to improve student performance.

To determine the minimum amount of money a school district must spend to achieve a specified improvement in student performance, we estimate an educational cost function using data from elementary and secondary school districts in the state of Texas. Texas is a particularly interesting state to study for two reasons. First, as is now well known, Texas has been administering annual student performance tests to its public school students since 1990 and using these tests as the basis for an accountability system that includes monetary rewards for schools and graduation requirements for individual students (Murnane and Levy 2001). Second, spurred by a series of court challenges to its school-financing system, Texas's system of state financial aid to local school districts takes explicit account of many of the factors that studies in other states have found to be systematically related to the costs of education.

The rest of this article is divided into six sections. We start with a brief overview of the school finance system in Texas. Then, in the following section, we derive our cost function and discuss a set of estimation issues. The following section presents the econometric results of our cost function estimation. In the next two sections, we address the question of how state aid formulas could be adjusted to account for differences in costs across school districts. We first discuss the calculation of a cost index that allows us to summarize the results of the estimation and then demonstrate how such an index can be used in a formula designed to guarantee that every district would have sufficient fiscal resources to achieve any state-imposed student performance goals. In the final section, we draw some conclusions.

SCHOOL FINANCE IN TEXAS

During the 1995-1996 academic year, public schools in Texas educated more than 3.8 million students. Of the $19.8 billion of revenues raised for public education in 1995-1996, 52% came from local sources, 44% from the state government, and 4% from the federal government (Texas Education Agency 1998). The state of Texas is divided into 1,045 school districts, with 968 providing K-12 education. The state uses a complex mechanism for distributing state aid to these districts. The major elements of the state aid system involve a $280 per-student grant to each district; a foundation formula, with the $2,387 per-pupil foundation level of spending adjusted for diseconomies of scale and for differences across districts in the cost of resources; and a guaranteed tax base formula for districts with property tax rates in excess of $8.60 for each $1,000 of property valuation and per-pupil property tax bases below $210,000. Using a system of pupil weights, additional state aid is provided to school districts with concentrations of children from economically disadvantaged families and children eligible for various special education programs designated for those with disabilities and with limited proficiency in English.[1] Finally, a unique element of the Texas system of school finance is that property-wealthy districts (those with more than $280,000 per weighted pupil) are required to "reduce their wealth to this level." In most cases, this is accomplished by agreeing to educate students residing in other districts or by purchasing "attendance credits."[2]

Although there has been considerable debate among scholars concerning the magnitude of improvement in student performance, the Texas Education Authority has argued that student performance on state-administered exams has improved dramatically (Murnane and Levy 2001). Nevertheless, data from testing done during the 1995-1996 school year demonstrate that student performance in school districts with a high percentage of poor children and districts with a high percentage of minorities was substantially below average. For example, students in the 55 school districts where more than 75% of students came from poor households had composite test scores that were one and two thirds standard deviations below average. Average student performance in some Texas cities was even weaker. For example, the average score in Fort Worth was nearly two standard deviations below average and the average score in San Antonio more than three standard deviations below average.

COST FUNCTION ESTIMATION

Using data on per-pupil school expenditures, student performance, and various characteristics of school districts, we estimate a cost function for K-12 public education in Texas. Estimating a cost function allows us to quantify the relationship between per-pupil spending, student performance, various student characteristics, and the economic, educational, and social characteristics of school districts. We follow Bradford, Malt, and Oates (1969) in specifying the output of public schools (measured, for example, by student performance on standardized exams) as a function of school resources, such as teachers and textbooks, the characteristics of the student body, and the family and neighborhood environment in which the students live. This relationship is represented by Equation 1, where S_{it} represents an index of school output, $\boldsymbol{X}_{it}$ is a vector of direct school inputs, $\boldsymbol{Z}_{it}$ is a vector of student characteristics, and $\boldsymbol{F}_{it}$ is a vector of family and neighborhood characteristics. The subscript i refers to the school district and subscript t refers to the year.

$$S_{it} = g(\boldsymbol{X}_{it}, \boldsymbol{Z}_{it}, \boldsymbol{F}_{it}). \quad (1)$$

To move from this education production function to a cost function, a relationship between school inputs and educational spending is specified. This is shown in Equation 2, where per-pupil expenditures, E_{it}, are considered as a function of school inputs, a vector of input prices, $\boldsymbol{P}_{it}$, and $\boldsymbol{\varepsilon}_{it}$, a vector of unobserved characteristics of the school district.

$$E_{it} = f(\boldsymbol{X}_{it}, \boldsymbol{P}_{it}, \boldsymbol{\varepsilon}_{it}). \quad (2)$$

The final step involves solving Equation 1 for X_{it} and then plugging X_{it} into Equation 2. This gives the cost function represented by Equation 3, where u_{it} is a random error term.

$$E_{it} = h(S_{it}, \boldsymbol{P}_{it}, \boldsymbol{Z}_{it}, \boldsymbol{F}_{it}, \boldsymbol{\varepsilon}_{it}, u_{it}). \quad (3)$$

Typically, Equation 3 is assumed to be log linear and estimated with district-level data for a given state. In the next section, we present estimates of Equation 3 using 1995-1996 data for K-12 school districts in Texas. The dependent variable is the log of per-pupil expenditures (excluding spending on transportation). The resulting coefficients indicate the contribution of various district characteristics to the cost of education, holding constant the level of output. There is some discussion in the literature on education production functions about the desirability of using school-level data (Hanushek, Rivkin, and Taylor 1996). We use district-level data here for two reasons: First, state aid in almost all states is distributed to the district, and there is very little systematic information on how money is spent at the school level. Second, several of the school and community variables that we include in our analysis are available only at the district level. In the remainder of this section, we discuss a number of methodological and data issues that must be addressed to carry out the estimation.

As pointed out by Duncombe and Yinger (1999), estimating cost functions provides a practical way to identify and quantify the factors that influence the costs of education, in which the output of school districts can be measured using multiple measures of school performance. Although student performance can, in principle, be measured in various ways, many states measure the effectiveness of schools by relying on standardized exams. For several years, Texas has been testing all students in Grades 3 though 8 and in Grade 10 in reading and math. The tests are administered in the spring of each year as part of the Texas Assessment of Academic Skills (TAAS). Considerable media attention is paid to the test score results, and improvements in average test scores (or lack thereof) are monitored closely.

One of the ways in which this study differs from other cost function studies is in the use of a *value-added* measure of student performance in each school district. As a measure of school district output, we compare the average of the composite passing rate on the TAAS exams across Grades 4 through 8 and in Grade 10 in 1995-1996 with the average passing rates in Grades 3 through 7 of the same cohort of students in 1994-1995 and the 8th-grade TAAS passing rate in 1993-1994 (to match the 10th-grade passing rate in 1995-1996).[3] Robert Meyer

(1996) provided a strong argument for using a value-added approach to isolate the contribution of school resources to increases in student achievement. He pointed out that the use of average scores from a single grade measures the average level of achievement prior to entering first grade, plus the average effects of school performance and of family, neighborhood, and student characteristics on the growth of student achievement from all years of previous schooling. It is thus likely that rather than providing a measure of the contribution of schools to the growth in student achievement, the single grade score primarily reflects the impact of family and neighborhood environment on student achievement. In addition, many of the recent policy proposals regarding standards, including those of the Bush administration, have focused on *improvement* in test scores from year to year. The value-added approach is thus more useful for simulating the effects of actual policies.

In addition to the TAAS scores, we also include student performance on the ACT exams as a measure of the quality of the preparation of students for higher education. Using scores on these exams as a measure of school quality can be problematic, however, because students decide whether to take the exam. Only students with a particular interest in continuing on to college will choose to take these exams, and these are presumably the “best” students, so their scores may reflect their own abilities and motivation rather than any influence of the school. By treating these scores as endogenous, we are able to control for this self-selection. As an instrument for ACT scores, we include the percentage of students who take a college entrance exam.

Estimation of the cost function must take account of the fact that the educational output variables and per-pupil expenditures are determined simultaneously. That is, although local school board decisions to raise the level of student performance are expected to have direct implications for the level of spending, decisions concerning per-student spending are likely to influence student performance. To deal with this simultaneity, we estimate Equation 3 using two-stage least squares, with the school output variables treated as endogenous. As instruments for these school output variables, we draw on a set of variables that are related to the demand for public education. Following a long literature on the determinants of local government spending, we model the demand for public education as a function of school district residents' preferences for education, their incomes, and the tax prices they face for education spending. To the extent that the median voter model provides a reasonable framework for modeling school district spending decisions, it is appropriate to use median income and the tax price faced by the median voter as instruments.[4] We also include as instruments two socioeconomic variables that may be related to the preferences for public education: the percentage of households with children and the percentage of household heads who are home owners.[5, 6]

For school input prices, we focus only on teacher salaries. Teachers are the single most important factor in the production of education, and not surprisingly, teacher salaries account for the largest share of school expenditures. It is important, however, to recognize that teacher payrolls are determined both by factors under the control of local school boards and factors that are largely outside of their control. In setting hiring policies, districts make decisions about the quality of teachers they wish to recruit. These decisions have obvious fiscal implications. For example, a district can limit its search for new teachers to those with advanced degrees, those with high grade-point averages, or those with a certain number of courses in their teaching specialty. Teacher salary levels are generally determined through a process of negotiation with teacher unions, and school boards have a substantial impact on the outcome of these negotiations. At the same time, the composition of the student body, working conditions within schools, and area cost of living play a potentially large role in determining the salary a school district must offer to attract teachers of any given quality. These factors will be reflected in student and district cost variables, to be described below. We would therefore like a measure of teacher salaries that reflects only salary differences that are outside the control of local school districts. One such measure is the teacher cost index developed by Jay Chambers (1995). Using 1990-1991 data from the nationally representative *Schools and Staffing Survey*, Chambers estimated hedonic wage equations for teachers. He isolated those factors that are outside the control of the local school district (such as the racial composition of the student body, local climate, crime rates, etc.) and used the coefficients for just those factors to construct a teacher salary index for each district in the country. By using this index as our measure of teacher salaries, differences across districts reflect true differences in costs rather than differences in school board choices.

The vectors of student, family, and neighborhood characteristics, $\boldsymbol{Z}_{it}$ and $\boldsymbol{F}_{it}$, include several variables that influence a district's level of spending per pupil. First, there is considerable evidence that there are higher costs associated with the education of children from low-income families. To measure the number of children from economically disadvantaged families, we use the percentage of students who qualify for the federal government-financed Free and Reduced Price Lunch program or other public assistance. Second, there is a substantial literature that documents the extra costs associated with educating students with various kinds of disabilities and students who enter the schools with limited knowledge of English. Therefore, we include the percentage of students who have been identified as limited English proficient and two measures of disabilities: the percentage of students who are classified as having any type of disability and the percentage of students who are classified as autistic, deaf, or deaf/blind. Third, to reflect the possibility that more resources may be needed to provide a high school as compared to an elementary school education, we also include the proportion of each school district's student body that is enrolled in high school. Finally, to reflect potential diseconomies of scale associated with both small and large school districts, we include each district's enrollment and enrollment squared. Summary statistics of all variables are presented in Table 1.

The variable $\boldsymbol{\varepsilon}_{it}$ in Equation 3 represents the unobserved factors in each school district that influence district spending. One such factor is the "inefficiency" of the district. That is, even after accounting for differences across school districts in cost factors, input prices, and student performance, some school districts will have higher levels of per-pupil expenditures than other districts because those school districts are inefficient. This could mean that they are inefficiently organized or managed or that they use ineffective teaching techniques or employ a particularly ineffective group of teachers.

A number of recent articles have used complex statistical techniques to identify spending that is high relative to spending in districts with similar student performance and costs.[7] Although great care must

TABLE 1: Descriptive Statistics

Variable	*Mean*	*Standard Deviation*	*Minimum Value*	*Maximum Value*
Per-pupil expenditures, 1995-1996 (excludes transportation) ($)	5,565	1,039	2,907	11,444
Composite Texas Assessment of Academic Skills (TAAS) pass rate, 1995-1996	79.6	8.3	51.3	96.2
Composite lagged TAAS pass rate, 1993-1995	75.5	9.5	37.1	95.4
Average ACT score	19.9	1.6	15	26
Teacher salary index	84.5	9.2	62.2	107.5
Percentage of students eligible for free and reduced-price lunch and other public assistance	44.4	18.3	0.1	100.0
Percentage of students with disabilities	13.4	4.0	0.7	36.6
Percentage of students with severe disabilities	0.21	0.20	0	1.82
Percentage of students with limited English proficiency	6.5	10.5	0	72.5
Percentage of students enrolled in high school	28.6	3.2	16.2	49.9
Student enrollment	4,081.5	8,614.1	124	74,772
Efficiency index	0.59	0.12	0.3	1
Tax price	0.5	0.3	0	1
Percentage of households with children	34.8	7.7	16.2	70
Percentage home owners	73.7	10.3	0.0	99.2
Median income ($)	23,814	7,258	8,196	58,135
Percentage of students taking college entrance exams	65.1	14.6	21.4	100

be taken in interpreting this extra spending as a measure of inefficiency, we include in our cost function estimates an efficiency index calculated using data envelopment analysis. Data envelopment analysis is a nonparametric estimation procedure that compares each district to a production frontier. Thus, after controlling for student performance and cost differences, lower spending districts are considered to be operating with "best practices," whereas any extra spending may be interpreted as a measure of school district inefficiency.

COST FUNCTION RESULTS

To account for the large variance in district size in Texas, we weight the regressions by district enrollment and drop Dallas and Houston from the sample. Because of missing test scores, we were also forced to exclude 163 of the 968 K-12 school districts. These excluded districts tend to be somewhat smaller, poorer, and higher spending than the 803 districts that remain in our sample and that provide the basis for the cost function estimation.

Recall that we treat the school outcome variables as endogenous and estimate Equation 3 using two-stage least squares. The results from the first-stage regressions are shown in Table 2. Although some of the instruments are not statistically significant, the instruments are jointly significant in each regression. There is likely a high degree of multicollinearity among the instruments and the independent variables that may be contributing to the imprecision of the estimates. As might be expected, in the regression for the TAAS exams, the lagged TAAS score is the clearest indicator of current performance. The other independent cost variables are generally negatively correlated with student performance.

The first two columns of Table 3 present cost function results that include a measure of school district efficiency, whereas the second two columns are estimated without that variable. The test scores have the expected signs; because lagged scores are a proxy for past levels of students achievement, high scores means that districts can spend less to achieve a given level of educational progress. The cost variables generally have the expected signs, and many are statistically significant. Consistent with previous studies, we find a U-shaped relationship between spending per pupil and school district size; with our estimates, the bottom of the U is at roughly 22,026 students when the efficiency measure is included and 9,115 when it is not included. In contrast to the results of some other studies, we find that costs do not appear to be higher for high school students, although that variable is not statistically significant.

The differences in the cost functions with and without the efficiency measure highlight one of the drawbacks of the technique we use to measure efficiency. Our measure of efficiency captures the effect of *all* factors that lead spending to be higher than the minimum

TABLE 2: Education Cost Function, 1995-1996, First Stage Regression, 803 Texas K-12 School Districts

	Dependent Variable			
	Log of 1995-1996 TAAS Score		*Log of Average ACT Score*	
Independent Variable	*Coefficient*	t *Statistic*	*Coefficient*	t *Statistic*
Intercept	0.944*	8.721	2.119*	13.194
Tax price	–0.005	–0.773	0.037*	3.826
Percentage of households with children	0.056*	2.469	–0.140*	–4.156
Percentage home owners	–0.011	–0.812	–0.078*	–3.752
Median income	0.001	0.124	0.056*	4.106
Percentage of students taking college entrance exams	–0.002	–0.175	0.007	0.511
Lagged TAAS	0.779*	53.755	0.123*	5.742
Teacher salary index	0.000	1.030	–0.001*	–5.242
Percentage of students eligible for free and reduced-price lunch	–0.011	–0.806	–0.148*	–7.165
Percentage of students with disabilities	–0.021	–0.476	0.037	0.560
Percentage of students with severe disabilities	–0.854	–1.080	–0.651	–0.556
Percentage of students with limited English proficiency	–0.069*	–4.319	0.008	0.342
Percentage of students enrolled in high school	0.107**	1.858	–0.034	–0.393
Log of student enrollment	0.006	0.551	0.009	0.547
Square of log of student enrollment	–0.001	–0.898	0.000	–0.390
R^2	0.937		0.728	

NOTE: TAAS = Texas Assessment of Academic Skills.
*$p < .05$. **$p < .10$.

cost of providing any given mix of public school output. Thus, school districts with above-average spending on things not measured by standardized tests (e.g., advanced music and arts courses) will be characterized as inefficient. Also, higher spending that is attributable to the higher costs of, for example, educating an above average share of economically disadvantaged students will, in part, be characterized as "inefficiency." As pointed out by Duncombe, Ruggiero, and Yinger (1996), the fact that these higher costs will be attributed in part to the efficiency measure and in part to the cost factors explicitly included in the cost function will mean that the cost function estimates with the efficiency measure will provide an underestimate of the full effects of the cost factors on education spending. This could explain, for example, why the coefficients on many of the cost factors increase when we do not include the efficiency measure. On the other hand, the coefficients in the model without the efficiency measure may be biased upward. We suspect that the "true" cost effects lie somewhere in between those indicated by the cost functions estimated with and without the efficiency adjustment.

In summary, our estimated cost function suggests that in Texas, characteristics of school districts beyond the control of local school officials contribute to the amount of money needed to achieve any given level of student performance. This implies that equal per-pupil spending should not be expected to result in equal student performance gains in all districts.

COST INDEX CONSTRUCTION

Estimating a cost function provides information about the contributions of various characteristics of school districts to the costs of education. The calculation of a cost index allows for the summarization of all the information about costs into a single number for each district. For example, if we assume that the policy makers in a state define the minimum standard for an accountability system as the current average level of student performance, then a cost index can be constructed that will indicate, for any given district, how much that district must spend, *relative to the district with average costs*, for its students to meet the state's student performance standards.

To demonstrate the calculation of cost indices, we set the TAAS scores and ACT scores at the average for all Texas districts. As discussed above, we use a value-added measure of student achievement in our cost function. Thus, the coefficient on 1995-1996 scores reflects the increase in spending associated with an increase in student performance *given* an initial level of test score performance in 1994-1995. In calculating the cost index, we set the lagged score equal to the

Table 3: Education Cost Function, 1995-1996: 803 Texas K-12 School Districts

	Dependent Variable Log of Expenditures per Pupil			
Independent Variable	*Coefficient*	t *Statistic*	*Coefficient*	t *Statistic*
Intercept	3.23**	1.66	–2.29	–0.47
Log of composite TAAS pass rate, 1995-1996	3.34*	2.25	7.29*	2.02
Log of lagged composite TAAS pass rate, 1993-1995	–2.53*	–2.16	–5.93*	–2.04
Log of average ACT score	1.03*	3.40	1.76*	2.44
Teacher salary index	0.0015**	1.88	0.0031*	2.10
Percentage of students eligible for free and reduced-price lunch	0.12	1.64	0.57*	2.92
Percentage of students with disabilities	0.02	0.12	0.55	1.42
Percentage of students with severe disabilities	3.58	1.03	9.43	1.29
Percentage of students with limited English proficiency	0.41*	3.86	0.66*	2.63
Percentage of students enrolled in high school	–0.20	–0.63	0.20	0.32
Log of student enrollment	–0.20*	–4.25	–0.31*	–3.24
Square of log of student enrollment	0.01*	3.95	0.017*	3.05
Efficiency index	–1.08*	–9.91		
SSE	8.571		8.571	

NOTE: TAAS = Texas Assessment of Academic Skills.
*$p < .05$. **$p < .10$.

average as well; thus, our performance standard is not the average *level* of student performance but the average *gain* in performance, that is, the average increase in the percentage of students passing the TAAS exams. The values of the cost factors are allowed to vary for each district, so we predict the level of spending required for each district to achieve this average gain, given their actual costs.

We want to emphasize that alternative performance standards could be used to calculate the cost index; we use the average gain in scores here only as an example. The use of a different standard will not affect the relative ranking of districts in terms of their costs but will change their absolute cost index values and thus will influence any distribution of state aid that depends on the cost index.

Using the cost function estimated without the efficiency index, we calculate that the school district in Texas with average costs (i.e., where each of the cost factors is set equal to its mean) must spend $5,610 per pupil (in 1995-1996) to reach our performance standard. For any given school district, the product of this number and its cost index (divided by 100) will indicate the minimum amount that district must spend to meet the student performance goal. Thus, for example, a Texas school district whose cost index is 125 will need to spend $7,012 per student ($5,610 times 1.25) to reach the student performance standard.

The first column of Table 4 shows the variation in costs across K-12 school districts in Texas. The district with the lowest costs could achieve average performance by spending about two thirds as much per pupil as the district with average costs. At the other extreme, the district with the highest costs must spend almost twice as much as the average cost district to provide an average educational outcome for its students. The large range of the index reflects in part the values of the index in a few districts. Ignoring the 10% of districts with the lowest index values and the 10% of districts with the highest values substantially reduces the range of the cost index. The *restricted range* in Table 4 shows that the district at the 10th percentile has costs that are about 20% below average cost and the district at the 90th percentile has costs that are 20% above average.

When the estimated cost functions include no measure of efficiency, it is possible that we are interpreting extra spending that is caused by inefficiencies on the part of school districts as higher costs. When a measure of efficiency is included in the calculation of the cost index, the maximum cost index falls from 192 to 136. This suggests that the high cost index numbers for some districts may reflect in part some degree of inefficiency on the part of these local school districts. It is important to emphasize that even after adjusting cost indices for inefficiency, the variation in costs across districts remains substantial. The correlation between the indices with and without the efficiency measure is 96%, suggesting that including a measure of efficiency has relatively little affect on the rank ordering of districts in terms of costs but can significantly reduce the range. As mentioned previously, how-

TABLE 4: Distribution of Education Cost Indices

	Cost Index With No Efficiency Adjustment	*Cost Index With Efficiency Adjustment*	*Texas Index*
Mean	100.0	100.0	100.0
Median	96.4	98.4	98.0
Standard deviation	17.7	7.1	14.9
Range	124.8	49.8	83.3
Minimum	67.1	86.7	75.1
Maximum	191.9	136.5	158.4
Restricted range	38.0	14.8	36.3
Minimum at 10%	82.1	93.0	83.3
Maximum at 90%	120.1	107.9	119.6
Correlations			
Cost index with no efficiency adjustment	1.000		
Cost index with efficiency adjustment	0.959	1.000	
Texas index	0.513	0.558	1.000

ever, one must take care in interpreting this difference as entirely attributable to inefficiency.

The school finance system in Texas distributes state aid to local school districts using several formulas that include a number of adjustments for cost differences across districts. Although the formulas do not include a single cost index, they do include separate adjustments for cost-of-living differences, for diseconomies of scale in small and midsize districts, and for the higher costs necessary to provide education to students from economically disadvantaged families, students with disabilities, and students with limited proficiency in English. Although the cost-of-living adjustments were developed from a careful empirical study, the origin of the other weights and adjustments is unclear. We suspect, however, that the explicit and implicit weights given to each of these cost factors were determined as a result of complex political negotiations and thus are not likely to reflect true cost differences. In contrast, the weighting of each cost factor in our cost index comes from the parameter estimates of the cost function. If our cost function is estimated correctly, these weights indicate the relative contribution of each cost factor to the overall costs of achieving a given student performance standard.

To determine whether the current set of cost adjustments used in the distribution of state aid in Texas is compatible with reaching student performance standards throughout the state, we compare our cost index to an *implicit* index generated from the Texas aid program. To construct this index, we add together the basic foundation level (called the "basic allotment" and equal to $2,387 in 1995-1996) and the total amount of each district's *special* allotments reflecting all of the cost adjustments mentioned previously (for district size, for student disabilities, etc.). For each district, this sum is converted into an index number by dividing each sum by $3,453, the mean value of these sums across all districts.[8] Summary statistics of the resulting index, labeled Texas Index, are shown in the third column in Table 4.

Although the range and the restricted range of the Texas index are between the ranges of the two variants of our cost index, the simple correlations between our indices and the implicit Texas index are relatively low—0.558 and 0.513 for our indices with and without the efficiency adjustment, respectively. As we shall demonstrate below, there are two important reasons why the indices differ. First, our index is quite highly correlated with the percentage of children from economically disadvantaged families, whereas the correlation between poverty and the implicit Texas index is much weaker. Second, although our cost function indicates that diseconomies of scale contribute to higher costs in small districts, the aid adjustments for small district size in the Texas aid formulas are much larger than the importance of small size indicated by our cost functions.

THE DESIGN OF SCHOOL FINANCE FORMULAS

Foundation formulas are currently used by the majority of states to distribute state aid to local school districts. The formulas are designed so that each school district that uses a state-determined "minimum" property tax rate will be able to achieve a "foundation" level of per-pupil spending. If costs were identical in all school districts, then the state could guarantee that each school district had sufficient resources to achieve the state-specified minimum performance level by defining the foundation level as the spending necessary to produce that particular level of "output."

The results presented in the previous section indicate that costs (at least in Texas) differ substantially among school districts. Thus, to guarantee that all school districts within a state will have sufficient resources to meet state performance standards, it is necessary to develop a foundation formula where the foundation level of spending varies according to differences in costs across districts and where the average foundation level equals the dollar amount necessary to meet the performance standards in districts with average costs.

A conventional foundation aid formula is presented in Equation 4, where A_i equals foundation aid per pupil in district i, E^* is the foundation level of per-pupil spending, t^* the mandated local property tax rate, and V_i the property value per pupil in school district i:

$$A_i = \text{MAX}\{E^* - t^*V_i, 0\}. \quad (4)$$

To adapt a foundation formula so that it will guarantee that every district has sufficient resources to meet the state's performance standards in our example, measured as the average gain in test scores, requires a determination of the amount of money school districts with average costs need to meet the state standard. Referring to this standard as S^*, $\hat{E}$ can be defined as the amount a school district with average costs must spend to meet the standard. A foundation formula designed to guarantee that every school district has sufficient resources to achieve S^* can be written as

$$A_i = \text{MAX}\{\hat{E}\, c_i - t^*V_i, 0\}, \quad (5)$$

where c_i is the value of the cost index in school district i.[9] To demonstrate the use of this formula using Texas data, we define $\hat{E}$ as the expenditure needed to achieve the average ACT scores and average TAAS performance gain in a district with average costs. The amount of aid allocated to district i using this cost-adjusted foundation aid formula will be a function of the per-pupil property wealth in district i and the relative costs in district i. We have chosen as the foundation level of per-pupil spending \$5,610, the amount needed to achieve the average performance in a district with average costs. Our choice for the required property tax rate (t^*) is 8.6 mills (or 0.86%), which was the actual required mill rate for the first tier of the Texas foundation program in 1995-1996.

The El Paso school district can be used to provide an example of the operation of the cost-adjusted foundation formula. In 1995-1996, El Paso had more than 64,000 students, 80% of whom were nonwhite, and two thirds were from poor families. El Paso's cost index was 29% above average when the index was calculated without an efficiency measure and 12% above average when the efficiency measure was included. These index values imply that to achieve the average gain in student achievement, El Paso will need to spend between 12% and 29% more than the district with average costs. State aid could provide these funds by establishing a cost-adjusted foundation level for El Paso between \$6,283 (1.12 × \$5,610) and \$7,237 (1.29 × \$5,610).

As discussed in the previous section, various cost factors and pupil weights influence the distribution of state aid in Texas. To focus on how the distribution of state aid would change by replacing the existing weights and adjustments with ones that are derived from our estimated cost function, we conducted several simulations of Texas school aid using a cost-adjusted foundation formula with alternative cost adjustments. The first two columns of Table 5 summarize the distribution of cost-adjusted foundation aid using our cost index, without and with the efficiency measure. The next column of Table 5 shows the distribution of aid using the Texas index. Recall that the Texas index reflects the pupil weights and other cost adjustments used in the actual distribution of state aid in academic year 1995-1996. All three simulations use the same foundation level ($\hat{E}$) and required tax rate (t^*).

The simulation results show that including an efficiency measure in the cost function used to construct the index has little effect on the size of the average grant but substantially reduces the magnitude of the largest grant.[10] Distributing grants using the cost-adjusted formulas based on our cost index would have required an aid budget of \$13.7 billion. Distributing aid using the Texas index would require an aid budget of only \$11.9 billion because the Texas index would distribute the largest per-pupil grants to the smallest school districts.

TABLE 5: Distribution of Aid Per Pupil Under Alternative Cost-Adjusted Foundation Formulas

	Cost Index (With No Efficiency Measure) (%)	*Cost Index (Including Efficiency Measure) (%)*	*Cost-Adjusted (With Texas Index) (%)*	*Percentage Difference Between Average of Cost Index Formulas and Texas Index Formula*
Mean	4,170	4,167	4,154	0.3
Standard deviation	1,580	1,200	1,325	4.9
Minimum	0	0	0	
Maximum	10,560	7,400	7,941	13.1
Total aid (in billion $)	13.7	13.7	11.9	15.1
District size quintiles				
1 (smallest)	4,236	4,202	4,385	–3.8
2	3,737	3,961	3,409	12.9
3	4,575	4,328	3,725	19.5
4	3,900	4,038	3,415	16.2
5 (largest)	4,534	4,280	3,564	23.6
Percent poor quintiles				
1 (fewest poor)	2,977	3,652	3,431	–3.4
2	3,557	3,891	3,953	–5.8
3	3,857	3,943	3,970	–1.7
4	4,587	4,350	4,475	–0.1
5 (most poor)	6,407	5,307	5,109	14.6

The differences in the pattern of aid distribution can be seen most clearly in the bottom two panels of Table 5. In the middle panel, we have divided school districts into pupil-weighted quintiles by district size. Each quintile thus includes approximately the same number of students but a different number of districts. Included in the first quintile are the 595 school districts with enrollment below 3,320, whereas the fifth quintile contains just 11 school districts, all of which have enrollments in excess of 43,550. The data show clearly that the Texas school aid formula allocates more aid to small school districts and considerably less aid to large school districts than would a foundation formula based on cost adjustments derived from our estimated cost functions. Comparing the average aid allocation from our two cost index simulations (with and without the efficiency measure) with the aid allocation from the Texas index simulation, aid would increase by nearly 25% in the largest district-size quintile, whereas aid would be reduced by about 4% in the smallest size quintile.

The data in the bottommost panel of Table 5 divide school districts into pupil-weighted quintiles by the percentage of district enrollment that is poor. Although all three simulations generate larger per-pupil grants to school districts with concentrations of poor pupils, comparing the aid distributions indicates that our cost functions imply a higher weight on concentrated poverty than the weight given to poverty in the actual Texas school aid formulas. On average, the two cost index simulations generate a 15% larger per-pupil grant in the highest poverty quintile than the grant generated by the pupil weights used in the existing state aid formulas.

By definition, the first two simulations in Table 5 are designed to distribute state aid in such a way that every school district would be provided with an amount of revenue sufficient to enable them to achieve at least the current state average gain in TAAS scores. Our cost function results clearly indicate that improving student performance requires additional resources. It is thus not surprising that the $13.7 billion budget for implementing either one of the cost-adjusted aid foundation formulas will be greater than the amount the state actually spent on school aid. In fact, for the 1995-1996 academic year, the state distributed $6.8 billion in state aid to the 800 school districts included in the simulations.[11] This implies that to provide all school districts with sufficient revenues to achieve average gains in TAAS scores would have required a doubling of state aid (actually a 101% increase in aid). To put this increase in state aid in context, Texas in 1995-1996 was a relatively low-spending state. At $5,473, it ranked 33rd in expenditures per pupil (National Center for Education Statistics 1998). In addition, at 42.9%, the state government's share of total education revenue was below the national average. The state share of education funding was higher in 31 other states. If the state government had increased aid to local school districts by 85%, the state share would have risen to 60.2% of total revenue, a share that would have still been lower than the state share in 11 other states.

CONCLUSIONS

Policy debates are raging about how student performance should be measured, the type of tests that should be used, and the appropriate role testing should play. Despite strong disagreement concerning the answers to these issues, there appears to be a growing consensus that measuring student academic performance is absolutely necessary if the quality of education provided to many of the nation's poor children is to improve. In this article, we have argued that if states are going to require their students to meet these more rigorous educational goals, they must recognize that achieving these goals will require more resources in some school districts than in other districts for reasons that are outside the control of local school officials. This implies that a necessary, though not sufficient, condition for achieving any given performance goal is that state fiscal assistance to local school districts account explicitly for differences in costs across districts within a state. We have demonstrated that a cost-adjusted foundation formula can be an effective instrument for this purpose.

We use data from Texas to show that it is possible to measure cost differences across districts and that these cost differences are large. We then demonstrate the use of cost-adjusted foundation formulas as a mechanism for distributing state aid in a way that will enhance the chances that a state can meet its student performance goals. In Texas, where cost considerations already play a major role in the distribution of state aid to local school districts, we conclude that reforming the existing state aid formulas to provide a heavier weight to children from economically disadvantaged families and a lower weight to small, mainly rural districts would better align the distribution of fiscal resources with the underlying costs of education.

It is important to note that the debates over education standards center around two different educational goals. In this article, we have focused on the goal of annual improvement in student performance. But a second goal involves bringing all students (or groups of students, characterized by race, gender, or location) up to a target performance *level*. Policies in a number of states requiring graduation tests and prohibiting social promotions are examples of absolute student performance standards. The total cost of achieving any absolute standard in a particular school or school district depends in large part on the size of the achievement gap between the current level of student achievement and the standard.

Because the level of student achievement in a number of Texas school districts is substantially below the average level of achievement, it is not surprising that these districts will require a substantial infusion of new resources if they are to close the achievement gap. We recalculated our cost index so that it indicated the cost, relative to the district with average costs, of reaching the statewide average level of student achievement on the TAAS.[12] The range of the resulting indexes increased substantially; the school district with the highest costs had an index value of 718 with no efficiency adjustment and 220 with the efficiency adjustment. To implement a cost-adjusted foundation formula that would guarantee each school district enough money to reach the average student performance level would require a substantial increase in the size of the state aid budget—to $21.2 billion without the efficiency measure and to $16.9 billion with the efficiency measure.

In this article, we have demonstrated that the costs of achieving a gains-based standard (in our example, the statewide average annual gain in test scores) will vary substantially across school districts. To ensure that all school districts have adequate resources to sustain annual student performance gains, districts with higher costs will have to be guaranteed additional state fiscal assistance. If annual achievement gains can be maintained, then over time, low-performing school districts will be able to meet absolute student achievement goals. Obviously, school districts with the lowest levels of current student performance will take the longest time to reach state-imposed standards.

One of the most contentious issues in the debate surrounding the reauthorization of the Elementary and Secondary Education Act was whether low-performance schools should be required to achieve state-imposed performance standards within a fixed number of years. Our estimated cost functions could be interpreted as suggesting that if a school district with high costs is provided with sufficient additional funds, it could fully offset the disadvantages of higher costs in a single year. We believe that this implication is not justified. In fact, school districts with large achievement gaps will, under most circumstances, take more time to reach any specified state standard than districts with smaller gaps. From a purely statistical point of view, using our estimated cost function to reach conclusions about the money needed to close any given achievement gap within a year generally requires extrapolation beyond the data.[13] More important, in recent years there have been substantial advances in the development of teaching techniques that are effective in improving the academic performance of low-achieving students. Experts on learning recognize, however, that the processing of new knowledge, information, and concepts takes time (Bransford, Brown, and Cocking, 2000). Although there is only limited research on the time needed to acquire and process knowledge, it is probably unrealistic to expect that students who are currently performing at substantially below grade level can catch up within a single year even if additional resources are devoted to their education.

Although providing additional financial aid to school districts with large achievement gaps is a crucial step toward reducing those gaps, it is also likely that in many school districts, a large, sudden increase in state aid would not be used effectively to increase student performance (Duncombe and Yinger 2000). Providing new money to schools and school districts with above-average costs is likely to be most effective in increasing student performance if it is phased in over a period of years.

Specifying a fixed time limit within which state performance standards must be met and imposing sanctions on those districts failing to meet the deadline is likely to penalize school districts that are currently performing at low levels, even if these districts succeed in making adequate annual progress in improving their students' test scores. Such a policy could lead to discouragement instead of improved achievement. Because an important role of higher student performance standards is to create incentives for schools, teachers, and students to increase the amount of learning that occurs, such standards must be set at reasonable levels.

There are still many issues to resolve in how educational costs and school outputs are measured and in how to reform policy to account for these costs, but it is clear that improving the educational performance of all students requires the annual measurement of student performance, the setting of reasonable goals, and the allocation of state and federal aid to school districts in a way that recognizes differences among school districts both in fiscal capacities and in the costs of providing education.

NOTES

1. For the 1995-1996 school year, 12.3% of state aid was distributed in the form of per-capita grants, 65.7% through the foundation aid formula (Tier 1), and 22% through the guaranteed tax base formula (Tier 2).

2. See Texas Education Agency (1998) for a full description of these provisions.

3. Test scores represent the same students in the two academic years to the extent that interdistrict student mobility is relatively low. A recent study of elementary school students in Texas by Hanushek, Kain, and Rivkin (2001) found that roughly 86% of fourth to seventh graders remain in the same district from one year to the next.

4. We use the tax price implied by Texas's aid formula.

5. As mentioned previously, we also include the proportion of students who take a college entrance exam as an instrument for ACT scores.

6. In the results presented in the next section, the 1995-1996 Texas Assessment of Academic Skills (TAAS) scores are treated as endogenous, but the lagged scores are not. Hausman specification tests could not reject the null hypothesis that the lagged scores are exogenous.

7. See, for example, Bessent and Bessent (1980); Deller and Rudnicki (1993); Duncombe, Ruggiero, and Yinger (1996); McCarty and Yaisawarng (1993); and Ruggiero (1996).

8. In 1995-1996, the cost adjustments and weights used in the state aid formulas resulted in $1,066 in additional state aid (above the basic allotment of $2,387) in the average district. The sum of these two numbers equals $3,453.

9. See Ladd and Yinger (1994) for a detailed derivation of a cost-adjusted foundation formula.

10. Ranking per-pupil grants by size, the grant at the 90th percentile is $580 larger when the efficiency measure is not included in the cost index calculation compared to the 90th percentile grant when the efficiency measure is included.

11. Because of missing data, three school districts had to be dropped before conducting the aid simulations reported in Table 5.

12. In the estimation of the cost function, lagged student performance is treated as an endogenous variable because, as with current performance, it is, in part, a choice of the district. In creating the cost index, we want to abstract away from any variation that is under the control of the district. Thus, to account for the endogeneity of the lagged scores, we calculate the cost index using predicted lagged scores, with the predictions based on the coefficient estimates from the first-stage regression, actual values of the cost factors, and state average values of for the demand instruments. That is, a district's predicted lagged score reflects the score expected from a district with average preferences and observed cost factors. Put together with the average 1995-1996 score, the level of spending predicted by the cost function is the spending required to reach average achievement given average tastes for education and actual cost factors.

13. If a high-cost district has a cost index value of 300, this implies that this district will need to spend three times as much per pupil as the district with average costs for its students to reach the student performance standard, say average performance on the TAAS. Although this conclusion may be correct, assuming that it can be achieved within a single year requires that we use our estimated cost function to extrapolate beyond our data; that is, there are no school districts that achieve average student performance while spending three times the spending level in the district with average costs.

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