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Background

Maine should be very proud of its public school system. Without question, since passage of the Sinclair Act in 1957, Maine has made great strides in the last 45 years in improving the quality of its public schools, and in expanding educational opportunities for more and more of its children. Maine citizens have increased their investment four-fold in our public schools since 1960; from approximately $1,870 per pupil in today's dollars to over $8,000 per student in 2002-03. At present, Maine spends approximately $900 more per student than the national average.

And this investment has paid off. Year in and year out, Maine's 4th and 8th graders score in the top five in the country on the National Assessment of Education Progress (NAEP). Maine has one of the most favorable teacher-pupil ratios in the country; it ranks 11th best in the country in terms of our high school graduation rate, and 7th highest in the country in how well Maine prepares students for college.

But as we enter the new century, we are faced with significant challenges. Although we rank high on national tests, a closer examination of our scores reveal that over two-thirds of our students do not score high enough to reach acceptable proficiency levels, both on the NAEP, and our own statewide tests, the Maine Education Assessments (MEAs). And while it is true that Maine has one of the best high school graduation rates in the country, the rate has not changed significantly in over 40 years. In 1960 our high school graduation rate was about 74%; today it is 76%.

In addition, student enrollments are declining significantly, while the cost of education has not declined. In the last decade alone, the school age population has decreased 6%, and it is projected to decline 12-13% by 2015, a total decline of 20,000 – 25,000 students. The portion of our school population that qualifies for special education services has reached an all time high of 17%

and the cost of special education has increased from $75 million per year in the late 1980's to over $225 million in 2002-03. And, in the last decade, real expenditures for education have increased 20%, while local communities have increased their expenditures three times as much as the state. At the same time, there have been very few changes in the governance structures of our schools since the end of the Sinclair Act funding. At present we have 286 separate school districts attempting to provide education to approximately 206,300 students. That is, on average, one school district for every 720 students, one administrator for every 200 students, and one school board member for every 115 students.

Clearly, we must address these challenges if we are to insure that **all** our children receive a quality K-12 education. We must find more efficient ways to operate our public school system to ensure equity of education opportunities for all of Maine's youth.

Among the emerging proposals for resolving these and related issues is the idea that more economic efficiencies and greater education opportunities for students may be found through further regionalizing of educational services. This study examined the question of whether some degree of consolidation of school districts or regionalization of functions might have the potential to yield reductions in educational costs without sacrificing educational quality. It reports the results of a study of the relationships in Maine school districts between district size, expenditures, and outcomes.

Cost Functions and Economies of Scale

Many characteristics and activities of a school district, its employees, its students, and the community or communities it serves have an effect on educational costs and outcomes. A cost function describes this relationship by equating cost with a function of these cost-relevant variables.

Some characteristics, such as the income of pupil's families, are entirely beyond the control of a district. Other characteristics are, to varying degrees and with varying degrees of difficulty, within the control of district. A district may have a degree of control over its own size, due to the possibility of

consolidation. A state, through incentives and directives, may also have influence over the size of school districts.

Scale, as measured by the number of pupils in a district and the number of pupils in each of its schools, should influence the costs and outcomes of education. Economic theory suggests that this influence will take the form of a U-shaped unit cost function. That is, as the number of units of output increases from zero, unit costs decrease as fixed costs are spread over more and more units. For example, as the number of students in a district increases, the fixed cost of operating school buildings become less per student. This decrease in unit cost is called economy of scale. However, beyond a certain number of units, unit costs begin to increase as the organization required to produce so many units becomes overly complex and cumbersome. This increase in unit costs is called diseconomy of scale. This study examines economies of scale at the school district level.

Selected Literature Review

In recent years, several researchers have examined the relationship between school district size and costs. Andrews, Duncombe, and Yinger (2002) provide a review of literature on economies of scale in education in the United States. They concluded that there is evidence that districts with around 2,000 to 4,000 pupils may have significantly lower costs than districts with fewer than 500 pupils, and that the minimum-cost size for school districts in the United States is around 6,000. They also suggest that elementary schools with between 300 and 500 pupils and high schools with between 600 and 900 students may be optimal, considering both economies of scale and the potential negative effects of larger schools. However, while providing useful information from a national perspective, this study provides little guidance in determining what the potential cost saving may be from school district consolidation in a rural state like Maine.

In 2000, Jacques, Brorsen, and Richter examined the relationship between school district size, expenditures, and standardized test scores in Oklahoma. Using a nonlinear regression analysis, they concluded that

economies of scale exist for districts in Oklahoma with enrollments up to 965 pupils. However, they also found that in Oklahoma, larger school districts tend to have lower test scores. They concluded that school district consolidation in Oklahoma would likely reduce both expenditures and student achievement. However, reduction in cost together with a reduction in outcomes is not necessarily an example of increased efficiency, and not a model Maine should attempt to replicate.

Duncombe, Miner, and Ruggiero (1995) examined economies of scale in the school districts of New York. They analyzed per pupil cost as a function of many variables, including enrollment. Other variables included were measures of outcomes, resource prices, physical factors, family background, student characteristics, and demand variables. By including these cost-related variables, in their regression analysis, Duncombe et al. were able to account statistically for nearly 80% of the variance in per pupil expenditures in New York, and concluded that per pupil costs in New York are reported to be at a minimum when district enrollment is around 6,500 students. Although the results are not directly applicable to Maine, Duncombe et al. methodology provides a potential model for analyzing Maine data.

Finally, in 2002, Allen, Bell, and Trostel examine the potential for taking advantage of economies of scale by consolidating school districts in Maine. They conducted a regression analysis of per-pupil cost in Maine school districts as a function of district enrollment. Based on the resulting regression equation, Allen et al. estimate that the minimum-cost district size in Maine should be 3,378 students. They also calculated a rough estimate of "the potential cost savings of moving all of Maine's school districts to the cost-minimizing size" (Allen et al., 2002, p. II - 12). However, few variables relating to cost were included in the analysis, and as a result, only 12.7% of the variance in per-pupil operating costs is statistically explained by district size. No variables that function as measures of ability to pay, demand for education, or measures of outcomes were included. Thus, while instructive, the Allen et

al. analysis is not comprehensive enough to provide guidance in developing education policy and action strategies for Maine.

Methodology

Accordingly, the methodology of the current study has been modeled after Duncombe et al. (1995), with some changes due to the different characteristics of the two states, the availability of data, and some slight differences in the research questions. Regression analysis (OLS) was used to estimate cost functions for school districts in Maine that operate schools. Expenditures were the dependent variable. Variables denoting district size, outcomes, and community and pupil characteristics were the independent variables.

As was noted above, economic theory suggests a U-shaped cost function. Due perhaps to the absence of large school districts in Maine—the largest is around 7,500 pupils, the second largest around 4,300—visual examination of scatter plots did not reveal a clear and definite upturn in cost among the larger districts. For this reason, rather than use a standard U-shaped mathematical equation such as quadratic (as used by Allen et al., 2002) or quadratic with a loglinear transformation of variables (as used by Duncombe et al., 1995), the current study uses a straight-linear regression equation with size entered as a series of indicator variables. Because the regression equation is not loglinear, coefficients represent slopes rather than elasticities and may be interpreted in terms of dollars. Coefficients of indicator variables result in additive increments rather than multipliers.

Districts

Not all of Maine's districts operate schools. Some districts fulfill their obligation to educate their pupils by sending them to nearby schools and paying tuition. Typically, the receiving school is a public school in a neighboring district. Since the current study attempts to find economies of scale in the provision, not the purchase, of educational services, only districts that operate schools are included in the study. That is, this study was attempting to examine costs associated with attending students, not resident

students, some of whom may be tuitioned to another school district. Table 1 summarizes included and excluded districts by grade span.

Table 1: Districts Included In and Excluded From the Study

Grade Span	Districts	Attending Enrollment	Resident Enrollment
SAUs Included in Study			
K-12	110	170,653	168,842
SAUs Excluded from Study			
K-8	106	25,012	28,696
9-12 or 6-12	7	3,568	8,721
No Schools	56	-	1,827
Big Eleven Schools	-	5,505	-

K-12 districts, which operate schools for all grades, are included in this study. They are modeled separately, because they are the only districts for which a true K-12 per-pupil cost can be computed, without distortion by tuition prices and other factors.

Districts that do not operate any schools and districts that do not operate high schools are excluded from the study. The Big Eleven are also excluded from the study, as are the seven Consolidated School Districts that operate high schools only or high schools and middle schools only.

Data Sources

All data is for the 2001-2002 school year and is from the Maine State Department of Education except the Salary Cost Index, which is from the Maine Education Policy Research Institute and was calculated based on data from the Maine State Department of Education. Table 2 on the next page summarizes the variables used.

Operating expenditure

For the K-12 regression model, the dependent variable is adjusted per-pupil operating expenditure. The adjusted rate includes all district expenditures except those for major capital outlay, debt service, bus purchase, and vocational education. Some of Maine's K-12 districts accept substantial numbers of secondary students from districts that do not operate high schools. Because such districts have a higher than average percentage of high school

students, their actual operating expenditures might constitute an inflated measure of true K-12 education costs. Therefore, per-pupil operating expenditures were further adjusted in these cases. Adjusted per-pupil operating expenditure is a weighted average of K-8 and 9-12 operating expenditures, with weights equal to the statewide proportion of K-8 and 9-12 pupils, respectively.

Table 2: Variables Used

	K-12 Analysis
Expenditures *(Dependent Variable)*	
Per-Pupil Operating Expenditure	Adjusted K-12
Scale	
Enrollment Group Indicator Variables	K-12 pupils
Outcomes *(3 year averages)*	
High School Completion Rate	✓
MEA Score Average	4th, 8th, & 11th
Student Characteristics	
Eligible for Free or Reduced Lunch	✓
Special Education Proportion	✓
District Characteristics	
Per-Pupil Valuation Index	✓
Median Household Income Index	✓
Pupil Sparsity	✓
Salary Cost Index	✓

Expenditures for vocational education were excluded because vocational education is provided by and funded through 26 vocational regions and centers. Therefore, vocational education expenditures would best be studied separately.

Many districts that do not operate schools for all K-12 grades do operate pupil transportation systems for all grades. Thus, in many cases, the district educating a pupil is not the district transporting the pupil. For this reason, per-pupil transportation operating expenditures were calculated based on resident pupils only, and transportation revenues from other districts were netted out.

Scale. District size was defined as the average of October 1 and April 1 school district enrollment, adjusted for those pupils that spend a portion of the day in vocational programs. Size was not entered into the regression analysis in the form of a standard mathematical equation such as straight-linear or quadratic. Rather, indicator variables denoting membership in size categories were used, and each K-12 district was assigned to one of nine groups based on enrollment, as listed in Table 3. Based on preliminary analysis, groups were further combined to form five significant groups.

Table 3: Size Groups for K-12 Analysis

Enrollment Range	Districts	Total Enrollment	Percent of State Total
5000+	1	7,539	4.4%
3,500 - 5,000	7	27,261	16.0%
2,500 - 3,500	16	45,443	26.6%
1,500 - 2,500	21	40,978	24.0%
1,000 - 1,500	21	25,234	14.8%
500 - 1,000	22	17,296	10.1%
250 - 500	14	5,479	3.2%
125 - 250	6	1,265	0.7%
1 - 125	2	159	0.1%

Outcome measures. If other things are equal, providing a higher quality education may cost more than a providing a lower quality education. Therefore, several outcome measures were used as independent variables, including high school completion rates and scores on the Maine Educational Assessment (MEA), a series of statewide standardized examinations for 4th, 8th, and 11th graders. The overall district MEA is the mean of the three years of composite scores, ending in 2001-02. The composite score for each grade is the mean of the district mean scores on the reading, writing, mathematics, science, and social studies assessments. For the analysis 4th, 8th, and 11th grade scores were averaged.

Student characteristics. Proportions of pupils qualifying for free or reduced-cost school lunches and for special education services were used in the analysis.

Community characteristics. Pupil sparsity is defined as the number of miles of road (Class 1 through Class 5 as defined by the US Department of Transportation) divided by the number of resident pupils in the district. State property valuation per pupil and median household income were also used. Both were analyzed as indices, with the state average set to 1.

To take account of geographic variation in labor costs, a teacher salary cost index is used. It is based on average teacher salaries in the 35 labor market areas designated by the Maine Department of Labor, after correcting for variation in teacher experience and education.

Descriptive statistics for the variables by size group for the K-12 districts in this study are presented in an appendix.

Findings

Table 4 on the next page shows the results of the K-12 regression analysis. Eight significant variables remain in the final analysis and accounted for approximately 78% of variance in school district cost. The inclusion of four size variables means that the nine groups were collapsed into five.

Table 5 on the next page shows the four size groups together with predicted expenditures and differences relative to the lowest-cost size group. The lowest predicted per-pupil cost in K-12 districts occurs at sizes of 2,500 or greater. The highest predicted per-pupil cost, if other things are equal, occurs in districts enrolling fewer than 125 pupils. Diseconomies of scale in the form of statistically significant positive cost increments in district size groups larger than 2,500 students were not detected, perhaps due to the lack of large districts in Maine.

Table 4: K-12 Regression Analysis Results
Dependent Variable: Adjusted Per-Pupil Cost

Variable	Unstandardized Coefficient	Standardized Coefficient	Significance
(Constant)	$6,636		.000
Scale			
Enrollment less than 2,500	$219	0.071	.192
Enrollment less than 1,000	$235	0.090	.185
Enrollment less than 500	$507	0.158	.023
Enrollment less than 125	$2,872	0.299	.000
Outcomes			
MEA Score	$83.66	0.158	.013
Student Characteristics			
% Eligible for Free or Reduced Lunch	$1,502	0.181	.029
% Special Education	$5,829	0.168	.002
District Characteristics			
Per-Pupil Valuation Index	$813	0.592	.000
Pupil Sparsity	-$1,232	-0.164	.038
Model Summary			
R^2	0.778		
Standard Error of the Estimate	632.7		

Table 5: K-12 Predicted Per-Pupil Expenditure by Size Group

Size Range	Total Districts	Total Pupils	Predicted Per-Pupil Expenditure*	Difference from 3,500 +	Difference Times Pupils
2,500 +	24	80,243	$6,635	-	-
1,000 - 2,500	42	66,212	$6,854	$219	$14,500,428
500 – 1,000	22	17,296	$7,309	$455	$7,869,680
125 - 500	20	6,744	$8,271	$962	$6,487,728
1 - 125	2	159	$12,105	$3,834	$609,606

*assuming state average in other variables

This analysis indicates that a variety of variables are related to per pupil costs. One of these is district size. That is to say, larger school districts tend to have lower costs than smaller districts. However, MEA performance does

not appear to be related directly to costs. A multiple regression analysis was performed using average MEA score as the dependent variable and all other variables, including per-pupil cost, as independent variables. Statistically insignificant variables at the 0.05 level were removed one by one until only statistically significant variables remained. All variables other than the logarithm of free and reduced lunch eligibility were removed as statistically insignificant. R^2 for the regression analysis was .516. MEA scores were not found to be statistically related to costs or school district size.

Summary

Efficiency is a matter of both costs and outcomes. A case of decreased cost and worsened outcomes is not necessarily a case of increased efficiency. However, a case of decreased cost without a worsening of outcomes is a case of increased efficiency. The finding that larger districts in Maine tend toward lower costs than smaller districts, together with the fact that no significant relation between MEA scores and district size was detected indicates that there may be potential for economies of scale to be realized though school district consolidation. In K-12 districts there appears to be potential for substantial savings through realizing economies of scale.

Theoretically, a cost function may be U-shaped, meaning that beyond a certain size, unit costs begin to increase. But the large size groups in the study were not associated with higher predicted costs. No evidence was found that even Maine's largest districts are so large that they experience diseconomies of scale.

Thus, the findings from this study suggest that school district consolidation may increase efficiency in the delivery of education services. However, caution must be used in extrapolating policy from these findings. Consolidating existing school administrative units into larger school districts may not be appropriate in all cases. As this study has shown, other variables need to be considered.

Additionally, it may be tempting to treat the differences between the predicted cost of the current size group and that of the lowest-cost size group

as shown in Table 5 as an estimate of the potential savings from greater school district consolidation. But there are several reasons to be skeptical of such an estimate. First, there is no reason to believe that combining school districts will guarantee savings if nothing else is done differently. To realize savings the new consolidated school district must operate differently, more like a larger district. But in some cases, it might not even be possible for a consolidated district to operate like Maine's current larger districts. For instance, a consolidated district might have to operate a larger number of schools if it covers a large geographic area or includes islands. Study and due diligence are required before it may be determined that any particular districts will save money by consolidating into larger school administrative districts.

In conclusion, this study has provided some basic information about the statistical relationship between the cost of education and the scale of school districts. It provides and early indication that there may be opportunities to increase efficiency by taking advantage of economies of scale through consolidation. The study provides some evidence to believe that where feasible, school district consolidation may increase efficiency.

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