Grade-Dependent Costs of Education:

Evidence from Illinois

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In this paper, I estimate cost functions for public education in Illinois and examine whether there are differences in the cost structures of K-12, elementary and high school districts and the implications of these differences for policy. I use the cost function results to generate cost indices for each district type. I find that the cost structures of unified and separated districts are likely to be different. Assuming that they are the same can lead to an over-statement of costs in elementary districts and an under-statement of costs in high school districts.

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I. Introduction

During the last decade, school finance reform in America has been shifting focus from the equalization of resources across districts to equalization of educational outcomes and accountability for those outcomes. This shift has sparked new research on the costs of achieving an adequate education and how such costs can be incorporated into the way in which states distribute aid to districts. This paper examines the cost structures of unified K-12, elementary and high school districts in order to ascertain whether each should be treated differently under a state aid program.

A number of authors have estimated state educational cost functions and used the results to develop cost indices that can be used to guide the distribution of state aid so that higher cost districts receive additional resources (e.g., Duncombe and Yinger, Imazeki and Reschovsky). However, previous studies have not distinguished between districts that serve different grade levels. Instead, all districts have been grouped together or analysis has been restricted to unified K-12 districts. Although there are practical reasons for doing this (e.g., data availability or small sample size), the policy question is whether the same cost function can be used to describe the cost structure of K-12, elementary and high school districts. If not, then great care must be taken in how costs are estimated and in applying the results of a cost analysis to individual districts.

This paper compares the cost functions for K-12, elementary and high school districts in Illinois and uses these cost functions to generate cost indices. It is found that the cost structures of unified and separate elementary and high school districts in Illinois do differ in specific ways. In particular, high school districts exhibit higher returns to scale and are more sensitive to changes in teacher salaries. Average costs are highest among high school districts and costs are also more variable. Furthermore, the results suggest that assuming the K-12 cost function applies identically to elementary and high school districts may cause over-estimates of the costs in elementary districts and under-estimates of costs in high school districts

In the next section, some general background on educational costs is presented. This is followed by a discussion of the estimation of educational cost functions and how such functions are used to develop cost indices. Section IV contains a discussion of the data used in the analysis and some of the issues involved in estimating separate cost functions for the three types of districts. Estimation results and a comparison of cost indices generated from different cost functions are presented in sections V and VI, and the paper concludes with a discussion of the policy implications of using different cost function specifications.

II. Background and Related Research

During the 1970's and 1980's, several states made reforms to their systems of school finance with the goal of equalizing the distribution of resources across districts, often under the direction of state courts. As public schools traditionally have been funded primarily with revenues from local property taxes, large disparities in spending can arise due to differences in community property wealth, even when the same tax rate is levied. School finance reforms sought to break this connection between per-pupil spending and property wealth. In many states, these reforms have been quite successful. However, as the distribution of resources has become more equitable, inequities in student performance have persisted. This has led the courts and policymakers to turn their attention to student outcomes more directly. In recent decisions, the courts in some states have argued that state governments are responsible for ensuring that all students receive an "adequate" education, where adequacy is defined as minimum standards of student performance.[1] These decisions essentially require that states develop a system of school finance that, rather than guaranteeing equal resources to all districts, guarantees an adequate education to all students.

In the movement toward adequacy, policymakers are beginning to recognize that school finance policies need to account for the fact that districts do not face equal costs. The cost of education can be defined as the minimum amount of money that a school district must spend in order to achieve a given educational outcome. Studies in several states indicate that the cost of education is not the same across all districts and that costs vary for reasons that are outside the control of the district. For example, districts with high proportions of special education, low-income and limited-English proficient students must spend more (for additional supplies, teachers, aides, etc.) in order to reach the same level of performance as other districts. Costs will also be higher if there are factors that increase the price of inputs, such as a high cost of living that means higher salaries are required to attract good teachers.[2]

One way to determine how much and why costs vary across districts is to estimate a cost or expenditure function for education across districts in a state. There are a number of studies that have done this, including Downes and Pogue, 1994 (Arizona), Courant, Gramlich and Loeb, 1995 (Michigan), Ratcliffe, Riddle and Yinger, 1990 (Nebraska), Duncombe and Yinger, 1999 (New York), and Reschovsky and Imazeki, forthcoming (Texas and Wisconsin). In each of these studies, only one function is estimated for each state and no distinction is made between

[1] For example, *Rose v. Council for Better Education, Inc.* (1989) in Kentucky, or *McDuffy v. Secretary of Education* (1993) in Massachusetts.

[2] Actual expenditures may also differ across districts because of choices made by the district. For example, one district may choose to spend a large amount of money on athletic programs that do not affect measured school

districts that serve different grade levels. That is, in some states, there are three kinds of districts: unified districts that provide K-12 education, separate elementary districts that only serve students through the eighth (perhaps ninth) grade, and secondary or high school districts that include only grades nine (possibly eight or ten) through twelve. In previous cost studies, no distinction has been made between unified, elementary and high school districts; either all districts are pooled together or only unified districts are used in the analysis. Downes and Pogue use a sample of both unified and elementary districts and the authors do test (and reject) the hypothesis that separate functions should be estimated. However, their sample does not include any high school districts. [3]

Given the different ages, learning skills and knowledge covered in the different grade levels, it seems plausible that unified, elementary and high school districts will have different cost structures. Twenty-eight states have school finance programs that already recognize possible differences in average costs for different grade levels (Gold, et al, 1995). In most of these states, there are adjustments in the school aid formula that give greater weight to older students (grades 9-12 or 7-12)[4]; in a handful, greater weight is given to younger students (kindergarten through the second or third grade). In the latter case, the additional funding tends to be targeted at class-size reduction. But while such adjustments account for higher *average* costs for certain grade levels, it is possible that there are differences in the effects of specific cost factors as well. That is, in terms of the cost functions for different grade levels, grade-adjusted

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output. Inefficiency in the use of resources could also be considered a "choice" of the district, rather than a true cost. An analysis of costs for the purpose of allocating state aid would want to abstract away from such choices.

[3] In 1995, Arizona had only 18 high school districts (Gold et al, 1995). Ratcliffe, Riddle and Yinger also use a mixed sample of all three types of districts in their estimation of an expenditure function, and they include dummy variables for elementary districts and mid-size to large unified districts. However, no adjustment is made for high school districts and small (population less than 1000) unified districts.

weights may account for differences in the intercepts but they do not allow for differences in the slopes. Yet, it is certainly plausible that the underlying production function for primary education is different than that for high school education.[5]

There is relatively little research on differences in the production function for education at different grade levels, since most production function studies focus on students of just one level (or group students of all grades together). However, the small handful of studies that analyze students of different grades provides some evidence that costs do vary across grades. For example, Ferguson (1991) finds that district size is negatively correlated with performance on reading exams for third-graders, but is positively correlated for eleventh-graders. Ferguson (1991), Sebold and Dato (1981), and Jaggia and Kelly-Hawke (1999) all find that socio-economic indicators have a stronger effect on performance of younger students than older students. And Summers and Wolfe (1975) find substantial differences in the best-fit functions for sixth, eighth and tenth graders, both in the variables included and the magnitudes of the effects of the variables that are common to all three functions. Since the cost function is the dual of the production function, it follows that differences in production across grade levels means differences in the cost function as well. Some of the cost studies mentioned earlier do implicitly recognize that the cost of education may differ by grade level by including a measure of the percentage of secondary students (in K-12 districts), but it is possible that differences in the cost structures are more complex than is captured by this measure. If cost effects differ across grade

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[4] That is, these students count as more than one pupil in determining district membership. For example, high school students may be assigned a weight of 1.7, indicating that for each high school student, the district will receive 70% more aid than for other students.

[5] Some states *do* include weights for specific cost factors (such as counting special education students or limited English proficient students as more than one student in the formula); however, in states that use such weights, they are the same for all grade levels.

levels, then an analysis that either uses K-12 districts alone, or a pooled sample of the three kinds of districts, will provide biased estimates of costs for elementary and high school districts.

It is also possible that the institutional and administrative structure of a district affects costs as well. For example, returns to scale could set in faster for separated districts where administrators can concentrate on one type of education production (i.e., primary or secondary, rather than both). If this is the case, then the cost of educating a high school or elementary student in a K-12 district may be different than educating that student in a high school-only or elementary-only district.

Although costs may vary in different types of districts, there are a number of practical reasons why prior studies of educational costs have focused on K-12 unified districts. In some states the number of elementary and high school districts is too small to estimate separate cost functions. For example, in Wisconsin, there are only ten high school districts. A cost function estimated from such a small sample is unlikely to be estimated with much precision. While one can certainly argue over what constitutes a "large enough" sample, the minimum requirement would be a sample that satisfies the identification condition of the estimation procedure.

Even when there are enough districts of each type to obtain reasonable statistical accuracy, problems may arise in the creation of an appropriate output measure. The most common output measure is scores on standardized exams and it has become standard to use a “value-added” measure in order to isolate the contribution of schools to increases in student achievement. That is, a lagged score is included in the analysis to control for the influence of family and neighborhood variables in the past (see Meyer, 1996). But to create a value-added score, the researcher must have a way of matching present and lagged scores of the same students. This becomes problematic for separate high school districts when students are only tested in certain grades and high school scores must be matched with lagged elementary scores. If several elementary districts feed into one high school district, or one elementary district feeds into several high school districts, great care must be taken in matching student cohorts to generate a lagged test score. Problems may also arise in the creation of a value-added measure for elementary or high school districts if a state only tests students in a few grades. For example, Wisconsin tests students in fourth, eighth and tenth grades. The only way to create a value-added score for elementary districts would be to use eighth-grade scores with the lagged fourth-grade score, a gap of four years. The longer the gap between tests, the more likely that the current score will reflect the influences of unobserved family and neighborhood characteristics and be less closely connected to current district spending. A longer gap also increases the likelihood that the cohort has fundamentally changed due to student mobility.

Because of these problems, it is often much simpler to conduct cost analyses using data from unified districts alone. From a policy perspective, the question is whether the cost function for unified districts also describes the cost structure of elementary and high school districts. This study uses data from Illinois, which has a relatively large sample of all three types of districts, to estimate separate cost functions for each type and see whether (and how) they differ.

III. Empirical Framework

Measuring the Costs of Education

There are several methods one could use to determine how much and why costs vary across districts. Researchers in the field of education often rely on case studies or the “expert professional judgment” of a team of educators within a state (e.g., Guthrie and Rothstein, 1999). Others advocate the use of input price indices (e.g., Chambers, 1995; McMahon, 1994). Many economists have instead relied on the statistical estimation of cost functions and educational cost indices.[6] This approach has the advantage of providing a straightforward way to incorporate several cost factors into a state's foundation aid formula.

To estimate a cost function for education, the output of public schools (measured, for example, by student performance on standardized exams) is first specified as a function of district 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 district output, X_{it} is a vector of direct district inputs, Z_{it} is a vector of student characteristics, and 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.

(1) $S_{it} = g(X_{it}, Z_{it}, F_{it})$

To move from this education production function to a cost function, a relationship between district inputs and educational spending is specified. This is shown in equation (2), where per pupil expenditures, E_{it}, are considered as a function of district inputs, a vector of input prices, P_{it}, and ε_{it}, a vector of unobserved characteristics of the school district.

(2) $E_{it} = f(X_{it}, P_{it}, \varepsilon_{it})$

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.[7]

(3) $E_{it} = h(S_{it}, P_{it}, Z_{it}, F_{it}, \varepsilon_{it}, u_{it})$

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[6] See Duncombe and Yinger, 1999, for a thorough discussion and comparison of different methods for measuring educational costs.

[7] Equation (2) is essentially an algebraic identity – total expenditure is the sum of what is paid for all inputs (the input price multiplied by the number of inputs). Equation (3) accounts for the fact that, in order to achieve a given level of output, some districts must use more inputs or pay higher prices.

Typically, equation (3) is assumed to be log-linear and estimated with district-level data for a given state. In addition, as pointed out by Baum (1986), districts make decisions about spending simultaneously with decisions about output levels and S_{it} should therefore be considered endogenous when estimating Equation (3). The resulting coefficients indicate the contribution of various district characteristics to the cost of education, holding constant the level of output. This approach, based on the general treatment of local public expenditures in Bradford, Malt and Oates (1969), is used in the studies mentioned earlier to estimate educational cost functions for a number of states, including Arizona, New York, Texas and Wisconsin.[8]

Note that if the production of elementary education is different from the production of secondary education, then equation (3) is grade-dependent. Thus, when equation (3) is estimated with data for only K-12 districts, the resulting coefficients will be some weighted average of the true grade-dependent effects. If equation (3) is estimated with data for all districts pooled together, the resulting coefficients may be biased for elementary and high school districts. This can be avoided by estimating equation (3) separately for each type of district. I estimate both pooled and separate functions to explore the extent of the bias.

The variable ε_{it} in equation (3) represents unobserved district factors that influence spending. One such factor that has received much attention is the "inefficiency" of the district; that is, the extent to which spending in the district is in excess of the amount necessary to achieve its chosen level of educational output. A number of recent papers have applied various methods of frontier analysis in an attempt to measure this inefficiency, by identifying spending that is high relative to spending in districts with similar student performance and costs (Bessent

[8] An alternative approach is to estimate an expenditure function instead, which does not require an explicit measure of output; see Downes and Pogue (1994). Courant, Gramlich and Loeb (1995) and Ratcliffe, Riddle and Yinger (1990) have estimated expenditure functions for Michigan and Nebraska, respectively.

and Bessent, 1990; Deller and Rudnicki, 1993; Duncombe, Ruggiero and Yinger, 1996; McCarty and Yaisawarng, 1993; and Ruggiero, 1996). However, great care must be taken before one interprets the results of such analysis as evidence of inefficiency. This is because the standard measure of inefficiency that arises from frontier analysis captures the effect of *all* factors that lead spending to be higher than the minimum cost. Thus, for example, higher spending in one school district that is due to higher costs of educating an above-average share of economically disadvantaged students could, at least 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 included in equation (3) means that when an efficiency measure is included, cost function estimates provide an underestimate of the full effects of the cost factors on education spending.

In addition, the correct interpretation of these efficiency measures also requires that public school output be adequately measured. If the cost function fails to include any school output that is important to local residents, then any expenditure devoted to achieving that output would be classified as "inefficiency." For example, if a school district devotes extra resources to courses in the arts or other subjects that are not captured in standardized exams, a standard frontier analysis is likely to characterize such spending as "inefficient." Because of these complexities with efficiency analysis, the analysis here does not include a measure of efficiency. Results from previous studies (particularly Duncombe, Ruggiero and Yinger, 1996, and Reschovsky and Imazeki, forthcoming) suggest that the inclusion of an efficiency measure will not affect the relative ranking of the estimated cost index but will decrease the variation and range.

Accounting for the Costs of Education in the Distribution of State Aid

Once a cost function (or set of cost functions) is estimated, the resulting estimates can be used to construct a cost index. An educational cost index generated in this way provides a simple way to measure the variation in spending due to exogenous cost factors, while holding constant output and variables under the control of the district. The index value for each district tells us how much more (or less) that district must spend, relative to the average district, in order to achieve a given level of output. The first step in constructing the index is to select a target level of output, S*. For example, policymakers could define S* as the state average level of current student performance. Once this choice has been made, the results of the cost function estimation are used to predict spending ($\tilde{E}$) for a district with average costs and output level S*. This is compared to predicted spending (E_I) for each district with actual cost factors and output level S*. That is, the regression coefficients are multiplied with the actual values of the cost factors in each district and the state average values of the output variables to obtain the hypothetical spending necessary for each district to achieve S*. The cost index value for each district, c_i, is the ratio $E_i/\tilde{E}$. Thus districts with higher-than-average values of the cost factors will have a cost index value greater than 1. This index can then be incorporated into a foundation aid formula to distribute aid in a way that guarantees each district has the resources to obtain output level S* (see Ladd and Yinger, 1994, for a full discussion of such an aid program).

Using cost indices in this manner accounts for costs in a much more comprehensive way than the weights that many states currently use. As mentioned in footnote five, many states include weights for specific cost factors. However, the value of these weights is often determined in an ad hoc way, and in no state are the weights determined separately for different grades.

IV. Data

This study uses 1997-98 data from the state of Illinois to estimate separate cost functions for unified, elementary and high school districts and to test whether the districts may be pooled. All data were compiled by the State Board of Education.

Recall that the cost function is represented by equation 3:

(3) $E_{it} = h(S_{it}, P_{it}, Z_{it}, F_{it}, \varepsilon_{it}, u_{it})$

where S_{it} represents an index of school output, P_{it} is a vector of input prices, Z_{it} is a vector of student characteristics, F_{it} is a vector of family and neighborhood characteristics, ε_{it} represents unobserved characteristics of the district and u_{it} is a random error term. The subscript i refers to the school district and subscript t refers to the year.

Although student performance can be measured in various ways, many states measure how effective school districts are in improving the academic performance of its students by relying on standardized exams.[9] For example, Illinois uses Illinois Goal Assessment Program (IGAP). IGAP exams in math and reading are administered to students in grades 3, 6, 8 and 10, and in science and social sciences to students in grades 4, 7 and 11.[10] To create a value-added measure, composite IGAP scores for students in grades 6 through 11 in 1997-98 are matched

[9] Another measure of output that is often considered is the dropout or graduation rate for high school students. However, the amount of error in this measure is likely to be high due to student mobility and the possibility of students getting their GED. Moreover, when this variable was included in the estimation of the cost function, it was never found to be significantly (statistically or in magnitude) correlated with spending and was dropped from the final specification.

[10] IGAP exams in writing are also administered, in the same grades as the math and reading exams. However, because the writing exams use a different score scale, they are not included in the composite scores used here.

with the scores of the same cohort of students in earlier years and grades.[11] Note that the grades included in the composite score for each district will vary depending on the level of the district. Specifically, the composite score for elementary districts includes grades 6 through 8 (with 3rd, 4th and 6th grades included in the lagged scores). The composite score for high school districts includes grades 10 and 11. In order to create the lagged scores for the high school districts, it was necessary to match each high school district with its feeder elementary districts. The lagged score is thus a weighted average of the 7th and 8th grade scores from the feeder elementary districts, with the weights based on the percent of enrollment in each high school district that comes from the feeder elementary district.[12]

Following Ladd and Yinger (1991) and Downes and Pogue (1994), the set of instruments for school output in this analysis are variables related to the demand for public education. In particular, Ladd and Yinger (1991) use the standard median-voter model of demand for local services to show that school output is related to school district residents' preferences for education, income, tax share, and the intergovernmental aid their school district receives. Specifically, the set of instruments used in this analysis includes district median income, each district's aid from the state equalization formula, aid from the federal government, and categorical aid received from the state. Also included is the ratio of residential property to the total tax base, which captures a district's ability to export some taxes onto non-residents and reduce the median voter's tax share. Finally, the percentage of adults with a four-year college

[11] Grades 6 and 8 in 1995-96 match grades 8 and 10 in 1997-98; grades 3 and 4 in 1994-95 match grades 6 and 7 in 1997-98; and grade 7 in 1993-94 matches grade 11 science and social science scores in 1997-98.

[12] It should be noted that the weights were created from information on the overlapping land area of each elementary and high school district. That is, the Illinois State Board of Education does not collect data on the direct percentage of high school enrollment coming from each elementary district but they have the percent of each elementary district's land area that falls in each high school district. Assuming that students are distributed uniformly within that land area, an enrollment percentage can be generated. There is surely error in this measure but it is the only way to create a lagged test score for high school districts.

degree, and the percentage of household heads that are homeowners, are included to reflect community preferences for public education.

Among inputs, teachers are the single most important factor in the production of education and teacher salaries dominate school district expenditures. Teacher salaries can vary widely across districts for reasons that may or may not be under the control of local school boards. For example, if a district has a strong demand for high-quality teachers and offers high salaries in order to attract those teachers, that is a choice of the district. On the other hand, a district may need to offer high salaries as compensating wages (e.g., for composition of the student body, working conditions within schools or area cost-of-living) in order to attract teachers of any given quality. This would be considered a cost to the district that is outside the control of district officials and these factors will be reflected in student and district cost variables, described below.

The objective is to isolate factors that contribute to higher levels of education spending, but are outside the control of local school districts. Thus, a teacher salary index is developed that only reflects differences in salaries that are due to factors outside local control. To construct this teacher salary index, data on the salary, education, and experience of every full-time public school teacher in the state is used. The log of salary is regressed on each teacher's background characteristics (including years of teaching experience and highest degree earned) plus a dummy variable for each school district. The coefficients on the district dummies are then used as the values of the teacher salary index. That is, the teacher salary index represents differences in salaries across districts, holding teacher background constant. To further control for salary differences that may be due to decisions of district officials, the salary index is treated as endogenous when estimating the cost function, and a cost-of-living index developed by Walter McMahon (1991, 1994) is used as an instrument.[13]

Previous research has suggested several student and school district characteristics that have a direct impact on costs. First, there is considerable evidence that there are higher costs associated with the education of children from low-income families. The number of children from economically disadvantaged families is measured by 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, the percentage of students who have been identified as limited English proficient is included, as well as 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.[14] Third, there are likely to be economies of scale that lead to lower costs for larger districts so each district's student enrollment is included as another cost factor. [15] Finally, although one of the main objectives of this study is to determine differences in the cost structure of unit, elementary and high school districts, it is possible that different amounts of resources may be needed to provide high school education, compared to

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[13] The salary index may be endogenous because while higher teacher salaries lead to higher per pupil expenditures, decisions by school districts to raise spending are likely to lead to higher teacher salaries. A Hausman specification test verifies that teacher salaries should be treated as endogenous, rejecting the null hypothesis of exogeneity at the one percent level.

[14] Studies have shown that the costs for students with these severe disabilities are far greater than other disabilities (see Chaikind, Danielson and Brauen, 1993).

[15] It is common also to include enrollment-squared, thus estimating a quadratic relationship for district size. However, when I included this variable in the cost function, it was statistically insignificant and the turning point (where costs begin to increase with size) was far, far beyond the size of the largest district in the state. Therefore it was not included in the final specification of the cost function.

elementary education, *within* K-12 districts. To capture this, the proportion of each unified district's student body that is enrolled in grades 9 through 12 is included as a final cost factor.

Descriptive statistics of the variables used in the analysis are displayed in Tables 1a and 1b. The first column contains the averages for all districts in the state; columns 2 through 4 are the averages for each district type. It should be pointed out that Chicago is an enrollment outlier – with over 400,000 students, it is almost eight times as large as the next largest district. Because Chicago is such an outlier, all the estimation was done both with and without Chicago. However, the results were all very similar; therefore, the results presented below are for the full sample, including Chicago.

V. Cost function results

The cost functions are estimated using two-stage least squares, with the current performance measure and the teacher salary index treated as endogenous.[16] Following much of the literature on education costs, the cost functions are estimated in natural logs, the dependent variable being the natural log of non-transportation spending per pupil for the 1997-98 school year.[17]

Table 2 presents the cost function estimates for different sub-samples of the data. First, columns 1 and 2 replicate the estimates found in other studies. In column 1, the cost function is estimated for unified K-12 districts only; in column 2, the cost function is estimated with data for all districts pooled together. All variables have the expected signs, most are statistically

[16] Reschovsky and Imazeki, forthcoming, also treat the lagged test scores as endogenous. However, Hausman specification tests could not reject the null hypothesis that this variable is exogenous in the Illinois data. In addition, specification tests were conducted to test the exogeneity of the instruments; in all cases, the null hypothesis of exogeneity could not be rejected at standard confidence levels.

[17] The regressions are also weighted by district enrollment and robust standard errors are calculated.

significant (at least in the K-12 function) and in general, the results are consistent with the findings in other states. Since lagged scores are serving as a proxy for past achievement, the negative sign on the coefficient is consistent with the idea that higher past scores implies that a district can spend less to reach a given level of current performance. Increases in the cost factors (i.e., percent low-income, disabled, and limited English proficient) are all associated with higher costs, and the negative coefficient on district enrollment suggests there are returns to scale for larger districts.

Columns 3 and 5 contain the estimates from separate regressions for elementary and high school districts; columns 4 and 6 show the difference between each column and column 1, the results from the K-12 regression. While the signs of the elementary cost function are consistent with expectations, the test scores and some of the cost factors are not statistically significant. An F-test suggests that we cannot reject the hypothesis that elementary and K-12 districts have the same cost structure (at the 5 percent level).

The high school cost function also has few variables that are statistically significant but an F-test strongly rejects the hypothesis that high school and unified districts have the same cost structure. Two variables in particular are driving the F-statistic up: high school districts appear to be more sensitive than unit districts to the teacher salary index and district enrollment. It thus does *not* appear appropriate to assume that the cost function for K-12 districts is identical to that for high school districts.[18]

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[18] It is possible that the difference between the cost functions is really capturing something other than a difference between K-12 and high school districts. In Illinois, the majority of high school and elementary districts are in wealthy suburban areas (e.g., around Chicago in the north and St. Louis in the south; see Figure 1) while the majority of unified districts are found in poorer rural areas throughout the state. Differences in preferences among residents of these areas could account for higher spending in high school (and to some extent elementary) districts overall (i.e., a larger intercept term). The production of education in suburban districts would also need to be fundamentally different in some way from education production in rural districts in order to explain the difference in the cost function slope coefficients.

VI. Constructing a cost index

While the cost function results are interesting in themselves for what they tell us about the cost structure of the districts, the main policy objective of estimating these cost functions has been to develop cost indices that can be used in the distribution of state aid. So what effect do the cost function results have on the cost index, or indices, generated?

As explained above, the cost index is created by predicting spending for a district with average values of the cost factors and output level S* (i.e., whatever performance level has been set as the standard).[19] Once the performance standard has been set, the results of the cost function estimation are used to predict average spending, $\tilde{E}$, which is predicted spending for a district with average costs and output equal to the performance standard. This average predicted spending is compared to predicted spending for each district with actual cost factors and output at the performance standard, E_i. The cost index value for each district, c_i, is the ratio $E_i/\tilde{E}$.[20] When different cost functions are estimated for the three types of districts, $\tilde{E}$ is determined separately for each type, using the average values of the cost factors for each type.

Table 3 shows what the distribution of costs looks like when we account for differences in the cost function of the different types of districts. Assuming that current average student performance is the measure of adequacy and averages are calculated separately for each district, the unified school district with average costs must spend $5,745 per pupil (in 1997-98) to reach the performance goal. Average spending for adequacy is $6,414 for elementary districts and

[19] It should be emphasized that any standard could be chosen for S*. In the cost indices calculated here, S* is set equal to the average scores for all districts. The use of different standards will not affect the relative ranking of districts in terms of their costs, but will alter their absolute cost index values, and hence, will influence any distribution of state aid that is dependent on the cost index.

$9,232 for high school districts. Higher average costs in high school districts are driven largely by higher teacher salaries (the average teacher salary index is 1.26 for high school districts while only 0.93 for K-12 districts and 1.003 for elementary districts).[21]

For any given district, the product of the average spending number and its cost index value will indicate the amount that district must spend in order to provide its students with an adequate education. Thus, an Illinois unit school district with a cost index value of 1.25 will need to spend $7,181 per pupil ($5,745 times 1.25) to provide an adequate education.

These separate indices can also be converted into one cost index to facilitate comparisons across district types. By comparing the average cost of achieving adequate education in each type of district, we can normalize each cost index to a single scale. For example, the average cost of achieving adequate education for high schools is 61% higher than the average cost for K-12 districts, thus a high school district with a cost index of 1.1 would have a normalized cost index of 1.771 (1.61*1.1). This normalized cost index is shown in the last column of Table 3.

Table 3 indicates that costs vary the most among high school districts. For high school districts, the district with lowest costs could achieve an average level of student achievement by spending about two-thirds as much per pupil as the district with average costs. At the other end of the spectrum, the high school district with highest costs must spend about seventy-six percent more than the average cost district. The range of this index reflects in part the values of the index in a few districts. Ignoring the ten percent of districts with the lowest and highest index values reduces the range of the cost index a bit. The restricted range shows that the high school

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[20] Since the teacher salary index is treated as endogenous in the cost function estimation, a predicted salary, based on the first-stage regression, is used in constructing the index.

[21] As noted in footnote 18, high school districts are primarily found in wealthier suburban areas. Since property wealth and income are generally correlated with higher "tastes" for education (i.e., a greater willingness and ability to pay for high-quality education), higher teacher salaries and higher spending in high school districts may therefore

district at the 10th percentile has costs that are 71 percent of the average costs and the high school district at the 90th percentile has costs that are 32 percent above the average. The range for elementary districts is quite similar, however the range for unit districts is much smaller.

The fact that elementary and high school districts exhibit wider cost variation than unit districts is not particularly surprising, though the reason for that variation may not be the same in each case. Costs can vary either because of differences in the underlying cost functions for the different types or because there is greater variation in the cost factors. The larger variation in high school costs compared to unit districts seems to be a case of the former; for example, costs in high school districts are more sensitive to changes in student enrollment so small differences in the size of the district leads to larger differences in costs. However, the large range of values of the cost index for elementary districts appears to be a result of more variation across districts in the cost factors themselves. From the summary statistics in Table 1, we can see that the variance and range of some of the cost factors are higher among elementary districts (e.g., percent poor students, percent of students with disabilities) than among high school and unified districts. This may be because elementary districts tend to be smaller and perhaps serve more homogeneous neighborhoods (thus there is less variation within districts but more variation across), in contrast to unified and high school districts which may serve several different communities (and thus have more variation within districts and less between).

Does the assumption of a common cost function matter?

Analysis of the cost function estimation suggested that it is not appropriate to assume a common cost function for all three district types. As this assumption is made in other cost

be partly a result of these tastes. One drawback of the cost function/index approach is a limited ability to separate studies, it is important to know what impact such an assumption is likely to have on the cost index and the resulting distribution of aid. The bottom panel of Table 3 shows the distribution of costs under the assumption that there is a single cost function for all districts; in this case, the K-12 cost function is used. Predicted average spending, $\tilde{E}$, is calculated using average performance for all districts and with the averages of the cost factors taken over all districts, thus generating a single index.

For elementary and high school districts, the assumption of a common cost function clearly distorts the picture of costs. Costs in elementary districts appear to vary considerably more than when separate cost functions are used, while costs in high school districts appear to vary considerably less. This reflects the difference in the reasons behind the variance of the cost indices when separate functions are used. The range in costs among high school districts is driven by greater sensitivity to changes in the cost factors (i.e., larger coefficients in the high school cost function); assuming a common cost function eliminates this source of variation. On the other hand, the range of costs among elementary districts is driven by variation in the cost factors themselves; when a common cost function is assumed, this translates into a wider range of cost index values than the other district types.

Not only does the range of costs in elementary districts increase, the average predicted spending also rises dramatically. When separate functions are used to generate cost indices, the cost for an average elementary district to achieve adequacy is $6,414, somewhat more than for the average unified district but quite a bit less than for the average high school district. When a common cost function is assumed, elementary districts appear to have the *highest* average costs, almost double the average unified district.

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the effect of these preferences from the district type.

It thus appears that, for Illinois, the choice of cost function specification *is* likely to have a significant impact on the cost index and the distribution of aid. If one assumes that the cost function estimated for K-12 districts can also be applied to elementary and high school districts, then costs for elementary districts are likely to be grossly over-stated while costs in many high school districts will be under-stated.

VII. Conclusion

The continuing focus in policy debates on the state of public education reflects the growing consensus that many students in this country are not receiving a high-quality education, and policymakers are under pressure to find ways to improve the schools. A number of scholars have argued that improving the performance of public education requires reform of the financing of public schools. One of the aims of the growing literature on educational cost functions and cost indices is to persuade policymakers to incorporate cost differences into state school finance programs to ensure that schools have the necessary resources to improve.

This paper set out to answer several questions that must be addressed if current research on educational cost functions and cost indices is to be integrated realistically into school finance policies. First, are the cost structures of unified, elementary and high school districts the same? Previous cost studies have estimated cost functions with data from a subset of districts (such as K-12 districts), but in order to apply the results to *all* districts, one must then assume the cost structure of all districts is the same. This paper has tested that assumption and found that it may not hold. In particular, in Illinois, the returns to scale are different for high school and unified districts, and teacher salaries have different effects in high school districts than in unified districts. When separate cost functions are used to generate cost indices for each district type, these differences translate into higher average costs, and a wider range of costs, for high school and elementary districts.

If possible, future work on educational costs should make every effort to estimate separate cost functions for each type of district and generate separate cost indices for each type. However, due to data restrictions and other problems, it simply may not be possible to estimate separate cost functions for each district type. Given differences in the cost structures, what then are the implications of assuming they are the same? Assuming that the K-12 cost function can be applied identically to elementary and high school districts, in Illinois, leads to an over-statement of costs in elementary districts and an under-statement of costs in high school districts.

These results highlight the need for caution as research on education costs continues, particularly as policymakers attempt to measure educational costs. Differences in costs across grade levels and district structures should be considered when possible. A key aspect in this will be the collection of appropriate data. It is clear that in order to hold schools accountable for performance improvement, there must be observable measures of performance and those measures should be gathered at regular intervals for all grades. This will facilitate the accurate estimation of costs for *all* districts.

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Table 1a: Summary Statistics, 1997-98

	All Districts	Unit K-12 Districts	Elementary Districts	High School Districts	Chicago
N	**886**	**398**	**384**	**104**	
Composite IGAP exam score, 1997-98	**270.60** *(30.25)* 195.0	**263.97** *(21.72)* 156.3	**280.75** *(34.90)* 195.0	**258.49** *(28.50)* 158.5	**202.4**
Lagged composite IGAP exam score	**272.93** *(29.75)* 201.4	**267.16** *(23.28)* 180.2	**278.59** *(35.09)* 192.3	**274.09** *(26.24)* 151.9	**190.5**
Non-transportation expenditures per pupil	**$6,604.57** *(2336.21)* 18880.25	**$5,841.14** *(1209.87)* 9480.88	**$6,583.62** *(2211.55)* 16258.02	**$9,603.51** *(3425.18)* 17722.79	**$8,045.08**
Teacher salary index	**1.001** *(0.19)* 1.22	**0.932** *(0.12)* 0.74	**1.003** *(0.18)* 0.84	**1.259** *(0.26)* 1.12	**1.267**
Percent of students eligible for free and reduced price lunch	**0.225** *(0.18)* 0.99	**0.257** *(0.15)* 0.94	**0.218** *(0.20)* 0.99	**0.127** *(0.13)* 0.73	**0.838**
Enrollment	**2217.47** *(14573.07)* 428,151	**3111.43** *(21626.48)* 428,030	**1333.13** *(1739.32)* 16,010	**2061.65** *(2187.81)* 12,002	**428184**
Percent of students with disabilities	**0.151** *(0.04)* 0.43	**0.153** *(0.03)* 0.20	**0.159** *(0.04)* 0.38	**0.116** *(0.03)* 0.19	**0.118**
Percent of students with severe disabilities	**0.002** *(0.003)* 0.04	**0.002** *(0.002)* 0.01	**0.003** *(0.003)* 0.04	**0.002** *(0.002)* 0.01	**0.003**
Percent of students enrolled in high school	**0.251** *(0.31)* 1.00	**0.298** *(0.03)* 0.33	**0.000** *(0.00)* 0.01	**1.000** *(0.00)* 0.01	**0.230**
Percent of students with limited English proficiency	**0.017** *(0.04)* 0.48	**0.008** *(0.03)* 0.26	**0.026** *(0.05)* 0.48	**0.016** *(0.03)* 0.16	**0.161**

*** Mean in bold, standard deviation in italics and parentheses, range in plain text

Table 1b: Summary Statistics, 1997-98

	All Districts	Unit K-12 Districts	Elementary Districts	High School Districts	Chicago
N	**886**	**398**	**384**	**104**	
Revenue from federal sources	**$281.88** *(222.89)*	**$315.72** *(225.71)*	**$266.53** *(226.84)*	**$209.07** *(168.84)*	**$969.40**
State equalization aid per pupil	**$1,676.91** *(1004.36)*	**$1,967.12** *(810.13)*	**$1,467.49** *(1097.38)*	**$1,339.54** *(1027.53)*	**$1,337.42**
Categorial aid per pupil	**$631.83** *(281.61)*	**$652.52** *(239.17)*	**$620.39** *(323.23)*	**$594.94** *(262.55)*	**$991.61**
McMahon cost of living index	**104.51** *(7.28)*	**100.9634** *(5.14)*	**107.4575** *(7.41)*	**107.1999** *(7.85)*	**111.24**
Percent homeowners	**0.757** *(0.10)*	**0.751** *(0.08)*	**0.766** *(0.11)*	**0.746** *(0.08)*	**0.415**
Percent adults with 4-year college degree	**0.156** *(0.12)*	**0.122** *(0.07)*	**0.183** *(0.14)*	**0.184** *(0.13)*	**0.1888983**
Median income	**$32,923.07** *(11760.07)*	**$28,297.35** *(8160.61)*	**$36,878.98** *(12906.39)*	**$36,018.86** *(12708.81)*	**$26,301.00**
Residential tax base/Total tax base	**0.533** *(0.21)*	**0.476** *(0.19)*	**0.578** *(0.22)*	**0.581** *(0.18)*	**0.353**

Table 2: Illinois Cost Function Estimates, 1997-98

	1 K-12 Districts	2 Pooled Sample	3 Elementary Districts	4 (Elem-K12)	5 High School Districts	6 (H.S.-K12)
Composite IGAP exam score, 1997-98	5.411 *	4.684 *	1.690	-3.721	0.364	-5.046 **
	1.83	*1.41*	*1.42*	*2.32*	*2.05*	*2.71*
Lagged composite IGAP exam score	-4.512 *	-4.342 *	-1.757	2.754	-0.600	3.911
	1.49	*1.23*	*1.19*	*1.91*	*1.91*	*2.38*
Teacher salary index	1.076 *	1.764 *	2.165 *	1.089 *	2.436 *	1.359 *
	0.28	*0.20*	*0.29*	*0.40*	*0.44*	*0.51*
Log of percent of students eligible for free and reduced price lunch	0.026	0.036	0.027	0.001	0.016	-0.011
	0.03	*0.02*	*0.02*	*0.04*	*0.04*	*0.05*
Log of student enrollment	-0.052 *	-0.078 *	-0.091 *	-0.039	-0.214 *	-0.162 *
	0.02	*0.01*	*0.03*	*0.03*	*0.06*	*0.07*
Percent of students with disabilities	1.135 **	0.412	1.099 **	-0.036	0.956	-0.179
	0.61	*0.48*	*0.59*	*0.85*	*0.82*	*1.00*
Percent of students with severe disabilities	16.824 **	-0.487	9.809	-7.016	22.191	5.367
	9.54	*8.11*	*8.29*	*12.68*	*19.90*	*21.56*
Percent of students with limited English proficiency	0.629	0.193	0.187	-0.442	-0.639	-1.268
	0.54	*0.28*	*0.24*	*0.60*	*0.77*	*0.93*
Percent of students enrolled in high school	-1.788 *	0.165				
	0.78	*0.15*				
Intercept	-0.575	-0.869	-0.529	0.047	0.068	0.644
	2.50	*1.19*	*1.22*	*2.79*	*2.02*	*3.19*

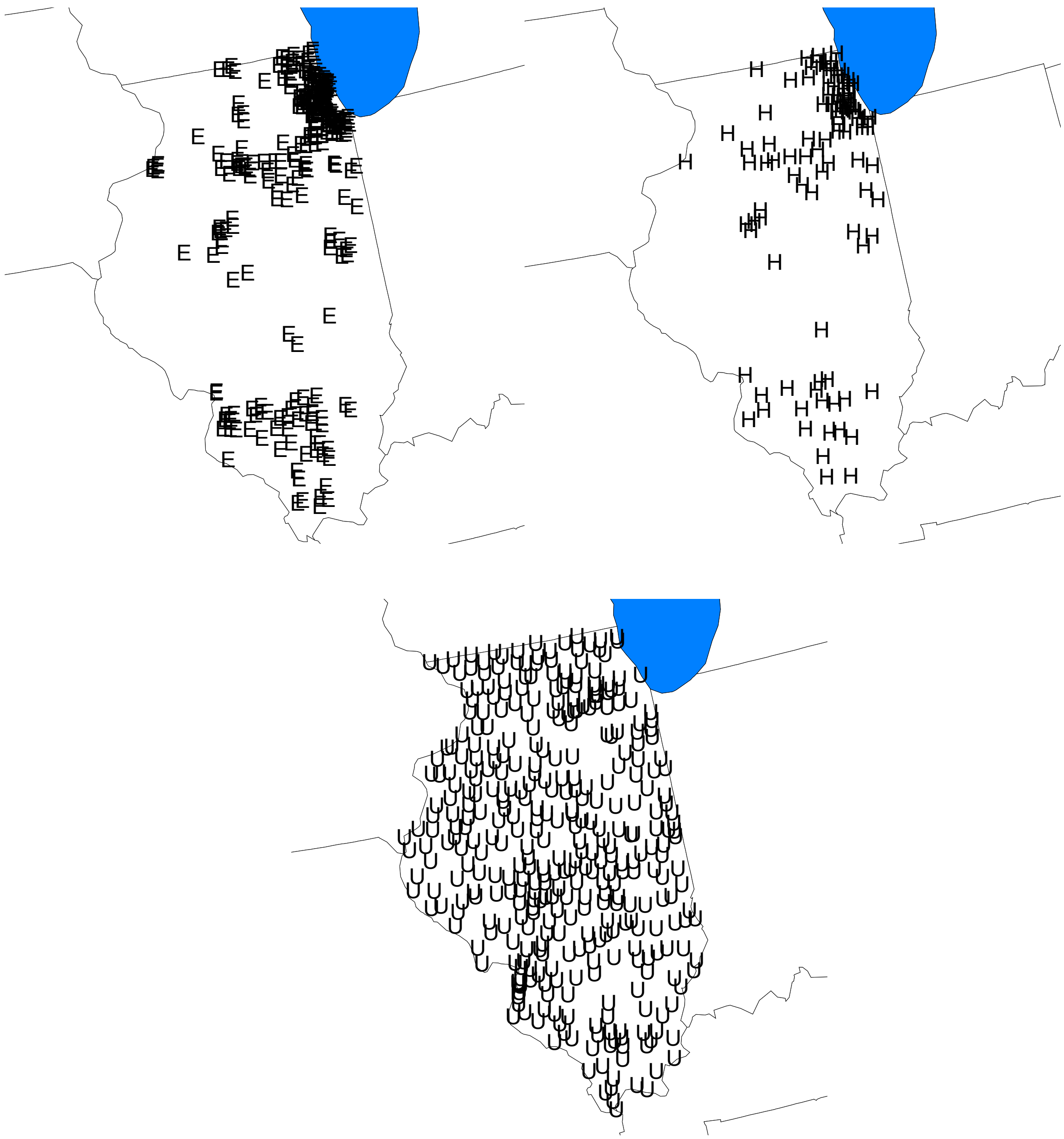
Std.errors in italics; All regressions weighted by district enrollment
* Statistically significant at the 5% level
** Statistically significant at the 10% level

Elementary districts, all variables: F(9,858) = 1.81
High school districts, all variables: F(9,858) = 3.68
High school districts, excluding salary index and enrollment: F(7,858) = 1.97

Table 3: Illinois Cost Indices

	K-12 Districts	Elementary Districts	High School Districts	All districts (index normed)
N	398	384	104	886
Mean	1	1	1	1
Median	0.979	0.928	0.968	0.912
Standard Deviation	0.114	0.205	0.251	0.255
Range	0.759	1.060	1.108	1.887
Minimum	0.715	0.677	0.654	0.637
Maximum	1.474	1.737	1.762	2.524
Restricted Range	0.280	0.527	0.609	0.541
Minimum at 10%	0.880	0.789	0.707	0.789
Maximum at 90%	1.161	1.316	1.316	1.330
Average predicted spending	$ 5,745.04	$ 6,414.27	$ 9,232.25	$ 6,444.42
Mean	0.698	1.265	1.178	1
Median	0.683	1.260	1.178	1.068
Standard Deviation	0.080	0.144	0.131	0.298
Range	0.530	1.296	0.660	1.578
Minimum	0.499	0.781	0.851	0.499
Maximum	1.029	2.077	1.511	2.077
Restricted Range	0.196	0.361	0.359	0.735
Minimum at 10%	0.614	1.089	1.006	0.641
Maximum at 90%	0.810	1.450	1.366	1.375
Average predicted spending	$ 5,695.60	$ 10,321.69	$ 9,612.60	$ 8,160.37
Correlation with index generated from separate cost functions:	1	0.507	0.584	0.480

Figure 3.1



E = Elementary districts
H = High School districts
U = Unified districts